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LOWER TURTLE LAKE, BARRON COUNTY

2020-24 AQUATIC PLANT MANAGEMENT PLAN

WDNR WBIC: 2079700

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LOWER TURTLE LAKE
MANAGEMENT DISTRICT

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PREPARED FOR THE LOWER TURTLE LAKE MANAGEMENT DISTRICT

INTRODUCTION

Lower Turtle Lake is located in west-central Barron County. The Lower Turtle Lake Management District (LTLMD) has been actively working to improve water quality conditions in the lake since the 1990s. The LTLMD initiated lake studies in 1994 and 2004 out of concern for degraded water quality conditions. These studies were combined to create the Revised Comprehensive Lake Management Plan for the Turtle Lakes in early 2009. This plan was the basis for a 2010-2014 Lake Protection Project focused on agricultural and riparian owner incentives to incorporate Best Management Practices (BMPs) that could reduce phosphorous loading to the lake. Developing Aquatic Plant Management (APM) Plans for both Upper and Lower Turtle Lake were a part of this five-year project. The original APM Plan for Lower Turtle Lake was written in 2010, and approved by the Wisconsin Department of Natural Resources early in 2011. In 2015-16 an Addendum was added to the 2010 APM Plan that laid out curly-leaf pondweed (CLP) management actions for the next three years. The same document recommended selected harvesting to open up navigation and access lanes through areas of dense growth native vegetation later in the season. These two documents guided management activities through 2017. No form of active management was done in 2018 or 2019. This plan will guide the implementation of aquatic plant management activities from 2020 to 2024.

PUBLIC PARTICIPATION AND STAKEHOLDER INPUT

Although an addendum was added to the 2010 Lower Turtle Lake Aquatic Plant Management Plan in 2015-16, the entire plan was not updated with current data. A project to update the existing APM Plan began with an Aquatic Invasive Species Education, Prevention, and Planning (AEPP) grant application prepared at the request of the LTLMD by Lake Education and Planning Services, LLC (LEAPS) in December 2017. The AEPP grant was awarded and management planning process began.

The planning project included point-intercept aquatic plant survey work completed by Endangered Resource Sciences (ERS), a shoreland habitat assessment completed by LEAPS, and an update of the Aquatic Plant Management Plan by LEAPS. The project was supported by volunteer time and donated services on the part of the LTLMD and its constituency.

The project was introduced to the LTLMD constituency in the spring of 2018. Updates were provided by LEAPS at the 2018 Annual Meeting in August 2018, a spring board meeting in April 2019, and again at the Fall Board meeting in October 2019. Also during the October 2019 meeting a summary of some of the basic findings of the plant survey and other data was presented along with the goals, objectives, and actions to be included in the new or update APM Plan.

The updated APM Plan was put out on the LTLMD webpage and the LEAPS webpage for public review and comment in November 2019. Final approval of the updated APM Plan by the LTLMD was obtained in December 2019.

OVERALL MANAGEMENT GOAL

The 2011 APM plan had six overall goals which were:

- Monitor, control, and manage aquatic invasive species;
- Educate residents and users about and prevent the introduction of aquatic invasive species;
- Monitor lake water quality;
- Promote and implement shoreland best management practices;
- Preserve, protect, and enhance native species;
- Evaluate the APM plan each year and revise as necessary

The goals of this plan are less focused on AIS management and more focused on increasing the overall health of the lake through an integrated management approach. This includes some, limited, management of both native and non-native plants, water quality monitoring, and engaging with lake residents with education and support for shoreline habitat improvements. This plan has six total goals:

- Support and implement aquatic plant management efforts that minimize negative impacts to the native plant communities.
- Maintain summer and late season access to open water
- AIS education and prevention.
- Monitor changes is water quality
- Promote and support nearshore, riparian, and watershed best management practices that will improve fish and wildlife habitat, reduce runoff, and minimize nutrient loading into Lower Turtle Lake.
- Implement the Lower Turtle Lake Management Plan effectively and efficiently with a focus on community and constituent education, information, and involvement.

The associated objectives and actions for these goals can be found in Appendix A.

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 Wisconsin'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 great concern over the spread of AIS, such as EWM that can negatively impact the health of the native aquatic plant community, or drastically change the make-up of it. 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 APMPs as part of a total lake management picture. Planning is a lot of work, and has a significant cost associated with it, but a sound management plan can have long-term benefits for a lake and the community living on and using the lake.

The impacts of humans on Wisconsin's waters over the past five decades have caused public resource professionals in 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's public resource professionals be responsible for the management of fish and wildlife resources and their sustainable use to benefit all Wisconsin citizens. Aquatic plants are 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, such as EWM.

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 development of long-term, integrated aquatic plant management strategies to identify important plant communities and manage nuisance aquatic plants in lakes, ponds or rivers is required by the State of Wisconsin. To promote the long-term sustainability of our lakes, the State of Wisconsin endorses the development of APMPs 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.

LOWER TURTLE LAKE WATERSHED CHARACTERISTICS

A watershed is defined as an area of land where all of the water that is under it, falls onto it, and that drains off of it collects into the same place like a lake. Figure 1 shows how a typical watershed works. Imagine a raindrop falling anywhere inside that watershed; no matter where it lands, it will eventually find its way to the main body of water at the bottom. If it lands in another watershed, it will drain to a different waterbody. A lake usually reflects how the land in its watershed is being used. Less human disturbance like home and business building, roadways, and agriculture within a lake's watershed generally means a healthier lake overall. Agricultural land, mowed lawns, and increased impervious (does not allow liquid to pass through) surfaces like roads and rooftops, cause more of the water falling on the land to "run off" into lakes, ponds, rivers and streams carrying dirt and other pollutants with it, rather than soaking into the ground where many pollutants are removed.

