AQUATIC PLANT REPORT FOR BIG ROCHE A CRI LAKE, ADAMS COUNTY, WI 1996-2013

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Executive Summary 1996-2013

Big Roche a Cri Lake is a 205-acre impoundment (man-made lake) located in the Town of Preston, Adams County, in the Central Sand Plains Area of Wisconsin. Big Roche-a-Cri Lake has a maximum depth of 22 feet and an average depth of 9 feet. This is a mesotrophic lake with good water quality and fair-to goodwater clarity. Both filamentous and planktonic algae are common in the lake, especially in the shallow areas.

Of the 46 aquatic macrophytes found in Big Roche a Cri Lake in 2008, 6% were emergent, 2% were rooted floating-leaf plants, 10% were free-floating plants and 84% were submerged plants. The latter included non-native invasives *Myriophyllum spicatum* (Eurasian Watermilfoil) and *Potamogeton crispus* (Curly-Leaf Pondweed). The emergent invasive plants *Phalaris arundicea* (Reed Canarygrass) and *Polygonum cuspidatum* (Japanese Knotweed) were also present. Rooted aquatic plants occurred throughout Big Roche a Cri Lake at 74% of all the sample sites to a maximum depth of 12.5 feet.

In 2013, the most frequently-occurring aquatic plant was *Vallisneria americana* (water celery), which was found at nearly 49% of the sample sites. Other commonly-occurring aquatic plants in 2013 were Eurasian Watermilfoil, then *Ceratophyllum demersum* (Coontail) and *Elodea canadensis* (Common Waterweed), in that order.

The aquatic plants found in 2013 did not occur at extremely high densities in the lake, although there was sometimes significant density of growth in a particular spot on the lake. 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. *Vallisneria americana* was the overall dominant plant in Big Roche a Cri Lake in 2013. No plants were subdominant.

The aquatic plant community of Big Roche a Cri Lake is characterized by average quality, good species diversity, and a significant tolerance to disturbance, likely the result the result of past and on-going disturbances. A healthy aquatic plant community is important because that plant community improves water quality, provides valuable habitat resources for fish and wildlife, resists the spread of non-native species and check excessive growth of tolerant species that could crowd out the more sensitive species, thus reducing diversity.

Management Recommendations

1) Continue involvement of the Lake District in water quality monitoring through the Citizen Volunteer Lake Monitoring Program.

2) Continue involvement of the Lake District & volunteers in aquatic invasive species monitoring through the Citizen Lake Monitoring Program and the Clean Boats, Clean Waters Program.

3) Chemical treatments for plant growth are still not recommended in Big Roche-a-Cri Lake due to the undesirable side effects of chemical treatments.

a) The decaying plant material releases nutrients that feed algae growth that further reduce water clarity.
b) The decaying material also enriches the sediments at the site.
c) The herbicides are toxic to an important part of a lake food chain, the invertebrates.
d) Broad-spectrum treatments would open up areas that would be vulnerable to the spread of the exotic species.

4) Continue with natural shoreland restoration. While the amount of restored shoreline has increased since 2004, there is still more to be done and there is still a fair amount of mowed lawn.

a) unmowed native vegetation reduces shoreline erosion and run-off into the lake and filters the run-off that does enter the lake thus reducing nutrient inputs.
a) Shoreline restoration could be a as simple as leaving a band of natural vegetation around the shore by discontinuing mowing.
b) Restoration could be as ambitious as extensive plantings of attractive native wetland species in the water and native grasses, flowers, shrubs and trees on the near shore area.

5) Continue to annually fine-tune the harvesting plan and to engage in an integrated approach to the management of the aquatic plants and the aquatic invasives.

a) The mechanical harvesting plan should be designed to remove nutrients, provide navigation, and recreation where appropriate, prevent the spread of overabundant species, and improve habitat.

b) Nutrient reduction. Harvesting removes the nutrients found in the plant tissue and filamentous algae mats. There is evidence that mechanical harvesting may already to be reducing filamentous algae and nutrients.
c) If curly-leaf pondweed increases to a nuisance condition, early spring harvesting for this species could be instituted. Skimming off coontail as the harvester is operating will help control this species that is becoming abundant.
d) Provide navigation and recreation where appropriate. Cutting channels through the areas that have the densest plant growth will aid navigation of the lake. Harvesting in the depth zone greater than 10 feet to maintain an open area for higher speed boat traffic would also aid navigation.
e) Prevent the spread of species that could become overabundant. *Vallisneria americana* is one of the few submergent aquatic plants that grow from the base, as grass does. Frequent harvesting in beds of *V. americana* will encourage its growth. Avoid these plant beds when they are not hindering navigation. When *V. americana* is harvested, cut near the sediment, or as deep as the cutter bar extends. The dam end of the lake supports the most *V. americana.* Harvesting the dam end in less than 10 feet of depth should be avoided.
f) Improve habitat. The mid-portion of the lake and the 5-10ft depth zone area could be improved the most with channels (not clear-cutting). Cutting channels in this area provides edge needed for habitat and allows the predator fish to better find prey, supporting a more balanced fishery. These open areas are also used by wildlife. The 0-1.5ft depth zone supports the best species richness and diversity. The only harvesting that should be conducted in this zone are hand-harvested channels next to the docks for land owner access.
g) Keep records of the amount of plants mechanically-harvested by weighing a trailer load and multiplying that amount by the number of loads removed.

6) Continue to take random plant tissue samples and submit them for lab testing to determine the amount of phosphorus being removed by mechanical harvesting. This should be done at least once per harvesting season. Keep records of the amount removed annually.

7) Conduct training for volunteers to hand-remove Eurasian Watermilfoil in areas where such removal is practical. Encourage such removal as often as possible. This will reduce this invasive in areas not reachable by mechanical harvester.

8) Continue to explore options of reducing Eurasian Watermilfoil, such as winter drawdowns.

9) Continue to cooperate with programs in the watershed to reduce nutrient inputs to the lake. Currently nearly half of the relatively large watershed is in agriculture.

10) Participate in the Big Roche a Cri Watershed Advisory Group.

11) An inventory of the stream banks in the Adams County portion of the Big Roche a Cri Creek Watershed was conducted during 2013. Plans are being made to finish the inventory in the Waushara portion of the watershed in 2014-2015. Cooperate with the Adams County LWCD and Waushara County LWCD in any steps necessary to correct problems discovered in these inventories, including invasives and sloughing banks.

12) Eliminate the use of fertilizers, both organic and inorganic, on properties around the lake.

13) Encourage board members of the lake district to attend the annual Wisconsin Lakes Conference and to participate in the UW-Extension Lakes Lake Leader program. Apply for grants to assist completion of this goal.

14) Make arrangements immediately for the removal of Japanese Knotweed from the shore before it spreads further.

The Aquatic Plant Community in Big Roche-a-Cri Lake, Adams County 2004-2013

INTRODUCTION

An updated aquatic plant survey was conducted in summer 2013 by staff from the Adams County Land & Water Conservation Department (Adams LWCD). Prior studies of the aquatic macrophytes (plants) in Big Roche-a-Cri Lake were conducted in 2008 and 2004. July 2004 was the first quantitative vegetation study of Big Roche-a-Cri Lake by the Wisconsin Department of Natural Resources (WDNR). The 2008 study was conducted by both the WDNR and Adams LWCD. Qualitative assessments were conducted in May 1964 by WI Water Pollution Committee staff and in 1996 by North Central Region staff - WDNR.

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

Background and History: Big Roche a Cri Lake is a 205-acre impoundment (man-made lake) located in the Town of Preston, Adams County, in the Central Sand Plains Area of Wisconsin. Big Roche-a-Cri Lake has a maximum depth of 22 feet and an average depth of 9 feet. The lake was originally formed in 1856 when a small dam was built on Big Roche-a-Cri River to form a mill pond of unknown size for operating a grist mill. Today's lake was formed when a new, larger dam was constructed on the same site in 1926 for power generation. The current dam is owned by Adams County. It is undergoing renovations needed to resume production of electricity.

As an impoundment of Big Roche a Cri Creek, this lake has both an inlet and outlet. Through Big Roche a Cri Lake moves input from a very large watershed of 177 square miles that extends into the next county east. Downstream of Big Roche a Cri Lake is another impoundment, Arkdale Lake. Big Roche a Cri Creek ultimately empties into the Wisconsin River.

A lake association was formed sometime during the 1930's or 40's. Complaints from lake users to the WI-DNR concerning aquatic plant growth are recorded as early as 1954. Currently, the lake is managed by the Big Roche a Cri Lake District.

A 2000 watershed analysis of Big Roche-a-Cri Lake determined that phosphorus loading to the lake from the watershed was approximately 826 pounds per year (Foth and Van Dyke, 2000). The size of the watershed means that the lake to watershed ratio is 208:1. Lakes with a watershed to lake ratio greater than 10:1 tend to have water quality problems (Field 1994).

There is a long history of chemical control of aquatic plants and algae in Big Roche-a-Cri Lake (Figure 2). Multiple treatments were conducted in many years; in 1975 there were 10 treatments in one year. Up to one-fourth of the lake has been treated in any one year.

Some herbicides that are problematic were used.

1) Arsenic is highly toxic. Between 1959 and 1966, more than 10 tons of arsenic was applied to Big Roche-a-Cri Lake (Table 2). Arsenic is no longer allowed as an aquatic pesticide because it is highly toxic to all species. Since it does not break down, arsenic stays in the sediments, resulting in the necessity to treat lake sediments as hazardous waste.
2) Another toxic compound used in Big Roche-a-Cri was Silvex (2,2,4,5-TP). Silvex is now banned as a possible carcinogen (Table 2).
3) Broad-spectrum chemicals have been used, Diquat and Endothall compounds. These compounds kill all plant species and inadvertently open up areas for the introduction of exotic and invasive species. Almost 100 gal of Diquat compounds had been used between 1970 and 1978. Endothall products have

been applied as 1) 77 gallons of Aquathol between 1967 and 1977 and 2) more than 5 tons of Hydrothol between 1965 and 1987 (Table 2).

4) The Hydrothol formulation of Endthall is more toxic to young fish.
5) Cutrine and CuSO4 are copper products that were used to kill algae and reduce swimmer's itch (Table 2). . Since copper is an element, it does not biodegrade further, building up the sediments. The drawbacks of copper treatments are:
    a) the very short effective time
    b) the toxicity of copper to aquatic insects, an important part of the food chain in a lake
    c) the build up of copper in the sediments, resulting in sediments that are toxic to mollusks that are the natural consumers of algae in a lake.

Figure 1. Herbicide Applied to Big Roche-a-Cri Lake

	Arsenic Trioxide (lbs.)	Silvex 2,4,5-TP	2,4-D (gal)	Cutrine (gal.)	Copper Sulfate (lbs.)	Diquat (gal.)	Endothall	Area Treated (acres)	# Treatments
1959	3720							33	2
1960	5220							47	
1962	4500							30	2
1963	1620							12	2
1964	2000							16	2
1965	1200						7.2g. 1200#	6	
1966	2700	35					25.4g.	23	1
1970			20	87	189	30		70	4
1972							25#	0.1	1
1975			14		975	36.4	23.6g. 150#	50	10
1976					450	9.5	12.5g. 550#	14	6
1977			10		550	6	9g. 500#	30	4
1978			10		350	17	1150#	23	3
1983							1200#	5.3	1
1984							1320 #	7	1
1985							1400#	8	1
1986							1400#	12	1
1987							2000#	8	1
Total	20,960	35	44	87	2514	98.9	77.7gal. 10,895#		

During the late 1970's or early 1980's a small cutter was used by groups of association members to cut 4-foot paths for lake access where needed.

In 1988, Big Roche-a-Cri Lake Association formed the Big Roche-a-Cri Lake District and purchased a mechanical harvester. Mechanical harvesting began in 1988 and continued during 2013. Records of harvesting are sent to the WDNR annually. Plants removed are tested for the amount of phosphorus they contain, so that the Big Roche a Cri Lake District can monitor how much phosphorus is being removed from the lake. The removal of vegetation from the lake helps counteract nutrient inputs; however, impoundments can be impacted by ongoing inputs of nutrients.

Harvesting generally starts in mid-May each year, sometimes as late as mid-June, and generally continues until late-September, sometimes as late as early October.

In 1996, the lake district produced a Lake Management Plan in order to purchase a second harvester. Recommendations were made to:

1) Protect the lake and watershed through town and county ordinances
2) Initiate a "Self-Help Monitoring Program" to obtain data annually on the lake
3) Reduce non-point source pollution through an education program and other measures
4) Protect water quality by developing an aquatic plant harvesting plan and purchasing a second harvester
5) The lake district also entered an agreement with native plant nurseries to remove wild celery tubers from the sediment to reduce the colonization of this species in the lake.

A survey of the residents during the planning process indicated that the most popular lake activity was fishing (88%); the largest perceived problem was aquatic plants (87%), requiring more aquatic plant removal (85%)

In 2001, the lake district contracted with a professor from the University of Wisconsin – Eau Claire to produce an updated bathymetric (depth) map. That map remains the most current bathymetric map available.

