THE AQUATIC PLANT COMMUNITY OF JORDAN LAKE, ADAMS COUNTY, WISCONSIN 2000-2016

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I. INTRODUCTION

A point intercept survey of the aquatic macrophytes (plants) in Jordan Lake was conducted during the summer of 2016 by the Adams County Land and Water Conservation Department. There have been a number of prior surveys using both transect and point intercept methods over the past 15 years.

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 ongoing information to be used for management of the lake and track any significant changes in the aquatic plant community that may indicate changes in the lake's overall health.

Background and History: Jordan Lake is located in the Town of Jackson, Adams County, Wisconsin. This natural seepage lake is over 213 surface acres in size. Maximum depth is 92 feet. According to an updated bathymetric map from 2007, 45% of the lake is over 20 feet deep. There are basically two deep lobes with a sandbar running between them across most of the lake vertically.

During the summer of 2016, when the most recent survey was conducted, the lake was at slightly higher level than usual due to significant rain events in the spring and most of the summer. There is public boat ramp located on the northwest 'corner' of the lake owned by the Adams County Department of Parks & Recreation. There are also several private-owned boat ramps, usually associated with a campground or condo development. In 2002, the residents of the area formed the Jordan Lake District. The Lake District completed a lake management plan in 2006 that was approved by the Wisconsin Department of Natural Resources (WDNR). This plan is reviewed annually for needed updates.

Residential development around the lake is found along most of the lakeshore. Both irrigated and non-irrigated agriculture are common in the watersheds. Wooded areas are also frequent. 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. There are also some natural beach areas in parts of the shore.

A fish shocking survey in 2006 found a good panfish population, including bluegills, crappie and perch. Less common were largemouth bass and northern pike. Ciscos have been reported in Jordan Lake, but were not found in the most recent fish survey. In a survey done a few years ago, 38.1% of the respondents rated fishing in Jordan Lake as “very good” or “good”, with another 57.1% calling it “fair’.

Soils directly around Jordan Lake tend to be sands or loamy sands of various slopes. Such soils are usually excessively-drained, with infiltration of water being rapid to very rapid, and permeability also high. Such soils also usually have 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. This is readily apparent when looking at some of the natural beach areas at the shore on Jordan Lake.

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 one year also occurring. Early treatments were broad-spectrum treatments that targeted all plant species and likely opened areas for invasion and colonization of the two non-native submergent species now in the lake. Later treatments, from approximately 1980 onwards, were more selective, targeting Eurasian Watermilfoil (*Myriophyllum spicatum*). The Jordan Lake District has generally continued to use chemical treatment for Eurasian Watermilfoil management. Pre-and-post-treatment surveys are conducted every year by the Adams County Land & Water Conservation Department and a Jordan Lake volunteer or by staff of the Wisconsin Department of Natural Resources.

However, no chemical treatment was conducted in 2016. The Lake District has been pursuing hand-pulling of invasives using snorkel and scuba divers. Chemical treatment will likely be resumed should it appear that Eurasian Watermilfoil, in particular, is spreading again.

Two other invasive aquatic plants have been found in Jordan Lake, but have remained in low frequency occurrence: Curly-Leaf Pondweed (*Potamogeton crispus*) and Reed Canarygrass (*Phalarais arundinacea*).

The critically-endangered plant-like algae, *Lychnothamnus barbatus*, was found in Jordan Lake in 2012. It may have been there before, but simply classified as a *Charophyte.* Until 2010-2011, this species had never been found in the Western Hemisphere. In 2010, it was discovered in Wolf Lake, Adams County, when the researcher was looking for another unusual *Charophyte.* Since that time, it has been found in at least seven other lakes in Adams County, three in Waushara County and one in Sauk County. Studies involving the New York Botanical Garden about the occurrence of this species are ongoing.

Two areas in Jordan Lake have been designated as “critical habitat areas”. Designation of critical habitat areas within lakes provides a holistic approach for assessing the ecosystem and for protecting those areas in and near a lake that are important for preserving the qualities of the lake. Wisconsin Rule 107.05(3)(i)(I) defines a “sensitive areas” as: “areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, sensitive areas often can provide the peace, serenity and beauty that draw many people to lakes in the first place.

<u>Area JO1</u> extends along approximately 2600 feet of the shoreline along the north side of the lake. 6% of the shore is wooded; 20% is native herbaceous cover. The balance of the shore is bare sand, cultivated lawn and hard structure. There is a shallow marsh area along this shoreline. Seven emergent species were found in this area. Emergents provide important fish habitat and spawning areas, as well as food and cover for wildlife. Three species of rooted, floating-leaf plants were also found. Floating-leaf vegetation provides cover and dampens waves, protecting the shore. Nineteen species of submergent aquatic plants were present in this area. Such a diverse submergent community provides many benefits.

<u>Area JO2</u> extends along approximately 1800 feet of the shoreline on the far east end of the lake, up to the ordinary high water mark. Average water depth here is about 15 feet, with a steep dropoff. 11% of the shore is wooded; 6% has shrubs; 23% is native herbaceous cover. The remaining shore is bare sand, cultivated lawn and hard structures, which tend to be concentrated at the edges of this area. The middle area is almost entirely undeveloped and contains some shallow marsh. Five emergent species were found, as well as one free-floating plant. Two floating-leaf rooted species were present. Fourteen species of submergent aquatic plants were also found. This community has a diversity of structure and species to support a diversity of fish and wildlife. With minimal human disturbance along this shoreline, the area has natural scenic beauty.

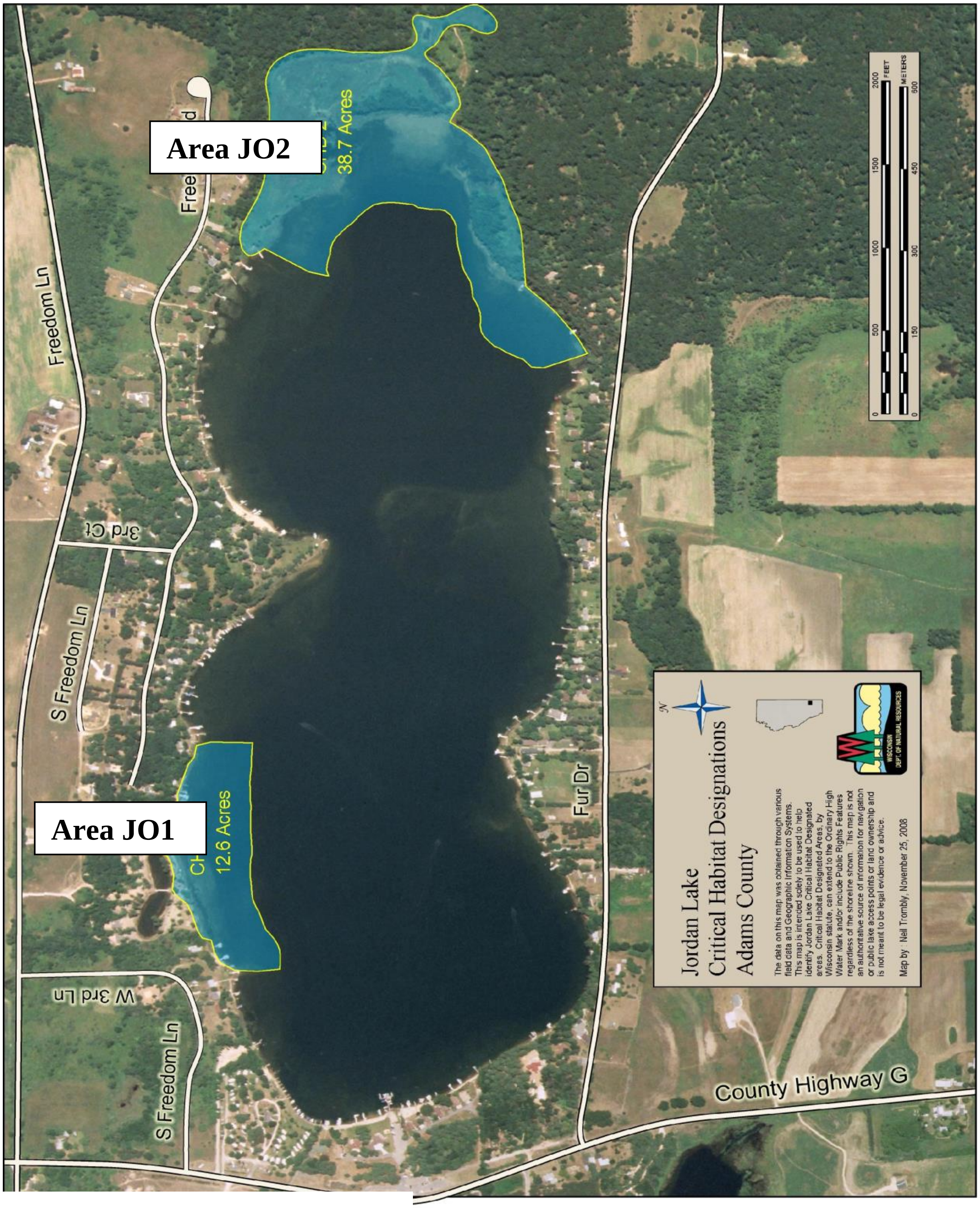


Figure 1: Critical Habitat Map for Jordan Lake

II. METHOD

Field Method

The survey method used was the Point Intercept (PI) Method. This involves calculating the surface area of a lake and dividing it (using a formula developed by the WDNR) into a grid of several points, always placed at the same interval from the next one(s). These points are related to a particular latitude and longitude reading. At each geographic point, the depth is noted and one rake is taken, with a score given between 1 and 3 to each species on the rake.

A rating of 1 = a small amount present on the rake;
A rating of 2 = moderate amount present on the rake;
A rating of 3 = large amount present on the rake.

A visual inspection was done between points 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.

