RED CEDAR LAKES, BARRON & WASHBURN COUNTIES

BALSAM (2112800), MUD, BASS (1833100), RED CEDAR (2109600), AND HEMLOCK (2109800) LAKES

2020-2024 Aquatic Plant Management Plan

Prepared by: Dave Blumer, Lake Educator & Heather Wood, Lake Management Assistant

October 2019

Red Cedar Lakes Association

Mikana, WI 54857

Mission Statement:

To preserve, protect and improve Red Cedar, Balsam, Hemlock, Bass and Mud Lakes and their watershed and ecosystem.

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PREPARED FOR THE RED CEDAR LAKES ASSOCIATION

INTRODUCTION

The Red Cedar Lakes are located in northwestern Barron County and southeastern Washburn County, northwest Wisconsin in the headwaters region of the Red Cedar River. The Red Cedar Lakes consist of three main stem lakes (Balsam, Red Cedar, and Hemlock) on the Red Cedar River, and Mud Lake, a small spring-fed lake flowing into Balsam Lake. The lakes cover more than 2,600 acres and have nearly 39 miles of shoreline. Bass Lake is a small (19-acre) seepage lake adjacent to the northeast shore of Red Cedar Lake. Bass Lake is listed as being 39-feet deep with an average depth of 13-feet. It primarily consists of a warm water fishery with largemouth bass, northern pike, and panfish.

The Red Cedar Lakes form a unique and important natural resource in north-west Wisconsin. Red Cedar Lake is listed as Outstanding Resource Water and Balsam Lake and Mud Lake are wild rice waters. The lakes are considered a highly desirable destination for residents and vacationers alike who participate in lake-centered activities year-round. Popular activities include fishing (and ice-fishing), boating, snowmobiling and Nordic skiing. A Barron County campground is located along Red Cedar Lake and several privately operated resorts are located throughout the system, including Stouts Island and Lodge, a high end resort and restaurant on an island in the center of Red Cedar Lake, only accessible via a ferry.

The RCLA has been very active in protecting the resources the Red Cedar Lakes provide. Several large-scale lake management planning projects and a lake protection project have been completed culminating in a Comprehensive Lake Management Plan in 2004. The comprehensive plan, however, only marginally addressed aquatic plants.

In 2009, the Red Cedar Lakes Association (RCLA) received an invasive species monitoring report completed by the Beaver Creek Reserve (BCR) Citizen Science Center, an environmental center located in Fall Creek, Wisconsin. The report summarized the results of invasive species survey work completed by the BCR on lakes in five different counties (Barron, Chippewa, Dunn, Eau Claire, and Rusk). Red Cedar and Hemlock Lakes were included in the survey work and the report indicated that curly-leaf pondweed (CLP), an aquatic invasive species that can negatively impact a water body, was widespread in the two lakes.

The Beaver Creek Reserve report included the first distribution map of CLP in the system. Although aquatic nuisance control records indicate CLP has been present in the lakes for some time, its extent came as a surprise to the RCLA given that the invasive species had only been officially recognized in the system in 2005.

In 2011, the RCLA implemented an aquatic plant management planning project to determine the impact CLP is having on the lakes and identify the best management practices. This process began with the creation of the 2012 Aquatic Plant Management (APM) Plan for the Red Cedar Lakes to help guide future management. The WDNR recommends that Aquatic Plant Management Plans are updated every five years in order to assess the success of the prior plan and modify management goals as needed. This plan is intended to guide management from 2020 through the 2024 season.

PROBLEMS AND THREATS TO THE RED CEDAR LAKES CAUSED BY CLP

CLP in the Red Cedar Lakes was first recognized as a potential problem during the 2011 whole-lake, point-intercept (PI) survey and bedmapping completed for the development of an Aquatic Plant Management (APM) Plan. In 2011, 4 beds of CLP totaling 27.3-ac were mapped in Balsam and Mud lakes; 7 beds totaling 71.5-ac were mapped in Red Cedar Lake; and 3 beds totaling 53.8-ac were mapped in Hemlock Lake (Figure 1). Of the total mapped, moderate to dense growth CLP (2-3 on a 1-3 rakehead density rating scale, Figure 2) covered about 17.86 acres. In 2012, RCLA volunteers with assistance from their consultant again mapped CLP in the three lakes. During this survey, there was a 13% increase in the total amount of CLP in the system. More alarming however, was that fact that the amount of moderate to dense growth CLP increased 340% to just over 61.5 acres (Table 1).

Lake	Bed #	Area (acres)
Balsam	1	5.1
	2	4.5
	3	5.7
Mud	4	12.0
Red Cedar	5	1.5
	6	6.0
	7	20.7
	8	2.0
	9	20.7
	10	17.1
	11	3.5
Hemlock	12	25.3
	13	13.9
	14	14.6
Total Area		152.6

Figure 1: 2011 CLP Beds and Acreage (FSS, 2011)

Density Rating	Rake Coverage	Description
1		Only a few plants retrieved
2		Plants cover full length of rake head, but do not cover the tines completely
3		Plants completely cover rake head and tines

Figure 2: Rakehead Density Ratings (WDNR)

Table 1: 2011 (FSS) and 2012 (RCLA) Bedmapping Totals and Density Ratings

Lake	Year	Total Acres	Low Acres (RHD-1)	Mod/Dense Acres (RHD 2 or 3)
Balsam	2011	15.30	22.64	1.61
	2012	10.69	3.71	6.98
Red Cedar	2011	71.50	64.20	7.30
	2012	65.29	19.07	46.22
Hemlock	2011	53.80	44.85	8.95
	2012	83.30	74.35	8.32

The rapid increase in CLP density raised concern with the RCLA and a 3-yr CLP chemical treatment program was proposed and an Aquatic Invasive Species Control of an Established Infestation (ACEI) Grant applied for in February 2013. The ACEI grant was awarded and management of two areas of dense growth CLP, one in Red Cedar Lake and one in Hemlock Lake, was started in 2013 and continued through 2015. No chemical management of CLP was proposed in Balsam Lake despite it having one of the densest areas of CLP in the entire system due to concerns about water flow and an area of wild rice in the lake.

RCLA CLP BEDMAPPING

Since 2012, RCLA volunteers completed CLP bedmapping in Red Cedar and Balsam lakes in 2014, 2015, 2016, 2017, and 2019. Bedmapping was done in Hemlock in 2015, 2016, 2017, and 2019. Bedmapping was completed using a methodology similar to another local aquatic plant survey specialist. RCLA volunteers toured the shallow, littoral area of all of the lakes in mid-June looking for CLP. When it was found, a GPS point was taken. If where it was found had a clearly definable edge and the CLP present made up 50% or more of the plants present, additional GPS points were taken around the outside edges of the bed. The bed was then given a rakehead density rating of 1 (sparse), 2 (moderate) or 3 (dense). GPS data and written notes are then given to the RCLA consultant and annual maps are made.

No data exists for 2013, and bedmapping in 2018 by Freshwater Scientific Services (FFS) did not use the same methodology as RCLA volunteers. FFS only mapped moderate to dense areas of CLP. They did not map total CLP acreage in the system.

During the second (2014) and third (2015) year of chemical treatment, the amount of bed-forming CLP in Red Cedar Lake mapped by RCLA volunteers stayed at or below 11% of the average total acreage from 2011 and 2012. It remained below 4% of the average total acreage from 2011 and 2012 on Hemlock Lake. In Balsam Lake, which was not chemically treated, the amount of bed-forming CLP stayed above 31% of the average total acreage mapped in 2011 and 2012.

Moderate to dense growth CLP mapped in 2014 and 2015 remained below 8% of the average total acreage from 2011 and 2012 in Red Cedar Lake and below 4% on Hemlock. Moderate to dense growth CLP remained at about 14% of the average total acreage from 2011 and 2012 on Balsam Lake.

Chemical treatment of CLP in Red Cedar and Hemlock lakes ended with the 2015 season. No treatment was done in any of the lakes in 2016 or 2017. In both 2016 and 2017 the total acreage of CLP in all three of the lakes increased, particularly in 2017 which provided outstanding growing conditions for CLP. The total acreage in 2017 went back up to 91.58 acres, still less than what was mapped in 2011 and 2012, but much higher than it had been from 2013 to 2016. Moderate to dense growth CLP increased to a little more than 52 acres or about 56% of the total mapped. More than 81% of the CLP mapped in Balsam Lake in 2017 was considered moderate to dense in nature. Only 59% and 14% of what was mapped in Red Cedar and Hemlock respectively was considered moderate to dense in nature. Little of the increase in Red Cedar and Hemlock lakes was in the two areas that had been chemically treated from 2013-2015 (Figure 3).

This occurrence was again supported by the spring 2018 CLP delineation completed by FFS. After three years of management, the density in those areas was reduced such that when the 2018 CLP survey was completed 3 years later, only a handful of plants were found (Figure 4).

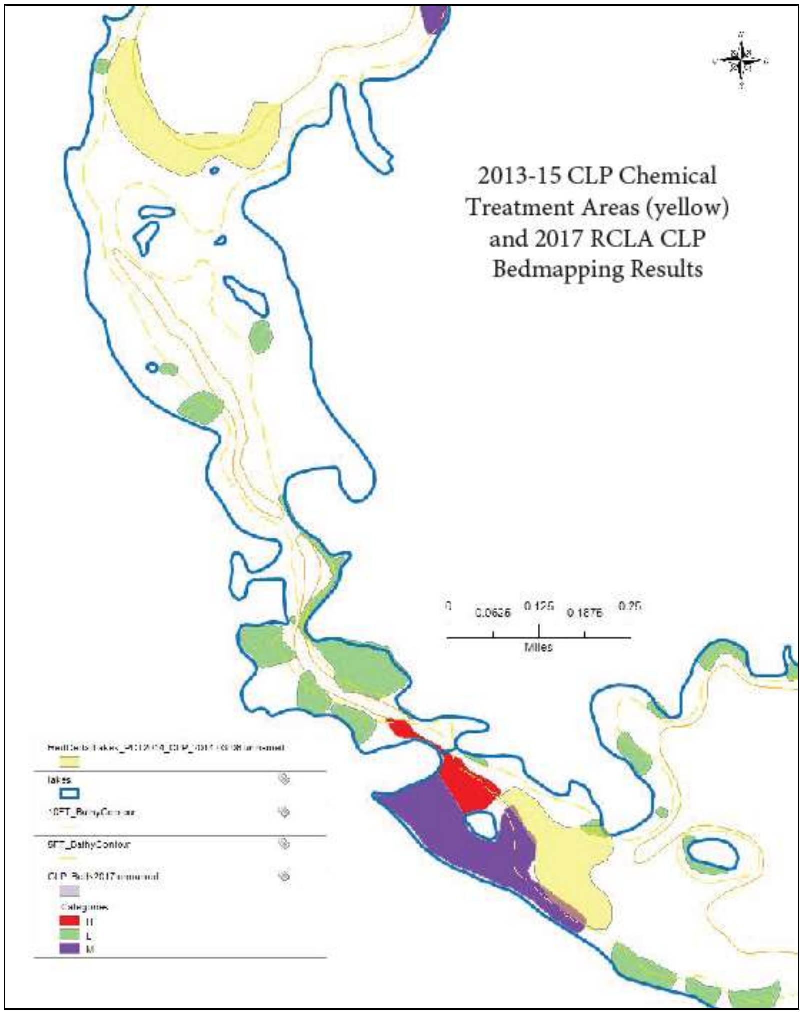
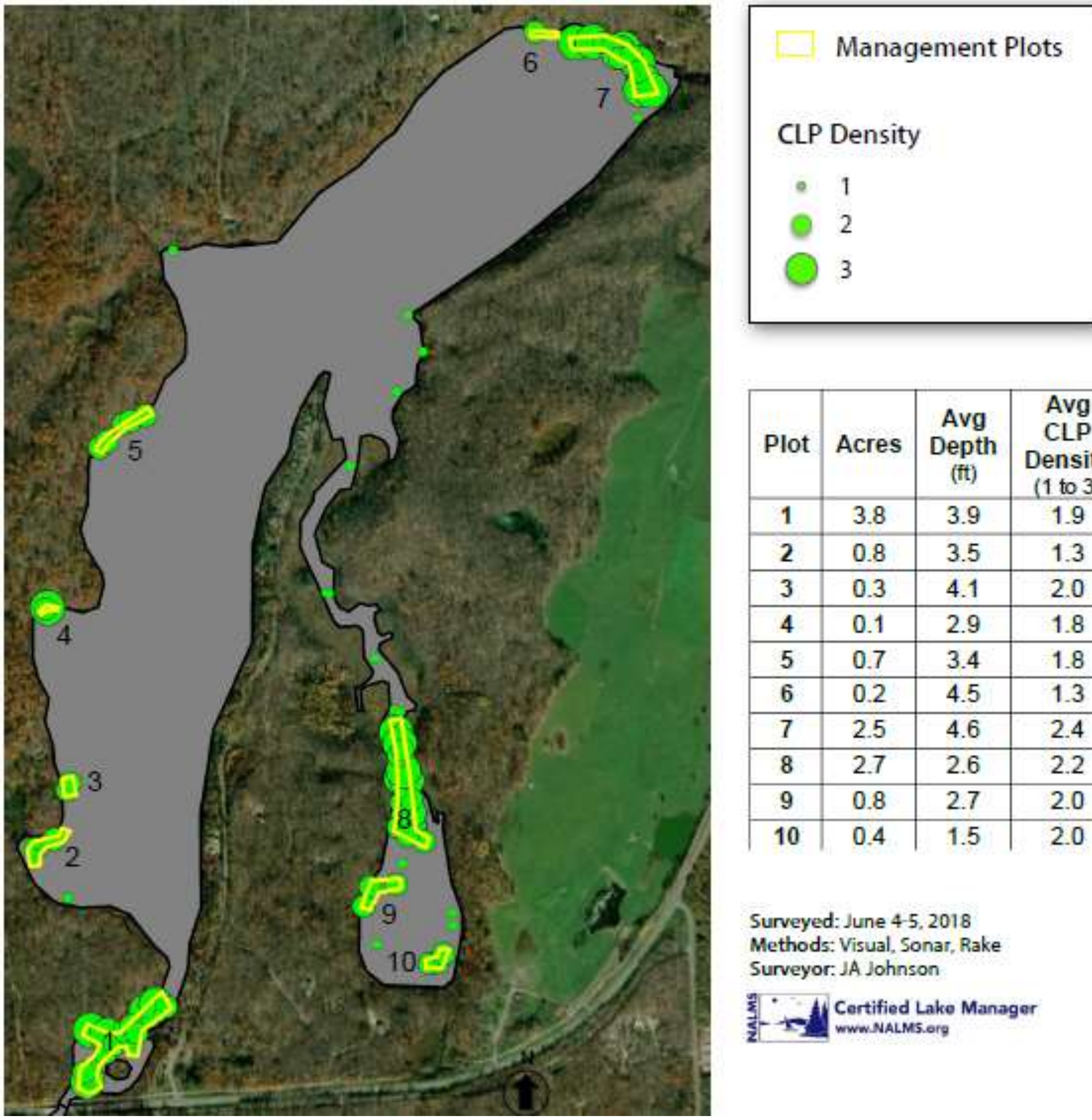


Figure 3: CLP treatment areas from 2013 to 2015 (yellow) in relation to 2017 RCLA bedmapping results (green, red, and purple)

Figure 4: 2018 CLP survey results in the Red Cedar 3-yr CLP treatment area (left) and the Hemlock 3-yr CLP treatment area (right)

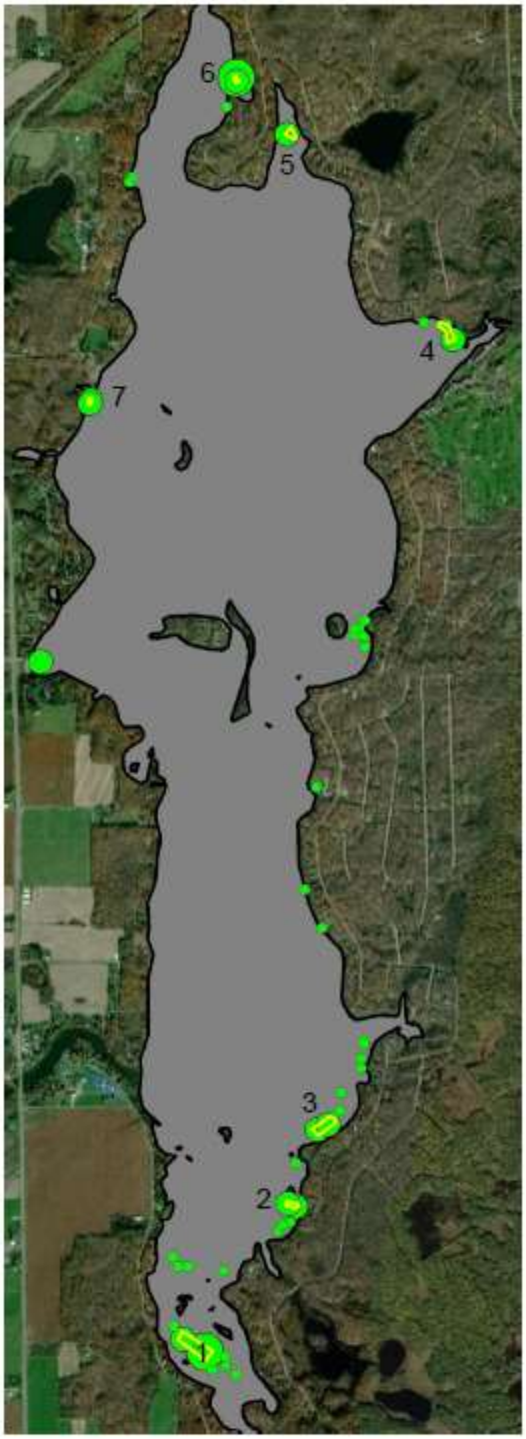
Areas outside of the treated areas of all three lakes continue to expand in size and density. The 2018 survey documented CLP fairly wide-spread throughout the system, with about 30 acres being considered as moderate to dense growth. Figures 5-7 show the results of the 2018 survey for each lake including where beds of moderate to dense growth CLP were located and how many acres each was.



Plot	Acres	Avg Depth (ft)	Avg CLP Density (1 to 3)
1	3.8	3.9	1.9
2	0.8	3.5	1.3
3	0.3	4.1	2.0
4	0.1	2.9	1.8
5	0.7	3.4	1.8
6	0.2	4.5	1.3
7	2.5	4.6	2.4
8	2.7	2.6	2.2
9	0.8	2.7	2.0
10	0.4	1.5	2.0

Surveyed: June 4-5, 2018
Methods: Visual, Sonar, Rake
Surveyor: JA Johnson
Certified Lake Manager
www.NALMS.org

Figure 5: 2018 Delineation of CLP in Balsam and Mud Lakes (FSS, 2018)



Management Plots

CLP Density

1
2
3

Plot	Acres	Avg Depth (ft)	Avg CLP Density (1 to 3)
1	2.6	4.1	2.5
2	0.3	6.7	2.0
3	1.4	8.6	1.7
4	0.9	8.4	1.2
5	0.4	9.8	1.3
6	0.1	3.3	2.5
7	0.1	6.6	2.0

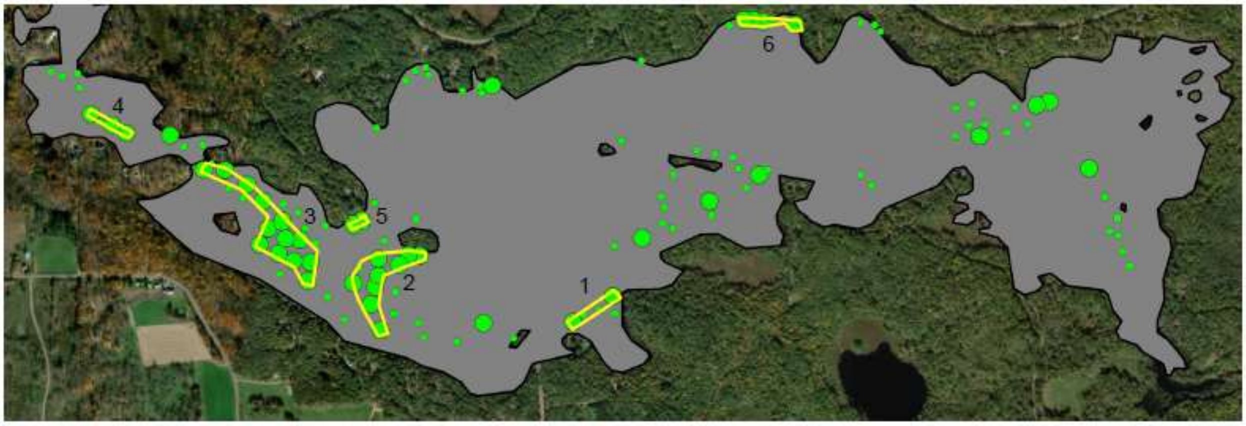
Surveyed: June 4-5, 2018
Methods: Visual, Sonar, Rake
Surveyor: JA Johnson

NALMS Certified Lake Manager
www.NALMS.org

Map produced for the
Red Cedar Lakes Association by:

freshwater SCIENTIFIC SERVICES

Figure 6: 2018 Delineation of CLP in Red Cedar Lake (FSS, 2018)



Plot	Acres	Avg Depth (ft)	Avg CLP Density (1 to 3)
1	1.0	9.1	1.5
2	4.0	6.7	1.9
3	5.6	6.4	1.8
4	0.6	5.3	1.8
5	0.2	6.3	1.7
6	0.8	4.3	1.6

Surveyed: June 4-5, 2018
Methods: Visual, Sonar, Rake
Surveyor: JA Johnson
Certified Lake Manager
www.NALMS.org
Map produced for the
Red Cedar Lakes Association by:
freshwater scientific services

Figure 7: 2018 Delineation of CLP in Hemlock Lake (FSS, 2018)

Based on 2017 RCLA volunteer bedmapping, a chemical treatment proposal was made initially covering two areas in Red Cedar Lake totaling 9.56 acre and two areas in Hemlock Lake totaling 8.25 acres. Pre-treatment survey work eliminated the two treatment areas in Hemlock Lake, but kept the two Red Cedar treatment areas and management was completed. During the 2018 CLP delineation, both treated areas in Red Cedar showed less CLP (Figure 8).

Figure 8: 2018 CLP chemical treatment locations in Red Cedar Lake and 2018 CLP delineation in the same areas

IMPACTS OF CLP TO THE RED CEDAR LAKES

CLP IN DESIGNATED SENSITIVE AREAS

The WDNR completed Lake Sensitive Area Reports on the Red Cedar Lakes in the 1990s. The Sensitive Area survey identified 9 areas on Balsam and Mud Lakes, 23 areas on Red Cedar Lake, and 12 areas on Hemlock Lake that merit special protection of the aquatic habitat (Figures 16-18). Sensitive areas on the lakes covered nearly 455 acres and fell into two basic categories: aquatic plant communities providing important fish and wildlife habitat (341 acres), and gravel and coarse rock rubble that provide important walleye spawning habitat (114 acres). RCLA CLP bedmapping in 2017 documented CLP beds in more than 87 acres of the total fish and wildlife sensitive area (27.7%) and 8.68 acres of the walleye spawning sensitive areas (7.61%).

The data and recommendations from the Sensitive Area Reports were reviewed and incorporated into this management plan. In general, the reports recommend that aquatic vegetation removal should be limited to navigation channels, preferably mechanically harvested, and only when severely impaired navigation or nuisance conditions are documented. It is important to maintain vegetated shoreland buffers in sensitive areas and stumps and woody habitat, which provides fish cover, should not be removed from sensitive areas. Although restrictions are in place to protect these areas during plant management operations, in some cases, short-term disruptions to habitat during the removal of monotypic stands of aquatic invasive species such as curly-leaf pondweed may lead to positive long-term improvements to the habitat of the lake. Disruptions to the sensitive areas may be warranted when responding to the discovery of a new invasive species.

CLP BEDS ADJACENT TO DEVELOPED SHORELINE

RCLA CLP bedmapping in 2017 identified a little more than 98.5 acres of bed-forming CLP in the three lakes. Of that area, a little more than 43 acres (43.7%) was adjacent to developed properties at 42 locations around the lakes. At the present time, the majority of CLP from the 2017 bedmapping survey was present in low or sparse density (rakehead density of 1), but it has already been shown that the distribution and density is increasing. It is in these areas that CLP is most likely to pose current or future navigational impairment.

CLP AND NATIVE AQUATIC PLANT RECOVERY

Whole-lake, point-intercept surveys were completed in 2011 and 2018 by FSS. Comparing changes in native aquatic plants within those areas of Red Cedar and Hemlock lakes that were chemically treated between the two PI surveys shows that measurements of aquatic plants including the maximum number of different plant species and the average number of species per site increased between 2011 and 2018 (Table 2). None of these changes were considered significant. This is also true when looking at all of the points surveyed in all the lakes during the 2011 and 2018 summer PI surveys, so it is not known whether the increase in native aquatic plant species is due to the treatments of CLP or just natural variation. What can be said is that chemical treatments of CLP did not hurt native aquatic plant species.

The density of native aquatic vegetation in the chemically treated areas was also looked at. Like the number of different aquatic plant species, within the chemically treated areas, the density of native vegetation during the summer PI surveys increased in 2018 from what they were in 2011. Native aquatic plant density was also up in the lakes as a whole in 2018, so again it can’t be said that treatment of CLP alone increased the density of native aquatic vegetation.

Table 2: 2011 and 2018 PI plant data comparisons in chemically treated areas

Red Cedar North Treatment Areas (2018 only, Pigeon Creek and Flagpole Bay)					
2011 Treatment Area Points	7				
2018 Treatment Area Points	7				
	2011	2018	p	Significant change	Increase/Decrease (proportional to # sampling points)
Minimum Natives per site	0	0			no change
Max Natives per site	6	10	Sample size too small		+
Average Natives per site	1.9	4.6	0.147923	n.s.	+

Red Cedar South Treatment Area (2013-2015)					
2011 Treatment Area Points	11				
2018 Treatment Area Points	11				
	2011	2018	p	Significant change	Increase/Decrease (proportional to # sampling points)
Minimum Natives per site	0	2	0.138011	n.s.	+
Max Natives per site	5	7	0.391805	n.s.	+
Average Natives per site	2.4	4.3	0.37875	n.s.	+

Hemlock Treatment Area (2013-2015)					
2011 Treatment Area Points	15				
2018 Treatment Area Points	15				
	2011	2018	p	Significant change	Increase/Decrease (proportional to # sampling points)
Minimum Natives per site	0	2	0.143235	n.s.	+
Max Natives per site	8	9	0.712547	n.s.	+
Average Natives per site	2.2	3.8	0.465209	n.s.	+

All Treatment Areas in Red Cedar and Hemlock (2013-2015, 2018)					
2011 Treatment Area Points	33				
2018 Treatment Area Points	33				
	2011	2018	p	Significant change	Increase/Decrease (proportional to # sampling points)
Minimum Natives per site	0	0			no change
Max Natives per site	8	10	0.58042	n.s.	+
Average Natives per site	2.2	4.2	0.405446	n.s.	+

All PI- Red Cedar					
All 2011 PI Points	375				
All 2018 PI Points	376				
	2011	2018	p	Significant change	Increase/Decrease (proportional to # sampling points)
Minimum Natives per site	0	0			no change
Max Natives per site	12	13	0.844107	n.s.	+
Average Natives per site	1.4	2.6	0.549217	n.s.	+

All PI- Hemlock					
All 2011 PI Points	339				
All 2018 PI Points	410				
	2011	2018	p	Significant change	Increase/Decrease (proportional to # sampling points)
Minimum Natives per site	0	0			no change
Max Natives per site	10	14	0.719216	n.s.	+
Average Natives per site	1.9	3.9	0.54369	n.s.	+

WATER QUALITY

The amount of CLP in the Red Cedar Lakes is still considered quite low and likely does not have a direct impact on water quality. In lakes where the distribution and density of CLP is much greater than what is present in the Red Cedar Lakes, water quality can be impacted when CLP dies and decays in early July adding phosphorus to the water column and using up available oxygen.

OVERALL CLP MANAGEMENT GOAL

Monitoring data supports that CLP is wide-spread in the three lakes and increasing in density. While not yet causing significant issues related to native aquatic plant growth, nuisance and navigation, and water quality it is moving in that direction. The main goal of CLP management in the Red Cedar Lakes is to keep CLP from having any negative impact on the lakes. The main CLP management objective in the 2012 APM Plan was to keep CLP from becoming the dominant plant in any area it occupied at that time. Specific beds were identified and targeted for management. A broader management perspective was not included in the 2012 APM Plan. The main CLP management objective in this new APM Plan is to reduce CLP to the point where there are no moderate to dense areas of CLP greater than 1-acre in size anywhere in the system, now and in at least the next five years. By doing so, CLP will be prevented from becoming a greater issue negatively impacting sensitive areas, native aquatic plants, navigation, and water quality.

This CLP management objective was supported by the WDNR in 2013 when a three year ACEI grant was awarded, and again in 2019 when another 3-yr ACEI grant was awarded to the RCLA. In 2019, more than 50 acres of moderate to dense growth CLP identified during the 2017 RCLA CLP bedmapping and 2018 FSS CLP delineation were targeted for chemical management. After pre-treatment aquatic plant survey work the amount of CLP chemically treated was reduced to 12 beds total in all three lakes covering about 28 acres (Figure 9).

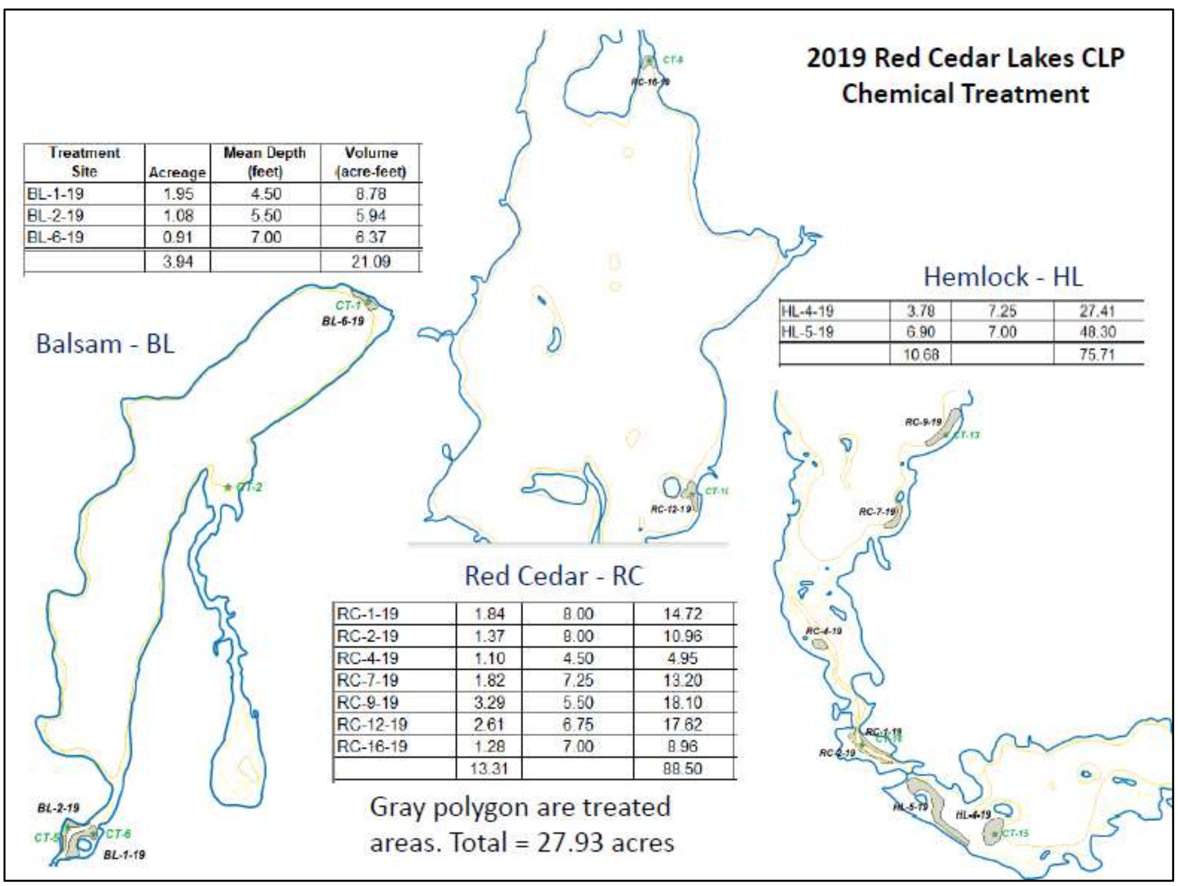


Figure 9: 2019 Chemical Treatment of CLP

RCLA CLP bedmapping in 2019 documented nearly 70 acres of bed-forming CLP in all three lakes, but only about 17% (11.76 acres) was considered moderate to dense. This level is down from the 2017 and 2018 surveys that were completed, so current management practices seem to be meeting their stated goal.

WISCONSIN'S AQUATIC PLANT MANAGEMENT STRATEGY

The waters of Wisconsin belong to all people. Their management becomes a balancing act between the rights and demands of the public and those who own property on the water's edge. This legal tradition called the Public Trust Doctrine dates back hundreds of years in North America and thousands of years in Europe. Its basic philosophy with respect to the ownership of waters was adopted by the American colonies. The US Supreme Court has found that the people of each state hold the right to all their navigable waters for their common use, such as fishing, hunting, boating and the enjoyment of natural scenic beauty.

The Public Trust Doctrine is the driving force behind all management in Wisconsin lakes. Protecting and maintaining that resource for all of the State's people is at the top of the list in determining what is done and where. In addition to the public trust doctrine, two other forces have converged that reflect Wisconsin's changing attitudes toward aquatic plants. One is a growing realization of the importance of a strong, diverse community of aquatic plants in a healthy lake ecosystem. The other is a growing concern with the spread of Aquatic Invasive Species (AIS). These two forces have been behind more recent changes in Wisconsin's aquatic plant management laws and the evolution of stronger support for the control of invasive plants.

To some, these two issues may seem in opposition, but on closer examination they actually strengthen the case for developing an Aquatic Plant Management Plans as part of a total lake management picture. Planning is a lot of work, but a sound plan can have long-term benefits for a lake and the community living on and using the lake.

The impacts of humans on State's waters over the past five decades have caused Wisconsin to evolve a certain philosophy toward aquatic plant management. This philosophy stems from the recognition that aquatic plants have value in the ecosystem, as well as from the awareness that, sometimes, excessive growth of aquatic plants can lessen our recreational opportunities and our aesthetic enjoyment of lakes. In balancing these, sometimes competing objectives, the Public Trust Doctrine requires that the State be responsible for the management of fish and wildlife resources and their sustainable use to benefit all Wisconsin citizens. Aquatic plants are also recognized as a natural resource to protect, manage, and use wisely.

Aquatic plant protection begins with human beings. We need to work to maintain good water quality and healthy native aquatic plant communities. The first step is to limit the amount of nutrients and sediment that enter the lake. There are other important ways to safeguard a lake's native aquatic plant community. They may include developing motor boat ordinances that prevent the destruction of native plant beds, limiting aquatic plant removal activities, designating certain plant beds as Critical Habitat sites and preventing the spread of non-native, invasive plants.

If plant management is needed, it is usually in lakes that humans have significantly altered. If we discover how to live on lakes in harmony with natural environments and how to use aquatic plant management techniques that blend with natural processes rather than resist them, the forecast for healthy lake ecosystems looks bright. To assure no harm is done to the lake ecology, it is important that plant management is undertaken as part of a long range and holistic plan.

In many cases, the State requires the development of long-term, integrated aquatic plant management strategies to identify important plant communities and manage nuisance aquatic plants in lakes, ponds or rivers. To promote the long-term sustainability of our lakes, the State of Wisconsin endorses the development of APM Plans and supports that work through various grant programs.

There are many techniques for the management of aquatic plants in Wisconsin. Often management may mean protecting desirable aquatic plants by selectively hand pulling the undesirable ones. Sometimes more intensive management may be needed such as using harvesting equipment, herbicides or biological control agents. These methods require permits and extensive planning.

While limited management on individual properties is generally permitted, it is widely accepted that a lake will be much better off if plants are considered on a whole lake scale. This is routinely accomplished by lake organizations or units of government charged with the stewardship of individual lakes.

RED CEDAR LAKES ASSOCIATION

The Red Cedar Lakes Association (RCLA) was first formed in the early 1970's due to local lakeshore owners' concern with a large development plan being introduced to the Red Cedar Lakes area lakeshore by a development company. Despite this, the lakeshore lots were developed and sold. As a result, the RCLA became inactive for a while but was reorganized in 1991 with 100 members attending the first meeting to define the RCLA's purpose, committees, by-laws, officers, and directors. At this time, they also became a non-profit organization. The RCLA continues to have a strong presence for the lakes with over 600 members.

The mission of the RCLA is "to preserve and protect Red Cedar, Balsam, and Hemlock Lakes, their watershed, and its ecosystem." Having a solid mission statement is critical to the operation of the RCLA for a number of reasons: keeping the organization grounded and helping to determine its direction; helping to focus the association's future and strategies for getting there; helping to provide a platform for decision making; and helping to form the basis for alignment. The success of the RCLA is not only because of the members and great volunteer base, but because it holds true to the mission statement that emphasizes its ongoing commitment to meeting the needs of the lake community.

