Aquatic Plant Management Plan

Minocqua Lake/Kawaguesaga Lake/Minocqua Thoroughfare/Tomahawk Thoroughfare(portion)

2015-16

Prepared by Ecological Integrity Service, LLC

Sponsored by Minocqua/Kawaguesaga Lake Protection Association and

Wisconsin Department of Natural Resources.

MINOCQUA / KAWAGUESAGA

LAKES PROTECTION ASSOCIATION

Executive Summary

This plan is an Aquatic Plant Management Plan (APMP). An APMP is required to be prepared and formally approved by the Wisconsin Department of Natural Resources in order to qualify for a wide array of grants to study, plan and manage the lakes. The first APMP was produced in 2009 and this 2015-16 plan is the result of the evaluation and revamping of the 2009 plan. This plan was produced with extensive public input and will help guide the Minocqua-Kawaguesaga Lake Protection Association (MKLPA) and the Wisconsin DNR in managing the aquatic plant community in Minocqua Lake, Kawaguesaga Lake, Minocqua Thoroughfare, and a portion of the Tomahawk Thoroughfare over the next five years (2016-2020) at which point it will be evaluated in 2021.

This APMP contains the most updated information on the water quality, watershed, fisheries and plant community associated with Minocqua Lake and Kawaguesaga Lake. The plan uses scientific data, public input, and Wisconsin DNR requirements to develop plant management schemes that consider the ecology of the lakes, the present status of the lakes, and stakeholders to achieve management goals.

The MKPLA vision and mission are reflected in this APMP.

The **MKPLA vision** states: *The vision of the MKLPA is to constantly improve the quality of our lakes.*

The **MKPLA mission** statement: *The mission of the Minocqua/Kawaguesaga Lakes Protection Association is to protect the Minocqua/Kawaguesaga lakes and their surroundings by enhancing water quality, fishery, and the aesthetic value of our lakes as public recreational facilities for today and future generations.*

Important lake system characteristics as well as public input were considered when establishing goals for plant management.

Minocqua Lake, Kawaguesaga Lake, Minocqua Thoroughfare, and Tomahawk Thoroughfare (up to the Thoroughfare bridge) have good water quality with Minocqua Lake and Kawaguesaga Lake consistently rated as mesotrophic based upon total phosphorus, chlorophyll a, and secchi disk monitoring results. The watershed includes extensive development and significant loading from urban land use.

These lakes contain numerous game fish species, which include large-mouth bass, muskellunge, northern pike and walleye. The lakes have natural reproduction of muskellunge and walleye, however the walleye populations have been in a steady decline.

The plant community in the lakes is very diverse and robust. More than 45 species of native plants were sampled in both lakes and two species of special concern were sampled. The committee and MKPLA acknowledge the importance of aquatic plants in the lake ecosystem.

There were six aquatic invasive plant species sampled/viewed or observed. These include: Eurasian water milfoil, curly-leaf pondweed, flowering rush, yellow iris, purple loosestrife, and

narrow-leaf cattail. Eurasian water milfoil has been managed in these lakes for several years and is a big component of this plan. Flowering rush appears to be expanding.

Public input from stakeholders reveals that there is concern over AIS introduction and expansion. The plant committee also expressed concern over the future expansion of AIS, especially EWM.

Considering the information that was available in regard to water quality, watershed, fisheries, the plant community and input from stakeholders, the following goals for aquatic plant management on the Minocqua Chain were established for this plan:

- Goal 1: Control the expansion of Eurasian watermilfoil in Minocqua Lake, Kawaguesaga Lake and the Thoroughfares.
- Goal 2: Preserve the native plant community in Kawaguesaga Lake and Minocqua Lake.
- Goal 3: Prevent the introduction of new invasive species and develop a rapid response plan if such an introduction should occur.
- Goal 4: Monitor other existing aquatic invasive species such as purple loosestrife, curly leaf pondweed, flowering rush and yellow iris.
- Goal 5: Restore native shoreline vegetation.
- Goal 6: Preserve and/or enhance water quality.
- Goal 7: Provide extensive education on lake ecology.

Various objectives and actions will be implemented over the next five years, directed by MKPLA with the full intent to reach each of these goals. The plant management methods consider the health of the lake's ecosystem, cost effectiveness, and stakeholder concerns. Herbicide use is guided by the Wisconsin DNR protocols and requirements. Historical AIS management has been carefully reviewed and adjusted for this plan.

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Introduction

This Aquatic Plant Management Plan is for Kawaguesaga Lake, Minocqua Lake, Minocqua Thoroughfare, and a portion of the Tomahawk Thoroughfare, which are located in Oneida County, Wisconsin (see Figures 1,2, and 3). The plan presents data about the plant community, fisheries, watershed, and water quality of Kawaguesaga and Minocqua Lake Chain. Based on this data and public input, this plan provides goals as well as strategies for the sound management of aquatic plants in the lakes. These goals include preservation of native species for their benefits to the lake ecosystem, reduction of Eurasian water milfoil, maintenance of good water quality, and reduction/prevention aquatic invasive species, such as Eurasian water milfoil (EWM). The plan reviews public input, summarizes data, discusses management options and alternatives, and recommends action items. This plan will guide the Minocqua/Kawaguesaga Lake Protection Association (MKLPA), Oneida County, and the Wisconsin Department of Natural Resources in aquatic plant management over the next five years (2016-2020). After 2020 (starting 2021), this plan will be evaluated and changed as deemed necessary from the APMP committee, the MKPLA Board, the Wisconsin DNR, and other stakeholders.

Public Input for Development

The Aquatic Plant Management Committee was comprised of members from the Lake Association, representatives from the Oneida County Conservation Department, and the Wisconsin Department of Natural Resources. This committee developed goals based on collected data as well as comments from concerned citizens. Based on public input, the Aquatic Plant Management Committee recognizes the importance of plant management in Minocqua and Kawaguesaga Lakes. They also understand the importance of aquatic plants in the lake ecosystem and the need for education about this issue.

<u>Aquatic Plant Management Committee members for the 2015-16 Plan:</u>

Regis Broast
Mark Clark
Dick Garrett
John Gray
Bob Hobson
Christy Justice
Sally Kovacik
Bob Madsen
Kevin McFerrin
Sally Murwin
Mark Pitman
Jerry Roseland,

Public Survey[1]

A property owners survey does not appear in any files with the Wisconsin DNR. However, in 2002, a lake boat use survey was conducted to assess boat traffic on Minocqua and Kawaguesaga Lakes. This survey demonstrated the extensive use of the lakes. As a result, the spread of invasive species is a high risk associated with the Minocqua Chain. This risk is both the introduction of new species and the spread of EWM to other lakes.

In January 2007, a report entitled Community Lake Survey Final Report was released. This report was written from data generated during a survey of the lakeshore owners on Minocqua and Kawaguesaga Lakes. This sociological survey was sent out to lake residents in September of 2006. Of the 834 surveys sent, 41% or 344 were returned. The results of the survey reported here will focus on aquatic plant management issues.

When asked about lake appearance, 51% stated it was clear, 29% cloudy, 17% green, with other and blank responses accounting for other percentages.

Question/concern	Better	Worse	Same
Fishing in the last 5 years.	5.2%	28.8%	27%
Fishing in the last 20 years	4.1%	36%	8.7%
Rate the "health" of the lake compared to 1 year ago	4.1%	34%	55.8%
Rate the "health" of the lake compared to 10 years ago	5.5%	50.6%	21.8%

Question/concern	Yes	No	Unsure
Should controlling aquatic invasive species be top priority?	78.5%	2.6%	11.3%
Support the use of chemicals to control invasive species	66.9%	7.6%	18.9%
Has the amount of aquatic plants increased in the last 15 years?	68%	6.1%	20.1%

Actions needed to improve water quality	%
Enforce fertilizer ordinance	76.4%
Enforce zoning and town ordinance	57.7%
Enforce vegetative buffer ordinance	24.2%
Keep people informed	65.3%
Monitor lake water quality	80.7%
Watch for/report aquatic invasive species	82.2%
Financially support programs	50.9%

Table 1: Public survey results related to plant management issues.

From this survey, it appears many people believe fishing is getting worse. In addition, a majority of people responding feel the water quality is declining. They also appear to be very concerned about aquatic plant growth and invasive species. Furthermore, water quality is a big concern based upon these results.

In 2014, a marketing analysis was conducted with a partnership between the Minocqua/Kawaguesaga Lake Protection Association (MKLPA) and Lakeland Union High School DECA. This analysis included a survey directed at the best methods to enhance the

[1] Boat Survey conducted by Blue Water Science for the Minocqua-Kawaguesaga Lakes Protection Association. 2002.

efforts of MKLPA. One question in the survey asked for the respondents to check areas of focus that MKLPA should pursue. The following results occurred (386 responses):

Activity	Members of MKLPA	Non-Members of MKLPA
Clean Boats/Clean Waters	40.8%	63.1%
Monitor water quality	56.7%	73.7%
Shoreline restoration	34.1%	31.6%
Fishing issues	27.1%	54.4%
Monitor/control AIS	88.6%	80.7%

The results of this survey show that AIS monitoring and control is the most important issue to both members and non-members of the Minocqua Kawaguesaga Lake Protection Association.

Lake Management Concerns

This Aquatic Plant Management Plan addresses the top concerns of the Aquatic Plant Management Committee, representing the Lake Association:

- The presence and increased growth of Eurasian water milfoil and its effect on the lake ecosystem and use of the lakes.
- Management needs of other invasive species, such as purple loosestrife and flowering rush.
- The introduction of other aquatic invasive species.
- The preservation/restoration of native shorelines.
- The protection of important fish/wildlife habitats.
- Water quality degradation.
- The lack of understanding in lake ecology among lake residents

Importance of Aquatic Plants

The lake ecosystem relies extensively on the littoral zone, which is the area of the lake where the water is shallow enough to hold plants. As a result, the aquatic plant community plays a very important role in maintaining a healthy lake ecosystem.

Emergent (above water surface) plants can help filter runoff that enters the lake from the watershed area. Their extensive root networks can stabilize sediments on the lake bottom. Emergent plants can also reduce wave energy, thus reducing shoreline erosion. Many of these beds provide important fish habitat and spawning areas, as well as key wildlife habitat. Many birds, waterfowl, and some mammals rely on these plants for nesting materials, as well as food.

Floating-leaf plants, such as water lily, provide shade and cover for invertebrates and fish. Although they appear thick on the surface, the underwater area beneath them is more open. This allows fish and other animals to move about hidden beneath the leaves. These plants can also reduce wave energy, which can lead to shoreline erosion.

Submergent plants provide many benefits to the lake ecosystem. These plants are nature's aerators, producing the essential oxygen byproduct from photosynthesis. Submersed plants absorb nutrients through their roots and in some cases through their leaves, decreasing the nutrients that would otherwise be available for nuisance algae growth. Roots stabilize bottom sediments, thus reducing re-suspended sediments. As a result, these plants help maintain water clarity.

Aquatic plants take on many shapes and sizes and provide excellent habitat. Many of the plants, such as the milfoils or water marigold, have fine leaves that provide key invertebrate habitat. These invertebrates comprise an important level in the food chain and result in excellent forage opportunities for fish. Other plants are adapted to grow in low nutrient substrates, such as sand and gravel. These plants maintain important fish and wildlife cover for areas that would otherwise be devoid of plants.

Many fish rely on aquatic plants for reproduction. *Esox sp.* often spawn amongst submergent plants. The Northern Pike has eggs that are adapted for attachment to the plants themselves. Once fish emerge from their eggs, the plants provide important cover and foraging areas.

Lake Information

Kawaguesaga Lake is a 670 acre lake located in Oneida County, Wisconsin in the Town of Minocqua (T39N R06E Sections 9,10,15,16,21,22); the water body identification code (WBIC) is 1542300. Its main drainage inlet is Minocqua Lake (Minocqua Chain). Its outflow is the Tomahawk River and the level controlled by a dam. The maximum depth is 44 feet, with a mean depth of 18 feet.

Minocqua Lake is a 1,360 acre lake located in Oneida County, Wisconsin and is connected to Kawaguesaga Lake. It is located in the Town of Minocqua (T39N R 06E Sections 11-15,22); the water body identification code (WBIC) is 1542400. This is also a drainage lake with the main inflow from the upstream chain of lakes through the Tomahawk and Minocqua Thoroughfares. Minocqua Lake outflows to Kawaguesaga Lake, and the same dam indirectly controls both lake levels. The maximum depth is 60 feet and has a mean depth of 23 feet.

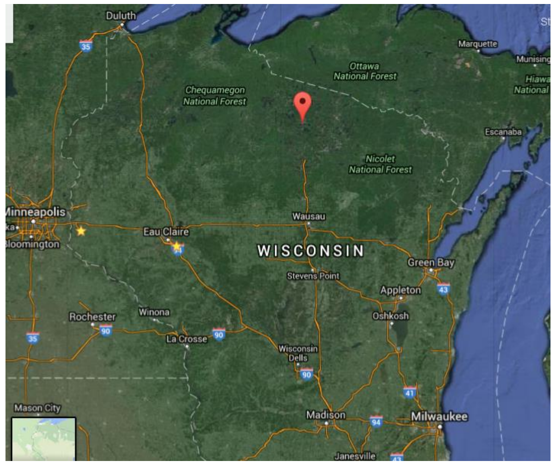


Figure 1: Aerial map of Kawaguesaga Lake and Minocqua Lake.

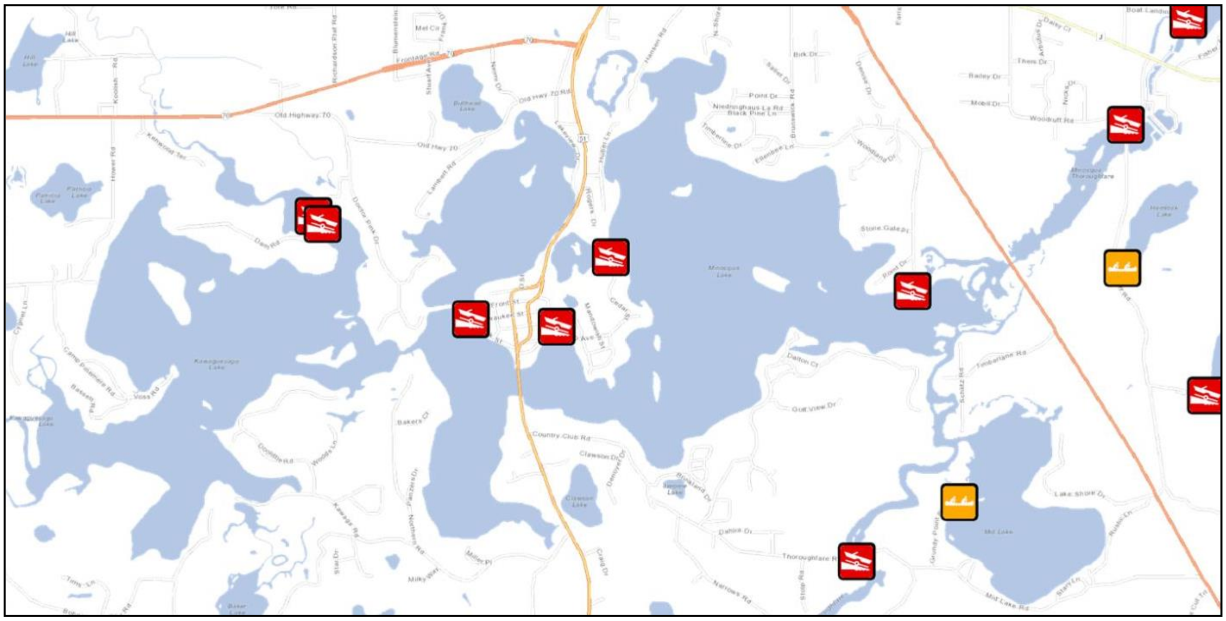


Figure 2: Map showing public access on Kawaguesaga Lake and Minocqua Lake.

Figure 3: Aerial map showing the management border for Minocqua Lake. The star designates the end of the management for Minocqua Lake in the Tomahawk Thoroughfare.

This plan includes waters outside of the Minocqua Lake property. They include the Minocqua Thoroughfare (labeled in Figure 2). Also a portion of the Tomahawk Thoroughfare is included. Figure 3 shows the cutoff for the boundary of this plan. The bridge at Thoroughfare Road is the landmark that ends the coverage of this plan.

Fisheries[2]

Both Kawaguesaga and Minocqua Lakes contain many significant sport fish species. These include:

Kawaguesaga Lake-Black crappie, bluegill, largemouth bass, muskellunge, northern pike, pumpkinseed, smallmouth bass, walleye, and yellow perch.

Minocqua Lake-Black crappie, bluegill, largemouth bass, muskellunge, northern pike, pumpkinseed, smallmouth bass, walleye, and yellow perch.

Other species have also been surveyed in these two lakes. In Kawaguesaga Lake these include: bluntnose minnow, rock bass, Johnny darter, grass pickerel, creek chub, mottled sculpin, and white sucker. In Minocqua Lake these include: bluntnose minnow, rock bass, grass pickerel, golden shiner, Johnny darter, roseyface shiner, yellow bullhead, spottail shiner, bowfin and white sucker.

It is important to consider fisheries in any lake when developing a plant management scheme. Both Kawaguesaga Lake and Minocqua Lake have desirable fisheries. For this reason, fish habitat, water quality, and reproduction need to be protected. The following table presents spawning information for some of the sport fish. Since management of plants may involve early season chemical treatment, spawning times and habitat needs are important. The highlighted areas point out species that spawn at temperatures similar to early season treatment. It is important to consider this during treatment since some herbicides may be toxic to fish.

Table 2: Fish species of Kawaguesaga and Minocqua Lakes.

Fish species[3]	**Spawning Temp in °F**	**Spawning substrates**
Black crappie	Upper 50s to lower 60s	Build nests in 1-6 feet of water in fine sand or gravel
Bluegill, Largemouth bass and Pumpkin seed	Mid 60s to lower 70s	Build nests in less than 3 feet of gravel or hard bottom
Muskellunge[4]	Mid 50s to near 60.	Broadcast eggs over organic sediment, woody debris and submerged vegetation.
Northern Pike	Upper 30s to mid 40s soon after ice-out	Broadcast eggs onto vegetation (eggs attach)
Smallmouth Bass	Usually between 62 and 64 but recorded as low as 53	Nests in circular, clean gravel

[2] Information provided by John Kubisiak, Wisconsin DNR Fisheries Manager, Rhinelander, Wisconsin.
[3] Information from Heath Benike. Wisconsin DNR Fisheries Biologist. 2006
[4] Information from: Rust, Ashely J., James Diana, Terry L. Margenau, and Clayton J. Edwards. Lake Characteristics Influencing Spawning Success of Muskellunge in Northern Wisconsin Lakes. *North American Journal of Fisheries Management*. 2002. p834.

Walleye	Low 40s to 50 degrees.	Gravel/rocky shoals with moving or windswept water 1-6 feet deep
Yellow perch	Mid 40s to lower 50s	Broadcast eggs in submergent vegetation or large woody debris

Spawning temperatures in the same range as recommended herbicide application. Any areas determined to be key spawning areas for these fish should be carefully considered when treating with herbicides. This could include treating at slightly higher temperatures when the spawning has been determined to be complete.

The Minocqua Lake fishery is managed for muskellunge, walleye, bass and panfish. Historically, muskellunge were stocked in Minocqua Lake but that was ceased and last occurred in 2001, largely due to catch and release ethics. Walleye were last stocked in 2008. In recent years, the walleye young of year recruitment has seen a significant decline. This has led to a concern for walleye populations and a reduction in bag limit[5].

Muskellunge and walleye spawning success are highly sensitive to the water and habitat quality. In the case of walleye, the high-quality spawning habitat is limited, and any loss of this habitat could have a negative affect on walleye spawning success.

From a plant management perspective, maintaining muskellunge spawning habitat, as well as rearing habitat is crucial. Major reductions in plant density could have a negative impact. Therefore, targeting AIS only is paramount. If necessary, this can be obtained through early season application of herbicides. Other means of controlling AIS where applicable could be beneficial. Maintaining a healthy, native plant community will help facilitate habitat for muskellunge recruitment.

When treating plants with herbicides, fish may be negatively impacted as fish and their eggs may be susceptible to the herbicides. A recent study found that formulations of the herbicide 2,4-D had different toxicological profiles than pure 2,4-D in fathead minnows. These included depressed male tubercles, depressed egg cell maturation in females and decreased larval survival. The authors suggest that based upon their findings, use of 2,4-D formulations in lakes should maybe be reconsidered.(DeQuattro and Karasov, 2015).

Two fish could potentially have newly distributed eggs during an early season herbicide treatment (muskellunge and black crappie). One treatment to eradicate AIS, such as EWM, could be justified even if it reduced fish recruitment for that year. However, a series of annual treatments could have a serious impact on fish populations even if it caused only a partial loss of each year's hatch. As a result, herbicide use must be used with caution and to a limited extent in spawning areas[6].

There are two areas that have been designated on Minocqua Lake where muskellunge spawning may occur. These areas are mapped and discussed in the management section of this plan. No such areas have been designated in Kawaguesaga Lake.

[5] Pesonal communication from John Kubsiak, Fish Biologist, Wisconsin DNR, 2015.
[6] Personal communication from John Kubsiak, Fish Biologist, Wisconsin DNR. 2008.

Sensitive areas/rare species and species of special concern

In 2003, a sensitive area survey was conducted by the Wisconsin Department of Natural Resources on Minocqua Lake (not Kawaguesaga). Sensitive areas are areas that contain aquatic/wetland plant species, terrestrial vegetation, gravel/rubble lake substrate, or downed woody cover. These areas can provide water quality benefits, reduce shoreline erosion, and provide habitat for seasonal and/or life stage requirements for fish, invertebrates, and wildlife. An area is designated 'sensitive' to alert interested parties that it contains habitat that is critical to a healthy lake ecosystem, or it features an endangered plant or animal. As a result, management personnel will carefully scrutinize any management activities proposed within a sensitive area. In this survey, 15 sites in Lake Minocqua were designated as sensitive due to their habitat importance.

In the sensitive area report, the following recommendations were listed for whole-lake management:

1. Promote the use of bioengineering, bio-logs, and native vegetation rather than rip rap for shoreline protection and erosion control.

2. Minimize shoreline disturbances (grading, cutting, mowing, placement of structures, etc.) below the ordinary high water mark, and within the 35-foot shoreland buffer and shoreland zone.

3. If using fertilizers on lawns, limit the applications and use only phosphorus free recipes.

4. Minimize the chance of additional invasions of exotic plants by protecting native aquatic plants.

5. Restore shoreland buffers on developed properties where near-shore upland vegetation has been removed.

6. Protect snag trees, large woody cover, and live den trees in the upland and shallow water habitat zone.

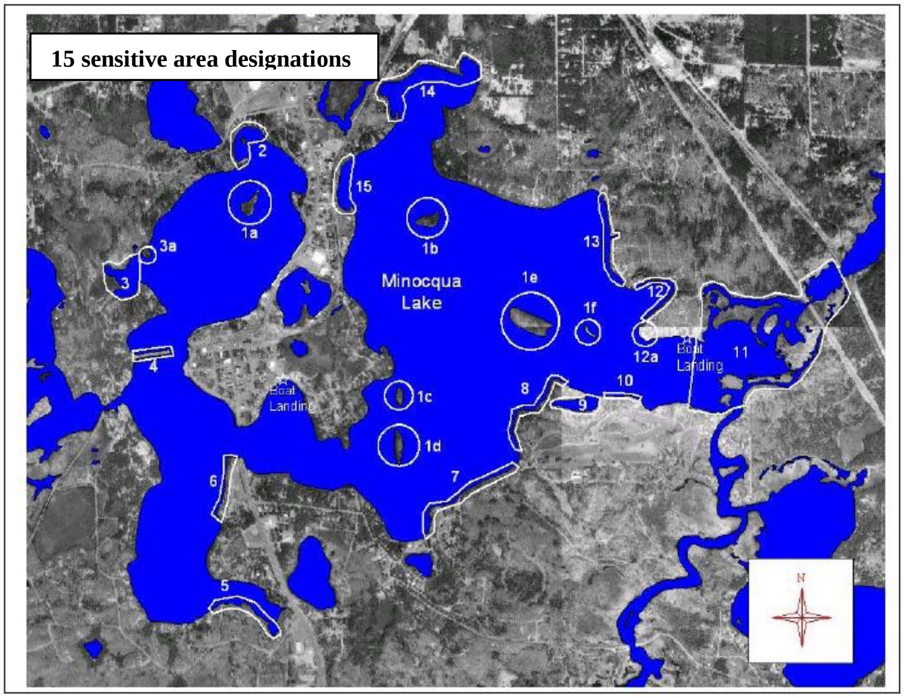


Figure 4: Map of designated sensitive areas Minocqua Lake

The following are special mention to consider for each area:

Site 1:
The islands-the primary reasons for designation:

A) Aquatic vegetation, wildlife habitat, and natural scenic beauty. Existing vegetation will reduce erosion and very little development.
B) Aquatic vegetation, wildlife habitat, and natural scenic beauty. Existing vegetation will reduce erosion and very little development.
C) Wildlife habitat and vegetation that will reduce erosion. Buffer zone with native vegetation will reduce invasive species.
D) Fisheries habitat, wildlife habitat, and natural scenic beauty. A biological buffer zone will reduce likelihood of exotic infestation. Sand with gravel/rubble substrate is present.
E) Fisheries habitat, wildlife habitat, aquatic vegetation, and natural scenic beauty. Buffer vegetation reduces likelihood of invasive infestation. Aquatic vegetation stabilizes sediments reducing nutrient recycling and algae blooms. Northern portion has gravel/rubble substrate.
F) Aquatic vegetation, wildlife habitat, and natural scenic beauty. Buffer vegetation reduces exotic infestation, and aquatic vegetation stabilizes sediment reducing nutrient recycling. Substrate is primarily sand and gravel.

Site 2: The primary reasons for designation at site 2 are fisheries habitat, wildlife habitat, and aquatic vegetation. Aquatic plants provide nutrient buffer zone, reducing nuisance algae blooms. Native plant beds reduce the chances of invasive infestation. Northern pike, muskellunge, largemouth bass, bluegill, pumpkinseed, yellow perch, and bullhead may all use this site for spawning, rearing, feeding, and protective cover. Emergent vegetation, submergent vegetation, snag trees, and perch trees provide valuable habitat for furbearers, birds, amphibians, and reptiles. The aquatic plant community is diverse and one of the few areas where floating and emergent plants are common. Purple loosestrife, curly leaf pondweed, and for-get-me-nots are common at this site.

Site 3 and 3a: The primary reasons for site 3 are fisheries habitat (due to large woody debris presence), wildlife habitat, aquatic vegetation, and natural scenic beauty. Site 3a was chosen since it is a gravel/rubble substrate point, thus providing valuable fish habitat. Walleye, smallmouth bass, and white sucker may all use this site for spawning since it is silt free.

Site 4: Fisheries habitat, wildlife habitat, and natural scenic beauty are the reasons for designation. A variety of game and non-game fish may use the submergent vegetation and gravel substrate for spawning, rearing, feeding and protective cover. There were numerous spawning beds present. Walleye, smallmouth bass, largemouth bass, bluegill, yellow perch, and pumpkin seed likely use this site for spawning, rearing, feeding, and protection. Muskellunge and Northern pike may use the large woody debris at this site for cover and protection. The aquatic vegetation was not diverse and contains a large amount of curly leaf pondweed.

Site 5: The primary reason for this site is wildlife habitat. The shoreline is mostly wooded with large amounts of large woody cover.

Site 6: The primary reasons for site 6 are for fisheries and wildlife habitat. This area contains a steep drop off of gravel/rubble substrate. This area is an excellent spawning site for walleye, smallmouth bass, and crappie. Walleye may also rely on this area for rearing. Shrubs, tress, and fallen logs provide important wildlife habitat.

Site 7: Fisheries and wildlife habitat are why site 7 was designated. Gravel and rubble substrate provide valuable spawning grounds for walleye, smallmouth bass, and white sucker. These species may also rely on this area for rearing with the large woody cover and aquatic plants. Emergent vegetation, shrubs, trees, and large woody cover provide good wildlife habitat.

Site 8: This site was designated due to fisheries and wildlife habitat. The gravel substrate provides quality spawning habitat for walleye, smallmouth bass, and white sucker. Shrubs, brush, trees, and large woody cover provide quality wildlife habitat.

Site 9: The reasons for designation were fisheries habitat, wildlife habitat, and aquatic vegetation. Aquatic plant beds provide a buffer from exotic infestations and reduce erosion. The extensive herbaceous, shrub and tree layers provide valuable wildlife habitat. Gravel substrate, submergent, emergent, and floating vegetation provide key habitat for many game and non-game fish species. This site has one of the few large floating plant beds on the lake.

Site 10: Fisheries habitat is the main concern at site 10. The substrate primarily consists of gravel and rubble. The shoreline is 20% natural and 80% developed. This area could provide important spawning habitat for walleye, smallmouth bass, and white sucker. Walleye and smallmouth bass may also use this area for rearing and feeding. This rock substrate is an area habitable for rusty crayfish, an exotic species.

Site 11: The primary reasons are fisheries habitat, wildlife habitat, aquatic vegetation, and natural scenic beauty for site 11 designation. Aquatic plants provide a nutrient buffer zone where existing vegetation at or within the lake takes up nutrients, potentially reducing nuisance algae blooms. These aquatic plant beds can also provide a biological buffer zone where native plants can reduce the risk of exotic invasive species. Healthy plant communities can reduce shoreline erosion. This site has well defined herbaceous, shrub and tree layers with 70% of the shoreline is natural and 30% developed.

This area (Stacks Bay) has the most valuable muskellunge and Northern pike spawning habitat in the entire lake. Muskellunge seek shallow, mucky bays covered with dead vegetation for spawning. Northern Pike rely on shallow bays with emergent vegetation for spawning. This site also contains valuable habitat for walleye feeding and protection. The shoreline near the boat launch contains some smallmouth bass spawning habitat. Largemouth bass, bluegill, pumpkinseed, yellow perch, black crappie, and bullheads may rely on this area for spawning, rearing, feeding, and protection.

Stacks Bay contains valuable habitat such as aquatic vegetation, shrubs, brush and snag trees, and perch trees for many different species of furbearers, birds, amphibians, and reptiles.

A special note is made regarding the concern over *Sparangium eurycarpum* (bur-reed). The plant looks similar to sterile flowering rush plants, which are non-native. Care should be taken to avoid inadvertently eliminating bur-reed during a flowering rush management program.

Site 12: Site 12 was designated due to wildlife habitat and aquatic vegetation. Site 12a (adjacent to Site 12) was designated because of fisheries. By reducing exotic species, the aquatic plants can provide a buffer. The shoreline is 40% wooded and 60% developed. Although the main reasons were not fishery related, the area in site 12 does provide valuable habitat with emergent and submergent vegetation for a variety of game fish and non-game fish species. Site 12a has a rock bar that extends out from the point. This gravel/rubble bar provides excellent spawning opportunities for walleye, smallmouth bass, and white suckers. It is also suitable habitat for rusty crayfish.