Data Analysis

Percent frequency of each species was calculated (number of sampling sites at which it occurred/total number of sampling sites). Relative frequency was calculated (number of occurrences of a species/sum of all species occurrences). Mean density was calculated for each species (sum of a species' density ratings/number of sampling sites). Relative density was calculated (sum of a species density/sum of all plant densities). The relative frequency and relative density of each species were summed to obtain a dominance value for each species. Species diversity was measured by Simpson's Diversity Index.

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

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. There are three main trophic states:

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

- Oligotrophic lakes are low in nutrients and support limited plant growth and smaller populations of fish.
- Mesotrophic lakes have intermediate levels of nutrients and biomass.

Jordan Lake has water quality records for a number of years. Water clarity readings go back to 1986, while total phosphorus levels records start in 1990 and cholorophyll-a results start in 1992.

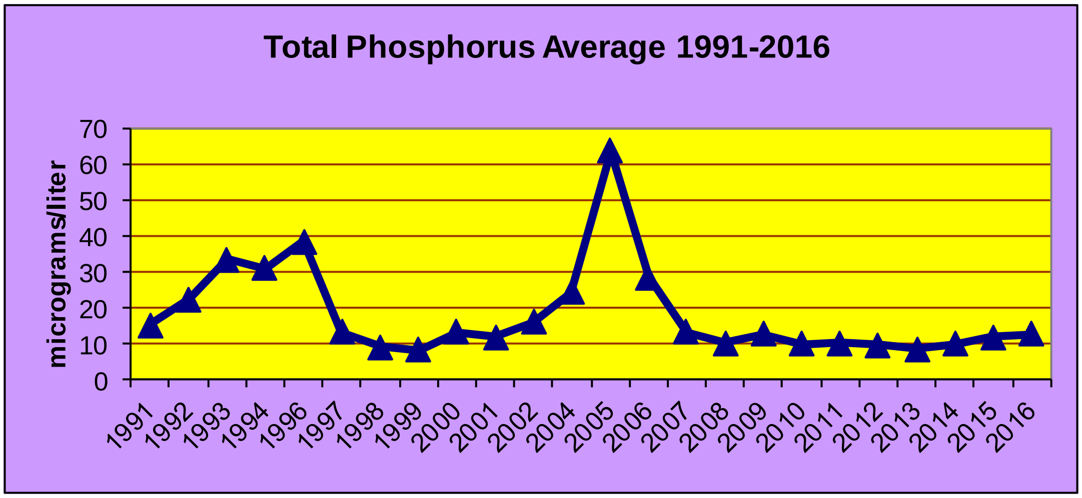
Figure 2: Trophic Status of Jordan Lake

	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
Jordan Lake Growing Season 1986-2016		**18.1**	**2.4**	**13.6**

Nutrients

Phosphorus is a limiting nutrient in many Wisconsin lakes, including Jordan Lake, 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. Starting from 1990, the average growing season (May through September) for total phosphorus levels is 13.1 micrograms/liter (good). If simply looking at the last ten years, the total phosphorus average during the growing season was even better at 12.4 micrograms/liter (good).

Figure 3: Average Total Phosphorus Levels in Jordan Lake 1990-2016



Algae/Chlorophyll-a

Chlorophyll-a 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. The 1992-2016 mean summer chlorophyll-a concentration in Jordan Lake was 2.4 micrograms/liter (very good). This average has remained the same over many years. Even if only the last 10 years are examined, the average is still only 2.4 micrograms/liter (very good).

Water Clarity

Water clarity is a critical factor for aquatic plants, because if they don't get more than 2% of surface illumination, they won't survive (Chambers and Kalff 1985, Duarte et. al. 1986, Kampa 1994). 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. The 1986-2016 Average Summer Secchi Disc clarity in Jordan Lake was 13.6 feet (very good). Looking at the last 10 years, the average is 14.9 feet (very good).

Figure 4: Average Chlorophyll-a Levels in Jordan Lake 1992-2016

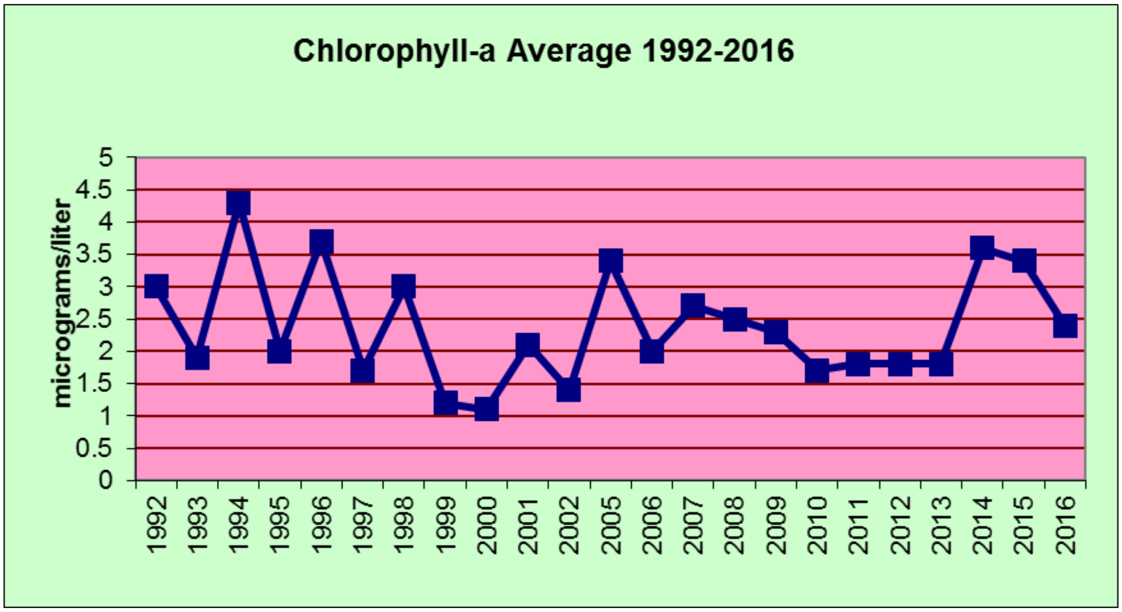
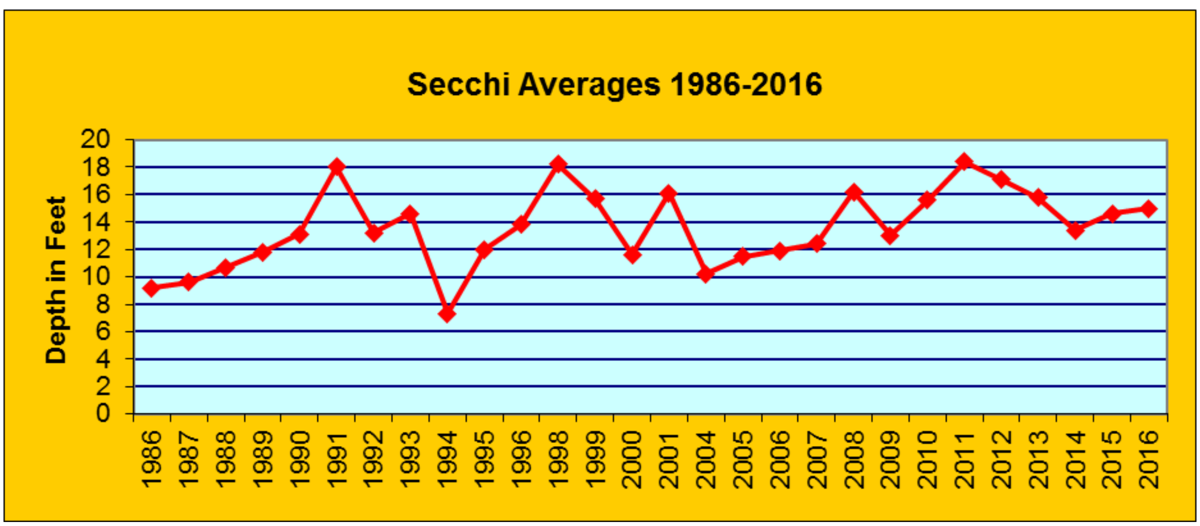