Part of the success of the RCLA is due to the time and commitment put in by members of the Committees it supports. The following is a list of the committees currently in place to gather information that helps to identify what actions and activities to implement, and implements them:

- Aquatic Invasive Species Committee
- Coupon Book Committee
- Fish Habitat Committee
- Lake Information and Safety Committee
- Membership Committee
- Nature Committee
- Communications Committee
- Shoreland and Island Restoration Committee
- Water Quality Committee

All of these committees support the health and well-being of the lakes and the people who use them. The Aquatic Invasive Species (AIS) Committee has led the fight against non-native, invasive species including purple loosestrife and CLP. For years, the AIS Committee has reared, released, and redistributed Gallerucella beetles around the lakes and surrounding wetlands for control of purple loosestrife. The AIS Committee spearheads the CLP control project completing large physical removal projects each year, and overseeing chemical management of CLP. It also protects the lakes from new AIS through its AIS Monitoring and Clean Boats, Clean Waters programs. The Water Quality Committee spearheads all lake and tributary water quality monitoring activities. The Nature Committee maps the wild rice beds and tracks other beneficial native wildlife. The Shoreland and Island Restoration Committee works to restore and protect the shoreline of the Red Cedar lakes. The Fish Habitat Committee works to maintain excellent fishing and installation of fish and wildlife habitat structures. The other Committees provide information and education to the Red Cedar lakes constituency, raises money to support RCLA actions, and continuously recruits new RCLA members and volunteer support.

PUBLIC PARTICIPATION AND STAKEHOLDER INPUT

Discussion related to the development of this Aquatic Plant Management Plan for the Red Cedar Lakes began in 2017 when a substantial increase in curly-leaf pondweed was documented in all of the Red Cedar Lakes. This finding prompted the RCLA to discuss an application for funding with the WDNR to update their existing APM Plan which was written in 2012 with a consultant, the WDNR, the RCLA board and many of its constituents, and with several partners including the University of St. Thomas in MN and the Big Chetac and Birch Lakes Association. This discussion led to an application for Aquatic Invasive Species Education, Prevention, and Planning grant to cover planning activities in 2018 and 2019. Along with funding to rewrite the APM Plan, the grant also provided funding to complete a Rhodamine Dye study in Balsam Lake due to concerns related to water movement and wild rice; cover costs associated with redoing cold and warm water, whole-lake, point-intercept aquatic plant surveys on all three lakes in the system; and to collect a year's worth of nutrient loading data from several tributaries to the lakes.

Data collected for the development of this APM Plan and analysis of that data was shared with RCLA constituents through its spring and fall newsletters in 2017, 2018, and 2019; at its Annual Meetings in July of 2018 and 2019; and at a special meeting in August 2019. The RCLA Board discussed progress in developing the plan during each of its monthly board meetings through 2018 and 2019.

A completed draft of the APM Plan was first sent to the RCLA Board for review in June 2019. Several board members made comments that were addressed in a second draft delivered to the RCLA in early August 2019. That version was approved by the RCLA during their August 2019 Board Meeting and put on the RCLA and consultant's webpage. The constituency was informed that it was there and open for review through the RCLA webpage and at the August 17, 2019 Project Education Event. The draft APM Plan and the accompanying Appendices were sent to the WDNR for review in early September 2019. WDNR comment was received back October 11, 2019. Few if any comments from the constituency were generated by posting the documents for review.

Final approval of the APM Plan is expected from both the RCLA and WDNR prior to the end of 2019.

Information related to the development of this APM Plan and the smaller studies funded with the AIS grant are posted on the RCLA webpage and on a Consultant's Project Page at:

https://redcedarlakes.com/ and

https://leapsllc.com/index.php/red-cedar-lakes-association/.

2012 MANAGEMENT GOALS, OBJECTIVES, AND ACTIONS

The following is a review of the management goals, objectives and actions from the 2012 Aquatic Plant Management Plan for the Red Cedar Lakes; how they were implemented; and the results of management. The following were goals in the 2012 plan:

- Preservation, protection, and enhancement of native aquatic plant species in the Red Cedar Lakes;
- Aquatic invasive species (AIS) monitoring and management within the Red Cedar Lakes;
- AIS education and prevention for RCLA constituents and other lake users;
- Educating RCLA constituents and other lake users about the importance of native aquatic plants in the Red Cedar Lakes;
- Instilling an appreciation for aquatic ecosystems and habitat in the Red Cedar Lakes within RCLA constituents and other lake users;
- Helping RCLA constituents and other lake users develop a better understanding of the lakes and the factors affecting lake water quality;
- Coordinating water level management among all dam owners/operators in the upper Red Cedar River Watershed; and
- Implementation of the actions in the 2012 Aquatic Plant Management Plan for the purpose of meeting stated objectives.

NATIVE AQUATIC PLANT SPECIES

Table 1 reflects the changes in aquatic plant parameters from 2011 to 2018. For the most part the changes are mostly positive. However, a difference in the number of points surveyed with vegetation may account for much of the significance in Hemlock and Red Cedar lakes. In both of these lakes, the number of points with vegetation surveyed increased by large percentages (Hemlock 47%, Red Cedar 16%). The number of points with vegetation surveyed in 2011 and again in 2018 on Balsam and Mud Lake remained nearly the same.

Table 3: Aquatic Plant Changes from 2011 to 2018

Native Aquatic Plant Changes from the 2011 PI survey to the 2018 PI Survey								
	Balsam		Red Cedar		Hemlock		Mud	
	2011	2018	2011	2018	2011	2018	2011	2018
Number of Points w/Vegetation	198	194	226	262	207	304	109	110
% Lake Area w/Vegetation	10	11.7	14	16.2	45	61		
% of Surface Matted Vegetation	5	3.5	1	3.4	26	26.5		
Max Depth of Plants (ft)	17	13.5	12	12.2	10	12.8		
% Littoral Area w/Vegetation	48	59.7	58	72.8	61	81.7		
Species Richness (#)	31	32	36	39	31	48		
Simpsons Diversity Index	89	91.3	91	93.1	87	93		
Native Plants/point (#)	1.6	2.3	2.3	3.52	3.2	4.39		
Species with Significant Changes from 2011 to 2018	14 (+)	4 (-)	14 (+)	4 (-)	18 (+)	2 (-)	10 (+)	8 (-)

AQUATIC INVASIVE SPECIES MANAGEMENT

CLP management recommendations in the 2012 APM Plan were implemented starting in 2013 with three years of chemical treatment of CLP in the extreme south end of Red Cedar Lake and in the west end of Hemlock Lake. The first treatment in 2013 covered 18.8 acres in two beds – one in Red Cedar and one in Hemlock. Chemical treatment in these two areas was continued in 2014 and 2015, although they were modified each year based on results and pre/post-treatment surveys.

These three years of chemical treatment succeeded in their goal to reduce the amount of CLP in these two areas to a fraction of what they were. As of 2018, CLP bedmapping still reflected a decline in the amount of CLP from what it was in 2011/12. CLP turion density testing completed in the fall of 2012, then again in the fall of 2015 also confirmed a reduction in turions from 100% of sites having turions pre-treatment to only 27% of sites with turions in 2015. Another turion density analysis is scheduled in 2021.

Table 4: 2011-19 Red Cedar Lakes Survey and CLP Management Implementation

2011-2019 Red Cedar Lakes Aquatic Plant Survey and Curly-leaf Pondweed Management									
Year	Surveys					Management			
	PI Survey	Pre/Post Survey	Bedmapping	Turion Density	Paleocore	Physical Removal	Chemical Treatment	Completed	ConcTest/DyeStudy
2011	FSS		FSS				29.7-ac, 7-bds, BL,RC,&HL	NO	
2012			RCLA	FSS		RCLA			
2013		FSS	RCLA			RCLA	18.8-ac, 2-bds, RC&HL	YES	ConcTest-RC&HL
2014		FSS	RCLA			RCLA	11.1-ac, 3-bds, RC&HL	YES	
2015		FSS	RCLA	FSS	Onterra Inc	RCLA	13.2-ac, 2-bds, RC&HL	YES	
2016			RCLA			RCLA			
2017			RCLA			RCLA			
2018	FSS		FSS				9.56-ac, 2-bds, RC	YES	DyeStudy-BL
2019		FSS	RCLA				27.9-ac, 12-bds, BL,RC,&HL	YES	ConcTest-BL,RC&HL

FSS-Freshwater Scientific Services | RC-Red Cedar Lake | ConcTest-Herbicide Concentration Testing
RCLA-Red Cedar Lakes Association Volunteers | HL-Hemlock Lake | DyeStudy-Rhodamine Dye Study for water movement
BL-Balsam Lake | Bds-Beds

AIS EDUCATION AND PREVENTION EFFORTS

The RCLA participated in several projects between the implementation of the 2012 APM Plan through 2018. Watercraft inspection via the Clean Boats Clean Waters Program tallied between 400 and 750 hours of inspection time each year at boat landings on Balsam, Red Cedar, and Hemlock lakes.

Monitoring for AIS was completed formally during the 3-year CLP management project (2013-2015), and continued less formally in 2016 and 2017. It was then made formal again in 2018 with a new grant award. AIS plant/animal monitoring was completed each month from June to September in each year. No new AIS was discovered during this time.

Beetles for control of purple loosestrife have been established in most areas around and near the Red Cedar Lakes and continue to help keep purple loosestrife populations in check. The RCLA continues to partner with the Birchwood Schools to raise and distribute additional beetles for purple loosestrife control. Volunteers will occasionally collect and redistribute beetles to other places around the lakes when new populations of purple loosestrife are found.

Wild rice mapping was formally completed by RCLA volunteers in 2014 using a GPS unit. Wild rice has only been found in the channel between Mud Lake and at the outlet of that channel to Balsam Lake.

The RCLA holds several AIS education and information events every year regardless of working with a grant or not. These events included special workshops, presentations at RCLA functions, publishing of a newsletter, and upkeep of a RCLA webpage.

LAKE STEWARDSHIP ACTIVITIES

A couple of the goals in the 2012 APM Plan had to do with lake stewardship efforts to get property owners and users of the lakes to become better lake stewards. The RCLA has sponsored a boater's safety course nearly every year of implementation of the 2012 APM Plan. The RCLA supports and promotes Healthy Lakes Initiative projects to help improve habitat along the shores of the lakes and to reduce runoff. The RCLA works every year to restore the islands that dot the open water areas of the lakes.

LAND USE

The vast majority of the land within the total Red Cedar Lakes Watershed consists of forest land (Table 1, Figure 10). The rest of the watershed is comprised of open water, wetlands, and pastures. The smaller sub-watersheds that make up the larger Red Cedar Lakes Watershed have a similar composition to the larger watershed, though there are some notable differences. The primary cover is forest land in all three of the sub-watersheds. In the Balsam Lake Sub-watershed, the second and third most common land cover is open water and wetlands respectively. In the Hemlock Lake Sub-watershed, the reverse is true with wetlands being the second most common land cover and open water being the third. In the Red Cedar Lake Sub-watershed, pastures are the second most common land cover type, and there is a notably lower percentage of forestland (62.27%) than is found in the Balsam and Hemlock Lakes Sub-watersheds (71.58% and 77.41% respectively) (Table 5).

Table 5: Land cover within the Red Cedar Lakes Watershed and Sub-watersheds

	Total Watershed	Sub-Watersheds		
		Balsam Lake	***Red Cedar Lake***	***Hemlock Lake***
Open Water	9.41%	11.10%	9.96%	4.75%
Light Development	4.37%	3.94%	5.64%	3.65%
Heavy Development	0.06%	0.10%	0.03%	0.00%
Barren	0.00%	0.00%	0.00%	0.00%
Forest	70.13%	71.58%	62.27%	77.41%
Grassland/Scrub	1.64%	1.46%	1.05%	2.84%
Pasture	6.34%	4.69%	11.92%	2.56%
Crop	0.90%	0.54%	1.20%	1.32%
Wetlands	7.16%	6.57%	7.93%	7.47%

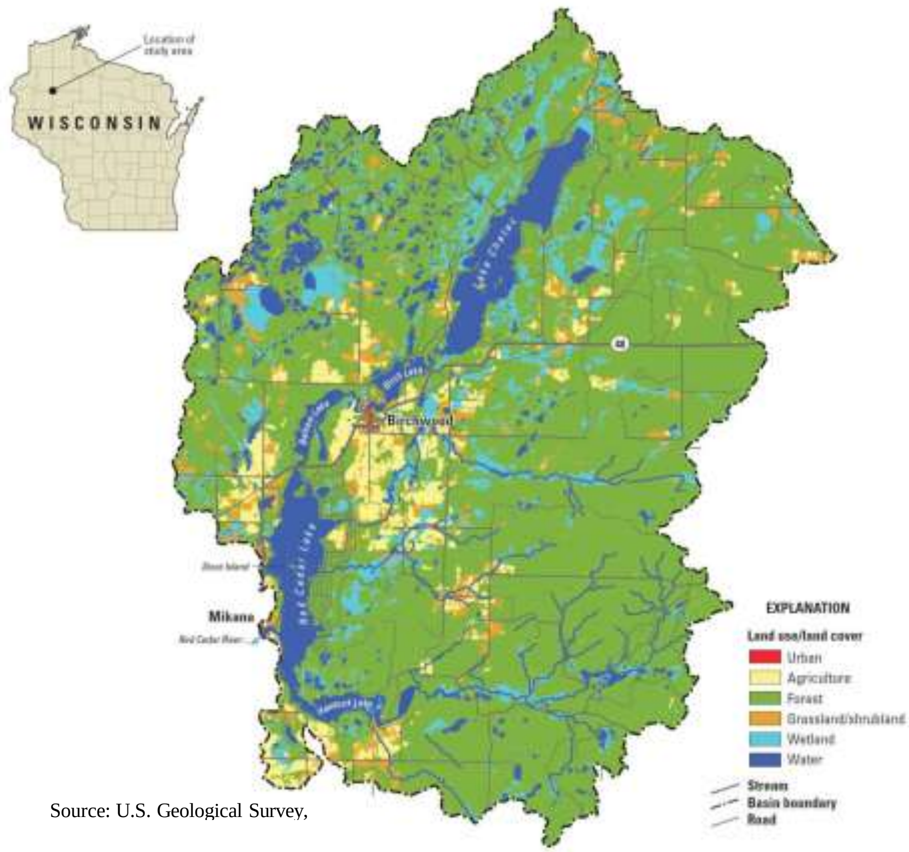


Figure 10: Red Cedar Lakes Watershed (USGS, 2003)

WETLANDS

A wetland is an area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions. Wetlands have many functions which benefit the ecosystem surrounding lakes and streams. Wetlands with a higher floral diversity of native species support a greater variety of native plants and are more likely to support regionally scarce plants and plant communities. Wetlands provide fish and wildlife habitat for feeding, breeding, resting, nesting, escape cover, travel corridors, spawning grounds for fish, and nurseries for mammals and waterfowl.

Wetlands also provide flood protection within the landscape. Due to the dense vegetation and location within the landscape, wetlands are important for retaining stormwater from rain and melting snow moving towards surface waters and retaining floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide water quality protection because wetland plants and soils have the capacity to store and filter pollutants ranging from pesticides to animal wastes.

Wetlands also provide shoreline protection to the lakes and streams they surround because shoreline wetlands act as buffers between land and water. They protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This shoreline protection is important in waterways where boat traffic, water current, and wave action can cause substantial damage to the shore. Wetlands also provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months. Aesthetics, recreation, education and science are also all services wetlands provide. Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes.

Approximately 7.2% of the land within the Red Cedar Lakes' Watershed is covered by wetland areas. These wetland areas are primarily smaller areas that are spread throughout the watershed (Figure 11). While the direct impact of these wetland areas has not been formally quantified, they likely provide a direct benefit to the lakes by containing stormwater, and naturally filtering some of the water that directly enters the lakes. In addition, these areas also provide valuable habitat for various species that live within them.

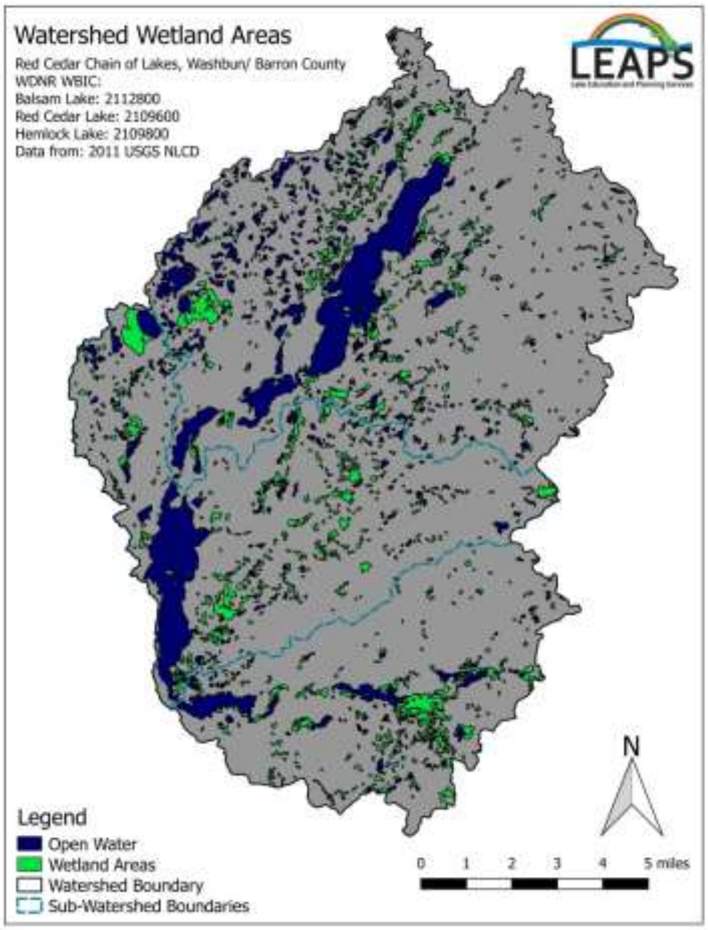


Figure 11: Red Cedar Lakes Watershed Wetland Areas

SOILS

Soils are classified into four main hydrologic soil groups (A, B, C, and D) to indicate their potential for producing runoff based off of the rate of infiltration. Group A soils have a high infiltration rate which makes the potential amount of runoff very low. These soils are, generally very sandy and allow water to pass through unimpeded. Conversely, group D soils have a very low infiltration rate making their runoff potential fairly high. Group D soils are generally very dense with high amounts of organic material. This causes water to move slowly through group D soils often resulting in standing water on flat surfaces and flowing water over sloped surfaces. Group D soils are generally found within wetland areas, but they can be problematic in areas that lack the hydrophitic vegetation found within those areas.

There are also three sub groups (A/D, B/D, and C/D) these indicated the infiltration rate of the soils with respect to the water table. If the water table is high and blocking infiltration, these soils are considered to have a high runoff potential and placed into group D, but when the water table is lower, these soils are similar to the first grouping (A, B, or C). Most of the soils (50.2%) within the Red Cedar Lakes' Watershed fall into groups C and C/D (Table 6) (NRCSa, Custom Soil Resource Report For Barrron County, Wisconsin, 2018). These soils have slow infiltration rates, so the potential for runoff is fairly high. The amount of undisturbed vegetation within the watershed can help reduce the amount of runoff that enters the lake as a result of these slow infiltration rates. Additionally, the majority of the land directly adjacent to the lakes contains soils with higher infiltration rates which can also help reduce runoff into the lakes (Figure 12).

Table 6: Hydrologic soil profile of the Red Cedar Lakes Watershed

Soils Within the Red Cedar Chain of Lake's Watersheds				
	Total Watershed	Balsam Lake Watershed	Red Cedar Lake Direct Watershed	Hemlock Lake Watershed
A	10.02%	16.64%	3.15%	4.00%
B	20.11%	17.39%	29.67%	13.38%
C	33.38%	29.62%	34.60%	40.43%
D	0.00%	0.00%	0.00%	0.00%
A/D	6.67%	7.15%	7.96%	3.81%
B/D	4.17%	3.06%	4.35%	6.50%
C/D	16.81%	15.72%	11.01%	27.27%
Open Water	8.84%	10.41%	9.26%	4.61%

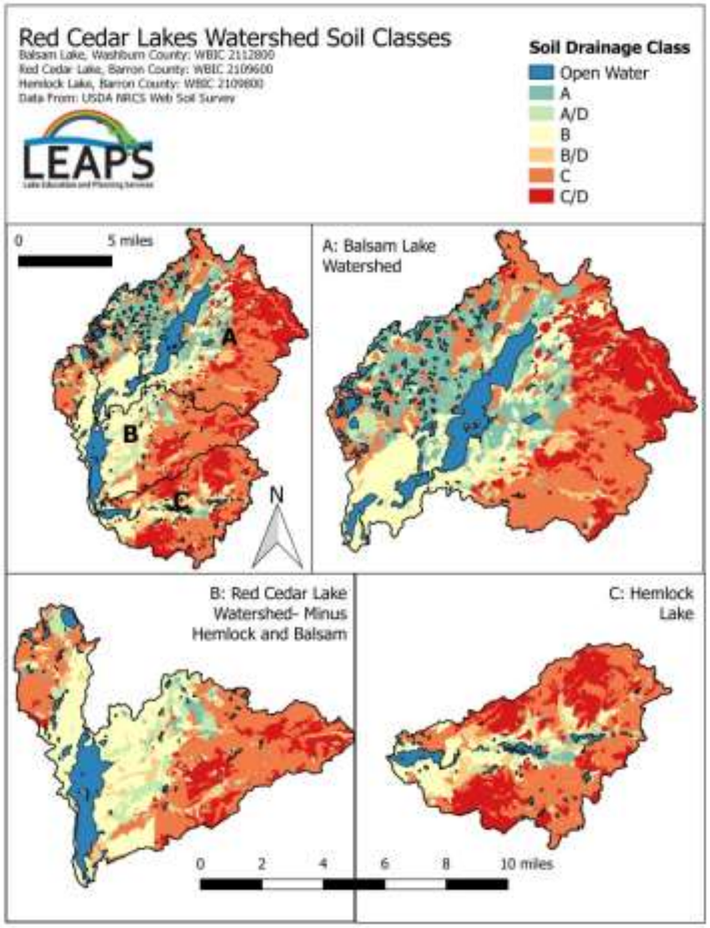


Figure 12: Soil Profile within the Red Cedar Lakes' Watershed and Sub-watersheds

WILDLIFE & THE NATURAL HERITAGE INVENTORY

The majority of the land within the Red Cedar Lakes Watershed is undeveloped. This allows a wide variety of plants and animals to reside within it. This includes several streams which are considered as Class I trout waters, and large areas of undisturbed forest and wetland which are home to bald eagles, black bear, muskrats, and many other fur bearing species. In addition to common species, the Red Cedar Lakes Watershed also contains several species which are listed on the Natural Heritage Inventory.

The Natural Heritage Inventory is a running list, produced by the WDNR, of organisms and natural communities that are listed as endangered, threatened, or considered to be of special concern by the State. Table 7 lists the species on this list that can be found in the PLSS townships containing the Red Cedar Lakes (T36N R10W and T37N R10W). In addition to the plant and animal species listed below, there are six natural communities within these townships. All six of these communities are found within T36N R10W which is where Red Cedar and Hemlock Lakes are found. These communities are Black spruce swamp, Lake--soft bog, Northern mesic forest, Northern sedge meadow, Northern wet forest, and Open bog.

Table 7: NHI Species within Red Cedar Lakes Townships

Scientific Name	Common Name	State Status	Group Name	T36N R10W	T37N R10W
Buteo lineatus	Red-shouldered hawk	THR	Bird	X	
Crotalaria sagittalis	Arrow-headed Rattle-box	SC	Plant		X
Notropis anogenus	Pugnose shiner	THR	Fish	X	X
Notropis nubilus	Ozark minnow	THR	Fish	X	
Pandion haliaetus	Osprey	THR	Bird		X

THR, threatened; SC, special concern; /FL, federally protected as endangered or threatened /P, fully protected; /N, no laws regulating use, possession or harvest.

Data current as of 2018-08-09

LAKE CHARACTERISTICS

The Red Cedar Lakes consist of three main stem lakes (Balsam, Red Cedar, and Hemlock) on the Red Cedar River, and Mud Lake, a large spring-fed bay of Balsam Lake. The lakes are located in northwestern Barron County (Hemlock and Red Cedar) and southeastern Washburn County (Balsam and Mud) in the townships of Cedar Lake and Birchwood. This area is the headwaters region of the Red Cedar River.

PHYSICAL CHARACTERISTICS

BALSAM & MUD LAKES

Balsam Lake has a surface area of 293 acres and a volume of approximately 46,000 acre-ft. The average depth of the lake is 26.7-ft and the maximum depth is 49-ft (Figure 13). Water enters the lake from the north via outflow from Birch Lake and from Mud Lake to the west. Water leaves the lake at the southern terminus through a connecting channel (at Hwy 48) to Red Cedar Lake. Mud Lake has a surface area of 36 acres and a volume of approximately 160 acre-feet. Its maximum depth is 25-ft and average depth is 4.3-ft. The majority of the water entering Mud Lake is via groundwater inflow (springs). The outlet of Mud Lake flows north into Balsam Lake. The WDNR considers Balsam and Mud Lakes to be one single lake covering about 325 acres. The bottom substrate is primary gravel (89%) with muck (10%) and rock (1%) making up the rest of the bottom substrate.

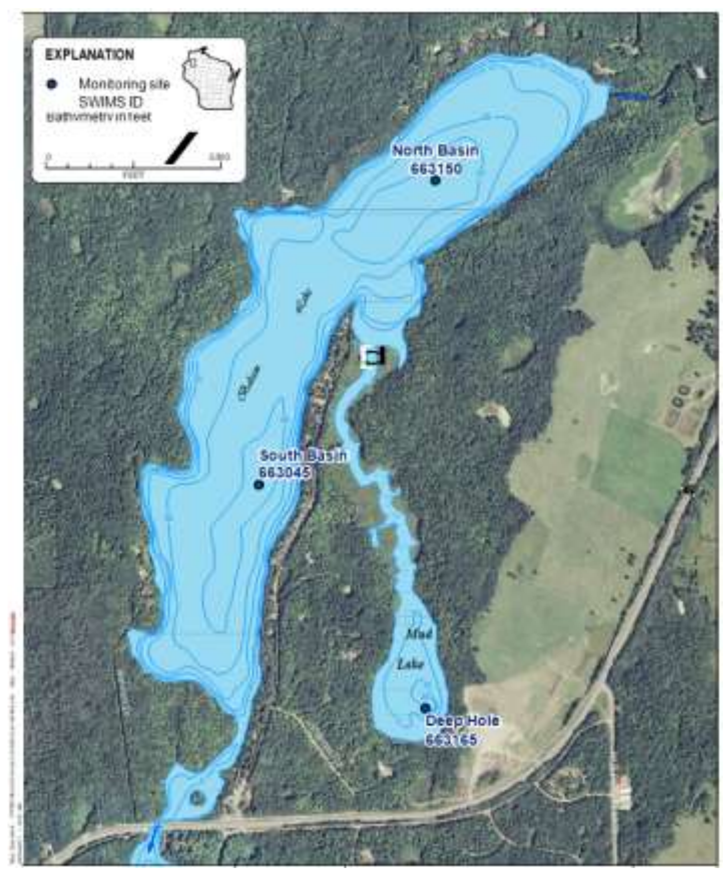


Figure 13: Balsam and Mud Lakes bathymetry and monitoring sites

RED CEDAR LAKE

Red Cedar Lake has a surface area of 1,934 acres and a volume of nearly 46,100 acre-ft. Its maximum depth is 53 ft. and average depth is 23.8 feet (Figure 14). The lake receives water from Balsam Lake, Hemlock Lake, and two main perennial tributaries on the northeast shore: Sucker Creek and Pigeon Creek. Outflow is over a dam in the community of Mikana, WI near the southern end of the lake. The bottom substrate is comprised primarily of sand (60%) with gravel (10%), rock (10%) and muck (20%) making up the rest of the substrate.

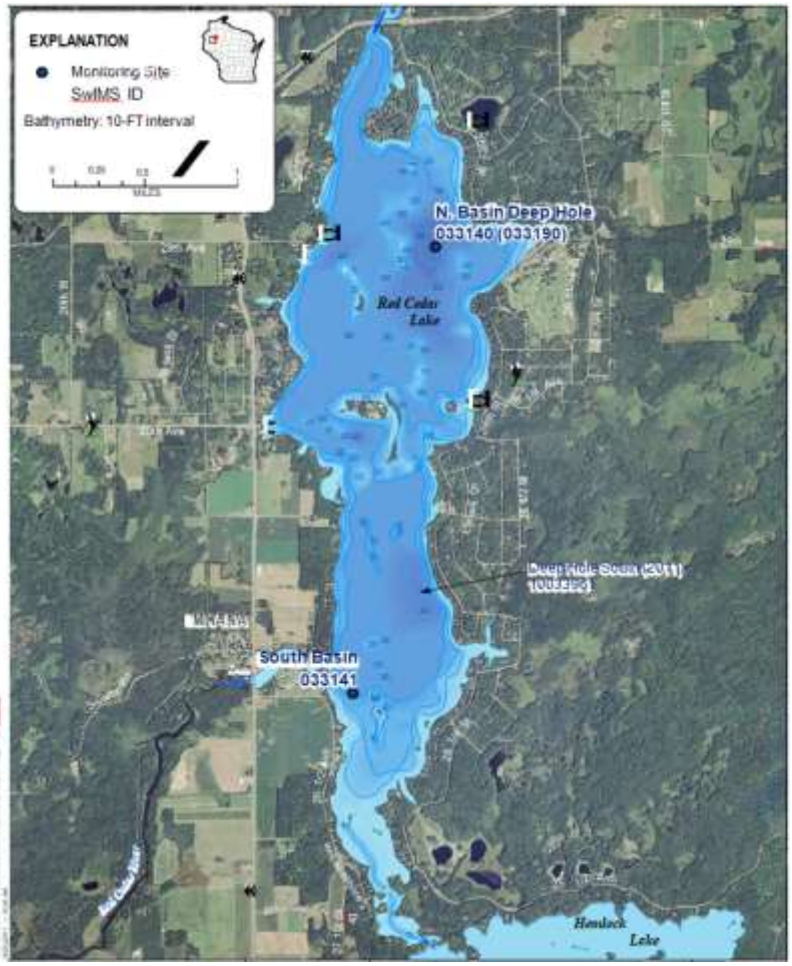


Figure 14: Red Cedar Lake bathymetry and monitoring sites

HEMLOCK LAKE

Hemlock Lake has a surface area of 377 acres and a volume of about 3,050 acre-ft. The average depth of the lake is 8.1-ft and its maximum depth is 21-ft (Figure 15). The majority of the water entering the lake is from Hemlock Creek flowing from the east. Water flows out of Hemlock Lake to Red Cedar Lake through the narrows connecting the two basins. Gravel (45%) and sand (40%) make up the bulk of the bottom substrate in Hemlock Lake with the remaining 15% consisting of muck.

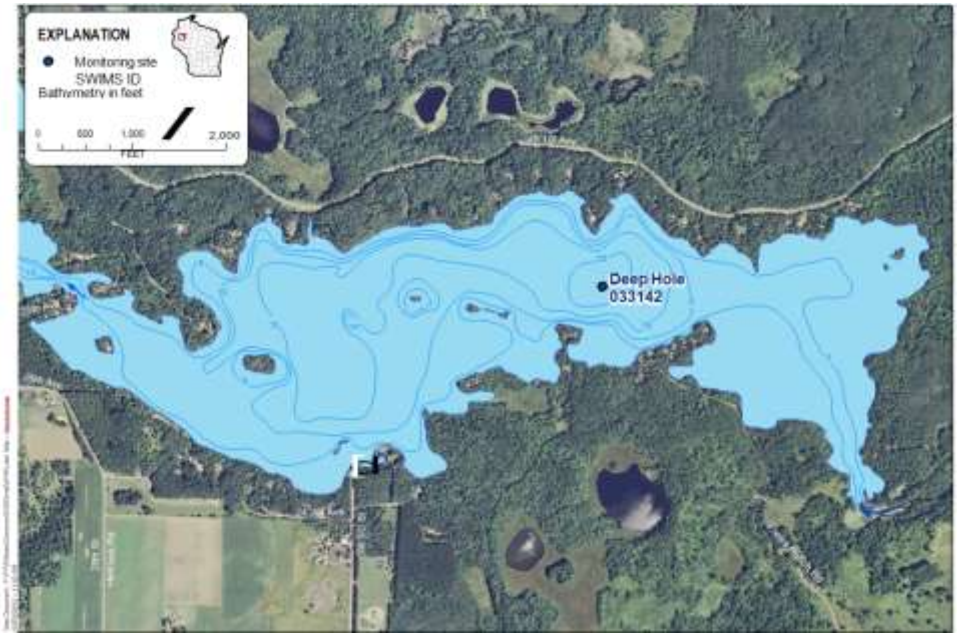


Figure 15: Hemlock Lake bathymetry and monitoring site

CRITICAL HABITAT

Every body of water has areas of aquatic vegetation or other features that offer critical or unique aquatic plant, fish and wildlife habitat. Such areas can be mapped by the WDNR and designated as Critical Habitat. Critical Habitat areas include important fish and wildlife habitat, natural shorelines, physical features important for water quality (for example, springs) and navigation thoroughfares. These areas, which can be located within or adjacent to the lake, are selected because they are particularly valuable to the ecosystem or would be significantly and negatively impacted by most human induced disturbances or development. Critical Habitat areas include both Sensitive Areas and Public Rights Features. Sensitive Areas offer critical or unique fish and wildlife habitat, are important for seasonal or life-stage requirements of various animals, or offer water quality or erosion control benefits.

The WDNR completed Lake Sensitive Area Reports on the Red Cedar Lakes in the late 1990s. The Sensitive Area surveys identified 9 areas on Balsam Lake and Mud Lake, 23 areas on Red Cedar Lake, and 12 areas on Hemlock Lake that merit special protection of the aquatic habitat (Figures 16-18). Sensitive areas on the lakes fell into two basic categories: aquatic plant communities providing important fish and wildlife habitat, and gravel and coarse rock rubble which provide important walleye spawning habitat.

The data and recommendations from the Sensitive Area Reports were reviewed and incorporated into this management plan. In general, the reports recommend that aquatic vegetation removal should be limited to navigation channels, preferably mechanically harvested, and only when severely impaired navigation or nuisance conditions are documented. It is important to maintain vegetated shoreland buffers in sensitive areas and stumps and woody habitat, which provides fish cover, should not be removed from sensitive areas. Although restrictions are in place to protect these areas during plant management operations, in some cases, short-term disruptions to habitat during the removal of monotypic stands of aquatic invasive species such as curly-leaf pondweed may lead to positive long-term improvements to the habitat of the lake. Disruptions to the sensitive areas may be warranted when responding to the discovery of a new invasive species.