Aquatic vegetation, shrubs, brush, snag trees, perch trees, large woody cover, and rocks provide valuable habitat for a variety of upland wildlife, furbearers, birds, amphibians, and reptiles.

Site 13: The primary reason for designation is wildlife habitat. The shoreline area is approximately 60% wooded and 40% developed. Large woody cover is present. Homes are fairly well buffered from the lake, but piers are abundant. The shoreline area contains shrubs, brush, snag trees, and perch trees that provide habitat for a variety of wildlife species. Ducks and loons may feed at this site as well.

Site 14: Designation occurred at site 14 for wildlife habitat and aquatic vegetation. The aquatic plant community is very diverse and is one of the few areas with floating and emergent vegetation. Again, avoid eliminating bur-reed when targeting the non-native flowering rush. The emergent, submergent, and floating leaf vegetation does provide valuable habitat for a variety of game and non-game fish species.

Valuable wildlife habitat such as emergent vegetation, floating leaf vegetation, shrubs, brush, snag trees, and perch trees provide an area that is useful for a variety of upland wildlife, furbearers, birds, amphibians, and reptiles. Loons and geese may feed in this bay also.

Site 15: The reasons for designation are fisheries habitat and wildlife habitat. The shoreline area is approximately 80% wooded and 20% developed. The aquatic plant community is fairly diverse. Flowering rush (an exotic species) is noted as a concern due to a large bed that is stated to be in need of management (reduction). Emergent vegetation, shrubs, brush, snag trees, and perch trees provide valuable habitat for a variety of upland wildlife, furbearers, birds, amphibians, and reptiles.

Endangered, threatened, and species of concern

The following species are listed as endangered, threatened, or of special concern in the Town Range T39 06E as determined by the Natural Heritage Survey. Records are provided to the public by Town rather than section, so there is no indication whether or not these species occur in or immediately surrounding Kawaguesaga Lake and Minocqua Lake:

Animals		
Haliaetus leucephalus	Bald Eagle	special concern
Pandion haleatus	Osprey	threatened
Sarex palustris	Water Shrew	special concern
Plants		
Callitriche heterophylla	Large water starwort	threatened
Clematis accidentalis	Purple clematis	special concern

Potamogeton vaseyi (Vasey's pondweed) was sampled in Kawaguesaga Lake and Minocqua Lake. This aquatic plant is a species of special concern, which does not indicate it is threatened or endangered, but has habitat needs that are very specific. The plant can also be susceptible to decline and is therefore a concern for future population declines. *Eleocharis robbinsii* (Robbin's spikerush) was sampled in Minocqua Lake in the 2014 plant survey. It is also a species of special concern.

Water quality

When evaluating lake water quality, the trophic status of a lake indicates its nutrient levels. Based on its nutrient level, a lake may be oligotrophic, mesotrophic, or eutrophic. Oligotrophic lakes lack productivity and are usually characterized by clear water with little algae and plant growth. Mesotrophic lakes have intermediate nutrient levels and result in more plant growth and occasional algae blooms. Eutrophic lakes are nutrient rich. They are characterized by abundant aquatic plant growth and low water clarity due to algae growth or blooms.

Secchi depth readings involve lowering a black and white disk into the water until it is no longer visible. This depth is recorded and reflects the clarity of the water, the higher the Secchi reading, the greater the water clarity. Factors other than algae growth can affect

Secchi depth results, so while this test may be used to indicate production (algae growth), it is not specific to algae production.

Chlorophyll-a is one of the photosynthetic pigments in plants. Its levels can be tested in water samples, directly reflecting the amount of algae in a water sample. More algae present results in more chlorophyll-a measured, therefore representing high algae abundance. This value can be coupled with the Secchi depth to indicate algae production. If the Secchi depth is low and the chlorophyll-a value is high, algae production is occurring.

Phosphorus is usually the limiting nutrient in lakes. An increase in phosphorus loading into a lake is the main culprit in excess production (eutrophication). As a result, the monitoring of phosphorus is paramount. Generally, the total phosphorus (TP) concentration is monitored. This measures all available forms of phosphorus in the lake that could eventually be available for plant growth. Small increases in this nutrient can lead to large increases in production (plant and algae growth).

Large amounts of data have been collected by citizen lake monitoring volunteers and submitted to the Citizen Lake Monitoring Data of the Wisconsin DNR. The key components of the Trophic State Index (TSI) were collected. They include Secchi disk, chlorophyll-a, and total phosphorus. The TSI considers all of these parameters and calculates an index to determine the trophic status of the lake. A lower TSI reflects a less productive lake. Oligotrophic lakes have TSI values below 30, mesotrophic values range around 40, and eutrophic values range 50 to 60. Any TSI above 70 is considered hyper-eutrophic which means the nutrient levels of the lake are excessive.

Kawaguesaga Lake has a shorter history of data collection. However, these data show that Kawaguesaga is mesotrophic for chorophyll a and Secchi disk. Total phosphorus values are in the eutrophic range, but water clarity remains quite high. The plants in Kawaguesaga could be helping retain water clarity by taking up the phosphorus.

Minocqua Lake has consistently had Secchi depth and chlorophyll a values in the mesotrophic (medium production) levels. However, the total phosphorus values have been consistently higher, approaching the eutrophic range. The water clarity in the lake is quite high, despite this apparent phosphorus loading. It is possible that the macrophyte community is helping the lake water clarity by absorbing excess nutrients from the sediments and water column, as is the case with plants such as *Ceratophyllum demersum* (coontail).

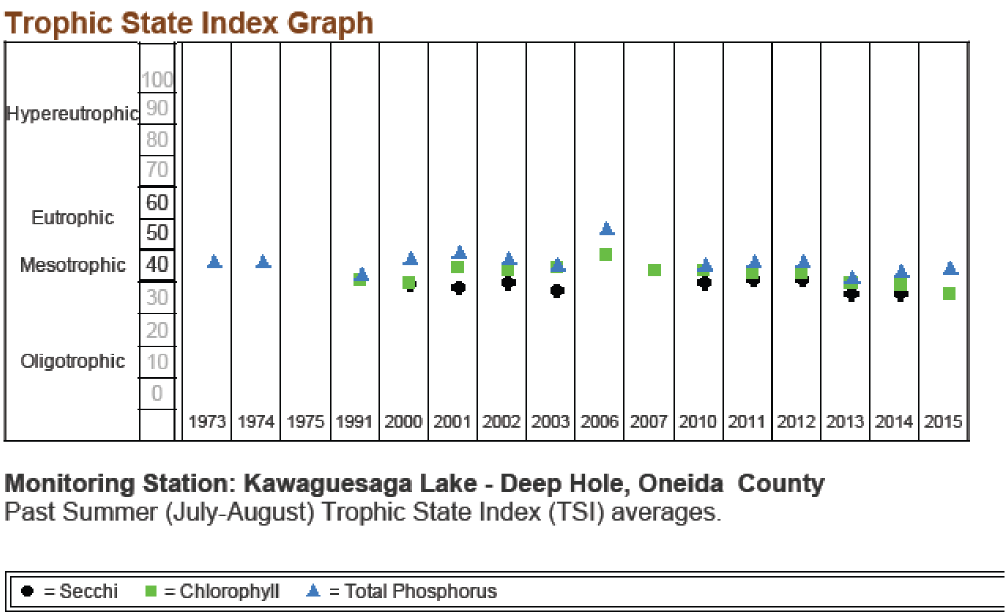
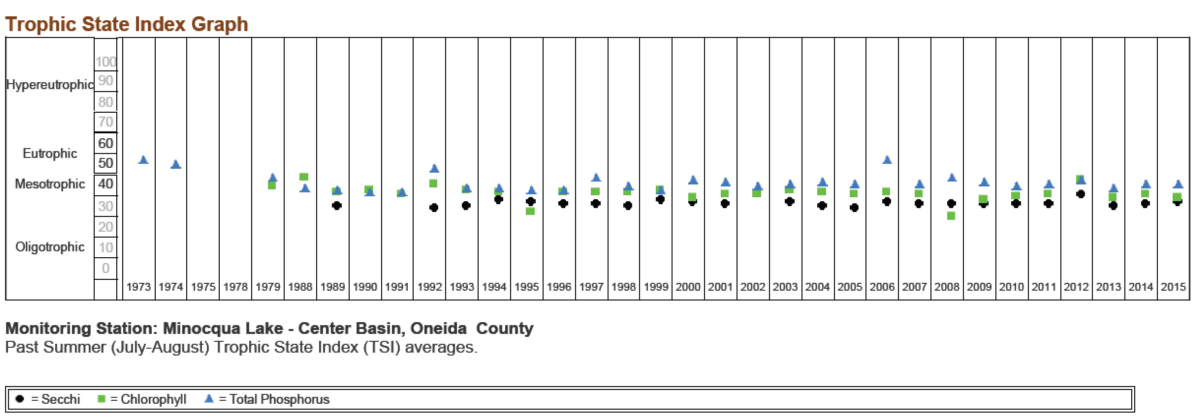


Figure 5: Trophic State Index Graph-Kawaguesaga Lake 1973-2015(some years missing)



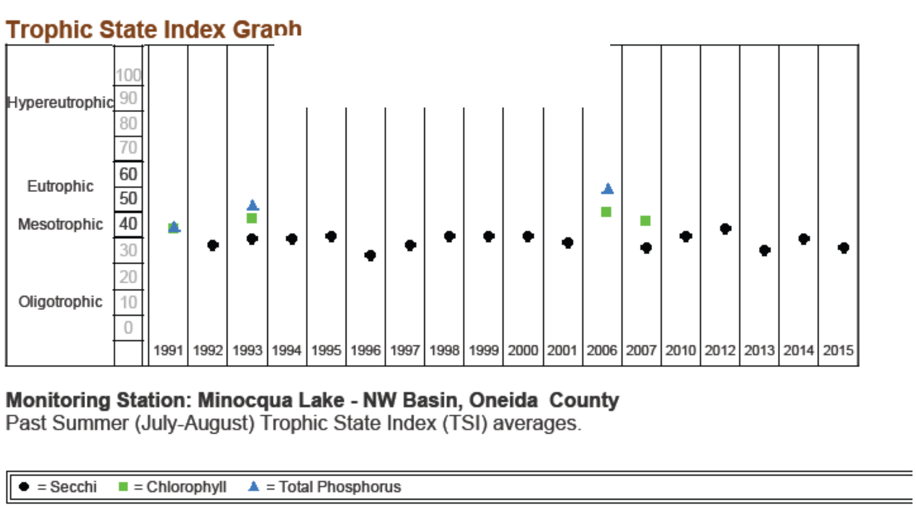


Figure 6: Trophic State Index Graph-Minocqua Lake 1973-2015 for central basin and 1991-2015 for northwest basin.

Water body	Mean TP 1973-2009(mg/L)	Range TP	Mean chl-a 1973-2009(µg/L)	Range chla-a
Minocqua(east basin)	0.016	0.009-0.03	5.1	1-19
Minocqua(nw basin)	0.018	0.007-0.043	9.4	1.73-23.2
Kawaguesaga	0.020	0.013-0.040	6.5	1-21.1

Figure 3: Total Phosphorus and chlorophyll-a historical concentrations for Kawaguesaga and Minocqua Lakes.

According to a USGS study conducted in 2006-07, the trends for Minocqua Lake total phosphorus changes appear to have increased slightly since 1988. However, there was a decrease from 1988 to 1996, and it is speculated that this may be the result of extended drought. The summer total phosphorus values for Minocqua Lake has remained consistently in the mesotrophic range (USGS, 2010).

Kawaguesaga Lake has a less extensive database of total phosphorus. The total phosphorus values have been consistently in the mesotrophic range since 1991.[7]

Sediment cores were obtained and analyzed for historical sedimentation rates. The results suggest that sedimentation rates were relatively stable for many decades until about 40 years ago. From that point on, the sedimentation rates have increased immensely. This is most likely due to increased development on and near Kawaguesaga Lake and Minocqua Lake during the last few decades[8].

Watershed[9]

The watershed for Kawaguesaga/Minocqua Lakes is very extensive when considering all water sources. The land cover map indicates the vast majority of land cover in the watershed is forested.

[7] Described in USGS Scientific Report-2010.
[8] From Wisconsin DNR files kept in Rhinelander WI. Reviewed January 2008.
[9] Watershed map from USGS, 2010.

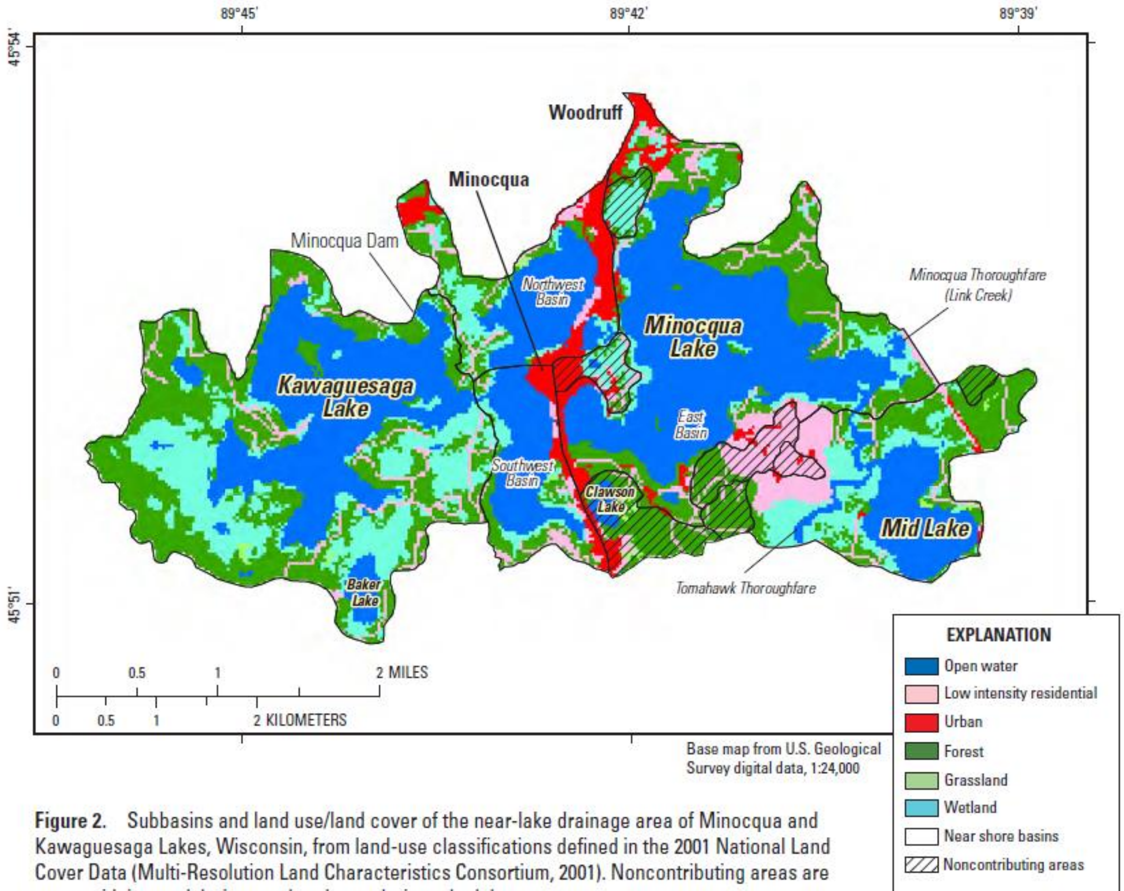


Figure 2. Subbasins and land use/land cover of the near-lake drainage area of Minocqua and Kawaguesaga Lakes, Wisconsin, from land-use classifications defined in the 2001 National Land Cover Data (Multi-Resolution Land Characteristics Consortium, 2001). Noncontributing areas are areas with internal drainages that do not drain to the lake.

Figure 10: Map of Minocqua Chain watershed with land cover type. Land cover for the Minocqua Thoroughfare and the Tomahawk Thoroughfare (which includes Tomahawk Lake) is not included.

The land use in the watershed has various impacts on the nutrient loading into the lake. Urban and residential land use contributes more phosphorus (both lakes are phosphorus limited so this is the focus nutrient) to the lake than other land use such as forested. In the immediate watershed, it is evident that various land uses can have varying contribution of phosphorus. Observed on the map, there is extensive urban development adjacent to these lakes. Furthermore, single-family residential development in the riparian zone is extensive, especially in Minocqua Lake. As a result, the runoff volume and nutrient content of the runoff increases. Table 2 summarizes the land use types contained within the waterbody.

Native vegetation that would normally remove sediments and nutrients from the runoff is replaced with lawns and/or impervious surfaces. The runoff increases in volume and little or no sediment is removed. The result is phosphorus-bound sedimentation in the lakes, which increases phosphorus concentrations and allows more plant and algae production.

Lake	Total area(acres)	Agriculture %	Forest %	Shrub/ Grassland%	Wetland %	Lo res.%	Urban %	Water %
Minocqua	1370	0.0	43.3	3.1	17.1	12.6	17.9	5.9
Kawaguesaga	1580	0.0	51.8	1.0	34.3	6.4	0.0	6.5
Minocqua Thor.	15200	0.0	62.5	1.0	10.1	5.2	0.3	20.9
Tomahawk Thor.	18700	0.2	56.4	2.0	6.7	5.1	1.2	28.4

Table 4: Watershed areas for Minocqua Lake and Kawaguesaga Lake as well as Thoroughfares. Landuse by percent of total of immediate watershed only.

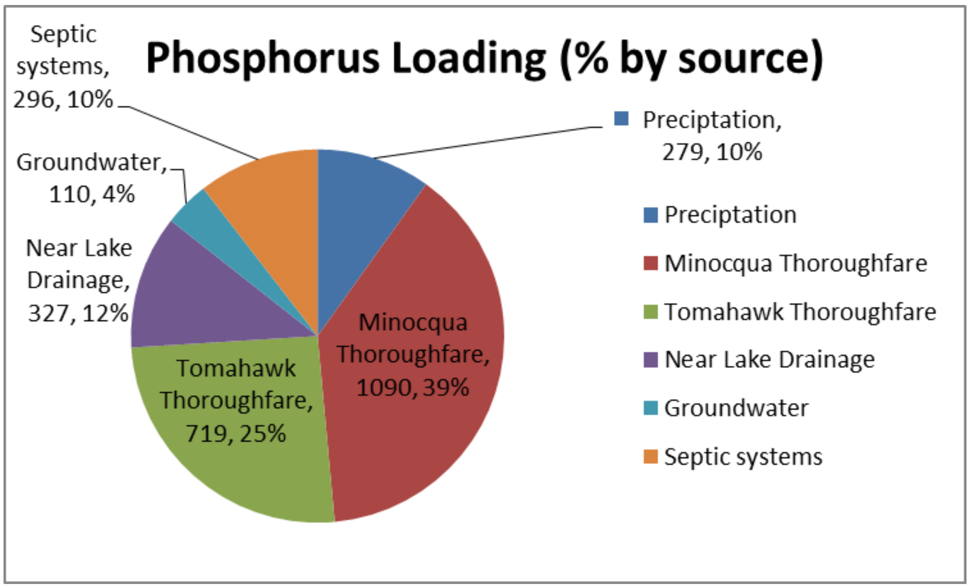


Figure 9: Phosphorus loading sources for Minoqua Lake and Kawaguesaga Lake. These values are from data collected by the USGS in 2006 and 2007 and are the two year average during this period. The first number is the pounds of phosphorus loaded followed by the % of the total phosphorus load.

Figure 9 shows the phosphorus loading into both lakes. It is important to note that there are two main sources of phosphorus that can be mitigated: near lake drainage and septic systems. Reduction in the phosphorus loading of these two areas can help reduce nutrient accumulation in the sediments which can lead to increased growth of unwanted plants, such as Eurasian water milfoil, in addition to an increase in algae growth.

The 2010, a USGS study indicates that future phosphorus loading due to land use changes would increase 160 lbs or a 5% increase (up to the year 2030). The study also predicts that if the phosphorus loading reduced 50% in the controllable phosphorus sources, the lake nutrient levels would decrease an average of 0.004 mg/L (about 26% average in-lake reduction)(USGS, 2010). Many practices can be implemented to work toward a significant reduction, but these are beyond the scope of this plan. One method that is part of this plan is shoreline restoration, which can reduce runoff and nutrient loading.

Plant Community

The plant community was re-evaluated with a full lake, point intercept survey conducted in June and July 2014. The point intercept survey methods outlined in the appendix were employed, and the results and interpretation are described in this section. As a plant management plan, the results and trends that these surveys reveal are paramount in the management of aquatic plants on Kawaguesaga and Minocqua Lakes.

Minocqua Lake

Minocqua Lake was surveyed and continues to show evidence of a very healthy, diverse, and dense aquatic plant community. Table 4 summarizes the statistic results from 2014.

Minocqua Lake Survey Statistics	
Total number of sites visited	1407
Total number of sites with vegetation	766
Total number of sites shallower than maximum depth of plants	934
Frequency of occurrence at sites shallower than maximum depth of plants	82.01
Simpson Diversity Index	0.93
Maximum depth of plants (ft)**	20.00
Average number of all species per site (shallower than max depth)	2.56
Average number of all species per site (veg. sites only)	3.12
Average number of native species per site (shallower than max depth)	2.50
Average number of native species per site (veg. sites only)	3.06
Species Richness	53
Species Richness (including visuals)	59
Mean depth of plants (ft)	8.38
Mean rake fullness (veg. sites only)	1.88

Table 5: Mincoqua aquatic plant survey statistics, 2014.

The plant coverage is extensive with 82% of the defined littoral zone (depth less than maximum depth with plants) having plants sampled. The density is also high with a mean rake fullness of 1.9 (on a scale of 0-3), where plants were sampled.

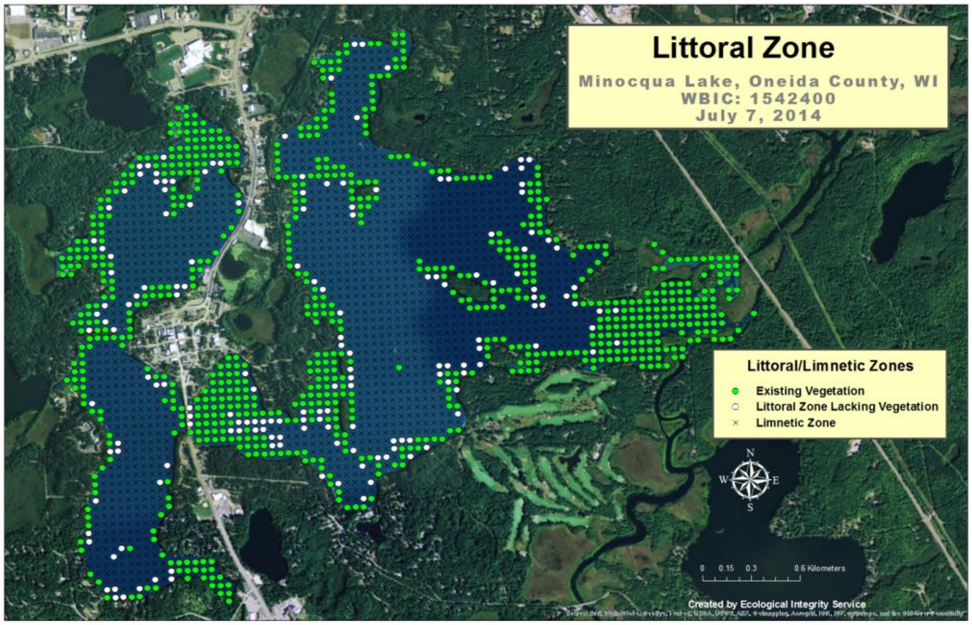


Figure 10: Map of littoral zone in Minocqua Lake from 2014 macrophyte survey.

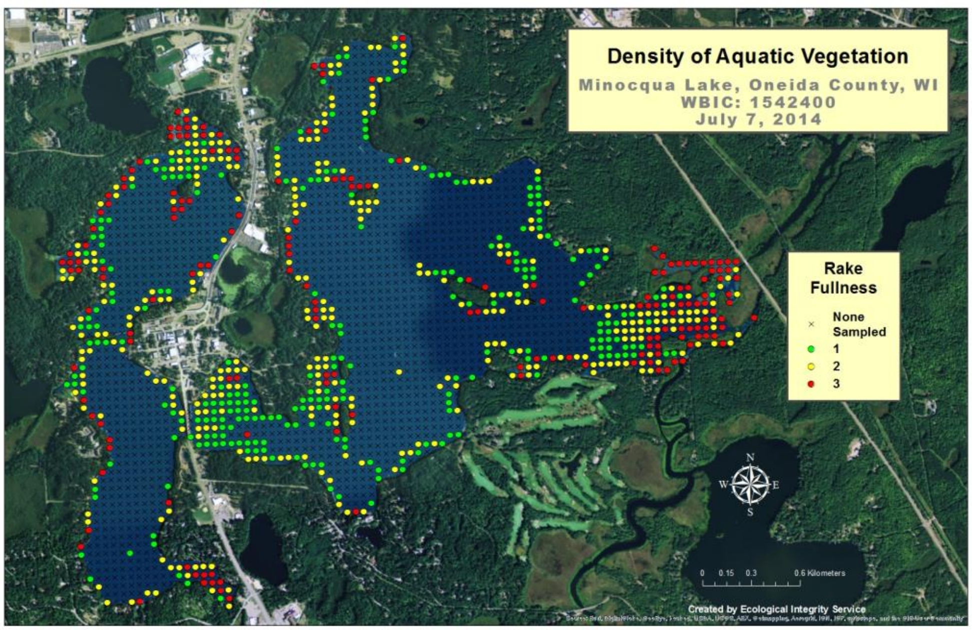


Figure 11: Map of rake fullness rating (density) in Minocqua Lake from 2014 macrophyte survey.

The diversity of plants is high in Minocqua Lake, with 53 native plants species sampled (species richness) and a Simpson's Diversity Index of 0.93. There were slightly more than 3 native species sampled at each site with plants growing. This diversity reflects the robust plant community of Minocqua Lake.

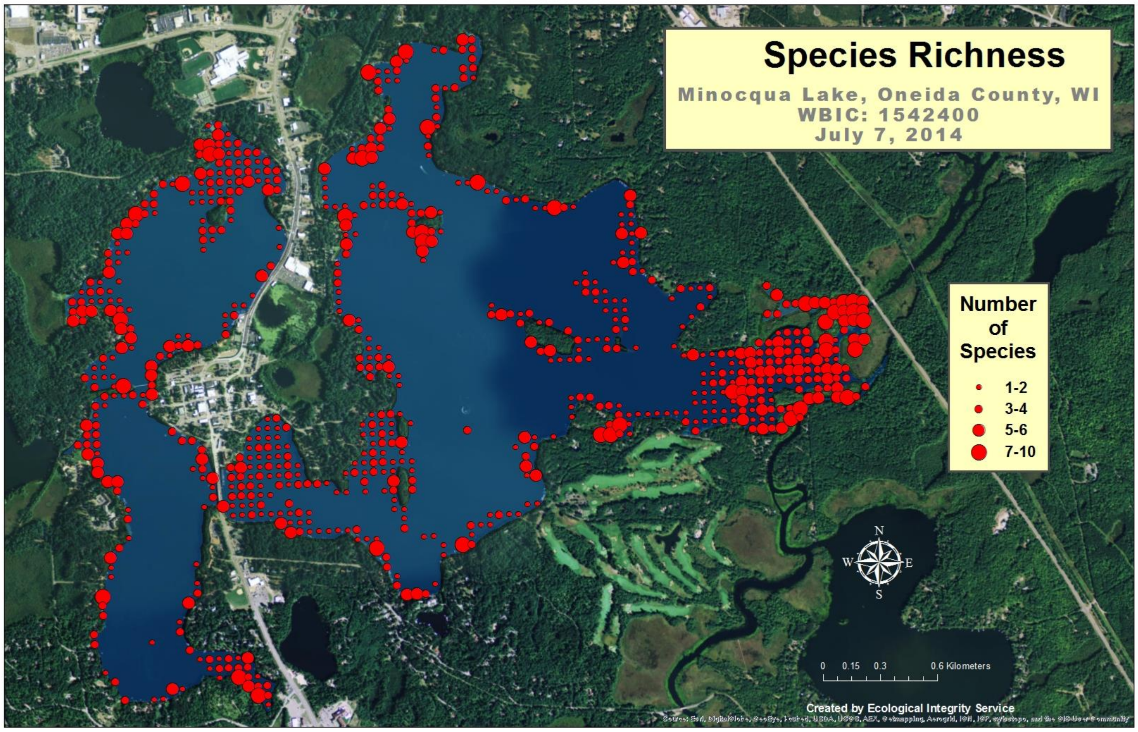


Figure 12: Species richness map for Minocqua Lake, July 2014. The highest richness is shown in Stack's Bay. There is also high diversity in various small bays and even in narrow littoral zones throughout the lake.

Table 6: Mincoqua Lake survey species list with frequency and density data.