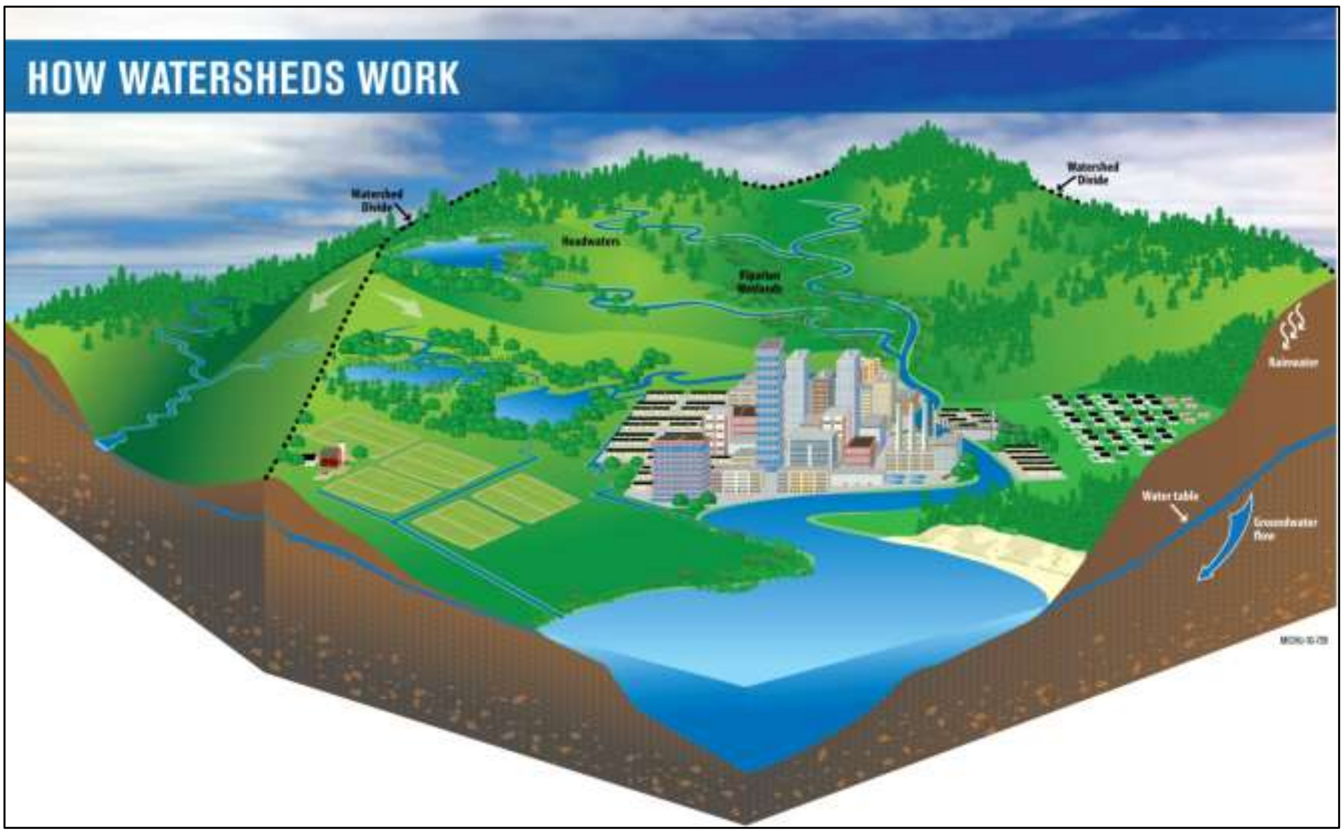


Figure 1: How a Watershed Work, Michigan Sea Grant

The Lower Turtle Lake watershed is 5,583 acres including an internally drained area of 195 acres that drains to a wetland known locally as Scheps' Wetlands. Internally drained areas are closed depressions within the watershed that can only provide surface runoff to the drainage network during the extreme wet conditions. During normal conditions, the Scheps' Wetlands basin drains northward, away from the lake.

Land cover and land use management practices within a watershed have a strong influence on water quality. Increases in impervious surfaces, such as roads, rooftops and compacted soils, associated with residential and agricultural land uses can reduce or prevent the infiltration of runoff. This can lead to an increase in the amount of rainfall runoff that flows directly into Lower Turtle Lake and its tributary streams. The removal of riparian, i.e., nearshore, vegetation causes an increase in the amount of nutrient-rich soil particles transported directly to the lake during rain events. The land use in the Lower Turtle Lake watershed is primarily classified as agricultural (row crops, pasture, etc.) and a mix of forests and wetlands (Table 1, Figure 2). The agricultural land use covers approximately 55% of the watershed and consists primarily of large-scale row cropping. Residential areas make up a relatively small portion of the land use; however, the majority of residential areas are concentrated around the lakes in the watershed leading to more immediate and likely greater impacts to water quality than areas located further away from the lakes.

Table 1: Land Use within Lower Turtle Lake Watershed

Cover Type	Area (Acres)	Percentage of Watershed
Open Water	731.0	13.1%
Wetlands	159.9	2.9%
Forest	1134.8	20.3%
Scrub/ Grassland	83.8	1.5%
Pasture	2223.5	39.8%
Crops	858.2	15.4%
Light Development	370.5	6.6%
Heavy Development	21.3	0.4%
Totals	5583.1	100.0%

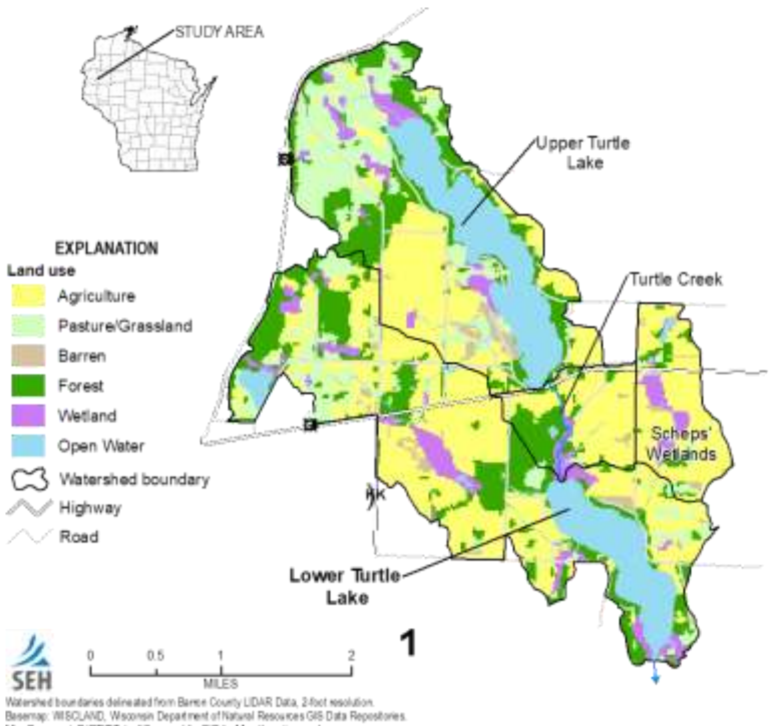


Figure 2: Lower Turtle Lake Watershed

SOILS

The soil types found in a watershed help determine the capacity for runoff into a lake. Soils are classified into four main groups (A, B, C, and D) to indicate their potential for producing runoff. Group A soils have a high infiltration rate (can soak up lots of water) 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 usually contained to wetland areas. Groups B and C fall somewhere in between groups A and D with group B being considered to have a moderately fast infiltration rate, and group C being considered to have a moderately slow infiltration rate. These soils have a wide variety of compositions and densities which is why they fall between groups A and D.