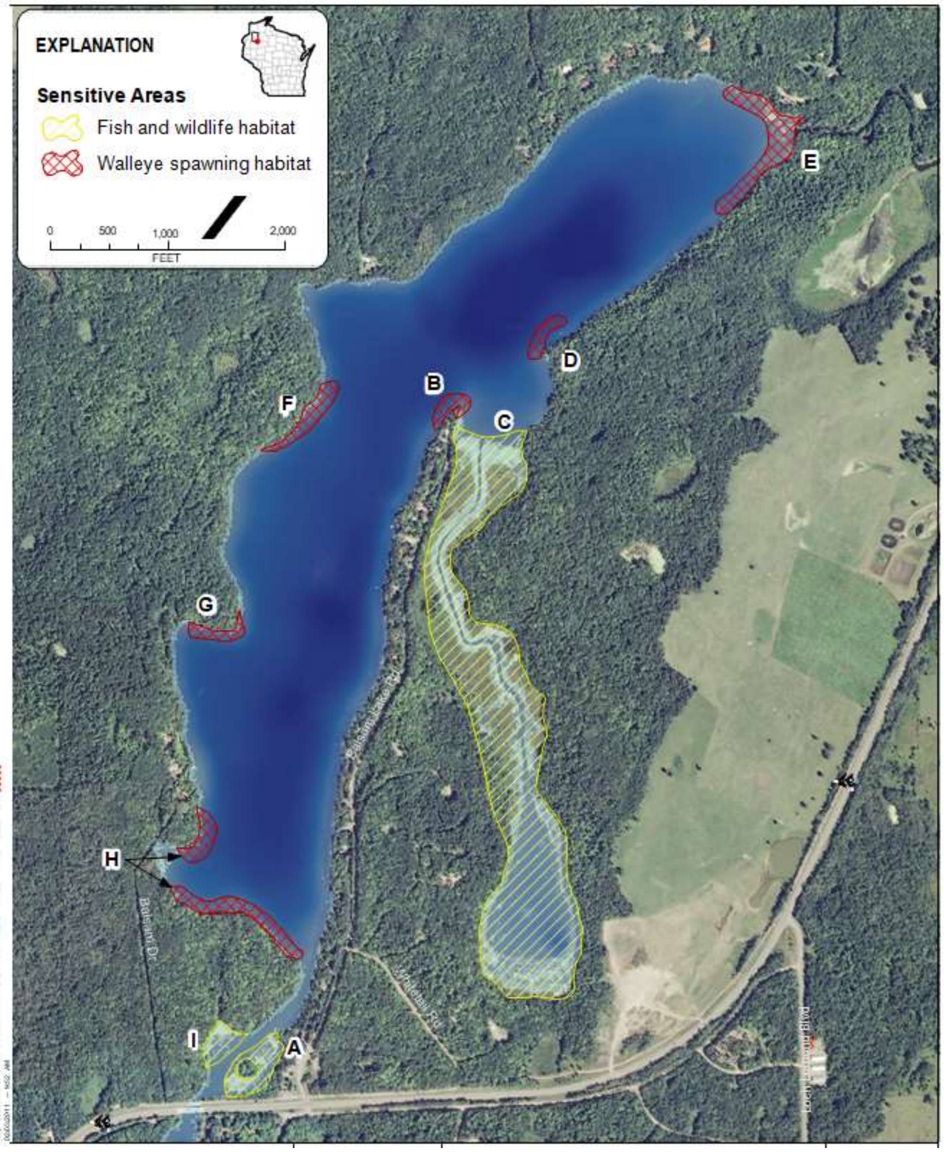


Figure 16: Sensitive Areas- Balsam and Mud Lakes

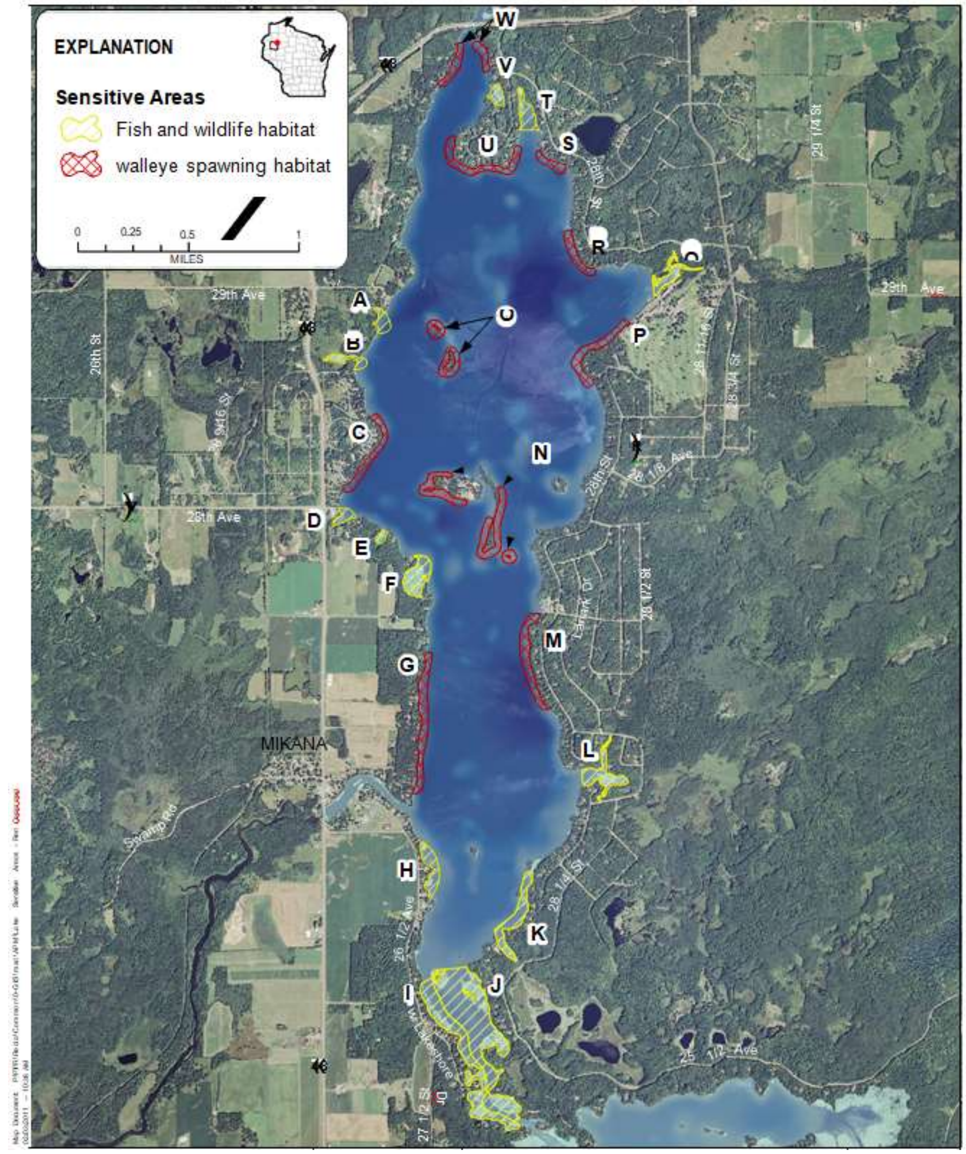


Figure 17: Sensitive Areas- Red Cedar Lake

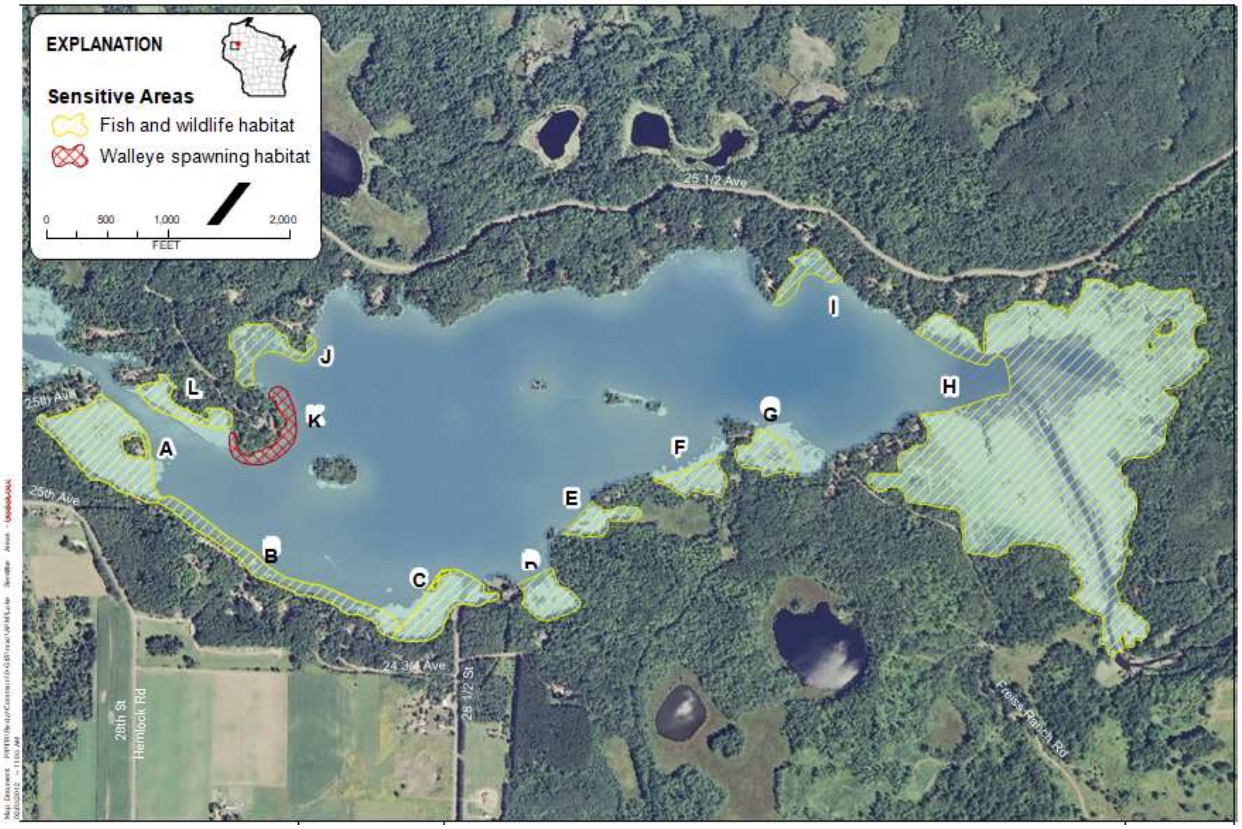


Figure 18: Sensitive Areas- Hemlock Lake

FISHERIES

The Red Cedar Lakes contain a diverse variety of fish species including gamefish species such as bass and walleye, panfish like crappie, perch, and bluegills, and a variety of less sought after, but still ecologically useful species like bullheads and bowfins. While the three lakes are all connected, the fisheries vary a fair bit between each lake.

BALSAM LAKE

In the 2016 survey, black crappies were the most common species found within Balsam Lake. 39 black crappies per mile of shoreline were captured ranging in size from 8.5 inches to 11 inches with an average size of 10.15 inches. Other panfish species found included bluegills, yellow perch, and pumpkinseeds (Table 5).

The most commonly found gamefish species within Balsam Lake in 2016 was the largemouth bass. Smallmouth bass was the second most common and walleye and norther pike were tied for third. On average largemouth bass were 14.3 inches in length, smallmouth bass were 11.88 inches, northern pike were 19.93 inches, and walleye were 16.49 inches (Table 8). For walleye, the average size changes some in other surveys conducted in 2016, but the highest average was 16.64 inches in the early spring assessment. This means that while most of the walleye captured in all of these surveys were WDNR defined “quality size,” very few were large enough for anglers to be able to legally harvest.

Table 8: 2016 Balsam Lake Fisheries Summary

Balsam Lake: 2016 Late Spring Fisheries Assessment				
Species	Relative Abundance (catch per mile)	Minimum Length (Inches)	Maximum Length (Inches)	Average Length (Inches)
Walleye	4.25	13.5	22.5	16.49
Black Crappie	39	8.5	11	10.15
Bluegill	10	3	8.5	6.85
Largemouth Bass	12.25	7.5	16.5	14.31
Northern Pike	4.25	11.5	30.5	19.93
Pumpkinseed	1	7	7	7
Rock Bass	3	7	8.5	7.92
Smallmouth Bass	6	7.5	15	11.88
Yellow Perch	4	4	9.5	8.25

RED CEDAR LAKE

Red Cedar Lake is known to anglers as a walleye lake, and while that was once true, walleye populations have declined in recent years due, in part, to a large amount of harvesting pressure (Benike, 2008). In the surveys conducted in 2016, the highest average length for walleye was 15.34 inches, and only 48% of the 2,322 walleye captured in that survey were considered to be WDNR "quality size" of 15 inches or larger.

Unlike Balsam Lake, largemouth bass are only the third most common gamefish species found in Red Cedar Lake. Despite this, the average size for largemouth bass in Red Cedar Lake (14.32 inches) is very close to those found in Balsam Lake (14.31 inches). Within Red Cedar Lake, the most common gamefish is smallmouth bass. These range in size from 7.5 to 18.5 inches with an average size of 12.24 inches. Northern pike can also be found within Red Cedar Lake, but to a lesser extent than other gamefish species (Table 9)

The panfish found in Red Cedar Lake are comprised primarily of bluegills and black crappies. The most common panfish within Red Cedar Lake are bluegills which range from 4 to 9 inches and average 6.64 inches. Black crappies are found in lesser numbers, and have a larger size distribution than other panfish species within the lake. Yellow perch and pumpkinseeds are less common, but also present in Red Cedar Lake (Table 9).

Table 9: 2016 Red Cedar Lake Fisheries Summary

Red Cedar Lake: 2016 Late Spring Fisheries Assessment				
Species	Relative Abundance (catch per mile)	Minimum Length (Inches)	Maximum Length (Inches)	Average Length (Inches)
Walleye	6.5	5.5	19.5	12.25
Black Crappie	12	6	13	10.67
Bluegill	38	4	9	6.64
Largemouth Bass	5.13	6.5	18	14.32
Northern Pike	3.38	9.5	28	19.97
Pumpkinseed	0.5	6.5	6.5	6.5
Rock Bass	34	4.5	10.5	8.04
Smallmouth Bass	15.13	7.5	18.5	12.47
Yellow Perch	1.5	5.5	8	6.58

HEMLOCK LAKE

Hemlock Lake has the fewer walleye than both Balsam and Red Cedar Lakes. What it lacks in quantity, Hemlock Lake's walleye population makes up for in quality. Most of the walleyes within Hemlock Lake range in size from 12 to 26 inches with an overall average of 21.17 inches (Table 10).

Largemouth bass are, by far, the most common gamefish species with Hemlock Lake, but the largemouth bass here are, on average, smaller than those found in Red Cedar and Balsam Lakes. Northern pike and smallmouth bass are also found in Hemlock Lake, but in significantly lower numbers than the largemouth bass (Table 10).

Hemlock Lake has the largest overall panfish population of the three lakes with bluegill being the most common fish species within the lake. The size distribution and average for bluegills in Hemlock Lake is on par with Balsam and Red Cedar Lakes. By comparison, the populations of other panfish species within Hemlock Lake are significantly smaller. Yellow Perch and black crappies can be found in Hemlock Lake, but are significantly fewer in number than bluegills, and the 2016 surveys did not encounter any pumpkinseeds (Table 10).

Table 10: 2016 Hemlock Lake Fisheries Summary

Hemlock Lake: 2016 Late Spring Fisheries Assessment				
Species	Relative Abundance (catch per mile)	Minimum Length (Inches)	Maximum Length (Inches)	Average Length (Inches)
Walleye	1.5	12	26	21.17
Black Crappie	3	9.5	11.5	10.58
Bluegill	152	3.5	8.5	6.62
Largemouth Bass	19.25	6	20	13.07
Northern Pike	1.5	13	23	19
Rock Bass	2	6.5	6.5	6.5
Smallmouth Bass	0.5	10.5	13	12
Yellow Perch	2	9.5	10.5	10.25

TWO-STORY FISHERY

Both Balsam and Red Cedar Lakes are considered to be two-story fisheries capable of supporting cold-water fish species (specifically cisco) assuming there is enough dissolved oxygen (DO) present in the colder water in the thermocline. Recent WDNR (Minahan, 2017) documentation suggests that cisco need DO levels >6.0mg/L and water temperatures <73°F to survive in a lake. The survival of cold water fish species like cisco depends on conditions in and below the thermocline that allow them to move up in the water column as oxygen levels in the bottom of the lake decline, while at the same time staying in cold enough water to keep them alive (Figure 19).

In new water quality criteria being developed by the WDNR, lakes designated as a two-story fisheries have to be able to maintain conditions that support that fishery in at least two out every three years. If it does not, then it will be considered impaired (Minahan, 2017). Based on temperature and DO data collected by volunteers within the past decade, these conditions are not met for a sustained period of time during the summer months within Red Cedar Lake. However, at the deep hole in Balsam Lake, conditions that could support cold-water fish tend to happen more often than not even through the summer months. Despite this cisco were noted as present in the system as recently as 2008 (Benike, 2008).

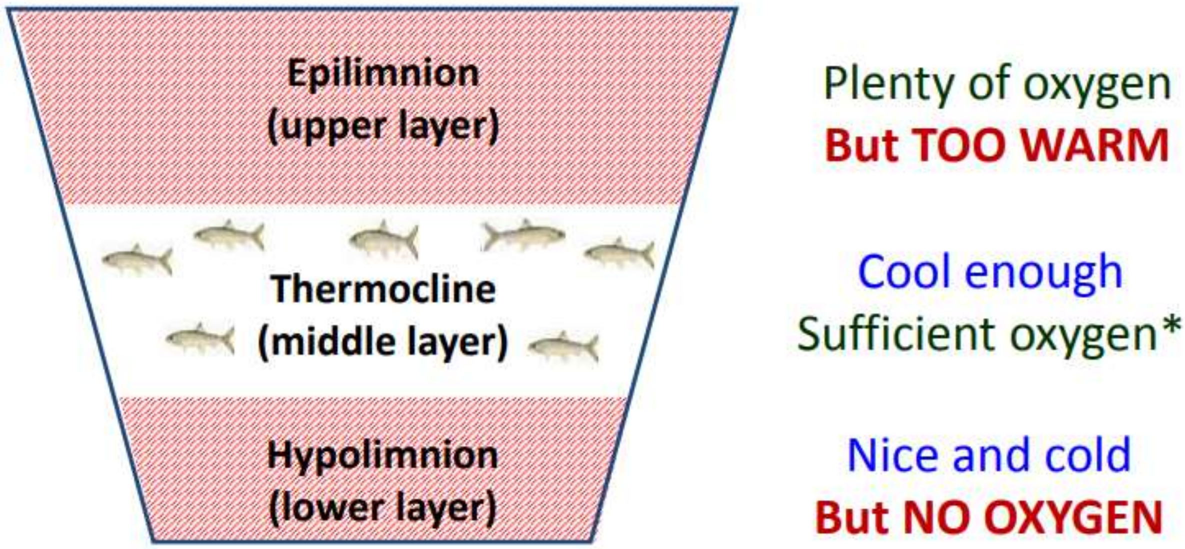


Figure 19: Lake Stratification Zones necessary to support a Two-story Fishery (Minahan, 2017)

CHANGES IN WALLEYE SIZE AND BAG LIMITS

In 2017, RCLA led a negotiation effort with the WDNR on behalf of its membership to change the walleye size and bag limit regulations in Balsam, Red Cedar, and Hemlock lakes. For many years anglers were only able to keep two walleyes that were over 18 inches in length. Fishermen were catching many walleyes in the chain, but few were taking any home as catching a fish over 18 inches was not a common occurrence. In 2017, a large discussion type meeting of the fishing interests on the Red Cedar Lakes and the WDNR was held. The end result was the WDNR willing to make changes in the walleye size and bag limit to a minimum length of 15 inches with a daily bag limit of three fish; but fish from 20" to 24" may not be kept, and only 1 fish over 24" can be kept. This change will first be enacted in the spring of 2019. The change was not without some concern, as a few fishermen are concerned that the smaller size limit will result in a whole lot more fish being taken from the lake which may negatively impact the overall population.

According to the WDNR, Red Cedar, Balsam, and Hemlock are on a six-year rotation for comprehensive fish surveys. All three lakes will come up for a full survey again in 2022. The WDNR also does an annual fall shocking survey on Red Cedar Lake to evaluate age-0 and age-1 walleye year classes. These surveys will continue (Aaron Cole, WDNR Fisheries Biologist – Personal Communication 5/13/2019).

WATER QUALITY

Red Cedar Lake is listed as "outstanding resource water" in Wisconsin. Outstanding Resource Water (ORW) maintains the highest value as a resource with excellent water quality and high quality fisheries. They do not currently receive wastewater discharges, nor will point source discharges be allowed in the future, unless the discharge waters meet or exceed the quality of the receiving water. Neither Balsam nor Hemlock Lakes are considered OWRs. Red Cedar and Balsam Lakes are both listed as 303(d) Impaired Waters. Every two years, Section 303(d) of the Clean Water Act requires states to publish a list of all waters that are not meeting the state's established water quality standards. Red Cedar Lake was listed in 2014 and Balsam Lake was listed in 2016. Both were listed due to total phosphorus levels exceeding the state threshold.

Water clarity and water chemistry are important indicators of water quality. Secchi disk readings of water clarity and chemistry parameters including total phosphorus, chlorophyll a, and temperature and oxygen profiles have been collected by Wisconsin Citizen Lake Monitoring Network (CLMN), formerly the Self-help Lake Monitoring Program, volunteers on all three lakes since 1993, with a few years where data was not collected.

WATER CLARITY

Water clarity is a measurement of how deep sunlight can penetrate into the waters of a lake. It can be measured in a number of ways, the most common being an 8" disk divided into four sections, two black and two white, lowered into the lake water from the surface by a rope marked in measurable increments (Figure 20). The water clarity reading is the point at which the Secchi disk when lowered into the water can no longer be seen from the surface of the lake. Water color (like dark water stained by tannins from nearby bogs and wetlands), particles suspended in the water column (like sediment or algae), and weather conditions (cloudy, windy, or sunlight) can impact how far a Secchi disk can be seen down in the water. Some lakes have Secchi disk readings of water clarity of just a few inches, while other lakes have conditions that allow the Secchi disk to be seen for dozens of feet before it disappears from view.

Figure 20: Black and white Secchi disk

BALSAM LAKE

In 2018, the most recent year for Secchi data, the average summer (July-September) Secchi depth at the deep hole site in Balsam Lake was 8.25 feet. The average for the Northwest Georegion was 8.7 feet, so Balsam Lake was slightly below average. The average summer Secchi depth has ranged from 5.2 feet in 2011 to 13.0 feet in 2007 (Figure 21). The average summer Secchi depth from 2005 through 2018 was 8.9 feet. Over this time period, a strong downward trend can be seen in the seasonal average for Secchi depth. This means the water clarity has steadily decreased since 2005 (Figure 13). The average Secchi depths for the entire year are, on average, slightly higher. From 2005-2018, Secchi depths ranged from 5.8 feet in 2011 up to 13.0 in 2007 with an overall average of 9.1 feet. The yearly Secchi depths also show a downward trend, though this is less steep than the trend shown in the seasonal averages.

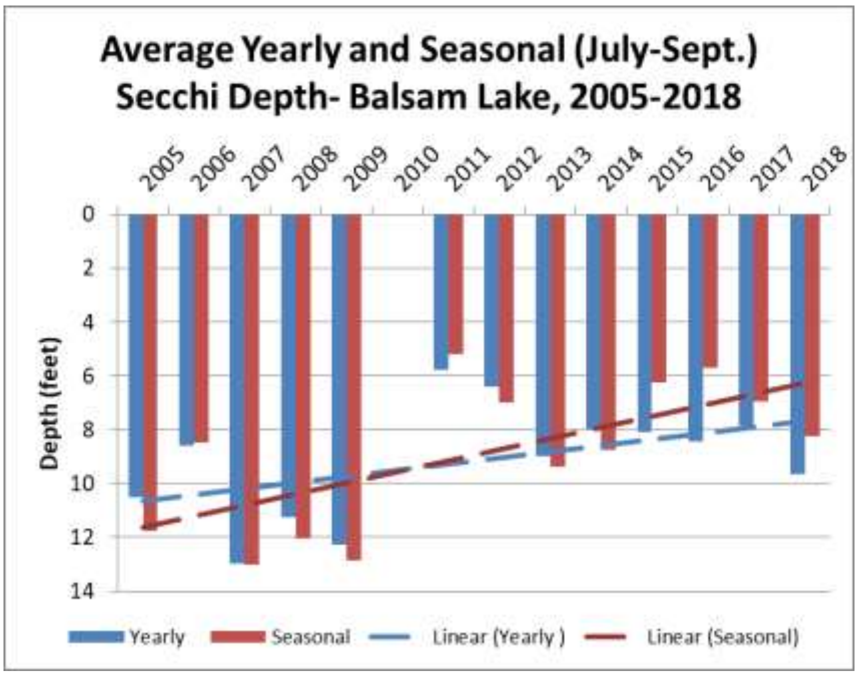


Figure 21: Average yearly and seasonal Secchi depth at the deep hole site on Balsam Lake

RED CEDAR LAKE

Volunteers have been collecting data at the deep hole site in the North Basin of Red Cedar Lake since 1987, and they resumed collecting data in the South Basin near Mikana in 2018. In 2018, the most recent year for Secchi data, the average summer (July-September) Secchi depth at the North deep hole site in Red Cedar Lake was 11.7 feet at the South site near Mikana the seasonal average was 11.8 feet. The average for the Northwest Georegion was 8.7 feet, so Red Cedar Lake was well above average in 2018. At the north deep hole site, the average summer Secchi depth has ranged from 5.8 feet in 2007 to 13.3 feet in 2009 (Figure 14). The average summer Secchi depth from 2001 through 2018 was 8.6 feet. The average Secchi depths for the entire year are, on average, slightly higher. From 2001-2018, Secchi depths ranged from 6.7 feet in 2007 up to 15.6 in 2007 with an overall average of 12.5 feet. Over the 2001-2018 time period, water clarity at the north deep hole has shown an upward trend which suggests that water clarity has been steadily increasing (Figure 22). Currently, there is not enough data to determine any sort of trend at the south site near Mikana.

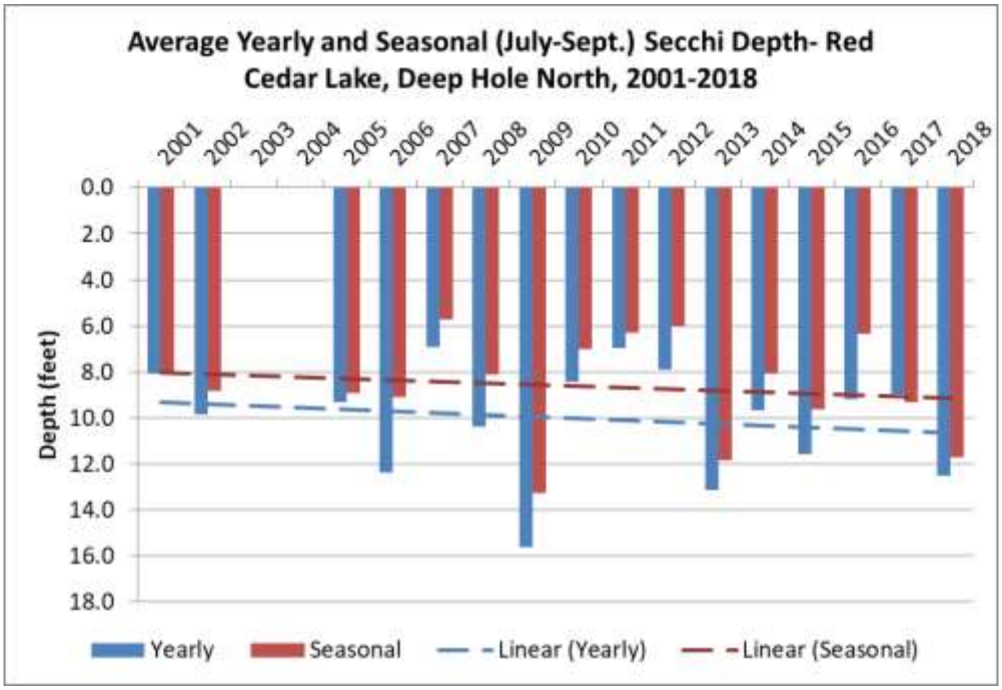


Figure 22: Average yearly and seasonal Secchi depth readings at the north deep hole site in Red Cedar Lake

HEMLOCK LAKE

In 2018, the most recent year for Secchi data, the average summer (July-September) Secchi depth at the deep hole site in Hemlock Lake was 7.0 feet. The average for the Northwest Georegion was 8.7 feet, so Hemlock Lake was below average for the region. The average summer Secchi depth has ranged from 4.1 feet in 2012 to 7.0 feet in 2018 (Figure 23). The average summer Secchi depth from 2000 through 2018 was 4.7 feet. The average Secchi depths for the entire year are, on average, slightly higher. From 2000-2018, Secchi depth averages for the year ranged from 4.7 feet in 2000 up to 7.5 feet in 2018 with an overall average of 5.5 feet. While Hemlock Lake has the lowest average water clarity of the three lakes, the trend suggests that it is improving at a steady rate since 2000 with 2018 being the best year on record (Figure 15)

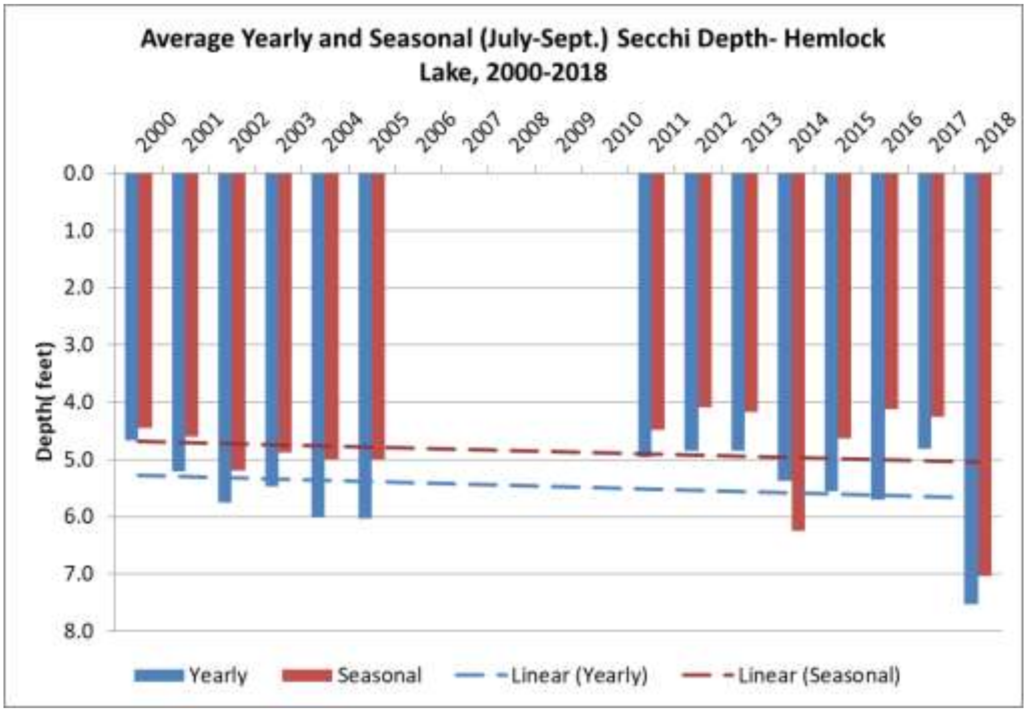


Figure 23: Average yearly and seasonal Secchi depth readings at the deep hole site of Hemlock Lake

WATER CHEMISTRY

Phosphorus is an important nutrient for plant growth and is commonly the nutrient limiting plant production in Wisconsin lakes. There are many sources of excess phosphorus to lake water: farm runoff, roadway runoff, failing septic systems, and decay of grass clippings, leaves, and other lawn debris that end up in the lake. This excess phosphorus can cause an increase in algae, and deteriorate the health of a lake if the amount of algae gets too high. Values greater than 10µg/L are considered indicative of eutrophic conditions and concentrations of 20µg/L or higher are associated with algal blooms. Chlorophyll-a is the green pigment found in plants and algae. The chlorophyll-a concentration is used as a measure of the algal population in a lake.

BALSAM LAKE

Chemistry data collected in 2018 at the Deep Hole on Balsam Lake showed an average summer Chlorophyll level of 9.4µg/l (compared to a Northwest Georegion summer average of 16.6µg/l). The summer Total Phosphorus average for 2018 was 21.97 µg/l. Lakes that have more than 20 µg/l of total phosphorus may experience noticeable algae blooms. The average summer chlorophyll level from 2013 to 2018 was 15.19µg/l; and the average total phosphorus level for the same time frame was 30.99µg/l (Figure 24). From 2013 to 2018, the data suggests there has been an upward trend in total phosphorus levels, but a very slight downward trend in chlorophyll-a levels (Figure 24). While this is something to watch in the future, six years is not enough time to establish any sort of long term trend.

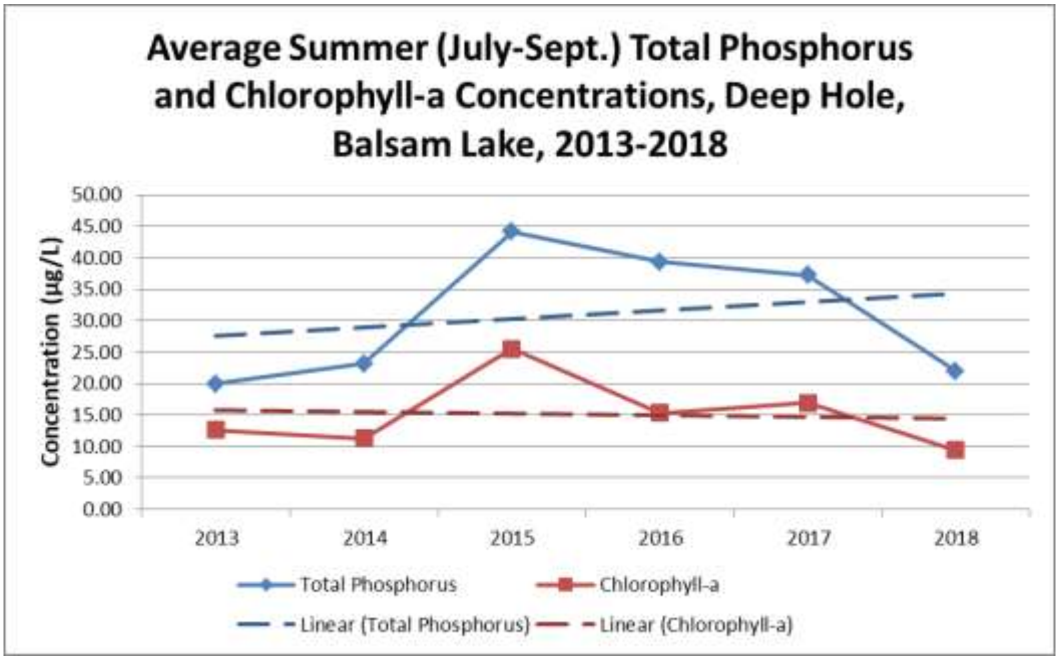


Figure 24: Balsam Lake water chemistry data, 2013-2018

As part of the Clean Water Act, states must produce a list of waters that do not meet the State's established water quality standards every two years. This list is known as the 303d Impaired Waters List. Water quality standards include the acceptable levels of total phosphorus, algae growth, and/or any number of miscellaneous pollutants. Balsam Lake was placed on the impaired waters list for excess total phosphorus levels in 2016.

RED CEDAR LAKE

Chemistry data collected in 2018 at the north deep hole on Red Cedar Lake showed an average summer Chlorophyll level of 5.82µg/l (compared to a Northwest Georegion summer average of 16.6µg/l). The summer Total Phosphorus average for 2018 was 13.42µg/l. The average summer chlorophyll level from 1993 to 2018 was 13.14µg/l; and the average total phosphorus level for the same time frame was 23.81µg/l (Figure 25). From 1993 to 2018, there is a fairly steady downward trend for both total phosphorus and chlorophyll-a levels (Figure 25). While there are peaks and valleys in the data year to year, this suggests that the overall levels of total phosphorus and chlorophyll-a are actually dropping within the lake.

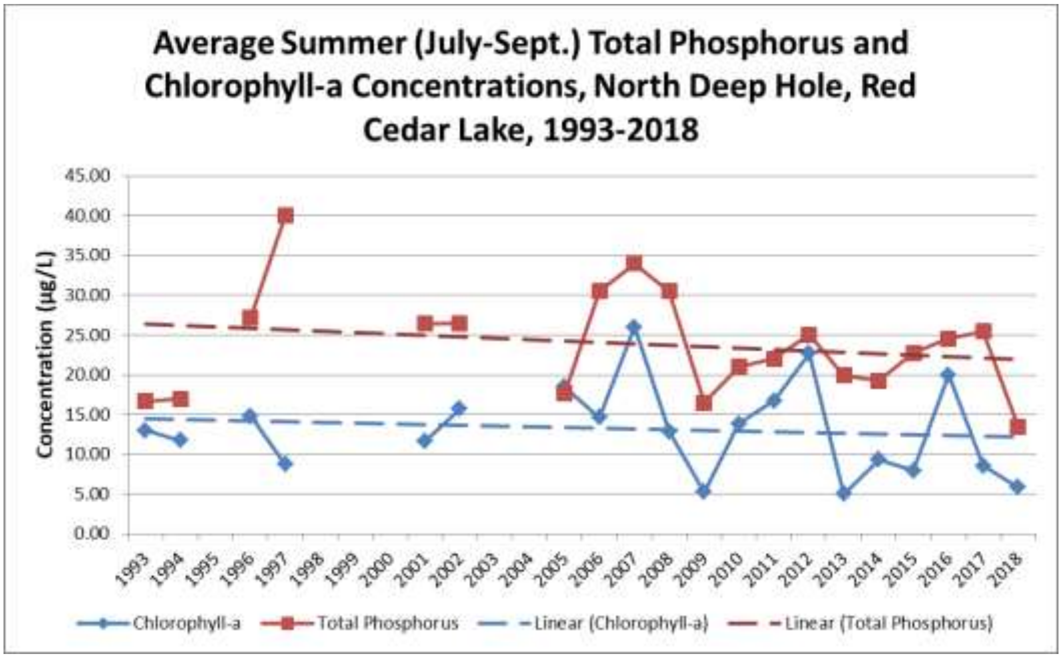


Figure 25: Red Cedar Lake-North deep hole site water chemistry data, 1993-2018

As part of the Clean Water Act, states must produce a list of waters that do not meet the State's established water quality standards every two years. This list is known as the 303d Impaired Waters List. Water quality standards include the acceptable levels of total phosphorus, algae growth, and/or any number of miscellaneous pollutants. In 2014, Red Cedar Lake was placed on this list for phosphorus levels that exceed the state standard.

HEMLOCK LAKE

Water chemistry data was collected intermittently since 1993, but collection became more regular in 2000. There was another gap from 2006-2012, but collection resumed in 2013. Chemistry data collected in 2018 at the deep hole on Hemlock Lake showed an average summer Chlorophyll level of 11.78µg/l (compared to a Northwest Georegion summer average of 16.6µg/l). The summer Total Phosphorus average for 2018 was 23.13µg/l. The average summer chlorophyll level from 2000 to 2005 and 2013 to 2018 was 17.47µg/l; and the average total phosphorus level for the same time frame was 33.38µg/l (Figure 26). For the timeframe that data is available, the levels of both chlorophyll-a and total phosphorus are not trending up or down. Of the three lakes, Hemlock Lake generally has the highest levels of chlorophyll-a and total phosphorus while Red Cedar Lake generally has the lowest.