Figure 5: Average Growing Season Secchi Depth 1986-2016



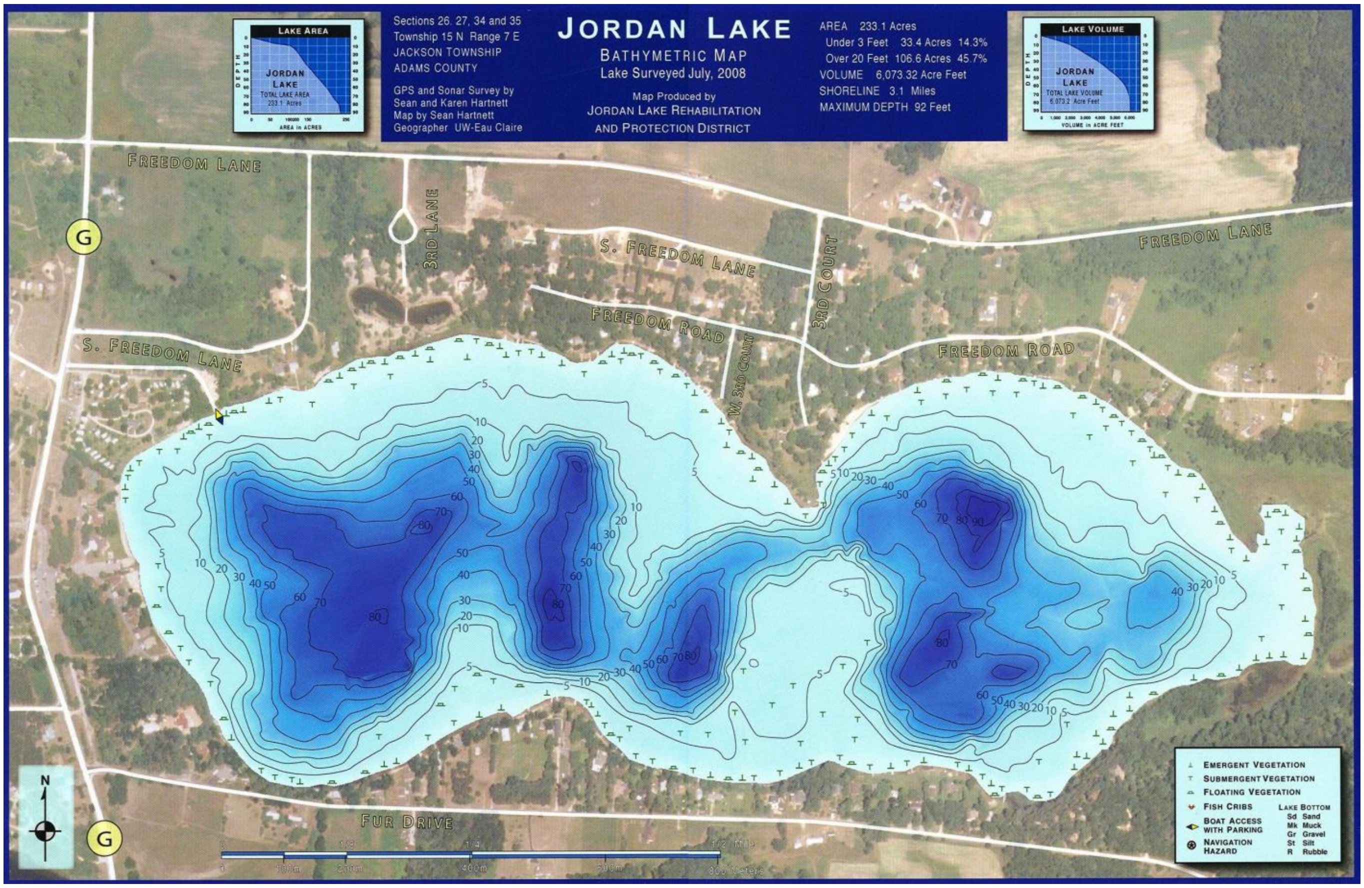
Overall Water Quality

The combination of phosphorus concentration, chlorophyll-a concentration and water clarity indicate that Jordan Lake is a borderline oligotrophic/mesotrophic lake with good-to-very good water quality and clarity. This trophic state should favor moderate plant growth and only occasional localized summer algal blooms.

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

Jordan Lake is an oval natural lake with several areas of sharply-dropping slopes, roughly divided into two basins. There is a sandbar in the middle of the lake that run from south to north, nearly bisecting the lake. In times of low water, some of this sand bar is exposed and the areas of it with water may only have water 2 feet deep. The south quarter of the lake has more steeply-sloped littoral zone, dropping to over 50 feet in depth. Gradual slopes provide a more stable rooting base and broader area of shallow water that would favor plant growth. 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.

Figure 6: Jordan Lake Bathymetric Map



INFLUENCE OF SEDIMENT COMPOSITION

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. The availability of mineral nutrients for growth is highest in sediments of intermediate density, such as silt, so these sediments are considered most favorable for plant growth (Barko and Smart 1986).   Mineral availability in sediments such as sand is often considerably reduced.

The most common sediment in Jordan Lake was sand. The shallower areas had more mixture of sediment types than the areas over 5 feet deep. With the low capacity of sand to hold nutrients, sand sediments in some instances can limit aquatic plant growth. However, with the majority of its littoral zone vegetated, this does not seem to be the case at Jordan Lake. The next most common sediments were peat (9%) and silt (5%). There were also small areas of mixtures of sand and other sediment types.

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.

Native herbaceous plant cover was the most frequently occurring shoreline cover at the transect sites. Cultivated lawn and hard structure (boat docks, patios, retaining walls, etc.) also were frequently occurring.

Frequency of occurrence does not always translate into amount of actual cover a shore type provides. For example, in 2012, although the most frequently-occurring shore type was herbaceous vegetation (91.3%), it only covered 31.6% of the shore. Similarly, although wooded vegetation had an occurrence frequency of 39.1% in 2012, it covered only 6.1% of the shore.

This land use not only affects what kind of runoff ends up in the lake (UW-Extension, 1999), but also wildlife habitat (Bryan & Charry, 2006). A 2016 survey of the woody debris along the shore in Jordan Lake revealed only 4 spots where woody debris sufficient for wildlife habitat occurred, despite research that shows that the presence of woody debris benefits fish & other wildlife (Milstein & Roni, 2015).

In 2016, the Wisconsin Department of Natural Resources issued a shoreland habitat survey protocol for general use. The woody debris survey on Jordan Lake was one step of that protocol. The other steps, including photographing the entire shore and rating each waterfront lot for buffer, runoff and other points, will be conducted on the lake in 2017.

MACROPHYTE DATA

SPECIES PRESENT

In the 2016 survey, 42 species of aquatic plants were found. Of these, two were invasive: the emergent Reed Canarygrass (*Phalaris arundinacea*) and the submergent Eurasian Watermilfoil (*Myriophyllum spicatum*). Included in the 40 native species were nineteen submergent species, three rooted floating-leaf plants, and twenty emergent species. In addition, a number of freshwater sponges were found in Jordan Lake in 2016.

Figure 7: Jordan Lake Aquatic Plant Species in 2016

Scientific Name	**Common Name**	2016PI
Bidens cernuus	Nodding Beggars-Tick	X
Bidens connatus	Tall Swamp Marigold	X
Brasenia schreberi	Watershield	X
Carex	Sedge spp	X
Ceratophyllum demersum	Coontail	X
Chara contraria	Opposite Stonewort	X
Cirsium muticum	Swamp Thistle	X
Echinochloa crus-galli	Barnyard Grass	X
Eleocharis palustris	Common Spikerush	X
Elodea canadensis	Common Waterweed	X
Eupatorium altimissum	Tall Joe Pye Weed	X

Eupatorium maculatum	Spotted Joe Pye Weed	X
Lycopus americanus	American Bugleweed	x
Lychnothamnus barbatus	Bearded Stonewort	x
Mentha arvensis	Field Mint	x
Megalodonta beckii	Water Marigold	X
Myriophyllum sibiricum	Northern Milfoil	X
Myriophyllum spicatum	Eurasian Watermilfoil	X
Najas flexlis	Bushy Pondweed	X
Najas guadelupensis	Southern Naiad	X
Nitellla flexilis	Slender Stonewort	X
Nitella tenuissima	Dwarf Stonewort	X
Nymphaea odorata	White Water Lily	X
Phalaris arundinacea	Reed Canarygrass	X
Phragmites	Common Reed Grass	X
Polygonum amphibium	Water Smartweed	X
Potamogeton amphifolius	Large-Leaf Pondweed	X
Potamogeton crispus	Curly-Leaf Pondweed	X
Potamogeton friesii	Fries' Pondweed	X
Potamogeton gramineus	Variable-Leaf Pondweed	X
Potamogeton natans	Floating-Leaf Pondweed	X
Potamogeton praelongus	White-Stemmed Pondweed	X
Potamogeton pusillus	Small Pondweed	X
Potamogeton zosteriformis	Flat-Stemmed Pondweed	X
Ranuculus aquatilis	White Water Crowfoot	X
Sagittaria rigidia	Stiff Arrowhead	X
Schoenoplectus acutus	Hard-Stemmed Bulrush	X
Schoenoplectus pungens	Chairmaker's Rush	X
Schoenoplectus tabernaemontani	Soft-Stemmed Bulrush	X
Stuckenia pectinata	Sago Pondweed	X
Typha spp	Cattail spp	X
Vallisneriaa americana	Water Celery	X
Verbena hastata	Blue Vervain	X
Zosterella dubia	Water Stargrass	X

FREQUENCY OF OCCURRENCE

Members of the *Charophyt*e family (plant-like algae) were the most frequently-occurring species, with Variable-Leaf Pondweed (*Potamogeton gramineus*) a far second. *Charophytes* in Jordan Lake in 2016 included *Chara contraria*, *Lychnothamnus barbatus*, *Nitella flexilis* and *Nitella tenuissima*. As is the case in most of the lakes in Adams County, submergent species were the most frequently-occcurring species in Jordan Lake in 2016.