In 2003, the invasive Eurasian Watermilfoil was found in Big Roche-a-Cri Lake. Like many exotic species, Eurasian Watermilfoil is able to out-compete native species when introduced into a new area. Exotic species can dominate because the new environment does not usually support the diseases and herbivores that kept it in check in its native country. A 3-foot drawdown of the lake occurred during the winter of 2005-2006 to assist in Eurasian Watermilfoil control. An accidental winter drawdown occurred in 2007 when there were problems with the dam that caused a lowering of the water level in the lake.

METHODS

Field Methods

The 2013 survey was done using the point-intercept method outlined by Madsen (1999) of the U.S. Army Corps of Engineers. The WDNR created a regular grid of sample points over the lake. These points were then downloaded onto a GPS unit. This allowed navigation to the points in the field. 455 points were located on Big Roche a Cri Lake, with 44 meters between sampling points. The 2013 survey included the addition of some near-shore sample sites, bringing the total number of sites sampled to 472.

A depth for each sample point was recorded. Sampling was done with either a thatching rake on a rope for deeper areas or a pole-handled thatching rake for shallower areas. One sample was taken at each point. Plant taxa were noted and the abundance of each taxa were estimated, using a 3-point scale:

> 1 = 1/3 or less of the rake head covered;
> 2 = 1/3 to 2/3 of the rake head covered;
> 3 = over 2/3 of the rake head covered.

Visual inspection was also made around each sample point and between sample points to record the presence of any species that did not occur at the sampling sites

Data Analysis

The 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/total occurrence of all species. The 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/total plant density). The relative frequency and relative density was summed to obtain a dominance value.

Species diversity was calculated by Simpson's Diversity Index. The Aquatic Macrophyte Community Index (AMCI) developed by Nichols et. al. (2000) was applied to Big Roche-a-Cri Lake. Measures for each of seven categories that characterize a plant community are converted to values between 0 and 10 and summed.

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

III. RESULTS

PHYSICAL DATA

Many physical parameters impact the aquatic plant community. Water quality (nutrients, algae, clarity and alkalinity) influence the plant community as the plant community can in turn modify these parameters. Lake morphology, sediment composition and shoreline use also affect the macrophyte community.

WATER QUALITY

The trophic state of a lake is one measure of water quality, basically defining the lake’s biological production status. Eutrophic lakes are very productive, with high nutrient levels, frequent algal blooms and/or abundant aquatic plant growth. Oligotrophic lakes are those low in nutrients with limited plant growth and small populations of fish. 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; often with a more varied fishery than either the eutrophic or oligotrophic lakes. 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.

A study conducted from 2004-2006 showed that the summer average phosphorus concentration in Big Roche a Cri Lake placed Big Roche a Cri Lake in the “fair” water quality section for impoundments, and in the “mesotrophic” level for phosphorus. In 1970, the earliest information available, eplimnetic total phosphorus averaged 2.7 micrograms/liter. By the summer of 1995, the eplimnetic total phosphorus averaged 18.5 micrograms/liter. It crept up to an average of 25.4 micrograms/liter by 1999. And in 2004-2006, it averaged 33.9 micrograms/liter. Results from volunteer water quality monitoring from 2007 through 2013 showed an average total phosphorus level during the growing season of 25.1 micrograms/liter

Figure 2: Trophic Table

Big Roche a Cri Lake = 55 → 50-60

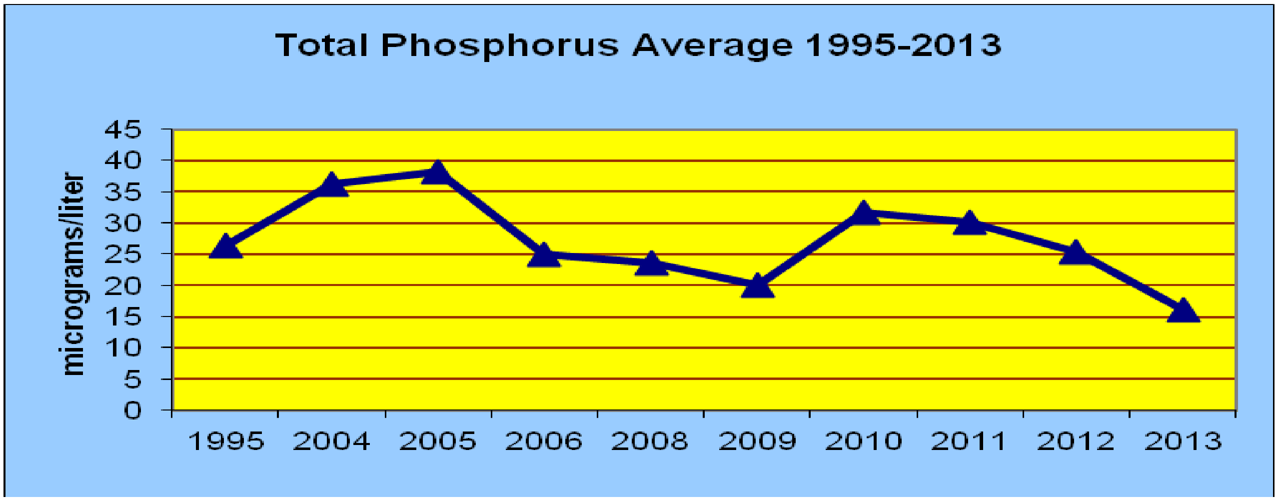
30-40	**Oligotrophic:** clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	**Mesotrophic:** moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer
50-60	**Mildly Eutrophic:** decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common
60-70	**Eutrophic:** dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill
70-80	**Hypereutrophic:** heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels

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, alternately, excess plant growth. Although there are several forms of phosphorus in water, the total phosphorus (TP) concentration is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. The highest average total phosphorus during the growing season in Big Roche a Cri Lake was 38.2 micrograms/liter, found in 2005. In the past five years, the growing season average is 24.4 micrograms/liter. Both these figures are considerably lower than the state average total phosphorus for impoundments, which is 65 micrograms/liter (Shaw et al, 1993).

Chlorophyll-a concentration 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, as well as result in unpleasing odor and appearance. Studies have shown that the amount of chlorophyll-a in lake water depends greatly on the amount of algae present;

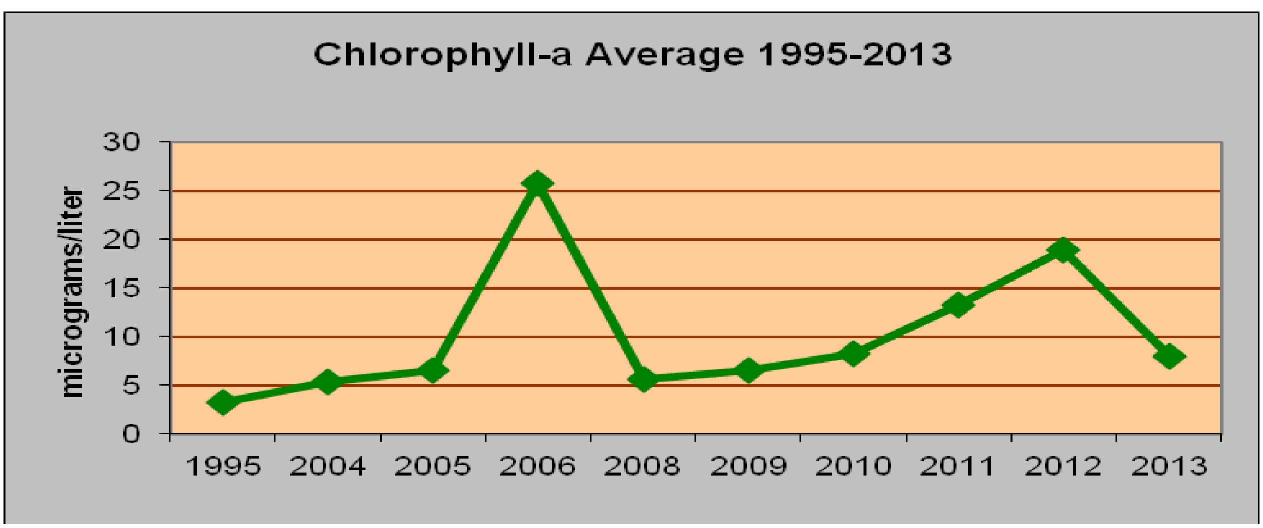
therefore, chlorophyll-a levels are commonly used as a water quality indicator. The 2004-2013 growing season (June-September) average chlorophyll-a concentration in Big Roche a Cri Lake was 12.3 micrograms/liter. Such an algae concentration places Big Roche a Cri Lake at the "fair" level for chlorophyll a results.

Figure 3: Total Phosphorus Averages 1995-2013



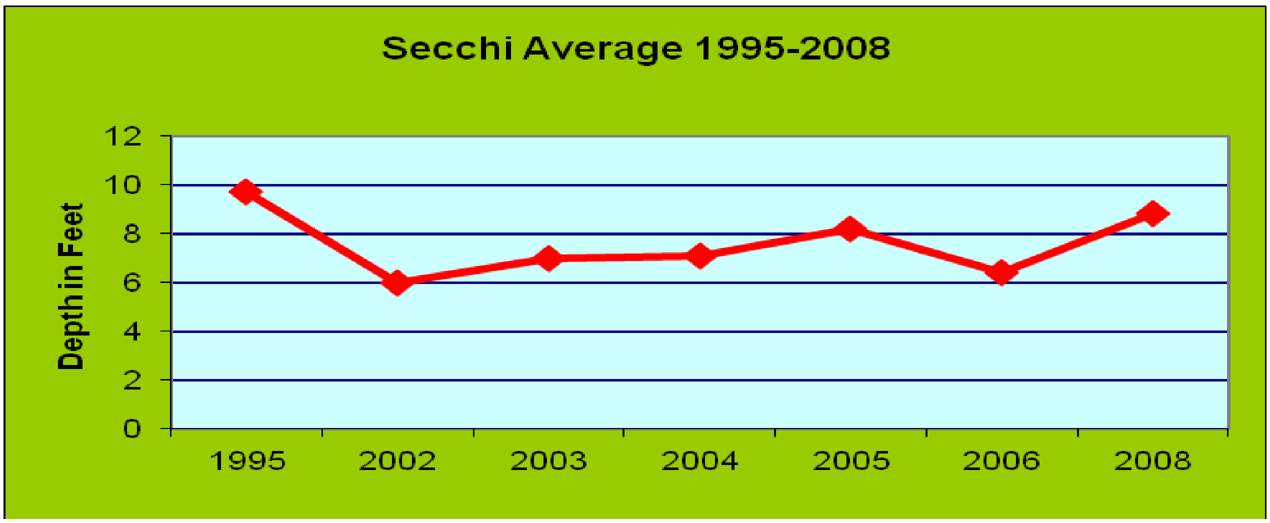
Except for spikes in the very hot drought years of 2006 and 2012, chlorophyll-a levels in Big Roche a Cri Lake have remained fairly low, especially for an impoundment. Generally, levels under 30 micrograms/liter indicate that any algae blooms are likely to be localized (Shaw et al, 1993).

Figure 4: Chlorophyll-a Averages 1995-2013



Water clarity is a critical factor for plants. If plants don't get more 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 Big Roche a Cri Lake in 2004-2013 was 7.7 feet. This is good water clarity, putting Big Roche a Cri Lake into the "mesotrophic" category for water clarity.

Figure 5: Summer Water Clarity Averages 1995-2008



When these figures are compared to the table outlining water quality status, it is clear that Big Roche a Cri scores as a mesotrophic lake, with all readings in the "fair" to "good" category

Figure 6: Water Quality Status Table

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
BRC Lake		**25.7**	**12.3**	**7.7**

A large ratio of watershed size to lake size tends to result in a concentrating of the nutrients into the lake. This is common with impoundments. Agricultural use, especially irrigated agriculture, is found in nearly one-half of the watershed, contributing significantly to the nutrient phosphorus load. Big Roche a Cri Lake has a large watershed (177 square miles), making it susceptible to such loading.

LAKE MORPHOLOGY, SEDIMENT, AND SHORELAND LAND USE

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). Most of Big Roche a Cri Lake is a narrow shallow basin that gradually slopes over most of the lake. There are small areas of steeper slopes near the dam. When those factors are added to the overall very shallow aspect of the lake, aquatic plant growth is highly favored in Big Roche a Cri Lake.

Figure 7: Sediment in Big Roche a Cri Lake

Sediment Type	% of Sample Sites
Sand	72
Rock	2
Sand/Gravel	1
Sand/Rock	1
Sand/Silt	6
Silt	6
Muck	5
Silt/Muck	4

Sediment composition can also affect plant growth, especially those rooted in the sediment. The fertility of the sediment will determine the type and abundance of macrophyte species that can survive in a particular lake. Previous sampling of the sediment of Big Roche a Cri Lake revealed that a sand substrate dominates the lake. In some instances, hard substrates like sand may restrict aquatic plant growth. However, in this lake, even the harder substrates like sand, gravel, and rock had aquatic vegetation. Sediment composition does not appear to inhibit aquatic plant growth in Big Roche a Cri Lake.