Minocqua Lake Species	Common name	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average Rake Fullness
Najas guadalupensis	Southern naiad	17.59	54.96	45.07	1.69
Ceratophyllum demersum	Coontail	11.70	36.55	29.98	1.29
Potamogeton robbinsii	Fern pondweed	7.86	24.54	20.13	1.48
Elodea canadensis	Common waterweed	7.19	22.45	18.42	1.28
Potamogeton pusillus	Small pondweed	6.94	21.67	17.77	1.10
Potamogeton zosteriformis	Flat-stem pondweed	5.89	18.41	15.10	1.20
Myriophyllum sibiricum	Northern water-milfoil	4.30	13.45	11.03	1.57
Potamogeton amplifolius	Large-leaf pondweed	3.51	10.97	8.99	1.29
Potamogeton gramineus	Variable pondweed	3.38	10.57	8.67	1.21
Potamogeton richardsonii	Clasping-leaf pondweed	3.22	10.05	8.24	1.22
Vallisneria americana	Wild celery	3.09	9.66	7.92	1.04

Minocqua Lake Species	Common name	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average Rake Fullness
	Filamentous algae	(not used)	9.40	7.71	1.68
Najas flexilis	Slender naiad	2.26	7.05	5.78	1.22
Lemna trisulca	Forked duckweed	2.13	6.66	5.46	1.04
Chara sp.	Muskgrass	1.96	6.14	5.03	1.15
Nymphaea odorata	White water lily	1.67	5.22	4.28	2.20
Potamogeton friesii	Fries' pondweed	1.55	4.83	3.96	1.19
Bidens beckii	Water marigold	1.50	4.70	3.85	1.11
Myriophyllum spicatum	Eurasian water milfoil	1.38	4.31	3.53	1.42
Ranunculus aquatilis	White water crowfoot	1.21	3.79	3.10	1.21
Utricularia vulgaris	Common bladderwort	1.17	3.66	3.00	1.21
Potamogeton crispus	Curly-leaf pondweed	1.09	3.39	2.78	1.08
Potamogeton praelongus	White-stem pondweed	1.09	3.39	2.78	1.31
Nuphar variegata	Spatterdock	1.04	3.26	2.68	1.92
Eleocharis acicularis	Needle spikerush	0.88	2.74	2.25	1.14
	Aquatic moss	*	2.22	1.82	1.59
Butomus umbellatus	Flowering Rush	0.63	1.96	1.61	1.47
Myriophyllum verticillatum	Whorled water-milfoil	0.63	1.96	1.61	1.27
Heteranthera dubia	Water star-grass	0.46	1.44	1.18	1.00
Lemna minor	Small duckweed	0.46	1.44	1.18	1.00
Decodon verticillatus	Swamp loosestrife	0.42	1.31	1.07	2.50
Isoetes echinospora	Spiny spored-quillwort	0.42	1.31	1.07	1.00
Potamogeton illinoensis	Illinois pondweed	0.38	1.17	0.96	1.11
Brasenia schreberi	Watershield	0.33	1.04	0.86	1.25
Nitella sp.	Nitella	0.29	0.91	0.75	1.29
Spirodela polyrhiza	Large duckweed	0.29	0.91	0.75	1.00
Pontederia cordata	Pickerelweed	0.25	0.78	0.64	1.83
Potamogeton strictifolius	Stiff pondweed	0.25	0.78	0.64	1.00
Sagittaria rigida	Sessile-fruited arrowhead	0.25	0.78	0.64	1.17
Utricularia minor	Small bladderwort	0.21	0.65	0.54	1.00
Potamogeton natans	Floating-leaf pondweed	0.17	0.52	0.43	1.25
Potamogeton vaseyi	Vasey's pondweed	0.17	0.52	0.43	1.75
Sparganium emersum	Short-stemmed bur-reed	0.17	0.52	0.43	1.00
Dulichium arundinaceum	Three-way sedge	0.08	0.26	0.21	2.00
Schoenoplectus tabernaemontani	Softstem bulrush	0.08	0.26	0.21	2.00

Minocqua Lake Species	Common name	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average Rake Fullness
Stuckenia pectinata	Sago pondweed	0.08	0.26	0.21	1.00
Eleocharis erythropoda	Bald spikerush	0.04	0.13	0.11	1.00
Eleocharis robbinsii	Robbins' spikerush	0.04	0.13	0.11	2.00
Equisetum fluviatile	Water horsetail	0.04	0.13	0.11	1.00
Iris pseudacorus	Yellow iris	0.04	0.13	0.11	3.00
Myriophyllum tenellum	Dwarf water-milfoil	0.04	0.13	0.11	1.00
Potamogeton alpinus	Alpine pondweed	0.04	0.13	0.11	1.00
Potamogeton obtusifolius	Blunt-leaf pondweed	0.04	0.13	0.11	1.00
Riccia fluitans	Slender riccia	(not used)	0.13	0.11	1.00
Sagittaria latifolia	Common arrowhead	0.04	0.13	0.11	1.00
Sparganium eurycarpum	Common bur-reed	0.04	0.13	0.11	2.00
Calla palustris	Wild calla	Viewed	only		
Carex comosa	Bottle brush sedge	Viewed	Only		
Lythrum salicaria	Purple loosestrife	Viewed	Only		
Potamogeton foliosus	Leafy pondweed	Viewed	Only		
Typha latifolia	Broad-leaved cattail	Viewed	Only		
Utricularia intermedia	Flat-leaf bladderwort	Viewed	Only		

The most common aquatic plant sampled was southern naiad (*Najas guadalupensis*) with a relative frequency of 17.59%. This plant is native but has increased immensely, reaching high density in several areas around the lake. The most growth was found in Stack's Bay on the far eastern end of the lake near the inlets of Minocqua Thoroughfare and Tomahawk Thoroughfare.

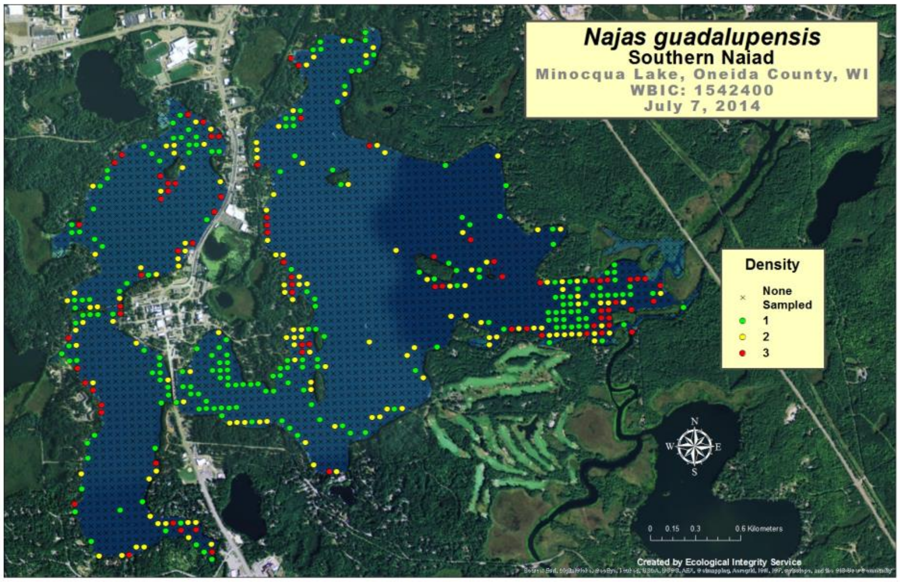


Figure 13: Most common plant sampled in Minocqua Lake July 2014.

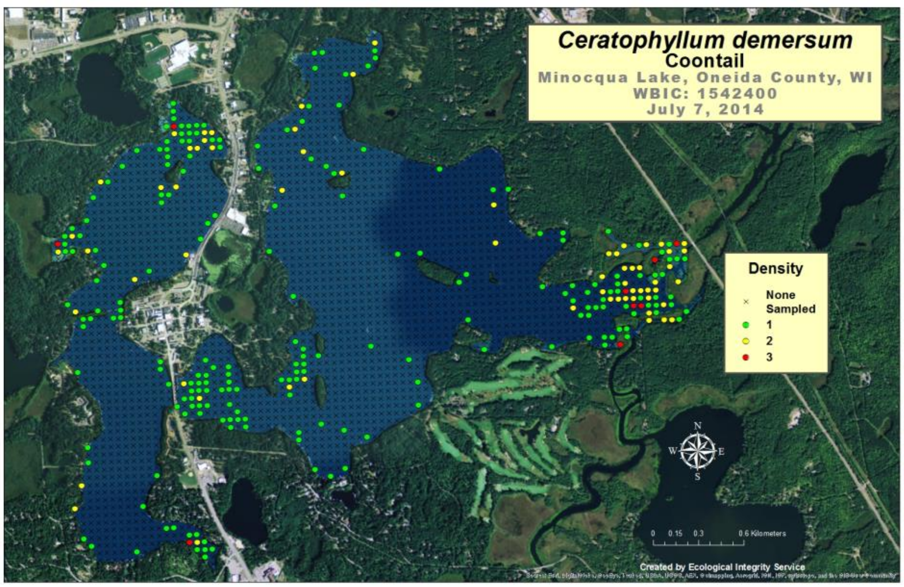


Figure 14: Second most common plant sampled in Minocqua Lake July 2014.

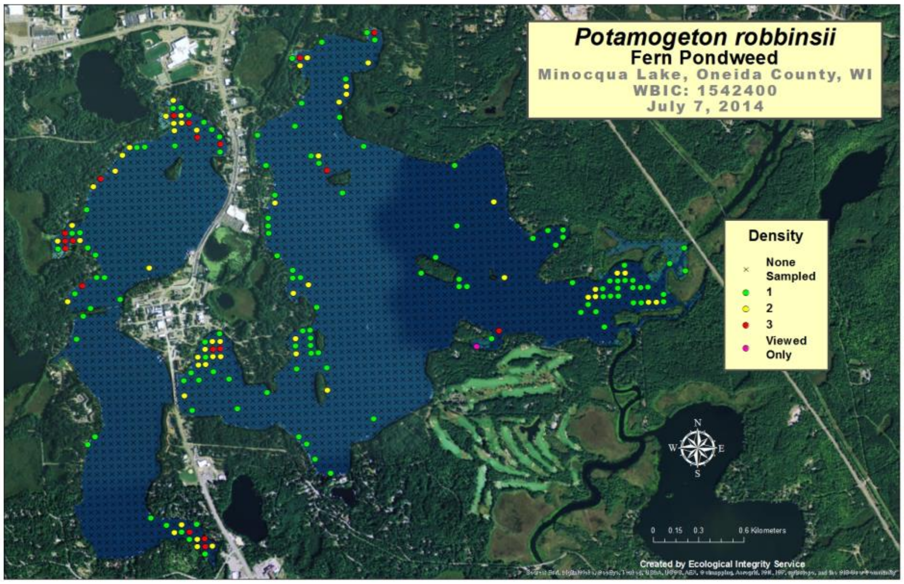


Figure 15: Third most common plant sampled in Minocqua Lake July 2014.

Coontail (*Ceratophyllum demersum*) and fern pondweed (*Potamogeton robbinsii*) were the second and third most common aquatic plants sampled respectively. Both of these plants are common in Wisconsin lakes and are both desirable plants. They provide good habitat for invertebrates and fish. They can also absorb excess nutrients to help maintain lake water clarity (Lombardo, 2003).

Kawaguesaga Lake

The point intercept survey in 2014 revealed a high coverage, high diversity, and high density plant community, although slightly less than Minocqua Lake. Table 6 summarizes the statistics from the 2014 point intercept survey on Kawaguesaga Lake.

Kawaguesaga Lake Survey Statistics	
Total number of sites visited	800
Total number of sites with vegetation	506
Total number of sites shallower than maximum depth of plants	671
Frequency of occurrence at sites shallower than maximum depth of plants	75.41
Simpson Diversity Index	0.92
Maximum depth of plants (ft)	21.50
Average number of all species per site (shallower than max depth)	2.44
Average number of all species per site (veg. sites only)	3.24
Average number of native species per site (shallower than max depth)	2.36
Average number of native species per site (veg. sites only)	3.14
Species Richness	47
Species Richness (including visuals)	54
Mean depth of plants (ft)	10.06
Median depth of plants (ft)	10.00
Mean rake fullness (veg. sites only)	1.81

Table 7: Kawaguesaga Lake 2014 macrophyte survey statistics.

The plant coverage on Kawaguesaga Lake is extensive with 75.4% of the defined littoral zone having plant growth. The density where plants grow is also high with a mean rake fullness of 1.8. Figures 16 and 17 show maps reflecting the plant growth coverage and density.

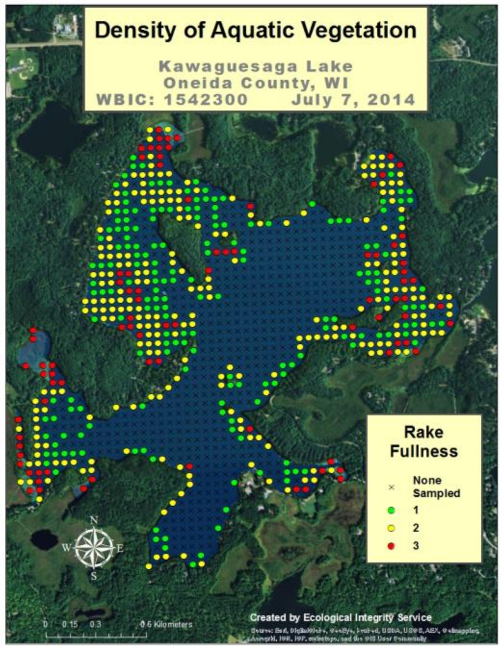


Figure 16: Map showing the plant density in Kawaguesaga Lake July 2014.

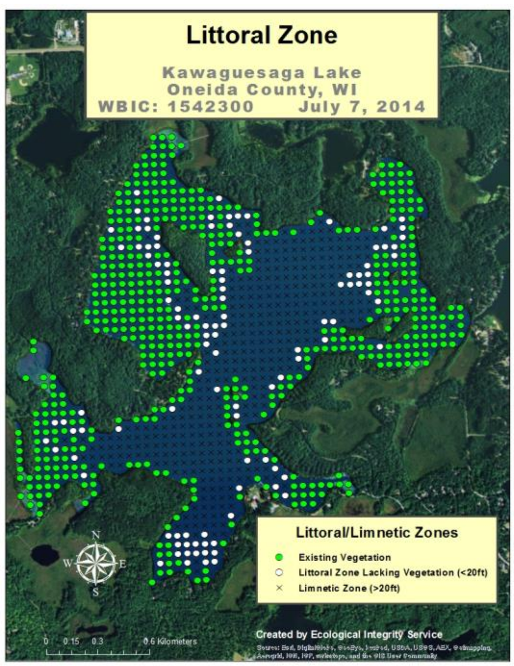


Figure 17: Map of the littoral zone and plant growth within the littoral zone, Kawaguesaga Lake July 2014.

The plant diversity in Kawaguesaga Lake is also very high. There were 47 plant species surveyed and a Simpson's Diversity Index of 0.92 (a high value), which indicates most plants surveyed at any given location are different species. On average, there were just over 3 species of native plants sampled at locations with plant growth. Table 7 contains a species list with frequency density data from the 2014 survey.

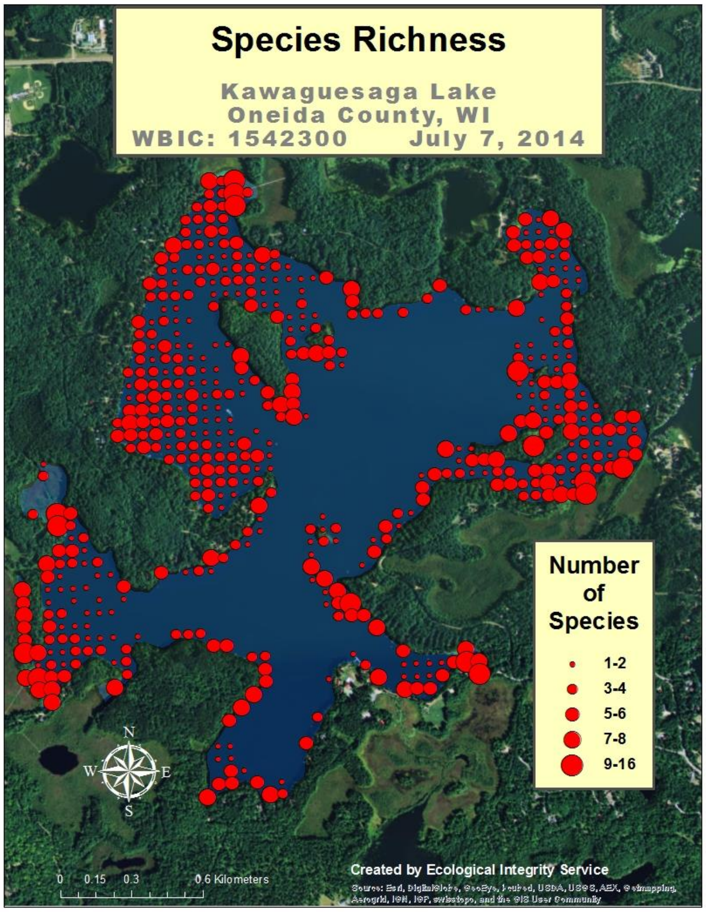


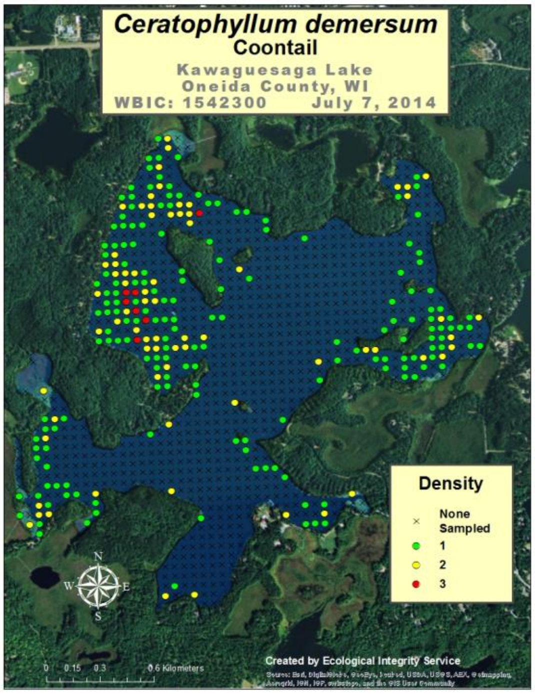
Figure 18: Species richness map of Kawaguesaga Lake July 2014. The various bays show the highest diversity per sample location.

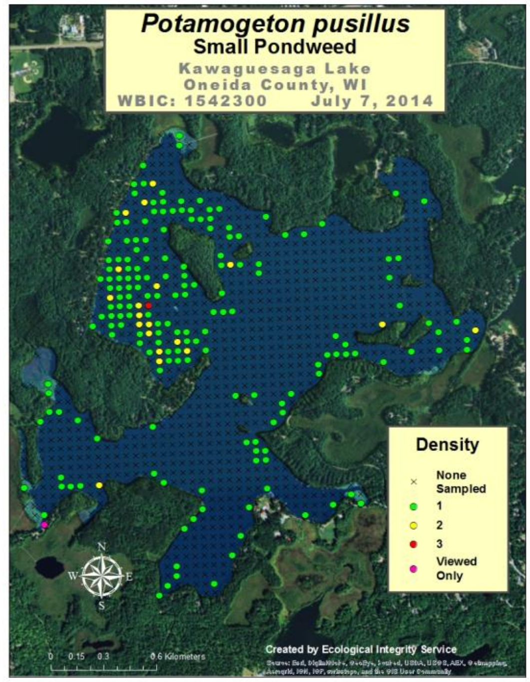
Table 8: Species list with frequency and density data, Kawaguesaga Lake July 2014.

Kawaguesaga Lake Species	Common name	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average Rake Fullness
Ceratophyllum demersum	Coontail	15.31	49.60	37.41	1.34
Potamogeton pusillus	Small pondweed	11.90	38.54	29.06	1.11
Potamogeton robbinsii	Fern pondweed	11.53	37.35	28.17	1.61
Potamogeton zosteriformis	Flat-stem pondweed	9.15	29.64	22.35	1.23
Elodea canadensis	Common waterweed	8.30	26.88	20.27	1.21
Najas guadalupensis	Southern naiad	6.22	20.16	15.20	1.68
Myriophyllum sibiricum	Northern water-milfoil	5.37	17.39	13.11	1.51
Potamogeton amplifolius	Large-leaf pondweed	3.60	11.66	8.79	1.22
Potamogeton richardsonii	Clasping-leaf pondweed	3.48	11.26	8.49	1.21
	Filamentous algae	(not used)	10.28	7.75	1.62
Vallisneria americana	Wild celery	2.81	9.09	6.86	1.02
	Aquatic moss	(not used)	7.51	5.66	1.53
Potamogeton gramineus	Variable pondweed	2.20	7.11	5.37	1.08
Potamogeton crispus	Curly-leaf pondweed	1.89	6.13	4.62	1.06
Najas flexilis	Slender naiad	1.71	5.53	4.17	1.14
Myriophyllum spicatum	Eurasian water milfoil	1.46	4.74	3.58	1.29
Lemna trisulca	Forked duckweed	1.34	4.35	3.28	1.05
Nymphaea odorata	White water lily	1.34	4.35	3.28	1.82
Potamogeton praelongus	White-stem pondweed	1.34	4.35	3.28	1.41
Chara sp.	Muskgrass	1.16	3.75	2.83	1.00
Bidens beckii	Water marigold	1.10	3.56	2.68	1.06
Heteranthera dubia	Water star-grass	0.98	3.16	2.38	1.13
Brasenia schreberi	Watershield	0.92	2.96	2.24	2.13
Ranunculus aquatilis	White water crowfoot	0.73	2.37	1.79	1.25
Nuphar variegata	Spatterdock	0.67	2.17	1.64	1.64
Utricularia vulgaris	Common bladderwort	0.55	1.78	1.34	1.11
Potamogeton friesii	Fries' pondweed	0.49	1.58	1.19	1.00
Utricularia intermedia	Flat-leaf bladderwort	0.49	1.58	1.19	1.13
Eleocharis acicularis	Needle spikerush	0.43	1.38	1.04	1.14
Nitella sp.	Nitella	0.37	1.19	0.89	1.00
Utricularia minor	Small bladderwort	0.37	1.19	0.89	1.33
Myriophyllum verticillatum	Whorled water-milfoil	0.31	0.99	0.75	1.20

Kawaguesaga Lake **Species**	**Common name**	**Relative Frequency (%)**	**Frequency of occurrence within vegetated areas (%)**	**Frequency of occurrence at sites shallower than maximum depth of plants**	**Average Rake Fullness**
Potamogeton strictifolius	Stiff pondweed	0.31	0.99	0.75	1.60
Isoetes echinospora	Spiny spored-quillwort	0.24	0.79	0.60	1.00
Typha latifolia	Broad-leaved cattail	0.24	0.79	0.60	2.75
Calla palustris	Wild calla	0.18	0.59	0.45	1.33
Carex comosa	Bottle brush sedge	0.18	0.59	0.45	1.33
Eleocharis erythropoda	Bald spikerush	0.18	0.59	0.45	1.67
Lemna minor	Small duckweed	0.18	0.59	0.45	1.67
Carex lasiocarpa	Narrow-leaved woolly sedge	0.12	0.40	0.30	3.00
Pontederia cordata	Pickerelweed	0.12	0.40	0.30	3.00
Potamogeton alpinus	Alpine pondweed	0.12	0.40	0.30	1.50
Potamogeton illinoensis	Illinois pondweed	0.12	0.40	0.30	1.00
Riccia fluitans	Slender riccia	*	0.40	0.30	1.50
Sagittaria rigida	Sessile-fruited arrowhead	0.12	0.40	0.30	1.00
Spirodela polyrhiza	Large duckweed	0.12	0.40	0.30	1.00
Juncus effusus	Common rush	0.06	0.20	0.15	1.00
Potamogeton natans	Floating-leaf pondweed	0.06	0.20	0.15	1.00
Potamogeton vaseyi	Vasey's pondweed	0.06	0.20	0.15	2.00
Sparganium emersum	Short-stemmed bur-reed	0.06	0.20	0.15	1.00
Butomus umbellatus	Flowering rush	Viewed	only		
Carex lacustris	Lake sedge	Viewed	only		
Comarum palustre	Marsh cinquefoil	Viewed	only		
Decodon verticillatus	Swamp loosestrife	Viewed	only		
Dulichium arundinaceum	Three-way sedge	Viewed	only		
Sparganium eurycarpum	Common bur-reed	Viewed	only		
Stuckenia pectinata	Sago pondweed	Viewed	only		

The most common plant sample in the 2014 survey was coontail (*Ceratophyllum demersum*), followed by small pondweed (*Potamogeton pusillus*), and fern pondweed (*Potamogeton robbinsii*). All three of these native plants are common in Wisconsin lakes and are desirable plants. Coontail is commonly grown in nutrient rich lakes and helps absorb excess nutrients (Lombardo, 2003). Coontail, as well as small pondweed and fern pondweed, provide important habitat for invertebrates and fish.





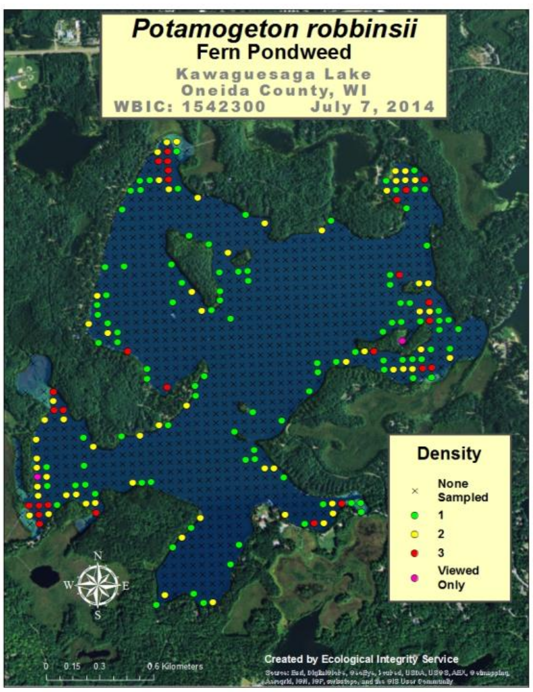


Figure 19: Three most common plant surveyed on Kawaguesaga Lake July 2014.

Minocqua Thoroughfare

The Minocqua Thoroughfare had 100% coverage of plants, making the entire waterbody within a littoral zone. This portion of the chain is shallow and has high nutrient substrate for plants to thrive. The density is also high with a mean rake fullness of 2.45. Table 8 summarizes the survey statistics. Figures 20 and 21 are maps showing the littoral zone and density from the 2014 survey.

Minocqua Thoroughfare	
Total number of sites visited	80
Total number of sites with vegetation	80
Total number of sites shallower than maximum depth of plants	80
Frequency of occurrence at sites shallower than maximum depth of plants	100.00
Simpson Diversity Index	0.92
Maximum depth of plants (ft)**	6.50
Average number of all species per site (shallower than max depth)	4.01
Average number of all species per site (veg. sites only)	4.01
Average number of native species per site (shallower than max depth)	3.96
Average number of native species per site (veg. sites only)	3.96
Species Richness	34
Species Richness (including visuals)	38
Mean depth of plants (ft)	3.33
Median depth of plants (ft)	3.00
Mean rake fullness (veg. sites only)	2.45

Table 9: Summary of point intercept survey statistics, July 2014.

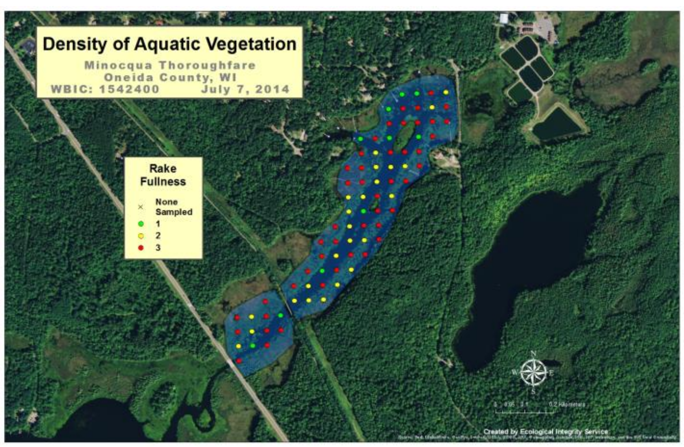


Figure 20: Map of plant density based upon rake fullness rating (0-3), July 2014.

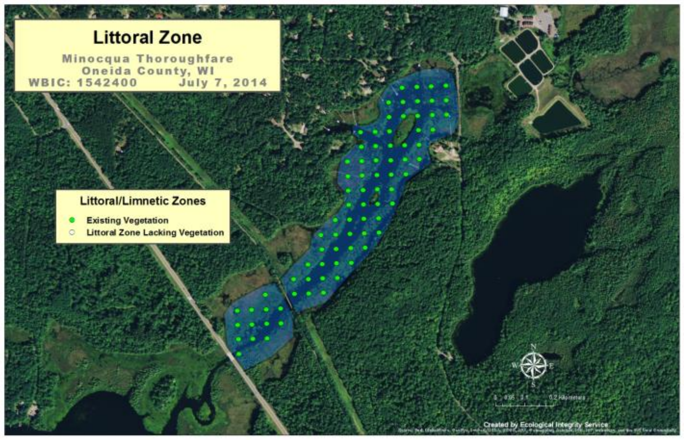


Figure 21: Littoral zone map from July 2014 survey, Minocqua Thoroughfare.

The diversity of plants in the Minocqua Thoroughfare is high. There were 34 species of plants sampled in only 80 sample locations. The Simpson's Diversity Index was 0.92, which again is high. There were nearly 4 native species of plants sampled at each sample location. Table 9 has the species list with the frequency and density data from the 2014 survey.

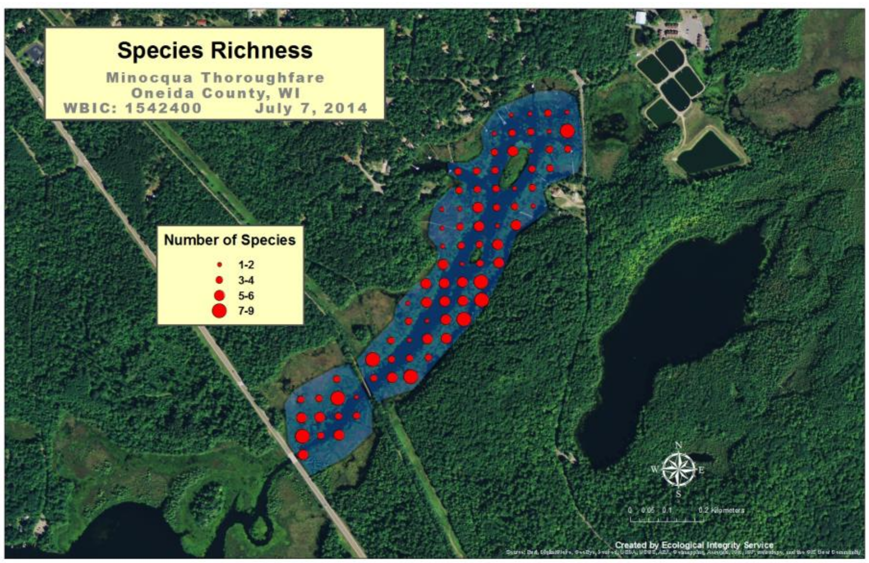


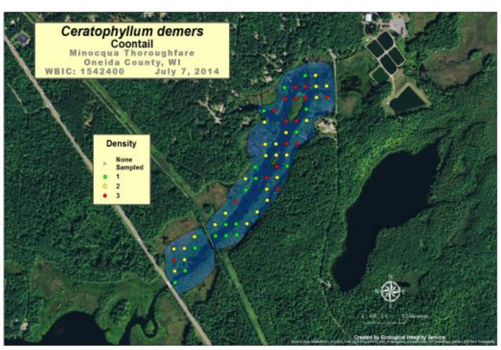
Figure 22: Species richness map showing a high richness throughout the entire thoroughfare.

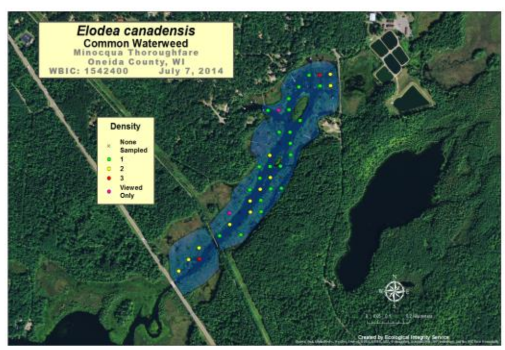
Table 10: Species list from July 2014 survey with frequency and density data.