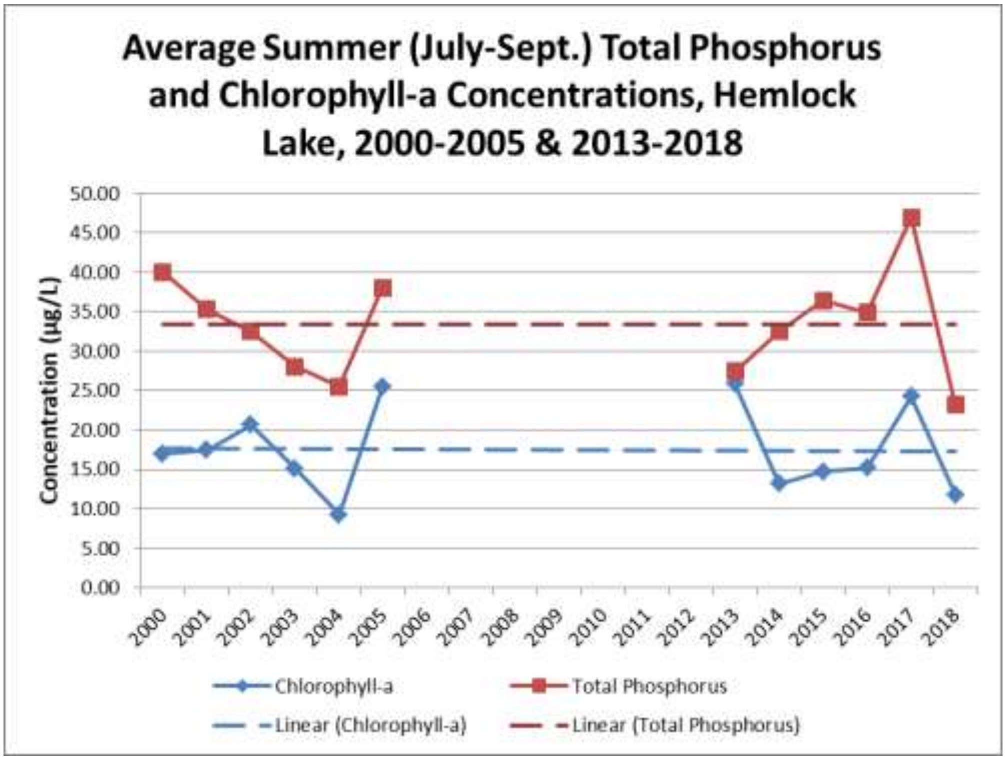


Figure 26: Hemlock Lake water chemistry data, 2000-2005 & 2013-2018

TROPHIC STATE INDEX

The water quality of a lake influences the aquatic plant community, which in turn can influence the chemistry of a lake. Water clarity, total phosphorus and chlorophyll a are measures of water quality that can be used to determine the productivity or trophic status of a lake. The Carlson trophic state index (TSI) is a frequently used biomass-related index. The trophic state of a lake is defined as the total weight of living biological material (or biomass) in a lake at a specific location and time. Eutrophication is the movement of a lake's trophic state in the direction of more plant biomass. Eutrophic lakes tend to have a large amount of biomass, high nutrient concentrations, and low water clarity due to algae blooms. Oligotrophic lakes, on the other end of the spectrum, are nutrient poor and have little plant and algae growth. Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms (Figure 27).

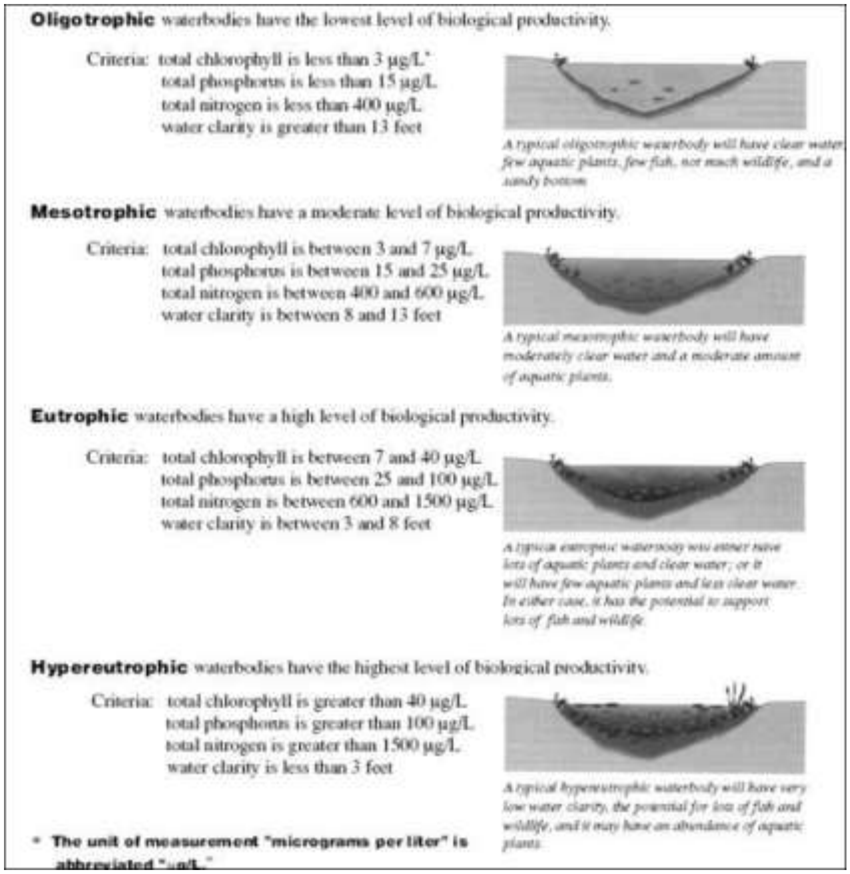


Figure 27: Trophic States in Lakes

Generally, TSI values from 0-40 are considered oligotrophic, 40-50 are mesotrophic, 50-70 are eutrophic, and anything above 70 is considered to be hypereutrophic. Values for total phosphorus, chlorophyll, and Secchi disk readings can all be used to calculate a lake's TSI. Preference is given to the chlorophyll-a trophic state index for classification because it is the most accurate at predicting algal biomass.

BALSAM LAKE

Balsam Lake is a eutrophic lake. While the Secchi depth TSI values usually fluctuate between mesotrophic and oligotrophic, the total phosphorus and chlorophyll TSI values have all been above 50 since monitoring resumed in 2013 (Figure 28). When the data is available for it, chlorophyll levels are used to determine the TSI level of a lake because this is an indirect measure of the amount of algae present within a system.

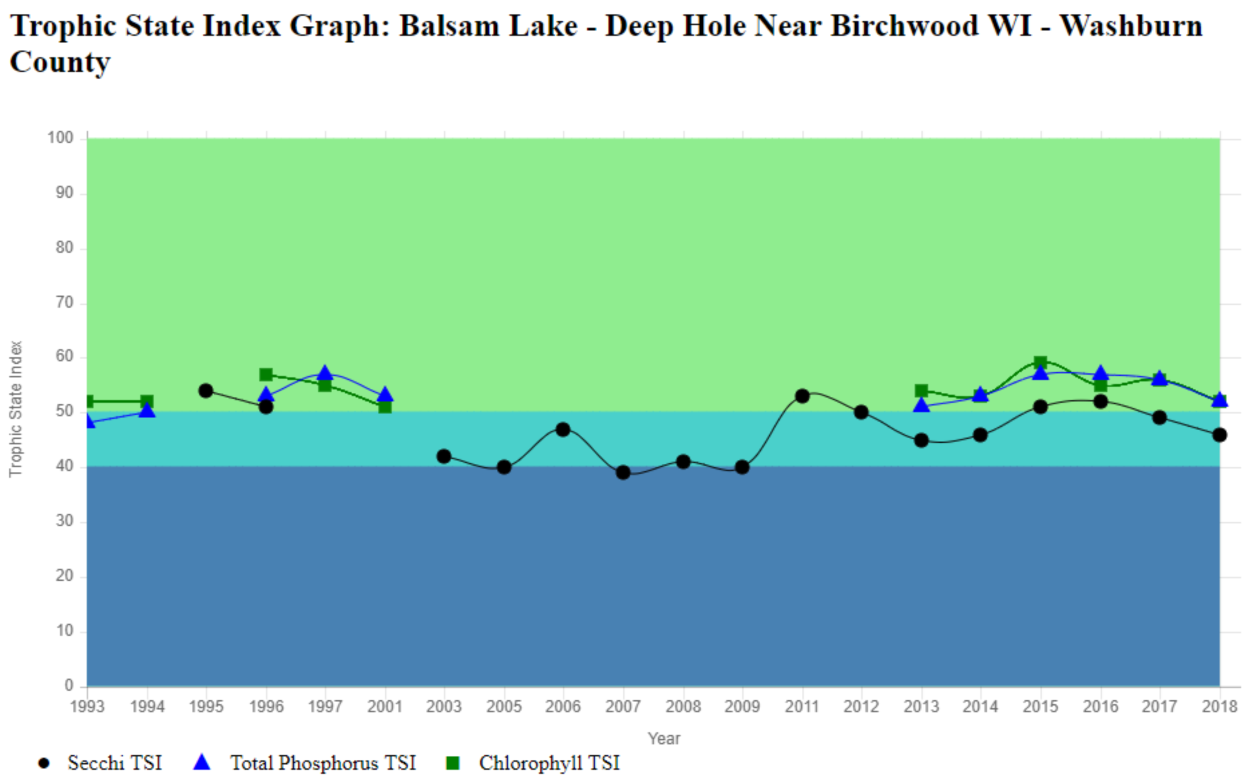


Figure 28: Balsam Lake Yearly TSI

RED CEDAR LAKE

Red Cedar Lake is listed as a eutrophic lake on the WDNR lakes page, but this can shift some from year to year (Figure 29). Since 2008, the average summer Secchi depth TSI was 46 which indicates a mesotrophic lake. The average summer TSI goes up to 47 for total phosphorus levels and 52 for the chlorophyll levels for the same time period. The chlorophyll levels are considered the most accurate indicator of a lake's trophic state, so Red Cedar Lake is considered to be a eutrophic lake. Despite this, Red Cedar Lake is only slightly eutrophic and it is bordering on being a mesotrophic state.

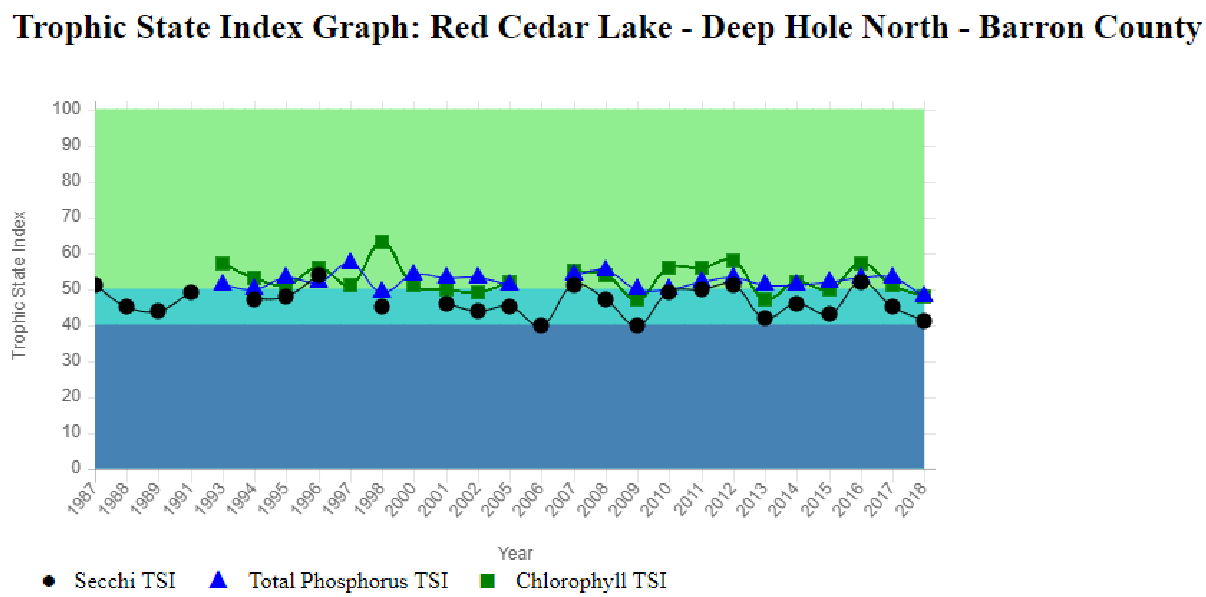


Figure 29: Red Cedar Lake Yearly TSI

HEMLOCK LAKE

Hemlock Lake is the most consistently eutrophic lake within the Red Cedar Lakes. With only a few exceptions, all of the water quality parameters point to Hemlock Lake being a eutrophic system (Figure 30). While there are peaks and valleys to these levels, the trophic state of Hemlock Lake appears to be fairly stable, and is unlikely to shift much either direction unless there is a dramatic shift in the nutrient levels.

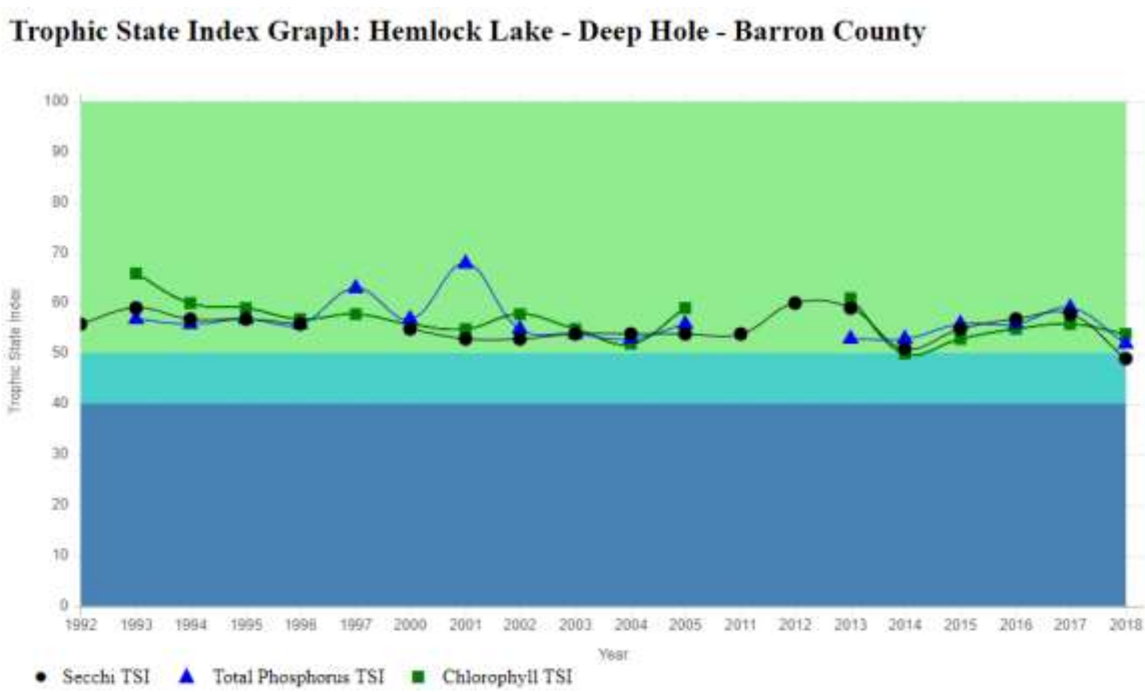


Figure 30: Hemlock Lake Yearly TSI

TEMPERATURE AND DISSOLVED OXYGEN

Temperature and dissolved oxygen are important factors that influence aquatic organisms and nutrient availability in lakes. As temperature increases during the summer in deeper lakes, the colder water sinks to the bottom and the lake develops three distinct layers as shown in Figure 31. This process, called stratification, prevents mixing between the layers due to density differences which limits the transport of nutrients and dissolved oxygen between the upper and lower layers. In most lakes in Wisconsin that undergo stratification, the whole lake mixes in the spring and fall when the water temperature is between 53 and 66°F, a process called overturn. Overturn begins when the surface water temperatures become colder and therefore denser causing that water to sink or fall through the water column. Below about 39°F, colder water becomes less dense and begins to rise through the water column. Water at the freezing point is the least dense which is why ice floats and warmer water is near the bottom (called inverse stratification) throughout the winter.

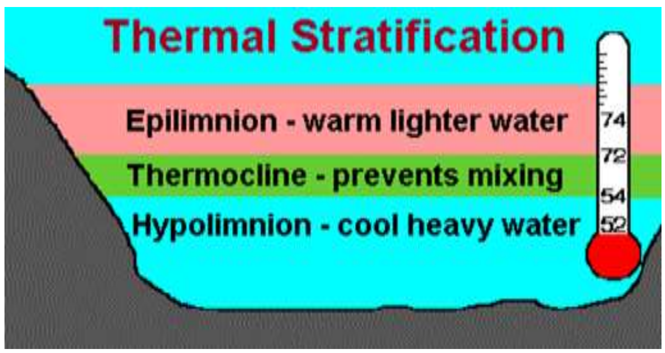


Figure 31: Summer thermal stratification

AQUATIC PLANT COMMUNITIES

To establish a baseline to measure from, a whole-lake, point-intercept survey was conducted on the Red Cedar Lakes in 2011. Another whole-lake, point intercept survey was conducted on the lakes in 2018. The 2011 and 2018 surveys both started with the point-intercept grids established by the WDNR, but only points in 20-ft of water or less were sampled. Tables 11-14 reflect the lake-wide and littoral zone metrics for all four lakes. In general, the health of the aquatic plant community in all four lakes was better in 2018 than it was in 2011. Species richness in each lake was higher in 2018 than it was in 2011 with Balsam up 1 species, Mud up 6 species, Red Cedar up 3 species, and Hemlock being up 17 species (almost 55% more plant species). The average number of native aquatic plants identified at each point also went up on all four lakes in 2018 with Balsam up 50%, Mud up 52%, Red Cedar up 61% and Hemlock up 63%.

FQI AND SDI

The Floristic Quality Index (FQI) and Simpsons Diversity Index (SDI) are two measures of the health of the aquatic plant community. Both are better in 2018 than they were in 2011 for all four lakes.

The FQI measures the impact of human development on a lake's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each native index species found in the lake during the point-intercept survey, and multiplying it by the square root of the total number of plant species (N) in the lake. Statistically speaking, the higher the index value, the healthier the lake's aquatic plant community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, North Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. The Red Cedar Lakes is in the Northern Lakes and Forests Region. Nichols reported a median FQI of 24.3 for the Northern Lakes and Forests Region (Nichols, 1999). The 2011 and 2018 FQI values for all four lakes were higher than the median FQI reported by Nichols meaning there is a large variety of native plant species that make up a healthy and diverse aquatic plant community.

The SDI allows the entire plant community at one location to be compared to the entire plant community at another location. It also allows the plant community at a single location to be compared over time thus allowing a measure of community degradation or restoration at that site. With Simpson's Diversity Index, the index value represents the probability that two individual plants (randomly selected) will be different species. The index values range from 0 -1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Perhaps most importantly, plant communities with high diversity also tend to be more resistant to invasion by exotic species. In the Red Cedar Lakes, diversity was quite high in 2018 with Simpson Index values of 0.92 in Balsam Lake and 0.93 in both Red Cedar and Hemlock Lakes. These numbers are notably higher than the 2011 survey in which Simpson Index values were 0.89 in Balsam Lake, 0.91 in Red Cedar Lake, and 0.87 in Hemlock Lake.

Table 11: Balsam Lake PI Survey Statistics

Balsam Lake	2011	2018
WHOLE-LAKE METRICS		
Lake Area (acres)	295	291
Total PI Points (WDNR)	1020	1020
Total Points Sampled	285	319
Vegetated Area (acres)	29.5	34
Area w/vegetation to the surface (acres)	14.75	10
Maximum Depth of Plant Growth (ft)	17	13.5
Average Density all points measureable (1,2,3)	2.16	2.19
Species Richness	31	32
LITTORAL METRICS		
Simpsons Diversity Index	0.89	0.92
Floristic Quality Index	26.1	30.1
Native Plants per point sampled	1.6	2.4

Table 12: Mud Lake PI Statistics

Mud Lake	2011	2018
WHOLE-LAKE METRICS		
Lake Area (acres)	28	34
Total PI Points (WDNR)	123	123
Total Points Sampled	123	116
Vegetated Area (acres)	26	33
Area w/vegetation to the surface (acres)	12.32	15
Maximum Depth of Plant Growth (ft)	10	6.9
Average Density all points measureable (1,2,3)	1.56	2.19
Species Richness	29	35
LITTORAL METRICS		
Simpsons Diversity Index	0.88	0.91
Floristic Quality Index	24.6	31.2
Native Plants per point sampled	2.7	4.1

Table 13: Red Cedar Lake PI Survey Statistics

Red Cedar Lake	2011	2018
WHOLE-LAKE METRICS		
Lake Area (acres)	1841	1897
Total PI Points (WDNR)	1208	1208
Total Points Sampled	376	376
Vegetated Area (acres)	258	308
Area w/vegetation to the surface (acres)	<20	65
Maximum Depth of Plant Growth (ft)	12	14.1
Average Density all points measureable (1,2,3)	1.81	2.33
Species Richness	36	39
LITTORAL METRICS		
Simpsons Diversity Index	0.91	0.93
Floristic Quality Index		34.1
Native Plants per point sampled	2.3	3.7

Table 14: Hemlock Lake PI Survey Statistics

Hemlock Lake	2011	2018
WHOLE-LAKE METRICS		
Lake Area (acres)	357	365
Total PI Points (WDNR)	486	486
Total Points Sampled	344	410
Vegetated Area (acres)	161	222
Area w/vegetation to the surface (acres)	93	97
Maximum Depth of Plant Growth (ft)	10	12.8
Average Density all points measureable (1,2,3)	2.3	2.25
Species Richness	31	48
LITTORAL METRICS		
Simpsons Diversity Index	0.87	0.93
Floristic Quality Index	28.8	38.7
Native Plants per point sampled	3.2	5.2

AQUATIC PLANT SPECIES PERCENT FREQUENCY OF OCCURRENCE

Plant frequency is the percent of sampled points where a given plant species was found. This indicates how common each plant species is, but does not reflect the density of the plant growth. Tables 15-22 reflect plant frequency for (1) the entire portion of the lake shallower than the observed maximum depth of plant growth, and (2) within areas shallower than a fixed depth of 15-ft to allow for easier comparisons between lakes. Tables 11-14 also show the overall density of aquatic plant growth in the lakes based on all points sampled with a measurable rakehead density of 1, 2, or 3. In addition, the average density of each plant species found in the littoral zone is given. The measurement reflects whether a specific plant forms widespread, dense growth patterns in the littoral zone that could be associated with nuisance growth. Generally a density rating greater than 2 would indicate a nuisance particularly if that plant grows to the surface of the lake.

BALSAM LAKE

In 2011, only five aquatic plant species in Balsam Lake showed a frequency of 10% Occurrence or more. In 2018, that number increased to ten species. No aquatic plant species in either survey was documented to grow to nuisance levels. Wild rice was documented in Balsam Lake in both 2011 and 2018, although its frequency of occurrence and density were very low.

MUD LAKE

In 2011, eight aquatic plant species in Mud Lake showed a frequency of 10% Occurrence or more. In 2018, that number increased to thirteen species. No aquatic plant species in either survey was documented to grow to nuisance levels. Wild rice was documented in Balsam Lake in both 2011 and 2018, although its frequency of occurrence and density were very low.

RED CEDAR LAKE

In 2011, nine aquatic plant species in Red Cedar Lake showed a frequency of 10% Occurrence or more. In 2018, that number increased to twelve species. No aquatic plant species in either survey was documented to grow to nuisance levels.

HEMLOCK LAKE

In 2011, eight aquatic plant species in Hemlock Lake showed a frequency of 10% Occurrence or more. In 2018, that number increased to seventeen species. No aquatic plant species in either survey was documented to grow to nuisance levels.

Table 15: 2011 PI – Balsam Lake

COMMON NAME	SCIENTIFIC NAME	%OCCURRENCE Max	%OCCURRENCE <15ft	LITTORAL DENSITY	BED DENSITY
SUBMERSED PLANTS					
Coontail	*Ceratophyllum demersum*	41	45	0.8	1.9
Canadian Waterweed	*Elodea canadensis*	16	17	0.2	1.1
Flat-stem Pondweed	*Potamogeton zosteriformis*	16	17	0.2	1.0
Star Duckweed	*Lemna trisulca*	15	16	0.2	1.0
Wild Celery	*Vallisneria americana*	9	10	0.1	1.0
Clasping-leaf Pondweed	*Potamogeton richardsonii*	7	7	0.1	1.0
Northern Watermilfoil	*Myriophyllum sibiricum*	6	7	0.1	1.1
Muskgrass	*Chara sp.*	5	5	0.1	1.3
Small Pondweed	*Potamogeton pusillus*	5	6	0.1	1.0
Stiff Water-crowfoot	*Ranunculus aquatilis*	5	6	0.1	1.0
Fries' Pondweed	*Potamogeton friesii*	4	4	<0.1	1.0
Curlyleaf Pondweed	*Potamogeton crispus*	3	3	<0.1	1.0
Large-leaf Pondweed	*Potamogeton amplifolius*	2	2	<0.1	1.0
Sago Pondweed	*Stuckenia pectinata*	2	2	<0.1	1.0
Water Marigold	*Bidens beckii*	2	2	<0.1	1.0
Water Stargrass	*Zosterella dubia*	2	2	<0.1	1.0
Fern-leaf Pondweed	*Potamogeton robbinsii*	1	1	<0.1	1.0
Slender Naiad	*Najas flexilis*	1	1	<0.1	2.0
Stonewort	*Nitella sp.*	1	1	<0.1	1.0
Variable-leaf Pondweed	*Potamogeton gramineus*	1	1	<0.1	1.0
FLOATING PLANTS					
White Waterlily	*Nymphaea odorata*	6	7	0.1	1.0
Giant Duckweed	*Spirodella polyrhiza*	3	3	<0.1	1.0
Small Duckweed	*Lemna minor*	3	3	<0.1	1.0
Watermeal	*Wolffia columbiana*	3	3	<0.1	1.0
Yellow Waterlily	*Nuphar variegata*	2	2	<0.1	1.0
Water Smartweed	*Polygonum amphibium*	1	1	<0.1	1.0
EMERGENT PLANTS					
Arrowhead	*Sagittaria sp.*	1	1	<0.1	1.0
Cattail	*Typha sp.*	1	1	<0.1	1.0
Northern Wild Rice	*Zizania palustris*	1	1	<0.1	1.0
Hard-stem Bulrush	*Schoenoplectus acutus*	P	P	–	–
Northern Blue Flag Iris	*Iris versicolor*	P	P	–	–

Table 16: 2011 PI – Mud Lake

COMMON NAME	SCIENTIFIC NAME	%OCCURRENCE Max	%OCCURRENCE <15ft	LITTORAL DENSITY	BED DENSITY
SUBMERSED PLANTS					
Coontail	*Ceratophyllum demersum*	74	73	0.9	1.2
Sago Pondweed	*Stuckenia pectinata*	26	26	0.3	1.0
Slender Naiad	*Najas flexilis*	25	25	0.3	1.2
Canadian Waterweed	*Elodea canadensis*	20	20	0.2	1.1
Star Duckweed	*Lemna trisulca*	20	20	0.2	1.0
Flat-stem Pondweed	*Potamogeton zosteriformis*	15	14	0.1	1.0
Clasping-leaf Pondweed	*Potamogeton richardsonii*	9	9	0.1	1.1
Fries' Pondweed	*Potamogeton friesii*	7	7	0.1	1.0
Muskgrass	*Chara* sp.	6	6	0.1	1.0
Water Stargrass	*Zosterella dubia*	5	5	0.1	1.0
Wild Celery	*Vallisneria americana*	5	5	0.1	1.2
Small Pondweed	*Potamogeton pusillus*	4	4	<0.1	1.0
Curlyleaf Pondweed	*Potamogeton crispus*	3	3	<0.1	1.0
Stonewort	*Nitella* sp.	3	3	<0.1	1.0
Large-leaf Pondweed	*Potamogeton amplifolius*	1	1	<0.1	1.0
Northern Watermilfoil	*Myriophyllum sibiricum*	1	1	<0.1	1.0
Stiff Water-crowfoot	*Ranunculus aquatilis*	1	1	<0.1	1.0
Common Bladderwort	*Utricularia vulgaris*	P	P	–	–
Fern-leaf Pondweed	*Potamogeton robbinsii*	P	P	–	–
White-stem Pondweed	*Potamogeton praelongus*	P	P	–	–
FLOATING PLANTS					
White Waterlily	*Nymphaea odorata*	22	22	0.2	1.1
Floating-leaf Pondweed	*Potamogeton natans*	15	15	0.2	1.1
Yellow Waterlily	*Nuphar variegata*	2	2	<0.1	1.0
Giant Duckweed	*Spirodella polyrhiza*	P	P	–	–
EMERGENT PLANTS					
Arrowhead	*Sagittaria* sp.	5	5	0.1	1.0
Burr-reed	*Sparganium* sp.	2	2	<0.1	1.0
Cattail	*Typha* sp.	P	P	–	–
Hard-stem Bulrush	*Schoenoplectus acutus*	P	P	–	–
Northern Wild Rice	*Zizania palustris*	P	P	–	–

Table 17: 2011 PI – Red Cedar Lake

COMMON NAME	SCIENTIFIC NAME	%OCCURRENCE Max	%OCCURRENCE <15ft	LITTORAL DENSITY	BED DENSITY
SUBMERSED PLANTS					
Coontail	*Ceratophyllum demersum*	41	35	0.6	1.4
Wild Celery	*Vallisneria americana*	28	25	0.3	1.0
Fern-leaf Pondweed	*Potamogeton robbinsii*	26	22	0.3	1.3
Flat-stem Pondweed	*Potamogeton zosteriformis*	23	20	0.3	1.2
Small Pondweed	*Potamogeton pusillus*	18	15	0.2	1.2
Northern Watermilfoil	*Myriophyllum sibiricum*	13	11	0.2	1.1
Canadian Waterweed	*Elodea canadensis*	12	11	0.1	1.1
Star Duckweed	*Lemna trisulca*	12	10	0.1	1.0
Clasping-leaf Pondweed	*Potamogeton richardsonii*	10	8	0.1	1.1
Water Marigold	*Bidens beckii*	7	6	0.1	1.0
Large-leaf Pondweed	*Potamogeton amplifolius*	5	5	0.1	1.3
Stonewort	*Nitella* sp.	4	3	<0.1	1.0
Slender Naiad	*Najas flexilis*	3	3	<0.1	1.0
Fries' Pondweed	*Potamogeton friesii*	3	3	<0.1	1.1
White-stem Pondweed	*Potamogeton praelongus*	3	3	<0.1	1.0
Stiff Water-crowfoot	*Ranunculus aquatilis*	2	2	<0.1	1.0
Muskgrass	*Chara* sp.	1	1	<0.1	1.0
Variable-leaf Pondweed	*Potamogeton gramineus*	1	1	<0.1	1.0
Aquatic Moss	*Fontinalis antipyretica*	1	1	<0.1	1.0
Common Bladderwort	*Utricularia vulgaris*	1	1	<0.1	1.0
Water Stargrass	*Zosterella dubia*	1	1	<0.1	1.0
Curlyleaf Pondweed	*Potamogeton crispus*	1	<1	<0.1	1.0
Quillwort	*Isoetes sp.*	P	P	–	–
Sago Pondweed	*Stuckenia pectinata*	P	P	–	–
FLOATING PLANTS					
White Waterlily	*Nymphaea odorata*	8	7	0.1	1.0
Yellow Waterlily	*Nuphar variegata*	4	4	0.1	1.1
Giant Duckweed	*Spirodella polyrhiza*	3	2	<0.1	1.0
Watermeal	*Wolffia columbiana*	1	1	<0.1	1.0
Small Duckweed	*Lemna minor*	<1	<1	<0.1	1.0
Floating-leaf Pondweed	*Potamogeton natans*	P	P	–	–
EMERGENT PLANTS					
Burr-reed	*Sparganium* sp.	3	2	<0.1	1.0
Cattail	*Typha* sp.	P	P	–	–
Purple Loosestrife	*Lythrum salicaria*	P	P	–	–
Arrowhead	*Sagittaria* sp.	P	P	–	–
Hard-stem Bulrush	*Schoenoplectus acutus*	P	P	–	–
Creeping Spikerush	*Eleocharis palustris*	P	P	–	–

Table 18: 2011 PI – Hemlock Lake

COMMON NAME	SCIENTIFIC NAME	%OCCURRENCE Max	%OCCURRENCE <15ft	LITTORAL DENSITY	BED DENSITY
SUBMERSED PLANTS					
Fern-leaf Pondweed	*Potamogeton robbinsii*	81	60	1.4	1.7
Coontail	*Ceratophyllum demersum*	60	44	0.9	1.5
Flat-stem Pondweed	*Potamogeton zosteriformis*	25	18	0.3	1.0
Canadian Waterweed	*Elodea canadensis*	18	14	0.2	1.0
Star Duckweed	*Lemna trisulca*	14	10	0.1	1.0
Common Bladderwort	*Utricularia vulgaris*	9	6	0.1	1.0
Small Pondweed	*Potamogeton pusillus*	8	6	0.1	1.1
Large-leaf Pondweed	*Potamogeton amplifolius*	6	5	0.1	1.0
Wild Celery	*Vallisneria americana*	5	4	0.1	1.0
Aquatic Moss	*Fontinalis antipyretica*	4	3	<0.1	1.0
Northern Watermilfoil	*Myriophyllum sibiricum*	4	3	<0.1	1.0
Water Marigold	*Bidens beckii*	3	2	<0.1	1.0
Clasping-leaf Pondweed	*Potamogeton richardsonii*	<1	<1	<0.1	1.0
Curlyleaf Pondweed	*Potamogeton crispus*	<1	<1	<0.1	1.0
Stiff Water-crowfoot	*Ranunculus aquatilis*	1	1	<0.1	1.0
Water Stargrass	*Zosterella dubia*	1	1	<0.1	1.0
White-stem Pondweed	*Potamogeton praelongus*	1	1	<0.1	1.0
Sago Pondweed	*Stuckenia pectinata*	P	P	–	–
Slender Naiad	*Najas flexilis*	P	P	–	–
Spiral-fruited Pondweed	*Potamogeton spirillus*	P	P	–	–
Variable-leaf Pondweed	*Potamogeton gramineus*	P	P	–	–
FLOATING PLANTS					
Giant Duckweed	*Spirodella polyrhiza*	32	24	0.3	1.0
White Waterlily	*Nymphaea odorata*	24	18	0.3	1.1
Yellow Waterlily	*Nuphar variegata*	15	11	0.2	1.0
Floating-leaf Pondweed	*Potamogeton natans*	6	5	0.1	1.0
Watermeal	*Wolffia columbiana*	2	1	<0.1	1.0
Slender Riccia	*Riccia fluitans*	1	1	<0.1	1.0
EMERGENT PLANTS					
Arrowhead	*Sagittaria* sp.	1	1	<0.1	1.0
Burr-reed	*Sparganium* sp.	P	P	–	–
Cattail	*Typha* sp.	P	P	–	–
Creeping Spikerush	*Eleocharis palustris*	P	P	–	–

Table 19: 2018 PI – Balsam Lake

COMMON NAME	SCIENTIFIC NAME	%OCCURRENCE Max	%OCCURRENCE <15ft	LITTORAL DENSITY
SUBMERSED PLANTS				
Coontail	*Ceratophyllum demersum*	49	47	0.8
Flat-stem pondweed	*Potamogeton zosteriformis*	25	23	0.3
Northern watermilfoil	*Myriophyllum sibiricum*	16	15	0.2
Clasping-leaf pondweed	*Potamogeton richardsonii*	16	15	0.2
Fern-leaf pondweed	*Potamogeton robbinsii*	15	15	0.2
Large-leaf pondweed	*Potamogeton amplifolius*	13	12	0.2
Wild celery	*Vallisneria americana*	13	12	0.1
Canadian waterweed	*Elodea canadensis*	11	10	0.1
Stiff water crowfoot	*Ranunculus aquatilis*	8	7	0.1
Water marigold	*Bidens beckii*	6	6	0.1
Stiff pondweed	*Potamogeton strictifolius*	6	5	0.1
Water stargrass	*Heteranthera dubia*	3	3	<0.1
Curly-leaf pondweed	*Potamogeton crispus*	2	2	<0.1
Muskgrass	*Chara* sp.	2	1	<0.1
Slender naiad	*Najas flexilis*	2	1	<0.1
Small pondweed	*Potamogeton pusillus*	2	1	<0.1
Nitella	*Nitella* sp.	1	1	<0.1
Sago pondweed	*Stuckenia pectinata*	<1	<1	<0.1
FLOATING PLANTS				
Star duckweed	*Lemna trisulca*	21	19	0.2
White waterlily	*Nymphaea odorata*	12	11	0.1
Small duckweed	*Lemna minor*	9	9	0.1
Bull-head pond-lily	*Nuphar variegata*	4	3	<0.1
Large Duckweed	*Spirodela polyrhiza*	4	3	<0.1
Common watermeal	*Wolffia columbiana*	3	2	<0.1
Floating-leaf pondweed	*Potamogeton natans*	1	1	<0.1
Water smartweed	*Polygonum amphibium*	<1	<1	<0.1
EMERGENT PLANTS				
Sparganium sp.	*Sparganium* sp.	2	1	<0.1
Arrowhead	*Sagittaria* sp.	1	1	<0.1
Northern wild rice	*Zizania palustris*	1	1	<0.1
Northern blue flag	*Iris versicolor*	P	P	–
Hardstem bulrush	*Schoenoplectus acutus*	P	P	–
Cattail	*Typha* sp.	P	P	–