Figure 8: Most Frequently-Occurring Species 2016

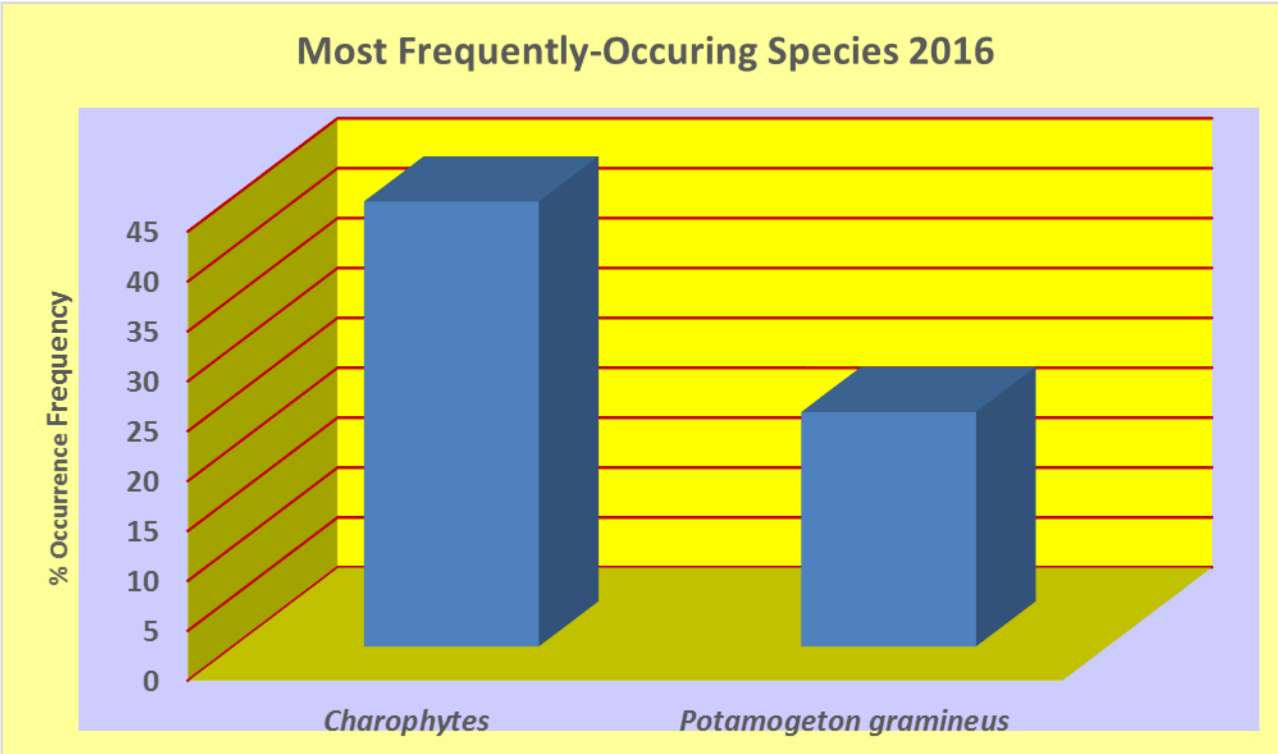
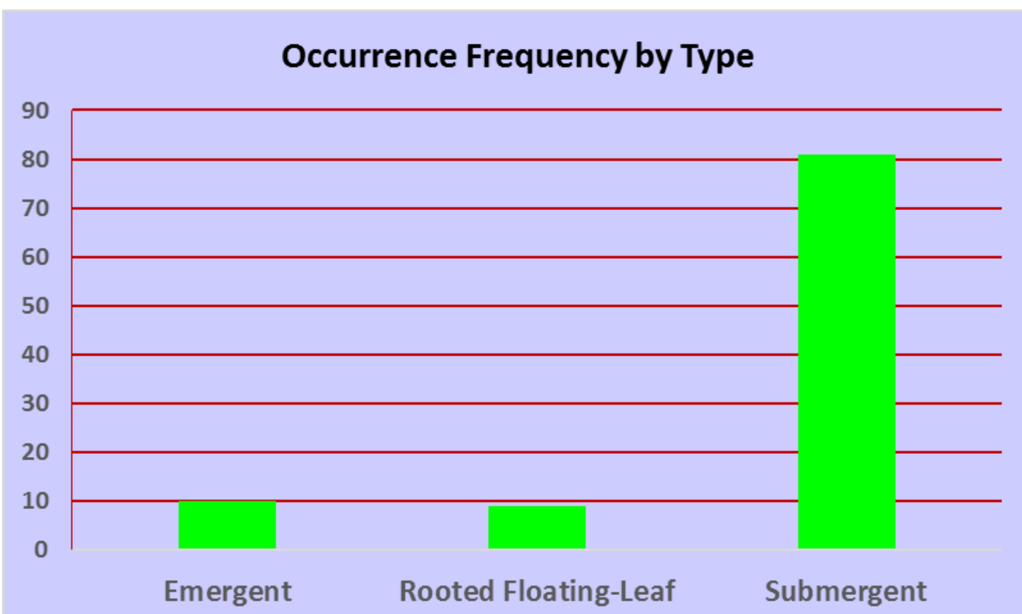


Figure 9: Mostly Frequently Occurring Species by Type 2016



DENSITY

Besides the frequency at which particular species occurs, the density of growth for each plant type is also evaluated. Some plants occur mostly in beds of growth with their own kind—those would have a considerably higher growth density where present than in the lake overall. In other instances, a specie is found scattered throughout the lake, mixed with other species. For example, the most densely-growing aquatic species in the lake overall, in the 2016 survey, were members of the *Charophyte* family. However, this family had a fairly consistent density of growth throughout the lake, rather than just being located in beds where present.

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. In this instance, *Chara contraria* and *Lychnothamnus barbatus* were calculated separately from the two *Nitellas* in order to more accurately represent their place on the dominance scale. Based on the Dominance Value, the *Charophyte contraria/Lychnothamnus barbatus* combination was the dominant aquatic species in Jordan Lake in 2016. The second-most dominant species overall and the dominant plant species was Variable-Leaf Pondweed. The *Nitella* combination was third most dominant species overall.

In looking at dominance, it may also be relevant to look at what type of aquatic species dominates. In 2016, submergent plants dominate the lake. Emergent species are the second most common plant type, with rooted floating-leaf plants the least common. No free-floating species were found in Jordan Lake in 2016.

Figure 10: Dominance in 2016

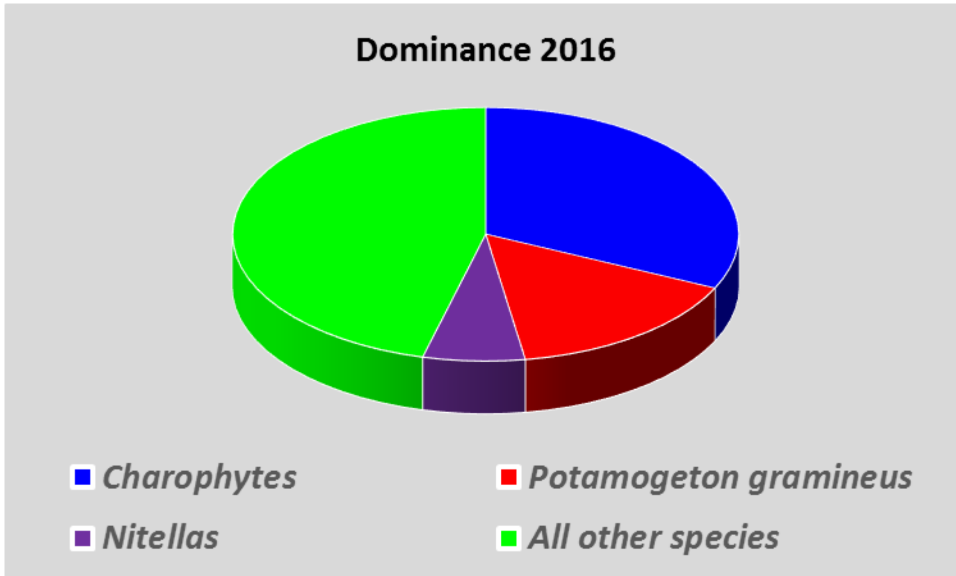
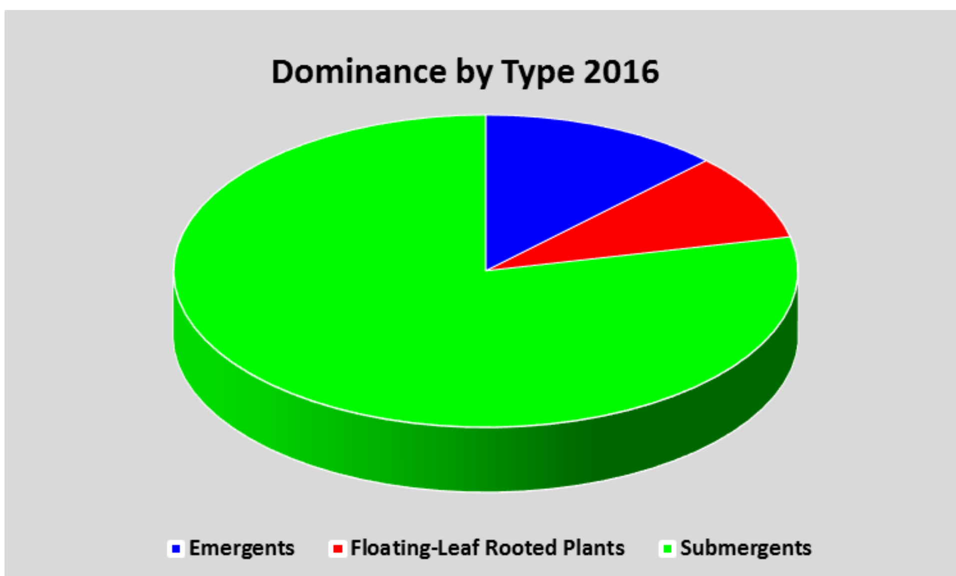


Figure 11: Dominance in 2016 by Type



The PI method generally looks at results from all sample sites, no matter what their depths. Using this method, Jordan Lake was 59.7% vegetated in 2016. However, if depths over 35 feet (the deepest spot where any vegetation was found) are eliminated, so that non-littoral points are eliminated, the lake is 89.5% vegetated.