Land use can strongly impact the aquatic plant community, & therefore the entire aquatic community. Land use can directly impact the plant community through increased erosion & sedimentation and increased run-off of nutrients, fertilizers and toxics applied to the land. These impacts occur in both rural & residential settings.

Big Roche a Cri Lake has a total shoreline 6.1 miles (32,208 feet). Most of the lakeshore is in residential use. Many of the areas near the shore are very sandy and steeply sloped. Because the PI protocol does not include evaluating shoreland status, results of a 2004 shore survey was examined. After the 2004 survey, Big Roche a Cri Lake District was awarded a lake management plan implementation grant that allowed several property owners to install shore protection practices to reduce some of the erosion, which may have changed the distribution of shoreland types somewhat. However, there remain several properties that do not comply with the state buffer standards.. Under the Adams County Shoreland Protection Ordinance, all waterfront properties must have 35 foot landward buffers (unless exempted or mitigated) by July 1, 2015.

Figure 8: Shore Evaluation in 2004

Shore Type	Occurrence Frequency	Coverage
Wooded	86%	45%
Shrub	52%	12%
Herbaceous	59%	12%
Cultivated Lawn	41%	20%
Hard Structures	28%	4%
Pavement	24%	4%
Rock Rip-Rap	21%	3%

A physical survey was done of the stream banks in the Big Roche a Cri Creek watershed from the Adams County line to the Wisconsin River in 2013 to identify, among other things, areas likely to be sources of sediment and/or nutrient loading to Big Roche a Cri. 261 sites were marked by GPS coordinates and photographs, owned by 100 landowners. 56.5% (147) of the sites showed bank erosion, ranging from undercutting to severe sloughing. 19 sites had beaver dams or other installations that diverted or interfered with the streams.

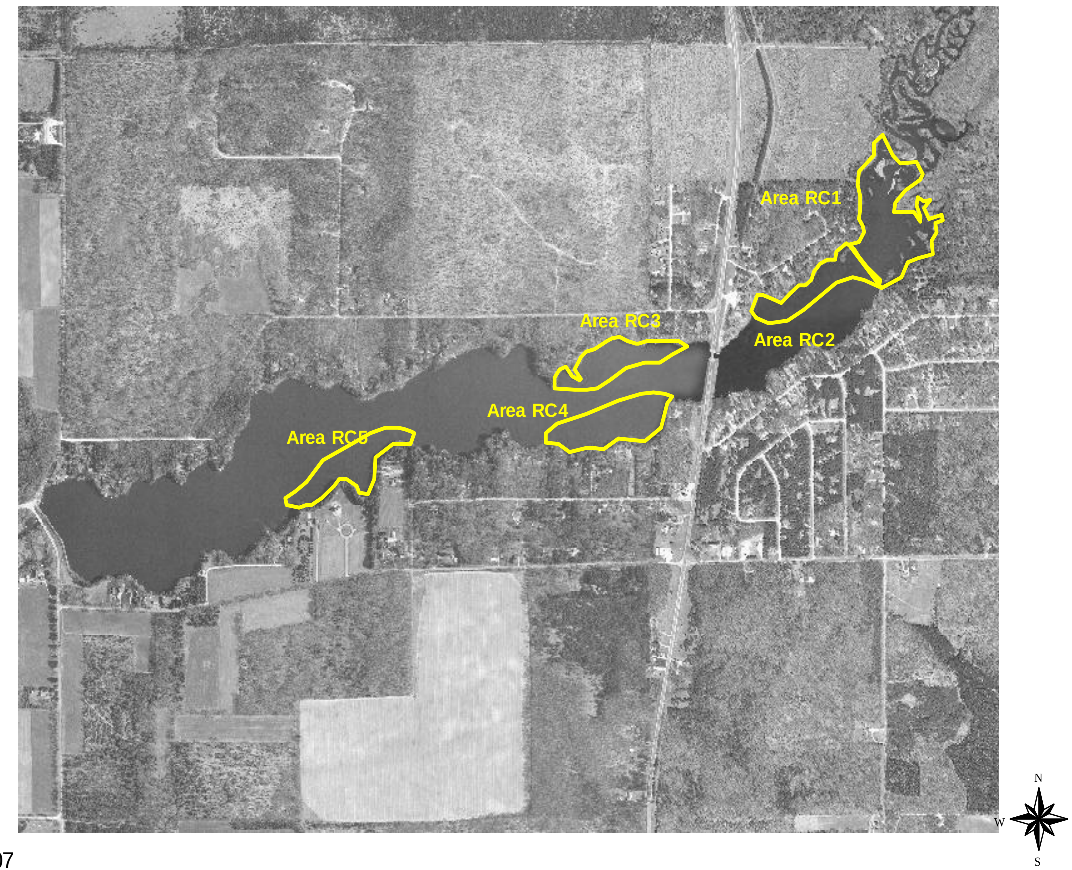
In addition, the invasive Reed Canarygrass was found all long the creeks (155 sites at least). Other invasives located included Purple Loosestrife, Eurasian

Watermilfoil, Curly-Leaf Pondweed, Garlic Mustard, Canada Thistle, and Carp. A fish kill involving sheepshead was also noted near the Wisconsin River and was reported to the Wisconsin Department of Natural Resources (WDNR).

Figure 9: Photos of Some of the Severe Erosion in the Watershed

Figure 10: Map of Critical Habitat Areas in Big Roche a Cri Lake

Critical Habitat Areas--Big Roche a Cri Lake



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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.

RC1: This 15.1 acre site was selected for its high quality fish and wildlife habitat, diverse aquatic vegetation, undisturbed and unique terrestrial vegetation, its importance for protecting water quality and its natural scenic beauty. It includes 13 acres of the upper end of the impoundment, which includes shallow marsh wetlands and shrub carr. The sediment is composed of sand and silt.

This site provides an area of natural scenic beauty for lake residents and visitors. It provides visible and audible buffers from noise, boat traffic and man-made structures. This site supports 16 species of aquatic plants. The emergent vegetation protects the shoreline and provides important food sources and cover for fish and wildlife and fish spawning habitat. The floating-leaf vegetation dampens wave action and provides important fish cover and wildlife habitat. The diverse submerged plant community provides many important habitat components for the fish and wildlife community. The non-native curly-leaf pondweed is also present at this site.

RC2: This site, nearly 7 acres in size, was selected for the diverse aquatic vegetation and the shoreline and littoral zone vegetation, providing important for fish habitat, wildlife habitat, protecting water quality and providing natural scenic beauty. It encompasses approximately 1500 feet of shoreline, out to the maximum rooting depth of 2.5 feet. The site includes deep marsh wetlands and shrub carr wetlands. The sediment is organic muck and silt.

The aquatic plant community at this site supports 19 species of plants. There are emergent species, floating-leaf species, plus several species of pondweed and other submergents. The non-native curly-leaf pondweed is also present at this site.

RC3: This area of just under 12 acres encompasses approximately 1500 feet along the northern shore, just west of the Highway 13 bridge, to a maximum rooting depth of 10 feet. It includes important shallow water habitat. The sediment is sand and silt.

The aquatic plant community at this site supports 13 species of plants. There are free-floating plants and a variety of submergent plants. The invasive Curly-Leaf Pondweed is present. The invasive Eurasian Watermilfoil is abundant.

RC4: This area encompasses approximately 1100 feet of shoreline on the south shore, just west of the Highway 13 Bridge, to the maximum rooting depth of 6 feet, comprising 11.14 acres. It supports important shallow water habitat. The sediment is a mixture of sand and silt.

The aquatic plant community is composed of 13 species at this site. Cattails protect the shoreline here and provide food and cover for fish and wildlife. Both rooted floating-leaf and free-floating species are here. There is a mixed submergent community. Eurasian Watermilfoil is common at this site.

RC5: This sensitive area of just over 9 acres includes approximately 1900 feet of shoreline on the south at the narrows area. It includes important near-shore terrestrial habitat and shallow water habitat. The sediment is sand.

The aquatic plant community consists of 6 species. Wild celery and coontail are dominant at this site, and common waterweed is common. The pondweed family is represented at this site by clasping-leaf pondweed, flat-stem pondweed and commonly occurring beds of sago pondweed. Eurasian Watermilfoil is abundant here, with Curly-Leaf Pondweed also present.

More detailed information on these sites can be found in the critical habitat report for Big Roche a Cri Lake.

AQUATIC MACROPHYTES PRESENT FROM 2004 TO 2013

Of the 46 aquatic macrophytes found in Big Roche a Cri Lake in 2013, 25 were emergent, 3 were rooted floating-leaf species, 3 were free-floating plants and 16 were submerged plants. This list includes exotic invasives *Myriophyllum spicatum* (Eurasian Watermilfoil), *Phalaris arundinacea* (Reed Canarygrass), *Polygonum cuspidatum* (Japanese Knotweed), and *Potamogeton crispus* (Curly-Leaf Pondweed).

Figure 11: Aquatic Vegetation in Big Roche a Cri Lake

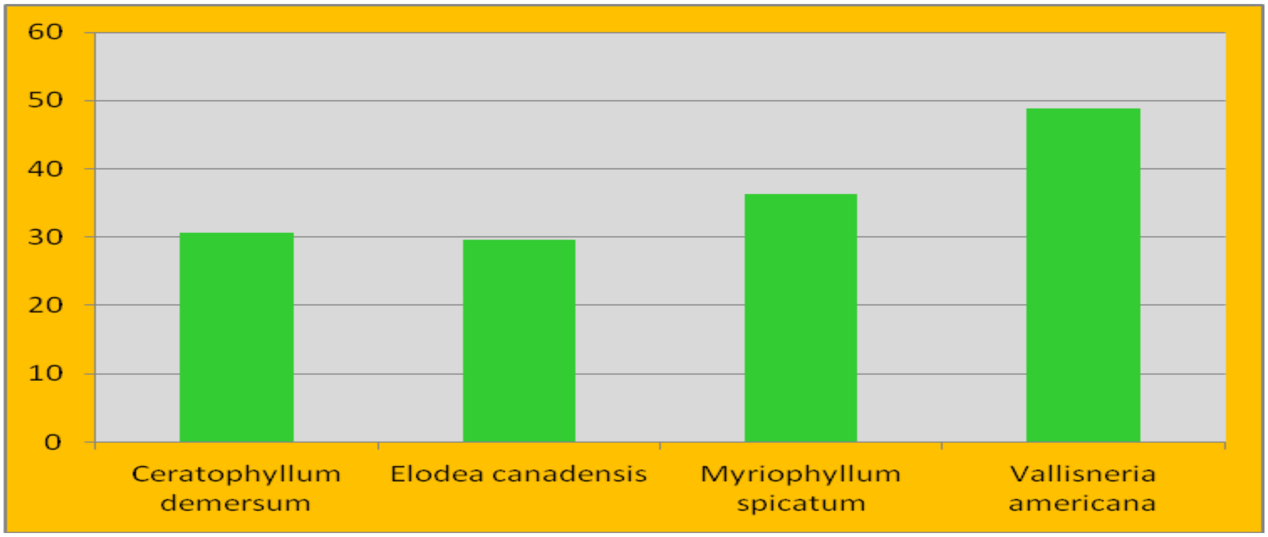
		2000 (t)	2008 (t)	2008 (pi)	2013 (pi)
Acorus americanus	Sweet Flag				x
Alisma trivale	Northern Water Plantain				x
Alnus incana	Tag alder				x
Bidens comosa	Swamp Tickseed				x
Brasenia schreberi	Watershield				
Calamagrostis canadensis	Blue-Joint Grass				x
Carex spp	Sedge species				x
Carex comosa	Porcupine Sedge	x	x	x	x
Ceratophyllum demersum	Coontail	x	x	x	x
Chara	Muskgrass species				x
Chelone glabra	Turtlehead				x
Cicuta bulbifera	Bulb-Bearing Water Hemlock	x	x	x	x

Cornus	Dogwood				x
Eleocharis palustris	Common Spikerush				x
Elodea canadensis	Common Waterweed	x	x	x	x
Eupatorium perfoliatum	Boneset				x
Impatiens capensis	Jewelweed	x	x	x	x
Iris versicolor	Blue-Flag Iris				x
Lemna minor	Small Duckweed	x	x		x
Lycopus uniflorus	Northern Bugleweed				x
Myriophyllum sibiricum	Northern Milfoil				x
Myriophyllum spicatum	Eurasian Watermilfoil	x	x	x	x
Najas flexilis	Bushy Pondweed		x	x	x
Najas guadelupensis	Southern Naiad	x			
Nuphar variegata	Yellow Pond Lily	x	x	x	x
Persecaria punctata	Dotted Smartweed				x
Phalaris arundinacea	Reed Canarygrass				x
Polygonum cuspidatum	Japanese Knotweed				x
Potamogeton amplifolius	Large-Leaf Pondweed	x	x	x	x
Potamogeton crispus	Curly-Leaf Pondweed	x	x	x	x
Potamogeton epihydris	Ribbon-Leaf Pondweed			x	x
Potamogeton friesii	Fries' Pondweed			x	x
Potamogeton illinoensis	Illinois Pondweed	x	x	x	x
Potamogeton natans	Floating-Leaf Pondweed	x	x	x	
Potamogeton pusillus	Small Pondweed	x	x	x	x
Potamogeton richardsonii	Clasping-Leaf Pondweed	x	x	x	x
Potmaogeton zosteriformis	Flat-Stemmed Pondweed	x	x	x	x
Rumex	Dock species	x	x	x	x
Sagittaria latifolia	Common Arrowhead			x	x
Salix spp.	Willow species	x	x		x
Sch. Tabernaemontani	Soft-Stemmed Bulrush	x	x	x	x
Solanum dulcamum	Bittersweed Nighshade				x
Sparganium spp	Bur-reed species				x
Spirodela polyrhiza	Greater Duckwood	x	x	x	x
Stuckenia pectinata	Sago Pondweed	x	x	x	x
Typha lspp	Cattail specis	x	x	x	x
Vallisnera americana	Water Celery	x	x	x	x
Wolffia columbiana	Watermeal			x	x
Zosterella dubia	Water Stargrass	x	x	x	x