Minocqua Thoroughfare **Species**	**Common name**	**Relative Frequency (%)**	**Frequency of occurrence within vegetated areas (%)**	**Frequency of occurrence at sites shallower than maximum depth of plants**	**Average Rake Fullness**
Ceratophyllum demersum	Coontail	18.07	72.50	72.50	1.98
Elodea canadensis	Common waterweed	10.90	43.75	43.75	1.43
Nymphaea odorata	White water lily	9.03	36.25	36.25	1.86
Lemna trisulca	Forked duckweed	8.10	32.50	32.50	1.15
Potamogeton zosteriformis	Flat-stem pondweed	8.10	32.50	32.50	1.23
Potamogeton robbinsii	Fern pondweed	5.30	21.25	21.25	1.29
Nuphar variegata	Spatterdock	4.98	20.00	20.00	2.31
Potamogeton friesii	Fries' pondweed	4.98	20.00	20.00	1.38
Utricularia vulgaris	Common bladderwort	4.36	17.50	17.50	1.21
Pontederia cordata	Pickerelweed	4.05	16.25	16.25	1.77
Potamogeton amplifolius	Large-leaf pondweed	3.74	15.00	15.00	1.00
Myriophyllum sibiricum	Northern water-milfoil	2.18	8.75	8.75	1.29
Potamogeton pusillus	Small pondweed	2.18	8.75	8.75	1.00
Decodon verticillatus	Swamp loosestrife	1.56	6.25	6.25	2.60
Typha angustifolia	Narrow-leaved cattail	1.56	6.25	6.25	2.60
Lythrum salicaria	Purple loosestrife	1.25	5.00	5.00	1.75
	Filamentous algae	(not used)	5.00	5.00	1.75
Bidens beckii	Water marigold	0.93	3.75	3.75	1.00
Potamogeton natans	Floating-leaf pondweed	0.93	3.75	3.75	1.00
Potamogeton praelongus	White-stem pondweed	0.93	3.75	3.75	1.00
Sparganium emersum	Short-stemmed bur-reed	0.93	3.75	3.75	1.00
Lemna minor	Small duckweed	0.62	2.50	2.50	1.00
Najas flexilis	Slender naiad	0.62	2.50	2.50	1.00
Potamogeton obtusifolius	Blunt-leaf pondweed	0.62	2.50	2.50	1.50
Potamogeton richardsonii	Clasping-leaf pondweed	0.62	2.50	2.50	1.50
Spirodela polyrhiza	Large duckweed	0.62	2.50	2.50	1.00
Brasenia schreberi	Watershield	0.31	1.25	1.25	1.00
Calla palustris	Wild calla	0.31	1.25	1.25	1.00
Carex comosa	Bottle brush sedge	0.31	1.25	1.25	1.00
Chara sp.	Muskgrass	0.31	1.25	1.25	1.00
Eleocharis erythropoda	Bald spikerush	0.31	1.25	1.25	1.00

Minocqua Thoroughfare **Species**	**Common name**	**Relative Frequency (%)**	**Frequency of occurrence within vegetated areas (%)**	**Frequency of occurrence at sites shallower than maximum depth of plants**	**Average Rake Fullness**
Eleocharis palustris	Creeping spikerush	0.31	1.25	1.25	1.00
Myriophyllum verticillatum	Whorled water-milfoil	0.31	1.25	1.25	1.00
Ranunculus aquatilis	White water crowfoot	0.31	1.25	1.25	1.00
Sagittaria cuneata	Arum-leaved arrowhead	0.31	1.25	1.25	2.00
Potamogeton crispus	Curly-leaf pondweed	viewed	only		
Comarum palustre	Marsh cinquefoil	viewed	only		
Potamogeton illinoensis	Illinois pondweed	viewed	only		
Typha latifolia	Broad-leaved cattail	viewed	only		

The most common species sampled in the Minocqua Thoroughfare were coontail (*Ceratophyllum demersum*), common waterweed (*Elodea Canadensis*), and white water lilly (*Nymphaea odorata*). These are all very common aquatic plants found in Wisconsin. They all provide key habitat for invertebrates and fish. Coontail and common waterweed are submergent plants and can absorb excess nutrients, helping maintain water clarity. White water lily can provide shade for fish and reduce wave energy, helping stabilize sediments.





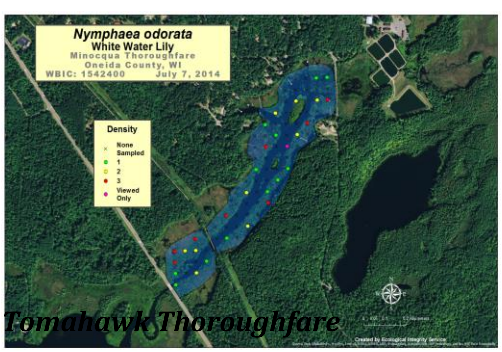


Figure 23: The three most common aquatic plants sampled in Minocqua Thoroughfare, July 2014 survey.

Tomahawk Thoroughfare

In 2007, the entire Tomahawk Thoroughfare was surveyed even though the portion to be managed by the MKPLA only goes to the bridge (marked earlier in this plan). The AIS locations were surveyed in 2014, but the point intercept survey will be updated in 2016. The data that follows is from the 2007 survey but will be evaluated and updated in this plan in 2016.

Table 11: Tomahawk Thoroughfare summary statistics from point intercept survey, 2007.

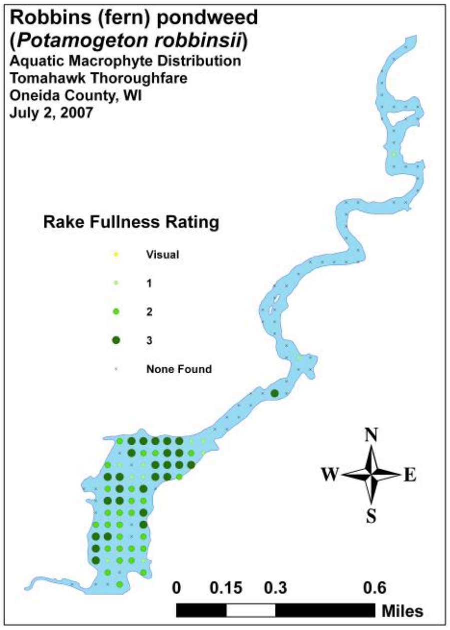
Summary Statistics:

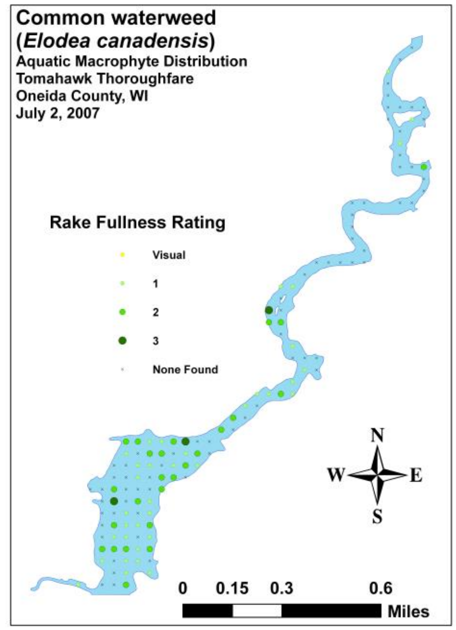
Total number of points sampled	134
Total number of sites with vegetation	130
Total number of sites shallower than the maximum depth of plants	133
Frequency of occurrence at sites shallower than maximum depth of plants	97.74
Simpson Diversity Index	0.95
Maximum depth of plants (ft)	11.00
Average number of all species per site (veg. sites only)	4.61
Average number of native species per site (veg. sites only)	4.57
Species Richness	44
Species Richness (including visuals)	47
Mean depth of plants (ft)	6.02

The Tomahawk Thoroughfare has high plant coverage with nearly all of the water body containing plants. The diversity is also high with 44 species of plants sampled with a Simpson's Diversity Index of 0.95 (again extremely high).

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.
Potamogeton robbinsii	Robbins (fern) pondweed	65	10.85	50.00
Elodea canadensis	Common waterweed	64	10.68	49.23
Ceratophyllum demersum	Coontail	45	7.51	34.62
Potamogeton zosteriformis	Flat-stem pondweed	41	6.84	31.54
Lemna trisulca	Forked duckweed	38	6.34	29.23
Potamogeton amplifolius	Large-leaf pondweed	33	5.51	25.38
Najas flexilis	Bushy pondweed	25	4.17	19.23
Potamogeton vaseyi	Vasey's pondweed	25	4.17	19.23
Potamogeton pusillus	Small pondweed	23	3.84	17.69
Potamogeton praelongus	White-stem pondweed	18	3.01	13.85
Vallisneria americana	Wild celery	18	3.01	13.85
Nuphar variegata	Spatterdock	17	2.84	13.08
Ranunculus aquatilis	Stiff water crowfoot	17	2.84	13.08
Aquatic moss	Aquatic moss	16	2.67	12.31
Utricularia vulgaris	Common bladderwort	16	2.67	12.31
Nymphaea odorata	White water lily	15	2.50	11.54
Megalodonta beckii	Water marigold	14	2.34	10.77
Myriophyllum sibiricum	Northern water-milfoil	14	2.34	10.77
Brasenia schreberi	Watershield	13	2.17	10.00
Heteranthera dubia	Water star-grass	12	2.00	9.23
Sparganium emersum	Narrow-leaved bur-reed	10	1.67	7.69
Potamogeton illinoensis	Illinois pondweed	9	1.50	6.92
Pontederia cordata	Pickerelweed	7	1.17	5.38
Potamogeton natans	Floating-leaf pondweed	6	1.00	4.62
Potamogeton epihydrus	Ribbon-leaf pondweed	4	0.67	3.08
Potamogeton gramineus	Variable pondweed	4	0.67	3.08
Potamogeton richardsonii	Clasping-leaf pondweed	4	0.67	3.08
Sagittaria cuneata	Arum-leaved arrowhead	4	0.67	3.08
Myriophyllum spicatum	Eurasian water milfoil	3	0.50	2.31
Potamogeton spirillus	Spiral-fruited pondweed	3	0.50	2.31
Potamogeton crispus	Curly-leaf pondweed	2	0.33	1.54
Nitella sp.	Nitella	2	0.33	1.54
Carex comosa	Bottle brush sedge	1	0.17	0.77
Chara sp.	Muskgrass	1	0.17	0.77
Elatine minima	Waterwort	1	0.17	0.77
Eleocharis acicularis	Needle spikerush	1	0.17	0.77
Eleocharis palustris	Creeping spikerush	1	0.17	0.77
Equisetum fluviatile	Water horsetail	1	0.17	0.77
Isoetes echinospora	Spiny-spored quillwort	1	0.17	0.77
Lemna minor	Small duckweed	1	0.17	0.77
Potamogeton alpinus	Alpine pondweed	1	0.17	0.77
Schoenoplectus subterminalis	Water bulrush	1	0.17	0.77
Sparganium fluctuans	Floating-leaf-bur-reed	1	0.17	0.77
Typha latifolia	Broad-leaved cattail	1	0.17	0.77
Polygonum amphibium	Water smartweed	Viewed	only	
Schoenoplectus tabernaemontani	Softstem bulrush	Viewed	only	
Juncus effusus	Common rush	Viewed	only	
Butomus umbellatus	Flowering rush	Viewed	only	
Cicuta bulbifera	Bulb-bearing water hemlock	Viewed	only	

Table 12: Tomahawk Thoroughfare species list with frequency data, 2007.





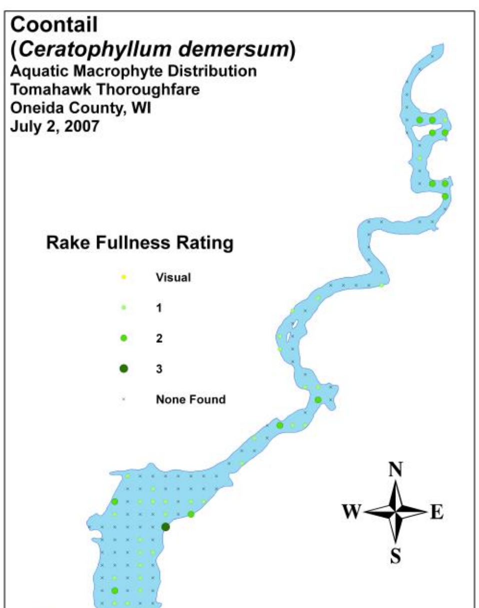


Figure 24: The three most common plants sampled in Tomahawk Thoroughfare, 2007

Fern pondweed (*Potamogeton robbinsii*), common waterweed (*Elodea canadensis*), and coontail (*Ceratophyllum demersum*) were the 3 most common plants sampled in 2007. All 3 are common and desirable native plants to have in the lake.

The floristic quality index (FQI) measures the response aquatic plants have to changes in habitat. Those plants with a high conservatism value are most susceptible. The FQI considers the number of species and the conservatism value to calculate the FQI. The higher the FQI, the less the plants have adversely responded to human activity on the lake. Table 12 shows the FQI for each waterbody from the 2014 macrophyte survey (except Tomahawk Thoroughfare is from 2007). The last row has the median for other lakes within the same eco-region that Minocqua and Kawaguesaga are contained.

FQI-2014	Number of species	Mean conservatism	FQI
Minocqua Lake	48	6.6	45.8
Kawauguesaga Lake	44	6.6	43.9
Minocqua Thoroughfare	32	6.2	35.2
Tomahawk Thoroughfare(entire waterbody and from 2007)	46	6.6	44.6
Median for other lakes in Northern Lakes and Forests eco-region	13	6.7	24.3

Table 13: FQI data from 2014 aquatic macrophyte survey. FQI = mean C $\sqrt{N}$

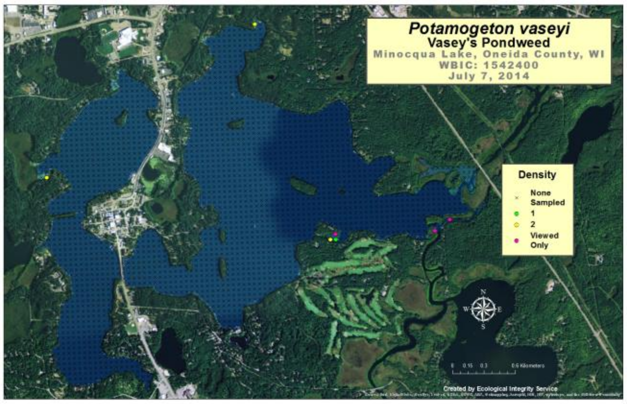
As this chart shows, the FQI of all waterbodies is much higher than the eco-region median. The mean conservatism is slightly lower in each waterbody than the eco-region median.

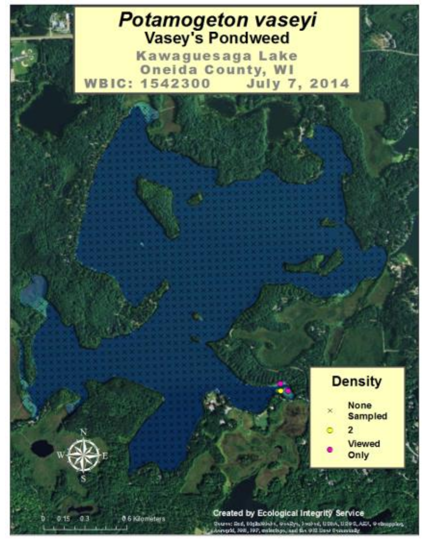
Species of special concern

Species that are not threatened or endangered but are uncommon and/or require specific habitat needs are considered species of special concern. These species need to be carefully monitored. The list below shows two species of special concern observed in Minocqua and Kawaguesaga lakes.

Plant	Lake sampled or viewed
Potamogeton vaseyi-Vasey's pondweed	Minocqua and Kawaguesaga
Eleocharis robbinsii-Robbins' spikerush	Minocqua

Figure 24 show the distribution maps of each of these species found in Minocqua Lake and Kawaguesaga Lake. These locations should be considered in management objectives and actions.





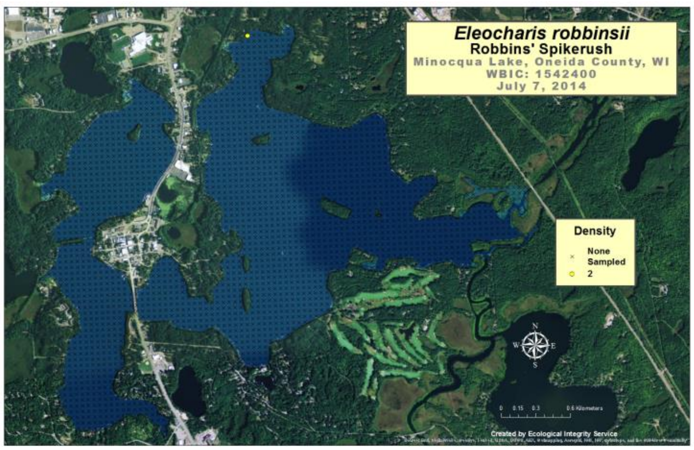


Figure 24: Distribution maps of species of special concern, Kawaguesaga and Minocqua Lakes-2014.

Invasive Plant Species

Invasive species are species that are not native and can cause ecological and/or economic harm. There were 4 different invasive species sampled or observed in Minocqua and Kawaguesaga Lakes. The list in each lake and the map of each species distribution from the point intercept survey follow.

Minocqua Lake Invasive Species:

Eurasian water milfoil-*Myriophyllum spicatum*
Flowering rush-*Butomus umbellatus*
Yellow iris-*Iris pseudacorus*
Curly leaf pondweed-*Potamogeton crispus*

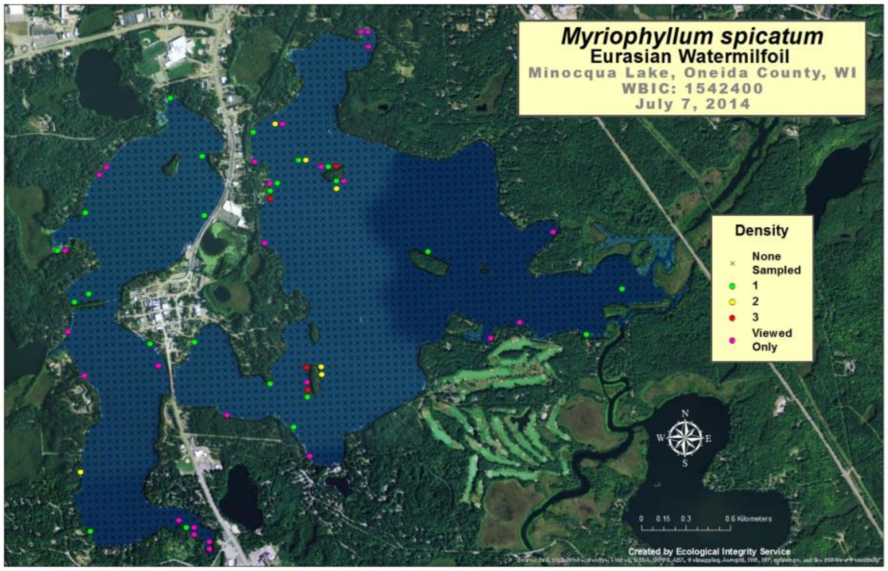


Figure 25: Map of Eurasian watermilfoil in July 2014, Minocqua Lake.

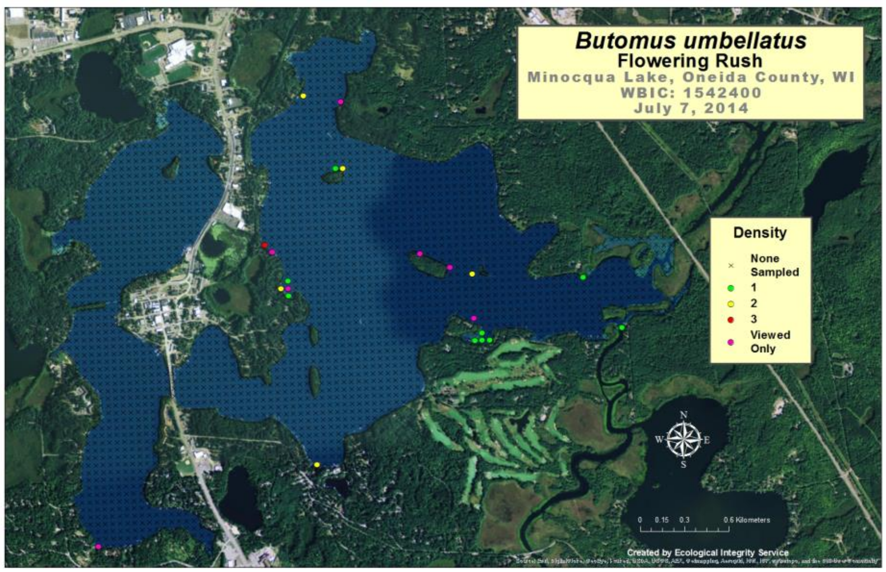


Figure 26: Map of flowering rush in July 2014, Minocqua Lake.

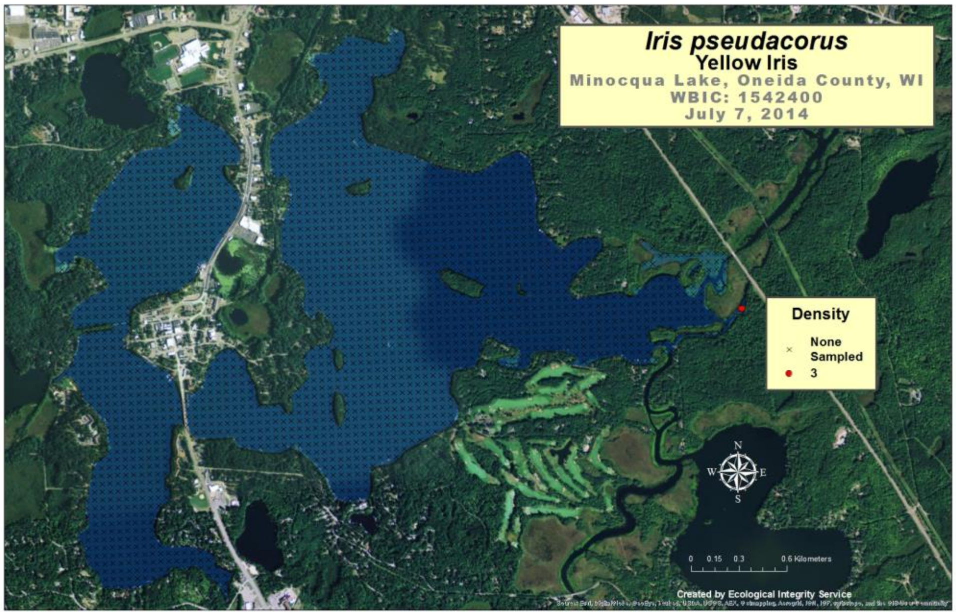


Figure 27: Map of yellow iris July 2014, Minocqua Lake.

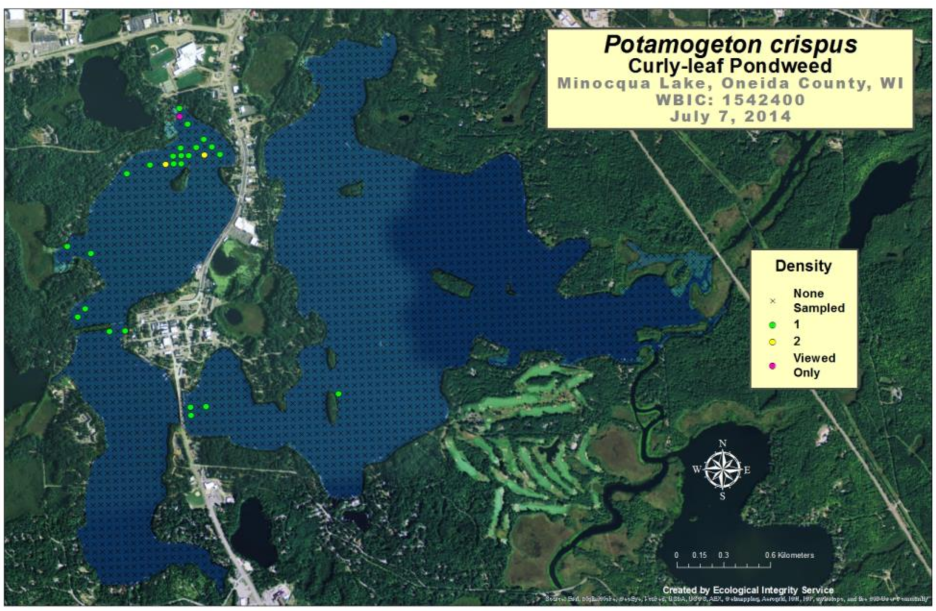
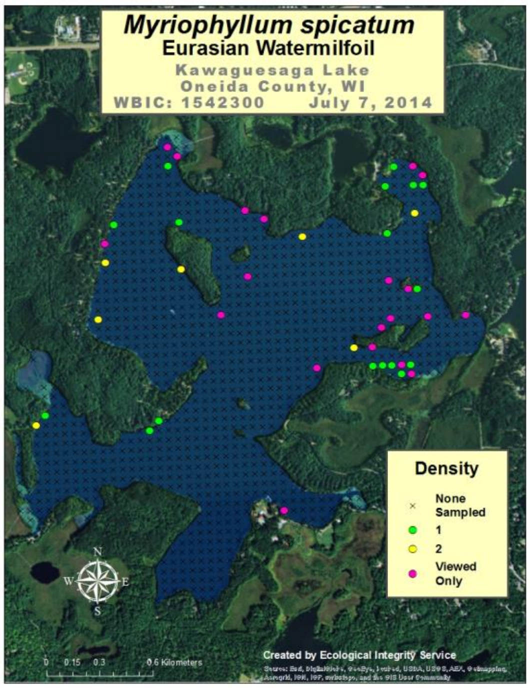


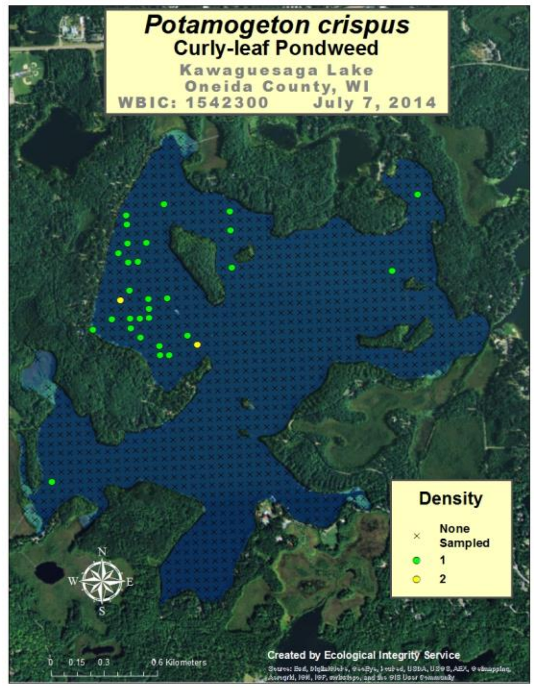
Figure 28: Map of curly leaf pondweed June/July 2014, Minocqua Lake.

Kawaguesaga Lake Invasive Species:

There were 3 invasive species surveyed in 2014. All 3 were also present in the 2007 survey, but EWM is the only invasive species that has been found to increase in frequency. Flowering rush was observed in some locations that were not part of the survey sample points, and therefore are not on the map.

Eurasian water milfoil-*Myriophyllum spicatum*
Curly leaf pondweed-*Potamogeton crispus*
Flowering rush-*Butomus umbellatus*





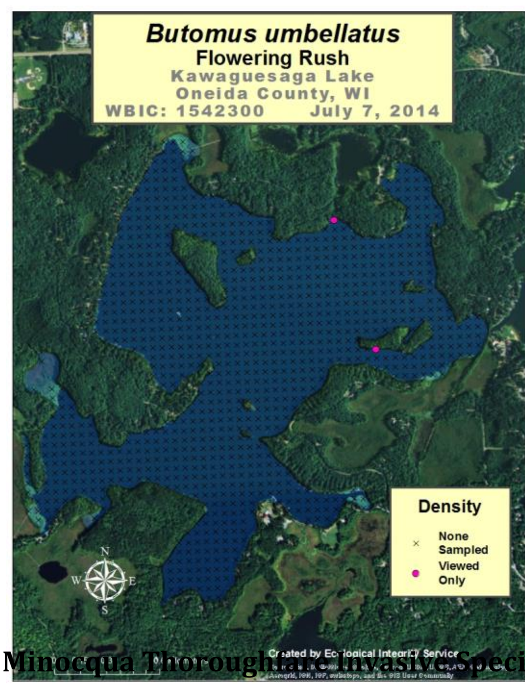
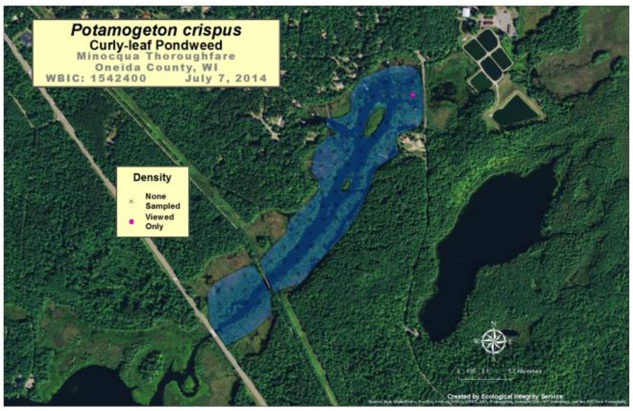


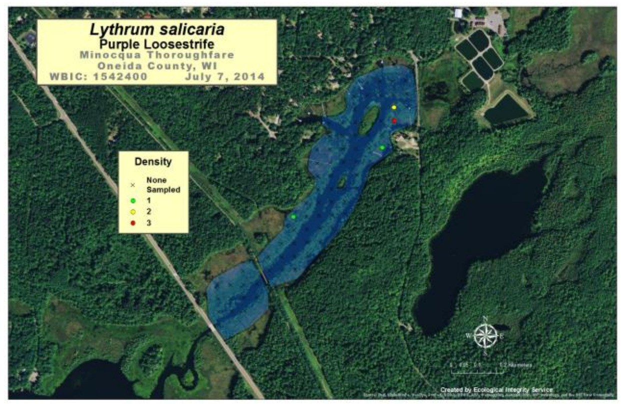
Figure 29: Aquatic invasive species sampled/viewed in Kawaguesaga Lake, 2014.

Minocqua Thoroughfare Invasive Species:

The 2014 survey had two invasive species sampled/viewed at sampling points in the Minocqua Thoroughfare. Both of these species were sampled in the 2007 survey. There was no EWM sampled in the Minocqua Thoroughfare. Yellow Iris was observed at a couple of locations, which is invasive.