There are also three sub groups (A/D, B/D, and C/D) these indicate the infiltration rate of the soils with respect to the water table. The water table is how close water in the ground is to the surface of that ground (see Figure 1). When the water table is close to the surface, some of the Group A soils act more like Group D soils, hence the A/D grouping. If the water table is lower, Group A/D soils act more like Group A soils. Within the Lower Turtle Lake Watershed, 13.7% of the area is covered by Upper and Lower Turtle Lakes, and 44.6% of the watershed is covered by either group C or C/D soils (Table 2, Figure 3). Because the majority of the soils in the Lower Turtle Lake Watershed have moderate infiltration rates, there is some potential for runoff if the shorelines remain undisturbed. If property owners begin to degrade the shoreline by creating mowed lawns to the edge of the lake, installing impervious pathways or patios, or placing buildings near the water's edge the likelihood of runoff that will carry sand, sediment, and other pollutants into the lake is likely to increase greatly.

Table 2: Breakdown of Hydrologic Soil Groups within Lower Turtle Lake Watershed

Hydrologic Soil Group	Area (Acres)	Percentage of Watershed
A	24.4	0.4%
B	1129.3	20.3%
C	1264.9	22.7%
D	0	0.0%
A/D	285.7	5.1%
B/D	880.5	15.8%
C/D	1220.2	21.9%
Open Water	763.8	13.7%
Total	5568.8	100.0%

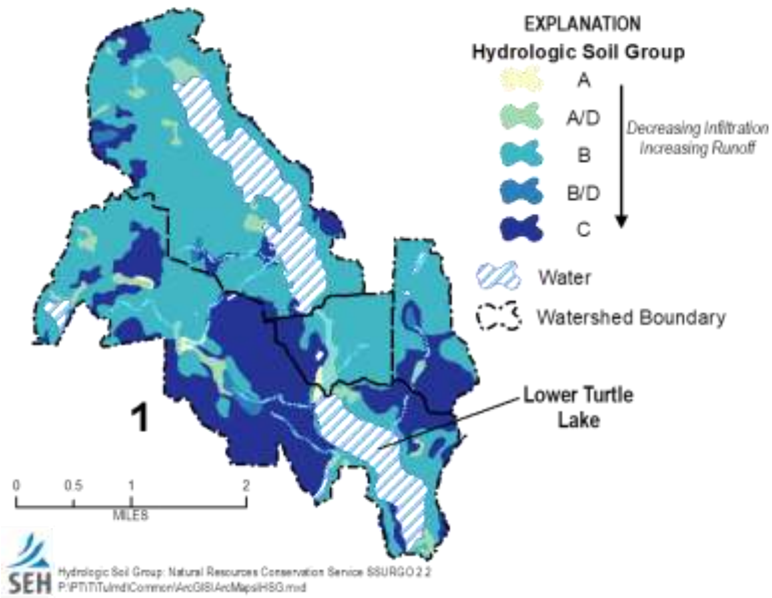


Figure 3: Hydrologic Soil Groups Within Lower Turtle Lake Watershed

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 Lower Turtle Lake. 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 Lower Turtle Lake by acting 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 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.

Only 2.9% of the Lower Turtle Lake Watershed is comprised of wetland areas. There are only three wetland areas that are adjacent to the shoreline of Lower Turtle Lake (Figure 4). The largest of these areas are found along the inlet and outlet to the lake. There is another small wetland area found on the eastern shoreline. The wetlands along the northern and eastern shoreline provide some protection from runoff, but the majority of the shoreline is not afforded that same protection.

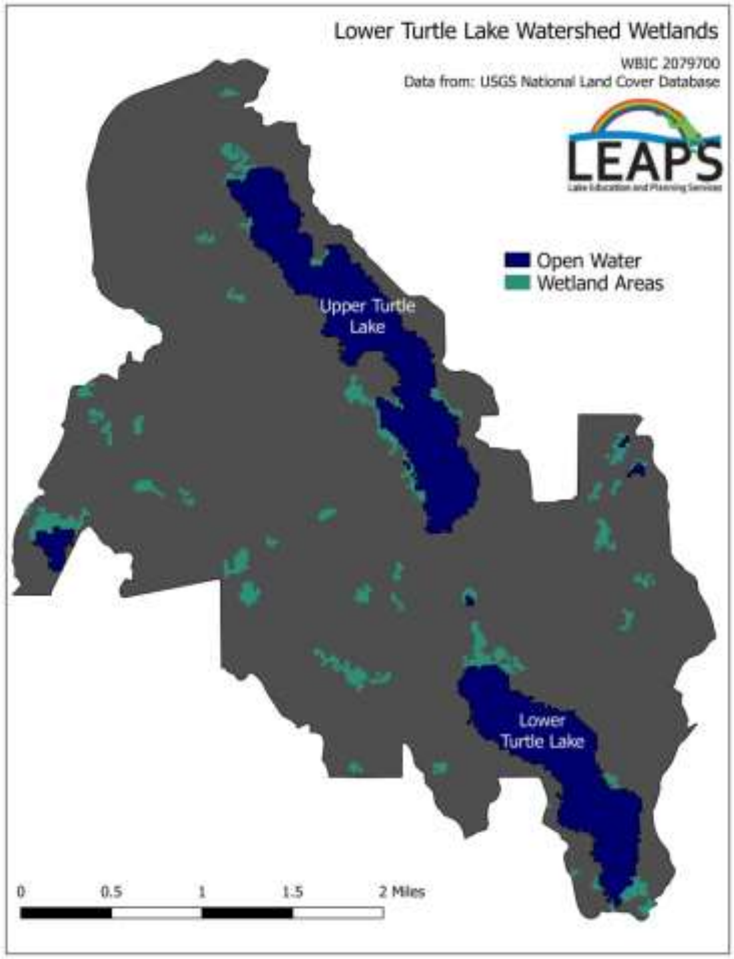


Figure 4: Wetland Areas within Lower Turtle Lake Watershed

LAKE CHARACTERISTICS

In order to make recommendations for aquatic plant and lake management, basic information about the water body of concern is necessary. A basic understanding of physical characteristics including size and depth, critical habitat, water quality, water level, fisheries and wildlife, wetlands and soils is needed to make appropriate recommendations for improvement.