FREQUENCY OF OCCURRENCE

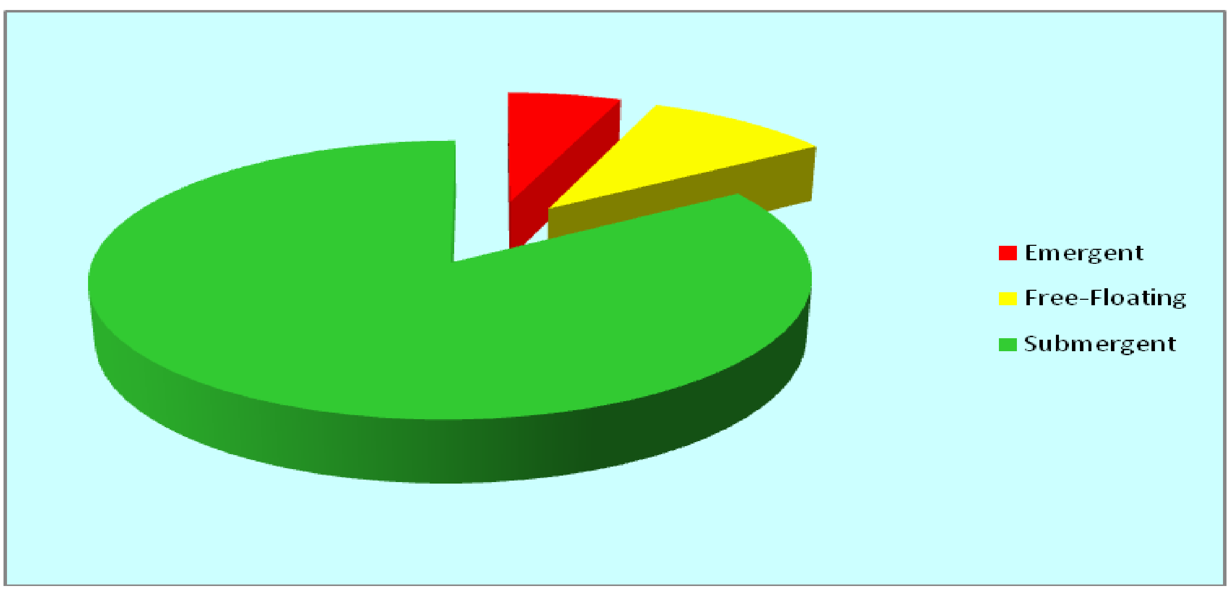
In 2013, the most frequently-occurring aquatic plant was *Vallisneria americana* (water celery), which was found at 30.7% of the sample sites. Other commonly-occurring aquatic plants included *Ceratophyllum demersum* (Coontail), *Elodea canadensis* (Common Waterweed), and the invasive *Myriophyllum spicatum* (Eurasian watermilfoil).

Figure 12: Most-Frequently Occurring Plants 2013



Submergent species dominated the aquatic plant community in 2013, making up 84% of the aquatic plant community in Big Roche a Cri Lake.

Figure 13: Type Composition of Aquatic Plant Community



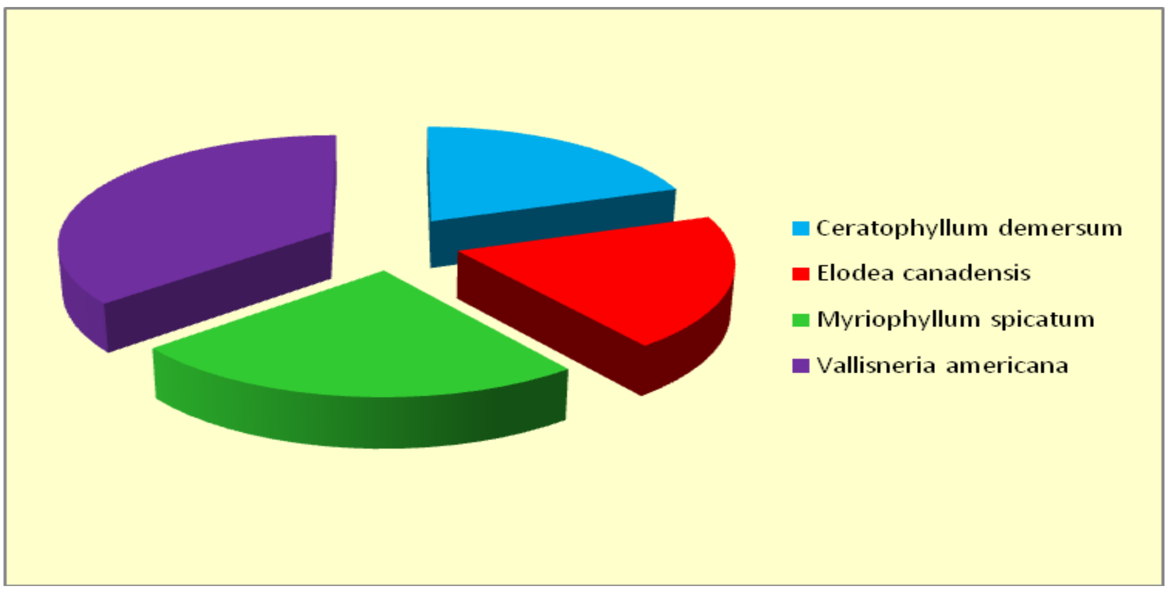
DENSITY OF OCCURRENCE

Athough *Vallisneria americana* had the highest relative density of all the aquatic plants found in Big Roche a Cri Lake in 2013, none of the species found occurred in heavy growth overall the lake. In some instances, plants such as Water Celery, Coontail, Common Waterweed, and Eurasian Watermilfoil had localized dense growth.

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. Water Celery was the overall dominant plant in Big Roche a Cri Lake in 2013. This plant alone comprised 20% of the aquatic plant community. If the other three most commonly-occurring plants—Common Waterweed, Coontail and Eurasian Watermilfoil—are added in, these four species were 55.5% of the aquatic plant community in Big Roche a Cri Lake in 2013.

Figure 14: Dominance in 2013



DISTRIBUTION

Aquatic plants occurred throughout at 77.5% of all the 2013 sample sites in Big Roche a Cri Lake. Most of the non-vegetated area was at the far west end of the lake near the dam in water deeper than 12.5 feet.

The deepest rooted aquatic plant in 2013 was Eurasian Watermilfoil, which was found at 12.5 feet. Emergent species were scattered throughout the nearshore area of the lake. Submergent species were found in all depths of the lake in 2013.

Several species of free-floating plants, which take their nutrients directly from the water column, occurred at nearly all depths in the lake. The only rooted floating-leaf plant found in 2013, Yellow Pond Lily, was found in water depths ranging from 1.3 feet to 7.5 feet.