Curly leaf pondweed-*Potamogeton crispus*
Purple loosestrife-*Lythrum salicaria*
Narrow-leaved cattail-*Typha augustifolia*





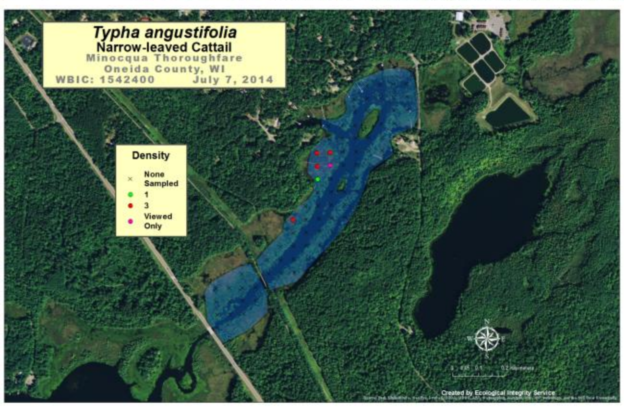
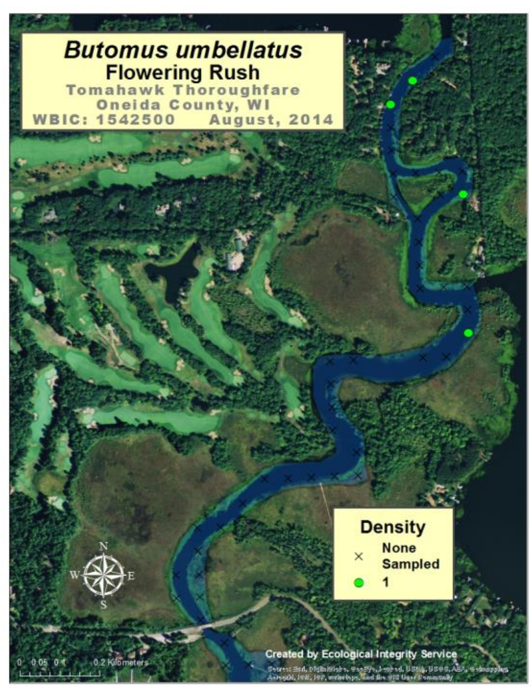


Figure 30: Invasive species sampled/viewed in Minocqua Thoroughfare, 2014.

Tomahawk Thoroughfare Invasive Species:

For MKPLA in 2014, there were two invasive species sampled/viewed at survey sampling points in the Tomahawk Thoroughfare within the zone of management. There were also several locations of purple loosestrife and yellow iris observed but not at sampling locations, and therefore, no map is available.

Eurasian water milfoil-*Myriophyllum spicatum*
Flowering rush- *Butomus umbellatus*



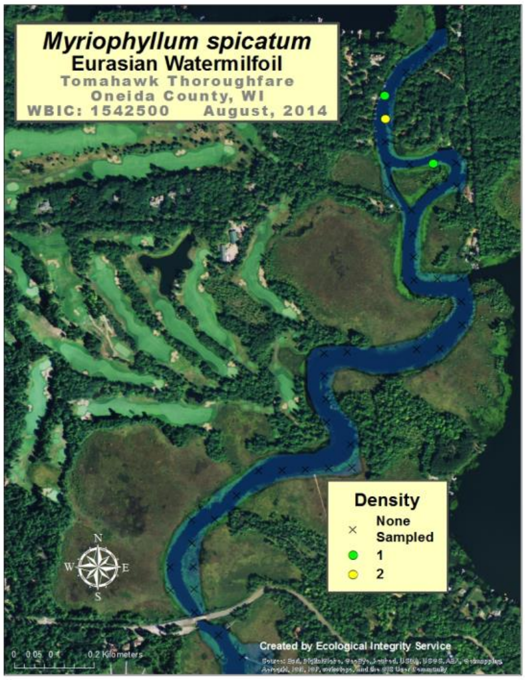


Figure 31: Invasive species sampled/viewed in Tomahawk Thoroughfare, 2014.

Comparison of 2007 and 2014 Point Intercept Surveys

An important part of managing aquatic plants is to evaluate any changes in the plant community through periodic point intercept surveys. In 2007, the first point intercept survey was conducted in Minocqua and Kawaguesaga Lakes. In June and July 2014, another point intercept survey was completed.

The purpose for this comparison is to determine if there were changes in the frequency of various species of plants, a change in diversity, and if any changes in the FQI occurred over the past seven years. Increases in native species are typically not a concern. If a plant increases to major dominance due to adverse conditions, such as reduced water clarity, then an increase would be a concern. Substantial decreases in various native species are a concern, especially if not coupled with an increase in a different native species.
The potential sources of native plant reductions over the course of several years are as follows:

1. Management practices such as herbicide treatments. Typically if herbicide treatments of invasive species are utilized, a pre and post treatment analysis is done in those specific areas. To determine if this is a cause of a reduction in the full lake survey, the treatment areas would need to be evaluated using the point intercept sample grid. Furthermore, if herbicide reduces the native species, it is dependent upon the type and concentration of the herbicide. A single species reduction is unlikely and more likely multiple species would be affected.
2. Sample variation can also occur. The sample grid is entered into a GPS unit. The GPS will allow the surveyors to get close to the same sample point each time, but there could easily be a difference of 20 feet or more (the arrow icon is 16 feet in real space). Since the distribution of various plants is not typically uniform but more

likely clumped, sampling variation could easily result in that plant not being sampled in a particular survey. Plants with low frequency could easily give significantly different values with surveys conducted within the same year.

3. Each year, the timing for aquatic plants coming out of dormancy can widely vary. A late or early ice-out could greatly affect the size of plants during a survey from one year to the next. A lake may have high density of a plant one year, only to have a very low density another year. The type of plant reproduction can immensely affect this. If the plant grows from seed or a rhizome each year, the timing can be paramount as to the frequency and density shown in a survey.
4. Identification differences can lead to frequency changes. The small pondweeds such as *Potamgeton pusillus, Potamogeton foliosus, Potamogeton friesii*, and *Potamogeton strictifolious* can easily be mistaken for one plant or another. It may be best to look at the overall frequency of all of the small pondweeds to determine if a true reduction has occurred. All small pondweeds collected were magnified and closely scrutinized in the 2014 survey.
5. Habitat changes and plant dominance changes can lead to plant declines. If an area received a large amount of sediment from human activity, the plant community may respond. For this to occur in 5-7 years may be unlikely. If a plant emerges more dominant over time, that plant may reduce the other plant's frequency and /or density.
6. Very large plant coverage reduction that is not species specific can occur from an infestation in the non-native rusty crayfish or common carp.

The FQI can change with a change in habitat. The FQI is used to compare the plant community to pre-development times (due to human activity). If human activity affects the habitat for plants, the FQI may change (decrease).

In order to determine if a change is statistically significant, a chi-square analysis is calculated. This analysis compares the frequency of both surveys and determines if the change is due to chance variation or something other than chance. The cutoff for significance is $P<0.05$, with the lower P value indicating more significance.

Table 14: Chi-square analysis comparing 2007 and 2014 survey frequencies. Yellow highlighted show significant decrease and green show a significant increase. Red shows invasive species increases.

Minocqua Lake 2007-2014 Change	**2007**	**2014**	**p**	**Significant change**	**(proportional to # sampling points)**
Ceratophyllum demersum	410	280	2.84E-10	***	-
Potamogeton robbinsii	301	188	3.22E-09	***	-
Potamogeton zosteriformis	296	141	1.67E-17	***	-
Potamogeton pusillus	240	166	5.14E-05	***	-
Elodea canadensis	224	172	0.005018	**	-
Myriophyllum sibiricum	186	103	1.68E-07	***	-
Vallisneria americana	160	74	2.82E-09	***	-
Ranunculus aquatilis	123	29	2.71E-15	***	-
Filamentous algae	118	72	0.000625	***	-
Potamogeton amplifolius	107	84	0.102151	n.s.	-
Lemna trisulca	105	51	9.34E-06	***	-

Minocqua Lake 2007-2014 Change	**2007**	**2014**	**p**	**Significant change**	**(proportional to # sampling points)**
Potamogeton praelongus	105	26	1.26E-12	***	-
Potamogeton crispus	98	26	3.37E-11	***	-
Potamogeton richardsonii	97	77	0.14056	n.s.	-
Potamogeton gramineus	82	81	0.961659	n.s.	+
Bidens beckii	71	36	0.000666	***	-
Najas flexilis	54	54	0.916786	n.s.	+
Chara sp.	50	47	0.828989	n.s.	-
Heteranthera dubia	38	11	0.000118	***	-
Eleocharis acicularis	37	21	0.038804	*	-
Nymphaea odorata	28	40	0.116383	n.s.	+
Sagittaria rigida	27	6	0.000274	***	-
Myriophyllum spicatum	24	33	0.197287	n.s.	+
Nuphar variegata	22	25	0.608701	n.s.	+
Potamogeton friesii	21	37	0.026637	*	+
Aquatic moss	14	17	0.549266	n.s.	+
Isoetes echinospora	13	10	0.559609	n.s.	-
Sparganium emersum	13	4	0.031176	*	-
Utricularia vulgaris	11	28	0.004823	**	+
Pontederia cordata	10	6	0.333909	n.s.	-
Decodon verticillatus	8	10	0.606152	n.s.	+
Lemna minor	8	11	0.462294	n.s.	+
Potamogeton obtusifolius	8	1	0.020828	*	-
Brasenia schreberi	6	8	0.566354	n.s.	+
Najas guadalupensis	6	421	1.3E-125	***	+
Spirodela polyrhiza	6	7	0.75379	n.s.	+
Potamogeton vaseyi	5	4	0.760253	n.s.	-
Eleocharis palustris	4	0	0.047338	*	-
Potamogeton natans	4	4	0.978063	n.s.	+
Carex comosa	3	0	0.085979	n.s.	-
Juncus effusus	3	0	0.085979	n.s.	-
Nitella sp.	3	7	0.193655	n.s.	+
Sagittaria cuneata	3	0	0.085979	n.s.	-
Sparganium eurycarpum	3	1	0.326137	n.s.	-
Wolffia columbiana	3	0	0.085979	n.s.	-
Juncus pelocarpus f. submersus	2	0	0.161073	n.s.	-
Potamogeton foliosus	2	0	0.161073	n.s.	-
Potamogeton illinoensis	2	9	0.031516	*	+
Potamogeton spirillus	2	0	0.161073	n.s.	-
Butomus umbellatus	1	15	0.000375	***	+
Dulichium arundinaceum	1	2	0.552011	n.s.	+
Potamogeton alpinus	1	1	0.989052	n.s.	+
Potamogeton epihydrus	1	0	0.321846	n.s.	-
Sagittaria latifolia	1	1	0.989052	n.s.	+
Schoenoplectus tabernaemontani	1	2	0.552011	n.s.	+
Stuckenia pectinata	1	2	0.552011	n.s.	+
Typha latifolia	1	0	0.321846	n.s.	-

Minocqua Lake 2007-2014 Change	**2007**	**2014**	**p**	**Significant change**	**(proportional to # sampling points)**
Myriophyllum verticillatum	0	15	8.5E-05	***	+
Potamogeton strictifolius	0	6	0.013206	*	+
Utricularia minor	0	5	0.023728	*	+
Eleocharis erythropoda	0	1	0.312462	n.s.	+
Eleocharis robbinsii	0	1	0.312462	n.s.	+
Equisetum fluviatile	0	1	0.312462	n.s.	+
Iris pseudacorus	0	1	0.312462	n.s.	+
Myriophyllum tenellum	0	1	0.312462	n.s.	+
Riccia fluitans	0	1	0.312462	n.s.	+

In Minocqua Lake, there was a statistically significant reduction in 19 plant species between 2007 and 2014. This is a large change in frequency in a high number of species. As outlined earlier, there are numerous possible causes for these reductions. Since the reduction is over the whole lake, herbicide use may only be a partial contributor. The summer growing season in 2014 started late with a late ice out and cold spring. This could also be a significant contributor to reductions, as the survey was conducted in early July when many plants may have been out of dormancy for only a short period of time.

There were also 9 species with an increase in frequency that was statistically significant. The small pondweed increases were likely due to identification differences[10]. Others could be due to sampling variations.

One invasive species, flowering rush, showed a statistically significant increase in frequency. Eurasian water milfoil also increased in frequency, but was not statistically significant.

[10] Surveyors for 2014 macrophyte survey commented that this was a likely explanation.

Kawaguesaga Lake

Table 15: Chi-square analysis comparing 2007 and 2014 survey frequencies. Yellow denotes significant decrease, green denotes significant increase. Red are invasive species increases.

Kawaguesaga Lake 2007-2014	2007	2014	p	Significant change	(proportional to # sampling points)
Ceratophyllum demersum	222	251	0.165107	n.s.	+
Potamogeton zosteriformis	222	150	3.74E-07	***	-
Potamogeton pusillus	210	195	0.173717	n.s.	-
Potamogeton robbinsii	180	189	0.821037	n.s.	+
Vallisneria americana	123	46	1.88E-11	***	-
Elodea canadensis	110	136	0.10136	n.s.	+
Myriophyllum sibiricum	105	88	0.110578	n.s.	-
Potamogeton crispus	84	31	5.74E-08	***	-
Najas flexilis	59	28	0.000288	***	-
Potamogeton richardsonii	57	57	0.86445	n.s.	-
Potamogeton amplifolius	53	59	0.665157	n.s.	+
Filamentous algae	39	52	0.200841	n.s.	+
Ranunculus aquatilis	35	12	0.000396	***	-
Bidens beckii	34	18	0.016815	*	-
Potamogeton praelongus	33	22	0.100818	n.s.	-
Potamogeton gramineus	27	36	0.294523	n.s.	+
Chara sp.	26	19	0.241481	n.s.	-
Potamogeton friesii	26	8	0.001235	**	-
Nymphaea odorata	19	22	0.703852	n.s.	+
Brasenia schreberi	14	15	0.915389	n.s.	+
Heteranthera dubia	12	16	0.492652	n.s.	+
Nuphar variegata	12	11	0.776414	n.s.	-
Aquatic moss	10	38	5.44E-05	***	+
Sagittaria rigida	9	2	0.0298	*	-
Lemna trisulca	8	22	0.012005	*	+
Myriophyllum spicatum	8	24	0.005291	**	+
Eleocharis acicularis	7	7	0.954784	n.s.	-
Potamogeton alpinus	7	2	0.085473	n.s.	-
Potamogeton vaseyi	7	1	0.029791	*	-
Isoetes echinospora	5	4	0.703773	n.s.	-
Nitella sp.	5	6	0.800237	n.s.	+
Potamogeton natans	5	1	0.093918	n.s.	-
Sparganium eurycarpum	5	0	0.022865	*	-
Utricularia vulgaris	5	9	0.307704	n.s.	+
Potamogeton foliosus	4	0	0.041911	*	-
Utricularia intermedia	4	8	0.267256	n.s.	+
Utricularia gibba	3	0	0.078245	n.s.	-
Eleocharis palustris	2	0	0.150691	n.s.	-
Juncus pelocarpus f. submersus	2	0	0.150691	n.s.	-
Pontederia cordata	2	2	0.975944	n.s.	-

Kawaguesaga Lake 2007-2014	2007	2014	p	Significant change	(proportional to # sampling points)
Potamogeton obtusifolius	2	0	0.150691	n.s.	-
Sagittaria cuneata	2	0	0.150691	n.s.	-
Sparganium emersum	2	1	0.545586	n.s.	-
Butomus umbellatus	1	0	0.309787	n.s.	-
Calla palustris	1	3	0.331065	n.s.	+
Lemna minor	1	3	0.331065	n.s.	+
Potamogeton illinoensis	1	2	0.580822	n.s.	+
Schoenoplectus tabernaemontani	1	0	0.309787	n.s.	-
Sparganium fluctuans	1	0	0.309787	n.s.	-
Spirodela polyrhiza	1	2	0.580822	n.s.	+
Typha latifolia	1	4	0.189709	n.s.	+
Carex comosa	0	3	0.087496	n.s.	+
Najas guadalupensis	0	102	8.61E-26	***	+
Utricularia minor	0	6	0.015512	*	+
Myriophyllum verticillatum	0	5	0.027229	*	+
Potamogeton strictifolius	0	5	0.027229	*	+
Eleocharis erythropoda	0	3	0.087496	n.s.	+
Carex lasiocarpa	0	2	0.163169	n.s.	+
Riccia fluitans	0	2	0.163169	n.s.	+
Juncus effusus	0	1	0.324349	n.s.	+

The chi-square shows there was a statistically significant decrease in 10 plant species from 2007 to 2014. Again, a major contributor could be the late spring and early survey. However, there has been extensive herbicide use on Kawaguesaga Lake for management of EWM and could be a contributor to some species reductions.

There was also a statistically significant increase in 6 species. One invasive species (Eurasian water milfoil) showed an increase from 2007 to 2014.

Minocqua Thoroughfare

Table16: Chi-square analysis of 2007 and 2014 survey comparison, Minocqua Thoroughfare.

Minocqua Thoroughfare 2007-2014	2007	2014	p	Significant change	(proportional to # sampling points)
Ceratophyllum demersum	**56**	**58**	**0.726828**	**n.s.**	**+**
Elodea canadensis	**53**	**35**	**0.004231**	**	**-**
Potamogeton zosteriformis	**34**	**26**	**0.191419**	**n.s.**	**-**
Lemna trisulca	**21**	**26**	**0.38548**	**n.s.**	**+**
Potamogeton obtusifolius	**20**	**2**	**3.59E-05**	***	**-**
Potamogeton robbinsii	**18**	**17**	**0.84834**	**n.s.**	**-**
Lemna minor	**16**	**2**	**0.000461**	***	**-**
Nymphaea odorata	**16**	**29**	**0.022263**	*	**+**
Nuphar variegata	**15**	**16**	**0.841461**	**n.s.**	**+**
Typha latifolia	**11**	**0**	**0.000588**	***	**-**
Eleocharis palustris	**9**	**1**	**0.008981**	**	**-**
Potamogeton amplifolius	**9**	**12**	**0.48245**	**n.s.**	**+**

Minocqua Thoroughfare 2007-2014	2007	2014	p	Significant change	(proportional to # sampling points)
Lythrum salicaria	8	4	0.229906	n.s.	-
Myriophyllum sibiricum	8	7	0.786218	n.s.	-
Najas flexilis	8	2	0.050044	n.s.	-
Pontederia cordata	8	13	0.241755	n.s.	+
Bidens beckii	6	3	0.303306	n.s.	-
Decodon verticillatus	6	5	0.754704	n.s.	-
Filamentous algae	6	4	0.513629	n.s.	-
Nitella sp.	5	0	0.023096	*	-
Ranunculus aquatilis	5	1	0.096012	n.s.	-
Typha angustifolia	5	5	1	n.s.	no change
Utricularia vulgaris	5	14	0.027845	*	+
Sagittaria cuneata	4	1	0.172848	n.s.	-
Vallisneria americana	4	0	0.042818	*	-
Carex comosa	3	1	0.311185	n.s.	-
Potamogeton richardsonii	3	2	0.649563	n.s.	-
Calla palustris	2	1	0.560001	n.s.	-
Chara sp.	2	1	0.560001	n.s.	-
Potamogeton gramineus	2	0	0.154697	n.s.	-
Schoenoplectus tabernaemontani	2	0	0.154697	n.s.	-
Sparganium emersum	2	3	0.649563	n.s.	+
Brasenia schreberi	1	1	1	n.s.	no change
Carex utriculata	1	0	0.315794	n.s.	-
Cicuta bulbifera	1	0	0.315794	n.s.	-
Eriophorum sp.	1	0	0.315794	n.s.	-
Heteranthera dubia	1	0	0.315794	n.s.	-
Potamogeton friesii	1	16	0.000119	***	+
Potamogeton natans	1	3	0.311185	n.s.	+
Potamogeton pusillus	1	7	0.029523	*	+
Stuckenia pectinata	1	0	0.315794	n.s.	-
Aquatic moss	1	0	0.315794	n.s.	-
Potamogeton praelongus	0	3	0.080374	n.s.	+
Spirodela polyrhiza	0	2	0.154697	n.s.	+
Eleocharis erythropoda	0	1	0.315794	n.s.	+
Myriophyllum verticillatum	0	1	0.315794	n.s.	+

Changes in the plant community from 2007 to 2014 in the Minocqua Thoroughfare were similar to Minocqua Lake and Kawaguesaga Lake in that there were about twice as many species with significant decreases as significant increases. There were 7 species with a statistically significant decrease, while there were increases in 4 species. No herbicide treatment has occurred in the Minocqua Thoroughfare, so all changes are due to growth variation and sampling variation. This may indicate that much of the change in Minocqua Lake and Kawaguesaga Lake is due to similar seasonal variation causes.

Floristic Quality Index comparison

The floristic quality index (FQI) is calculated to reflect any changes the plant community has undergone due to human development on lakes. The index considers the number of species and the mean conservatism. The higher the FQI, the less the plant community has been affected by lake development pressures. If the FQI decreases over time, it indicates the plant community is degrading, either through a reduction in total species richness or from loss of more sensitive species. Table 17 shows a comparison of the FQI values from the 2007 and 2014 plant surveys.

Waterbody	2007 FQI	2014 FQI
Minocqua Lake	45.0	45.8
Kawaguesaga Lake	45.1	43.9
Minocqua Thoroughfare	35.3	35.2

Table 17: FQI comparison from 2007 and 2014 plant surveys. A decrease in FQI shows degradation in the plant community.

The FQI comparison shows no change in the FQI, with the exception of a small decrease in Kawaguesaga Lake. The lack of changes in two of the water bodies and the small change in Kawaguesaga Lake show the plant community has no change due to human impact since 2007.

Invasive Species of Concern

Eurasian watermilfoil[11] *(Myriophyllum spicatum)*

The ecological risks associated with an infestation of Eurasian water milfoil appear to surpass those associated with curly leaf pondweed. As a result, management of Eurasian water milfoil is the species of highest concern for this management plan (although other invasives are present in the lakes).

There is 1 public boat landing on Kawaguesaga Lake and 4 landings on Minocqua Lake. Many anglers travel to these lakes for fishing and access the lake at these boat landings. With Eurasian water milfoil present in Minocqua and Kawaguesaga Lakes, there is danger of transporting plant fragments on boats and motors. The lakes are part of a highly used tourism area with easy access to many lakes with EWM. There is a high risk of transport to lakes with EWM.

The Wisconsin Department of Natural Resource EWM distribution lists Eurasian water milfoil in the following Oneida County Lakes (other than Kawaguesaga and Minocqua): Bridge Lake, Crescent Lake, Eagle River, Hancock Lake, Horsehead Lake, Kathan Lake, Lake Nakomis, Little Bearskin Lake, Longstone Lake, Long Lake, Manson Lake, Mid Lake, Oneida Lake, Pelican Lake, Rainbow Flowage, Rice River Flowage, Sand Lake, Squash Lake, Sugar Camp Creek, Tomahawk Lake, Tomahawk River, Townline Lake, Upper Kaubashine Lake, Virgin Lake, Willow Flowage, Willow Lake, and the Wisconsin River.

[11] Wisconsin DNR Invasive Species Factsheets from www.dnr.state.wi.us.

In nearby Vilas County, the following locations are listed: Anvil Lake, Arrowhead Lake, Big Lake, Big Sand Lake, Boot Lake, Brandy Lake, Catfish Lake, Clearwater Lake, Cranberry Lake, Duck Lake, Eagle Lake, Forest Lake, Kentuk Lake, Lac Vieux Desert, Little St. Germain Lake, Long Lake, Lost Lake, Lynx Lake, Middle Gresham Lake, North Twin Lake, Otter Lake, Scattering Rice Lake, Silver Lake, Smokey Lake, South Twin Lake, Upper Buckatabon Lake, Upper Gresham Lake, Voyager Lake, Watersmeet Lake, Wisconsin River, and Yellow Birch Lake.[12]

The following Eurasian water milfoil information is taken from a Wisconsin DNR fact sheet. Both Northern milfoil and coontail, mentioned below, is frequently mistaken for Eurasian water milfoil are present in Kawaguesaga and Minocqua Lakes.

Identification
Eurasian water milfoil is a submersed aquatic plant native to Europe, Asia, and northern Africa. It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, Eurasian water milfoil is nearly impossible to distinguish from Northern water milfoil. Eurasian water milfoil has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.

Characteristics
Eurasian water milfoil grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is usually restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lakebeds, lakes laden with nitrogen and phosphorous, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon. High water temperatures promote multiple periods of flowering and fragmentation.

Reproduction and dispersal
Unlike many other plants, Eurasian water milfoil does not normally rely on seed for reproduction but can sexually reproduce. Its seeds germinate poorly under natural conditions. It reproduces vegetatively by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. Milfoil is readily dispersed by boats, motors, trailers, bilges, live wells, or bait buckets, and can stay alive for weeks if kept moist.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, Eurasian water milfoil is adapted for rapid growth early in spring.

[12] Taken from the 2006 list of waterbodies with EWM. Wisconsin DNR Website.

Ecological impacts

Eurasian water milfoil's ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of Eurasian milfoil provide only a single habitat and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of Eurasian water milfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by Eurasian water milfoil may lead to deteriorating water quality and algae blooms of infested lakes.

Control methods

Preventing a Eurasian water milfoil invasion requires various efforts. The first component is public awareness of the necessity to remove weed fragments at boat landings. Inspection programs should provide physical inspections as well as a direct educational message. Native plant beds must be protected from disturbance caused by boaters and indiscriminate plant control that disturbs these beds. The watershed management program will keep nutrients from reaching the lake and reduce the likelihood that Eurasian milfoil colonies will establish and spread.

Monitoring is also important so that introduced plants can be controlled immediately. The lake association and lakeshore owners should check for new colonies and control them before they spread. The plants can be hand pulled or raked. It is imperative that all fragments be removed from the water and the shore.

As always, prevention is the best approach to invasive species management. However, since Eurasian water milfoil has already been introduced, additional control methods should be considered, including mechanical control, chemical control, and biological control.

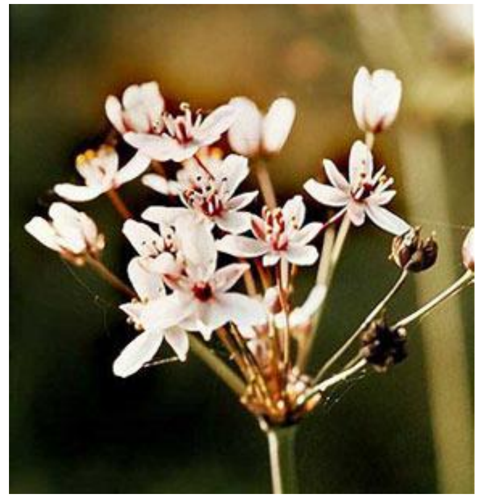
With Eurasian water milfoil found in nearby lakes and in small amounts in Kawaguesaga and Minocqua Lakes themselves, it is prudent to provide a contingency plan to be best control milfoil. A contingency plan should include a systematic monitoring program and a fund to provide timely treatments.

This plant is often confused with Northern water milfoil (*Myriophyllum sibiricum*), which is native and found in Kawaguesaga and Minocqua Lakes. Northern milfoil is a desirable plant that tends to grow in similar habitat as EWM. It has fine leaves that provide habitat for small planktonic organisms, which make up a key part of the food chain.

Flowering rush - *Butomus umbellatus*

Identification

Flowering rush has stiff, three-sided leaves that can be as much as 3 feet long and 0.5 inches wide. The leaves are often emergent but can remain submerged in deeper water (plants were found in water depth approaching 10 feet in Minocqua Lake). If submerged, the leaves are much more limp. The flowers are white to light pink-rose in color. The flowers have 3 petals, 3 sepals, and red anthers. Terminal umbels bloom June through August and rise above leaves. Flowering rush will not emerge or flower if in deeper water where they are submergent.



Rhizomes grow in the sediment and form small bulbs that can be easily distributed in the water. Flowering rush may be mistaken with bur-reeds (*Sparganium sp.*). Bur-reeds have V shaped leaves, and the flowers are little spiked balls.

Ecological Impacts

Flowering rush can grow in marshes, backwaters, and along shorelines. They can form dense colonies, crowding out native populations. Emergent plants can serve important purposes for a lake, and flowering rush can dominate these habitats if it grows too densely.

Control methods

Flowering rush has been successfully controlled through mechanical methods. These include cutting below the water line several times during the year. The plants can also be removed by digging the plants, but all root fragments must be removed. Herbicide application may also control flowering rush.

Aquatic Plant Management

This section presents aquatic plant management goals for Kawaguesaga Lake and Minocqua Lake, the potential management methods available to reach these goals, and selection of action items for plant management. These goals were developed by the plant committee and reflect the concerns resulting from public involvement, the Lake Association Board of Directors, and suggestions from the Wisconsin Department of Natural Resources.

Techniques to control the growth and distribution of aquatic plants are discussed in the fooloing text. In most cases, a combination of techniques must be used to reach plan goals. The application, location, timing, and combination of techniques must be considered carefully.

Permitting requirements

The Wisconsin Department of Natural Resources regulates the removal of aquatic plants when chemical and mechanical methods are used or when plants are removed manually from an area greater than 30 feet in width along the shore. The requirements for chemical plant removal are described in Administrative Rule NR 107-Aquatic Plant Management. A permit is required for any aquatic chemical application in Wisconsin.

The requirements for manual and mechanical plant removal are described in NR 109-Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations. A permit is required for manual and mechanical removal, except when a riparian (waterfront) landowner manually removes or gives permission to someone to manually remove plants, (with the exception of wild rice) from his/her shoreline, limited to a 30-foot corridor. A riparian landowner may also manually remove the invasive plants Eurasian water milfoil, curly leaf pondweed, and purple loosestrife along his or her shoreline without a permit. Manual removal means the control of aquatic plants by hand or hand-held devices without the use or aid of external or auxiliary power.

Northern Region Strategy

The Northern Region of the Wisconsin DNR has established a management strategy for future plant management and can affect permitting for management. Their approach is as follows:[13]

1. After January 1, 2009, no individual permits for control of native aquatic plants will be issued. Treatment of native species may be allowed under the auspices of an approved lake management plan and only if the plan clearly documents "impairment of navigation" and/or "nuisance conditions." Until January 1, 2009, individual permits will be issued to previous permit holders, only with adequate documentation of "impairment of navigation" and/or "nuisance conditions." No new individual permits will be issued during the interim.

2. Control of aquatic plants (if allowed) in documented sensitive areas will follow the conditions specified in the report. (Note: Minocqua Lake has several documented sensitive areas)

3. Invasive species must be controlled under an approved lake management plan, with 2 exceptions:
   a. Newly discovered infestations: If found on a lake with an approved plan, the invasives can be controlled via an amendment to the approved plan. Without an approved plan, they can be controlled under the WDNR's Rapid Response protocol.

   b. Individuals holding past permits for control of invasive aquatic plants and/or "mixed stands" of native and invasive species will be allowed to treat via individual Permit until January 1, 2009, if "impairment of navigation," and/or "nuisance conditions" is [are] adequately documented.

4. Control of invasive stands or "mixed stands" of invasive and native plants will follow current best management practices approved by the Department and contain an explanation of the strategy to be used. Established stands of invasive plants will generally use a control strategy based on spring treatment (water temperatures of less than 60 degrees F).

5. Manual removal (by definition) is allowed. However, wild rice may not be removed.

[13] Aquatic Plant Management Strategy. Northern Region of Wisconsin DNR. 2007.

Biological control[14]

Biological control is the purposeful introduction of parasites, predators, and/or pathogenic microorganisms to reduce or suppress populations of plant or animal pests. Biological control counteracts the problems that occur when a species is introduced into a new region of the world without a complex or assemblage of organisms that feed directly upon it, attack its seeds or progeny through predation or parasitism, or cause severe or debilitating diseases (i.e., pathogenic microorganisms). With the introduction of native pests to the target invasive organism, the exotic invasive species may be maintained at lower densities.