Table 20: 2018 PI – Mud Lake

COMMON NAME	SCIENTIFIC NAME	%OCCURRENCE Max	%OCCURRENCE <15ft	LITTORAL DENSITY
SUBMERSED PLANTS				
Coontail	*Ceratophyllum demersum*	82	81	1.2
Slender naiad	*Najas flexilis*	54	52	0.8
Canadian waterweed	*Elodea canadensis*	47	47	0.6
Muskgrass	*Chara* sp.	29	29	0.5
Clasping-leaf pondweed	*Potamogeton richardsonii*	18	18	0.2
Wild celery	*Vallisneria americana*	15	14	0.2
Flat-stem pondweed	*Potamogeton zosteriformis*	13	13	0.1
Sago pondweed	*Stuckenia pectinata*	11	10	0.1
Fern-leaf pondweed	*Potamogeton robbinsii*	10	10	0.1
Whorled watermilfoil	*Myriophyllum verticillatum*	7	8	0.1
Aquatic moss	*Aquatic moss*	4	4	<0.1
Northern watermilfoil	*Myriophyllum sibiricum*	5	4	<0.1
Common bladderwort	*Utricularia vulgaris*	5	4	<0.1
Small pondweed	*Potamogeton pusillus*	4	3	<0.1
Stiff water crowfoot	*Ranunculus aquatilis*	4	3	<0.1
Water stargrass	*Heteranthera dubia*	3	3	<0.1
Curly-leaf pondweed	*Potamogeton crispus*	2	3	<0.1
Water marigold	*Bidens beckii*	2	2	<0.1
Nitella	*Nitella* sp.	1	2	<0.1
Large-leaf pondweed	*Potamogeton amplifolius*	2	2	<0.1
Stiff pondweed	*Potamogeton strictifolius*	2	2	<0.1
Horned pondweed	*Zannichellia palustris*	P	P	–
FLOATING PLANTS				
White waterlily	*Nymphaea odorata*	36	35	0.4
Star duckweed	*Lemna trisulca*	21	23	0.2
Floating-leaf pondweed	*Potamogeton natans*	22	21	0.2
Small duckweed	*Lemna minor*	11	10	0.1
Large Duckweed	*Spirodela polyrhiza*	4	3	<0.1
Bull-head pond-lily	*Nuphar variegata*	1	1	<0.1
EMERGENT PLANTS				
Arrowhead	*Sagittaria* sp.	3	3	<0.1
Sparganium sp.	*Sparganium* sp.	1	1	<0.1
Creeping spikerush	*Eleocharis palustris*	P	P	–
Hardstem bulrush	*Schoenoplectus acutus*	P	P	–
Cattail	*Typha* sp.	P	P	–
Northern wild rice	*Zizania palustris*	P	P	–

Table 21: 2018 PI – Red Cedar Lake

COMMON NAME	SCIENTIFIC NAME	%OCCURRENCE Max	%OCCURRENCE <15ft	LITTORAL DENSITY
SUBMERSED PLANTS				
Coontail	*Ceratophyllum demersum*	46	44	0.6
Wild celery	*Vallisneria americana*	45	42	0.6
Flat-stem pondweed	*Potamogeton zosteriformis*	33	31	0.4
Canadian waterweed	*Elodea canadensis*	31	29	0.4
Clasping-leaf pondweed	*Potamogeton richardsonii*	29	28	0.4
Northern watermilfoil	*Myriophyllum sibiricum*	28	26	0.4
Fern-leaf pondweed	*Potamogeton robbinsii*	18	18	0.3
Slender naiad	*Najas flexilis*	16	15	0.2
Stiff pondweed	*Potamogeton strictifolius*	16	15	0.2
Large-leaf pondweed	*Potamogeton amplifolius*	10	10	0.1
Nitella	*Nitella sp.*	8	8	0.1
Stiff water crowfoot	*Ranunculus aquatilis*	8	8	0.1
Water marigold	*Bidens beckii*	6	6	0.1
Small pondweed	*Potamogeton pusillus*	6	6	0.1
Common bladderwort	*Utricularia vulgaris*	6	6	0.1
Water stargrass	*Heteranthera dubia*	5	5	0.1
White-stem pondweed	*Potamogeton praelongus*	5	5	0.1
Creeping bladderwort	*Utricularia gibba*	5	5	<0.1
Muskgrass	*Chara sp.*	3	3	<0.1
Aquatic moss	*Aquatic Moss*	1	1	<0.1
Curly-leaf pondweed	*Potamogeton crispus*	1	1	<0.1
Variable pondweed	*Potamogeton gramineus*	1	1	<0.1
Ribbon-leaf pondweed	*Potamogeton epihydrus*	1	1	<0.1
Needle spikerush	*Eleocharis acicularis*	<1	<1	<0.1
Illinois pondweed	*Potamogeton illinoensis*	<1	<1	<0.1
Twin-stemmed bladderwort	*Utricularia geminiscapa*	<1	<1	<0.1
FLOATING PLANTS				
Star duckweed	*Lemna trisulca*	12	11	0.1
White waterlily	*Nymphaea odorata*	11	10	0.1
Small duckweed	*Lemna minor*	5	5	<0.1
Bull-head pond-lily	*Nuphar variegata*	4	4	<0.1
Common watermeal	*Wolffia columbiana*	3	3	<0.1
Large Duckweed	*Spirodela polyrhiza*	2	2	<0.1
Crystalwort	*Riccia fluitans*	1	1	<0.1
Floating-leaf pondweed	*Potamogeton natans*	<1	<1	<0.1
EMERGENT PLANTS				
Arrowhead	*Sagittaria sp.*	1	1	<0.1
Sparganium sp.	*Sparganium sp.*	1	1	<0.1
Creeping spikerush	*Eleocharis palustris*	P	P	–
Hardstem bulrush	*Schoenoplectus acutus*	P	P	–
Cattail	*Typha sp.*	P	P	–

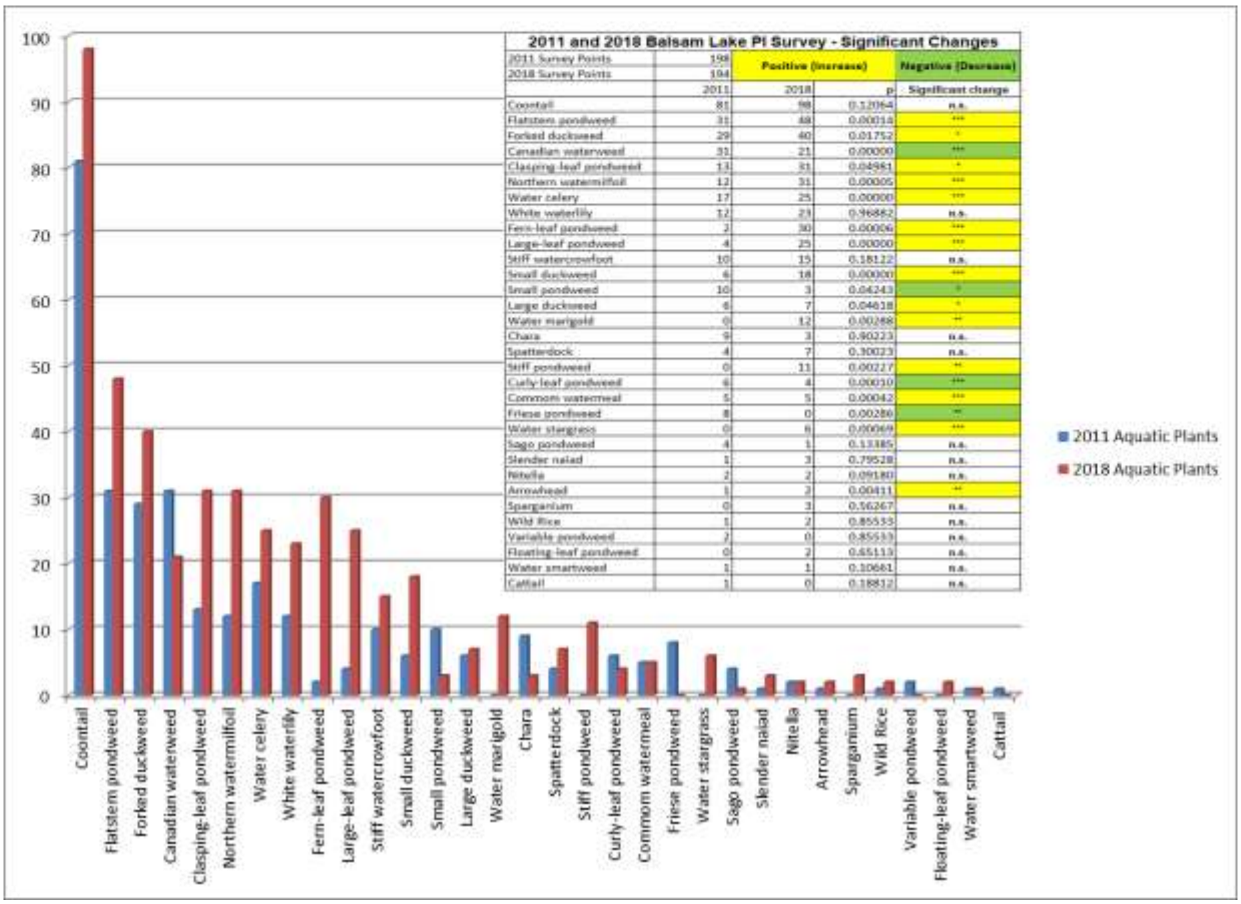
Table 22: 2018 PI – Hemlock Lake

COMMON NAME	SCIENTIFIC NAME	%OCCURRENCE Max	%OCCURRENCE <15ft	LITTORAL DENSITY
SUBMERSED PLANTS				
Coontail	*Ceratophyllum demersum*	85	73	1.3
Fern-leaf pondweed	*Potamogeton robbinsii*	54	47	0.9
Canadian waterweed	*Elodea canadensis*	43	37	0.5
Flat-stem pondweed	*Potamogeton zosteriformis*	25	21	0.3
Common bladderwort	*Utricularia vulgaris*	24	21	0.2
Water marigold	*Bidens beckii*	20	17	0.2
Small pondweed	*Potamogeton pusillus*	17	15	0.2
Creeping bladderwort	*Utricularia gibba*	17	15	0.2
Wild celery	*Vallisneria americana*	13	11	0.2
Northern watermilfoil	*Myriophyllum sibiricum*	13	11	0.1
Large-leaf pondweed	*Potamogeton amplifolius*	9	8	0.1
Twin-stemmed bladderwort	*Utricularia geminiscapa*	9	7	0.1
Nitella	*Nitella* sp.	4	3	<0.1
Stiff water crowfoot	*Ranunculus aquatilis*	4	3	<0.1
Clasping-leaf pondweed	*Potamogeton richardsonii*	4	3	<0.1
Whorled watermilfoil	*Myriophyllum verticillatum*	3	3	<0.1
Aquatic moss	*Aquatic moss*	3	3	<0.1
Water stargrass	*Heteranthera dubia*	3	3	<0.1
White-stem pondweed	*Potamogeton praelongus*	2	2	<0.1
Curly-leaf pondweed	*Potamogeton crispus*	2	1	<0.1
Slender naiad	*Najas flexilis*	1	1	<0.1
Blunt-leaf pondweed	*Potamogeton obtusifolius*	1	1	<0.1
Stiff pondweed	*Potamogeton strictifolius*	1	1	<0.1
Muskgrass	*Chara* sp.	<1	<1	<0.1
Alpine pondweed	*Potamogeton alpinus*	<1	<1	<0.1
Variable pondweed	*Potamogeton gramineus*	<1	<1	<0.1
Needle spikerush	*Eleocharis acicularis*	P	P	–
Ribbon-leaf pondweed	*Potamogeton epihydrus*	P	P	–
FLOATING PLANTS				
Star duckweed	*Lemna trisulca*	36	30	0.4
White waterlily	*Nymphaea odorata*	31	26	0.3
Large Duckweed	*Spirodela polyrhiza*	23	19	0.2
Bull-head pond-lily	*Nuphar variegata*	17	15	0.2
Small duckweed	*Lemna minor*	13	11	0.1
Crystalwort	*Riccia fluitans*	13	11	0.1
Common watermeal	*Wolffia columbiana*	13	11	0.1
Floating-leaf pondweed	*Potamogeton natans*	8	6	0.1
Water smartweed	*Polygonum amphibium*	P	P	–
EMERGENT PLANTS				
Sparganium sp.	*Sparganium* sp.	3	3	<0.1
Arrowhead	*Sagittaria* sp.	2	1	<0.1
Creeping spikerush	*Eleocharis palustris*	1	1	<0.1
Hardstem bulrush	*Schoenoplectus acutus*	<1	<1	<0.1

Additional emergent taxa observed in Hemlock Lake: *Equisetum fluviatile (horsetail/scouring rush), Heteranthera reniformis (kidneyleaf mudplantain), Iris versicolor (blue-flag iris), Schoenoplectus pungens (three-square rush), Schoenoplectus tabernaemontani (softstem bulrush), Typha sp. (cattail), Zizania palustris (wild rice)*

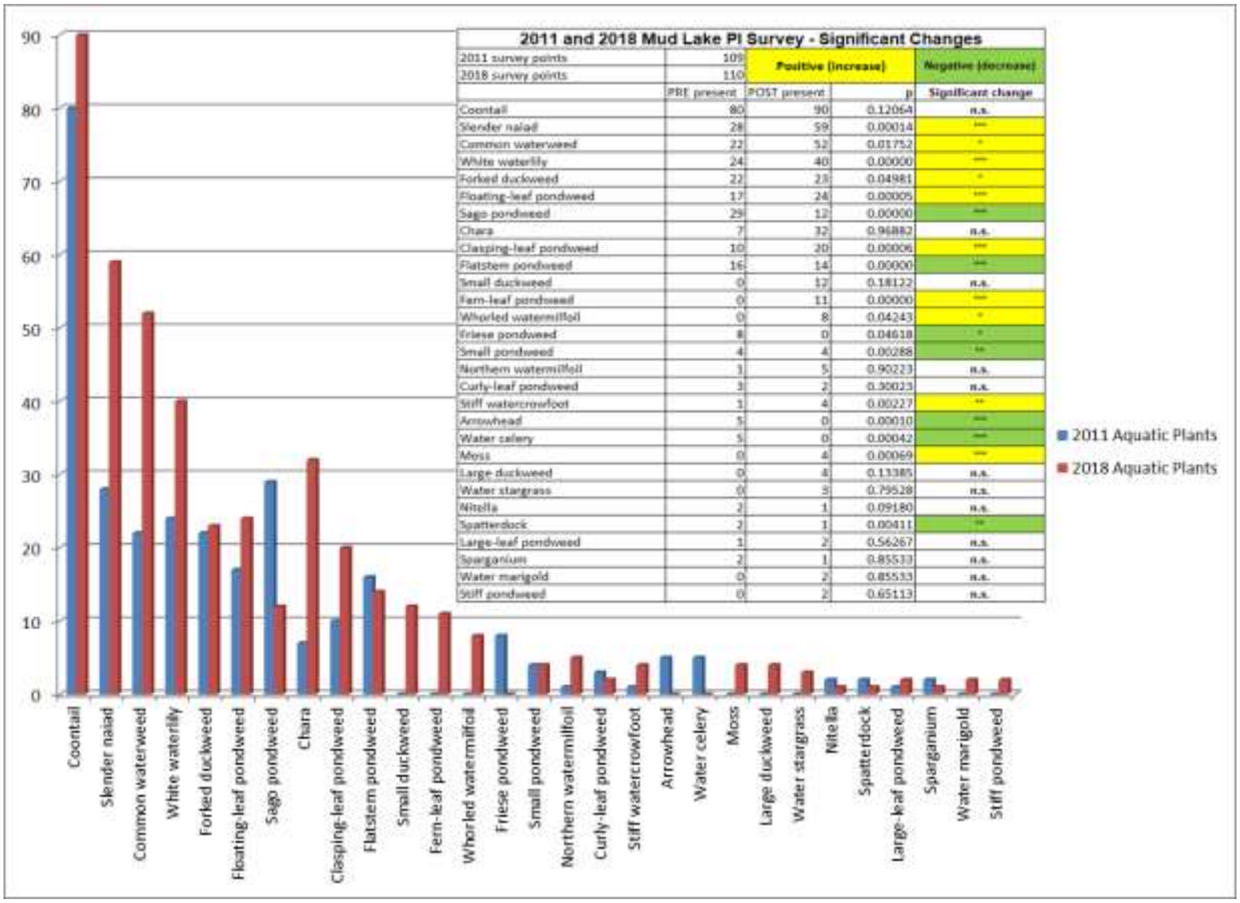
SIGNIFICANT CHANGES IN INDIVIDUAL PLANT SPECIES FROM 2011 TO 2018

The 2011 and 2018 whole-lake PI surveys also documented changes in the number of points with each species and a chi-square analysis was completed to determine which changes were significant, either because there were more points with a particular plant species or because there were less points with a particular plant species. Figures 32-35 and the tables therein show the changes in the points with aquatic plants and whether or not those changes were significant. Significance in the yellow boxes reflects a positive change, and those in green boxes reflect negative changes. In Balsam Lake, 18 species showed significant changes with only 4 of those being negative changes. In Mud Lake, 17 species showed significant changes with only 7 of those being negative changes. In Red Cedar Lake, 18 species showed significant changes with only 4 of those being negative changes. Finally, in Hemlock Lake, 20 species showed significant changes with only 2 of those being negative changes.



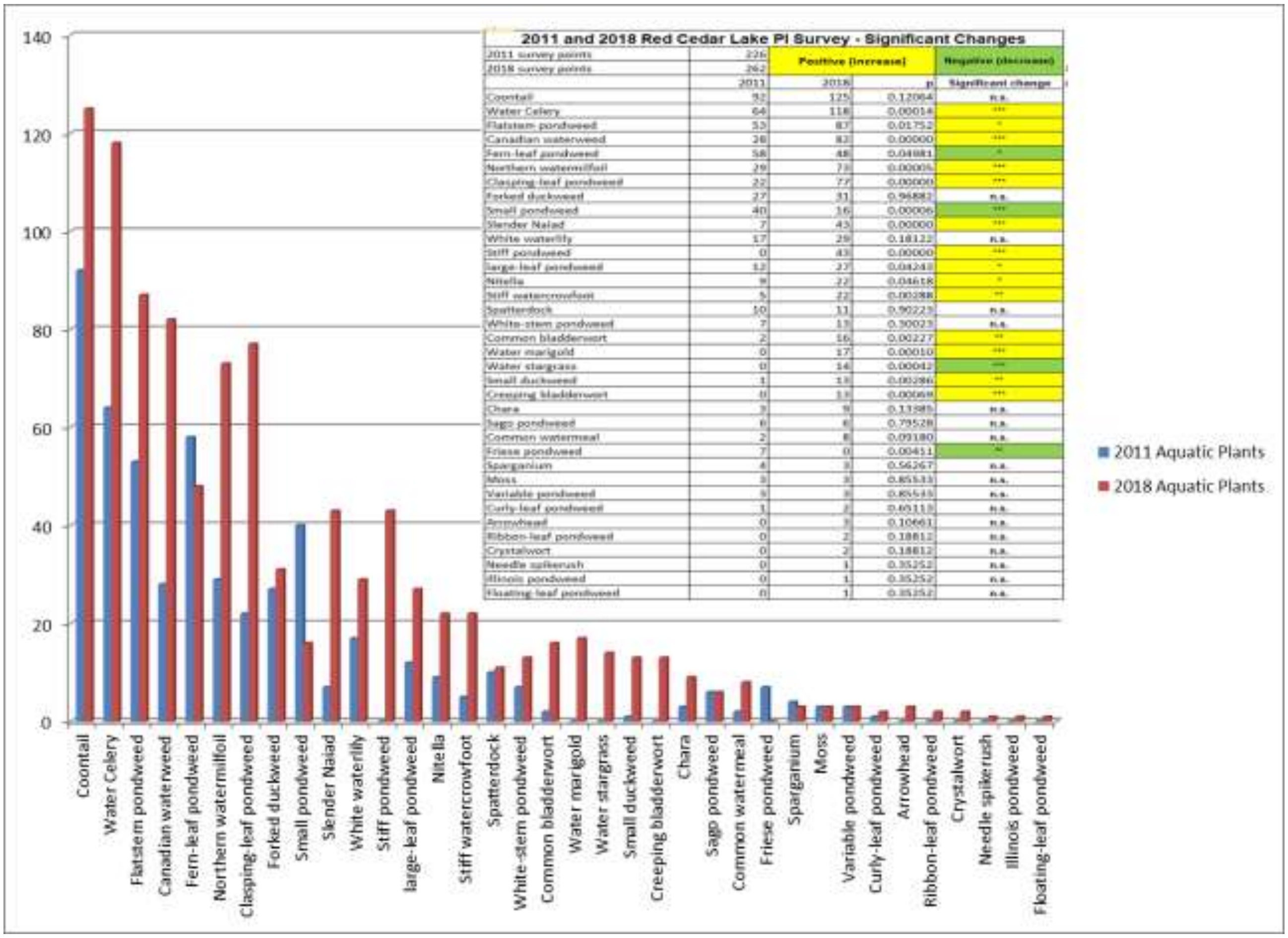
2011 and 2018 Balsam Lake PI Survey - Significant Changes				
2011 Survey Points	198	Positive (Increase)		Negative (Decrease)
2018 Survey Points	194			
	2011	2018	p	Significant change
Coontail	81	98	0.12064	n.s.
Flatstem pondweed	31	48	0.00014	***
Forked duckweed	29	40	0.01752	*
Canadian waterweed	31	21	0.00000	***
Clasping-leaf pondweed	13	31	0.04981	*
Northern watermilfoil	12	31	0.00005	***
Water celery	17	25	0.00000	***
White waterlily	12	23	0.96882	n.s.
Fern-leaf pondweed	2	30	0.00006	***
Large-leaf pondweed	4	25	0.00000	***
Stiff watercrowfoot	10	15	0.18122	n.s.
Small duckweed	6	18	0.00000	***
Small pondweed	10	3	0.04243	*
Large duckweed	6	7	0.04618	*
Water marigold	0	12	0.00288	**
Chara	9	3	0.90223	n.s.
Spatterdock	4	7	0.30023	n.s.
Stiff pondweed	0	11	0.00227	**
Curly-leaf pondweed	6	4	0.00010	***
Common watermeal	5	5	0.00042	***
Friese pondweed	8	0	0.00286	**
Water stargrass	0	6	0.00069	***
Sago pondweed	4	1	0.13385	n.s.
Slender naiad	1	3	0.79528	n.s.
Nitella	2	2	0.09180	n.s.
Arrowhead	1	2	0.00411	**
Sparganium	0	3	0.56267	n.s.
Wild Rice	1	2	0.85533	n.s.
Variable pondweed	2	0	0.85533	n.s.
Floating-leaf pondweed	0	2	0.65113	n.s.
Water smartweed	1	1	0.10661	n.s.
Cattail	1	0	0.18812	n.s.

Figure 32: Significant changes in aquatic plants in Balsam Lake between 2011 and 2018



2011 and 2018 Mud Lake PI Survey - Significant Changes				
2011 survey points	109	Positive (increase)		Negative (decrease)
2018 survey points	110			
	PRE present	POST present	p	Significant change
Coontail	80	90	0.12064	n.s.
Slender naiad	28	59	0.00014	***
Common waterweed	22	52	0.01752	*
White waterlily	24	40	0.00000	***
Forked duckweed	22	23	0.04981	*
Floating-leaf pondweed	17	24	0.00005	***
Sago pondweed	29	12	0.00000	***
Chara	7	32	0.96882	n.s.
Clasping-leaf pondweed	10	20	0.00006	***
Flatstem pondweed	16	14	0.00000	***
Small duckweed	0	12	0.18122	n.s.
Fern-leaf pondweed	0	11	0.00000	***
Whorled watermilfoil	0	8	0.04243	*
Friese pondweed	8	0	0.04618	*
Small pondweed	4	4	0.00288	**
Northern watermilfoil	1	5	0.90223	n.s.
Curly-leaf pondweed	3	2	0.30023	n.s.
Stiff watercrowfoot	1	4	0.00227	**
Arrowhead	5	0	0.00010	***
Water celery	5	0	0.00042	***
Moss	0	4	0.00069	***
Large duckweed	0	4	0.13385	n.s.
Water stargrass	0	3	0.79528	n.s.
Nitella	2	1	0.09180	n.s.
Spatterdock	2	1	0.00411	**
Large-leaf pondweed	1	2	0.56267	n.s.
Sparganium	2	1	0.85533	n.s.
Water marigold	0	2	0.85533	n.s.
Stiff pondweed	0	2	0.65113	n.s.

Figure 33: Significant changes in aquatic plants in Mud Lake between 2011 and 2018



2011 and 2018 Red Cedar Lake PI Survey - Significant Changes				
2011 survey points	226	Positive (increase)		Negative (decrease)
2018 survey points	262			
	2011	2018	p	Significant change
Coontail	92	125	0.12064	n.s.
Water Celery	64	118	0.00014	***
Flatstem pondweed	53	87	0.01752	*
Canadian waterweed	28	82	0.00000	***
Fern-leaf pondweed	58	48	0.04881	*
Northern watermilfoil	29	73	0.00005	***
Clasping-leaf pondweed	22	77	0.00000	***
Forked duckweed	27	31	0.96882	n.s.
Small pondweed	40	16	0.00006	***
Slender Naiad	7	43	0.00000	***
White waterlily	17	29	0.18122	n.s.
Stiff pondweed	0	43	0.00000	***
large-leaf pondweed	12	27	0.04243	*
Nitella	9	22	0.04618	*
Stiff watercrowfoot	5	22	0.00288	**
Spatterdock	10	11	0.90223	n.s.
White-stem pondweed	7	13	0.30023	n.s.
Common bladderwort	2	16	0.00227	**
Water marigold	0	17	0.00010	***
Water stargrass	0	14	0.00042	***
Small duckweed	1	13	0.00286	**
Creeping bladderwort	0	13	0.00069	***
Chara	3	9	0.13385	n.s.
Sago pondweed	6	6	0.79528	n.s.
Common watermeal	2	8	0.09180	n.s.
Friese pondweed	7	0	0.00451	**
Sparganium	4	3	0.56267	n.s.
Moss	3	3	0.85533	n.s.
Variable pondweed	3	3	0.85533	n.s.
Curly-leaf pondweed	1	2	0.65113	n.s.
Arrowhead	0	3	0.10661	n.s.
Ribbon-leaf pondweed	0	2	0.18812	n.s.
Crystalwort	0	2	0.18812	n.s.
Needle spikerush	0	1	0.35252	n.s.
Illinois pondweed	0	1	0.35252	n.s.
Floating-leaf pondweed	0	1	0.35252	n.s.

Figure 34: Significant changes in aquatic plants in Red Cedar Lake between 2011 and 2018

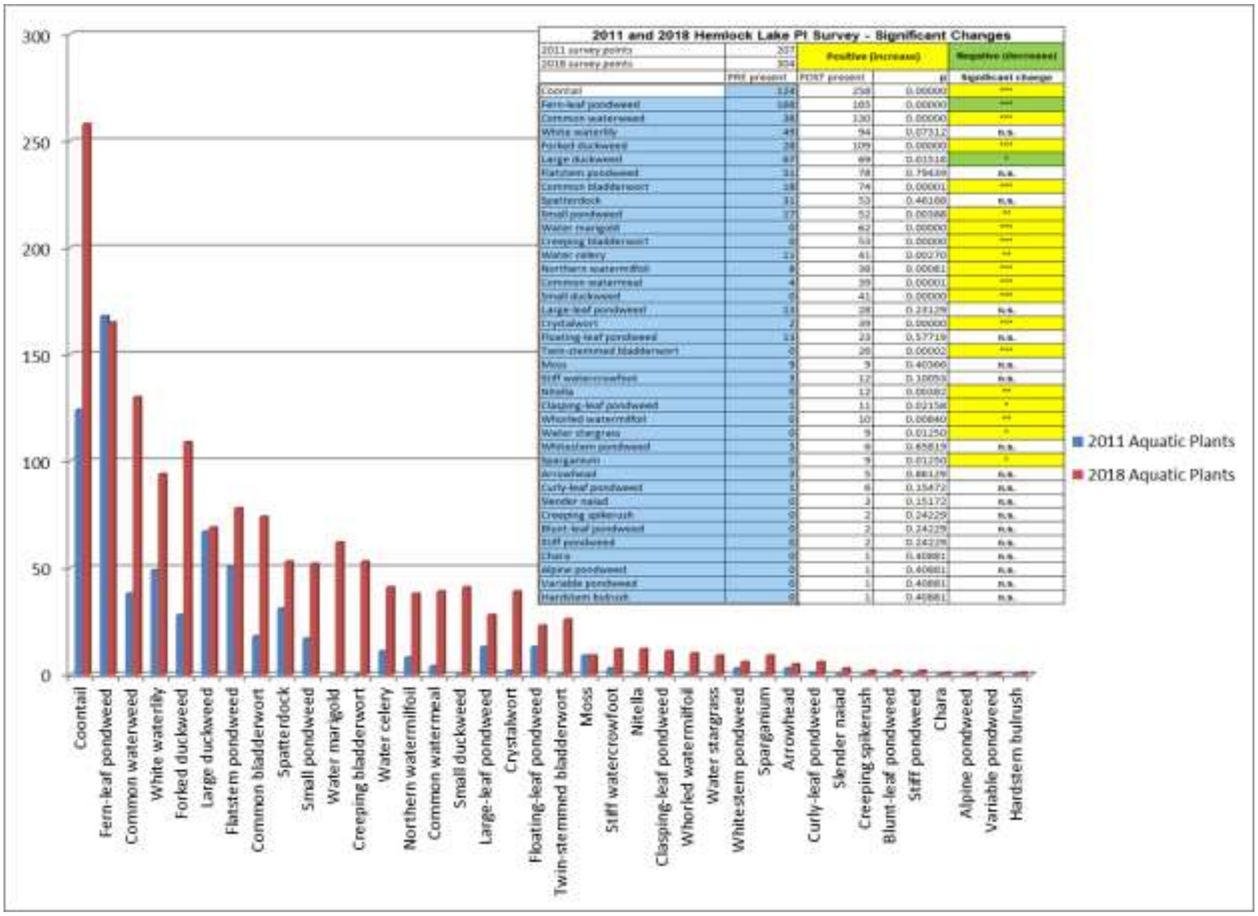


Figure 35: Significant changes in aquatic plants in Hemlock Lake between 2011 and 2018

SIGNIFICANT NEGATIVE CHANGES AND THEIR RELATION TO THE USE OF AQUATIC HERBICIDES IN RED CEDAR AND HEMLOCK LAKES

Three of the four species in Balsam Lake that experienced significant negative changes (Small pondweed, curly-leaf pondweed, and Fries pondweed) could be negatively impacted by the aquatic herbicides used to control CLP. However, in this case, no chemical treatment was completed in Balsam Lake between the 2011 and 2018 surveys. Fries pondweed, small pondweed, and Flat-stem pondweed saw negative declines in Mud Lake and would be susceptible to the impacts of the chemicals used. However, like in Balsam Lake, no herbicides were used in Mud Lake between 2011 and 2018. Fern-leaf pondweed, small pondweed, Fries pondweed, and water stargrass saw significant negative changes in Red Cedar Lake. All of these species are susceptible to the effects of the aquatic herbicide used, so the declines could be associated with it use in Red Cedar Lake. In Hemlock Lake, only fern-leaf pondweed saw a decline, but it is susceptible to herbicide use and could have been impacted by the treatments completed in Hemlock Lake.

Further analysis of the PI points that are within the treated areas in Red Cedar Lake and Hemlock Lake show a greater decline than what was saw lakewide, so it is reasonable to assume that the herbicides in these areas did negatively impact a couple native aquatic plant species while at the same time taking out almost all of the CLP. Given that the areas to be chemically treated in all four lakes are a very small percentage of the larger littoral zone, these negative impacts may be justifiable if management controls CLP.

WILD RICE

Wild rice is an aquatic grass which grows in shallow water in lakes and slow flowing streams. This grass produces a seed which is a nutritious source of food for wildlife and people. The seed matures in August and September with the ripe seed dropping into the sediment, unless harvested by wildlife or people. It is a highly protected and valued natural resource in Wisconsin. Only Wisconsin residents may harvest wild rice in the state. According to the WDNR, Balsam Lake (of which Mud Lake is considered to be a part of) and Red Cedar Lake are wild rice waters while Hemlock Lake is not considered to be wild rice waters. A 2012 survey completed by RCLA volunteers found wild rice and the head waters of Mud Lake into Balsam Lake (Figure 36). The 2018 aquatic plant surveys confirmed the presence of wild rice in both Balsam and Mud Lakes. In Balsam Lake, wild rice was found at 4 of the 410 points sampled. In Mud Lake, wild rice was visually spotted by the surveyors while on the lake, but was not present at any of the points sampled. No other wild rice was found in the system.

Figure 36: 2012 Wild Rice in Balsam Lake (RCLA-SEH)

The presence of wild rice adds another level of concern to management actions taken. Wild rice seedlings are susceptible to the killing effects of the most of the aquatic herbicides used for invasive species management

(Nelson, Owens, & Getsinger, 2003). As such, the use of aquatic herbicides within or near areas of wild rice will not be considered.

In 2018, a red rhodamine dye study was completed on Balsam Lake simulating what could be a chemical treatment of CLP at the north end of Balsam Lake, one of the most dense areas of CLP growth in the entire Red Cedar lakes system. The dye study showed that herbicide applied to this area of the lake could reach the wild rice areas at the mouth of Mud Lake to Balsam. It took at least three hours after the herbicide was applied to make it to the rice areas and it remained in the area for at least 72 hours, albeit at concentrations 50% or less of what was originally applied. These results do not preclude the use of herbicides to control CLP at the north end of Balsam Lake, but it does drive home the importance of monitoring herbicide residuals at and near the rice areas during every possible herbicide application. Furthermore, it suggests that if another method of CLP control, like physical removal, can be done in this area effectively, it should be.

AQUATIC INVASIVE SPECIES

Past invasive species monitoring efforts have identified several different plant and animal non-native, invasive species in the Red Cedar Lakes. Most of these species are considered aquatic, although some are also considered shoreland or wetland type invasive species.

NON-NATIVE, AQUATIC INVASIVE PLANT SPECIES

Curly-leaf pondweed (CLP) is the most problematic non-native, aquatic invasive species in the lake. CLP is a submerged vegetation species (rooted to the bottom of the lake and growing under the surface of the water) that have the potential to outcompete more desirable native aquatic plants. Purple loosestrife, Japanese knotweed, yellow iris, and reed canary grass are shoreland or wetland plants not generally problematic within the lake, but can be very problematic on the shores and in the wetlands adjacent to the lake. More information is given for each non-native species in the following sections.

CURLY-LEAF PONDWEED

Curly-leaf pondweed (CLP) is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia (Figure 37). It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. CLP is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures. It has been reported in all of Lower 48 States and most of Canada.

CLP spreads through burr-like winter buds (turions) (Figure 26), which are moved among waterways. These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf pondweed one of the first nuisance aquatic plants to emerge in the spring. It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out-compete native plants in the spring. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. CLP forms surface mats that interfere with aquatic recreation.

CLP was officially recognized within the system in 2005. In 2009, the RCLA was provided with the first distribution and density maps of the CLP within Red Cedar and Hemlock Lakes. Although aquatic nuisance control records indicate CLP has been present in the lakes for some time, its extent came as a surprise to the RCLA given that the invasive species had only been officially recognized in the system in 2005. The RCLA began more actively managing CLP which has been relatively successful. CLP is still present within all three lakes, but the density has been greatly reduced. Despite this, continued monitoring and management will be necessary.

Figure 37: CLP Plants and Turions (Not from the Red Cedar Lakes)

PURPLE LOOSESTRIFE

Purple loosestrife (Figure 38) is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers that vary from purple to magenta possess 5-6 petals aggregated into numerous long spikes, and bloom from August to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

Purple loosestrife is a wetland herb that was introduced as a garden perennial from Europe during the 1800's. It is still promoted by some horticulturists for its beauty as a landscape plant, and by beekeepers for its nectar-producing capability. Currently, more than 20 states, including Wisconsin have laws prohibiting its importation or distribution because of its aggressively invasive characteristics. It has since extended its range to include most temperate parts of the United States and Canada. The plant's reproductive success across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America.

Purple loosestrife was first detected in Wisconsin in the early 1930's, but remained uncommon until the 1970's. It is now widely dispersed in the state, and has been recorded in 70 of Wisconsin's 72 counties. Low densities in most areas of the state suggest that the plant is still in the pioneering stage of establishment. Areas of heaviest infestation are sections of the Wisconsin River, the extreme southeastern part of the state, and the Wolf and Fox River drainage systems.

This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many of our wetlands, lakes, and rivers.

Purple loosestrife can germinate successfully on substrates with a wide range of pH. Optimum substrates for growth are moist soils of neutral to slightly acidic pH, but it can exist in a wide range of soil types. Most seedling establishment occurs in late spring and early summer when temperatures are high.

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local perturbation is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. Plants may be quite large and several years old before they begin flowering. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. Invasion usually begins with a few pioneering plants that build up a large seed bank in the soil for several years. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland. The plant can also make morphological adjustments to accommodate changes in the immediate environment; for example, a decrease in light level will trigger a change in leaf morphology. The plant's ability to adjust to a wide range of environmental conditions gives it a competitive advantage; coupled with its reproductive strategy, purple loosestrife tends to create monotypic stands that reduce biotic diversity.

Purple loosestrife displaces native wetland vegetation and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size, and almost entirely eliminate the open water habitat. The plant can also be detrimental to recreation by choking waterways.

Purple loosestrife is present at many locations in and around the Red Cedar Lakes, however, since the late 1990's the RCLA, in cooperation with the WDNR and more recently Washburn County and the Birchwood Area School District, has raised and released tens of thousands of Galerucella beetles as a means to keep purple loosestrife distribution and density in balance with other wetland and shoreland plants. A substantial, self-producing population of beetles has already been established in and around the Red Cedar Lakes. These beetles reduce the ability of the plant to invade and take over places with suitable habitat.