Figure 14a: Distribution of Emergent Species in 2013 on Western 2/3

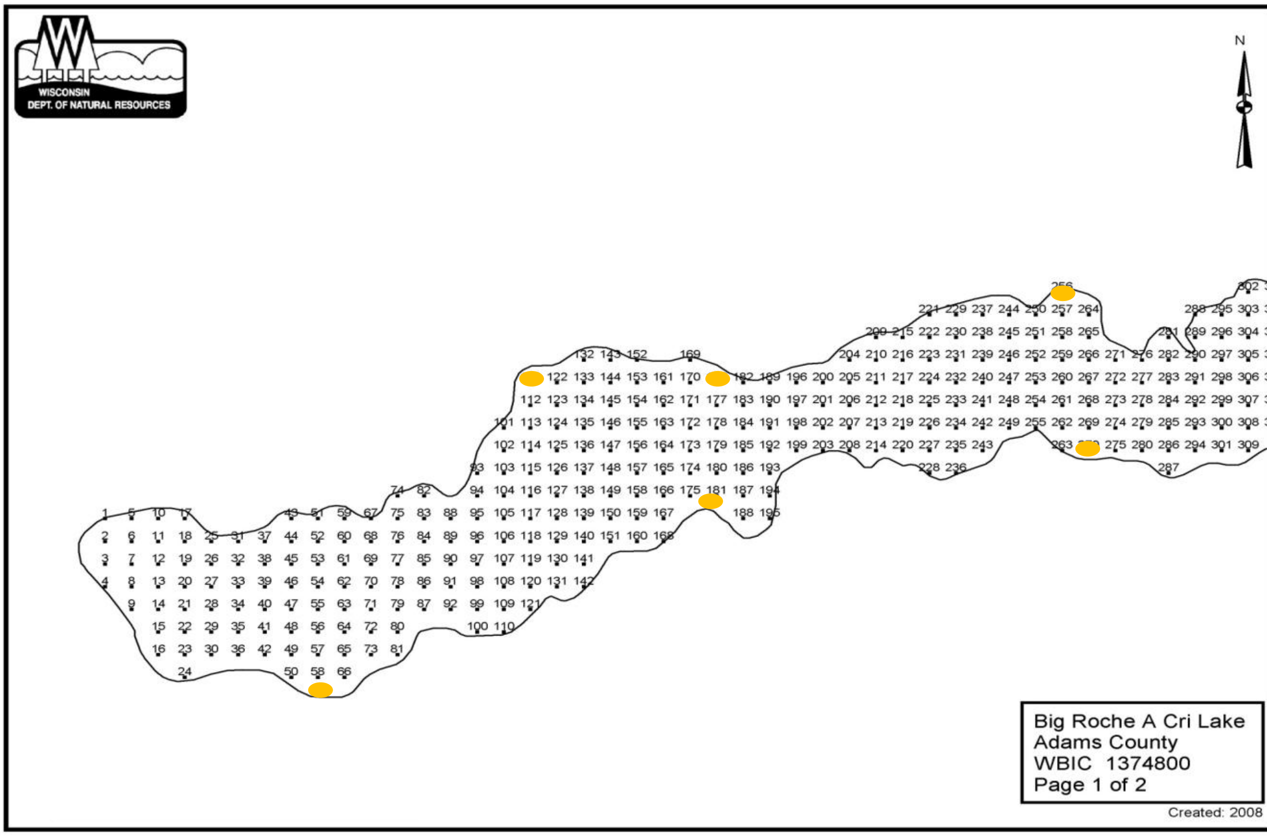


Figure 14b: Distribution of Emergent Plants at Eastern End of Lake

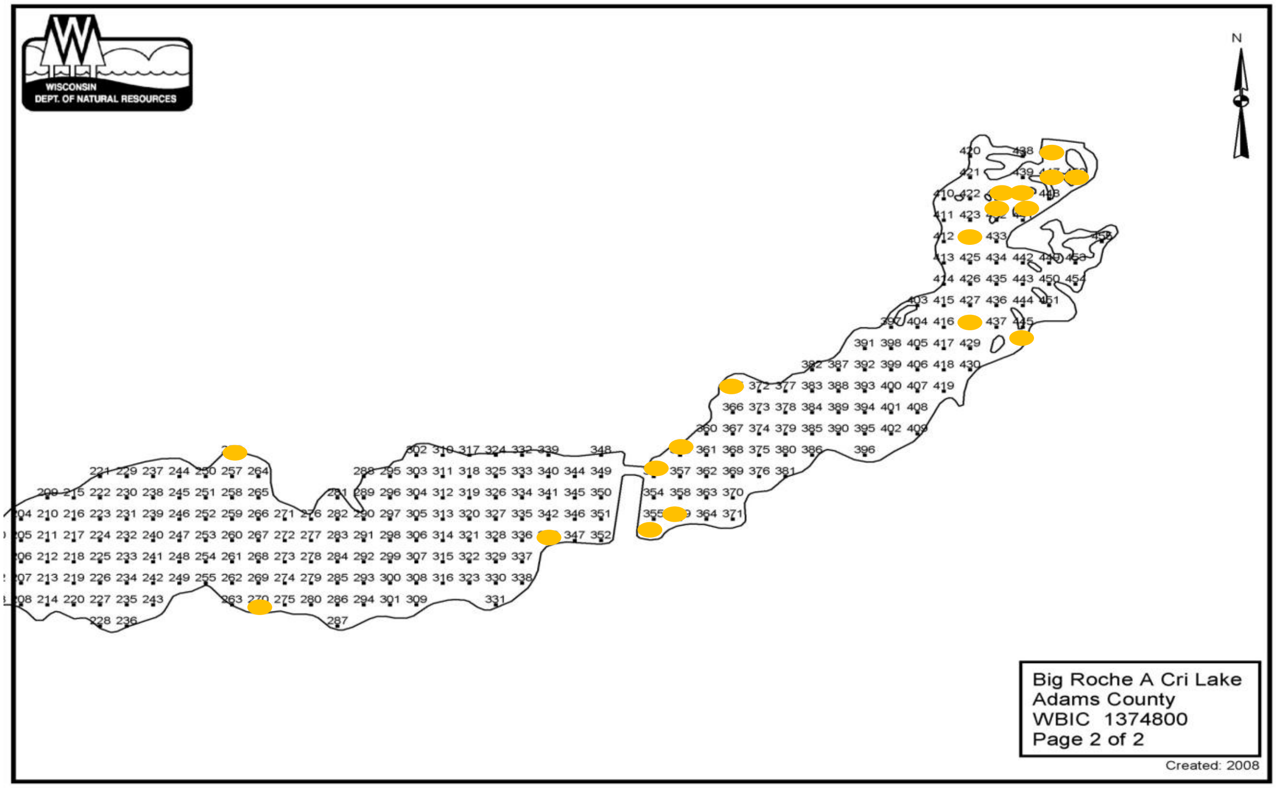
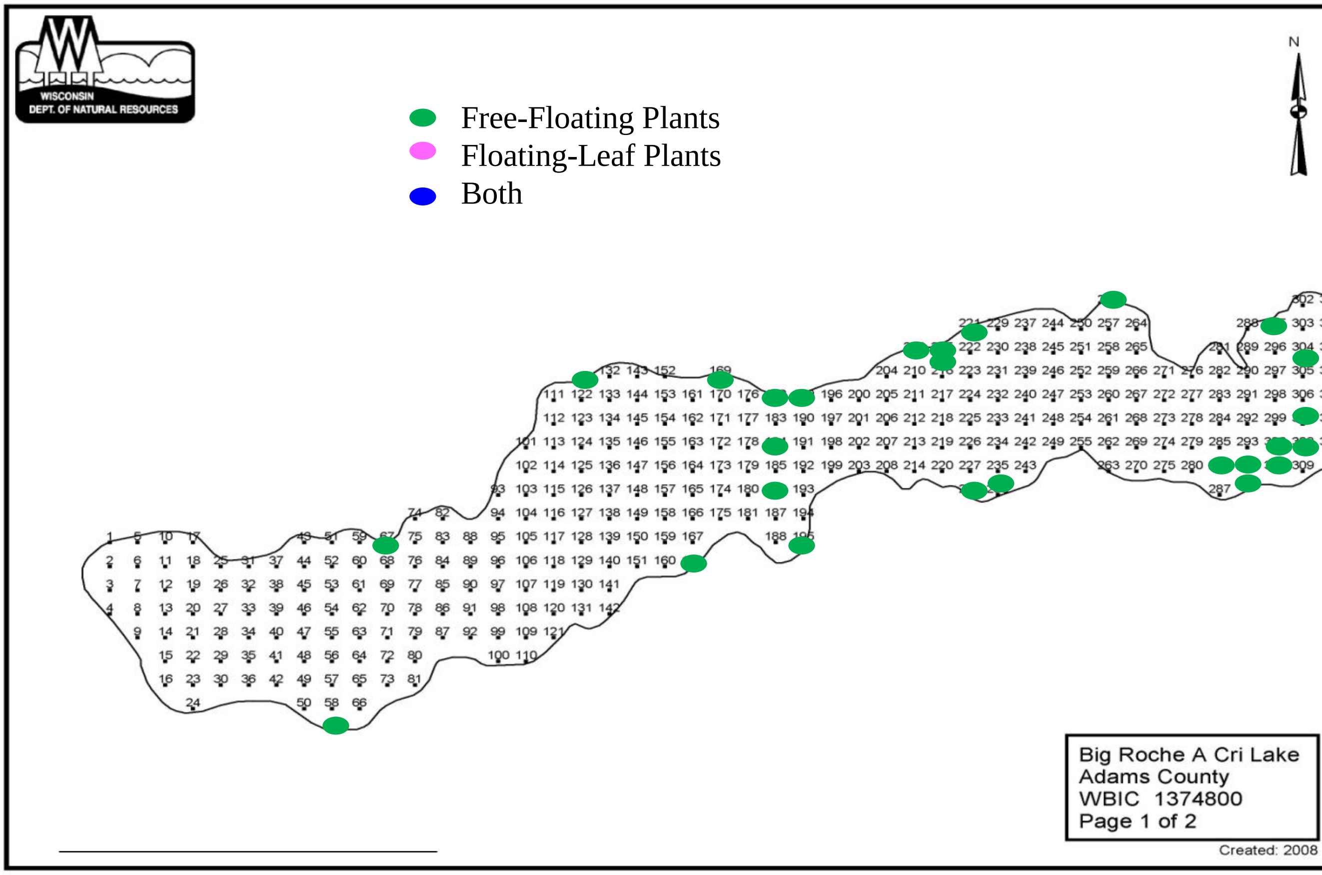


Figure 16: Distribution of Rooted Floating-Leaf and Free-Floating Plants



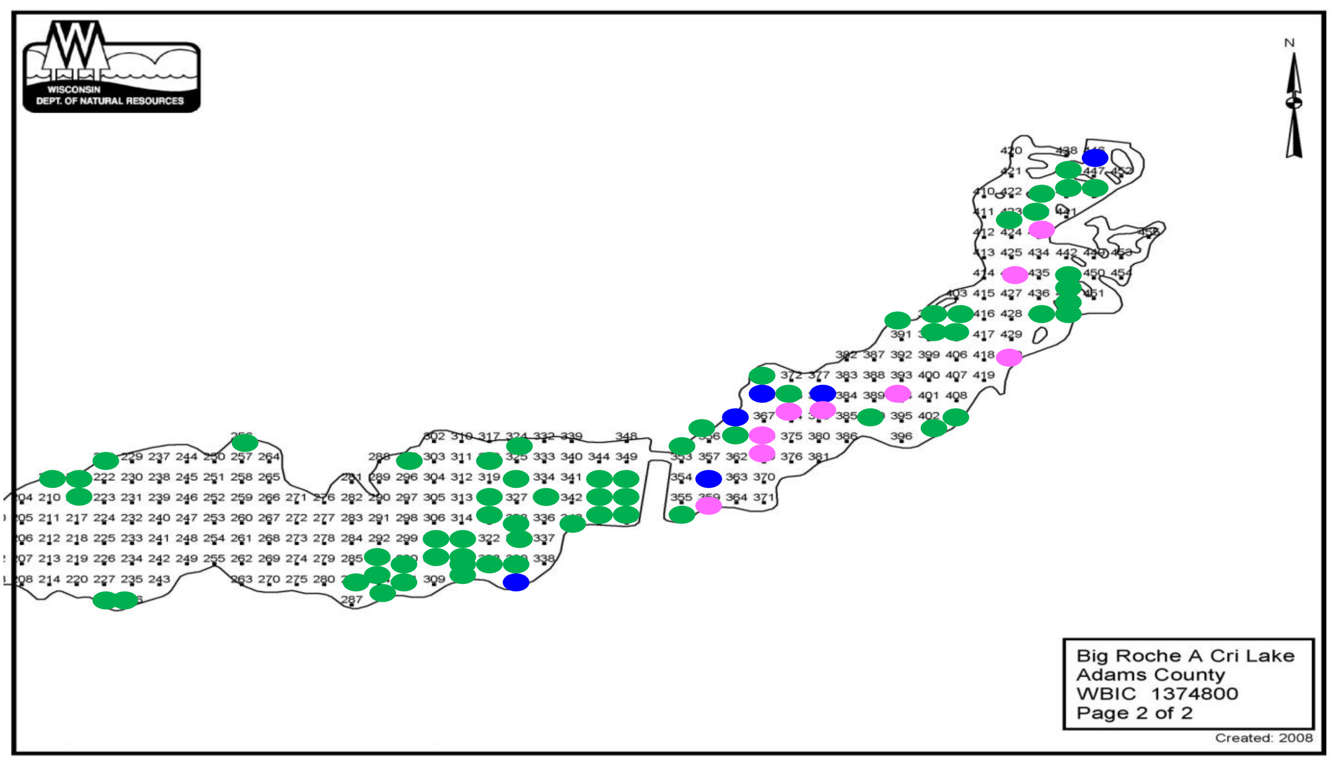
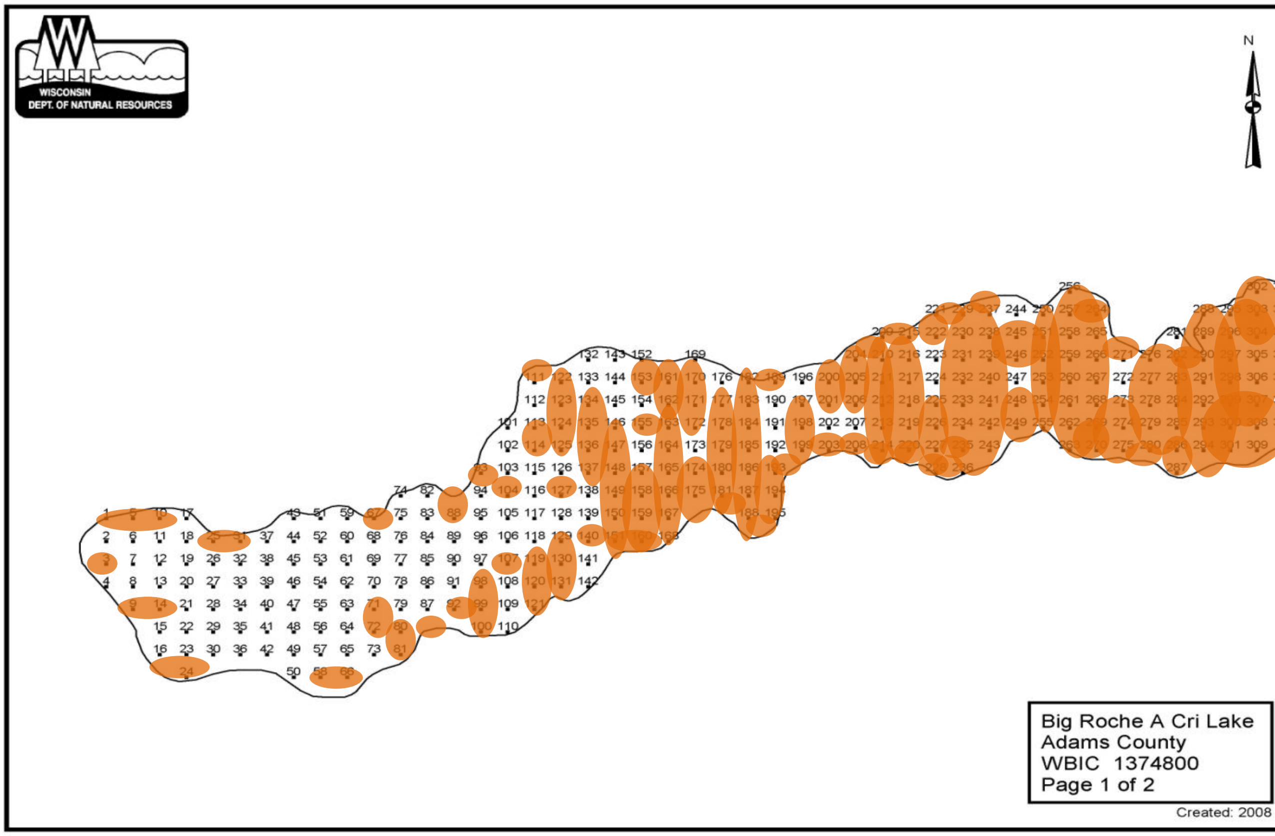
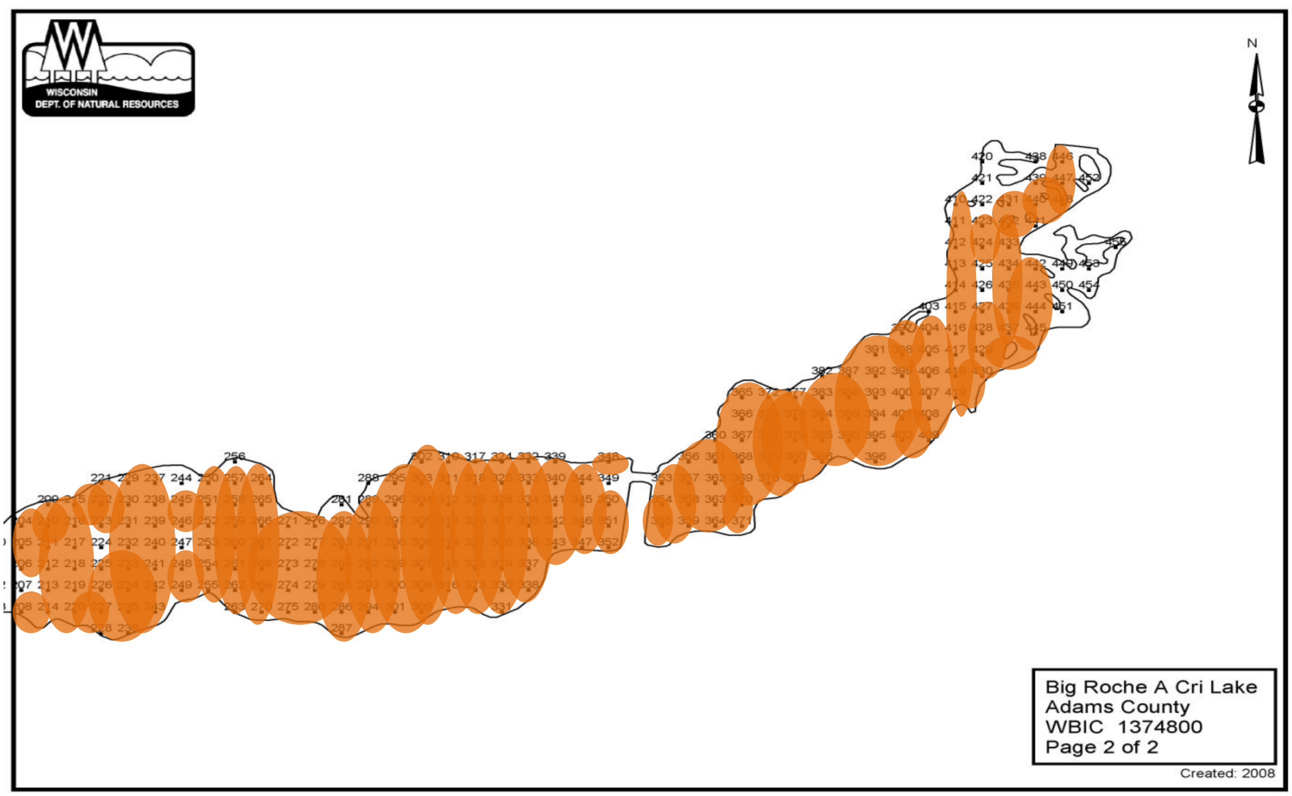