Figure 12: Distribution of Emergent Plants 2016

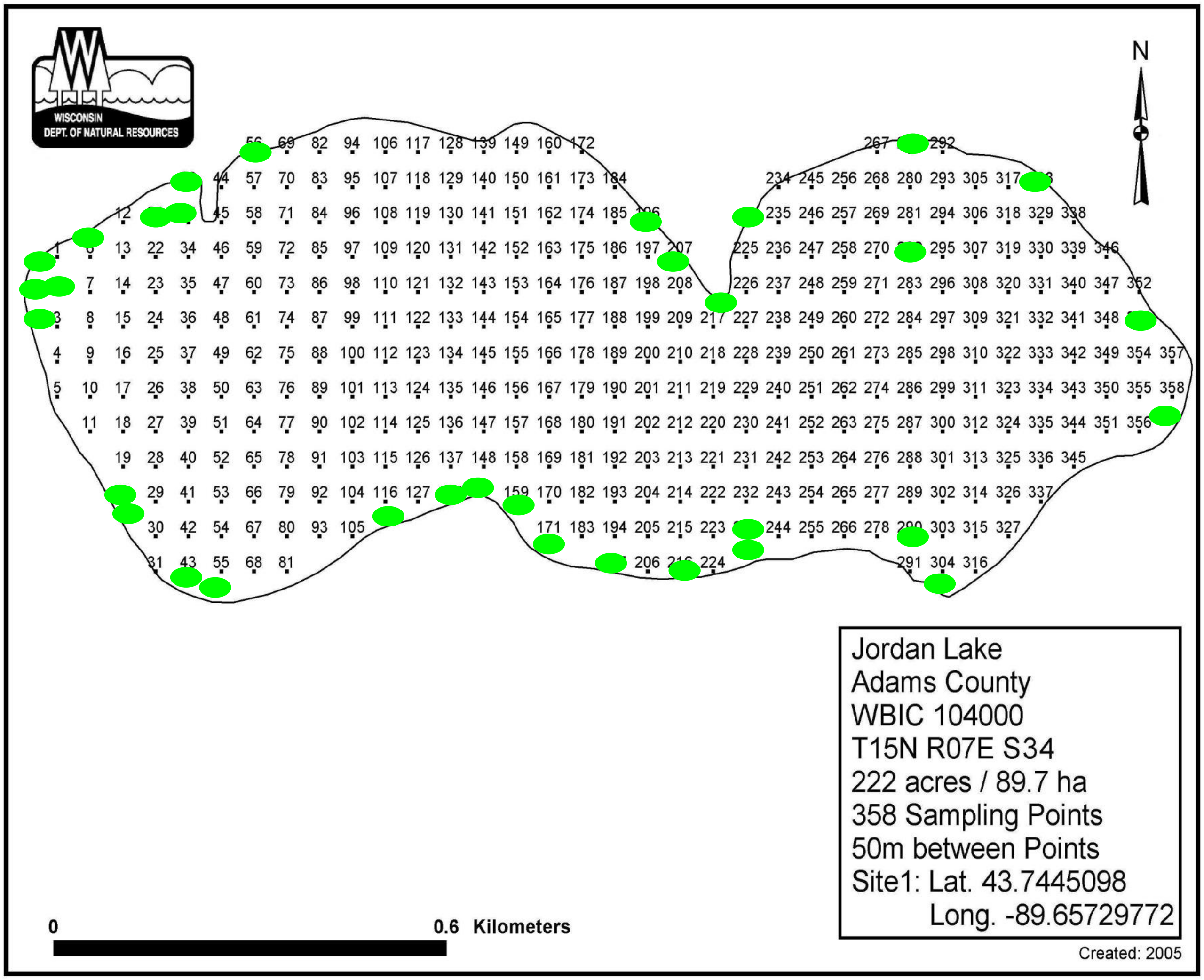


Figure 13: Distribution of Rooted Floating-Leaf Plants 2016

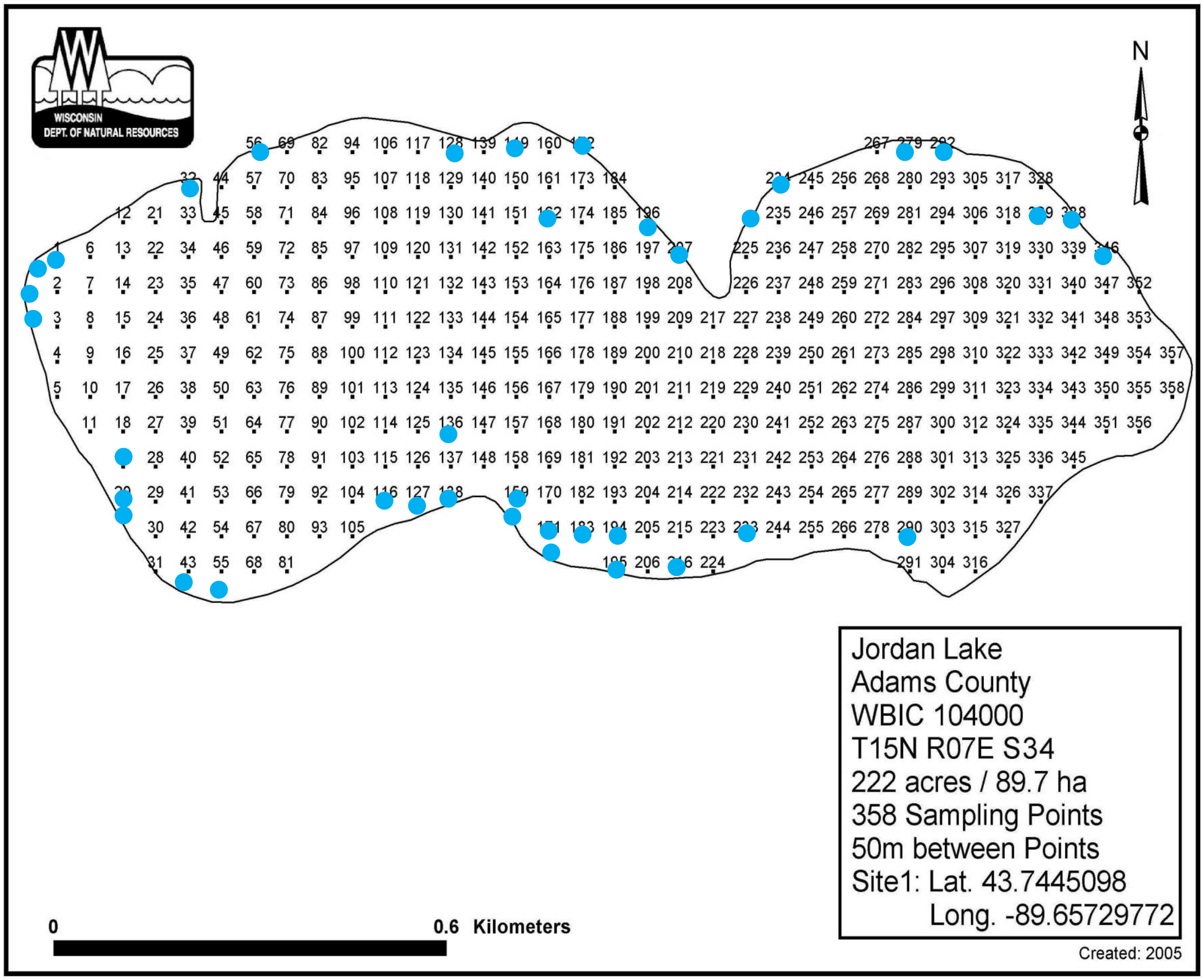
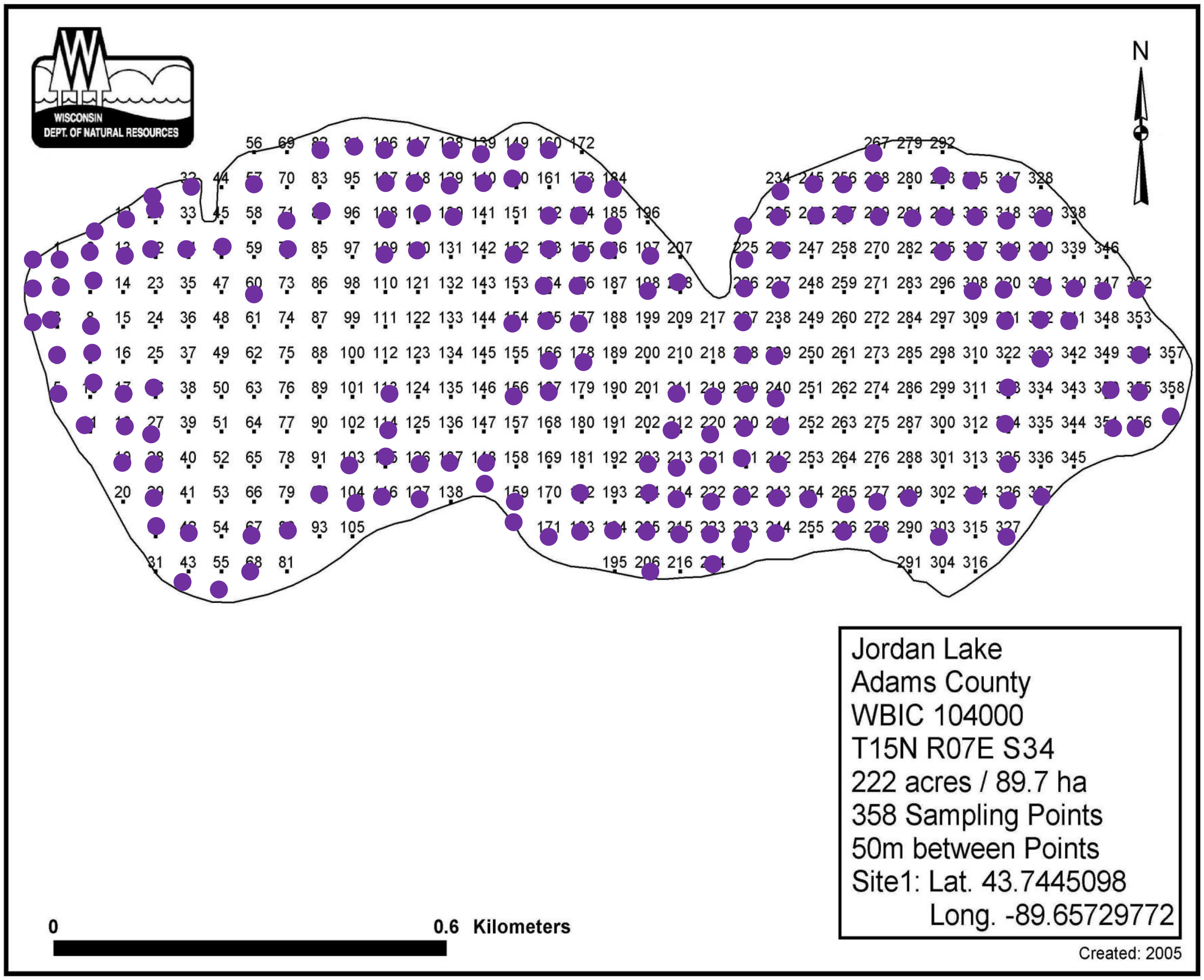
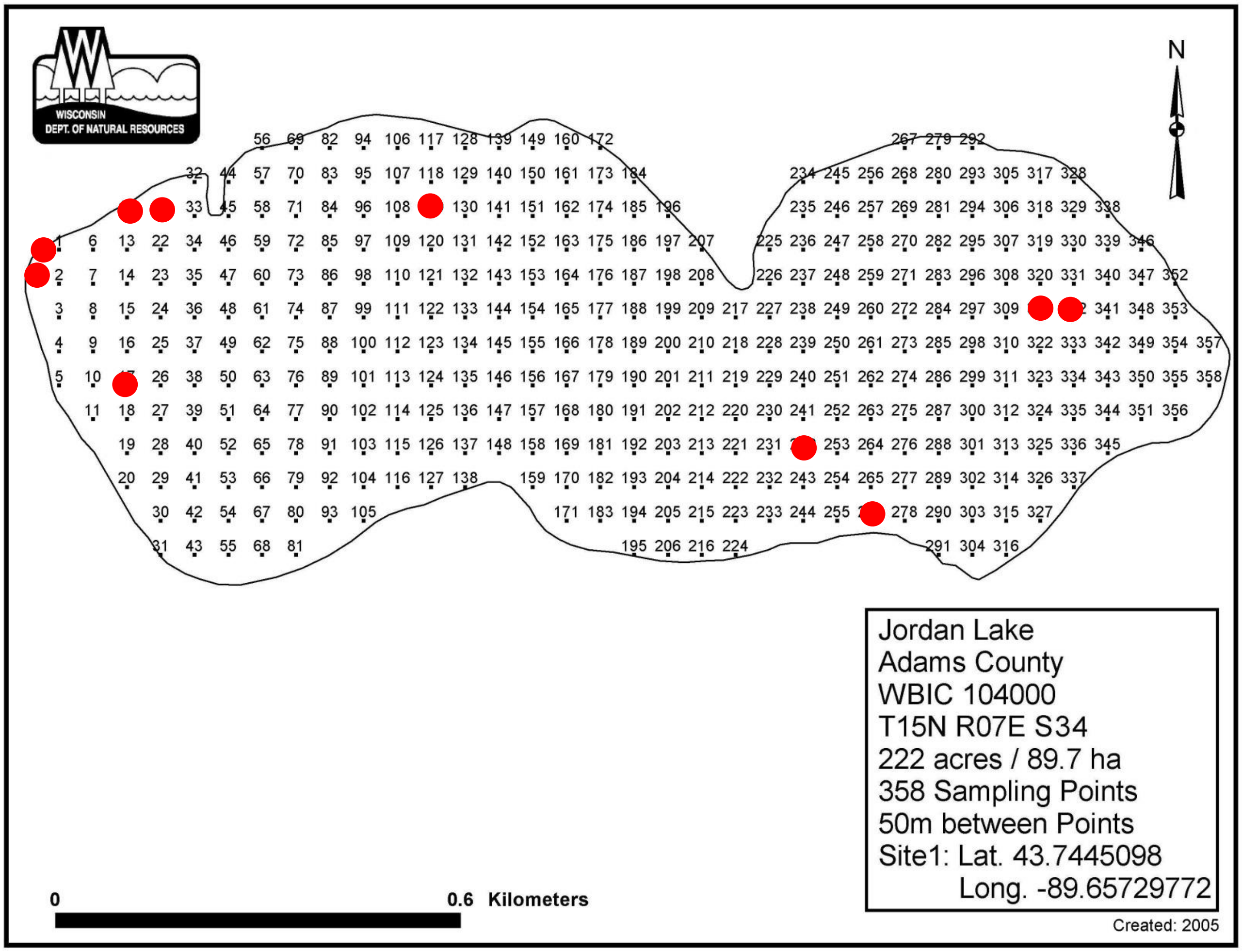