Figure 38: Purple Loosestrife (Not from the Red Cedar Lakes)

EURASIAN WATER MILFOIL

EWM is a submersed aquatic plant native to Europe, Asia, and northern Africa (Figure 39). 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, EWM is difficult to distinguish from Northern water milfoil. EWM 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.

EWM grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is 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 lake beds, lakes receiving nitrogen and phosphorous-laden runoff, 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.

Unlike many other plants, EWM does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces 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. EWM is readily dispersed by boats, motors, trailers, bilges, live wells, and 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, EWM is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of EWM 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 EWM 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 EWM may lead to deteriorating water quality and algae blooms in infested lakes.

To date, no EWM has been found within any of the Red Cedar Lakes or either Big Chetac or Birch Lakes directly upstream of the Red Cedar Lakes. EWM is currently found in several nearby lakes including Rice Lake, Lower Vermillion Lake, Duck Lake, and Beaver Dam Lake in Barron County as well as Lac Courte Oreilles, Whitefish Lake, and Lake Chippewa in Sawyer County. Because of the ease with which EWM can spread, the RCLA will need to continue the watercraft inspection program it currently has in place for the foreseeable future in order to try to prevent the introduction of EWM.

Figure 39: EWM fragment with adventitious roots and EWM in a bed

JAPANESE KNOTWEED

Japanese knotweed (Figure 40) is an herbaceous perennial, growing up to 10-ft tall. Hollow reddish, arching, bamboo-like stems are smooth and stout, and they can persist after the plant dies back each year. The base of the stem above each joint is swollen and surrounded by a membranous sheath. It has alternate, egg-shaped to almost triangular 4-6" long, 3-4" wide leaves that are dark green on the upper surface and pale green on the lower. Numerous tiny, creamy white or greenish flowers that are highly branched and found where the leaf attaches to the stem bloom in late summer. Small, winged, triangular fruits carry very small shiny seeds. Plants growing from seed have a taproot up to 6-ft deep. Stout rhizomes can reach 65-ft or more from the parent plant, and give rise to new stalks.

Japanese knotweed invades upland and lowland sites that are disturbed and undisturbed, often posing significant threat to riparian areas where it can rapidly spread. It tolerates shade, high temperatures, high salinity, and drought. It can be transported to new sites as a contaminant in fill dirt or on equipment. During floods, it can spread downstream by shoot fragments, rhizomes, or seeds. Escapees from neglected gardens and discarded cuttings are common routes of dispersal from more urban areas.

Although it is very hard to kill, consistent management over five or more years can eradicate it. Management includes both non-chemical and chemical control. Non chemical controls include physical removal, mowing, prescribed burning, grazing, and manipulation of the growing environment. Chemical control includes application of a pre-emergent herbicide directly to the soil, and foliar application applied directly to individual plants. Cut stump application of herbicide has also been effective. If a combination of all of these management options is used, control/eradication may be possible in 3-5 years.

Japanese knotweed has not been found around any of the Red Cedar Lakes, but this can be found near Rice Lake, and Sand Lake in Barron County as well as Slim Lake in Northern Washburn County. While Japanese knotweed is not currently found anywhere around the Red Cedar Lakes, it should still be considered a part of regular AIS monitoring and prevention efforts.

Figure 40: Japanese Knotweed

PHRAGMITES

Non-native phragmites (Figure 41) is a very robust perennial grass that is able to create dense stands that, if left unchecked will quickly result in a monoculture wetland. It has a rough textured stem that is usually about 0.5 inches in diameter at the base can reach 20 feet in height. This stem is a dull tan color, but is mostly covered by tightly clinging leaf sheathes that do not readily fall off of the plant. The leaves are a darker blue-green color and measure 4 to 20 inches long and 0.4 to 2 inches wide at maturity. At the top of the stem there is a bushy cluster of panicles. Through most of the growing season, the panicles are a grayish purple color, and they slowly turn to a beige color later in the season.

There are two types of phragmites that can be found within Wisconsin. Both of these are subspecies of the same species which is also referred to as a haplotype. The European haplotype is not native to Wisconsin, and is significantly larger and more robust than the native haplotype. The non-native haplotype is able to withstand a wide range of nutrients, soil types, and pH levels. Because of this hearty nature, the non-native haplotype easily overruns the native variety.

The European haplotype has a much longer growing season than its native counterpart and most other native wetland plants. This extended growing season as well as the size of the plant causes many native plants to be shaded out before they are able to establish resulting in die-offs of native species and expansion of the non-native phragmites population.

These grasses spread, primarily through vegetative growth meaning that they generally do not have a high survival rate among seeds. This is done through two methods: the production of above ground stolons and below ground rhizomes. Both of these structures are horizontal outgrowths of the stem that can spread out and sprout new plants that are simply clones of the parent plant. Non-native phragmites produces very small brown seeds which are able to spread very easily and establish new populations despite the low survival rate among the seeds.

The best methods of control are cutting the stems in late July and applying herbicide to kill off portions of the rhizomes and stolons. This method has to be done multiple times to get the population under control, so prevention is ideal. By keeping the wetlands and surrounding area undisturbed, it is much more difficult for a non-native phragmites population to become established.

Non-native phragmites have not been observed in the wetlands surrounding the Red Cedar Lakes, but like Japanese knotweed, AIS monitoring volunteers should still look out for this plant.

Figure 41: Non-native Phragmites

YELLOW IRIS

Yellow iris (Figure 42) is a showy perennial plant that can grow in a range of conditions from drier upland sites, to wetlands, to floating aquatic mats. A native plant of Eurasia, it can be an invasive garden escapee in Wisconsin's natural environments. The leaves are broad and pointed at the tip. These are rather rigid and grow upright from the stem. The entire plant can grow 3-4 feet tall and boasts bright yellow flowers. Each flower can produce several hundred seeds which contain a small air pocket within the hard external coat of the seed which allows them to float very easily. Yellow iris is able to spread easily around aquatic environments because of the broad habitat requirements coupled with these floating seeds. While the seeds are an effective way for this plant to spread, like many other invasive wetland plants, it also utilizes rhizomes to spread through vegetative growth.

Yellow iris presents a unique threat to wetlands because of its ability to colonize areas that have not been disturbed. This issue is magnified by all parts of the plant being toxic to wildlife, so there are no natural controls in place to slow the expansion of yellow iris once it has become established. As with any invasive species, prevention is the best for of control. If yellow iris is found, physical removal can work to eradicate or control it if the entire plant, including the roots and rhizomes, is removed and properly disposed of. Due to the toxic nature of this plant, some people exhibit a sensitivity to yellow iris sap and tissues, so skin should be covered to prevent exposure. There are some chemical control methods that work to control yellow iris with aquatic herbicide. Chemical control often requires permits, and is more expensive than manual removal, so unless there is a large established population, hand removal is usually the best method to control yellow iris.

Yellow iris has not been found around the Red Cedar Lakes, or any other lake within Barron or Washburn Counties. While it has not been found around any local lakes, it could still find its way to the nearby wetlands with relative ease. Yellow iris should be monitored for as a part of the AIS monitoring efforts around the lakes.

Figure 42: Yellow Iris

REED CANARY GRASS

Reed canary grass (Figure 43) is a large, coarse grass that reaches 2 to 9 feet in height. It has an erect, hairless stem with gradually tapering leaf blades 3 1/2 to 10 inches long and 1/4 to 3/4 inch in width. Blades are flat and have a rough texture on both surfaces. The lead ligule is membranous and long. The compact panicles are erect or slightly spreading (depending on the plant's reproductive stage), and range from 3 to 16 inches long with branches 2 to 12 inches in length. Single flowers occur in dense clusters in May to mid-June. They are green to purple at first and change to beige over time. This grass is one of the first to sprout in spring, and forms a thick rhizome system that dominates the subsurface soil. Seeds are shiny brown in color.

Both Eurasian and native ecotypes of reed canary grass are thought to exist in the U.S. The Eurasian variety is considered more aggressive, but no reliable method exists to tell the ecotypes apart. It is believed that the vast majority of our reed canary grass is derived from the Eurasian ecotype. Agricultural cultivars of the grass are widely planted.

Reed canary grass also resembles non-native orchard grass (*Dactylis glomerata*), but can be distinguished by its wider blades, narrower, more pointed inflorescence, and the lack of hairs on glumes and lemmas (the spikelet scales). Additionally, bluejoint grass (*Calamagrostis canadensis*) may be mistaken for reed canary in areas where orchard grass is rare, especially in the spring. The highly transparent ligule on reed canary grass is helpful in distinguishing it from the others. Ensure positive identification before attempting control.

Reed canary grass is a cool-season, sod-forming, perennial wetland grass native to temperate regions of Europe, Asia, and North America. The Eurasian ecotype has been selected for its vigor and has been planted throughout the U.S. since the 1800's for forage and erosion control. It has become naturalized in much of the northern half of the U.S., and is still being planted on steep slopes and banks of ponds and created wetlands.

Reed canary grass can grow on dry soils in upland habitats and in the partial shade of oak woodlands, but does best on fertile, moist organic soils in full sun. This species can invade most types of wetlands, including marshes, wet prairies, sedge meadows, fens, stream banks, and seasonally wet areas; it also grows in disturbed areas such as bergs and spoil piles.

Reed canary grass reproduces by seed or creeping rhizomes. It spreads aggressively. The plant produces leaves and flower stalks for 5 to 7 weeks after germination in early spring and then spreads laterally. Growth peaks in mid-June and declines in mid-August. A second growth spurt occurs in the fall. The shoots collapse in mid to late summer, forming a dense, impenetrable mat of stems and leaves. The seeds ripen in late June and shatter when ripe. Seeds may be dispersed from one wetland to another by waterways, animals, humans, or machines.

This species prefers disturbed areas, but can easily move into native wetlands. Reed canary grass can invade a disturbed wetland in just a few years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, and deforestation of swamp forests, sedimentation, and intentional planting. The difficulty of selective control makes reed canary grass invasion of particular concern. Over time, it forms large, monotypic stands that harbor few other plant species and are subsequently of little use to wildlife. Once established, reed canary grass dominates an area by building up a tremendous seed bank that can eventually erupt, germinate, and recolonize treated sites.

Reed canary grass is located in many locations along the shoreland of the Red Cedar Lakes. There are several dense patches in the wetlands that boarder the edge of the lake but most of the other locations have a healthy mix of native plants mixed in with the reed canary grass.

Figure 43: Reed Canary Grass (not from the Red Cedar Lakes)

NON-NATIVE AQUATIC INVASIVE ANIMAL SPECIES

Several non-vegetative, aquatic, invasive species are in the Red Cedar Lakes. Chinese mystery snails have been verified by the WDNR within Red Cedar and Hemlock Lakes while rusty crayfish have been verified in all of the lakes and the Red Cedar River. Additionally, there are some species that are not currently known to be present within the system that people on and around the lakes should be aware of and monitoring for. It is important for lake property owners and users to be knowledgeable of these species in order to identify them if and when they show up in any of the Red Cedar Lakes.

MYSTERY SNAILS

The Chinese mystery snails, Japanese mystery snails, and the banded mystery snails (Figure 44) are non-native snails that have been found in a number of Wisconsin lakes. There is not a lot yet known about these species, however, it appears that they have a negative effect on native snail populations. The mystery snail's large size and hard operculum (a trap door cover which protects the soft flesh inside), and their thick hard shell make them less edible by predators such as rusty crayfish.

The female mystery snail gives birth to live crawling young. This may be an important factor in their spread as it only takes one impregnated snail to start a new population. Mystery snails thrive in silt and mud areas although they can be found in lesser numbers in areas with sand or rock substrates. They are found in lakes, ponds, irrigation ditches, and slower portions of streams and rivers. They are tolerant of pollution and often thrive in stagnant water areas. Mystery snails can be found in water depths of 0.5 to 5 meters (1.5 to 15 feet). They tend to reach their maximum population densities around 1-2 meters (3-6 feet) of water depth. Mystery snails do not eat plants. Instead, they feed on detritus and in lesser amounts algae and phytoplankton. Thus removal of plants in your shoreline area will not reduce the abundance of mystery snails.

Lakes with high densities of mystery snails often see large die-offs of the snails. These die-offs are related to the lake's warming coupled with low oxygen (related to algal blooms). Mystery snails cannot tolerate low oxygen levels. High temperatures by themselves seem insufficient to kill the snails as the snails could move into deeper water.

Many lake residents are worried about mystery snails being carriers of the swimmer's itch parasite. In theory they are potential carriers, however, because they are an introduced species and did not evolve as part of the lake ecosystem, they are less likely to harbor the swimmer's itch parasites.

The WDNR has verified that Chinese mystery snails are present within both Red Cedar and Hemlock Lakes, and banded mystery snails have been verified directly upstream in Big Chetac and Birch Lakes. While neither species has been verified as present by the WDNR within Balsam Lake, it is a very real possibility that one or both species are present.

Figure 44: Banded Mystery Snails (not from the Red Cedar Lakes)

RUSTY CRAYFISH

Rusty crayfish (Figure 45) live in lakes, ponds and streams, preferring areas with rocks, logs and other debris in water bodies with clay, silt, sand or rocky bottoms. They typically inhabit permanent pools and fast moving streams of fresh, nutrient-rich water. Adults reach a maximum length of 4 inches. Males are larger than females upon maturity and both sexes have larger, heartier, claws than most native crayfish. Dark "rusty" spots are usually apparent on either side of the carapace, but are not always present in all populations. Claws are generally smooth, with grayish-green to reddish-brown coloration. Adults are opportunistic feeders, feeding upon aquatic plants, benthic invertebrates, detritus, juvenile fish and fish eggs.

The native range of the rusty crayfish includes Ohio, Tennessee, Kentucky, Indiana, Illinois and the entire Ohio River basin. However, this species may now be found in Michigan, Massachusetts, Missouri, Iowa, Minnesota, New York, New Jersey, Pennsylvania, Wisconsin, New Mexico and the entire New England state area (except Rhoda Island). The Rusty crayfish has been a reported invader since at least the 1930's. Its further spread is of great concern since the prior areas of invasion have led to severe impacts on native flora and fauna. It is thought to have spread by means of released game fish bait and/or from aquarium release. Rusty crayfish are also raised for commercial and biological harvest.

Rusty crayfish reduce the amount and types of aquatic plants, invertebrate populations, and some fish populations--especially bluegill, smallmouth and largemouth bass, lake trout and walleye. They deprive native fish of their prey and cover and out-compete native crayfish. Rusty crayfish will also attack the feet of swimmers. On the positive side, rusty crayfish can be a food source for larger game fish and are commercially harvested for human consumption.

Rusty crayfish may be controlled by restoring predators like bass and sunfish populations. Preventing further introduction is important and may be accomplished by educating anglers, trappers, bait dealers and science teachers of their hazards. Use of chemical pesticides is an option, but does not target this species and will kill other aquatic organisms.

It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except the Mississippi River). It is also illegal to release crayfish into a water of the state without a permit.

Rusty Crayfish have been verified throughout the entire Red Cedar Lakes as well as the Red Cedar River, and several of the tributaries to the lakes.

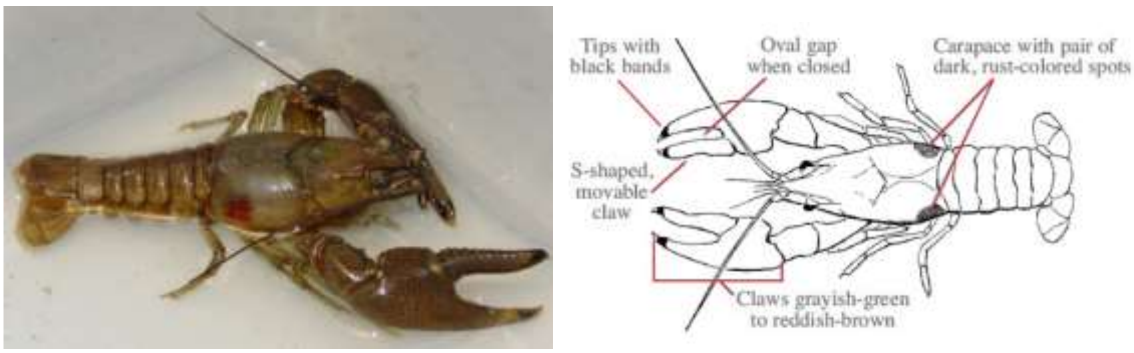


Figure 45: Rusty Crayfish and identifying characteristics

ZEBRA MUSSELS

Zebra mussels have not been identified within the Red Cedar Lakes, but prevention efforts should place a special emphasis on zebra mussels because of the extensive damage these invasive mussels could have on the native mussel populations.

Zebra Mussels (Figure 46) are an invasive species that have inhabited Wisconsin waters and are displacing native species, disrupting ecosystems, and affecting citizens' livelihoods and quality of life. They hamper boating, swimming, fishing, hunting, hiking, and other recreation, and take an economic toll on commercial, agricultural, forestry, and aquacultural resources. The zebra mussel is a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe and Asia. Zebra mussels were introduced into the Great Lakes in 1985 or 1986, and have been spreading throughout them since that time. They were most likely brought to North America as larvae in ballast water of ships that traveled from fresh-water Eurasian ports to the Great Lakes. Zebra mussels look like small clams with a yellowish or brownish D-shaped shell, usually with alternating dark- and light-colored stripes. They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals.

Zebra Mussels feed by drawing water into their bodies and filtering out most of the suspended microscopic plants, animals and debris for food. This process can lead to increased water clarity and a depleted food supply for other aquatic organisms, including fish. The higher light penetration fosters growth of rooted aquatic plants which, although creating more habitat for small fish, may inhibit the larger, predatory fish from finding their food. This thicker plant growth can also interfere with boaters, anglers and swimmers. Zebra mussel infestations may also promote the growth of blue-green algae, since they avoid consuming this type of algae but not others.

Zebra mussels attach to the shells of native mussels in great masses, effectively smothering them. A survey by the Army Corps of Engineers in the East Channel of the Mississippi River at Prairie du Chien revealed a substantial reduction in the diversity and density of native mussels due to Zebra Mussel infestations. The East Channel provides habitat for one of the best mussel beds in the Upper Mississippi River. Future efforts are being considered to relocate such native mussel beds to waters that are less likely to be impacted by zebra mussels.

Once zebra mussels are established in a water body, very little can be done to control them. It is therefore crucial to take all possible measures to prevent their introduction in the first place. Some of the preventative and physical control measures include physical removal, industrial vacuums, and back flushing.

Chemical applications include solutions of chlorine, bromine, potassium permanganate and even oxygen deprivation. An ozonation process is under investigation (patented by Bollyky Associates Inc.) which involves the pumping of high concentrations of dissolved ozone into the intake of raw water pipes. This method only works in controlling veligers, and supposedly has little negative impacts on the ecosystem. Further research on effective industrial control measures that minimize negative impacts on ecosystem health is needed.

In the fall of 2016, zebra mussels were found in a northwest Wisconsin lake for the first time. With this discovery, it increases the likelihood that zebra mussels will spread faster throughout northwest Wisconsin. Zebra mussels are have not been found within the Red Cedar Lakes, but due to the high volume of traffic, prevention and monitoring should remain a top priority for the RCLA. In 2018, records from Clean Boats, Clean Waters inspectors show that the Red Cedar Lakes were visited by people who had been to zebra mussel waters prior to entering the Red Cedar Chain. While it is hoped that these people drained livewells/ ballast water, it serves as a reminder of the importance of prevention and education efforts.

Figure 46: Zebra Mussels

AIS PREVENTION STRATEGY

The Red Cedar Lakes already has several established AIS. However there are many more that could be introduced to the lakes. The RCLA will continue implementing a watercraft inspection and AIS Signage program at several of the main public access points on the lakes. In addition to the watercraft inspection program, an in-lake and shoreland AIS monitoring program will be implemented. Both of these programs will follow UW-Extension Lakes and WDNR protocol through the Clean Boats, Clean Waters program and the Citizen Lake Monitoring Network Aquatic Invasive Species Monitoring program.

Additionally, having an educated and informed lake constituency is the best way to keep non-native aquatic invasive species at bay in the Red Cedar Lakes. To foster this, the RCLA will host and/or sponsor in cooperation with other stakeholders, lake community events including AIS identification and management workshops; distribute education and information materials to lake property owners and lake users through the newsletter, webpage, and general mailings.

AQUATIC PLANT MANAGEMENT IMPLEMENTATION IN THE RED CEDAR LAKES

All aquatic plant management techniques have positive and negative attributes. None of the techniques is without some adverse environmental impact; all have both strengths and weaknesses. No management technique is intrinsically superior to another, nor will one management technique be sufficient for all situations in a management program. Rather, all techniques should be considered tools in the manager's toolbox. Some are more expensive but will better control dense populations in larger areas. For small nuisance plant populations or new colonies, hand picking may actually be the best approach. Each site should be evaluated and management techniques selected based on the desired level of control, and environmental and economic constraints (Madsen J. , 2000).

Management should be tailored to the priority and goals of each site. All areas within the lake should be categorized as to use, restrictions, and priority. Based on these categories, management techniques can then be selected. For instance, swimming beaches and boat launches are high-use areas, and should have a high priority. Wildlife areas (e.g., refuges) have lower intensity use, and some restrictions to management. The high-priority, high-intensity use sites might justify high-cost management techniques such as benthic barriers or diver-operated suction harvesting. Low-intensity use areas might either remain untreated if resources are low, or would be categorized for less expensive techniques such as herbicides. Likewise, areas with higher concentrations of plants should receive more resources than areas with no plants or with acceptable levels of infestation (Madsen J. , 2000).

As dense colonies are brought under control, maintenance management approaches can be used. After a target plant species has entered a system, continuous management will be required. However, under no circumstances should management be discontinued once plant densities are low. If management techniques are very successful, management may entail only monitoring the system and hand-removing individuals that are occasionally found. Scale the control technique to the level of infestation, the priority of the site, the use, and the availability of resources (Madsen J. , 2000).

CLP was officially documented as present within the Red Cedar Lakes in 2009, but was present prior to then. The RCLA has been monitoring the CLP annually and using chemical applications for control when CLP populations warrant it. The following sections review management alternatives for control of CLP and justify the use of or not of each of the different alternatives.

MANAGEMENT ALTERNATIVES

Nuisance aquatic plants can be managed a variety of ways in Wisconsin. The best management strategy will be different for each lake and depends on which nuisance species needs to be controlled, how widespread the problem is, and the other plants and wildlife in the lake. In many cases, an integrated approach to aquatic plant management that utilizes a number of control methods is necessary. The eradication of non-native aquatic invasive plant species such as EWM or CLP is generally not feasible, but preventing them from becoming a more significant problem is an attainable goal. It is important to remember however, that regardless of the plant species targeted for control, sometimes no manipulation of the aquatic plant community is the best management option. Plant management activities can be disruptive to a lake ecosystem and should not be done unless it can be shown they will be beneficial and occur with minimal negative ecological impacts.

Management alternatives for nuisance aquatic plants can be grouped into four broad categories: manual and mechanical removal, chemical application, biological control, and physical habitat alteration. Manual and mechanical removal methods include pulling, cutting, raking, harvesting, suction harvesting, and other means of removing the physical plant from the water. Chemical application is typified by the use of herbicides that kill or impede the growth of the aquatic plant. Biological control methods include organisms that use the plant for a food source or parasitic organisms that use the plant as a host, killing or weakening it. Biological control may also include the use of species that compete successfully with the nuisance species for resources. Physical habitat alteration includes dredging, installing lake-bottom covers, manipulating light penetration, flooding, and drawdown. It may also include making changes to or in the watershed of a body of water to reduce nutrients going in.

Each of the above control categories are regulated by the WDNR and most activities require a permit from the WDNR to implement. Mechanical harvesting of aquatic plants and under certain circumstances, physical removal of aquatic plants, is regulated under Wisconsin Administrative Rule NR 109. The use of chemicals and biological controls are regulated under Administrative Rule NR 107. Certain habitat altering techniques like the installation of bottom covers and dredging require a Chapter 30/31 waterway protection permit. In addition, anytime wild rice is involved one or more of these permits will be required.

Informed decision-making on aquatic plant management implementation requires an understanding of plant management alternatives and how appropriate and acceptable each alternative is for a given lake. The following sections list scientifically recognized and approved alternatives for controlling aquatic vegetation.

While not all of these management actions may apply to the Red Cedar Lakes, their descriptions are included to show the girth of management actions that exist so as not to be criticized for a lack of thorough review.

NO MANAGEMENT

When evaluating the various management techniques, the assumption is erroneously made that doing nothing is environmentally neutral. In dealing with some nonnative species, the environmental consequences of doing nothing may be high, possibly even higher than any of the effects of management techniques. Unmanaged, these species can have severe negative effects on water quality, native plant distribution, abundance and diversity, and the abundance and diversity of aquatic insects and fish (Madsen J. D., 1997). Nonindigenous aquatic plants are the problem, and the management techniques are the collective solution. Nonnative plants are a biological pollutant that increases geometrically, a pollutant with a very long residence time and the potential to "biomagnify" in lakes, rivers, and wetlands (Madsen J. , 2000).

In more layman's terms this means that nonnative, aquatic invasive species like CLP can have a negative impact on a body of water if and when the distribution and density reaches the point where a more diverse and healthy aquatic plant community begins to change and lake use suffers. Active management of CLP may not be necessary every year all the time on the Red Cedar Lakes, but some level of monitoring is recommended and management should be considered when certain criteria are met. Keeping CLP at the current low density or even lower is the goal. Targeted management in areas of dense growth CLP to reduce the density and prevent small areas from getting larger is recommended.

HAND-PULLING/MANUAL REMOVAL

Manual or physical removal of aquatic plants by means of a hand-held rake or cutting implement; or by pulling the plants from the lake bottom by hand is allowed by the WDNR without a permit per NR 109.06 Waivers under the following conditions:

- Removal of native plants is limited to a single area with a maximum width of no more than 30 feet measured along the shoreline provided that any piers, boatlifts, swim rafts and other recreational and water use devices are located within that 30-foot wide zone and may not be in a new area or additional to an area where plants are controlled by another method (Figure 47)
- Removal of nonnative or invasive aquatic plants as designated under s. NR 109.07 is performed in a manner that does not harm the native aquatic plant community
- Removal of dislodged aquatic plants that drift on-shore and accumulate along the waterfront is completed.
- The area of removal is not located in a sensitive area as defined by the department under s. NR 107.05 (3) (i) 1, or in an area known to contain threatened or endangered resources or floating bogs
- Removal does not interfere with the rights of other riparian owners
- If wild rice is involved, the procedures of s. NR 19.09 (1) are followed.

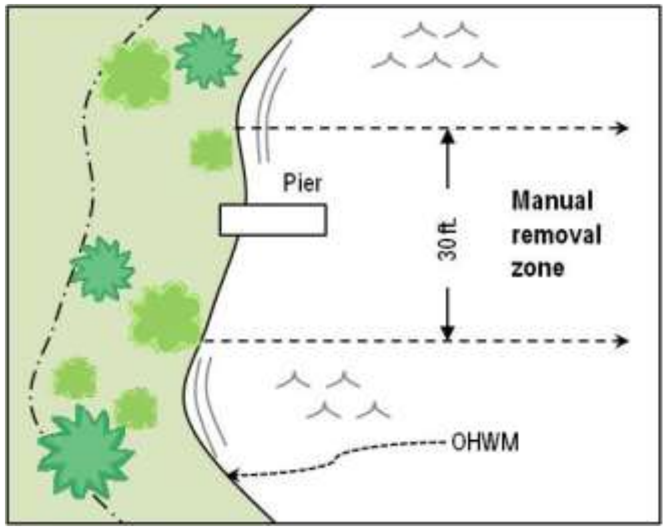


Figure 47: Aquatic vegetation manual removal zone

Although up to 30 feet of aquatic vegetation can be removed, removal should only be done to the extent necessary. There is no limit as to how far out into the lake the 30-ft zone can extend, however clearing large swaths of aquatic plants not only disrupts lake habitats, it also creates open areas for non-native species to establish. Manual or physical removal can be effective at controlling individual plants or small areas of plant growth. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. In shallow, hard bottom areas of a lake, or where impacts to fish spawning habitat need to be minimized, this is the best form of control. If water clarity in a body of water is such that aquatic plants can be seen in deeper water, pulling aquatic invasive species while snorkeling or scuba diving is also allowable without a permit according to the conditions in NR 106.06(2) and can be effective at slowing the spread of a new aquatic invasive species infestation within a lake when done properly.

Physical removal of CLP in the Red Cedar system has been implemented over several years. Throughout the 2012-2015 CLP management project, groups of students from the local high school, under the guidance of a RCLA volunteer spent many hours completing physical removal of CLP. Efforts were concentrated in Balsam Lake and in a couple of areas in Red Cedar Lake. Despite the huge level of effort, not much headway was gained in controlling CLP. On the Red Cedar Lakes, large-scale hand removal has proven not to be a very effective management strategy for the CLP, however, property owners who wish to physically remove CLP from around their property will continued to be encouraged to do so by the RCLA. If grant funding is used to help cover the costs of CLP management, property owners will be asked to track their removal time for reimbursement/required match purposes. Training of property owners and other volunteers in how to identify non-native, aquatic plant species and the proper ways to physical remove them will continued to be supported by the RCLA.

DIVER ASSISTED SUCTION HARVESTING

Diver assisted suction harvesting or DASH, as it is often called, is a fairly recent aquatic plant removal technique. It is called "harvesting" rather than "dredging" because, although a specialized small-scale dredge is used, bottom sediment is not removed from the system. The operation involves hand-pulling of the target plants from the lake bed and inserting them into an underwater vacuum system that sucks up plants and their root systems taking them to the surface. It requires water pumps on the surface (generally on a pontoon system) to move a large volume of water to maintain adequate suction of materials that the divers are processing (Figure 48). Only clean water goes through the pump. The material placed by the divers into the suction hose along with the water is deposited into mesh bags on the surface with the water leaving through the holes in the bag. The bags have a large enough 'mesh' size so that silts, clay, leaves and other plant material being collected do not immediately clog them and block water movement. If a fish or other living marine life is sucked into the suction hose it comes out the discharge unharmed and is returned to the body of water. It can have some negative impacts to other nearby non-target plants if not done carefully, particularly those plants that are perennials and expand their populations by sub-sediment runners (Eichler, Bombard, Sutherland, & Boylen, 1993).

Figure 48: DASH - Diver Assisted Suction Harvesting (Chuck Druckery, 2016 Wisconsin Lakes Convention Presentation)

DASH is most effective in small, monotypic stands of AIS in clear water lakes. Current prices in northwest Wisconsin run about $2,300.00 a day for contracted services with no guarantee on how many acres of aquatic plants can be removed in any given day. These costs may be lower if the equipment necessary to do DASH is owned by the lake group, but there are additional costs for overhead, maintenance, storage, plant disposal, and operator costs is volunteers cannot be utilized. DASH could be effective on smaller, dense beds of CLP that are less than an acre in size and not targeted through an herbicide application program. It could also be used in places where the use of herbicides is not permitted or water movement prevents adequate contact time between herbicide and target plant.

MECHANICAL REMOVAL

Mechanical management involves the use of devices not solely powered by human means to aid removal. This includes gas and electric motors, ATV's, boats, tractors, etc. Using these instruments to pull, cut, grind, or rotovate aquatic plants is illegal in Wisconsin without a permit. DASH is also considered mechanical removal. To implement mechanical removal of aquatic plants a Mechanical/Manual Aquatic Plant Control Application is required annually. The application is reviewed by the WDNR and other entities and a permit awarded if required criteria are met. Using repeated mechanical disturbance such as bottom rollers or sweepers can be effective at control in small areas, but in Wisconsin these devices are illegal and generally not permitted.

Large-scale Mechanical Harvesting

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water. This is a commonly used control for CLP populations. The size, and consequently the harvesting capabilities, of these machines vary greatly. As they move, harvesters cut a swath of aquatic plants that is between 4 and 20 feet wide, and can be up to 10 feet deep. The on-board storage capacity of a harvester ranges from 100 to 1,000 cubic feet (by volume) or 1 to 8 tons (by weight). Most harvesters can cut between 2 and 8 acres of aquatic vegetation per day, and the average lifetime of a mechanical harvester is 10 years.

Mechanical harvesting of aquatic plants presents both positive and negative consequences to any lake. Its results—open water and accessible boat lanes—are immediate, and can be enjoyed without the restrictions on lake use which follow herbicide treatments. In addition to the human use benefits, the clearing of thick aquatic plant beds may also increase the growth and survival of some fish. By eliminating the upper canopy, harvesting reduces the shading caused by aquatic plants. The nutrients stored in the plants are also removed from the lake, and the sedimentation that would normally occur as a result of the decaying of this plant matter is prevented. Additionally, repeated treatments may result in thinner, more scattered growth.

Aside from the obvious effort and expense of harvesting aquatic plants, there are many environmentally-detrimental consequences to consider. The removal of aquatic species during harvesting is non-selective. Native and invasive species alike are removed from the target area. This loss of plants results in a subsequent loss of the functions they perform, including sediment stabilization and wave absorption. Shoreline erosion may therefore increase. Other organisms such as fish, reptiles, and insects are often displaced or removed from the lake in the harvesting process. This may have adverse effects on these organisms' populations as well as the lake ecosystem as a whole.

While the results of harvesting aquatic plants may be short term, the negative consequences are not so short lived. Much like mowing a lawn, harvesting must be conducted numerous times throughout the growing season. Although the harvester collects most of the plants that it cuts, some plant fragments inevitably persist in the water. This may allow the invasive plant species to propagate and colonize in new, previously unaffected areas of the lake. Harvesting may also result in re-suspension of contaminated sediments and the excess nutrients they contain.

Disposal sites are a key component when considering the mechanical harvesting of aquatic plants. The sites must be on shore and upland to make sure the plants and their reproductive structures don't make their way back into the lake or to other lakes. The number of available disposal sites and their distance from the targeted harvesting areas will determine the efficiency of the operation, in terms of time as well as cost.

Timing is also important. The ideal time to harvest, in order to maximize the efficiency of the harvester, is just before the aquatic plants break the surface of the lake. For CLP, it should also be before the plants form turions (reproductive structures) to avoid spreading the turions within the lake. If the harvesting work is contracted, the equipment should be inspected before and after it enters the lake. Since these machines travel from lake to lake, they may carry plant fragments with them, and facilitate the spread of aquatic invasive species from one body of water to another.

Large-scale mechanical harvesting is a very viable management option on some parts of the Red Cedar Lakes. Contracted harvesting is not likely an option for controlling all of the CLP on the system but it could be used for some of the CLP beds in areas where herbicide treatment is less effective or not permitted. There is currently one contractor that offers harvesting services within northern Wisconsin, so timing could be an issue if the RCLA chose to contract harvesting services. Contracted services in northwest WI currently runs about $2,500.00 per day if the contractor also has to dispose of the harvested material, or slightly less at $2,000.00 a day if the lake group hauls away and disposes of harvested material on their own. Alternatively, the RCLA could purchase and operate a small mechanical harvester for between $60,000.00 and $130,000.00 new depending on what is purchased. The RCLA would also need a truck and trailer to haul the harvester, and other challenges like operator costs, maintenance, and winter storage would have to be overcome. Additionally, the RCLA would need to coordinate a dump site for any vegetation that is harvested. It should be noted that if the RCLA chooses either harvesting option, none of the costs associated are eligible for WDNR grant funding, except the possibility of limited grant funds (35-50%) to help buy the initial harvester and equipment. If this option were pursued, harvesting could be used system-wide as the more the harvester is used in any given season the lower the costs become for operation.

Small-Scale Mechanical Harvesting

There are a wide range of small-scale mechanical harvesting techniques, most of which involve the use of boat mounted rakes, scythes, and electric cutters. As with all mechanical harvesting, removing the cut plants is required. Commercial rakes and cutters range in prices from $200 for rakes to around $3000 for electric cutters with a wide range of sizes and capacities. Using a weed rake or cutter that is run by human power is allowed without a permit, but the use of any device that includes a motor, gas or electric, would require a permit. Dragging a bed spring or bar behind a boat, tractor or any other motorized vehicle to remove vegetation is also illegal without a permit.

Although not truly considered mechanical management, incidental plant disruption by normal boat traffic is a legal method of management. Active use of an area is often one of the best ways for riparian owners to gain navigation relief near their docks. Most aquatic plants won't grow well in an area actively used for boating and swimming. It should be noted that purposefully navigating a boat to clear large areas is not only potentially illegal it can also re-suspend sediments, encourage aquatic invasive species growth, and cause ecological disruptions.

Regular boat use generally maintains navigation channels for property owners from docks to open water, however there are areas like in the channel between Red Cedar and Hemlock lakes where native aquatic plant growth is dense enough to consider some small-scale harvesting in addition to or in lieu of other management alternatives.

BOTTOM BARRIERS AND SHADING

Physical barriers, fabric or other, placed on the bottom of the lake to reduce CLP growth would impact all plants, inhibit fish spawning, affect benthic invertebrates, and could cause anaerobic conditions which may release excess nutrients from the sediment. Gas build-up beneath these barriers can cause them to dislodge from the bottom and sediment can build up on them allowing CLP to re-establish. Bottom barriers are typically used for very small areas and provide only limited relief. Currently the WDNR does not permit this type of control, and this management alternative is not recommended for the Red Cedar Lakes.

Creating conditions in a lake that may serve to shade out aquatic plant growth has also been tried with mixed success. The general intention is to reduce light penetration in the water which in turns limits the depth at which plants can grow. Typically dyes have been added to a small water body to darken the water. Intentional shading caused by adding dyes to the lake water is not recommended due to the size of the waterbodies.