Figure 17: Distribution of Submergent Plants





The invasive Eurasian Watermilfoil (*Myriophyllum spicatum*) has long been the most frequently-occurring invasive aquatic species in Big Roche a Cri Lake. Despite historical efforts to reduce the population, including chemical treatments, targeted harvesting, and winter water drawdown, it has continued to have a significant presence in the lake. In the 2013 survey, it comprised 13.5% of the aquatic plant population. This is the same position it occupied in the 2008 survey, so it hasn't spread since then. However, that it remains in the top four most frequently-occurring plant in Big Roche A Cri suggests that the potential is still very high for future expansion.

The next most commonly-occurring invasive aquatic plant in Big Roche a Cri Lake is Curly-Leaf Pondweed (*Potamogeton crispus*). It has been present in the lake since at least the mid-2000s. Although it increased slightly in its position in the overall aquatic plant community from 2008 to 2013, going from 1% of the community to 2.5%, it remains low in occurrence, density and dominance.

Figure 18a: Distribution of Eurasian Watermilfoil and Curly-Leaf Pondweed

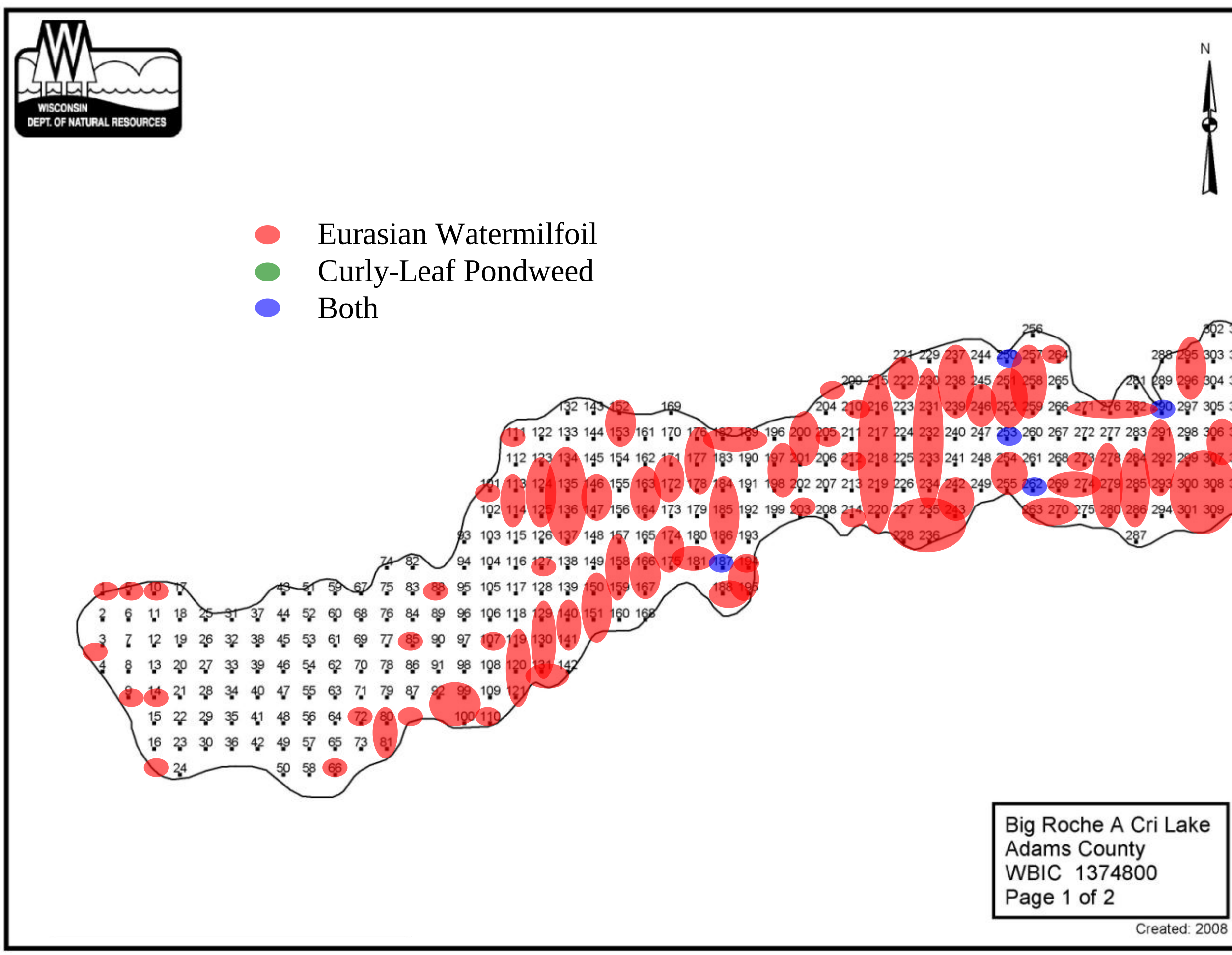
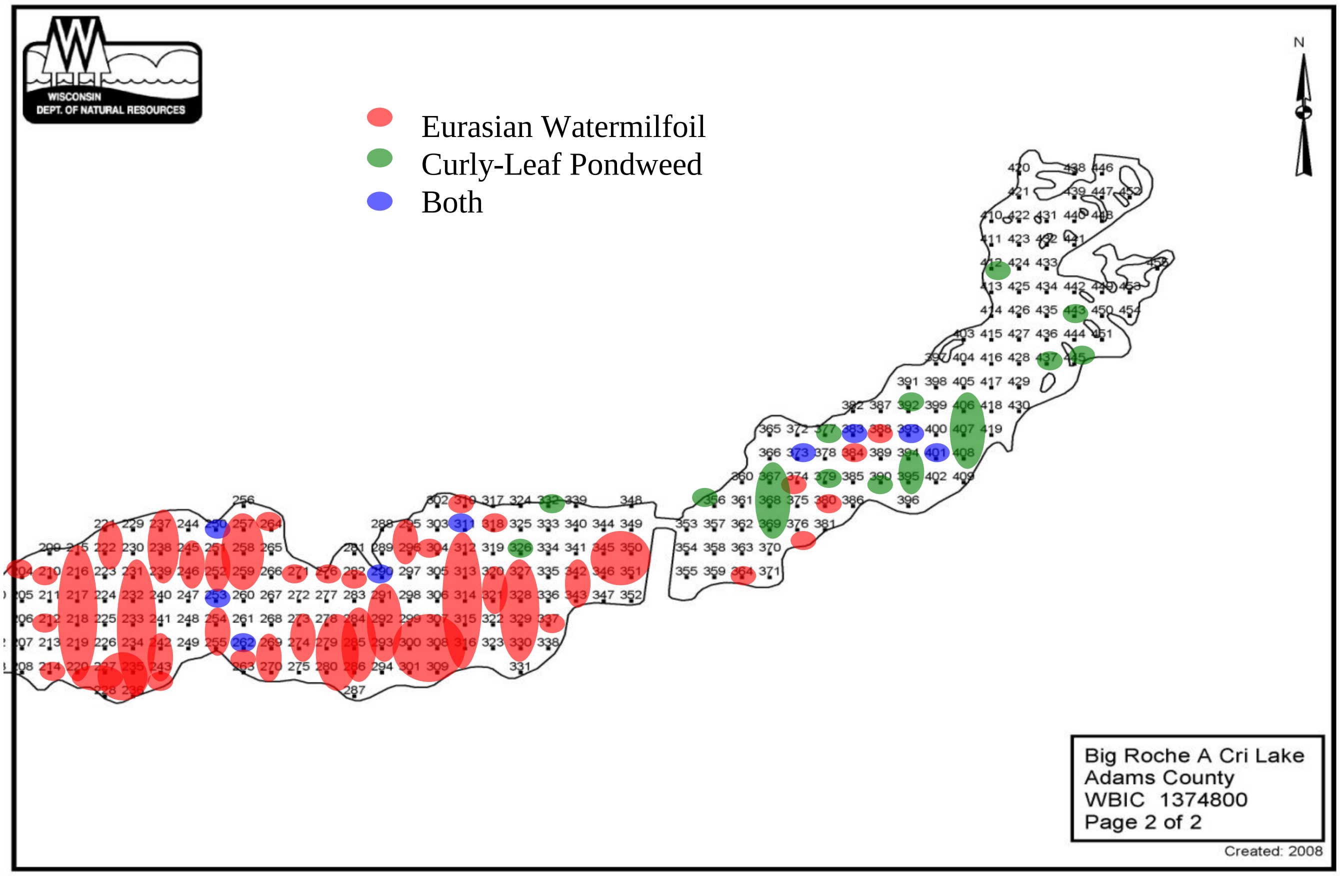


Figure 18b: Distribution at East End of Lake

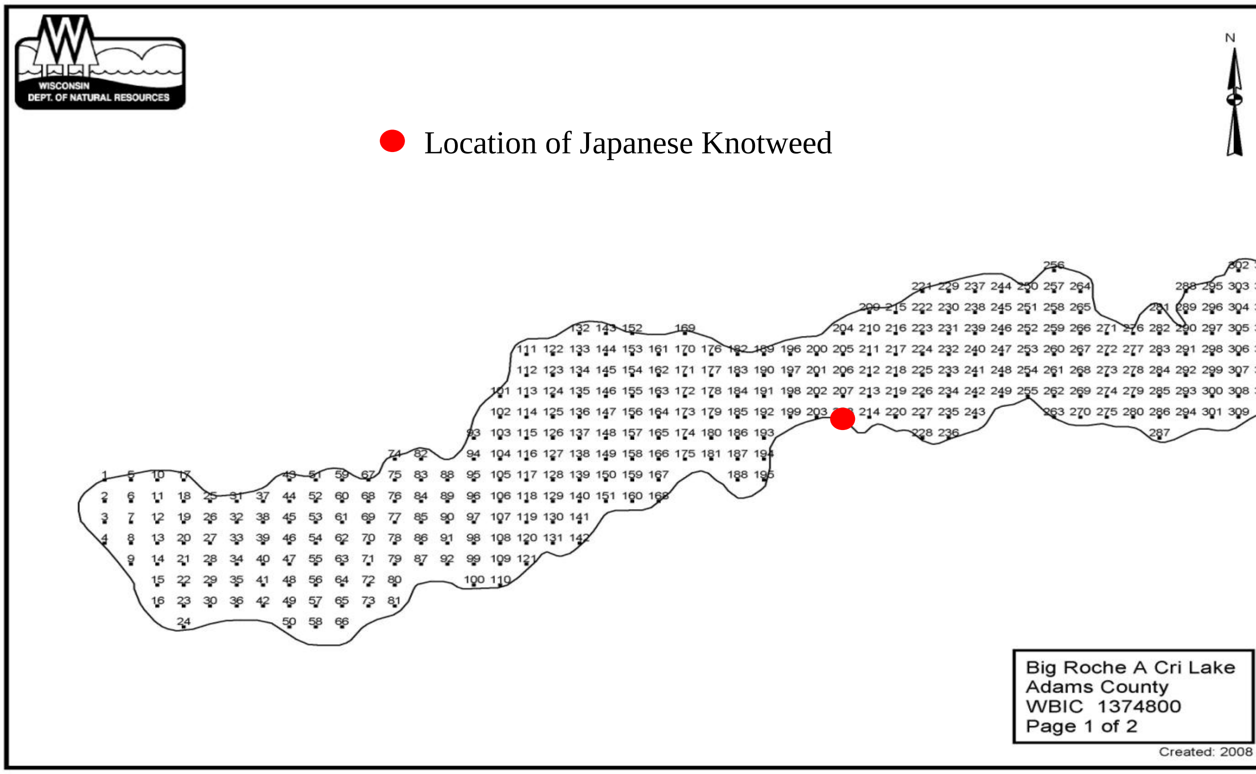


The emergent invasive Reed Canarygrass has been around Big Roche a Cri Lake for many years, but has stayed a small part of the aquatic plant community. Currently, it is only found in the far eastern section of the lake.