PHYSICAL CHARACTERISTICS

Lower Turtle Lake is a hard-water drainage lake in west-central Barron County, Wisconsin about 2.5 miles east of the Village of Turtle Lake. The lake covers about 294 acres and has a maximum depth of 24 feet and an average depth of 13.4 feet (Figure 2). Additional physical characteristics of the lake are provided in Table 3. Turtle Creek, which flows from Upper Turtle Lake, is the main tributary to Lower Turtle Lake. The stream enters at the north end of the lake and exits at the south end. The lake is also fed by three intermittent streams and wetland drainage. The bottom substrate is primarily comprised of a mix of sand (49%) and muck (44%) with small areas of rock (7%) spread throughout the lake.

Table 3: Physical characteristics of Lower Turtle Lake (2011 APM Plan, SEH)

Lake Area (acres)	294
Watershed Area (acres)	5,569
Watershed to Lake Ratio	18:1
Maximum Depth (feet)	24
Mean Depth (feet)	13.4
Volume (acre-feet)	3,933.7
Elevation (feet AMSL)	1,172
Maximum Fetch (miles)	1.5
Miles of Shoreline	4.42
Lake Type	Drainage

WATER QUALITY

Water clarity and water chemistry are important indicators of water quality. Secchi disk readings of water clarity have been collected by Wisconsin Citizen Lake Monitoring Network (CLMN), formerly the Self-help Lake Monitoring Program, volunteers since 1987. The WDNR website indicates CLMN volunteers have collected water quality data from 1987-2018. According to the volunteers collecting this data, lake levels appear to be mostly normal. There are several years where lake levels appear to be either high or low, but there is no real pattern or specific conditions that appear to cause this. The appearance of the water in the lake is predominately clear with a few murky readings. The color of the water ranged from blue to green to brown with green being the predominant reported coloration. Perception is based on a volunteer's familiarity with lake conditions at any given time of year and was predominantly listed as being "enjoyment somewhat impaired (algae)" or "very minor aesthetic problems".

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" Secchi disk. A Secchi disk is divided into four sections, two black and two white, and is lowered into the lake water from the surface by a rope marked in measurable increments (Figure 5). 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 5: Black and white Secchi disk

Figure 6 shows the average total and summer (July-Sept.) Secchi disk readings since CLMN began in 1987. In 2018, the average summer Secchi disk reading for Lower Turtle Lake at the Deep Hole was 3.25 feet. The average for the Northwest Georegion was 8.1 feet. The summer Secchi readings have a relatively narrow range from as low as 2.25 feet in 2012 up to 5.5 feet in 1989 with an overall average of 3.4 feet from 1989 through 2018. The trendline in Figure 6 shows a decreasing trend suggesting that overall water clarity has deteriorated some since monitoring first began.

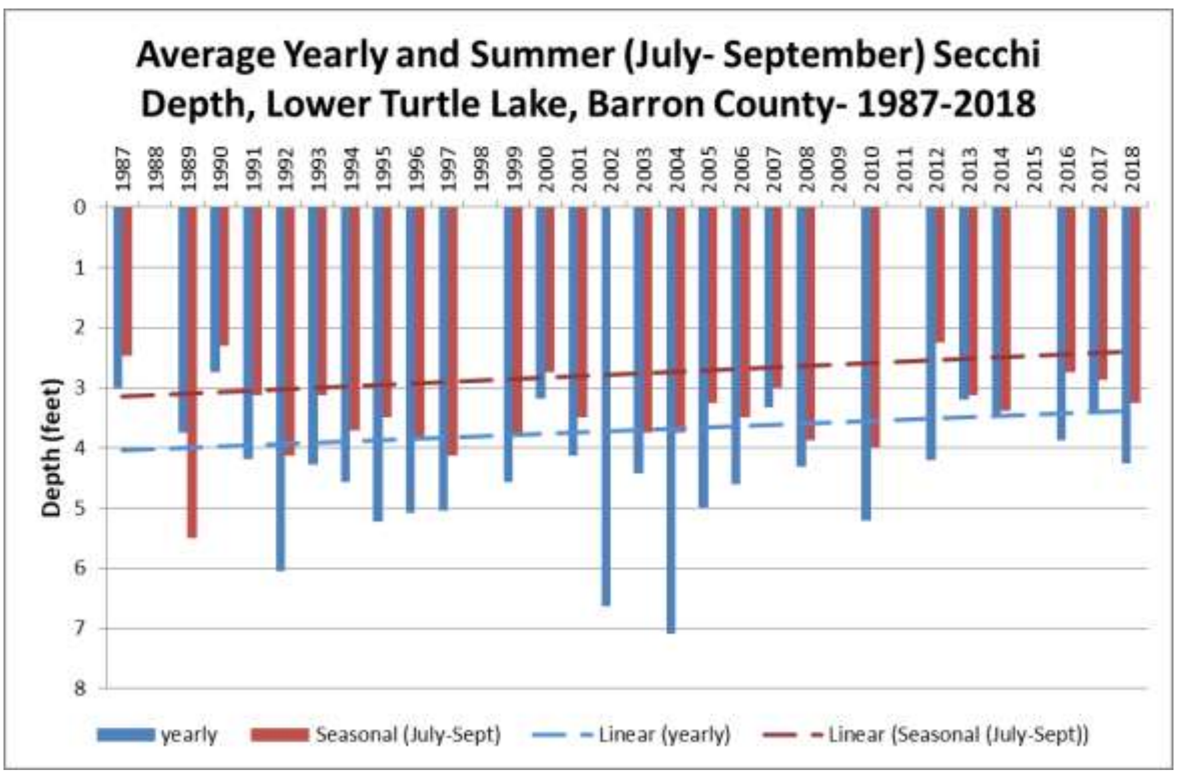


Figure 6: Average yearly and summer (July- September) Secchi disk readings at the Deep Hole

Typically the summer (July-Sept.) water was reported as MURKY and GREEN. This suggests that the Secchi depth may be mostly impacted by algae (very small plant particles) suspended in the water. An over-abundance of algae is generally considered to decrease the aesthetic appeal of a lake because people prefer clearer water to swim in and look at. This did seem to impact the volunteer's perception of Lower Turtle Lake to some degree. The most commonly selected perception of the lake was "3-Enjoyment somewhat impaired (algae)." However the second most common perception was "2- Very minor aesthetic problems," so the perception of Lower Turtle Lake is not entirely negative. Algae are always present in a balanced lake ecosystem. They are the photosynthetic basis of the food web. Algae are eaten by zooplankton, which are in turn eaten by fish.