While this theory has worked in application for control of some non-native aquatic plants, results have been varied (Madsen, 2000). Beetles are commonly used to control purple loosestrife populations in Wisconsin with good success. Weevils are used as an experimental control for Eurasian water milfoil once the plant is established. Tilapia and carp are used to control the growth of filamentous algae in ponds. Grass carp, and herbivorous fish are sometimes used to feed on pest plant populations. Grass carp introduction is not allowed in Wisconsin.

There are advantages and disadvantages to the use of biological control as part of an overall aquatic plant management program. Advantages include longer-term control relative to other technologies, lower overall costs, and plant-specific control. On the other hand, there are several disadvantages to consider, including longer control times (years instead of weeks), a lack of available agents for particular target species, and relatively strict environmental conditions required for success.

Biological control is not without risks; new non-native species introduced to control a pest population may cause problem of its own. Biological control is going to be explored for Eurasian water milfoil reduction.

Weevil augmentation

A potential management method for EWM is the use of the native weevil *Euhrychiopsis lecontei*. This weevil has a larvae stage that feeds on both native milfoils and Eurasian water milfoil. The larvae tunnel into the stem, and the plant presumably loses the ability to tranport nutrients and gases. *E. lecontei* adults swim and climb from plant to plant, feeding on leaflets and stem material. After mating, the female lays an average of 1.9 eggs a day, usually 1 egg per watermilfoil apical meristem (growing tip). One female may lay hundreds of eggs in her lifetime. The eggs hatch, and the larvae first feed on the apical meristem and then mine down into the stem of the plant, consuming internal stem tissue. Weevils pupate inside the stem in the pupal chamber, a swelled cavity in the stem. Adults emerge from the pupal chamber to mate and lay eggs. In the autumn, adults travel to the shore where they over-winter on land. In the laboratory, *E. lecontei* take 20 to 30 days to complete 1 life cycle, depending on water temperatures. For complete development, weevils require about 310

[14] Information from APIS(Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.

degree-days with temperatures above 10 degrees C. In the field, generally 2 to 4 generations per year are observed.[15]

Since this weevil naturally occurs in many Wisconsin Lakes, its use involves the augmentation of the natural population of weevils present in the lake. This augmentation significantly increases the population of larvae per stem of milfoil. The premise is that this increase will lead to more destruction of the plants.

Results of weevil augmentation on control of EWM in actual lakes are mixed. Some documentation suggests reduction of EWM density in Wisconsin lakes. Other studies have shown little reduction. There does not seem to be any standard indicating the stem count of larvae needed. Also, the wide variation of seasonal changes and the effects on the weevils seem to play a role in long-term decline of the EWM. This could be linked to the shoreline habitat and fish feeding on the larvae. It is known that a good leaf litter and shrub layer is needed for over-winter habitat of adults. Also, it is known that bluegills (present in Minocqua and Kawaguesaga Lakes) eat this weevil when present.

Starting in 2009, the Minocqua and Kawaguesaga Lakes Protection Association utilized weevil augmentation during the implementation of the Aquatic Plant Management Plan. The project was not successful and all of the 6 beds were treated with herbicide. Weevil augmentation will not be considered for near future management.

Re-vegetation with native plants

Another aspect to biological control is native plant restoration. The rationale for re-vegetation is that restoring a native plant community should be the end goal of most aquatic plant management programs (Nichols, 1991; Smart and Doyle, 1995). However, in communities that have only recently been invaded by non-native species, a propagule bank that probably exists will restore the community after non-native plants are controlled (Madsen, Getsinger, and Turner, 1994). Re-vegetation following plant management implementation should not be necessary, as both lakes have extensive native populations and any management will involve selection for target species only.

Physical control[16]

In physical management, the environment of the plant is manipulated, which in turn acts upon the plants. Several physical techniques are commonly used: dredging, draw down, benthic (lake bottom) barriers, and shading or light attenuation. Because they involve placing a structure on the bed of a lake and/or affect lake water level, a Chapter 30 or 31 DNR permit is required.

Dredging removes accumulated bottom sediments that support plant growth. Dredging is usually not performed solely for aquatic plant management but is used to restore lakes that have been filled in with sediments, have excess nutrients, need deepening, or require removal of toxic substances (Peterson, 1982). Dredging is not a viable option for

[15] *Euhrychiopsis lecontei* fact sheet. Cornell University Research Ponds Facility.
< http://www.eeb.cornell.edu/ponds/weevil.htm>
[16] Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.

Kawaguesaga and Minocqua Lakes since this is not recognized as an aquatic plant management tool alone and is not regarded as an effective tool for these lakes.

Drawdown, or significantly decreasing lake water levels, can be used to control nuisance plant populations. Essentially, the water body has all of the water removed to a given depth. It is best if this depth includes the entire depth range of the target species. Drawdowns, in order to be effective, need to be at least 1 month long to ensure thorough drying (Cooke 1980). In northern areas, a drawdown in the winter that will ensure freezing of sediments is also effective. Although drawdown may be effective for control of hydrilla for 1 to 2 years (Ludlow 1995), it is most commonly applied to Eurasian watermilfoil (Geiger 1983; Siver et al. 1986) and other milfoils or submersed evergreen perennials (Tarver 1980). Drawdown requires that there be a mechanism to lower water levels.

Although it is inexpensive and has long-term effects (2 or more years), it also has significant environmental effects and may interfere with use and intended function (e.g., power generation or drinking water supply) of the water body during the drawdown period. Lastly, species respond in different manners to draw down often not in a consistent fashion (Cooke 1980a). Drawdowns may provide an opportunity for the spread of highly weedy or adventive species, particularly annuals. When drawbacks are compared to the benefits, other options appear better for Kawaguesaga and Minocqua Lakes as the primary management tools. However, if there is a need for lowering the lake level for dam repair, drawdown may be evaluated as an option. In order to be considered, the possible amount of drawdown would need to be determined. This would need to be compared to the bathymetry of the lake to see how much of the littoral zone and where in the littoral zone plants would be exposed. These areas that would be affected would have to correlate to the EWM sites. Although this would be a small possibility, it should not be completely ruled out for the future.

Benthic barriers or other bottom-covering approaches are another physical management technique. The basic idea is that the plants are covered over with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic and synthetic materials; sediments such as dredge sediment, sand, silt or clay, or fly ash; and combinations of the above materials (Cooke 1980b; Nichols 1974; Perkins 1984; Truelson 1984). The problem with using sediments is that new plants establish on top of the added layer (Engel and Nichols 1984). The problem with synthetic sheeting is that the gasses evolved from decomposition of plants and sediment decomposition collects under and lifts the barrier (Gunnison and Barko 1992). Benthic barriers will typically kill plants under them within 1 to 2 months, after which time they maybe removed (Engel 1984). Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively (Carter et al. 1994). Sites from which barriers are removed will be rapidly re-colonized (Eichler et al. 1995). In addition, synthetic barriers may be left in place for multi-year control but will eventually become sediment-covered and will allow colonization by plants. Benthic barriers, effective and fairly low-cost control techniques for limited areas (e.g., <1 acre), may be best suited to high-intensity use areas such as docks, boat launch areas, and swimming areas. However, they are too expensive to use over widespread areas, and heavily affect benthic communities by removing fish and invertebrate habitat. A Department of Natural Resources permit would be required.

Although a benthic barrier may be a potential option for riparian owners, there is no plan to use this as a management tool for Kawaguesaga and Minocqua Lakes. Since the main use of management tools will be to reduce EWM, benthic barriers are not prudent; the coverage is too extensive and would be too labor intensive.

Shading or light attenuation reduces the light plants need to grow. Shading has been achieved by fertilization to produce algal growth, by application of natural or synthetic dyes, shading fabric, or covers, and by establishing shade trees (Dawson 1981, 1986; Dawson and Hallows 1983; Dawson and Kern-Hansen 1978; Jorga et al. 1982; Martin and Martin 1992; Nichols 1974). During natural or cultural eutrophication, algae growth alone can shade aquatic plants (Jones et al. 1983). Although light manipulation techniques may be useful for narrow streams or small ponds, in general, these techniques are of only limited applicability. As a result, management of Kawaguesaga Lake and Minocqua Lake will not use this management tool.

Manual removal[17]

Manual removal involving hand pulling, cutting, or raking plants will remove plants from small areas. It is likely that plant removal will need to be repeated during the growing season. Best timing for hand removal of herbaceous plant species is after flowering but before seed head production. For plants that possess rhizomatous (underground stem) growth, pulling roots is not generally recommended since it may stimulate new shoot production. Hand pulling is a strategy recommended for rapid response to a Eurasian water milfoil infestation. If curly leaf pondweed or Eurasian water milfoil is present at or near shore locations in low density, hand pulling by residents may be effective. Caution needs to be exercised in removing the entire plant and any fragments to reduce spreading through fragmentation.

Mechanical control

Larger-scale control efforts require more mechanization. Mechanical cutting, mechanical harvesting, diver-operated suction harvesting, and rotovating (tilling) are the most common forms available. Department of Natural Resources permits under Chapter NR 109 are required for mechanical plant removal.

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water. The cutter head uses sickles similar to those found on farm equipment and generally cuts from 1 to 6 feet deep. A conveyor belt on the cutter head is always in motion, bringing the clippings onboard the machine for storage. Once full, the harvester travels to shore to discharge the load of weeds off of the vessel.

Harvesters come in a variety of sizes with cutting swaths ranging from 4 to 12 feet in width. The onboard storage capacity varies as well and is measured in both volume and weight. Harvester storage capacities generally range from 100 to 1000 cubic feet of vegetation by volume or from 1 to 8 tons. They are usually propelled by 2 paddle wheels that provide excellent maneuverability and will not foul in dense plant growth.

[17] Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.

Because large-scale mechanical control tends to be nonselective and leaves plant fragments in the lake, this method is not recommended for Kawaguesaga Lake or Minocqua Lake. Also for established invasive species control, mechanical harvesting would be largely for aesthetic reasons. Since spreading of the plant is likely, it would reduce plant density for a brief time, only to have the plants return in the near future. A resident has expressed a concern about plant growth that may potentially be considered at nuisance level (though it has not yet been determined to be native or invasive). It is located in the Minocqua Thoroughfare, and affects navigation. If this area is considered a nuisance for navigation, harvesting may be an option.

Diver dredging operations use pump systems to collect plant and root biomass. The pumps are mounted on a barge or pontoon boat. The dredge hoses are from 3 to 5 inches in diameter and are handled by 1 diver. The hoses normally extend about 50 feet in front of the vessel. Diver dredging is especially effective against pioneering infestations of submersed invasive plant species. When a weed is discovered in a pioneering state, this methodology should be considered. To be effective the entire plant, including the subsurface portions, should be removed.

Plant fragments can be formed from this type of operation. Fragmentation is not as great a problem when infestations are small. Diver dredging operations can be an ongoing mission. When applied toward a pioneering infestation, control can be complete. However, periodic inspections of the lake should be performed to ensure that all the plants have been found and collected.

Lake substrates can play an important part in the effectiveness of the operation. Soft substrates are easy to work in. Divers can remove the plant and root crowns with little difficulty. Hard substrates however, pose more of a problem. Divers may need hand tools to help dig the root crowns out of hardened sediment. Many areas of Minocqua Lake that need management are far too large for this method. However in some regions of sporadic Eurasian water milfoil infestation, this method may be useful. Since actual dredging calls for separate permits for the removal of lake basin material, dredging would not be performed. Instead, the use of a suction device to move plants to the surface without removing bottom material would be utilized.

Rotovation involves using large underwater rototillers to remove plant roots and other plant tissue. Rotovators can reach bottom sediments to depths of 20 feet. Rotovating may significantly affect non-target organisms and water quality as bottom sediments are disturbed. However, the suspended sediments and resulting turbidity produced by rotovation settles fairly rapidly once the tiller has passed. Tilling sediments that are contaminated could possibly release toxins into the water column. If there is any potential of contaminated sediments in the area, further investigation should be performed to determine potential impacts from this type of treatment. Tillers do not operate effectively in areas with many underwater obstructions, such as trees and stumps. There may be a need to collect the plant material that is tilled from the bottom. If operations are releasing large amounts of plant material, harvesting equipment should be on hand to collect this material and transport it to shore for disposal.

Rotovation would release too much sediment and too many plant fragments and therefore would not be a good method for Kawaguesaga and Minocqua Lakes. Also, potential treatment of non-native plants by rotovation is not a good option, as it could increase spreading of non-native plants while not selecting the target species.

Herbicide and algaecide treatments

Herbicides are chemicals used to kill plant tissue. Currently, no product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of biomagnification, bioavailability, or persistence in the environment (Joyce, 1991). Thus, there are a limited number of active ingredients that are assured to be safe for aquatic use (when used according to the label) (Madsen, 2000).

An important caveat is that these products are safe when used according to the label. The U.S. Environmental Protection Agency (EPA)-approved label gives guidelines protecting the health of the environment, the humans using that environment, and the applicators of the herbicide. In most states, additional permitting or regulatory restrictions on the use of these herbicides also apply. Most states require these herbicides be applied only by licensed applicators. Wisconsin Department of Natural Resources permits under Chapter NR 107 are required for herbicide application.

Herbicide use will likely be the main management tool for Kawaguesaga and Minocqua Lakes. Considering the potential treatment areas, costs, location, and time of season, this option is most viable.

Recent studies conducted in part by the Wisconsin DNR have shown that the size of treated beds can affect the efficacy of treatment. In a study of several Wisconsin lakes treating EWM with 2,4-D, it was found that beds less than 10 acres had a less consistent reduction in EWM frequency than beds greater than 10 acres. The smaller beds did have frequency reduction (>50% reduction in approximately half of the studied beds), but the larger beds (>10 acres) were more consistent in reduction of 80-100% reduction (Nault, et al 2015).

Some herbicides can be carried in liquid and granular form. Recent studies of the concentration of herbicide after application show that liquid formulations of 2,4-D had higher initial concentrations than the granular, but both quickly dissipated below the target concentration. Neither formulation appeared to have distinctly better results Nault et al, 2015).

General descriptions of chemical control are included below.

Contact Herbicides

Contact herbicides act quickly and are generally lethal to all plant cells that they contact. Because of this rapid action or other physiological reasons, they do not move extensively within the plant and are effective only where they contact plants directly. For this reason, they are generally more effective on annuals (plants that complete their life cycle in a single year). Perennial plants (plants that persist from year to year) can be defoliated by contact herbicides but they quickly resprout from unaffected plant parts. Submersed aquatic plants that are in contact with sufficient concentrations of the herbicide in the water for long enough periods of time are affected, but regrowth occurs from unaffected plant parts, especially plant parts that are protected beneath the sediment. Because the entire plant is not killed by contact herbicides, retreatment is necessary, sometimes two or three times per year. **Endothall, diquat** and **copper** are contact aquatic herbicides.

Systemic Herbicides

Systemic herbicides are absorbed into the living portion of the plant and move within the plant. Different systemic herbicides are absorbed to varying degrees by different plant parts. Systemic herbicides that are absorbed by plant roots are referred to as "soil active herbicides", and those that are absorbed by leaves are referred to as "foliar active herbicides". Some soil active herbicides are absorbed only by plant roots. Other systemic herbicides, such as glyphosate, are only active when applied to and absorbed by the foliage. **2,4-D, dichlobenil, fluridone, and glyphosate** are systemic aquatic herbicides. When applied correctly, systemic herbicides act slowly in comparison to contact herbicides. They must move to the part of the plant where their site of action is. Systemic herbicides are generally more effective for controlling perennial and woody plants than contact herbicides. Systemic herbicides generally have more selectivity than contact herbicides. Since it is best at targeting the EWM as an herbicide for dicot plants (most aquatic plants are monocots), this will be the preferred type of chemical treatment for Kawaguesaga and Minocqua Lakes.

Broad spectrum herbicides

Broad spectrum (sometimes referred to as nonselective) herbicides are used to control all or most species of vegetation. This type of herbicide is often used for total vegetation control in areas such as equipment yards and substations where bare ground is preferred. **Glyphosate** is an example of a broad spectrum aquatic herbicide. **Diquat, Endothall, and fluridone** are used as broad spectrum aquatic herbicides, but can also be used selectively under certain circumstances. While glyphosate, diquat, and endothall are considered broad spectrum herbicides, they can also be considered selective in that they only kill the plants that they contact. Thus, you can use them to selectively kill an individual plant or plants in a limited area, such as a swimming zone.

Selective herbicides

Selective herbicides are those that are used to control certain plants, but not others. 2,4-D, which can be used to control water hyacinth with minimum impact on eel grass, is a good example of a selective aquatic herbicide. Herbicide selectivity is based upon the relative susceptibility or response of a plant to an herbicide. Many related physical and biological factors can contribute to a plant's susceptibility to an herbicide. Physical factors that contribute to selectivity include herbicide placement, formulation, and rate of application. Biological factors that affect herbicide selectivity include physiological factors, morphological factors, and stage of plant growth.

Environmental Considerations

Aquatic communities consist of aquatic plants including macrophytes (large plants) and phytoplankton (free floating algae), invertebrate animals (such as insects and clams), fish, birds, and mammals (such as muskrats, otters, and manatees). All of these organisms are interrelated in the community. Organisms in the community require a certain set of physical and chemical conditions to exist such as nutrient requirements, oxygen, light, and space. Aquatic weed control operations can affect water chemistry, or one or more of the organisms in the community. Both of these can, in turn, affect other organism. The effects of aquatic plant control on the aquatic community can be separated into direct effects of the herbicides or indirect effects. Direct effects would include actually killing of aquatic organisms themselves, such as fish or fish eggs. Indirect effects could include adversely affecting the food chain through reduction of small invertebrates that fish may feed on.

General descriptions of the breakdown of commonly used aquatic herbicides are included below.[18]

Copper compounds

Copper is a naturally occurring element that is essential at low concentrations for plant growth. It does not break down in the environment but forms insoluble compounds with other elements and is bound to charged particles in the water. It rapidly disappears from water after application as an herbicide. Because it is not broken down, it can accumulate in lake bottom sediments after repeated high application rates. Accumulation rarely reaches levels that are toxic to organisms or significantly above background concentrations in the sediment.

2,4-D

2,4-D photodegrades on leaf surfaces after being applied to leaves and is broken down by microbial degradation in water and sediments. Complete decomposition usually takes about 3 weeks in water but can be as short as 1 week. 2,4-D breaks down into naturally occurring compounds.

Diquat

When applied to enclosed ponds for submersed weed control, diquat is rarely found longer than 10 days after application and is often below detection 3 days after application. The most important reason for the rapid disappearance of diquat from water is that it is rapidly taken up by aquatic vegetation and binds tightly to particles in the water and bottom sediments. When bound to certain types of clay particles, diquat is not biologically available. When it is bound to organic matter, microorganisms can degrade it slowly. When diquat is applied foliarly, it is degraded to some extent on the leaf surfaces by photodegradation, and because it is bound in the plant tissue, a proportion is probably degraded by microorganisms as the plant tissue decays.

Endothall

Like 2,4-D, endothall is rapidly and completely broken down into naturally occurring compounds by microorganisms. The by-products of endothall dissipation are carbon dioxide and water. Complete breakdown usually occurs in about 2 weeks in water, and 1

[18]These descriptions are taken from Hoyer/Canfield: Aquatic Plant Management. North American Lake Management Society. 1997.

week in bottom sediments. This will be the chemical of choice for early season CLP treatments.

Fluridone

Dissipation of fluridone from water mainly occurs by photodegradation. Metabolism by tolerant organisms and microbial breakdown also occurs, and microbial breakdown is probably the most important method of breakdown in bottom sediments. The rate of breakdown of fluridone is variable and may be related to time of application. Applications made in the fall or winter, when the sun's rays are less direct and days are shorter, result in longer half-lives. Fluridone usually disappears from pond water after about 3 months but can remain up to 9 months. It may remain in bottom sediment between 4 months and 1 year.

Glyphosate

Glyphosate is not applied directly to water for weed control, but when it does enter the water, it is bound tightly to dissolved and suspended particles and bottom sediments and becomes inactive. Glyphosate is broken down into carbon dioxide, water, nitrogen, and phosphorus over a period of several months.

Algaecide treatments for filamentous algae

Copper-based compounds are generally used to treat filamentous algae. Common chemicals used are copper sulfate and Cutrine Plus, a chelated copper algaecide.

Herbicide use to manage invasive species

Curly leaf pondweed

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies 3 herbicides for control of curly leaf pondweed: Diquat, Endothall, and Fluridone. Fluridone requires exposure of 30 to 60 days, making it infeasible to target a discreet area in a lake system. The other herbicides act more rapidly. Herbicide labels provide water use restriction following treatment. Diquat (Reward) has the following use restrictions: drinking water 1 to 3 days, swimming and fish consumption 0 days. Endothall (Aquathol K) has the following use restrictions: drinking water 7 to 25 days, swimming 0 days, fish consumption 3 days.

Early season herbicide treatment:[19]

Studies have demonstrated that curly leaf can be controlled with Aquathol K (a formulation of Endothall) in 55 to 60 degree F water, and treatments of curly leaf this early in its life cycle can prevent turion formation. Staff from the Minnesota Department of Natural Resources and the U.S Army Engineer Research and Development Center are conducting further trials of this method. Balsam Lake (Polk County, Wisconsin) treated 2 sites totaling 13 acres in early June of 2004, and will follow up with ongoing treatment and monitoring of the effectiveness of this method.

[19] Research in Minnesota Control of Curly Leaf Pondweed. Wendy Crowell, Minnesota Department of Natural Resources. Spring 2002.

Because the dosage is at lower rates than dosage recommended on the label, a greater herbicide residence time is necessary. To prevent drift of herbicide and allow greater contact time, application in shallow bays is likely to be most effective. Herbicide applied to a narrow band of vegetation along the shoreline is likely to drift, rapidly decrease in concentration and be rendered ineffective.[20]

Eurasian water milfoil
The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies the following herbicides for control of Eurasian water milfoil: complexed copper, 2,4-D, diquat, endothall, fluridone, and triclopyr. Early season treatment of Eurasian water milfoil is also recommended by the Department of Natural Resources to limit the impact on native aquatic plant populations. The choice for treatment at these lakes for this plan will be 2,4-D used in an early season application.

Shoreland restoration

Shallow areas of lakes are very important to the lake ecosystem. About 90% of the fish, amphibians, insects, birds and other lake dwelling wildlife around found in the shallow areas and nearshore areas of the lake. There is significantly more diversity of living organisms in the shoreline area of a lake than the upland areas. Shoreland plants provide food and habitat for aquatic life. They also help prevent erosion through reduced wave energy as well as reducing runoff from the watershed. These plants help filter pollutants, including excess nutrients that would be available for excessive algae growth.

Shoreland buffers help protect the water quality of the lake and maintain consistent habitat. A buffer can reduce flow of water into the lake from the surrounding land, help facilitate infiltration of the water into the soil. This infiltration can help recharge ground water in addition to reducing soil erosion which can significantly increase sedimentation of the lake. Native herbaceous plants, shrubs and trees help stabilize soil which will reduce nutrient loading due to phosphorus into the lake. In addition, invasive species tend to flourish in disturbed areas. Removal of native plants and continued disturbance through weeding and mowing only increase the opportunity of undesirable plants.

When riparian owners develop near shorelands with structurs, driveways, garages, boat houses, decks, piers and other structures disturbances can be significant. These include soil compaction, removal of native plants and trees, as well as reducing infiltration of water through the increased use of impervious surfaces (such as concrete). These practices can result in decreased habitat and increased nutrient loading, resulting in a declining lake quality. Numerous activities such as these listed on a lake can be extremely detrimental. No only is the water quality affected but fish can be adversely affected. Warm run-off can reduce oxygen levels for fish. Sediment can reduce visual acuity for fish relying on sight for feeding, sediment can cover important spawning substrate reducing fish recruitment.

Shoreland restoration entails returning disturbed shoreland back to native vegetation, shrubs and trees. Restoration can also include infiltration devices such as rain gardens.

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[20] Personal communication, Frank Koshere. Wisconsin DNR. March 2005.

Below the definition is in detail.

DEFINITIONS
Natural shoreland restoration, shoreland habitat restoration, and shoreland/shoreline buffer restoration are frequently used interchangeably. They all refer to restoring the natural characteristics of the area near the water by planting native vegetation or allowing it to grow. Shoreland habitat restoration is the term used in state standards for restoring native vegetation. Shoreland buffers or vegetation protection areas are the terms used in county shoreland ordinances to refer to areas required to remain in native vegetation or to be restored to native vegetation. Shoreland buffers generally extend from the ordinary high water mark inland at least 35 feet nearly the entire length of the shoreline. They allow for an opening or view corridor for access and views to the lake. Standards for shoreland buffers vary by county and are explained in county shoreland ordinances.

Natural shoreline restoration may also involve smaller areas of native plantings that may be less deep and cover a lower percentage of the shoreline length.

Shoreland restoration assistance can come from many entities. Oneida County has conservation professionals that can help evaluate a site and assist in planning restoration projects. Some lake organizations provide assistance in the form of guidebooks and brochures. There are several professional landscapers that specialize in shoreland restoration that can plan restoration projects for various sites. Professional assistance is typically provided through cost assistance programs. These programs may include incentives through cost share programs, tax incentives or coupons. Presently MKPLA is implementing an incentive program through a Wisconsin DNR grant. More incentives such as this may be warranted to help increase shoreland restoration.

Wisconsin Healthy Lakes Initiative

The Wisconsin DNR is now providing funding for the Healthy Lakes Initiative. The program provides a 75% state share (up to 10% for technical assistance), with a 25% match, up to $25,000 for projects outlined in the initiative. Projects include: Native plantings, fish sticks, diversion practices, rock infiltration practices and rain gardens.

Historical Plant Management

Chemical treatment for aquatic plants in these lakes has a long history. Chemical control of plants in Kawaguesaga and Minocqua Lakes dates back to 1967. During these early years, records indicate a few private riparian owners (largely resorts and camps) treated plants mainly for swimming use. No pre and post treatment surveys were conducted, as they were not utilized during this time. Acreage was quite limited in coverage with no areas listed greater than an acre[21]. As a result the long-range impact, if any, has not been established. In addition, the target species were not indicated, and one might assume it was plant reduction in general and not to specifically treat invasive species.

[21] Records provided by Wisconsin DNR, Rhinelander Office. Reviewed January, 2008.

In July 2005 after Eurasian water milfoil was determined to be present, a permit was granted to chemically treat 25.5 acres for EWM on Kawaguesaga Lake and Minocqua Lake. The treatment was with 2,4-D at the locations highlighted on the map below.

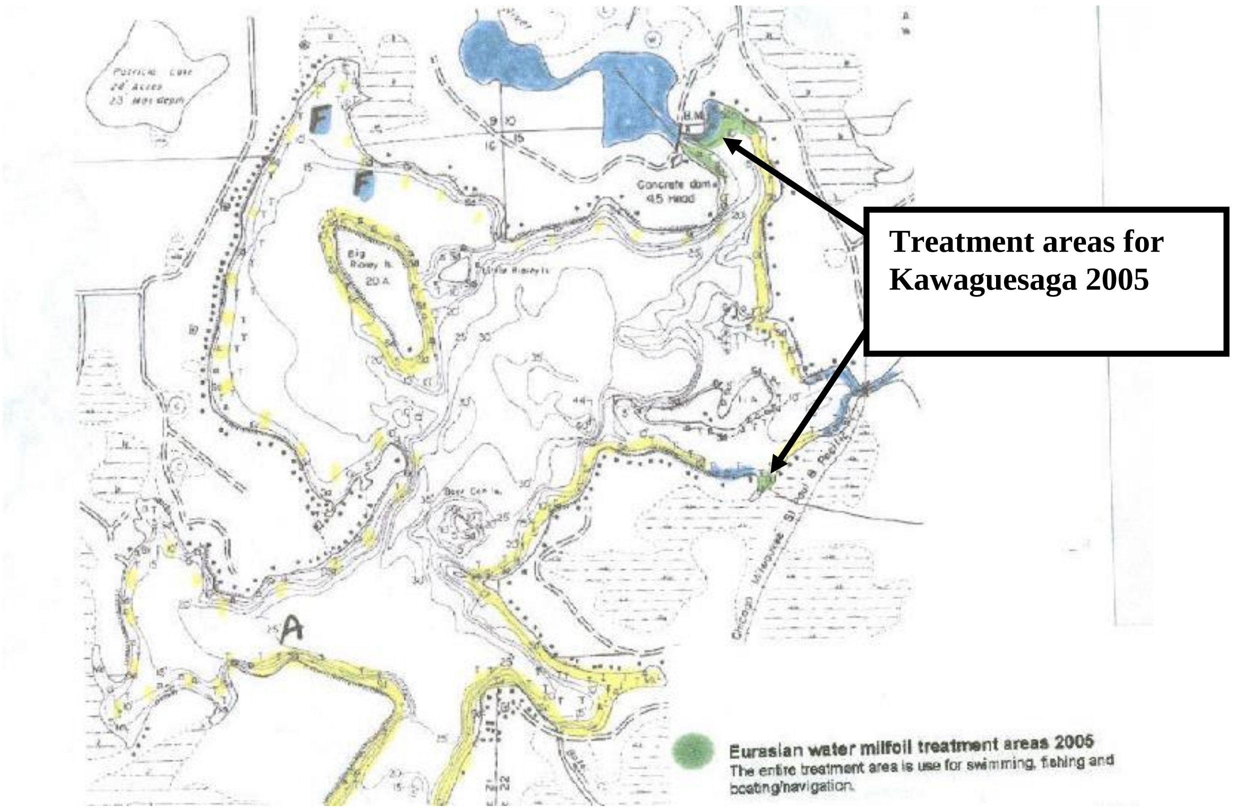

Figure 32: Map of EWM treatment locations-Kawaguesaga Lake, 2005

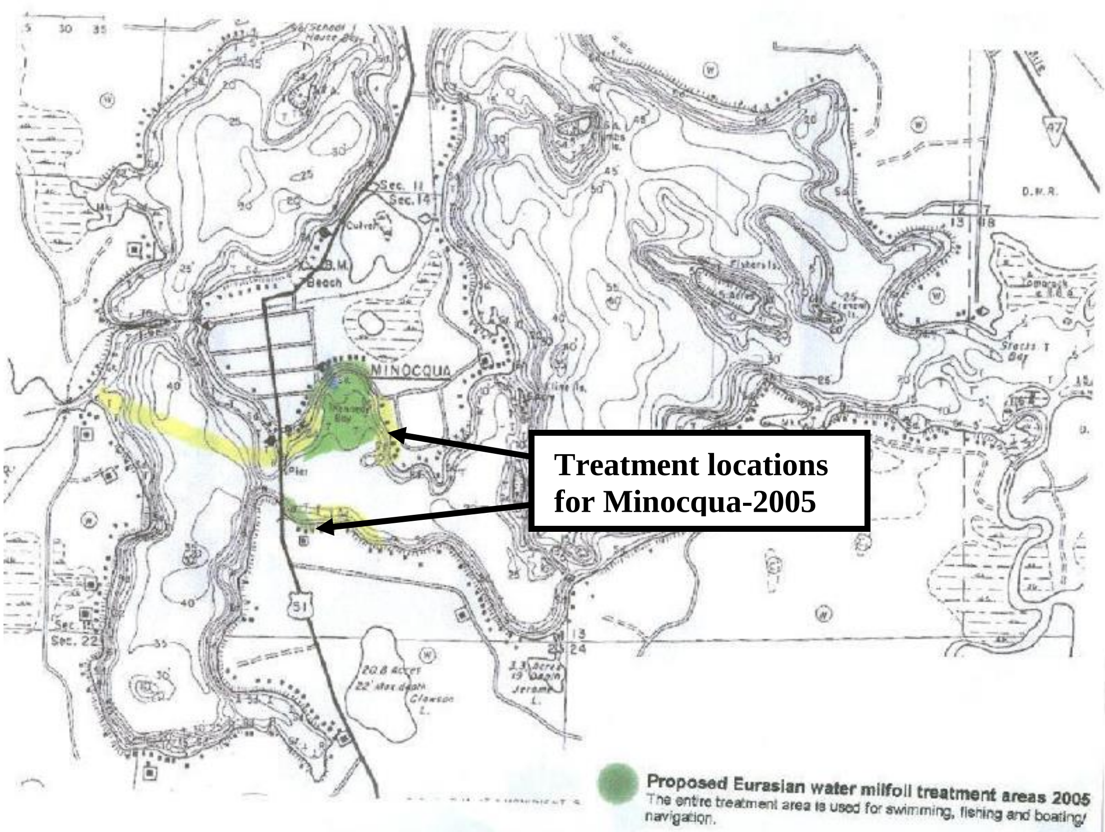

Figure 33: Map of EWM treatment locations-Minocqua Lake, 2005

A letter in the treatment file from the Lake Association described the treatment as successful, reducing EWM by 95 to 99% based on a post treatment survey[22]. However, it did not indicate the protocol for the survey or any data to substantiate this claim. Therefore, there is no data to support or not support his claim.