Figure 14: Distribution of Submergent Plants 2016



Eurasian Watermilfoil has been consistently found in Jordan Lake for many years. This has been monitored every year. If chemical treatment is being contemplated, there are both pre-and-post chemical treatment surveys. Otherwise, there is a survey to locate any Eurasian Watermilfoil for hand-pulling. Hand-pulling efforts have usually used people snorkeling or scuba-diving. This removal has focused on the removal of individual plants or small isolated populations and continues each year. No chemical treatment was done in 2016, but it is being considered for 2017. That decision is likely to depend on results of a pre-treatment survey in the spring of 2017.

Figure 15: Location of Eurasian Watermilfoil 2016



The other two invasives found at Jordan Lake since 2006--Curly-Leaf Pondweed and Reed Canarygrass-- have consistently been found in low frequency of occurrence and low density of growth. It appears that neither of these invasives pose a significant threat to the Jordan Lake aquatic plant community.

THE COMMUNITY

The Simpson's Diversity Index (SI) for the 2016 survey was .87. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). This score place Jordan Lake in the middle for diversity for all the lakes in Wisconsin (.80 to .90) and for the North Central Hardwoods Region (.81 to .90).

The Average Coefficient of Conservation and Floristic Quality Index were calculated as outlined by Nichols (1998) to measure plant community disturbance (see Figure 18). A coefficient of conservation 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 Conservationism is the mean of the coefficients for the species found in the lake. Generally, plants scoring 1 to 3 are found in a wide range of tolerances and plant communities, while ones with scores of 4 to 6 are associated with intermediate plant communities. Plants with scores of 7 or 8 have a small range of tolerance. Those scoring 9 or 10 are found only in a narrow range of very high-quality and undisturbed habitats.

The coefficient of conservatism is used to calculate the Floristic Quality Index (FQI), a measure of a plant community's closeness to an undisturbed condition. The Floristic Quality Index is also a tool that can be used to identify areas of high conservation value, monitor sites over time, assess the anthropogenic (human-caused) impacts affecting an area and measure the ecological condition of an area (M. Bourdaghs, 2006).

The Average Coefficient of Conservatism for Jordan Lake was 4.5 in 2016. The Average Coefficient of Conservatism places Jordan Lake in the lowest quartile of lakes for Average Coefficient of Conservatism for lakes in Wisconsin overall and the North Central Hardwoods Region.

The 2016 FQI was 28.98, placing the aquatic plant community in Jordan Lake above average for Wisconsin lakes and in the highest quartile of North Central Hardwood Region lakes. These figures indicate that the plant community in Jordan Lake is closer to an undisturbed condition than the average lake in Wisconsin and within the group of lakes in the region closest to an undisturbed condition.

Figure 16: Floristic Quality and Coefficient of Conservatism of Jordan 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
Jordan Lake 2012	4.5	28.98

***** - 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).

These results may seem contradictory, but that is because they measure different aspects of the community. A high FQI depends on the weighted presence of species with high C values. Such plants show strong fidelity to specific habitats. Such fidelity goes hand-in-hand with rarity. But a high C value does not necessarily mean that the species is "endangered" or "threatened". This depends on the commoness of the required habitat of a plant with high C value. However, the Coefficient of Conservatism is not weighted.

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.

The major disturbances in Jordan Lake are likely:

1) the introduction of non-native aquatic plant species; and
2) high use of the lake by jetskiers, waterskiers, tubers, and speedboats.

The Aquatic Macrophyte Community Index (AMCI) for Jordan Lake in 2016 was 59. This is slightly above average for lakes in the North Central Hardwoods Region (48 to 57) and Wisconsin (45 to 57) and similar to prior survey results.

Figure 16: AMCI Results for 2016

	Parameter	Score
	2016	2016
Maximum Rooting Depth	19.2	10
% of Lake Vegetated	59.7	10
% Submergent Plants	65	6
% Invasive Plants	4	6
% Sensitive Plants	27	10
Simpson's Index	0.87	7
taxa #	42	10
		59

COMPARISON TO PRIOR RESULTS

Several aquatic species surveys have been conducted on Jordan Lake since 2006, including three using the Transect method and at least three using the Point Intercept method. The previous number of species found has varied from a low of 25 found during the 2006 transect survey to a high of 37 found during the 2008 transect survey and the 2012 PI survey. The 42 found in 2016 may be the result of a higher-than-usual lake level, resulting in some plants being in the water that previously were found only on the shore out of water.