TROPHIC STATE INDEX

One of the most commonly used metrics of water quality is the trophic state of a lake. The trophic state is defined as the total load of biomass in a waterbody at any given time (Carlson & Simpson, 1996). To determine the trophic state of any given lake, the Tropic State Index (TSI) is generally used. This index uses the three main variables for water quality measurement in WI: Secchi depth (water clarity), total phosphorus (nutrients in the water), and chlorophyll concentration (the amount of algae in the water). TSI values are technically limitless, but when applied, they almost always fall between 0 and 100. To make sense of these values, they are broken into different trophic states. The four main trophic states are oligotrophic (TSI<40), mesotrophic (TSI 40-50), eutrophic (TSI 50-70), and hypereutrophic (TSI>70) (Figure 7). Oligotrophic lakes are usually very clear, clean lakes with low nutrient levels. Mesotrophic lakes are moderately clear with some nutrients and more plants present within the system. Eutrophic lakes have excess nutrients that support a great deal of algae growth, and may have a large aquatic plant community. Hypereutrophic lakes are typically very green with dense algae and limited plant growth.

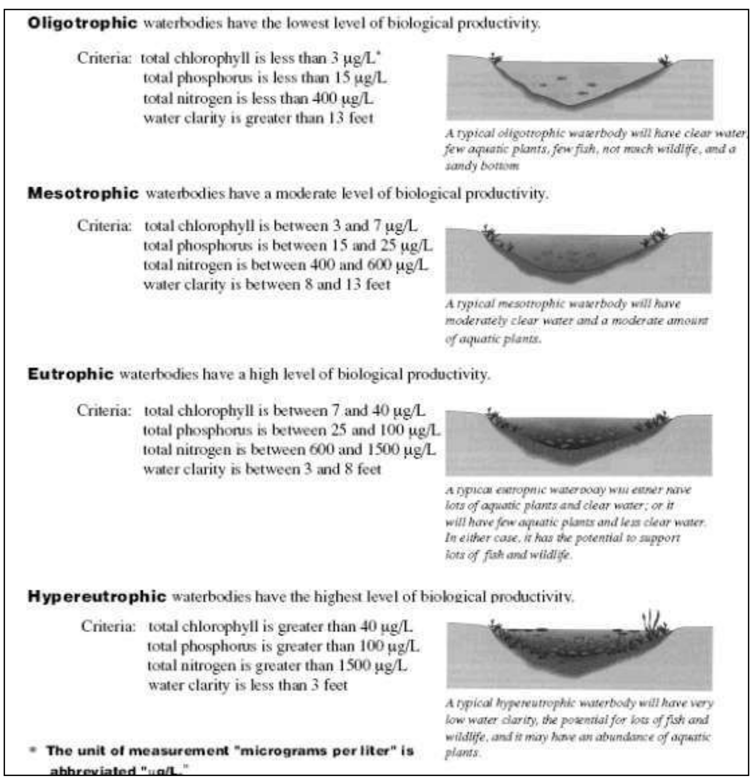


Figure 7: Trophic status in lakes

Lower Turtle Lake has consistently been a highly eutrophic lake since monitoring began in 1987. Generally, the levels of chlorophyll within a lake are considered the most accurate indication of that lake's trophic status. This is because chlorophyll is an indirect measurement of how much algae is present in a lake. In Lower Turtle Lake, the chlorophyll TSI is around 60 on average, but this has ranged from 55 in 1997 up to 78 in 2000 (Figure 8).