DREDGING

Dredging is the removal of bottom sediment from a lake. Its success is based on altering the target plant's environment. It is not usually performed solely for aquatic plant management but rather to restore lakes that have been filled in with sediment, have excess nutrients, inadequate pelagic and hypolimnetic zones, need deepening, or require removal of toxic substances (Peterson, 1982). In shallow lakes with excess plant growth, dredging can make areas of the lake too deep for plant growth. It can also remove significant plant root structures, seeds turions, rhizomes, tubers, etc. In Collins Lake, New York the biomass of curly-leaf pondweed remained significantly lower than pre-dredging levels 10-yrs after dredging (Tobiessen, Swart, & Benjamin, 1992). Dredging is very expensive, requires disposal of sediments, and has major environmental impacts. It is not a selective procedure so it can't be used to target any one particular species with great success except under extenuating circumstances. Dredging must be permitted by the WDNR unless the dredging project meets a very specific set of parameters. It should not be performed for aquatic plant management alone. It is best used as a multipurpose lake remediation technique (Madsen J. , 2000).

Dredging is not a recommended management action for the Red Cedar Lakes due to the cost, potential harm it could cause, and because there are few places where it could really be used successfully.

DRAWDOWN

Drawdown, like dredging, alters the plant environment by removing all water in a water body to a certain depth, exposing bottom sediments to seasonal changes including temperature and precipitation. A winter drawdown is typically a low cost and effective management tool for the long-term control of certain susceptible species of nuisance aquatic plants. Cooke et al, 2005 created a list of aquatic plants likely to increase, decrease, or stay the same as a result of a winter drawdown (Table 23). In a review of a wide array of winter drawdown research, Carmignani and Roy further described what character traits in a given aquatic plant would make it susceptible to a winter drawdown (Table 24). CLP is one of those species likely to see a decline if a winter drawdown was implemented.

Several other studies reviewed by Carmignani and Roy indicate that fast growing plant species with annual seeds, winter buds, or turions can remain viable in seedbanks that can last for multiple years until suitable germination conditions arise. Such is the case with CLP.

Another issue associated with winter drawdowns is the extent to which the water level is reduced. If it is not lowered to the deepest point with offending vegetation, re-colonization of the drawdown exposure zone from deeper residing individuals can occur during the growing season if suitable growing conditions exist (Carmignani & Roy, 2017). During the 2018 CLP survey completed by FSS the average depth of CLP in Balsam Lake was 3.4-ft and in Red Cedar and Hemlock lakes it was 6.4-ft. This was the average depth so, CLP was established in much deeper water.

Aside from being a cost-effective means to control certain species of unwanted aquatic vegetation, a drawdown may offer several other benefits including increasing shoreline emergent vegetation, consolidation of some lake sediments, making shoreline improvements easier (subject to WDNR permits), identifying possible septic system issues, and when used as a part of an integrated management, may reduce the amount of herbicides needed to control an unwanted species (Cooke, Welch, Peterson, & Nichols, 2005).

Possible undesirable side effects include negative impacts to benthic fauna, loss or reduction of desirable plant species, invasion by drawdown resistant undesirable plants, reduced attractiveness to waterfowl, possible fishkills if oxygen demand exceeds aeration efforts, loss of aesthetic appeal during drawdown, possible algal blooms after refill, reduction in water supply to wells, and impairment of recreational activities during the drawdown (Cooke et al. 2005). Amphibians and reptiles could also be impacted depending on their ability to move around and how fast lake level changes are made. An inability to rapidly refill a drawn down lake is a basic concern in evaluating the potential for a drawdown.

Table 23: Predicted changes in aquatic plant growth after a winter drawdown *(Cooke, Welch, Peterson, & Nichols, 2005)*

Species	Common Name	Decrease	Increase	Same
Brasenia schreberi	Watershield	x		
Ceratophyllum demersum	Coontail	x		
Eleocharis acicularis	Needle spikerush	x		
Eleocharis palustris	Creeping spikerush	x		
Eleocharis robbinsii	Robbins spikerush	x		
Elodea canadensis	Common waterweed	x		
Myriophyllum sibiricum	Northern water-milfoil	x		
Myriophyllum spicatum	Eurasian water-milfoil	x		
Myriophyllum verticillatum	Whorled water-milfoil	x		
Nuphar variegata	Spatterdock	x		
Nymphaea odorata	White water lily	x		
Potamogeton amplifolius	Large-leaf pondweed	x		
Potamogeton crispus	Curly-leaf pondweed	x		
Potamogeton robbinsii	Robbins (fern) pondweed	x		
Spirodela polyrhiza	Large duckweed	x		
Utricularia intermedia	Flat-leaf bladderwort	x		
Utricularia vulgaris	Common bladderwort	x		
Megalodonta beckii	Water marigold		x	
Najas flexilis	Bushy pondweed		x	
Polygonum amphibium	Water smartweed		x	
Potamogeton epihydrus	Ribbon-leaf pondweed		x	
Potamogeton gramineus	Variable pondweed		x	
Potamogeton natans	Floating-leaf pondweed		x	
Potamogeton richardsonii	Clasping-leaf pondweed		x	
Potamogeton zosteriformis	Flat-stem pondweed		x	
Sagittaria latifolia	Common arrowhead		x	
Chara sp.	Muskgrass			x
Sagittaria graminea	Grass-leaved arrowhead			x

Table 24: Macrophytes that are sensitive (unshaded) or tolerant (shaded) to winter drawdowns
(Carmignani & Roy, 2017)

Assemblage		Trait	Taxa Examples	Source
Macrophytes	Sensitive	Submergent species that propagate mostly by rhizomes (perennials); low propagation via seeds	*Potamogeton robbinsii*	Beard et al. 1973; VANR 1990; Wilcox and Meeker 1991
			Myriophyllum spicatum	Siver et al. 1986; Olson et al. 2012
			Nuphar lutea	Beard et al. 1973; VANR 1990; Hellsten 2000; Mjelde et al. 2012
		Sensitive to ice scour	*Isoetes lacustris* (i.e., large Isoetids)	Rorslett 1984; Turner et al. 2005; Keto et al. 2006; Mjelde et al. 2012
	Tolerant	High seed/oospore production	*Najas flexilis* *Chara* sp.	Turner et al. 2005 Wagner and Falter 2002
		Amphiphytic & polymorphic growth forms	*Eleocharis acicularis*	Wilcox and Meeker 1992; Hellsten 2000; Mjelde et al. 2012
		Fast growth	*Elodea* sp.	Wagner and Falter 2002
		Multiple viable propagation strategies	*Potamogeton spirillus, P. epihydrus*	Turner et al. 2005

While it is possible to draw down the Red Cedar Lakes because there is a dam at the outlet of Red Cedar Lake it is unlikely that this would have much of an impact on CLP populations. Furthermore to draw down the water far enough to possibly impact CLP growth, a huge amount of water would have to be released. The proximity of Rice Lake downstream of the Red Cedar Lakes means that a tremendous amount of coordination would be required to prevent unintended negative consequences. A drawdown is not recommended for the control of CLP within the Red Cedar Lakes.

BIOLOGICAL CONTROL

Biological control involves using one plant, animal, or pathogen as a means to control a target species in the same environment. The goal of biological control is to weaken, reduce the spread, or eliminate the unwanted population so that native or more desirable populations can make a comeback. Care must be taken however, to insure that the control species does not become as big a problem as the one that is being controlled. A special permit is required in Wisconsin before any biological control measure can be introduced into a new area.

Galerucella Beetles

Two species of Galerucella beetles are currently approved for the control of purple loosestrife in Wisconsin (Figure 49). The entire life cycle of Galerucella beetles is dependent on purple loosestrife. In the spring, adults emerge from the leaf litter below old loosestrife plants. The adults then begin to feed on the plant for several days until they begin to reproduce. Females lay their eggs on loosestrife leaves and stems. When the larvae emerge from these eggs they begin feeding on the leaves and developing shoots. When water levels are high these larvae will burrow into the loosestrife stems to pupate into adult beetles. These new adults emerge and begin feeding on the loosestrife again (Sebolt, 1998). Galerucella beetles do not forage on any plants other than purple loosestrife. Because of this the populations, once established, are self-regulating. When the purple loosestrife population drops off, the beetle population also declines. When the loosestrife returns, the beetle numbers will usually increase.

Figure 49 - Galerucella Beetle

These beetles will not eradicate purple loosestrife entirely. This is true of almost all forms of biological control. Galerucella beetles help regulate loosestrife which allows native plants to re-establish, or too maintain their competitiveness, rather than be replaced.

Beetles can be obtained from many of the public wetlands around Wisconsin. Because rearing these beetles requires the cultivation of a restricted species, a permit from the WDNR is necessary. Beetle rearing and release is not recommended for the Red Cedar Lakes in this management plan, simply due to the established beetle population that already exists. However, if there are lake residents or others who wish to propagate beetles for release, or collect and transfer beetles to other parts of the system, this would only benefit the lakes.

OTHER BIOLOGICAL CONTROLS

There are other forms of biological control being used or researched. It was thought at one time that the introduction of plant eating carp could be successful. It has since been shown that these carp have a preference list for certain aquatic plants. EWM is very low on this preference list (Pine & Anderson, 1991). Use of "grass carp" as they are referred to in Wisconsin is illegal as there are many other environmental concerns including what happens once the target species is destroyed, removal of the carp from the system, impacts to other fish and aquatic plants, and preventing escapees into other lakes and rivers. Several pathogens or fungi are currently being researched that when introduced by themselves or in combination with herbicide application can effectively control EWM and lower the concentration of chemical used or the time of exposure necessary to kill the plant (Sorsa, Nordheim, & Andrews, 1988). None of these have currently been approved for use in Wisconsin and are not recommended for use on the Red Cedar Lakes.

CHEMICAL CONTROL

Aquatic herbicides are granules or liquid chemicals specifically formulated for use in water to kill plants or cease plant growth. Herbicides approved for aquatic use by the U.S. Environmental Protection Agency (EPA) are considered compatible with the aquatic environment when used according to label directions. Some individual states, including Wisconsin, also impose additional constraints on herbicide use.

The Wisconsin Department of Natural Resources evaluates the benefits of using a particular chemical at a specific site vs. the risk to non-target organisms, including threatened or endangered species, and may stop or limit treatments to protect them. The Department frequently places conditions on a permit to require that a minimal amount of herbicide is needed and to reduce potential non-target effects, in accordance with best management practices for the species being controlled. For example, certain herbicide treatments are required by permit conditions to be in spring because they are more effective, require less herbicide and reduce harm to native plant species. Spring treatments also means that, in most cases, the herbicide will be degraded by the time peak recreation on the water starts.

The WDNR encourages minimal herbicide use by requiring a strategic Aquatic Plant Management (APM) Plan for management projects over 10 acres or 10% of the water body or any projects receiving state grants. WDNR also requires consideration of alternative management strategies and integrated management strategies on permit applications and in developing an APM plan, when funding invasive species prevention efforts, and by encouraging the use of best management practices when issuing a permit. The Department also supervises treatments, requires that adjacent landowners are notified of a treatment and are given an opportunity to request a public meeting if they want, requires that the water body is posted to notify the public of treatment and usage restrictions, and requires reporting after treatment occurs.

The advantages of using chemical herbicides for control of aquatic plant growth are the speed, ease and convenience of application, the relatively low cost, and the ability to somewhat selectively control particular plant types with certain herbicides. Disadvantages of using chemical herbicides include possible toxicity to aquatic animals or humans, oxygen depletion after plants die and decompose which can cause fishkills, a risk of increased algal blooms as nutrients are released into the water by the decaying plants, adverse effects on desirable aquatic plants, loss of fish habitat and food sources, water use restrictions, and a need to repeat treatments due to existing seed/turion banks and plant fragments. Chemical herbicide use can also create conditions favorable for non-native aquatic invasive species to outcompete native plants (for example, areas of stressed native plants or devoid of plants).

When properly applied, the possible negative impacts of chemical herbicide use can be minimized. Early spring to early summer applications are preferred because exotic species are actively growing and many native plants are dormant, thus limiting the loss of desirable plant species; plant biomass is relatively low minimizing the impacts of de-oxygenation and contribution of organic matter to the sediments; fish spawning has ceased; and recreational use is generally low limiting human contact. The concentration and amount of herbicides can be reduced because colder water temperatures enhance the herbicidal effects. Selectivity of herbicides can be increased with careful selection of application rates and seasonal timing. Lake hydro-dynamics must also be considered; steep drop-offs, inflowing waters, lake currents and wind can dilute chemical herbicides or increase herbicide drift and off-target injury. This is an especially important consideration when using herbicides near environmentally sensitive areas or where there may be conflicts with various water uses in the treatment vicinity.

HOW CHEMICAL CONTROL WORKS

Aquatic herbicides are sprayed directly onto floating or emergent aquatic plants or are applied to the water in either a liquid or granular form. Herbicides affect plants through either systemic or direct contact action. Systemic herbicides are capable of killing the entire plant. Contact herbicides cause the parts of the plant in contact with the herbicide to die back, leaving the roots alive and able to re-grow.

Herbicides can be classified as broad-spectrum (kill or injure a wide variety of plant species) or selective (effective on only certain species). Non-selective, broad spectrum herbicides will generally affect all plants that they come in contact with. Selective herbicides will affect only some plants. Often dicots, like Eurasian water milfoil, will be affected by selective herbicides whereas monocots, such as common waterweed will not be affected. The selectivity of a particular herbicide can be influenced by the method, timing, formulation, and concentration used.

Sonar® whose active ingredient is fluridone, is a broad spectrum herbicide that interferes with the necessary processes in a plant that create the chlorophyll needed to turn sunlight into plant food through a process called photo-synthesis. Rodeo® whose active ingredient is glyphosate is another broad spectrum herbicide that prevents an aquatic plant from making the protein it needs to grow. As a result the treated plant stops growing and eventually dies.

2,4-D and triclopyr are active ingredients in several selective herbicides including Shredder Amine 4®, Navigate®, DMA 4®, and Renovate®. These herbicides stimulate plant cell growth causing them to rupture, but primarily in dicots. These herbicides are considered selective as they have little to no effect on monocots in treated areas. Fluridone, glyphosate, 2,4-D, and triclopyr are all considered systemic. When applied to the treatment area, plants in the treatment area draw the herbicide in through the leaves, stems, and roots killing all of the plant, not just the part that comes in contact with the herbicide. These herbicides are rarely used to control CLP.

Aquathol whose active ingredient is endothall and Reward whose active ingredient is diquat are considered broad spectrum contact herbicides. They destroy the outer cell membrane of the material they come in contact with and therefore kill a plant very quickly. Neither of these is considered selective and has the potential to kill all of the plant material that they come in contact with regardless of the species. As such, great care should be taken when using these products. Certain plant species like curly-leaf pondweed begin growing very early in the spring, even under the ice, and are often the only growing plant present at that time. This is a good time to use a contact herbicide like Aquathol, as few other plants would be impacted. Using these products later in the season, will kill all vegetation in contact with the herbicide and can provide substantial nuisance relief from a variety of aquatic plants. Endothall based herbicides are the most commonly used herbicides for CLP control, but diquat can be used under the appropriate circumstances.

It is possible to apply more than one herbicide at a time when trying to establish control of unwanted aquatic vegetation. An example would be controlling EWM and CLP at the same time with an early season application, and controlling aquatic plants and algae at the same time during a mid-season nuisance relief application. Applying systemic and contact herbicides together has a synergistic effect leading to increased selectivity and control. Single applications of the two could result in reduced environmental loading of herbicides and monetary savings via a reduction in the overall amount of herbicide used and of the manpower and number of application periods required to complete the treatment.

MICRO AND SMALL-SCALE HERBICIDE APPLICATION

The determining factor in designating chemical treatments as micro or small-scale is the size of the area being treated. Small-scale herbicide application involves treating areas less than 10 acres in size. The dividing line between small-scale and micro treatments is not clearly defined, but is generally considered to be less than an acre. Small-scale chemical application is usually completed in the early season (April through May). Recent research related to micro and small-scale herbicide application generally shows that these types of treatment are less effective than larger scale treatments due to rapid dilution and dispersion of the herbicide applied. Some suggested ways to increase the effectiveness is to increase the concentration of herbicide used, use a contact herbicide like diquat that does not require as long a contact time to effective, or in some manner contain the herbicide in the treated area by artificial means. If combined micro or small-scale treatments exceed 10 acres or 10% of the littoral zone of a lake it is considered a large-scale treatment.

Pre- and post-treatment aquatic plant surveys and testing for herbicide residuals are not required by the WDNR for small-scale treatments. Nor is an approved Aquatic Plant Management Plan if the organization sponsoring the application is not using grant funding to help defer the costs. Even though not required by the WDNR, participating in these activities is recommended as it helps to gain a better understanding of the impact and fate of the chemical used.

LARGE-SCALE HERBICIDE APPLICATION

Large-scale herbicide application involves treating areas more than 10 acres in size. Like small-scale applications, this is usually completed in the early-season (April through May) for control of non-native invasive species like CLP while minimizing impacts on native species. It is generally accepted that lower concentration of herbicide can be used in large-scale applications as the likelihood of the herbicide staying in contact with the target plant for a longer time is greater. If the volume of water treated is more than 10% of the volume of the lake, or the treatment area is ≥160 acres, or 50% of the lakes littoral zone, effects can be expected at a whole-lake scale. Large-scale herbicide application can be extended in some lakes to include whole bay or even whole lake treatments. The bigger the treatment area, the more contained the treatment area, and the depth of the water in the treatment area, are factors that impact how whole bay or whole lake treatments are implemented.

Pre- and post-treatment aquatic plant surveying and having an approved Aquatic Plant Management Plan are required by the WDNR when completing large-scale chemical treatments. Residual testing is not required by the WDNR, but highly recommended to gain a better understanding of the impact and fate of the chemical used.

WHOLE-LAKE APPLICATION

Whole-lake or whole-basin treatments are those where the herbicide may be applied to specific sites, but the goal of the strategy is for the herbicide to reach a target concentration when it equally distributes throughout the entire volume of the lake (or lake basin). The application rate of whole-lake treatments is dictated by the volume of water in with which the herbicide will reach equilibrium. Because exposure time is expected to be so much longer, effective herbicide concentrations for whole-lake treatments are significantly less than required for spot treatments. Whole-lake treatments are typically conducted when the target plant is spread throughout the majority of the lake or basin.

If the herbicide exposure time of the target aquatic plant can be extended, the concentration of the herbicide applied can be lowered. If the contact time between the applied herbicide and the target plant in a whole body of water or protected bay can be increased to, or is already expected to be several days to a week or more, the concentration of herbicide can be in the range of 0.25-0.5 ppm instead of the 2-4 or more ppm that is typically used in small-scale, spot, or micro treatments.

Planning to treat the whole lake can be further designed to minimize the herbicide needed to affect the desired outcome. The method used to implement whole-lake treatments changes with the type of lake. Herbicide applied to a shallow, mixed lake is expected to mix throughout the entire volume of the lake. In deep water lakes that stratify, herbicide can be applied at such a time when it is expected that it will only mix with the surface water above the thermocline in an area known as the epilimnion. This large-scale management action is not appropriate for the Red Cedar Lakes as the CLP is not dense or widespread enough to justify this level of treatment.

PRE AND POST TREATMENT AQUATIC PLANT SURVEYING

When introducing new chemical treatments to lakes where the treatment size is greater than ten acres or greater than 10% of the lake littoral area and more than 150-ft from shore, the WDNR requires pre and post chemical application aquatic plant surveying.

The WDNR protocol assumes that an APM Plan has identified specific goals for non-native invasive species and native plants species. Such goals could include reducing coverage by a certain percent, reducing treatments to below large-scale application designations, and/or reducing density from one level to a lower level. A native plant goal might be to see no significant negative change in native plant diversity, distribution, or density. Results from pre and post treatment surveying are used to improve consistency in analysis and reporting, and in making the next season's management recommendations.

The number of pre and post treatment sampling points required is based on the size of the treatment area. Ten to twenty acres generally requires at least 100 sample points. Thirty to forty acres requires at least 120 to 160 sampling points. Areas larger than 40 acres may require as many as 200 to 400 sampling points. Regardless of the number of points, each designated point is sampled by rake recording depth, substrate type, and the identity and density of each plant pulled out, native or invasive.

In the year prior to an actual treatment, the area to be treated must have a mid-season/summer/warm water point intercept survey completed that identifies the target plant and other plant species that are present. A pre-treatment aquatic plant survey is done in the year the herbicide is to be applied, prior to application to confirm the presence and level of growth of the target species. A post-treatment survey should be scheduled when native plants are well established, generally mid-July through mid-August. If treating CLP a post treatment survey needs to be completed before seasonal growth ends (i.e. mid-June). For the post-treatment survey, repeat the PI for all species in the treatment polygons, as was done the previous summer. For whole-lake scale treatments, a full lake-wide PI survey should be conducted.

CHEMICAL CONCENTRATION TESTING

Chemical concentration testing is often done in conjunction with treatment to track the fate of the chemical herbicide used. Testing is completed to determine if target concentrations are met, to see if the chemical moved outside its expected zone, and to determine if the chemical breaks down in the system as expected. Monitoring sites are located both within and outside of the treatment area, particularly in areas that may be sensitive to the herbicide used, where chemical drift may have adverse impacts, where movement of water or some other characteristic may impact the effect of the chemical, and where there may be impacts to drinking and irrigation water. Water samples are collected prior to treatment and for a period of hours and/or days following chemical application.

RHODAMINE DYE STUDY

A dye study was implemented on Balsam Lake in the summer of 2018 mimicking what could have been a small-scale herbicide application. The dye was applied on the north end of the lake where there is usually a CLP bed and the main inlet flows into the lake. The dye was tracked at 16 points with 11 points within

Balsam Lake, one in the channel that connects Balsam and Red Cedar Lakes, and four points extending into Red Cedar Lake with the final point at the channel that leads to the Red Cedar Dam.

The dye dispersed through the system rather quickly due to the high volume of water flowing in at the application area. Dye was traceable at all of the points within Balsam Lake by three hours after treatment (HAT). By five HAT, the dye was traceable in the channel connecting Balsam and Red Cedar Lakes. At this point the movement of the dye slowed, and it was not until 72 HAT, that dye could be traced in Red Cedar Lake (Figure 50). Trace amounts of dye were still found within Balsam Lake at the 72 hour mark.

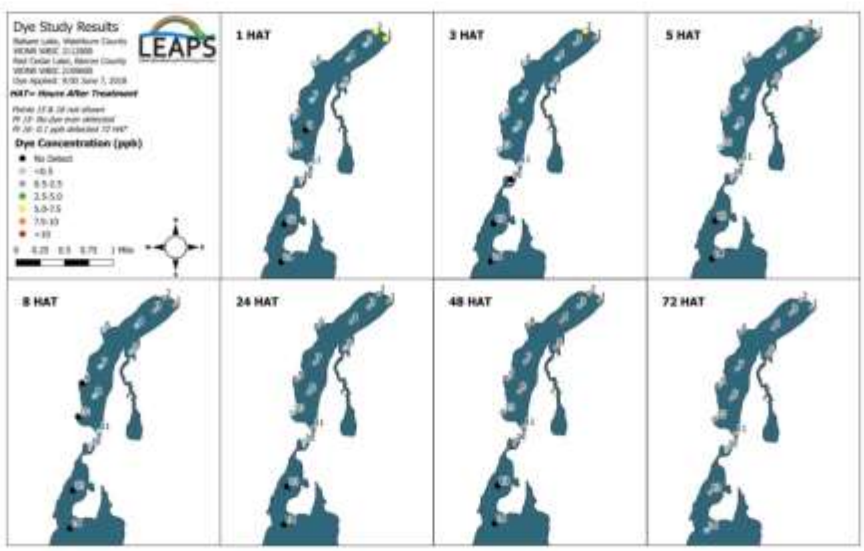


Figure 50: 2018 Rhodamine dye study results

The use of rhodamine dye could be considered again to track movement of applied herbicide in Balsam or any of the other lakes. The dye could be mixed with the herbicide before it is applied making it easier to get immediate feedback related to how the dye and herbicide moves after application. Herbicide concentration testing will give the same feedback, but results are not as immediate. Samples have to be collected, processed, shipped to a lab for analysis, and then results sent back, a process that typically takes a month or more. Using the same or a similar dye setup to what was done in 2018 would give nearly immediate results.

CHEMICAL MANAGEMENT IN THE RED CEDAR LAKES

Chemical management to control larger areas of moderate to dense growth CLP in the Red Cedar Lakes is a reasonable management approach. The estimated cost of chemical management is estimated to cost in the neighborhood of $780.00 to $1,000.00 per acre treated based on the cost of chemical management on the Red Cedar Lakes in previous years. This cost estimate does not include the cost of additional plant survey work, herbicide concentration testing, or permit fees. However, plant survey work and permit fees would still apply if using harvesting or DASH, only concentration testing would be eliminated, so those costs would be about the same regardless of the management action implemented. It is difficult to compare the actual costs of harvesting, DASH, and herbicides across the board because with harvesting and DASH the acreage of management involved is subject to many different parameters including plant type, plant density, plant distribution, water clarity, travel distance to dispose of harvested material, etc.

PAST MANAGEMENT

Since first being documented as more than just a few scattered CLP plants in the Red Cedar Lakes by the Beaver Creek Reserve AIS Survey in 2009, the RCLA has actively pursued monitoring and management of CLP in three of the four lakes (Balsam, Red Cedar, and Hemlock). Table 25 lays out aquatic plant/CLP survey and management activities between 2011 and 2018. Proposed management and survey plans for 2019 area also included.

Recommendations in the 2012 APM Plan were implemented starting in 2013 with three years of chemical treatment of CLP in the extreme south end of Red Cedar Lake and in the west end of Hemlock Lake. The first treatment in 2013 covered 18.8 acres in two beds – one in Red Cedar and one in Hemlock. Chemical treatment in these two areas was continued in 2014 and 2015, although they were modified each year based on results and pre/post-treatment surveys.

These three years of chemical treatment succeeded in their goal to reduce the amount of CLP in these two areas to a fraction of what they were. As of 2018, CLP bedmapping still reflected a decline in the amount of CLP from what it was in 2011/12. CLP turion density sampling within the treated areas completed in the fall of 2012 prior to any actual treatment, and then again in the fall of 2015 after three consecutive years of chemical treatment confirmed a reduction in turions from 100% of sites having turions pre-treatment to only 27% of sites with turions in 2015. Another turion density analysis is scheduled in 2021.

Table 25: 2011-19 Red Cedar Lakes Survey and CLP Management Implementation

2011-2019 Red Cedar Lakes Aquatic Plant Survey and Curly-leaf Pondweed Management									
Year	Surveys					Management			
	PI Survey	Pre/Post Survey	Bedmapping	Turion Density	Paleocore	Physical Removal	Chemical Treatment	Completed	ConcTest/DyeStudy
2011	FSS		FSS				29.7-ac, 7-bds, BL,RC,&HL	NO	
2012			RCLA	FSS		RCLA			
2013		FSS	RCLA			RCLA	18.8-ac, 2-bds, RC&HL	YES	ConcTest-RC&HL
2014		FSS	RCLA			RCLA	11.1-ac, 3-bds, RC&HL	YES	
2015		FSS	RCLA	FSS	Onterra Inc	RCLA	13.2-ac, 2-bds, RC&HL	YES	
2016			RCLA			RCLA			
2017			RCLA			RCLA			
2018	FSS		FSS				9.56-ac, 2-bds, RC	YES	DyeStudy-BL
2019		FSS(proposed)	RCLA(proposed)				57.7-ac, 21-bds, BL,RC,&HL	Proposed	ConcTest-Proposed

FSS-Freshwater Scientific Services	RC-Red Cedar Lake	ConcTest-Herbicide Concentration Testing
RCLA-Red Cedar Lakes Association Volunteers	HL-Hemlock Lake	DyeStudy-Rhodamine Dye Study for water movement
BL-Balsam Lake	Bds-Beds	

The CLP management plan laid out in the first APM Plan proved to be successful on a smaller scale. The goal of reducing competition from CLP with native aquatic plants, reducing navigation impacts, and reducing the potential for negative impacts on water quality was met in the 2013-2015 treatment areas. In the update of the 2012 plan, the goal is to implement a similar plan in the rest of the system treating those areas with the densest and largest CLP beds.

MANAGEMENT DISCUSSION

The goal of aquatic plant management over the course of the next five years in the Red Cedar Lakes from the perspective of the RCLA is reduce all areas of moderate to dense growth CLP in the system to the point they are no longer considered moderate to dense growth. The RCLA recognizes that even a non-native, invasive, aquatic plant species like CLP can have minimal negative effects on a waterbody if its distribution and density are not overwhelming the native aquatic plant community, causing nuisance and navigation issues, or impairing water quality. Throughout much of the surface water area of the four connected Red Cedar Lakes, this is the case. CLP is present in low/sparse concentrations with only a few more problematic areas. Annual monitoring/mapping of CLP in the system completed by RCLA volunteers and corroborated by more official/professional aquatic plant surveys completed less frequently, indicate that CLP distribution and density is increasing throughout the lakes. Each lake is impacted differently by this expansion, and has its own areas of concern.

Purple loosestrife is another non-native, aquatic plant species that is present in many wetlands, ditches, and bays connected to and adjacent to the Red Cedar lakes. Management consists of annual survey work with some physical removal completed by RCLA volunteers, and distribution of biological control agents (Galerucella beetles) raised in cooperation with Washburn County and the Birchwood School District.

BALSAM AND MUD LAKE CLP MANAGEMENT

The north end of Balsam Lake has one of the densest areas of CLP in the entire system (Figure 5). Whether this is due to exceptional growing conditions that exist on the north end supporting continued growth or because it is where material carried in by upstream waters from Birch and Big Chetac lakes is deposited is unknown. CLP, likely in the form of turions, is likely continually re-introduced into this area but the extent that this happens has not been documented. Big Chetac Lake, at its worst, has over 600 acres of moderate to dense growth CLP in it. Water moving between Big Chetac and Birch Lake likely carries turions into Birch Lake. Birch Lake is very deep and has a limited littoral zone capable of supporting CLP growth but CLP is located in most of that area already. From Birch Lake, water moves into Little Birch Lake, shallower and with a larger percentage of its surface area capable of supporting CLP growth. From Little Birch water flows over the dam and through a large wetland complex (Figure 51) before it enters Balsam Lake more than a mile downstream of the Birchwood dam. The wetland area has never been surveyed for CLP, so it is not known whether it catches upstream materials, or whether it simply passes that material on through, or worse adds more in the way of CLP turions before the water enters Balsam Lake. Regardless, this area is likely a source location for many turions dispersing around the lake. Fortunately, there is not a lot of shallow water in Balsam Lake so CLP distribution is limited.

The north end of Balsam Lake at the inlet from Birch Lake is also listed as a “sensitive area” for walleye spawning. Several other areas of Balsam Lake are also listed as walleye spawning areas totaling 15.5 acres. CLP mapping in 2017 identified CLP in 7.2 acres of that total area with more than 4 of the 7.2 acres being moderate to dense growth CLP which could reduce the effectiveness of walleye spawning in this area (Figure 52).

Figure 51: Wetland complex between Little Birch Lake (right) and Balsam Lake (left) Google Earth Image 9/29/2015

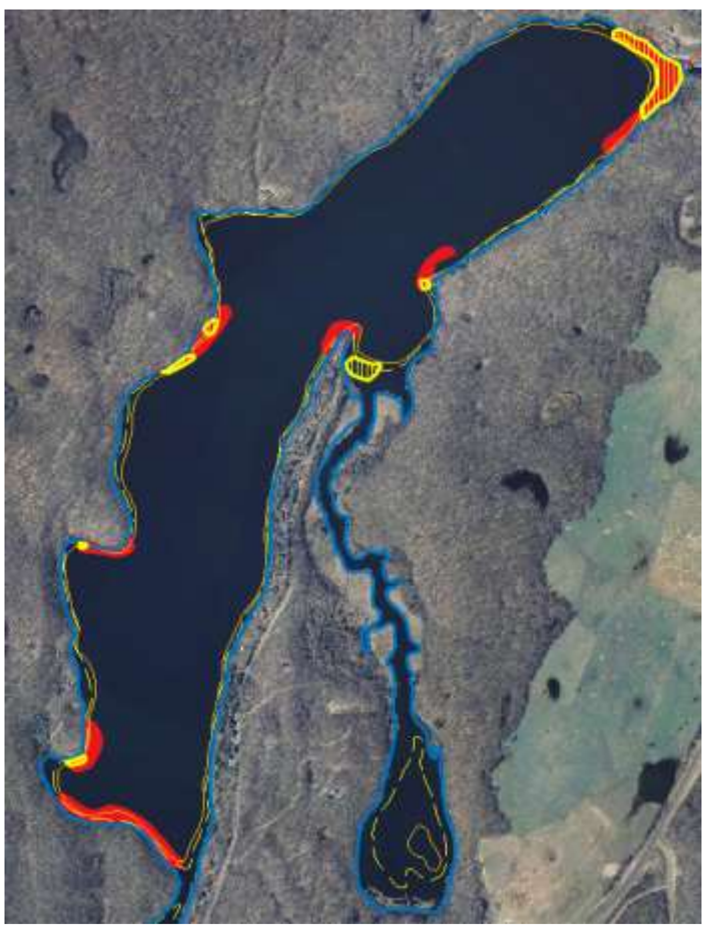


Figure 52: 2017 CLP beds (yellow) overlapped with 1992 walleye spawning areas (red)

Physical removal has been attempted in the north end of Balsam Lake with very limited success. The amount of CLP present makes physical removal an arduous task requiring a great deal of time and manpower. The dye study completed in 2018 showed that herbicide would stay in a treated area in part due to the backwater effect of inflow from the river so that remains a potential treatment activity in that area and other areas of Balsam Lake.

Balsam Lake and the attached Mud Lake is also the one known location of wild rice in the entire system. Last mapped in 2019 by RCLA volunteers, wild rice has been identified at the mouth of the Mud Lake channel into Balsam Lake and in the Mud Lake channel itself. In total, 1.5 acres of wild rice was mapped in this area in 2019 (Figure 53). All of Mud Lake, including the channel is considered "sensitive area" for aquatic plant and wildlife (Figure 16). No management of CLP except by physical removal has ever been proposed in Mud Lake, the channel, or the mouth of the channel to Balsam Lake because of the wild rice. This will continue to be the case through the duration of this new plan.

Figure 53: 2019 RCLA volunteer wild rice bedmapping results

Of the three main lakes in the Red Cedar system, Balsam is the one lake that is experiencing a consistent trend of worsening water clarity (Figure 21). Most concerning with this trend is that it could lead to less native aquatic vegetation in the system late season, while CLP continues to thrive early. When comparing the 2011 and 2018 PI plant surveys, some of this concern can already be substantiated. The maximum depth of aquatic plant growth is down by 3 or more feet in both Balsam and Mud lakes in 2018 when compared to 2011 (Table 11). The same parameter is up in Red Cedar and Hemlock lakes. Balsam Lake had less area with aquatic vegetation to surface in 2018, and the smallest increase in new native aquatic plant species identified of all the lakes. While the current distribution and density of CLP in Balsam and Mud lakes likely does not contribute much to this trend, it is something to watch.

Much of the shoreline around Balsam Lake is undeveloped particularly along the west and northeast shores of the lake. There are several developed lots around Mud Lake, but none along its channel to Balsam Lake. In 2017, two areas of CLP were mapped in Balsam Lake that were adjacent to developed property (Figure 54). These were located at the north end of the lake and along a portion of the west shore. Both of these areas were considered moderate to dense growth CLP in 2017, and to a lesser degree, again in 2018. These areas could be considered a nuisance and hamper navigation in years when growing conditions are good for CLP.

Figure 54: 2017 moderate to dense growth CLP near developed shoreline in Balsam Lake

Moderate to dense growth consistently grows in the outlet area of Balsam Lake to Red Cedar Lake (Figure 55). This area is likely a source area for CLP turions entering Red Cedar Lake. It also creates nuisance and navigation issues through the month of June. Water movement in the channel is fairly swift through this area, but the several locations off the main channel make it possible to manage CLP using aquatic herbicides, particularly if a faster acting contact herbicide like diquat is used, or an endothall based herbicide is used at a higher concentration.

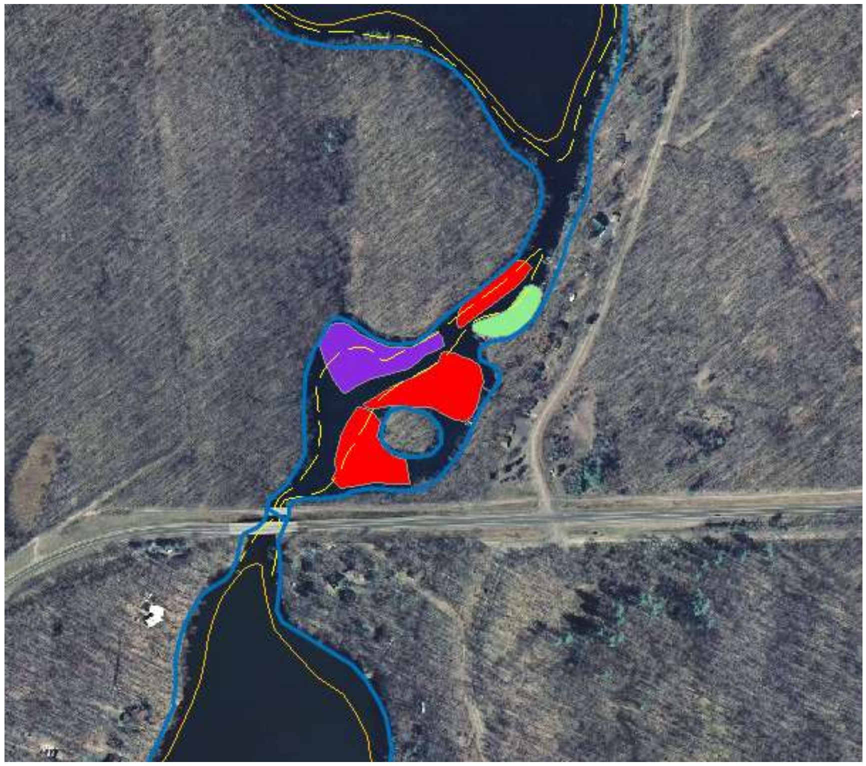


Figure 55: 2017 CLP beds in the Balsam Lake outlet to Red Cedar Lake (red=dense, purple=moderate, green=sparse)

CLP management in Balsam Lake will consist of continued physical removal of CLP by property owners and RCLA sponsored events. CLP mapping in June will continue on an annual basis with results used to aid subsequent year planning. The use of aquatic herbicides with either diquat (north end and outlet) or endothall (other locations) based applications will be completed. Preliminary treatment proposals will be based on prior year CLP bedmapping surveys. Actual or the final annual chemical treatment plan will be based on pretreatment aquatic plant survey work. Once an area is proposed for chemical treatment it will be considered for treatment for up to three consecutive years, but actual treatment will be based on annual pretreatment survey results.