In June 2006, another permit was issued. This permit was for the treatment of 0.7 acres near the Kennedy Bay boat landing. Again the target species was EWM. In July 2007, a 0.5 acre treatment in front of the same boat landing was permitted.

Summary of EWM treatments:

Date	Location	Acres	Chemical Applied
5/2005	Various (see Figure 30 &31)	25.5	2,4-D 100 lbs/acre
5/2006	Various (see figure 32)	21	2,4-D (application rate unknown)
6/2006	Kennedy Landing	0.7	2,4-D (application rate unknown)
7/2007	Kennedy Landing	0.5	2,4-D (application rate unknown)
4/2008	Various	12	2,4-D early season at application rate outlined in this plan

[22] Letter to Mr. Kevin Gauthier, Wisconsin DNR from Minocqua-Kawaguesaga Lakes Protection Association. January 12, 2006.

After 2008, MKPLA started following the Wisconsin DNR herbicide management evaluation protocol. This evaluation involves completing a pretreatment survey, which verifies the presence of the AIS and allows for adjustments to the treatment polygons. This is followed by a post treatment survey that is conducted several weeks later to determine the frequency and density after treatment. These frequencies and densities are then compared to this same data that was collected the previous year in the treatment beds. A chi-square analysis is also conducted to determine if any changes (hopefully a decrease) are statistically significant. The native plants species are also evaluated from the 2 annual surveys to determine if any adverse effects on the native plants have occurred.

Figures 34 and 35 show the historical treatment areas after 2008 to 2015 in Minocqua Lake and Kawaguesaga Lake.

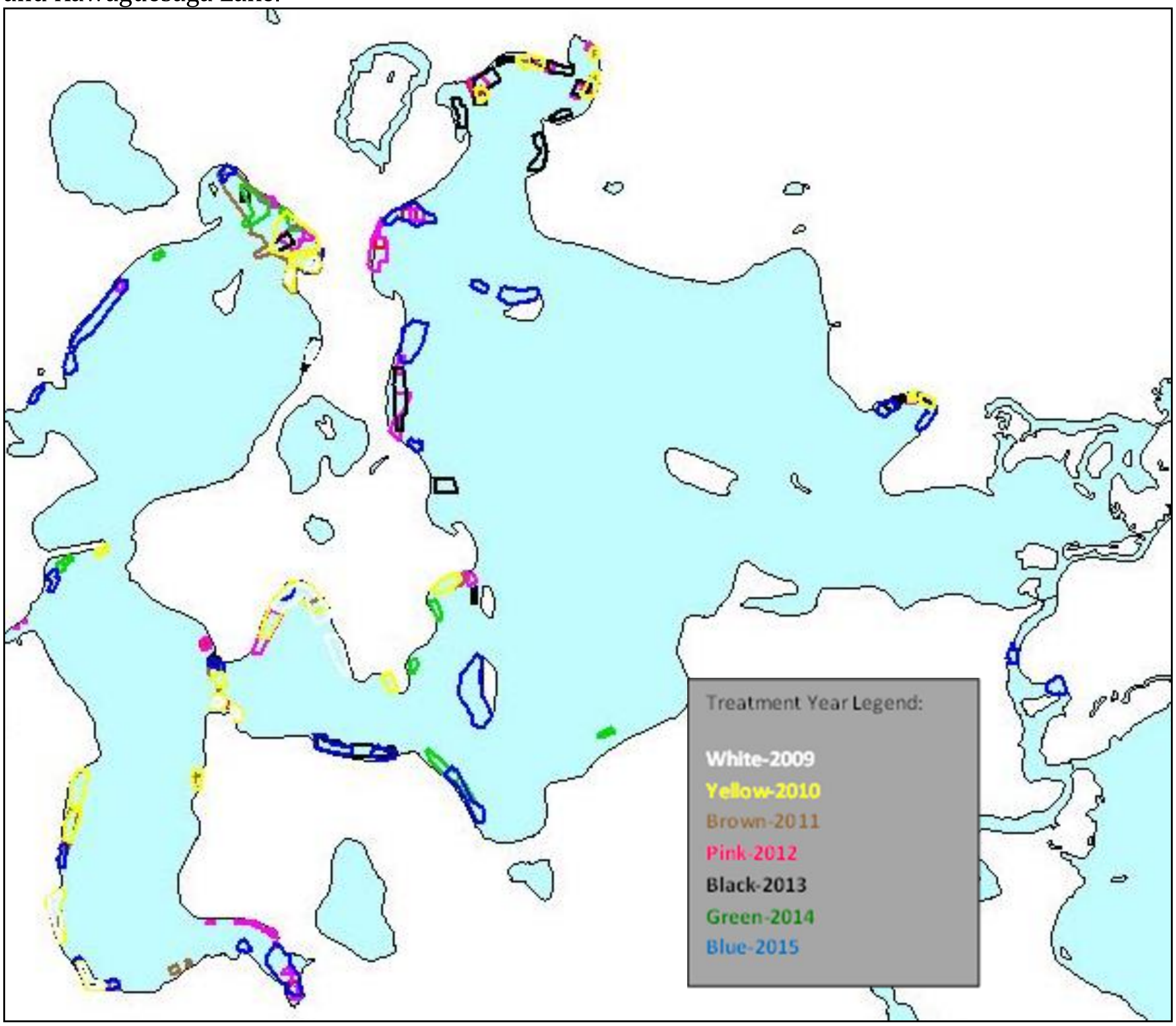

Figure 34: Historical herbicide treatment beds on Minocqua Lake, 2009-2015.

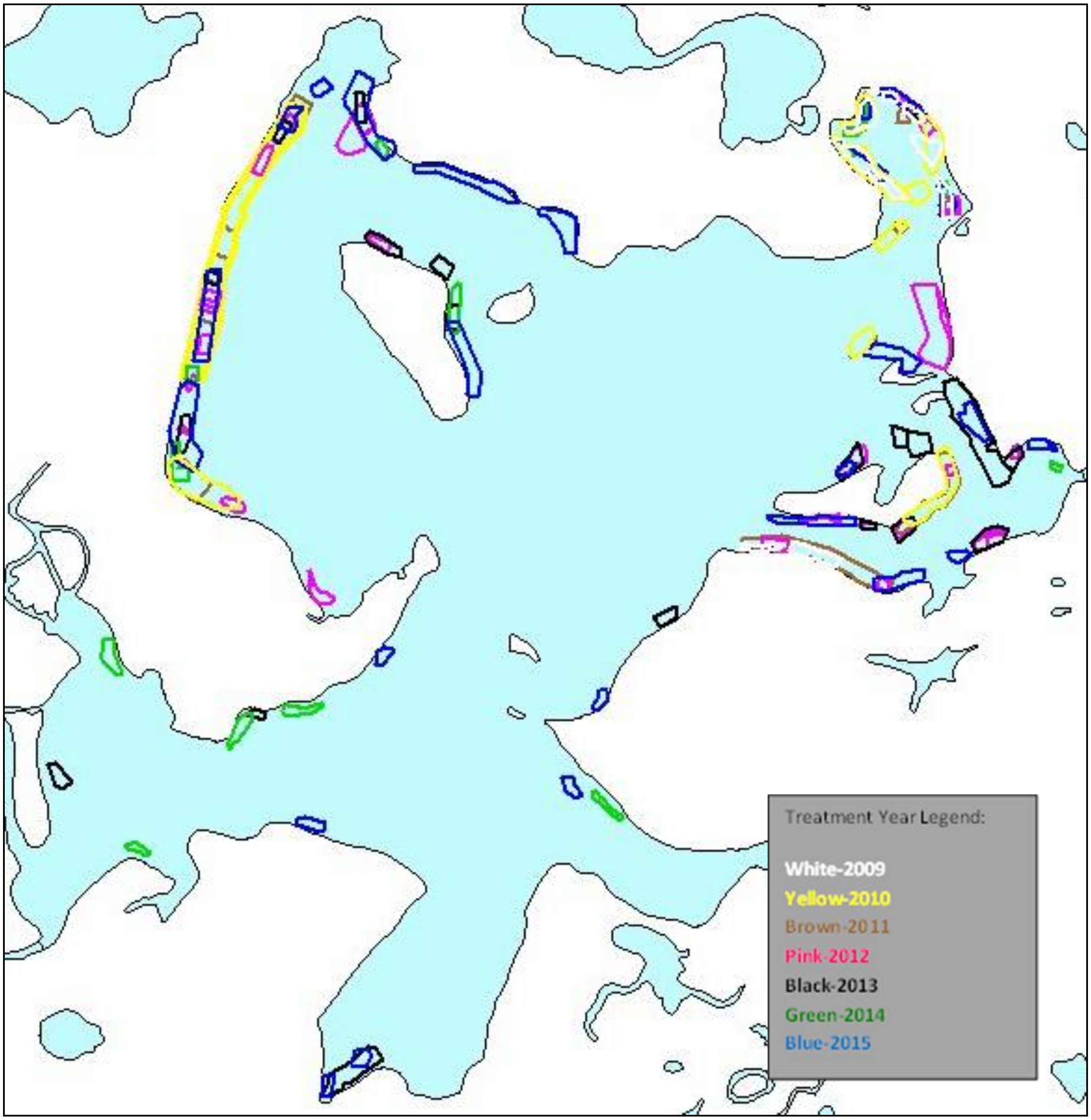

Figure 35: Historical herbicide treatment beds on Kawaguesaga Lake, 2009-2015.

Year of treatment	Treatment acres(includes 20ft buffer)	% reduction Pre vs post	Stat. sig?	density	success by APMP?	Native species reduction (#dicots)
2008	2.7	19	no	1.82	no	0
2009	16	40	yes	1.07	no	0
2010	47.33	67	yes	0.65	no	0
2011	40.98	80	yes	0.09	no	6 (2)
2012	33.52	79.5	yes	0.2	no	3(1)
2013	29.59	91.2	yes	0.07	yes	1(0)
2014	10.85	74.1	yes	0.24	no	0
2015	51.26	80.2	yes	0.20	no	1(0)
Total	232.23					

Table 18: Summary of treatment area, reductios and impact on native species, both lakes 2009-2015.

The effectiveness has been varied over the years with only one treatment year where, overall, the reduction in EWM was not statistically significant on both lakes (2008). The 2007 APMP goal was to reduce the EWM by 90% after treatment, and although the reductions were quite high each year, only 1 year (2013) was this accomplished. This goal may need to be revisited, as it may not be realistic as demonstrated by the historical results.

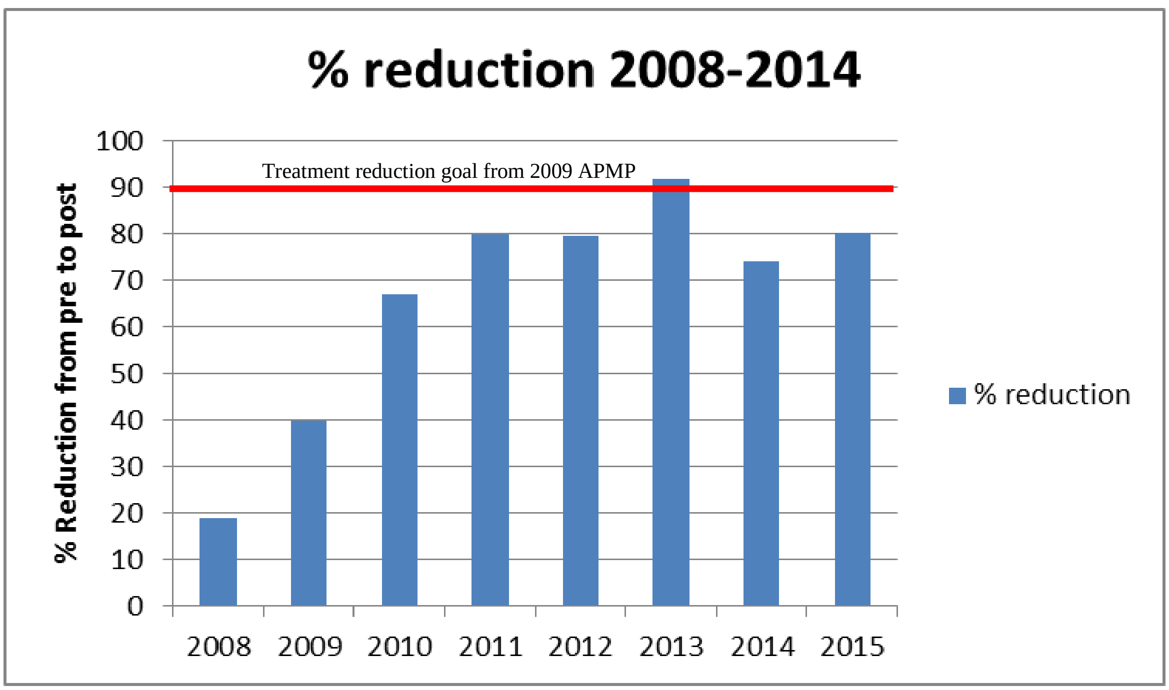

Figure 32: Graph showing the frequency reduction for each year 2008 to 2015 for both lakes.

The density goal for the 2007 APMP was to have the density maintained below a mean of "1" after treatment. After 2009, this goal was met each year. Figure 37 shows the mean density rating after each herbicide treatment within the treatment beds.

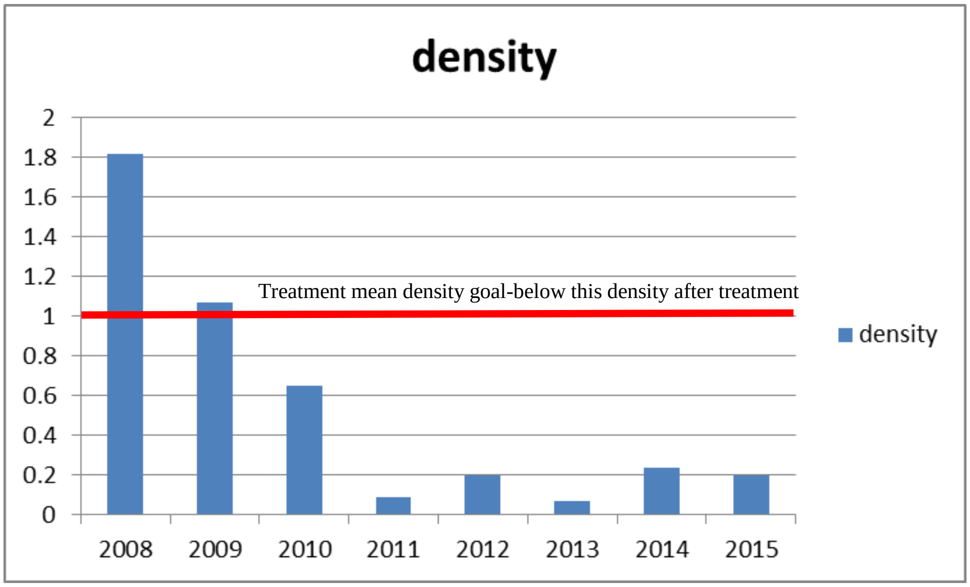

Figure 37: Graph showing the density of EWM after treatment each year 2008-2015.

Weevil augmentation review

In 2008, Use of weevils (*Euhrychiopsis lecontei*) to manage EWM was started on Minocqua Lake and Kawaguesaga Lake. Due to lack of effective reduction, all weevil sites were treated with herbicide by 2013. This transfer started in 2011 with weevil bed S5. Tables 17 and 18 show frequency and density data, and it is clear the weevil augmentation was not effective at reducing EWM. There was also concern that the thick, dense weevil beds may have contributed to spreading of EWM. There is no data to support this concern, but each year EWM spread to numerous new locations.

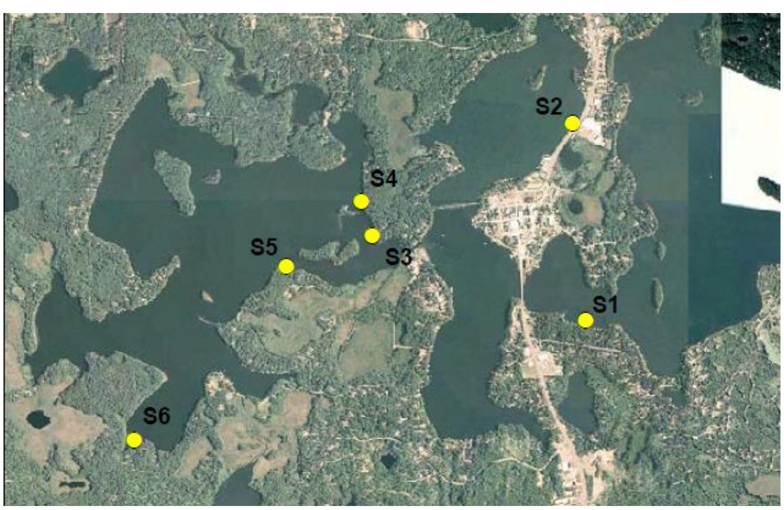

Figure38: Weevil augmentation sites on Minocqua and Kawaguesaga Lakes.

Weevil Site	2008 Freq	2010 Freq	2011 Freq	2012 Freq
S1	1.0	1.0	0.40	1.0
S2	1.0	1.0	0.43	0.75
S3	1.0	1.0	0.86	0.90
S4	1.0	0.89	0.89	herbicide
S5	1.0	1.0	herbicide	n/a
S6	1.0	0.75	1.0	1.0
All	1.0	0.91	0.62	0.93

Table 19: Frequency data of EWM from weevil augmentation beds from 2008-2012.

Weevil Site	2010 Mean density	2011 Mean density	2012 Mean density
S1	1.7	0.5	2.0
S2	2.25	0.43	1.0
S3	2.33	2.5	2.3
S4	2.0	2.0	Herbicide applied
S5	2.58	Herbicide applied	n/a
S6	1.2	1.4	2.6
All	1.91	1.13	2.11

Table 20: Mean density data of EWM from weevil augmentation beds from 2010-2012.

Diver removal history

Beginning in 2010, divers have been employed to remove EWM from low density areas and from herbicide treatment beds where EWM remained several weeks after treatment. This program has continued until present, and data was collected each year since 2011, except in 2012 where the divers provided no data. In 2014, the data collection protocol changed, but that data was manipulated to allow a comparison to the previous years. For 2014 and 2015 (not shown here), a stem count before diver removal and a stem count after removal is being used to evaluate the diver removal success. The reduction in stem counts (by percent) was used to estimate the aerial coverage reduction for comparison purposes. From 2014 and beyond, the data will be stem count reductions.

Year (reduction by aerial coverage)	20-60% reduction	60-79% reduction	80-100% reduction	Mean % reduction all sites	Estimated Mass removal(wet mass)
2010	*not recorded*			*n/a*	
2011	4 sites	8 sites	19 sites	79.6%	
2012	*not recorded*			*n/a*	
2013	10 sites	6 sites	36 sites	82.2%	5815 lbs*
2014	10 sites	6 sites	12 sites	67.5%	6136 lbs*
2015		6 sites	20 sites	84%	3917 lbs*

**Estimated wet mass based upon volume of EWM removed. The method was changed in 2015.*

Table 21: Diver reduction summary from 2010 to 2014.

As table 19 shows, a diver removal has an impact in the reduction of EWM. This method has allowed control of EWM in small areas where herbicide application is not warranted and to augment the control in herbicide beds that did not respond well enough to treatment.

Management Recommendations

Minocqua Lake and Kawaguesaga Lake have diverse aquatic plants communities that are important to preserve. There are no plant nuisance concerns in the lake at this time. The lakes have substantial developed areas with heavy use in the lake both by residents and non- residents. For these reasons, management of AIS, as well as preserving the native plants, is important and is considered in the management goals and objectives contained within this plan.

There are several invasive species present in Kawaguesaga Lake and Minocqua Lake. Curly leaf pondweed has decreased without management since 2007 and is not a concern or priority. Flowering rush is spreading immensely compared to 2007, and these beds should be mapped and monitored, as well has some management. Purple loosestrife management using biocontrol is ongoing and should continue. Yellow iris mostly occurs in the thoroughfare and will be monitored. Eurasian watermilfoil is the invasive species that management is focused.

Plant Management Goals:

Goal 1: Control the expansion of Eurasian watermilfoil in Minocqua Lake, Kawaguesaga Lake and the Thoroughfares.

Goal 2: Preserve the native plant community in Kawaguesaga Lake and Minocqua Lake.

Goal 3: Prevent the introduction of new invasive species and develop a rapid response plan if such an introduction should occur.

Goal 4: Monitor other existing aquatic invasive species such as purple loosestrife, curly leaf pondweed, flowering rush and yellow iris.

Goal 5: Restore native shoreline vegetation.

Goal 6: Preserve and/or enhance water quality.

Goal 7: Provide extensive education on lake ecology.

Goal 1: Control the expansion of Eurasian watermilfoil in Minocqua Lake, Kawaguesaga Lake and the Thoroughfares.

Eurasian water milfoil has been growing in these lakes for several years. The management in previous years has been relatively aggressive. The EWM has spread over the course of this management (see 2007 and 2014 PI survey comparisons), but in most growing seasons, the growth is limited to broken clumps of plants rather than dense, monotypic beds (after herbicide treatment). Typically, treatment areas have been effectively reduced with most of the subsequent year's treatment (some areas have needed herbicide treatment years later) needed in new areas (see treatment history data from previous section). This has shown that EWM often spreads to new areas even after effective treatments. From this history, MKPLA is concerned about EWM reaching high density in large areas and spreading of EWM within the lakes. After careful discussion and evaluation, it has been determined that management should continue to control expansion of EWM as much as possible and to keep the EWM at a low density in areas it does grow. The most effective and most economical methods will be utilized and the effect on the ecology of the lake will be used in all management decisions. Figures 39 and 40 show areas of concern based upon historical treatment needs.

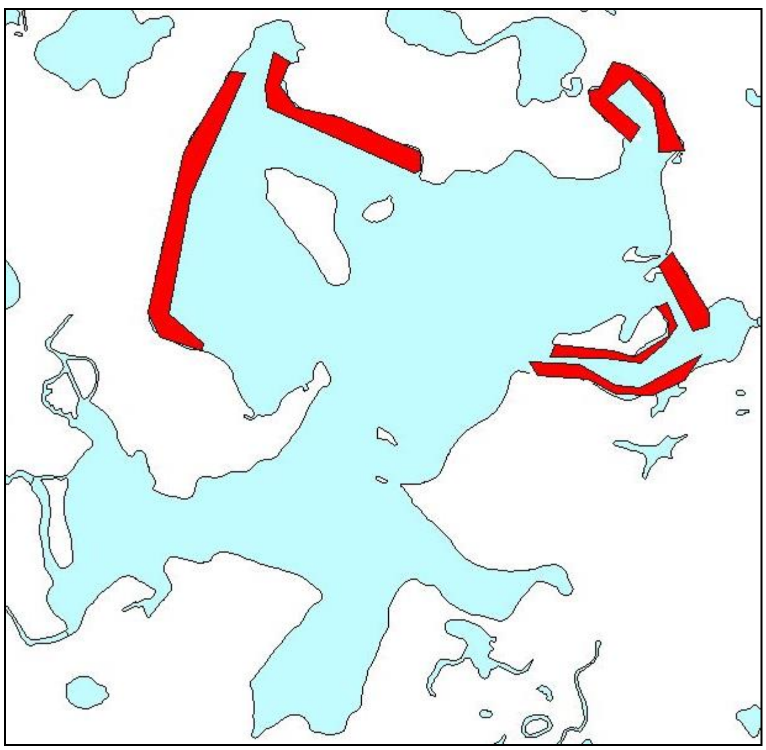

Figure 39: Map showing areas of historical Kawaguesaga Lake EWM herbicide treatment sites. This map allows for the designation of areas of high concern based upon repeated treatment.

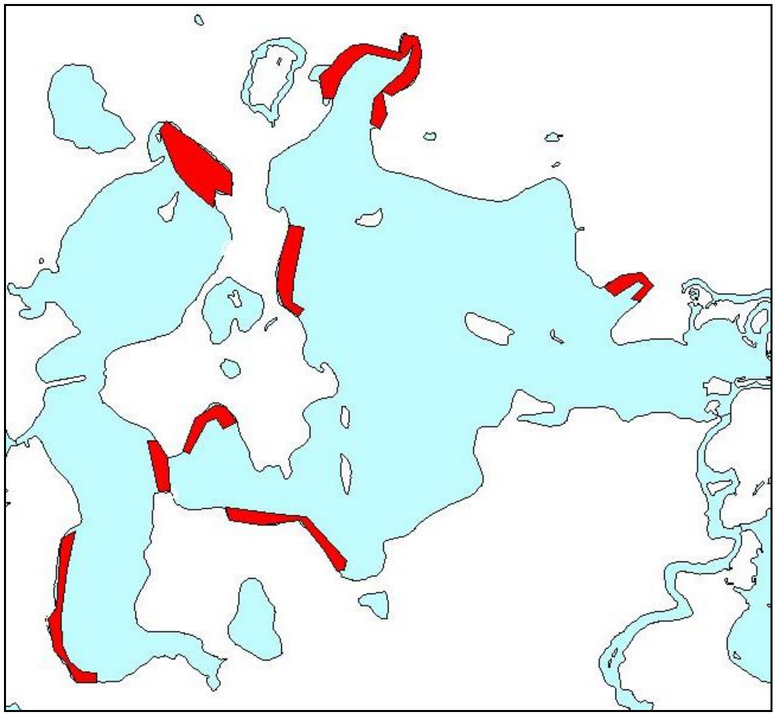

Figure 40: Map showing historical areas of Mincoqua Lake EWM herbicide treatment sites. This map allows for the designation of areas of high concern based upon repeated treatment.

The Minocqua/Kawaguesaga Lake Protection Association (MKLPA) is concerned about protecting the lake ecosystem. It recognizes that as more research becomes available about the measured potential negative effects of herbicide, use of herbicide may be adjusted based upon that research. At the time of this plan development, the Association would like to continue using herbicide to control EWM beds, realizing that small beds are not as effectively reduced as large beds. Analysis of herbicide use on small beds in Minocqua/Kawaguesaga has shown that effectiveness has been acceptable in many beds treated based upon pre and post treatment analysis. It is understood that large beds have more consistent reduction results from herbicide use than do small beds. The Wisconsin DNR indicates that larger scale treatment (> 10 acres) seem to have more consistent reduction from herbicide use (based upon data collection in many EWM treated lakes)(Nault et al, 2015). MKPLA is concerned about allowing EWM beds to becoming larger than 10 acres before treatment as spreading of EWM is of great concern and has been an issue during EWM management the past several years..

Objective 1.1: Herbicide (2,4-D) will be used to control larger, dense beds to reduce coverage of EWM to 10% (or less) and density to less than "1" within treatable beds. Control goal will include aerial coverage of EWM less than five acres with a mean density <1 in August of each growing season.

A "large dense bed" is defined as follows:

1. A minimum aerial coverage footprint of 0.1 acres (with a 20 ft buffer added to the treatment area to improve coverage of herbicide and account for location error).
2. A mean density from all sample points within the footprint of greater than 1.5.

3. A frequency of occurrence from all sample points within the footprint of greater than 60%.
4. A specific sample grid within each footprint will be generated for sampling as outlined in the pre/post sampling protocol, and all sample points will be used to institute the standards listed.

Sample grid protocol:

1. All sample points will be evenly distributed within the polygon with the edge points within 2 meters of border, spaced approximately 20m X 20m and at a 45 degree angle from north.

2. All sample points will be sampled and used for calculations of freq. and density.

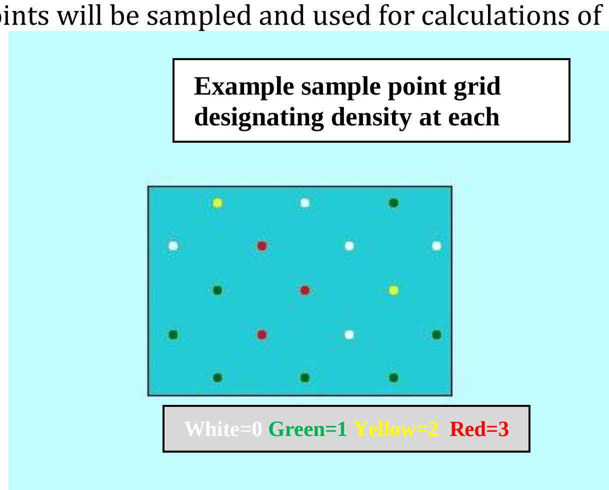

Figure 41: Example sample grid to demonstrate using frequency and density to evaluate the EWM beds for treatment.

In addition, smaller "spot treatments" will be considered on beds of EWM smaller than 0.1 acres, but larger than 0.05 acres. Consideration of the smaller beds will depend on the density, development of shoreline, and lake traffic when deciding to treat or not. MKPLA is concerned that herbicide resistance could occur over time[23] and will use spot treatment with caution and consider alternative herbicide if warranted.

Objective 1.2: Herbicide treatment will be considered on beds ranging from 0.05 acres to 0.1 acres that have a mean density >2.0 and an aerial coverage >75% within the footprint. The beds that are in high traffic areas and/or adjacent to riparian owner piers will be of higher priority.