A new emergent invasive, Japanese Knotweed (*Polygonum cuspidatum*), was verified in the lake in 2013. Presently, it was found at only one site, mid-lake, along the southern shore. Although only present at this one site, it covered the entire shore of that parcel. Plans will be made to remove this population in 2014 before further spread occurs. This will likely take more than one season.

Japanese knotweed is also called “Mexican bamboo” or “Japanese bamboo” due to its tall hollow stocks. It was originally used as an ornamental. However, it quickly spreads and crowds out all other plants. A common habitat for Japanese knotweed is sunny, moist areas, including riverbanks and lake banks.

Figure 19: Locations of Japanese Knotweed and Reed Canarygrass



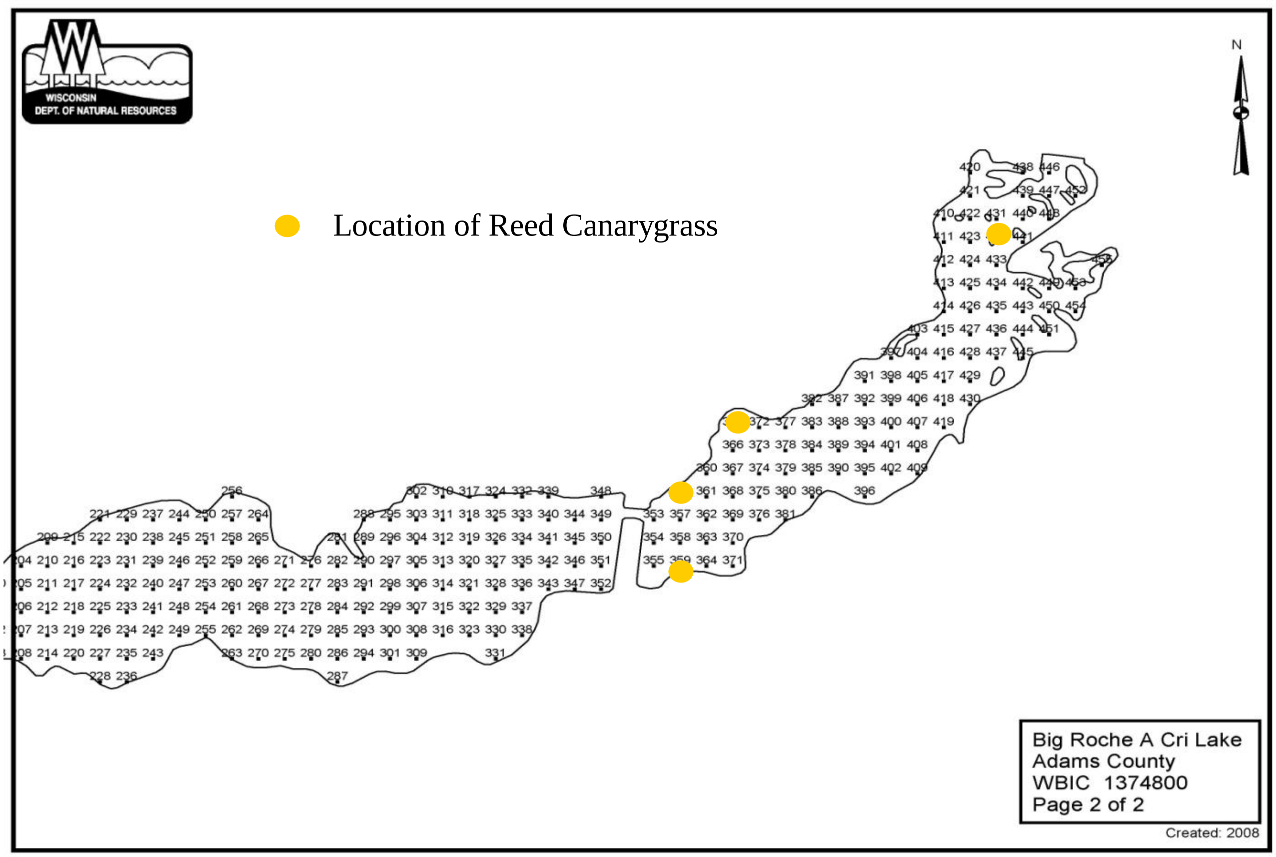


Figure 20: Photos of Japanese Knotweed

THE AQUATIC PLANT COMMUNITY IN 2013

The Simpson's Diversity Index (SI) measures the diversity of a plant community. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). In 2013, the Big Roche a Cri Lake SI was 0.90, indicating good species diversity. This was up slightly from the 2004 ranking of .88 and the 2008 ranking of .87.

The Aquatic Macrophyte Community Index (AMCI) was developed to assess the biological quality of aquatic plant communities in lakes. It measures seven parameters: maximum depth of plant growth; percentage of littoral zone vegetated; Simpson’s Diversity Index; relative frequency of submerged species; relative frequency of sensitive species; relative frequency of invasive species; and number of species (taxa). The highest value for this index is 70. For Big Roche-a-Cri Lake in 2013, the AMCI was 55. This value is in the average range for lakes in Wisconsin and of lakes in the North Central Region. The 2008 AMCI was 54. Both of these were an increase from the 2004 figure of 49.

Figure 21: AMCI scores 2004 to 2013 for Big Roche a Cri Lake

Category	Parameter	2004	Parameter	2008	Parameter	2013
Maximum Rooting Depth	13 feet	7	15 feet	9	12.5 feet	7
% Littoral Zone Vegetated	87%	10	73.5%	10	77.5%	10
Simpson's Diversity Index	0.886	8	0.87	7	0.90	8
# of Species	25	9	23	9	46	10
Rel Freq of Exotic Species	13%	4	10.1%	4	15.0%	4
Rel Freq of Submergent Species	61%	6	81.2%	10	79.0%	10
Rel Freq of Sensitive Species	8%	5	7.6%	5	12.0%	6
Total AMCI		49		54		55

Information is also available about the median range for all Wisconsin Lakes and the range for the North Central Hardwood Region (which contains Adams County) (Nichols et al, 2000). Big Roche a Cri Lake falls within the median ranges for all Wisconsin lakes and lakes within its geographical region in terms of Simpson's Index, percent of submergent species, and percent of sensitive species; however, it is above the median for percent of invasives.

Figure 22: Comparison of Several AMCI Factors

	Statewide	NCHF	BRC
% submergents	78-98	78-100	79
% iinvasives	0-13	0-10	15
% sensitive	5-25	10-25	12
Simpson's Index	.80-.90	.81-.90	0.90

A Coefficient of Conservatism and a Floristic Quality Index calculation were performed on the field results. Technically, 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 2013 Average Coefficient of Conservatism (CoC) was 4.4, down from the 2008 average of 5.0. Both these numbers are in the lowest quartile for all Wisconsin lakes and lakes in the North Central Hardwood Region. This suggests the Big Roche a Cri Lake aquatic plant community is among the group of lakes in Wisconsin and in the region that are the most tolerant of disturbance.

Figure 23: Average Coefficient of Conservatism and FQI

	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
Big Roche a Cri Lake	4.4	28.27

***** - 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 2013 score was 28.27, up from the 2008 score of 24.19 and the 2004 score of 21.06. While the 2008 reading was average for the lakes in Wisconsin and for the North Central Hardwoods Region, the 2013 score is slightly above average for both scales. This suggests that the aquatic plant community in Big Roche a Cri Lake has been impacted by a little less than average amount of disturbance.

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 sensitive species by resuspension of sediments, sedimentation from erosion and increased algae growth due to nutrient inputs.

3) Biological disturbances include competition from non-native/invasive plant species, grazing from an increased population of aquatic herbivores and destruction of plant beds by a fish or wildlife population.

Major disturbances in Big Roche-a-Cri Lake include shoreline development, past herbicide treatments, invasion of invasive species and mechanical plant harvesting.

Comparison of 1964, 1996, 2004, 2008, and 2013 Aquatic Plant Assessments

The 1964 and 1996 plant surveys were not quantitative surveys using the same methods as the 2004 plant study. The earlier surveys were qualitative, not designed to record all species, but possibly just to characterize the common species. And since the 2004 aquatic plant survey was done using the transect method, while the 2008 and 2013 surveys were done using the point intercept method, none of these results can be compared very specifically. However, it is possible to look at species present as some indication as to the status of the aquatic plant community of Big Roche a Cri Lake.

In 1964, a simple species list was made and the dominant species was identified. The 1964 assessment found that curly-leaf pondweed was the dominant species, with sago pondweed (*Stuckenia pectinata*), flat-stemmed pondweed (*Potamogeton zosteriformis)* and wild celery (*Vallisneria* americana) also present.

In 1996, a qualitative assessment of the Big Roche a Cri plant community was made. Species in each area were characterized as scattered, common, abundant or thick. 11 species were identified. All were submergent except Yellow Pond Lily. Curly-Leaf Pondweed was also found.

The dominant aquatic plant species changed from *Potamogeton crispus* (an invasive) in 1964 to *Vallisneria americana* in 1996, then to *Ceratophyllum demersum* in 2004, and back to *Vallisneria americana* in 2008 and 2013.

Figure 24: Comparison of Plants Found in Various Surveys

Plant Type	Scientific Name	1964	1996	2004	2008	2013
Emergent	*Acorus americanus*					x
	Alisma trivale					x
	Alnus incana					x
	Bidens comosa					x
	Calamagrostis canadensis					x
	Carex spp					x
	Carex comosa			x	x	x
	Chelone glabra					x
	Cicuta bulbiferea			x		x
	Cornus spp					x
	Elocharis palustris					x
	Eupatorium perfoliatum					x
	Impatiens capensis			x		x
	Iris versicolor					x
	Lycopus uniflorus					x
	Persecaria punctata					x
	Phalaris arundinacea					x
	Polygonum cuspidatum					x
	Rumex spp			x		x
	Sagittaria latifolia				x	x
	Salix exigua			x		x
	Schoenoplectus tabernaemontani			x	x	x
	Solanum dulcamum				x	x
	Sparganium spp					x
	Typha spp			x	x	x
Floating Leaf	*Brasenia schreberi*				x	x
	Nuphar variegata		x	x	x	x
	Potamogeton natans					x
Free-Floating	*Lemna minor*			x	x	x
	Spirodela polyrhiza			x	x	x
	Wolffia columbiana				x	x
Submergent	*Ceratophyllum demersum*		x	x	x	x
	Chara				x	x
	Elodea canadensis		x	x	x	x
	Myriophyllum sibiricum		x			x
	Myriophyllum spicatum			x	x	x
	Najas flexilis					x
	Najas guadelupensis			x		x
	Potamogeton amplifolius			x	x	x
	Potamogeton crispus	x	x	x	x	x
	Potamogeton epihydrus				x	x

	Potamogeton friesii					x
	Potamogeton illinoiensis			x		x
	Potamogeton natans			x		x
	Potamogeton nodosus		x			
	Potamogeton pusillus			x	x	x
	Potamogeton richardsonii		x	x	x	x
	Potamogeton zosteriformis	x	x	x	x	x
	Stuckenia pectinata	x		x	x	x
	Vallisneria americana	x	x	x	x	x
	Zosterella dubia		x	x	x	x

DISCUSSION

Based on water clarity, chlorophyll-a and phosphorus data, Big Roche-a-Cri Lake is a mesotrophic lake with good water quality and fair-to-good water clarity. This trophic state should support significant plant growth and occasional algae blooms. Adequate nutrients (mesotrophic status), the hard water, the shallow depth in most of the lake and the gradually sloped littoral zone favor plant growth in Big Roche-a-Cri Lake. The dominance of high-density sand sediments in Big Roche-a-Cri Lake do not appear to limit the density of plant growth. Favorable silt and muck sediments occur mainly in the east end of the lake.

Besides the invasive aquatic plant species, Big Roche a Cri Lake has three aquatic invasive animals. The Chinese Mystery Snail has been in the lake for several years. Research is being conducted by the WDNR to determine the impact of such populations.