Research in the late 1990's suggested that the use of aquatic herbicides like endothall and diquat can be effective at reducing not only biomass of the CLP but also annual turion production if done early enough in the season (Poovey, Skogerboe, & Owens, 2002). Additional research completed in MN showed that in lakes where CLP was chemically treated, the number of turions in the sediment was consistently lower each year than turions in the sediment of untreated lakes (Johnson, Jones, & and Newman, 2012). It is expected that one or more years of early season chemical treatment in designated beds in Balsam Lake will reduce CLP biomass and turion production in the year of treatment, and reduce the number of turions in the sediment that could grow more CLP in subsequent years.

Only beds that are >1 acre and that have a previous year mapping density of moderate to dense (2 or 3 rakehead density) will be considered for chemical management. Further consideration will be given to the location of the proposed CLP bed in the lake, possibility of using other management methods effectively, and proximity to moving water. Areas with a shorter expected contact time will be treated with diquat. In areas with a longer expected contact time, endothall based herbicides will be considered. At the present time, no CLP management will be considered in Mud Lake or the Mud Lake channel.

RED CEDAR LAKE CLP MANAGEMENT

Red Cedar Lake has the largest surface area of the four lakes and the least amount of CLP per surface acre. Much of Red Cedar Lake is deeper water with a hard rocky bottom limiting where CLP can grow. However, there are several areas where CLP is abundant and consists of fairly dense beds. There is a small bay just off the east side of the lake near the inlet from Balsam; Flagpole Bay on the east side of the point extending down from Hwy 48; near the golf course on the east side; where Pigeon Creek enters the lake on the east side; the southeastern shoreline; the channel area between Red Cedar and Hemlock lakes, the outlet of the Red Cedar River in Mikana; and several small bays along the western shoreline (Figure 6). RCLA volunteer CLP bedmapping in 2017 identified more than 29 acres of CLP in Red Cedar Lake of which 23.4 acres were considered moderate to dense in nature. In 2018, 5.8 acres of Red Cedar Lake was considered treatable (Figure 6).

More than 95 acres of walleye spawning sensitive areas were identified in Red Cedar Lake in the 1990's, and another 144 acres of sensitive area for aquatic plants and wildlife (Figure 17). In 2017, moderate to dense growth CLP was mapped in nearly 12 acres of the fish and wildlife sensitive area and 0.2 acres of the walleye spawning area.

There are four boat landings on Red Cedar Lake: Stouts Island, Waldo Carlson, Loch Lomond, and Tagalong. All four have some level of CLP present and are places to watch for increasing density and distribution that could interfere with navigation. Nearly all of the shoreland around Red Cedar Lake is developed. Of the CLP mapped in 2017, 21.25 acres of it is along developed shoreline, 16.65 acres in 15 areas was considered to have moderate to dense CLP growth that could impair navigation.

Like Balsam Lake, CLP management in Red Cedar Lake will consist of continued physical removal of CLP by property owners and RCLA sponsored events. CLP mapping in June will continue on an annual basis with results used to aid subsequent year planning. The use of aquatic herbicides with either diquat or endothall based applications will be completed. Preliminary treatment proposals will be based on prior year CLP bedmapping surveys. Actual or the final annual chemical treatment plan will be based on pretreatment aquatic plant survey work. Once an area is proposed for chemical treatment it will be considered for treatment for up to three consecutive years, but actual treatment will be based on annual pretreatment survey results.

Research in the late 1990's suggested that the use of aquatic herbicides like endothall and diquat can be effective at reducing not only biomass of the CLP but also annual turion production if done early enough in the season (Poovey, Skogerboe, & Owens, 2002). Additional research completed in MN showed that in lakes where CLP was chemically treated, the number of turions in the sediment was consistently lower each year than turions in the sediment of untreated lakes (Johnson, Jones, & and Newman, 2012). It is expected that one or more years of early season chemical treatment in designated beds in Red Cedar Lake will reduce CLP biomass and turion production in the year of treatment, and reduce the number of turions in the sediment that could grow more CLP in subsequent years.

Only beds that are >1 acre and that have a previous year mapping density of moderate to dense (2 or 3 rakehead density) will be considered for chemical management. Further consideration will be given to the location of the proposed CLP bed in the lake, possibility of using other management methods effectively, and proximity to moving water. Areas with a shorter expected contact time will be treated with diquat. In areas with a longer expected contact time, endothall based herbicides will be considered.

HEMLOCK LAKE CLP MANAGEMENT

More than 50% of the total surface area of Hemlock Lake is considered in the littoral zone and capable of supporting the growth of CLP. CLP bedmapping by RCLA volunteers in 2017 identified almost 44 acres of CLP in the lake with almost 14 acres of that considered moderate to dense growth. The 2018 CLP survey identified a little more than 12 acres of treatable CLP. Most of the moderate to dense growth CLP is in the west end just before the start of the channel area to Red Cedar Lake (Figure 56).

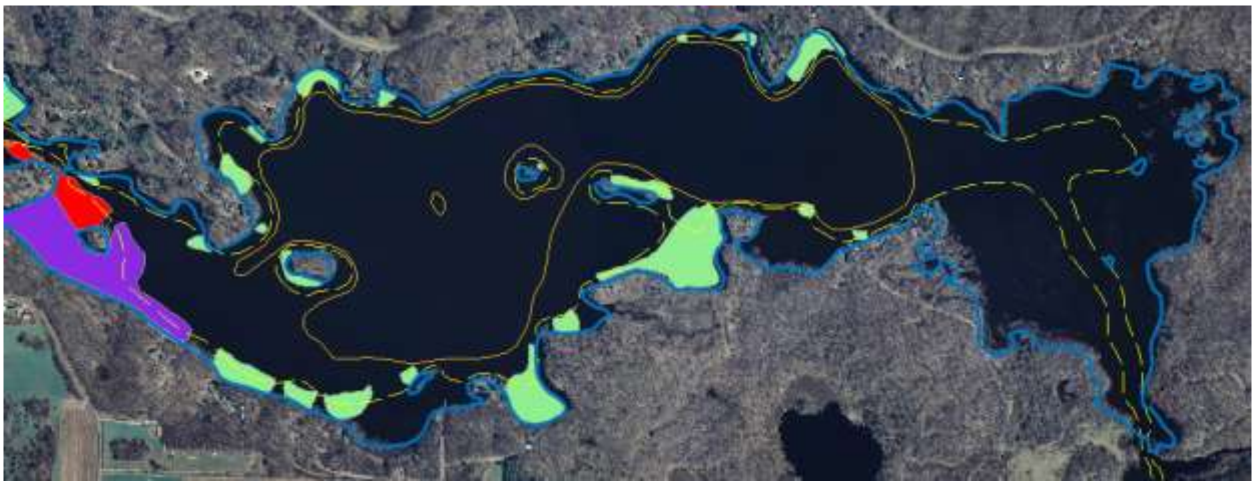


Figure 56: 2017 CLP beds in Hemlock Lake (red=dense, purple=moderate, green=sparse)

The WDNR identified 2.53 acres of walleye spawning habitat in Hemlock Lake and nearly 130 acres of fish and wildlife habitat (Figure 57). From the 2017 RCLA volunteer CLP bedmapping survey, 1.3 acres of the walleye spawning area has CLP and nearly 28 acres of the fish and wildlife area has CLP in it. In addition there were 13 beds of CLP totaling 12.76 acres adjacent to developed property on Hemlock Lake (Figure 57).

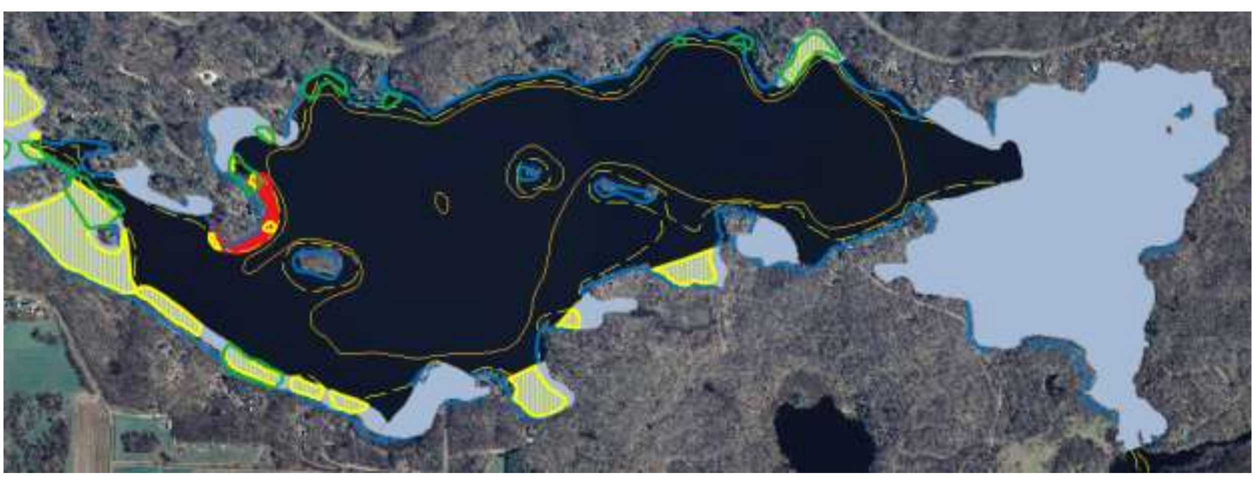


Figure 57: Sensitive areas (blue), walleye spawning areas (red), developed shoreline (green lines), 2017 CLP beds (yellow)

CLP management in Hemlock Lake will consist of continued physical removal of CLP by property owners and RCLA sponsored events. CLP mapping in June will continue on an annual basis with results used to aid subsequent year planning. The use of aquatic herbicides with either diquat or endothall based applications will be completed. Preliminary treatment proposals will be based on prior year CLP bedmapping surveys. Actual or the final annual chemical treatment plan will be based on pretreatment aquatic plant survey work. Once an area is proposed for chemical treatment it will be considered for treatment for up to three consecutive years, but actual treatment will be based on annual pretreatment survey results.

Research in the late 1990's suggested that the use of aquatic herbicides like endothall and diquat can be effective at reducing not only biomass of the CLP but also annual turion production if done early enough in the season (Poovey, Skogerboe, & Owens, 2002). Additional research completed in MN showed that in lakes where CLP was chemically treated, the number of turions in the sediment was consistently lower each year than turions in the sediment of untreated lakes (Johnson, Jones, & and Newman, 2012). It is expected that one or more years of early season chemical treatment in designated beds in Hemlock Lake will reduce CLP biomass and turion production in the year of treatment, and reduce the number of turions in the sediment that could grow more CLP in subsequent years.

Only beds that are >1 acre and that have a previous year mapping density of moderate to dense (2 or 3 rakehead density) will be considered for chemical management. Further consideration will be given to the location of the proposed CLP bed in the lake, possibility of using other management methods effectively, and proximity to moving water. Areas with a shorter expected contact time will be treated with diquat. In areas with a longer expected contact time, endothall based herbicides will be considered.

CLP MANAGEMENT SUMMARY

CLP in the Red Cedar Lakes was first identified in 1978, but it wasn't until 2009 that it was officially documented. An aquatic plant management planning project started in 2010 evaluated CLP and the native aquatic plant population in the lakes. During 2011 CLP survey work, more than 150-ac of the 3 lakes had CLP growing in it. Not all of this was dense growth, but enough was that from 2013 to 2015 the RCLA implemented a CLP chemical management plan focused on the most dense areas of CLP in the south end of Red Cedar Lake and the west end of Hemlock Lake. This project was successful and the amount of CLP in these areas was still down in 2017, a year when the CLP in untreated areas of the Red Cedar Lakes increased.

This plan has a goal of extending what was successfully implemented from the 2012 APM Plan to the rest of the system. Basically targeting those areas in all three lakes (Balsam, Red Cedar, and Hemlock) with the most dense and largest CLP beds as mapped in 2017. Table 26 reflects what would be a preliminary CLP chemical treatment in all three lakes based on 2017 RCLA volunteer bedmapping. Table 27 reflects what a preliminary CLP chemical treatment proposal might look like based on 2018 bedmapping done by FSS.

Table 26: Preliminary CLP chemical treatment proposal for Red Cedar Lakes based on 2017 RCLA volunteer bedmapping (example only)

Preliminary CLP Chemical Treatment Proposal based on 2017 RCLA Volunteer Bedmapping					
Lake	# of Beds	Min Bed Size (acres)	Max Bed Size (Acres)	Ave Bed Size (Acres)	TotalAcreage
Balsam	6	1.01	5.27	2.28	13.65
Red Cedar	9	1.1	4.94	2.33	20.93
Hemlock	2	2.74	10.81	6.78	13.56
	17				48.14

Table 27: Preliminary CLP chemical treatment proposal for the Red Cedar Lakes based on 2018 FSS bedmapping (example only)

Preliminary CLP Chemical Treatment Proposal based on 2018 FSS Bedmapping					
Lake	# of Beds	Min Bed Size (acres)	Max Bed Size (Acres)	Ave Bed Size (Acres)	TotalAcreage
Balsam	3	2.5	3.8	3	9
Red Cedar	2	1.4	2.6	2	4
Hemlock	3	1	5.6	3.5	10.6
	17				23.6

Based on a combination of the 2017 and 2018 CLP bedmapping data, the actual CLP chemical treatment plan for the Red Cedar Lakes in 2019 included 6 CLP beds totaling 9.5 acres in Balsam Lake; 13 CLP beds totaling 35.95 acres in Red Cedar Lake; and 2 beds totaling 12.21 acres in Hemlock Lake. Based on pre-treatment aquatic plant point-intercept survey work completed in 2019, the actual number of beds and total acreage was modified. Table 28 reflects what the actual 2019 CLP chemical treatment plan for the Red Cedar Lakes included.

Table 28: 2019 Red Cedar Lakes final CLP treatment details

2019 Red Cedar Lakes Proposed Large-Scale CLP Chemical Treament					
Treatment Characteristics				CLP Control Treatment application	
Treatment Site	Acreage	Mean Depth (feet)	Volume (acre-feet)	Treatment a.i. ppm	gallons†
BL-1-19	1.95	4.50	8.78	2.00	11.7
BL-2-19	1.08	5.50	5.94	2.00	7.9
BL-6-19	0.91	7.00	6.37	2.00	8.5
	3.94		21.09		28.0
RC-1-19	1.84	8.00	14.72	2.00	19.6
RC-2-19	1.37	8.00	10.96	2.00	14.6
RC-4-19	1.10	4.50	4.95	1.50	5.0
RC-7-19	1.82	7.25	13.20	1.50	13.2
RC-9-19	3.29	5.50	18.10	1.50	18.1
RC-12-19	2.61	6.75	17.62	1.50	17.6
RC-16-19	1.28	7.00	8.96	1.50	9.0
	13.31		88.50		97.0
HL-4-19	3.78	7.25	27.41	1.50	27.4
HL-5-19	6.90	7.00	48.30	1.50	48.3
	10.68		75.71		75.71
* Aquathol K® liquid aquatic herbicide (a.i. endothall)					
	27.93				

As already demonstrated in 2019, pre and post-chemical, point-intercept aquatic plant survey work will be completed in the proposed treatment areas in each year of treatment. CLP beds treated in the previous year will automatically be included in a treatment proposal, however pre-treatment point-intercept surveys will ultimately determine what is and what isn't treated in a given year. Herbicide concentration testing and/or an herbicide movement study using red rhodamine dye will be completed in at least the first year of chemical management. Annual CLP bedmapping will continue.

CLP TURION DENSITY MONITORING

While documenting a reduction in CLP turions in the sediment below each chemically treated area is not a management planning action included in this plan, reducing the abundance of CLP turions system wide is an objective of completing CLP management. The measurement of this objective will be provided at the end of a minimum of three years of CLP management implementation associated with this plan, probably in 2022, when a CLP turion density survey last completed in 2012 will be repeated.

In 2012, 91 random and 63 non-random sample points established within areas of CLP growth based on 2012 mapping were sampled for turion density (Figure 58). Analysis of the results of the 2012 turion density survey provided by FSS in the 2012 Turion Density Summary Report (Johnson J. , 2012) found that the lakewide mean turion abundance was low with only 11-19% of the points surveyed having any turions at all. However, points with turions that were surveyed within a delineated CLP bed were 2-3 times greater than the lakewide average. While most of these areas still had only a low to moderate turion density, there were several areas with high turion abundance. It is these areas that would likely support CLP growth that could impair navigation and recreation. Johnson goes on to say that the RCLA could successfully manage impairments caused by CLP by focusing management on those CLP beds found to have moderate to high turion abundance. This strategy would effectively reduce recreational impairments, minimize the cost of management, and reduce the potential for negative effects on native aquatic plants. The following areas were listed as places to consider management:

- Northeast shoreline of Balsam Lake (around the river inlet),
- Channel between Balsam and Red Cedar Lake,
- Southern end of Red Cedar Lake,
- Western portion of Hemlock Lake, and
- Additional "hot spots" in shallow mucky bays if they impair navigation or recreation.

At the end of three years of chemical management, a CLP turion density survey will be completed and results compared to 2012 results. The objective is to show less turion abundance lakewide and in previously delineated CLP areas, many of which are to be included in chemical or other forms of CLP management, as a result of management.

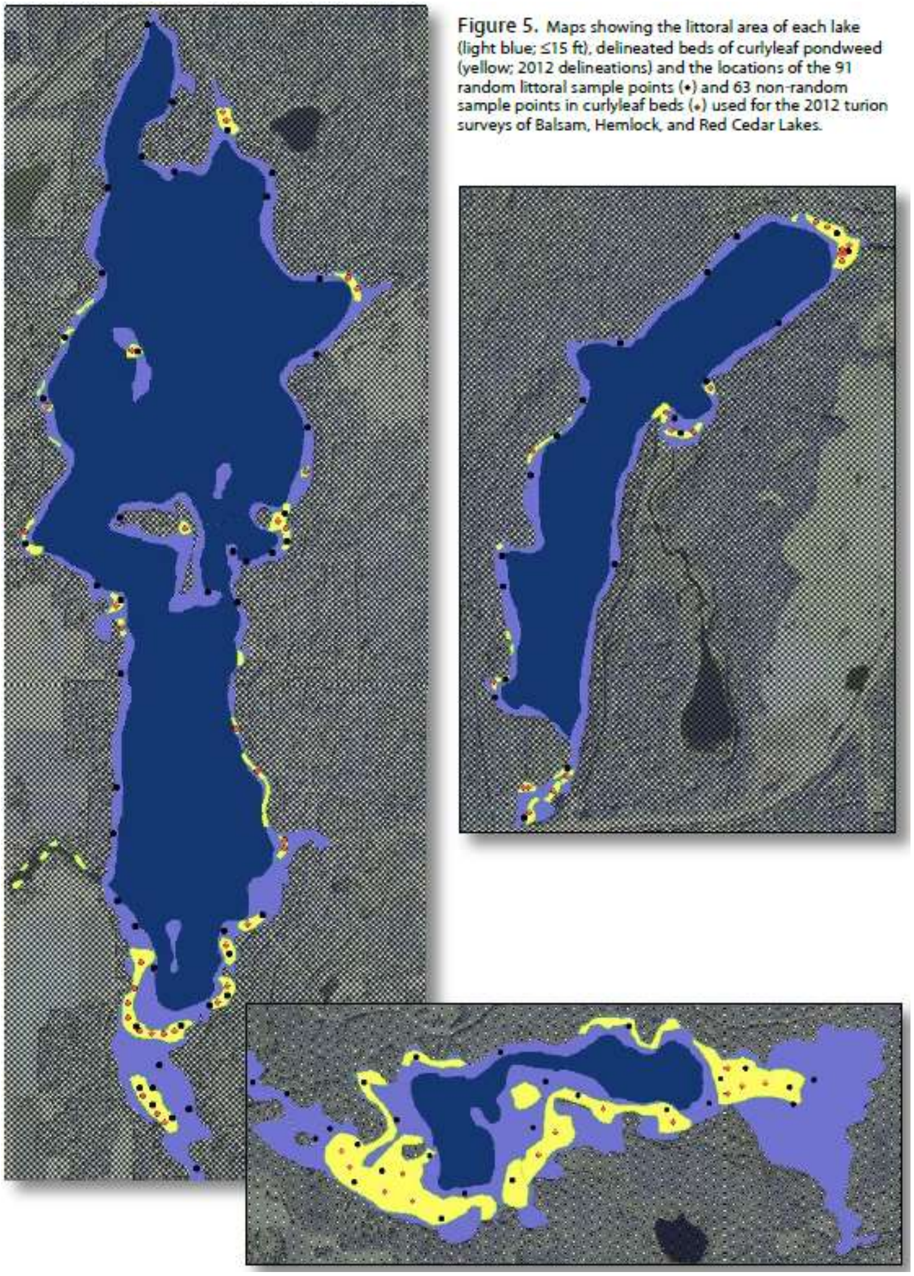


Figure 58: Maps showing the littoral area of each lake (blue), 2012 delineated beds of CLP (yellow), and the locations of 91 random and 63 non-random points used for the 2012 turion survey of all three lakes (FSS, 2012, Appendix A)

CLP MANAGEMENT JUSTIFICATION

The presence of CLP in the littoral zone of the Red Cedar Lakes is increasing, even though the overall frequency of occurrence is still low. It is the goal of the RCLA through this management plan to keep the frequency of occurrence low. By doing so, there will be less opportunity now and in the future for CLP to increase its distribution and density, negatively impacting native aquatic plant growth, interfering with lake use and navigation, and possibly impacting water quality. These management actions are considered a pro-active approach to maintaining what is and has been a consistent and long-term, diverse and healthy native aquatic plant community in the Red Cedar lakes.

PURPLE LOOSESTRIFE MANAGEMENT

The RCLA in partnership with the WDNR, Barron County, Washburn County, and the Birchwood School District have been rearing and distributing Galerucella beetles as biological control agents on the lakes in in adjacent wetlands and ditches around the lake for at least 20 years. For the most part, Gallerucella beetles are present at some level in just about all areas with purple loosestrife. The RCLA surveys the lakeshore within the system annually looking for purple loosestrife and physically removing what they can. The RCLA continues to work with Washburn County and the Birchwood Schools to raise and release additional beetles each year. These efforts will continue throughout the duration of this plan.

MANAGEMENT OF OTHER AIS IN THE RED CEDAR LAKES

At the present time rusty crayfish and Chinese mystery snails are known to be in the Red Cedar Lakes. No management actions other than monitoring and public awareness/education are recommended for these AIS in this plan. Monitoring for zebra mussels by the RCLA using plate samplers will be continued by the RCLA as will monitoring for other AIS like EWM, phragmites, Japanese knotweed through the Citizen Lake Monitoring Network AIS Monitoring program.

MUD LAKE AND BASS LAKE

No management of AIS or native aquatic vegetation other than physical removal by property owners is recommended in this plan for Mud Lake or Bass Lake. Monitoring for AIS is recommended.

2020-24 AQUATIC PLANT MANAGEMENT GOALS

The following is a list of the goals, objectives, and recommended actions included in the 2020-24 Red Cedar Lakes Aquatic Plant Management Plan. As stated earlier, the main goal of this plan is to reduce CLP in the entire Red Cedar Lake system to the point where there are no beds or high density areas in the lakes that exceed 1.0 acres in size and a rakehead density of 2 or more. Should there be areas that exceed these levels that are not targeted with herbicide applications over the next three years other non-chemical management efforts will be implemented. The goals in this plan are broad, but the objectives are more focused and are measurable. The actions listed will make it possible to meet each objective and hence accomplish the broader goals. Although these goals, objectives, and actions are intended to be a "plan" to improve the Red Cedar Lakes over the next five years, they are not meant to be static or unchanging. They can be adapted to better suit the conditions that present themselves over the course of the next five years. A separate document, Appendix B, is included in this plan

1) Goal 1 – Prevent the expansion of curly-leaf pondweed in the Red Cedar Lakes.

a) Objective 1 – Document changes in CLP distribution and density in the Red Cedar Lakes.

(1) Action – RCLA volunteers will complete CLP bedmapping in mid to late June each year to compare annual changes.

(2) Action – The RCLA will hire a specialist to repeat the same turion density survey that was completed in the fall of 2012, in the fall of 2021 and compare results.

(3) Action – The RCLA will hire a specialist to complete a cold-water, CLP, point-intercept survey in 2023 and compare to results from 2011 and 2018 surveys.

b) Objective 2 – Reduce the current (2017) distribution and density of CLP in the Red Cedar Lakes to the point where there are no beds >1 acre in size with a rakehead density of 2 or more.

(1) Action – The RCLA will implement a multi-year chemical treatment plan that includes areas that are ≥1 acre with a rakehead density of 2 or more based on prior year CLP bedmapping results.

(a) Preliminary CLP chemical treatment plans will be completed no later than February 1st each year and based on prior year CLP bedmapping.

(i) In areas with 18-24 hour expected herbicide/target plant contact time, endothall based herbicides in liquid form will be utilized

(ii) In areas with an expected herbicide/target plant contact time <18 hours, diquat based herbicides will be utilized

(iii) Concentration of herbicide applied will be based on past management experience and accepted treatment and herbicide use guidelines

(b) Pre and post-treatment, point-intercept aquatic plant survey work will be completed in each area where chemical treatment is planned

(i) Final treatment areas will be determined via the results of pre-chemical treatment point-intercept aquatic plant surveying

(ii) Any bed where chemical management of CLP was completed in a previous year will automatically be on the list of areas to complete pre-chemical treatment point-intercept aquatic plant surveying regardless of the results of prior year June bedmapping

(c) Herbicide concentration-dispersion testing will be completed in a representative set of points in at least the first year of herbicide application and in subsequent years if requested by the WDNR

(2) Action – The RCLA and individual property owners will complete small-scale, manual removal of CLP in nearshore areas

(3) Action – Contracted DASH or aquatic plant harvesting will be incorporated into the annual CLP management plan if appropriate.

(a) An example of an area to consider DASH or harvesting would be in Balsam Lake near known wild rice beds

c) Objective 3 – After a minimum of three years of system wide management of CLP the turion density established during the 2012 survey will be less in lake-wide and in previously delineated areas of CLP.

(1) Action – Repeat the system wide CLP turion density survey that was completed by FSS in 2012

(a) Compare results from the new survey to what was found in the 2012 survey

2) Goal 2 – Maintain or improve current (2018) measurements of the health of the native aquatic plant community in the Red Cedar Lakes.

a) Objective 1 – Compare measurements of the health of the native aquatic plant community in the Red Cedar Lakes prior to and after a multi-year CLP management project.

(1) Action – The RCLA will hire a specialist to complete a summer, whole-lake, littoral zone, point-intercept Survey in 2023 and compare results to previous whole-lake, point-intercept survey results in 2011 and 2018.

(2) Action: The RCLA will monitor and map known wild rice populations annually and survey the entire shoreline/littoral area for wild rice at least every other year.

3) Goal 3 – Monitor changes in water quality

a) Objective 1 – Maintain or improve measurements of water quality in Balsam, Red Cedar, Hemlock, and Bass Lakes including Secchi, temperature, dissolved oxygen, total phosphorus, and chlorophyll a

(1) Action – The RCLA will continue to participate in the expanded level of the Citizen Lake Monitoring Network (CLMN) on Balsam, Red Cedar, and Hemlock lakes.

(2) Action – The RCLA will add water quality data collection on Bass Lake as a part of the CLMN

b) Objective 2 – Share in-lake and tributary water quality data between lakes in the upper Red Cedar River watershed.

(1) Action - Work with/partner with the Big Chetac and Birch Lakes Association to monitor and share water quality data between lakes

4) Goal 4 – Reduce the threat that new aquatic invasive species will be introduced into and go undetected in the Red Cedar Lakes, and that existing AIS like purple loosestrife will continue to spread.

a) Objective 1 – Complete at least 400 total hours of watercraft inspection time annually and maintain applicable AIS signage at multiple landings on the Red Cedar Lakes to educate boaters and other lake users about AIS and how they are transferred from lake to lake.

(1) Action – The RCLA will implement a Clean Boats, Clean Waters programs annually.

(2) Action – The RCLA will inspect, maintain and/or improve AIS signage at all landings annually.

b) Objective 2 – Locate and identify any new AIS that may be introduced to the Red Cedar Lakes as early as possible.

(1) Action – The RCLA will implement an AIS Monitoring Program annually following guidelines provided by the Citizen Lake Monitoring Network

(2) Action – The RCLA will implement fall dock and boatlift removal survey for zebra mussels annually

c) Objective 3 – Increase opportunities for the RCLA constituency, property owners, visitors, and other lake users to be made aware of and learn about AIS.

(1) Action – The RCLA will annually distribute AIS education and identification materials to RCLA constituency via newsletters, on the web or Facebook page, at local businesses and during meetings and other events attended by RCLA members

(2) Action – The RCLA will plan and implement at least one event/opportunity annually for the RCLA constituency and other community members to learn how to look for and identify AIS; learn who to report new findings too; and learn how to properly remove what they find from the lake.

d) Objective 4 – Keep the spread of purple loosestrife along the shores of the Red Cedar Lakes and in adjacent wetlands and ditches.

(1) Action – Continue managing of purple loosestrife through physical removal and release of Galerucella beetles

(a) Complete shoreland surveys of the lakes with physical removal in August each year

(b) Partner with Washburn County and the Birchwood School District to raise and release additional beetles in and around the Red Cedar Lakes

e) Objective 4 – Determine a plan of action to follow if a new AIS is discovered in the Red Cedar Lakes

(1) Action – The RCLA will develop, maintain, and update as necessary, a formal AIS Rapid Response Plan in the first year covered by this plan.

5) Goal 5 – Improve shoreland habitat and capability of the shoreland to filter runoff entering the lakes

a) Objective 1 – Promote and support nearshore and riparian projects that will improve fish and wildlife habitat, reduce runoff, and minimize nutrient loading into the Red Cedar Lakes.

(1) Action – Apply for at least two Wisconsin Healthy Lakes Initiative Grants over the next five years to support multiple projects that will improve fish and wildlife habitat and reduce runoff into the Red Cedar Lakes in the next five years

6) Goal 6 – Assess the progress and results of this project annually and report to and involve other stakeholders in planning efforts.

a) Objective 1 - Build and support new and existing partnerships each year.

(1) Action – The RCLA will work with WDNR, Barron-Washburn-Sawyer Counties, Towns of Cedar Lake-Birchwood-Wilson, Villages of Birchwood and Mikana, the Big Chetac and Birch Lakes Association, Red Cedar Watershed Water Quality Partnership, Landmark Conservancy, local businesses, contractors, and other resources to support management actions on the Red Cedar Lakes

b) Objective 2 – Complete annual project activity and assessment reports

(1) Action – The RCLA and their Consultant will prepare end-of-year reports summarizing the management actions completed and how they impacted the lake and share/review them with the RCLA constituency, partners, and the WDNR.

c) Objective 3 – Provide multiple opportunities and venues annually for lake residents, users, and other partners to keep informed about management planning and implementation activities

(1) Action – The RCLA will post management planning and implementation information on the RCLA webpage, Facebook, in newsletters, and at RCLA meetings and events.

d) Objective 4 – Stay within the budget constraints of the RCLA to establish and prioritize the best management actions to implement annually

(1) Action – The AIS Program Coordinator for the RCLA will work with other members and committees of the RCLA to determine management actions to pursue each year.

(2) Action – The RCLA will apply for State of Wisconsin grant funding to support the education, planning, and management actions recommended in this plan.

FUNDING AND IMPLEMENTATION

This plan is intended to be a tool for use by the RCLA and other Stakeholders to move forward with aquatic plant management actions that will maintain the health and diversity of the Red Cedar Lakes and its aquatic plant community. This plan is not intended to be a static document, but rather a living document that will be evaluated on an annual basis and updated as necessary to ensure goals and community expectations are being met. This plan is also not intended to be put up on a shelf and ignored. Implementation of the actions in this plan through funding obtained from the WDNR and/or other funds available through other stakeholders is highly recommended. An Implementation and Funding Matrix is provided in Appendix C.

Since many actions occur annually, a calendar of actions to be implemented was created in Appendix D.

WDNR AIS GRANT PROGRAMS

There are several different WDNR grant programs that may be applicable to and/or support the goals, objectives, and actions in this Aquatic Plant Management Plan.

AQUATIC INVASIVE SPECIES GRANTS

Aquatic Invasive Species grants can be used to support education, prevention, and planning projects, Clean Boats, Clean Waters programs, aquatic plant survey costs, plant management permitting costs, and many other actions. In some cased they can be used to support management implementation as well. Currently these grants require that 25% of a total projects cost be covered by the sponsor through volunteer time, donated services and/or equipment, and/or cash. Application due dates are December 10 and February 1.

LAKE MANAGEMENT PLANNING GRANTS

Lake management planning grants are intended to provide financial assistance to eligible applicants for the collection, analysis, and communication of information needed to conduct studies and develop management plans to protect and restore lakes and their watersheds. Projects funded under this subprogram often become the basis for implementation projects funded with Lake Protection grants. There are two categories of lake management planning grants: small-scale and large-scale.

SMALL SCALE LAKE MANAGEMENT PROJECTS

Small-scale projects are intended to address the planning needs of lakes where education, enhancing lake organizational capacity, and obtaining information on specific lake conditions are the primary project objectives. These grants are well suited for beginning the planning process, conducting minor plan updates, or developing plans and specification for implementing a management recommendation.

LARGE SCALE LAKE MANAGEMENT PROJECTS

Large-scale projects are intended to address the needs of larger lakes and lakes with complex and technical planning challenges. The result will be a lake management plan; more than one grant may be needed to complete the plan.

Currently these grants require that 33% of a total projects cost be covered by the sponsor through volunteer time, donated services and/or equipment, and/or cash. The application due date is December 10.

LAKE PROTECTION GRANTS

Lake protection and classification grants assist eligible applicants with implementation of lake protection and restoration projects that protect or improve water quality, habitat or the elements of lake ecosystems. There are four basic Lake Protection subprograms: a) Fee simple or Easement Land Acquisition b) Wetland and Shoreline Habitat Restoration c) Lake Management Plan Implementation d) Healthy Lakes Projects.

HEALTHY LAKES PROJECTS

The Healthy Lakes grants are a sub-set of Plan Implementation Grants intended as a way to fund increased installation of select best management practices (BMPs) on waterfront properties without the burden of developing a complex lake management plan. Details on the select best practices can be found in the

Wisconsin Healthy Lakes Implementation Plan and in best practices fact sheets available through the Healthy Lakes Initiative.

Eligible best practices with pre-set funding limits are defined in the Wisconsin Healthy Lakes Implementation Plan, which local sponsors can adopt by resolution and/or integrate into their own local planning efforts. By adopting the Wisconsin Healthy Lakes Implementation Plan, a lake organization is immediately eligible to implement the specified best practices. The intent of the Healthy Lakes grants is to fund shovel-ready projects that are relatively inexpensive and straight-forward. The Healthy Lakes grant category is not intended for large, complex projects, particularly those that may require engineering design. All Healthy Lake grants require a 25% sponsor match and have a standard 2-year timeline. Applications are due on February 1 each year.

For more information about these or any other lake related WDNR grant, visit the WDNR's Surface Water Grants page at https://dnr.wi.gov/aid/surfacewater.html.

GRANT FUNDS TO ASSIST IMPLEMENTATION OF THIS APM PLAN

The RCLA has already, and will continue to seek Aquatic Invasive Species (AIS) Control of an Established Population (ACEI) grant funding from the WDNR to support implementation of many of the actions included in this plan. Specifically grant funding will be sought for CLP management planning; chemical management of CLP; associated activities including pre and post chemical treatment aquatic plant survey work, herbicide concentration testing, and turion density survey work; water quality testing; and AIS education, prevention, and planning efforts. If AIS ACEI grant funding cannot be secured, the RCLA will apply for AIS Education, Prevention, and Planning (AEPP) grant funding. If AIS AEPP grant funding cannot be secured the RCLA will seek AIS Maintenance and Containment grants to recoup WDNR permit fees for management.

Funding for watercraft inspection will be sought via the expedited Clean Boats Clean Waters grant program. Shoreland improvement funding will be sought via the Healthy Lake grant program.

In addition, the RCLA is embarking on a much larger water quality and water movement project for the Red Cedar Lakes and has already applied for and received lake management planning grant funds to support this effort.

WDNR approval of this document is required for AIS ACEI grant funding. The RCLA is already seeking that approval.

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Appendix A – 2012 Freshwater Scientific Services Turion Density Survey

Appendix B – Red Cedar Lakes Aquatic Plant Management Goals, Objectives, and Actions

Appendix C – Implementation and Funding Matrix

Appendix D – Calendar of Actions

Appendix E – Preliminary 2020 CLP Chemical Management Map and Details