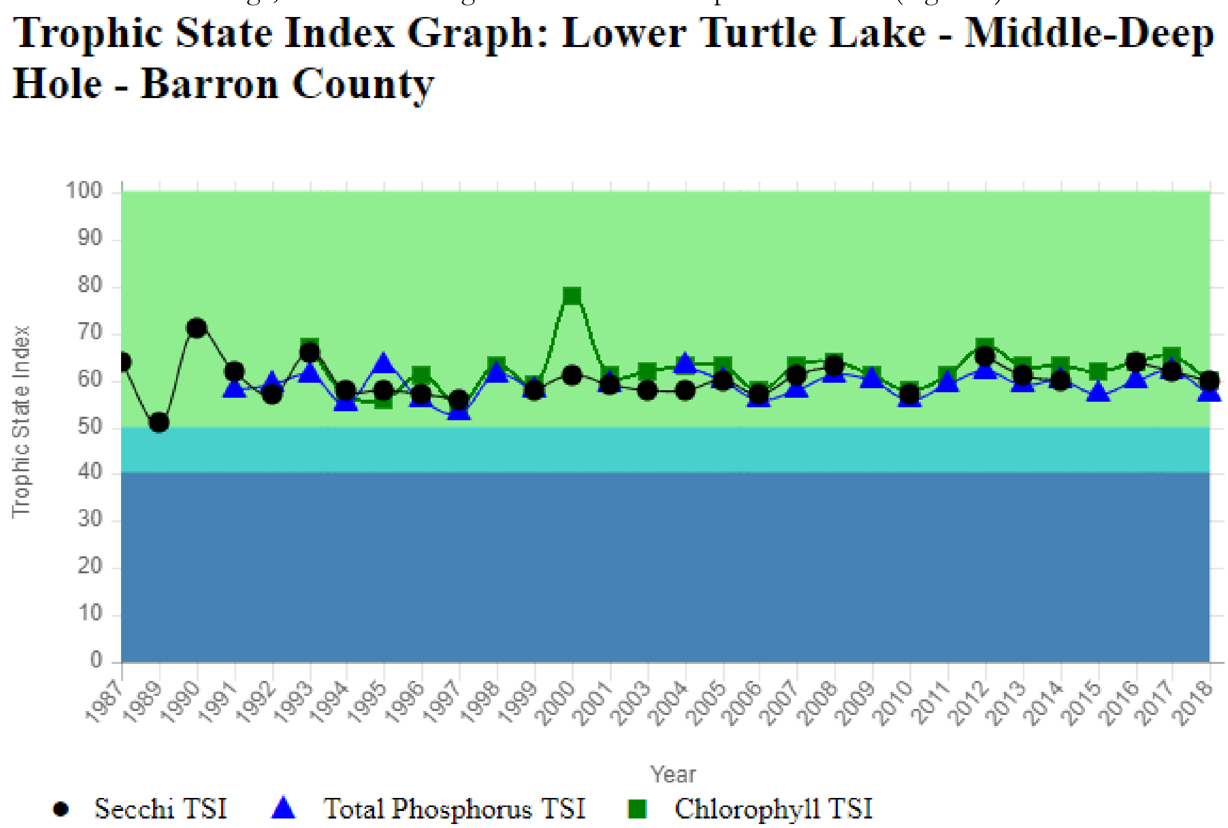


Figure 8: Average Seasonal Trophic State Index for Lower Turtle Lake

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 9. This process, called stratification, prevents mixing between the layers due to water density differences at different temperatures 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 top to bottom in the lake 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.

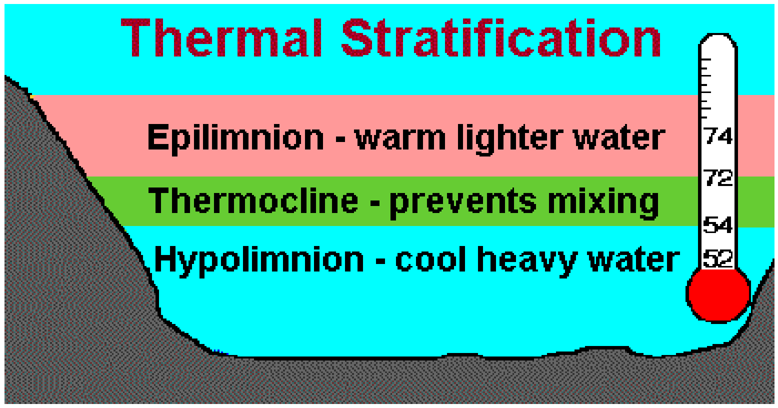


Figure 9: Summer thermal stratification

During the summer months, the upper warm layer, called the epilimnion, remains well oxygenated due to wind and wave action and photosynthesis. Photosynthesis is the process by which green plants use sunlight to synthesize foods for growth from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and generates oxygen as a byproduct. Much of this oxygen is held in the water in a dissolved state, hence the term dissolved oxygen (DO). The middle layer, called the metalimnion or thermocline, is where changes in temperature and DO between the surface of a lake and the bottom of the lake are greatest. This middle layer acts as a barrier that prevents warmer, oxygen rich waters in the upper layer from mixing with colder, deeper waters called the hypolimnion. It is common for DO levels to be depleted in the hypolimnion, as there are no sources of new oxygen in the deep water when other natural processes that occur in the deep water use up existing oxygen.

The amount of DO in the water (measured in parts per million (ppm)) impacts many lake parameters. Fish need at least 4.0 ppm of DO to survive in a lake. When DO drops below 2.0 ppm in the hypolimnion, a condition called hypoxia, nutrients built up in the sediment at the bottom of the lake can be released back into the lake. If the phosphorus released from bottom reaches the upper part of the lake through spring or fall overturn or when natural or human induced wave action mixes the lake, it can provide a significant internal source of phosphorus to fuel algae growth. Rapid growth of algae is called an algae bloom and can turn a lake from a clearer water state to a cloudy state literally overnight.

The temperature and DO data (Figure 10) collected suggests that Lower Turtle Lake is stratified for a short period in the summer. Generally, the lake begins to form a thermocline in early to mid- July, but the lake is usually completely mixed again by early September. This is not at all abnormal for shallow lakes like Lower Turtle Lake, and could actually help prevent the water quality from experiencing a significant drop late in the summer.

05/13/2019		
Depth FEET	Temp. DEGREES F	D.O. MG/L
0	57.1	14.05
3	56.3	14.31
6	54.7	13.66
9	53.4	13.04
12	52.8	11.39
15	52.1	10.45
18	51.4	9.81
20	50.8	.13

06/25/2019		
Depth FEET	Temp. DEGREES F	D.O. MG/L
0	70.4	8.81
3	70.1	8.9
6	69.9	8.59
9	69.8	8.64
12	69.6	8.3
15	65.3	.21
18	59.6	.09
20	57.5	.06

07/24/2019		
Depth FEET	Temp. DEGREES F	D.O. MG/L
0	77.7	10.08
3	76.4	9.22
6	76	7.67
9	75.3	6.07
12	74	3.31
15	72.5	.17
18	68.6	.09
20	64.7	.05

08/25/2019		
Depth FEET	Temp. DEGREES F	D.O. MG/L
0	71.6	6.09
3	71.7	6.04
6	71.8	5.97
9	71.8	5.92
12	71.7	5.67
15	71.7	5.52
18	71.4	3.66
20	68	.12

Figure 10: 2019 Dissolved Oxygen and Temperature Profiles (CLMN, 2019)

FISHERIES AND WILDLIFE

The Lower Turtle Lake fishery is a warm-water fishery comprised primarily of walleye, largemouth bass, northern pike, and a mix of panfish. In addition to the usual mix of warm-water fish, Lower Turtle Lake also has a small population of brook trout within the lake. Bluegill, crappie, and perch were the most commonly found fish in the 2011 WDNR fisheries surveys with decent size structure for both bluegill and crappie. Perch were somewhat on the smaller size. Walleye were the most commonly found game fish species, and through three different surveys (early spring shocking, late spring shocking, and sprint fyke netting) the largest fish surveyed was 28" with many quality size fish (>15"). Largemouth bass were also found in relatively high numbers, with the largest fish surveyed at 19" with many quality fish (>12"). The largest northern pike surveyed was 41" with many quality size fish (>21"). Since 2000, the WDNR has been stocking walleye fingerings on even numbered years (Figure 11), and the survey results suggest these efforts have yielded some success. The next fisheries survey will provide a better idea about the long term walleye population trends within Lower Turtle Lake.