The first Rusty Crayfish was discovered partially-digested in the stomach of a large mouth bass caught in the lake. Since then, reproducing rusty crayfish have been collected from the lake. Monitoring is being conducted to evaluate any impact at the lake. These crayfish are known to outcompete native crayfish, plus eat native crayfish and fish roe, as well as pull up aquatic plants.

Most problematic was the discovery of adult zebra mussels on platform samples in the fall of 2013. These platforms had been hung in the lake during the summer for several years with no result. However, when they were pulled from the lake in September 2013, it was discovered that both had a few adult zebra mussels on them. This was reported to the WDNR for further investigation.

Figure 25: Invasive Aquatic Animals in Big Roche a Cri Lake


Chinese Mystery Snail

Zebra Mussel



Rusty Crayfish

The current plant survey results can be compared to those found in 2008 under the PI method by calculating to coefficient of similarity. The coefficient of similarity is an index, first developed by Jaccard in 1901, that compares the similarity and diversity of sample sets. In this instance, the index considers the frequency of occurrence and relative frequency of all species found, then determines the similarity of the two aquatic plant communities. Similarity percentages of 75% or more are considered statistically similar.

When comparing the results of the 2008 and the 2013 surveys, the aquatic plant community scores as similar in regards to both actual and relative frequency of occurrence, with a score of 77.7% similar based on actual occurrence frequency and 91.1% on relative frequency of occurrence.

This suggests that although there were plants found in 2008 that weren't found in 2013 and vice versa, the aquatic plant community of Big Roche a Cri Lake has remained relatively stable in the past 5 years. The same four aquatic plant species—Common Waterweed, Coontail, Eurasian Watermilfoil, and Water Celery—are the most-frequently-occurring plants in the lake (although not necessarily in the same order). The primary invasive plant, Eurasian Watermilfoil, comprises the same percent—13.5%--of the overall aquatic plant community. Curly-Leaf Pondweed, although slightly up, remains a low part of that community.

Figure 24: Changes in the Macrophyte Community 2008-2013

Big Roche a Cri	2008	2013	change
Number of Species	23	46	23
Maximum Rooting Depth (feet)	15.0	12.5	2.5
% of Littoral Zone Vegetated	88.3	77.8	-10.5
%Emergents	0%	6%	6.0
%Free-floating	12%	10%	-2.0
%Floating-leaf	1%	0%	-1.0
%Submergents	87%	84%	-3.0
% Invasive	10.1	15	4.9
% Sensitive	7.6	12	4.4
Simpson's Diversity Index	0.87	0.90	0.04
Species Richness	2.9	2.7	-0.2
Floristic Quality Index	24.19	28.27	4.08
Average Coefficient of Conservatism	5.03	4.41	-0.62
AMCI Index	54	55	1.00

CONCLUSIONS

Based on water clarity, chlorophyll and phosphorus data, Big Roche-a-Cri Lake is a mesotrophic lake with good water quality and fair-to-good water clarity. This trophic state should support significant plant growth and occasional algae blooms.

The Simpson's Diversity Index was 0.90, indicating good species diversity. The

Aquatic Macrophyte Community Index (AMCI) for Big Roche-a-Cri Lake in 2013 was 55. This value is average quality range for lakes in Wisconsin and for lakes in the North Central Hardwood Region.

The aquatic plant community is characterized by average quality for Wisconsin lakes and good species diversity, but impacted by significant levels of disturbance. Big Roche-a-Cri Lake is one of the lakes in the state quite tolerant of disturbance and far from an undisturbed condition. Disturbances include invasions of exotic species, boat traffic, shoreline development, harvesting and past herbicide treatments.

The aquatic plant community colonized a little over three-quarters of the littoral zone to a maximum depth of 12.5 feet. The east end of the impoundment had the greatest coverage of aquatic plants. *Vallisneria americana* dominated all depth zones and all areas of the lake. The invasive *Myriophyllum spicatum* continued to be a significant, but stable, presence.

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.

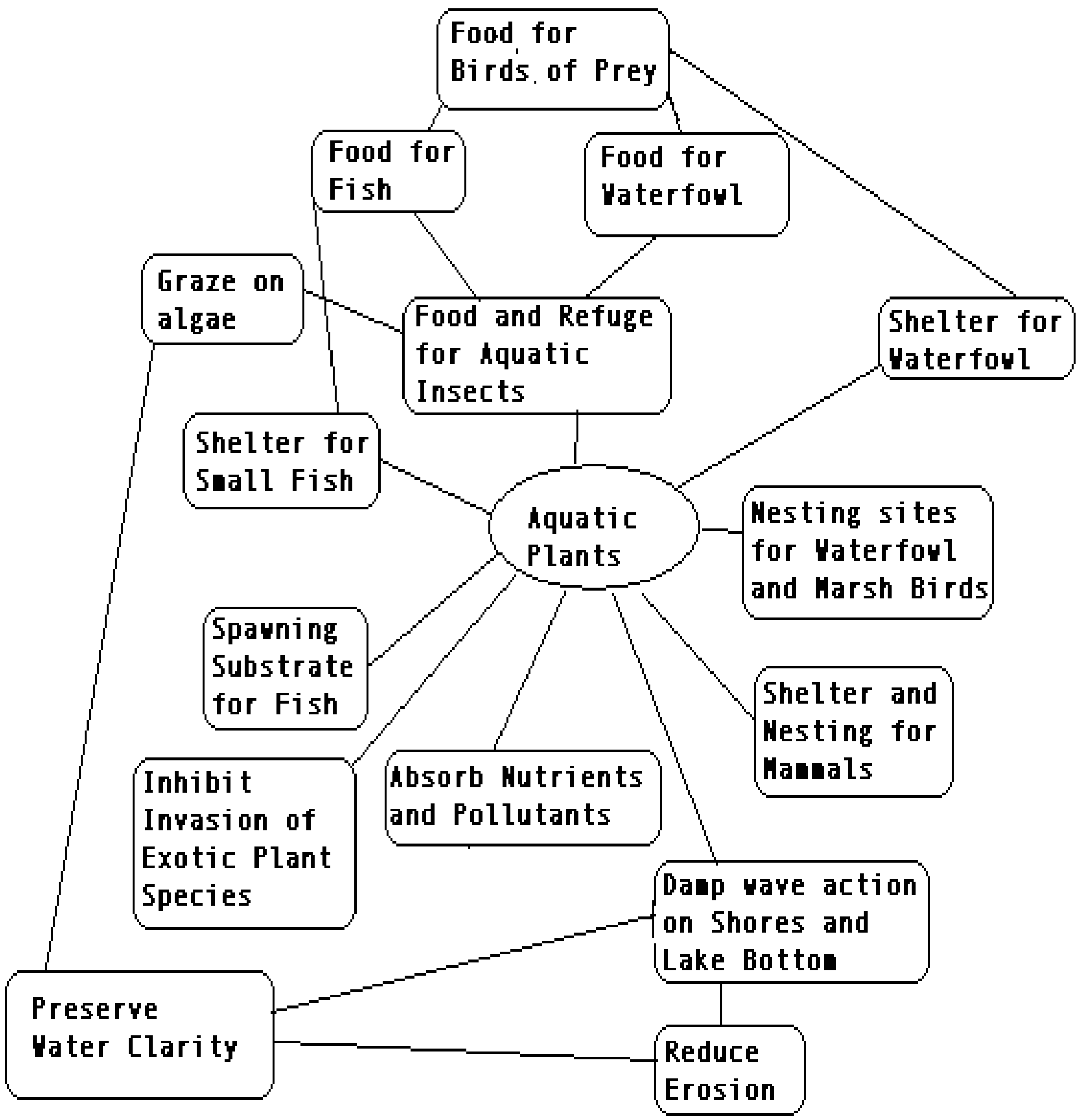
1) Aquatic plant communities improve water quality in many ways:
   - they trap nutrients, debris, and pollutants entering a water body;
   - they absorb and break down some pollutants;
   - they reduce erosion by damping wave action and stabilizing shorelines & lake bottoms;
   - they remove nutrients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

2) Aquatic plant communities provide important fishery and wildlife resources:
- Plants and algae start the food chain that supports many levels of wildlife;
- Plants & algae produce oxygen needed by animals;
- Plants are used as food, cover and nesting/spawning sites by a variety of wildlife and fish;
- Plant cover within the littoral zone of Big Roche-a-Cri Lake is 73.5%, which is within the ideal coverage (25-85%) to support a balanced fishery.

3) Compared to non-vegetated lake bottoms, macrophyte beds support larger, more diverse invertebrate populations that in turn will support larger and more diverse fish and wildlife populations (Engel 1985).

4) Additionally, mixed stands of macrophytes 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. Macrophyte beds of moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel 1990).

Figure 25: Lake Food Web



Management Recommendations

1) Continue involvement of the Lake District in water quality monitoring through the Citizen Volunteer Lake Monitoring Program.

2) Continue involvement of the Lake District & volunteers in aquatic invasive species monitoring through the Citizen Lake Monitoring Program and the Clean Boats, Clean Waters Program.

3) Chemical treatments for plant growth are still not recommended in Big Roche-a-Cri Lake due to the undesirable side effects of chemical treatments.

    a) The decaying plant material releases nutrients that feed algae growth that further reduce water clarity.
    b) The decaying material also enriches the sediments at the site.
    c) The herbicides are toxic to an important part of a lake food chain, the invertebrates.
    d) Broad-spectrum treatments would open up areas that would be vulnerable to the spread of the exotic species.

4) Continue with natural shoreland restoration. While the amount of restored shoreline has increased since 2004, there is still more to be done and there is still a fair amount of mowed lawn.

    a) Unmowed native vegetation reduces shoreline erosion and run-off into the lake and filters the run-off that does enter the lake thus reducing nutrient inputs.
    b) Shoreline restoration could be a as simple as leaving a band of natural vegetation around the shore by discontinuing mowing.
    c) Restoration could be as ambitious as extensive plantings of attractive native wetland species in the water and native grasses, flowers, shrubs and trees on the near shore area.

5) Continue to annually fine-tune the harvesting plan and to engage in an integrated approach to the management of the aquatic plants and the aquatic invasives.

a) The mechanical harvesting plan should be designed to remove nutrients, provide navigation, and recreation where appropriate, prevent the spread of overabundant species, and improve habitat.
b) Nutrient reduction. Harvesting removes the nutrients found in the plant tissue and filamentous algae mats. There is evidence that mechanical harvesting may already to be reducing filamentous algae and nutrients.
c) If curly-leaf pondweed increases to a nuisance condition, early spring harvesting for this species could be instituted. Skimming off coontail as the harvester is operating will help control this species that is becoming abundant.
d) Provide navigation and recreation where appropriate. Cutting channels through the areas that have the densest plant growth will aid navigation of the lake. Harvesting in the depth zone greater than 10 feet to maintain an open area for higher speed boat traffic would also aid navigation.
e) Prevent the spread of species that could become overabundant. *Vallisneria americana* is one of the few submergent aquatic plants that grow from the base, as grass does. Frequent harvesting in beds of *V. americana* will encourage its growth. Avoid these plant beds when they are not hindering navigation. When *V. americana* is harvested, cut near the sediment, or as deep as the cutter bar extends. The dam end of the lake supports the most *V. americana*. Harvesting the dam end in less than 10 feet of depth should be avoided.
f) Improve habitat. The mid-portion of the lake and the 5-10ft depth zone area could be improved the most with channels (not clear-cutting). Cutting channels in this area provides edge needed for habitat and allows the predator fish to better find prey, supporting a more balanced fishery. These open areas are also used by wildlife. The 0-1.5ft depth zone supports the best species richness and diversity. The only harvesting that should be conducted in this zone are hand-harvested channels next to the docks for land owner access.
g) Keep records of the amount of plants mechanically-harvested by weighing a trailer load and multiplying that amount by the number of loads removed.

6) Continue to take random plant tissue samples and submit them for lab testing to determine the amount of phosphorus being removed by mechanical harvesting. This should be done at least once per harvesting season. Keep records of the amount removed annually.

7) Conduct training for volunteers to hand-remove Eurasian Watermilfoil in areas where such removal is practical. Encourage such removal as often as possible. This will reduce this invasive in areas not reachable by mechanical harvester.

8) Continue to explore options of reducing Eurasian Watermilfoil, such as winter drawdowns.

9) Continue to cooperate with programs in the watershed to reduce nutrient inputs to the lake. Currently nearly half of the relatively large watershed is in agriculture.

10) Participate in the Big Roche a Cri Watershed Advisory Group.

11) An inventory of the stream banks in the Adams County portion of the Big Roche a Cri Creek Watershed was conducted during 2013. Plans are being made to finish the inventory in the Waushara portion of the watershed in 2014-2015. Cooperate with the Adams County LWCD and Waushara County LWCD in any steps necessary to correct problems discovered in these inventories, including invasives and sloughing banks.

12) Eliminate the use of fertilizers, both organic and inorganic, on properties around the lake.

13) Encourage board members of the lake district to attend the annual Wisconsin Lakes Conference and to participate in the UW-Extension Lakes Lake Leader program. Apply for grants to assist completion of this goal.

14) Make arrangements immediately for the removal of Japanese Knotweed from the shore before it spreads further.

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