Action 1.1a-An early season herbicide application of up to 4ppm of 2,4-D (as determined by Wisconsin DNR and applicator) will be applied when plant level water temperatures are 50 to 60 degrees F. *(A 20 foot buffer will be added to treatment polygon to account for GPS error and increase herbicide efficacy.)* In smaller beds, the use of the herbicide diquat may be considered. The Wisconsin DNR will be consulted in determining if this herbicide should be in any treatment.

[23] In a personal communication with Scott Van Egeren (Wisconsin DNR) concern over the development of herbicide resistance was expressed.

Use of herbicide with regard to fisheries-Any treatment that is within an area the musky are suspected to spawn will be evaluated and potentially avoided. Since musky spawn within vegetation during similar water temps as when treatments typically are conducted, the herbicide could adversely affect the fish. There were 2 areas listed in the sensitive area survey on Minocqua where musky are suspected to use for spawning. These are in School House Bay, where EWM has been treated with herbicide numerous times. The other is Stack's Bay in the far eastern bay where the Minocqua and Tomahawk Thoroughfares come into Minocqua. There has been no EWM detected or treated in this area but is good habitat for EWM. Potential treatment areas should be evaluated by a DNR fisheries biologist.

In addition, recent research indicates that 2,4-D formulations can have an adverse effect on fathead minnow reproduction and larval survival (DeQuattro and Karasov, 2015. This may indicate that the use of various formulations can negatively affect fish recruitment.

Figure 42: Aerial view of two potential musky spawning locations as indicated by the Wisconsin Dept. of Natural Resources sensitive habitat survey.

A MKPLA unlisted goal for herbicide use is to be able to manage EWM in future years through the use of divers/hand pulling only and no need for herbicide application. Since the effectiveness of small bed herbicide application is quite variable and long-term use of herbicides is a concern, hand pulling is a more desirable method for EWM reduction. Large areas of EWM are not conducive to diver hand pulling as it is labor intensive, so this method will be limited to smaller areas that are not treated with herbicide.

Objective 1.2-Areas of EWM that do not meet herbicide treatment will be reduced using hand pulling techniques that are most effective and most economical. Reduction in 50% density from prior to hand pulling will be the goal reduction.

In the past 4 years, the MKPLA has been utilizing divers (snorkel and possibly SCUBA in future) to hand pull EWM in lower density areas of growth. This technique has been found to be quite effective at reducing EWM in these areas. Another method, known as DASH (Diver Assisted Suction Harvest), is being utilized by some other lake organizations. This method involves using a suction system in which SCUBA divers use to remove plants that are propelled up to the surface into a catch system in a boat. This method will be evaluated in terms of effectiveness and costs in comparison to the present method MKPLA is using. If the DASH method is more effective in terms of cost and reduction of EWM, then MKPLA will potentially pursue this approach.

Action 1.2a- Divers will be utilized to remove EWM from areas of growth not qualifying for herbicide treatment. Pre and post hand removal surveys will be conducted to evaluate the EWM removal effectiveness.

In order to evaluate the effectiveness of hand pulling (regardless of method) the following protocol will be followed:

1. Prior to diver removal of EWM, a 14 tine survey rake will be lowered into the EWM location, turned 3 full rotations, pulled straight up and the number of EWM stems will be counted and recorded. Caution will be used to remove all EWM fragments from sampling.
2. This will be repeated in locations throughout the EWM growth area approximately 20 feet apart.
3. A survey will be repeated at the same locations (using GPS) after diver removal. The reduction in stems per rake sample will be calculated.
4. Divers will measure removed EWM volume in known sized containers. An established standard of mass/volume will be used to complete a mass calculation to quantify wet EWM mass removed.

Action 1.2b-DASH will be evaluated and compared to the present diver system to determine if a more effective method. This evaluation will be completed by 2017.

The spread of EWM in these waters is a large concern. There are many sporadic coverage areas of EWM. It is unknown if these colonies are sporadic because they are newly established or because the natives may be competing with the invasive species. As a result, monitoring of new areas as well as maintaining a robust native plant community is paramount.

Objective 1.3: A volunteer monitoring team will be established and implement periodic monitoring of the lakes for EWM in 5 regions on Minocqua Lake and 4 regions on Kawaguesaga Lake.

Action 1.3a-Volunteer monitors will be trained in the identification of EWM and monitoring techniques. After training, the monitors will survey once in July and once in August in their region. This information will be shared with a professional surveyor to evaluate the same areas for reduction method determination.

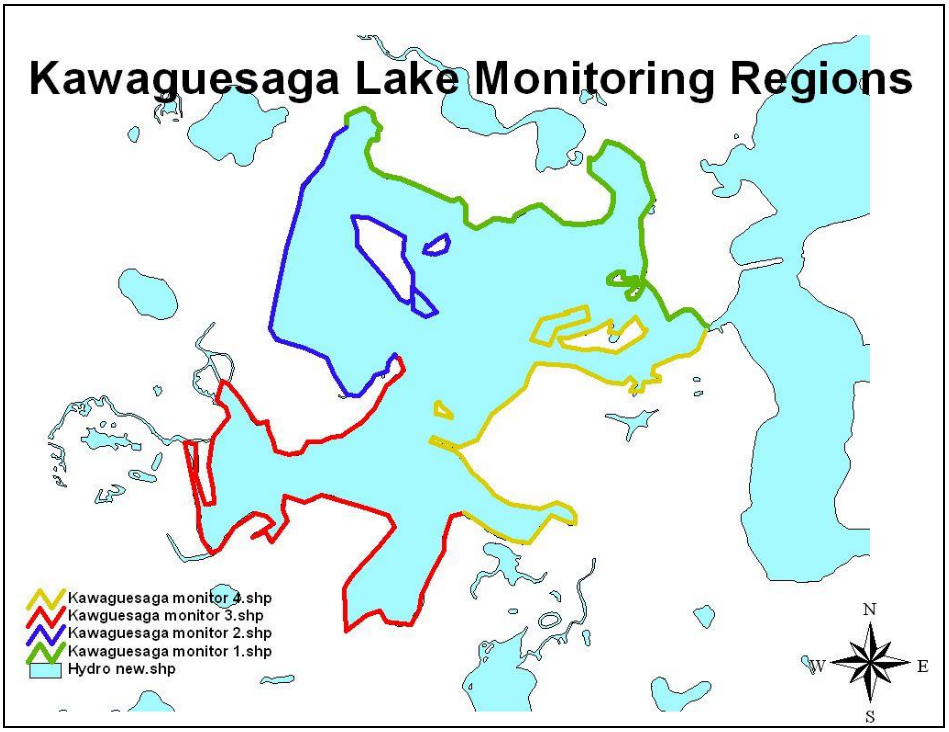

Figure 43: Monitoring regions for AIS on Kawaguesaga Lake.

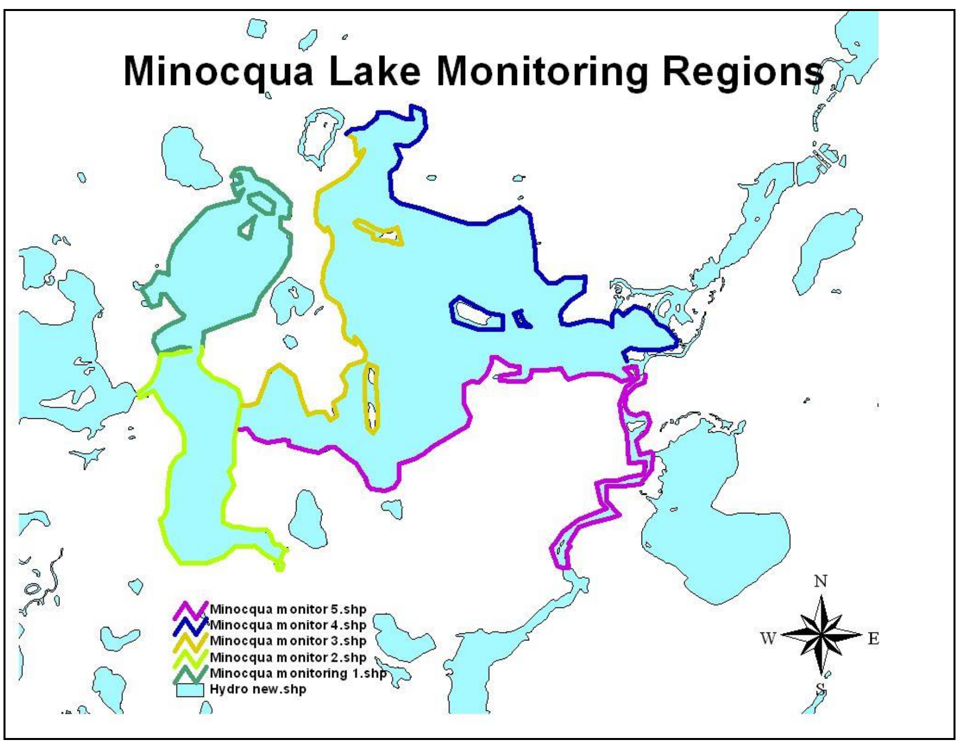

Figure 44: Monitoring regions for AIS on Minocqua Lake.

Goal 2: Preserve the native plant community in Kawaguesaga Lake and Minocqua Lake.

Kawaguesaga Lake and Minocqua Lake have high native plant diversity. This diversity is important for maintaining a healthy lake ecosystem. The Minocqua/Kawaguesaga Lake Protection Association recognizes the importance of preserving this native community. The 2014 macrophyte survey revealed a significant reduction in several native species (see plant community section of this plan on starting on p. 19). The cause of these reductions is not known, but needs to be considered in future lake management.

Objective 2.1-Native plants will be monitored within the herbicide treatment beds (for EWM). The frequency of occurrence of each native species sampled will be compared before treatment (August/September prior to year of treatment) and after treatment (August year of treatment). Number of native species and FQI will also be determined to evaluate any negative impacts.

Action 2.1a-Proper surveys (based upon Wisconsin DNR protocol) will be conducted to delineate and determine frequency of occurrence of EWM and density. These surveys will be conducted as follows:

Spring-Pretreatment survey to verify presence/absence of EWM within treatment polygons.

August/Sept-Post treatment evaluating frequency, density of EWM and native plants within treatment polygons. A chi-square analysis will be calculated to determine significance of any reduced native species.

August/Sept.-Delineation of treatment beds for the next year (if needed). These delineated beds will be the beds managed the following season.

Objective 2.2-MKLPA will implement methods to help maintain a healthy native plant community leading no reduction in FQI, native species richness and Simpson's diversity index in the 2020 macrophyte point intercept survey (as compared to 2014 survey).

To help facilitate this protection, the Association will implement the following:

- Extensive public education about the importance of the plant community to the lakes.

- Encourage riparian owners to protect native plant beds in front of their property by not removing native plants.

- Monitor invasive species spread into native plant communities.

- Conduct management practices for invasive species that target those species with minimal impact on native species. This includes early season herbicide treatment when water temperatures are 50 to 60 degrees F and targeting invasive species only in reduction efforts. Only trained divers will conduct hand pulling.

Action 2.1a-A point intercept survey will be conducted in June (early CLP) and August[24] 2018 to evaluate changes in native species (as well as invasive species). The data will be compared to the 2007 and 2014 point intercept surveys.

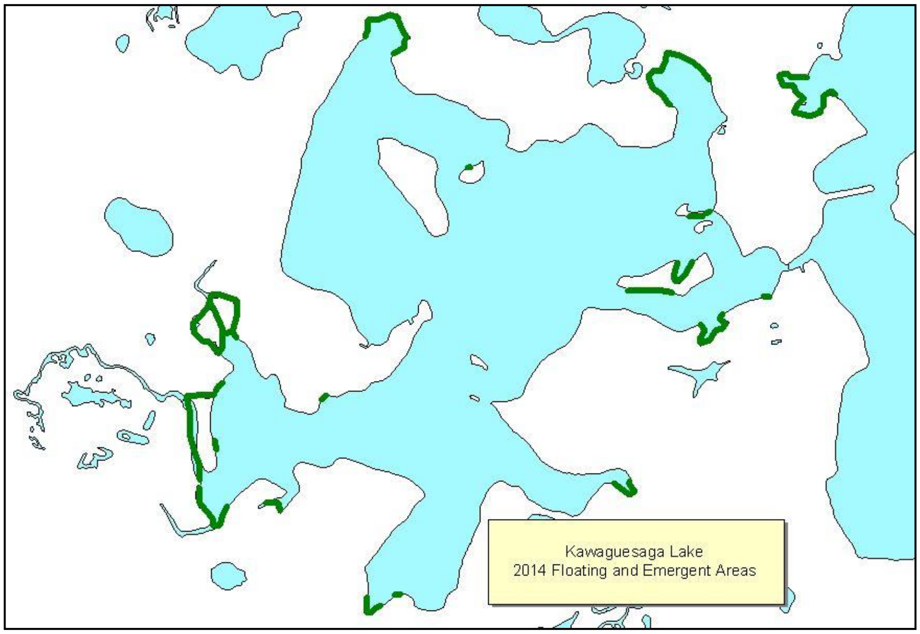

Figure 45: Map of floating-leaf and emergent plant areas in Kawaguesaga Lake.

Figure 45 shows the areas of Kawaguesaga Lake that have floating leaf plants and where emergent plants were sampled. These areas provide important fish, wildlife, and bird habitat. Every effort should be used preserve these important areas. These efforts could include educating residents and lake users about their importance, the need for preservation, and to avoid herbicide applications in or near these areas. The areas highlighted in Figure 45 would be a good consideration as sensitive habitat.

[24] The 2007 and 2014 PI surveys were conducted in early July. One concern in 2014 was a very late growing season in the lake, which could affect the results. An August survey could reduce those growth variations and better reflect the actual diversity at peak growth.

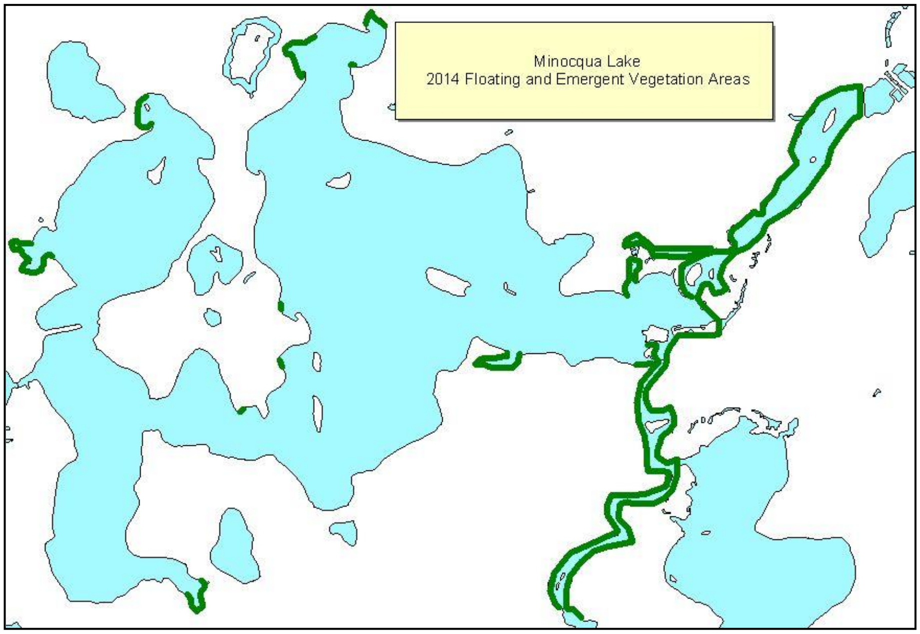

Figure 46: Map of floating-leaf and emergent plant areas in Minocqua Lake.

Figure 46 maps the floating/emergent vegetation beds in Minocqua Lake. These areas should be preserved in any management strategies. Some of these emergent plants are flowering rush, which is an invasive species. These plants can and should be removed be hand when possible.

Goal 3: Prevent the introduction of new invasive species and follow a rapid response plan if such an introduction should occur.

Although a few different invasive species are present in Minocqua and Kawaguesaga Lakes, introduction of more invasive species (such as Hydrilla or Starry Stonewort) could be detrimental to the ecosystem. For this reason, a response protocol will be followed should an introduction occur. In addition, a Clean Boats/Clean Waters has been ongoing and will continue. The landings will be checked for proper information, and fishing tournaments will be a focus for public education.

Objective 3.1-MKLPA will continue coordinating (with other entities as necessary) the Clean Boats/Clean Waters program at the high use boat landing(s). The monitors will be present at the landing(s) a minimum of 200 hrs during the spring/summer months (late May to September).

Action 3.1a-MKLPA will coordinate the hiring of boat landing monitors to fulfill the hour commitment. These monitors will be trained through the CBCW training sessions offered in the area. These monitors will be compensated at an agreed hourly rate.

Objective 3.2-A rapid response plan will be on file and utilized for any new invasive species introduced new to the lake. See appendix "A" for this plan.

Action 3.1b-Should a new invasive species be introduced into Minocqua Lake, Kawaguesaga Lake, and/or the Thoroughfares, MKLPA will implement the rapid response protocol and determine and carry out the most effective response to that introduction of AIS.

Goal 4: Monitor other existing aquatic invasive species such as purple loosestrife, curly leaf pondweed, flowering rush and yellow iris.

Presently, Kawaguesaga Lake and Minocqua Lake, as well as the Thoroughfares, have other aquatic invasive species. In the 2014 plant survey, curly leaf pondweed, flowering rush, yellow iris, and purple loosestrife were sampled and/or observed in addition to the Eurasian water milfoil. Although Eurasian water milfoil has been the emphasis of historical management, the presence of these other species is cause for concern. Monitoring these species is paramount to determine if they are spreading. If this spreading should occur, management may become necessary. *(See invasive species section of the plant community earlier in this plan for maps and statistics for these plant species)*

Objective 4.1-All known invasive species will be monitored using the point intercept survey process every 5-6 years. Flowering rush expansion will be monitored to establish the size and density of existing flowering rush footprints in summer, 2016 and begin reducing flowering rush through hand pulling in riparian owners shorelines.

Curly leaf pondweed
The 2014 point intercept survey showed a reduction in curly leaf pondweed compared to 2007. Curly leaf pondweed is not a high priority and is not a concern at this time. However, the change in curly leaf pondweed will be monitored using future point intercept surveys in 5 to 6 years.

Purple loosestrife
In the Minocqua Thoroughfare, the macrophyte survey revealed the most extensive growth of purple loosestrife in/around the lakes. There is also substantial loosestrife near the Tomahawk Thoroughfare inlet. Purple loosestrife can dominate wetland areas and choke out native vegetation. This may be of concern for the Minocqua Thoroughfare area. As a result, a more specific survey may need to be conducted to evaluate the degree of growth and if there is substantial cause for concern. If this plant has sporadic coverage, the plants will be hand pulled prior to flowering and disposed of in a compost or waste receptacle. Use of biological control (*Gallerucella* beetles) has been utilized, and this will continue and possibly increase as the purple loosestrife is quite prevelent.

High density purple loosestrife areas will be monitored to determine if it is spreading. It is recommended that individual plants be carefully hand-pulled prior to flowering (July).

Beetle use for control has occurred in various locations around Minocqua Lake and the Thoroughfares since the mid-1990s. The most recent documented release of beetles was in

2013. The Oneida County AIS coordinator and some involvement of the Wisconsin DNR have overseen the beetle release has been overseen. It is recommended that the beetle release continue. This could possibly be expanded through other entities, such as the local school.

Flowering rush
Since 2007, flowering rush locations and density have expanded, especially in Minocqua Lake (see locations in Fig. 26 on page 40). Flowering rush can spread and choke out native species (see appendix for flowering rush information). Before management of flowering rush is considered, all flowering rush "beds" will be mapped and specific density determined in all flowering rush areas.

Action 4.1a- A professional surveyor will be hired to map all flowering rush beds and the density. This data will be mapped in GIS and volunteer monitors will then monitor any additional areas beyond the mapped locations.

Volunteers and riparian owners should be trained on the identification of flowering rush and hand removal. Riparian owners, with the possible help of other volunteers, can hand remove flowering rush from their littoral zone areas (in shallow water). This would begin some minor management of flowering rush and possibly reduce spreading.

Action 4.1b-Train riparian owners (especially those with flowering rush in the littoral zone within their property borders) on the identification of flowering rush and the proper removal techniques.

Yellow Iris
Yellow iris is becoming more prevalent mostly in the Thoroughfare leading to Tomahawk Lake. These areas will be monitored through the evaluation of future point intercept surveys and, if expansion continues, will be considered for management. Annual monitoring will also occur using the volunteer monitors in the various regions described in the EWM monitoring protocol.

Action 4.1c-A professional (or volunteer expert) surveyor will survey yellow iris and purple loosestrife outside of the point intercept grid. Volunteeer EWM monitor teams will also monitor other known AIS by recording locations new to the lakes (based upon maps provided to the monitors showing known locations of different AIS).

Monitoring protocol
When monitoring occurs, the following steps should be taken to adequately monitor invasive species of concern. The main emphasis in the monitoring program will be EWM, but other AIS are also important to monitor.

1. Locate present, recorded sites by GPS coordinates July or later. Refer to maps provided for historic AIS locations. If different from those locations, make note.
2. Observe for presence and coverage (single plant, clumps, or bed) of the invasive species.
3. Survey the vicinity of these points for other potential sites. If located, record Latitude/Longitude -GPS coordinates.

Goal 5: Restore native shoreline vegetation.

The future projections for phosphorus loading into Kawaguesaga Lake and Minocqua Lake are high (see water quality section). As a result, shoreline restoration on developed shorelines is important. The native shoreline will reduce sediment and phosphorus loads, which would otherwise increase nutrients in lake sediment in which EWM flourishes. Excess nutrients could be available for excess algae growth, which would reduce the water clarity associated with these lakes at this time.

Objective 5.1-MKLPA will coordinate 15 shoreline restoration projects by 2021[25].

Action 5.1a-A cost share program will be utilized to help achieve the objective of 15 projects. A landscape/restoration planning professional will be secured from the local area to help facilitate/plan these projects.

Action 5.2b-A public information campaign will be used to help recruit shoreline restoration projects in order the meet the goal of 15. This will include publications, site visits of previous projects, and presentation/discussions at meetings.

Figure 47: Example of shoreline restoration project incorporated on Minocqua Lake in 2014.

Goal 6: Preserve and/or enhance water quality.

The water quality of Minocqua and Kawaguesaga Lakes is good. In order to keep these lakes at a level of high quality, a number of activities can be implemented. A management plan for preserving water quality, including strategies, has been developed in a separate plan. Best management practices can substantially help preserve water quality. Many of

[25] An AIS grant funds some of this program and ends in 2018. If the 15 projects are not reached by 2018 MKPLA is committed to reaching 15 by 2021.

these strategies are beyond the scope of plant management, but a BMP, such as shoreline restoration, is one that overlaps.

Minocqua Lake volunteers have been part of an expanded citizen lake monitoring program for many years. This has also been done in Kawaguesaga, but for fewer years. Continued monitoring is important to evaluate any changes that may occur in water quality. Total phosphorus, secchi depth, and chlorophyll-*a* readings should continue to be tested at least during the growing season. A qualified water quality specialist should conduct review of this data with MKPLA.

Predicted nutrient loading for these lakes indicates an increase, largely due to urban influences. The future water quality of Minocqua and Kawaguesaga Lakes will most likely be determined in large part by urban runoff. For this reason, the Town of Minocqua should work with the MKPLA and the Wisconsin DNR to help implement practices to reduce urban runoff. Water quality is a high priority for MKPLA and a coordinated effort between plant management practices and BMP's is needed by all stakeholders to ensure high water quality preservation.

Objective 6.1-Plant management activities will be used in the best way possible to help maintain water quality and water clarity. Total phosphorus increases will be minimal and sechhi readings maintained at the 10 year average. This will be part of a coordinated effort with all BMP's to maintain water quality.

The preservation of water quality is an issue too large to be encompassed by this plan. However, from a plant management perspective, water quality can be preserved and/or enhanced in the following ways:

- Preserve all native plant communities in Kawaguesaga and Minocqua Lakes to help absorb excess nutrients and compete against invasive species.

- Preserve natural shoreline areas and restore developed shorelines to native vegetation. These shoreline areas will be identified in a shoreline assessment.

- Maintain and protect all floating leaf and emergent plant beds to reduce wave energy and erosion. These areas are located in numerous areas and maps of such species can be located in the appendix.

- Manage the plant community carefully so as to not adversely affect native plants. Using methods that target only invasive plants with little harm to natives can do this. This would include early season treatment with herbicides and hand pulling of invasive species.

- Encourage retaining native plant beds in front of riparian owners' properties. Education components in newsletters and lectures at the annual meeting will be utilized to help people understand removal of these plants is not recommended.

Goal 7: Provide extensive education on lake ecology.

One of the plant committee's concerns is the lack of understanding about lake ecology by people living on or using Kawaguesaga and Minocqua Lakes. To address this concern, the Minocqua/Kawaguesaga Lake Protection Association is committed to providing education for the lake residents and users.

Each year, the Association publishes 3 newsletters. Each of these newsletters will be a great opportunity to provide lake ecology information. Furthermore the local newspaper, the Lakeland Times, has been historically committed to lake issues. The Association will try to facilitate the publication of information about lake ecosystems ranging from water quality preservation to the importance of aquatic plants and other pertinent topics.

Objective 7.1: MKLPA will provide lake ecology education on an annual basis through at least on article in newsletters, one speaker at an association meeting and information on the website.

Action 7.1a: The MKLPA will continue to publish newsletters in which at least one article on a lake ecology topic pertinent to these lakes is contained. MKPLA will also strive to have 1 speaker at a meeting each year provide information about lake ecology and/or management.

Herbicide environmental concerns related to lake ecology

2,4-D has some environmental concerns associated with its use. The following list contains some considerations when applying this herbicide (label should be followed by applicator and used for public notification prior to application)[26].

- This chemical may toxic to fish and aquatic invertebrates.
- Can become a groundwater contaminant if allowed to enter groundwater table.
- Potable water sources that are treated should be shut off prior to treatment.
- Wait 21 days before using as drinking water and concentration is less than 70ppb.
- Should not swim in treated water for 24 hours after application (if ester form is utilized).

The retention of 2,4-D in the water column is of interest for a couple of reasons. First is the concentration of 2,4-D must be above a particular threshold to be effective. If that concentration is not retained for a long enough period of time, the plants will not be adequately affected by the treatment. Second is the length of time the 2,4-D remains at the treatment site and how those concentrations change.

In order to determine these levels, an assay measuring the 2,4-D concentrations over time can be conducted. This allows these concentration changes to be evaluated and determine the residual 2,4-D that remains as well as the length of time the 2,4-D remains in the treated area.

Historical data on residual monitoring has shown variability of herbicide concentrations over time in many lakes studied[27]. Many of the data has shown that target concentrations

[26] Information provided by Frank Koshere, Wisconsin DNR. March, 2008.

are not met or quickly dissipate, reducing contact time of the herbicide on the plants. Although this should immensely reduce efficacy, this has not always been the case. The future of residual monitoring is unknown, but MKLPA could consider participation if inquired.

Action 7.1b-The MKLPA will work with the Wisconsin DNR and the Army Corp of engineers, if requested, to monitor residual herbicide concentration during herbicide treatments.

MKLPA is also concerned about any long term, deleterious effects of herbicide use. As more research is conducted, the Association will pay close attention to the reported findings and adjust use accordingly. Development of herbicide resistance in EWM through repeated used of herbicide should also considered in management decisions. There is growing concern over this potential effect of long-term use.[28]

[27]Residual monitoring data provided by Jon Skogerboe Army Corp of Engineers and data presented in Nault et al, 2015.
[28] Personnel communication, Scott Van Engren, Wisconsin DNR. 2016.

Implementation plan/timeline/estimated cost

Below is the implementation plan for each Plan Action Item. The time and responsible party is listed, along with the estimated cost and what grant the action may be eligible for in future management.

Table 22: Implementation timeline/responsible parties

Plan Action Item	Time	Responsible entity	Grant Eligiblility	Estimated cost
Chemical treatment of qualifying EWM beds (initial survey completed)	Continue annually as needed based upon appropriate surveys	Minocqua-Kawaguesaga Association/Wisconsin DNR/Professional AIS Mgr	AIS control	$30,000/yr(applicator) $425/yr (permit app.)
Train volunteers-monitoring	May/June 2016. Annual updates as needed	Consultant/Lake Association	AIS control/education	$1410/yr
Monitor flowering rush stands and map in GIS	Summer 2016	Professional consultant OR Oneida County AIS	AIS planning	$1500.00
Flowering rush ID to Riparian owners adjacent to present stands; hand removal	July 2016 and As needed annually	Oneida County AIS OR MKPLA trained volunteer OR Professional consultant	AIS planning	$0 if County or Volunteer (hourly in-kind if grant) or $500 for consultant.
Pre/Post Monitoring of EWM beds	May and Sept 2008 and any year treatment occurs	Consultant	AIS control	$5880/yr
Monitor EWM/other invasives	June-August annually	Volunteers/Professional consultant		50 hrs-$1800/yr Consultant $2000
Hand-pull sporadic/lower density EWM	July/August 2009 and each year based on success	Hired divers/possible consultant or hired divers	AIS control	$18,200/yr(divers) $3800/yr(boat)

Plan Action Item	Time	Responsible entity	Grant Eligiblility	Estimated cost
stands.				
Monitor EWM hand-pulling areas for reduction	June and August annually	Professional AIS consultant	AIS control	$1450/yr
Evaluate most effective manual removal comparing present diving methods with DASH	Summer 2016	MKPLA	n/a	n/a
Continue Clean Boats/Clean Waters Program	May-Sept annually	Lake Protection Association/Volunteers	CBCW Grant	$6000/yr
Purple loosestrife monitoring and biological control with beetles	July, 2016 Beetle application annually as available	Volunteers Oneida County AIS Coordinator Wisconsin DNR	n/a	n/a assuming can obtain and rear beetles at no cost.
2,4-D assay of EWM treatment areas	Treatment time (May/June) annually if program in place	Lake Protection Association and the Wisconsin DNR	n/a	
Shoreline restoration at various riparian residents.	2015 to 2017 and continue to 2021 (possibly)	Lake Association/Oneida County (cost share)/Wisconsin DNR	Lake Protection Grant	$2000/yr (planner) $250/yr (incentive)
Facilitate shoreline restoration projects	2015-2017 and continue to 2021	MKPLA and possibly Oneida County		
Continue Expanded Self Help Monitoring	May-Sept annually	Lake Association Volunteers/Wisconsin DNR		

Plan Action Item	Time	Responsible entity	Grant Eligiblility	Estimated cost
Lake Ecology Education **(see chart that follows with more specifics)**	Newsletter annually and annual meeting	Lake Association/Consultants/Oneida County Professionals/Wisconsin DNR	AIS education	$900/yr meetings $5000/yr newsletter
Rapid Response to Invasive Species	Plan in place 2016-2021 and implemented if needed anytime	Monitoring volunteers/Consultants/Oneida County AIS Coordinator/Wisconsin DNR	AIS-Rapid Response	Up to $20,000
Plan evaluation and whole lake PI survey	2020-21	Consultant/Lake Association/Wisconsin DNR	AIS control/education/planning	Survey $15,000 Plan $7000

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