Wisconsin Department of Natural Resources
Fish Stocking Summary
DNR Hatcheries, Ponds, and Coop Ponds

Please Note: The stocking records for the current stocking year will be posted annually after verification by our fisheries biologists. Please contact your local fisheries biologist if you have questions about our current stocking practices.

County Name	Waterbody Name	Local Waterbody Name	Location (TRS)
BARRON	LOWER TURTLE LAKE		

Year	Stocked Waterbody Name	Local Waterbody Name	Location	Species	Strain (Stock)	Age Class	Number Fish Stocked	Avg Fish Length (IN)
2018	LOWER TURTLE LAKE		33N-14W-2	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	2,857	6.20
2016	LOWER TURTLE LAKE		33N-14W-2	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	2,859	7.00
2014	LOWER TURTLE LAKE		33N-14W-2	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	2,859	6.20
2012	LOWER TURTLE LAKE		33N-14W-2	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	2,760	7.40
2010	LOWER TURTLE LAKE		33N-14W-2	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	2,760	7.30
2008	LOWER TURTLE LAKE		33N-14W-2	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	2,755	7.00
2006	LOWER TURTLE LAKE		33N-14W-2	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	2,759	6.80
2004	LOWER TURTLE LAKE		33N-14W-2	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	5,506	6.80
2002	LOWER TURTLE LAKE		33N-14W-2	WALLEYE	MISSISSIPPI HEADWATERS	SMALL FINGERLING	27,450	1.35
2000	LOWER TURTLE LAKE		33N-14W-2	WALLEYE	UNSPECIFIED	SMALL FINGERLING	13,800	1.50

Figure 11: WDNR walleye stocking data (WDNR, 2019)

Bald eagles, loons, and furbearers can be found on or near the lake on a regular basis. The Natural Heritage Inventory (Table 4) lists several plant species and one amphibian species of special concern as present within the same township and range as Lower Turtle Lake (T34N, R14W).

Table 4: Natural Heritage Inventory Report for T34N, R14W (last accessed 9-28-2019)

Scientific Name	Common Name	WI Status	Federal Status	Group
Elatine triandra	Longstem Water-wort	SC		Plant~
Eleocharis robbinsii	Robbins' Spike-rush	SC		Plant~
Lake--shallow, soft, seepage	Lake--Shallow, Soft, Seepage	NA		Community~
Lithobates septentrionalis	Mink Frog	SC/H		Frog~
Northern dry-mesic forest	Northern Dry-mesic Forest	NA		Community
Potamogeton bicupulatus	Snail-seed Pondweed	SC		Plant~
Potamogeton diversifolius	Water-thread Pondweed	SC		Plant~
Potamogeton vaseyi	Vasey's Pondweed	SC		Plant~
Schoenoplectus torreyi	Torrey's Bulrush	SC		Plant~

SHORELANDS

How the shoreline of a lake is managed can have big impacts on the water quality and health of that lake. Natural shorelines prevent polluted runoff from entering lakes, help control flooding and erosion, provide fish and wildlife habitat, may make it harder for aquatic invasive species to establish themselves, muffle noise from watercraft, and preserve privacy and natural scenic beauty. Many of the values lake front property owners appreciate and enjoy about their properties - natural scenic beauty, tranquility, privacy, relaxation - are enhanced and preserved with good shoreland management. And healthy lakes with good water quality translate into healthy lake front property values.

Shorelands may look peaceful, but they are actually the hotbed of activity on a lake. 90% of all living things found in lakes - from fish, to frogs, turtles, insects, birds, and other wildlife - are found along the shallow margins and shores. Many species rely on shorelands for all or part of their life cycles as a source for food, a place to sleep, cover from predators, and to raise their young. Shorelands and shallows are the spawning grounds for fish, nesting sites for birds, and where turtles lay their eggs. There can be as much as 500% more species diversity at the water's edge compared to adjoining uplands.

Lakes are buffered by shorelands that extend into and away from the lake. These shoreland buffers include shallow waters with submerged plants (like coontail and pondweeds), the water's edge where fallen trees and emergent plants like rushes might be found, and upward onto the land where different layers of plants (low ground cover, shrubs, trees) may lead to the lake. A lake's littoral zone is a term used to describe the shallow water area where aquatic plants can grow because sunlight can penetrate to the lake bottom. Shallow lakes might be composed entirely of a littoral zone. In deeper lakes, plants are limited where they can grow by how deeply light can penetrate the water.

Shorelands are critical to a lake’s health. Activities such replacing natural vegetation with lawns, clearing brush and trees, importing sand to make artificial beaches, and installing structures such as piers, can cause water quality decline and change what species can survive in the lake.

PROTECTING WATER QUALITY

Shoreland buffers slow down rain and snow melt (runoff). Runoff can add nutrients, sediments, and other pollutants into lakes, causing water quality declines. Slowing down runoff will help water soak (infiltrate) into the ground. Water that soaks into the ground is less likely to damage lake quality and recharges groundwater that supplies water to many of Wisconsin's lakes. Slowing down runoff water also reduces flooding, and stabilizes stream flows and lake levels.

Shoreland wetlands act like natural sponges trapping nutrients where nutrient-rich wetland sediments and soils support insects, frogs, and other small animals eaten by fish and wildlife.

Shoreland forests act as filters, retainers, and suppliers of nutrients and organic material to lakes. The tree canopy, young trees, shrubs, and forest understory all intercept precipitation, slowing runoff, and contributing to water infiltration by keeping the soil's organic surface layer well-aerated and moist. Forests also slow down water flowing overland, often capturing its sediment load before it can enter a lake or stream. In watersheds with a significant proportion of forest cover, the erosive force of spring snow melts is reduced as snow in forests melts later than snow on open land, and melt water flowing into streams is more evenly distributed. Shoreland trees grow, mature, and eventually fall into lakes where they protect shorelines from erosion, and are an important source of nutrients, minerals and wildlife habitat.