Figure 17: Aquatic Plant List

Scientific Name	Common Name	2006 T	2006 PI	2010PI	2011PI	2012 T	2012PI	2016PI
Bidens cernuus	Nodding Beggars-Tick							X
Bidens connatus	Tall Swamp Marigold							X
Brasenia schreberi	Watershield	x	x	x	x	x	x	X
Carex	Sedge spp	x	x	x		x	x	X
Carex comosa	Porcupine Sedge				x			
Ceratophyllum demersum	Coontail	x	x	x	x	x	x	X
Chara sp	Muskgrass	x	x	x	x	x	x	X
Cirsium muticum	Swamp Thistle							X
Echinochloa crus-galli	Barnyard Grass							X
Eleocharis palustris	Common Spikerush				x	x	x	X
Elodea canadensis	Common Waterweed	x	x	x	x	x	x	X
Eupatorium altimissum	Tall Joe Pye Weed							X
Eupatorium maculatum	Spotted Joe Pye Weed							X
Impatiens capensis	Jewelweed	x						
Juncus spp	Rush spp					x	x	
Iris versicolor	Blue-Flag Iris				x			
Lemna minor	Lesser Duckweed	x						
Lycopus americanus	American Bugleweed							x
Lychnothamnus barbatus	Bearded Stonewort							x
Mentha arvensis	Field Mint							x
Megalodonta beckii	Water Marigold			x		x	x	X
Myriophyllum sibiricum	Northern Milfoil	x	x	x	x	x	x	X
Myriophyllum spicatum	Eurasian Watermilfoil	x	x	x	x	x	x	X
Najas flexlis	Bushy Pondweed	x	x	x	x	x	x	X
Najas guadelupensis	Southern Naiad			x	x	x	x	X
Nitellla flexilis	Slender Stonewort	x	x	x	x	x	x	X
Nitella tenuissima	Dwarf Stonewort							X
Nymphaea odorata	White Water Lily	x	x	x	x	x	x	X
Phalaris arundinacea	Reed Canarygrass	x		x		x	x	X

Phragmites spp	Common Reed Grass							X
Polygonum amphibium	Water Smartweed	x						X
Potamogeton amphifolius	Large-Leaf Pondweed	x	x	x	x	x	x	X
Potamogeton crispus	Curly-Leaf Pondweed	x	x	x	x		x	X
Potamogeton foliosus	Leafy Pondweed	x						
Potamogeton friesii	Fries' Pondweed		x	x		x	x	X
Potamogeton gramineus	Variable-Leaf Pondweed	x	x	x	x	x	x	X
Potamogeton illinoensis	Illinois Pondweed	x	x	x	x	x	x	
Potamogeton natans	Floating-Leaf Pondweed	x	x	x	x	x	x	X
Potamogeton praelongus	White-Stemmed Pondweed	x	x	x	x	x	x	X
Potamogeton pusillus	Small Pondweed	x	x	x	x	x	x	X
Potamogeton richardsonii	Clasping-Leaf Pondweed	x	x	x	x	x	x	
Potamogeton robbinsii	Fern-Leaf Pondweed					x	x	
Potamogeton zosteriformis	Flat-Stemmed Pondweed	x	x	x	x	x	x	X
Ranuculus aquatilis	White Water Crowfoot			x	x	x	x	X
Ranunculus lonigirostris	Beaked Crowfoot	x						
Sagittaria latioflia	Common Arrowhead	x	x	x			x	
Sagittaria rigidia	Stiff Arrowhead					x	x	X
Salix spp	Willow spp	x				x	x	
Schoenoplectus acutus	Hard-Stemmed Bulrush	x		x	x	x	x	X
Schoenoplectus pungens	Chairmaker's Rush			x	x	x	x	X
Schoenoplectus tabernaemontani	Soft-Stemmed Bulrush	x	x	x	x	x	x	X
Solanum ptycanthum	Bittersweet Nightshade	x						
Solidago spp	Goldenrod	x						
Stuckenia pectinata	Sago Pondweed	x	x	x	x	x	x	X
Typha spp	Cattail spp	x	x	x	x	x	x	X
Vallisneriaa americana	Water Celery	x	x	x	x	x	x	X
Verbena hastata	Blue Vervain							X
Zosterella dubia	Water Stargrass	x			x	x	x	X

There are multiple years of PI surveys, although most of them are from the last few years. The first one was done in 2006, followed by one in 2010, one in 2011, one in 2012, and the most recent on in 2013. Understandably, the results have been very similar, as shown in the chart below.

The PI plant communities for 2013 and 2016 were compared by calculating coefficients of similarity (developed by Jaccard in 1901), using both actual frequency of occurrence and relative frequency of occurrence. Based on actual frequency of occurrence, the 2013 and 2016 aquatic plant communities were 88.0% similar.

Based on relative frequency, they were 89.7% similar. Coefficients of similarity over 75% suggest that the aquatic plant community is substantially the same, despite the difference in numbers of species. This suggests that the aquatic community in Jordan Lake is relatively stable.

Figure 18: Comparison of PI Surveys

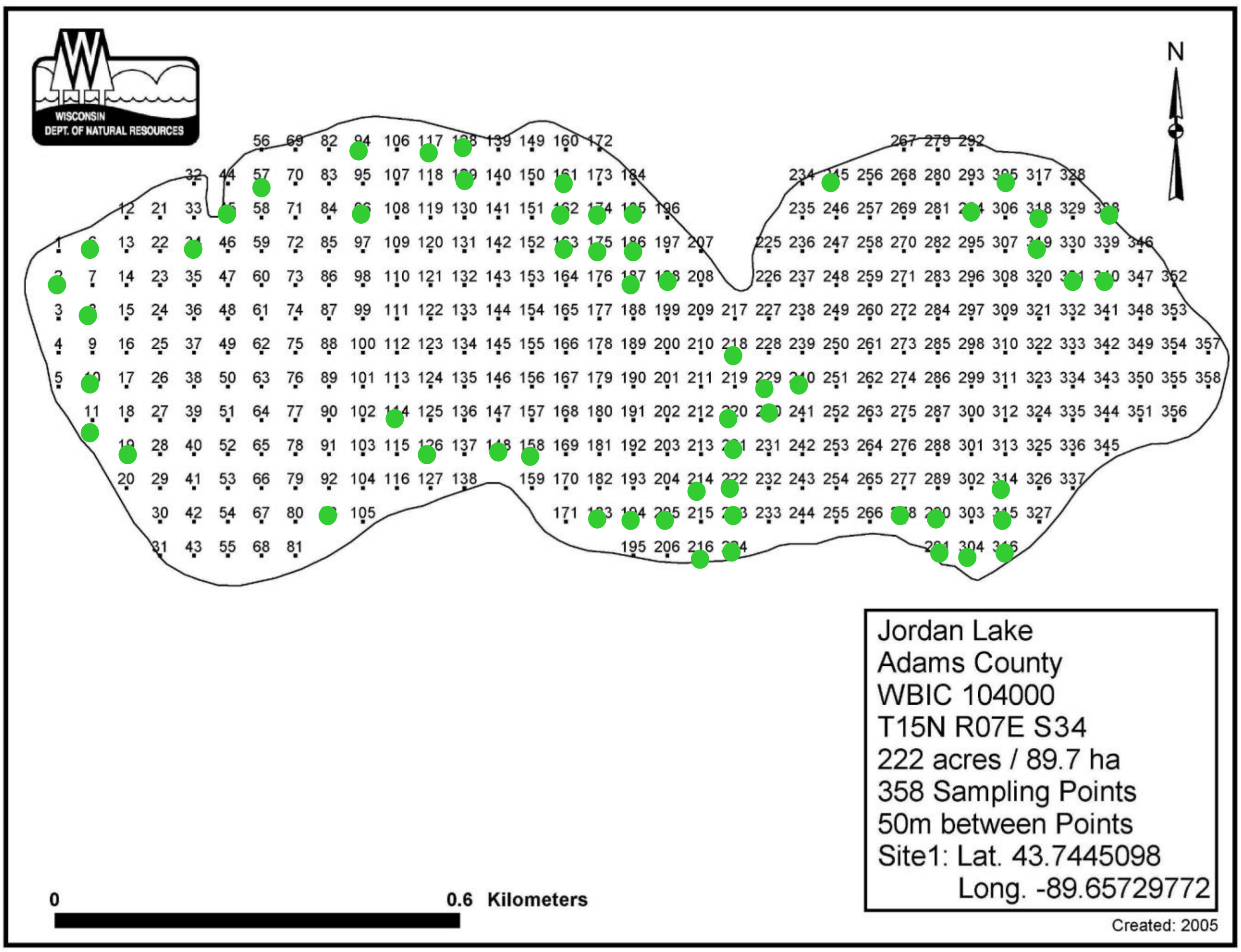
Jordan--PI	2006	2010	2011	2012	2013	2016
Number of Species	25	30	30	34	35	42
Maximum Rooting Depth	18.0	26.0	22.5	18.0	20.0	19.2
% of Littoral Zone Vegetated	81.5	86.2	93.0	98.1	95.5	89.5
% Emergents (sites)	2%	4%	5%	12%	5%	8.8%
%Floating-leaf (sites)	4%	4%	3%	5%	5%	8.8%
%Submergents (sites)	94%	92%	92%	83%	62%	59.7%
Simpson's Diversity Index	0.87	0.80	0.79	0.81	0.8	0.87
Species Richness	2.01	1.90	2.04	2.4	1.27	1.51
Floristic Quality	24.2	28.4	28.5	30.6	26.3	28.28
Average Coefficient of Conservatism	5.04	5.28	5.2	5.17	5.15	4.64
AMCI Index	58	58	58	60	59	59

V. DISCUSSION

Based on water clarity, chlorophyll and phosphorus data, Jordan Lake is a borderline oligotrophic/mesotrophic lake with very good water clarity and good-to-very-good water quality. Adequate nutrients (including sediments), good water clarity, hard water, and the large shallow areas in the lake would favor plant growth. The steep slopes found in the two lobes of the lake would not favor plant growth. High traffic and a significant presence of aquatic invasive plants, especially Eurasian Watermilfoil, regularly disturb the aquatic plant community.

Freshwater sponges are common in Jordan Lake. Although sponges are animals, they are included in this report because they are sometimes mistaken for aquatic plants or algae. Sponges are multicellular animals consisting of masses of cells embedded in a gelatinous matrix. Aquatic mosses are less common, but do have a presence in the lake. Aquatic mosses are small plants with delicate stems and small closely overlapping leaves. These plants can have branched, stem-like, and root-like structures.

Figure 19: Map of Freshwater Sponge Locations



V. CONCLUSIONS

Jordan Lake is a mesotrophic/oligotrophic lake with good-to-very good water quality and very good water clarity. Members of the *Charophyte* family dominated the aquatic community in 2016, just as it has in all prior surveys (see below chart).

Figure 20: % of Aquatic Community Composed of *Charophytes*

2006	2010	2011	2012	2013	2016
45.0%	48.0%	46.5%	41.0%	47.5%	38.5%

Charophytes are very advanced green algae found on all continents except Antarctica. Fossils over 443 million years old of them have been found, and they are considered the ancestors of land plants. These species play multiple roles in an aquatic ecosystem as part of the food web, in providing habitat, and in increasing water quality. Studies have indicated that the more *Charophytes* that are present, the healthier that aquatic ecosytem habitat.

Almost all groups in an aquatic food web benefit from the presence of *Charophytes*. They are an important grazing and habitat location, especially in winter, for insects that in turn provide food for fish and other wildlife. Perhaps the most important role in an aquatic ecosystem that *Charophytes* serve is in water quality. They naturally filter the water and play an important part in nutrient cycling, often serving as a phosphorus and/or nitrogen sink. Studies have shown that *Charophytes* restrict the resuspension of sediments up to 100 times more than other aquatic vegetation.

The dominant aquatic plant has varied through the years. In 2006, the front runner was Slender Pondweed (*Najas flexilis)*. By 2010, that plant was less a presence in the aquatic plant community, with Variable-Leaf Pondweed (*Potamogeton gramineus)* and Southern Naiad *(Najas guadelupensis*) vying for the dominant aquatic plant. By 2011, Variable-Leaf Pondweed subsided, with Southern Naiad becoming a greater part of the aquatic plant community, followed closely by Illinois Pondweed (*Potamogeton illinoensis)*. In 2012, Variable-Leaf Pondweed was the only aquatic plant dominant, but by 2013, it was competing with Southern Naiad again. In 2016, Variable-Leaf Pondweed alone was 15.5% of the aquatic plant community. Together, the *Charophytes* and Variable-Leaf Pondweed made up 54% of the aquatic community in 2016.

Two other invasive aquatic plant species, Curly-Leaf Pondweed and Reed Canarygrass, have been present in Jordan Lake for some time, but only in low numbers and low density.

The Jordan Lake aquatic plant community is characterized by at least average quality and good species diversity. Depending on the indices used, the plant community is either in the top quartile or median of lakes in the region, with an above average tolerance to disturbance.

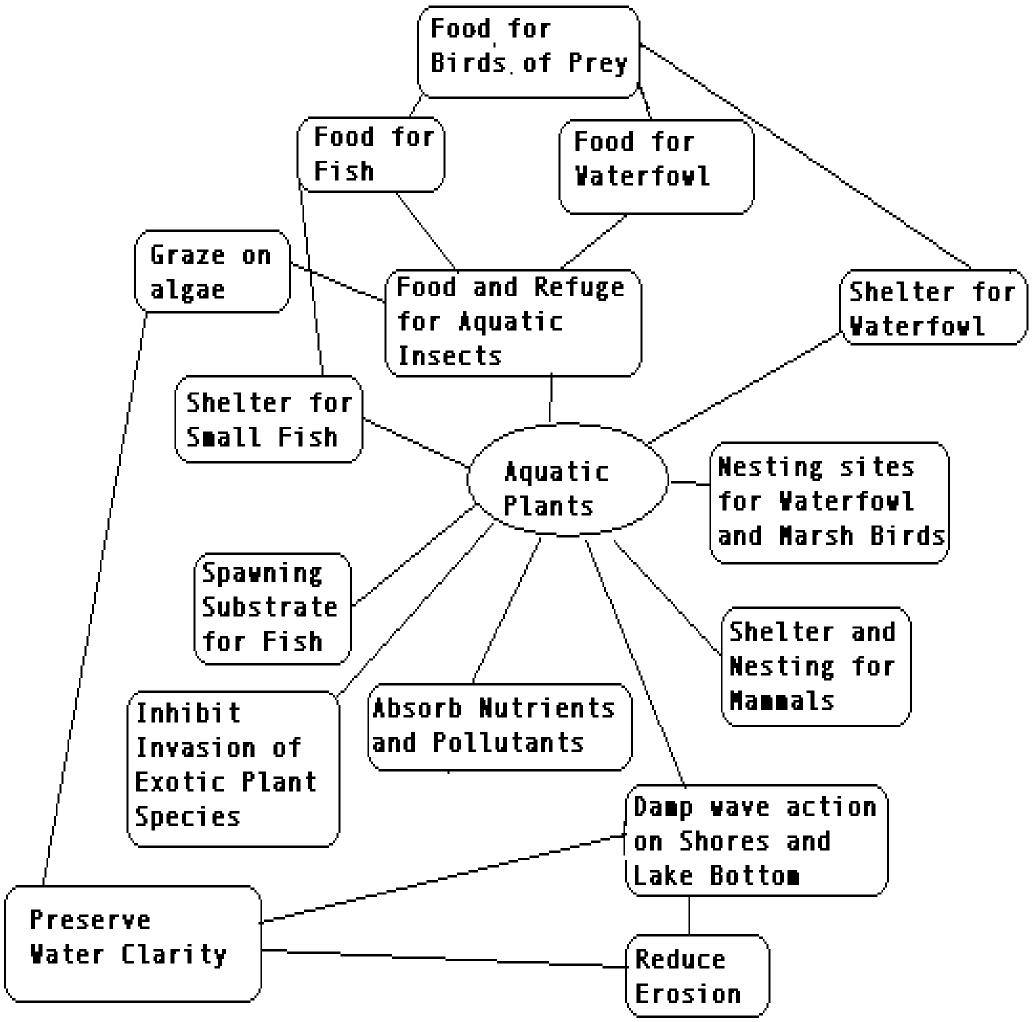
A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in: 1) improving water quality; 2) providing valuable habitat resources for fish and wildlife; 3) resisting invasions of non-native species; and 4) checking excessive growth of tolerant 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 and are an essential part of the ecological web of a lake (Figure 21).

Lakes with diverse aquatic plant beds support larger, more diverse invertebrate populations that in turn 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, 1985). 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).

Figure 21: Aquatic Food Web



MANAGEMENT RECOMMENDATIONS

1) All lake residents should practice best management on their lake properties. Jordan Lake is borderline between oligotrophic and mesotrophic. A small increase in nutrients could push the lake into another trophic state, resulting in noticeably worse water quality. Conversely, reducing nutrients could have a noticeable favorable impact on water quality.

- Keep septic systems cleaned and in proper condition;
- Use no lawn fertilizers;
- Clean up pet wastes;
- No composting should be done near the water nor should yard wastes & clippings be allowed to enter the lake (Do not compost near the water or allow yard wastes and clippings to enter the lake);
- Stop mowing lawn to water's edge; instead, install buffers that will intercept runoff (keeping it from entering the lake) and hold the sandy shores.

2) Continued involvement in regular water quality monitoring (through the Citizen Lake Monitoring Program) and aquatic invasive species monitoring should occur. This is important for keeping track of changes in the lake and also for evaluating the effect of the management plan activities.

3) Jordan Lake is heavily used by the outside public. The Clean Boats, Clean Waters should continue. Prior surveys have shown that many lake users come to Jordan Lake from superspreaders like Petenwell and Castle Rock Lakes or the Wisconsin River. Grants have become available specifically to help with Clean Boats, Clean Waters activities. If volunteers are not available, the

Jordan Lake District could apply for a grant and hire a boat inspector to increase the likelihood of no new invasives entering the lake.

4) Since there is so little woody debris, the Lake Management Plan should include installation of woody debris, either through tree drops directly at shore or a practice like Fish Sticks (available through the Healthy Lakes grant program), to increase the amount of woody debris.

5) The shoreland habitat assessment should be completed in 2017. Once it has been completed, the Jordan Lake District can evaluate modifying its lake management plan to improve shore habitat.

6) With critical habitat areas designated, a map of these areas should be posted at the public boat ramp with a sign encouraging avoidance of motorboat disturbance to these areas. Education about what these areas mean to the lake would also be a good idea. Landowners on the lake should watch for disturbance of these areas and report any violations. These areas are very important for habitat, the high value aquatic plant community, maintaining the positive water quality, and for preserving endangered and rare species.

7) The Jordan Lake District should continue working with the Adams County Land & Water Conservation Department and the Wisconsin Department of Natural Resources in the ongoing Eurasian Watermilfoil removal project. Hand-pulling efforts should be continued.

8) Pre-and-post treatment monitoring for the presence of aquatic invasives should also continue when chemical treatment is being contemplated. The pre-treatment monitoring permits accurate location of beds appropriate for

treatment and also identifies isolated plants that could be hand-pulled. The post-treatment monitoring not only helps determine the success of the chemical treatment, but also provides a basis for likely treatment sites for the next year.

9) Annual monitoring for invasives should be conducted every spring and/or fall to keep track of any new invasion or spread of invasives already present. This information can be used for the Jordan Lake District to decide whether chemical treatment or some other approach is most appropriate.

10) New WDNR rules require a contingency plan that outlines how the district would manage invasion by a new invasive and/or spread of the current invasives known. This plan needs to be developed and made a part of the Peppermill Lake Management Plan.

11) Lake residents should protect natural shoreline around Jordan Lake and install buffers practices in the areas that don't comply with the state shoreland zoning requirements. There are still several areas of cultivated lawn at the shore and also some areas of bare sand. Cost-share funds to assist in installing such practices may be available for such practices.

12) Steps should be taken to regulate boat speed and jetskis in the shallow water areas to reduce disturbance to plants. Water-skiing in these areas should be prohibited.

13) All lake users should protect the aquatic plant community in Jordan Lake. The standing-water emergent community, floating-leaf community, and submergent plant community are all unique plant communities. Each of these

plant communities provides their own benefits for fish and wildlife habitat and water quality protection.

14) An aquatic plant survey should be repeated in 3 to 5 years in order to continue to track any changes in the community and the lake's overall health.

15) The Jordan Lake District should consider approaching the landowners who own the undeveloped waterfront property on the lake and see if those landowners would be interested in conservation easements. If so, the Jordan Lake District Lake could apply for a WDNR grant to gain these easements.

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