NATURAL SHORELANDS ROLE IN PREVENTING AQUATIC INVASIVE SPECIES

In addition to removing essential habitat for fish and wildlife, clearing native plants from shorelines and shallow waters can open up opportunities for invasive species to take over. Like tilling a home garden to prepare it for seeding, clearing shoreland plants exposes bare earth and removes the existing competition (the cleared shoreland plants) from the area. Nature fills a vacuum. While the same native shoreland plants may recover and reclaim their old space, many invasive species possess "weedy" traits that enable them to quickly take advantage of new territory and out-compete natives.

The act of weeding creates continual disturbance, which in turn benefits plants that behave like weeds. The modern day practice of mowing lawns is an example of keeping an ecosystem in a constant state of disturbance to the benefit of invasive species like turfgrass, dandelions, and clover, all native to Europe. Keeping shoreline intact is a good way to minimize disturbance and minimize opportunities for invasive species to gain a foothold.

THREATS TO SHORELANDS

When a landowner develops a waterfront lot, many changes may take place including the addition of driveways, houses, decks, garages, sheds, piers, rafts and other structures, wells, septic systems, lawns, sandy beaches and more. Many of these changes result in the compaction of soil and the removal of trees and native plants, as well as the addition of impervious (hard) surfaces, all of which alter the path that precipitation takes to the water.

Building too close to the water, removing shoreland plants, and covering too much of a lake shore lot with hard surfaces (such as roofs and driveways) can harm important habitat for fish and wildlife, send more nutrient and sediment runoff into the lake, and cause water quality decline.

Changing one waterfront lot in this fashion may not result in a measurable change in the quality of the lake or stream. But cumulative effects when several or many lots are developed in a similar way can be enormous. A lake's response to stress depends on what condition the system is in to begin with, but bit by bit, the cumulative effects of tens of thousands of waterfront property owners "cleaning up" their shorelines, are destroying the shorelands that protect their lakes. Increasing shoreline development and development throughout the lake's watershed can have undesired cumulative effects.

SHORELAND PRESERVATION AND RESTORATION

If a native buffer of shoreland plants exists on a given property, it can be preserved and care taken to minimize impacts when future lake property projects are contemplated. If a shoreline has been altered, it can be restored. Shoreline restoration involves recreating buffer zones of natural plants and trees. Not only do quality wild shorelines create higher property values, but they bring many other values too. Some of these are aesthetic in nature, while others are essential to a healthy ecosystem. Healthy shorelines mean healthy fish populations, varied plant life, and the existence of the insects, invertebrates and amphibians which feed fish, birds and other creatures. Figure 12 shows the difference between a natural and unnatural shoreline adjacent to a lake home. More information about healthy shorelines can be found at the following website: https://healthylakeswi.com/ (last accessed 4-8-2019).

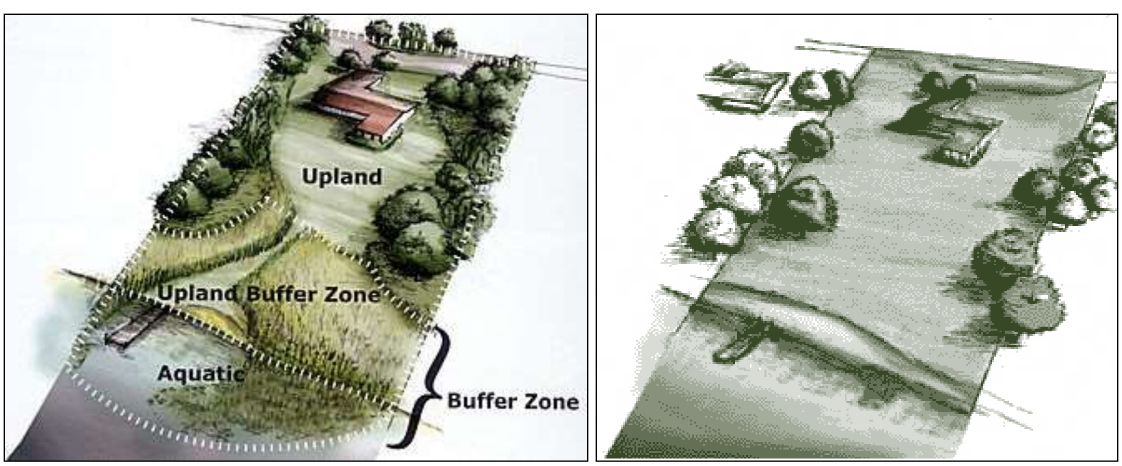


Figure 12: Healthy, AIS Resistant Shoreland (left) vs. Shoreland in Poor Condition

SHORELAND HABITAT ASSESSMENT

In 2018, a shoreland habitat assessment was completed on Lower Turtle Lake. The protocol used in this survey was developed by the WDNR as a way to evaluate shoreline habitat. The survey is intended to provide management recommendations for individual property owners based on the evaluation of their property. This protocol involves photographing each parcel from the lake which is then matched to land use information about the riparian zone. For this survey, the riparian zone is defined as the strip of land, along the shore, from the high water level back 35 feet. The information collected includes ground cover which includes lawn, impervious surfaces, and native plants. Additional land use information includes the number of human structures in the riparian zone and various other runoff concerns. This protocol also assesses the amount of woody debris present in the lake however this is done for the entire lake instead of for each individual parcel. Woody debris provides habitat for fish, birds, and numerous other types of wildlife as well in addition to providing some protecting from bank erosion. This protocol defines woody debris as wood in no deeper than 2 feet of water that is at least 4 inches in diameter, at the widest point, and at least 5 feet long.

PROPERTY PROJECT POTENTIAL RANKING

Once the shoreland habitat has been completed each property evaluated is given a ranking based on whether there are projects that could be done that would improve shoreland habitat and reduce runoff. These rankings were developed by this consultant to aide in determining what type of projects could realistically be completely on each parcel. The parameters used to determine the priority were considered to be those that would have the biggest impact on rainwater runoff and habitat quality. This includes percentage of canopy (tree) cover, the percentage of undisturbed vegetation, and a summed percentage of ground covered by manicured lawn, impervious surfaces, and easily eroded surfaces such as exposed soil or shredded vegetation such as pine needles, loose leaves, small branches, etc. Additional consideration was given to the number of buildings present in the 35-ft area and the presence or absence of lawns that sloped directly to the lake. For each parameter that was considered, value ranges were assigned and aligned with a color in order to come up with a numerical value for each property. Values that fall within the red range are worth 2 points, values in the yellow range are worth 1 point, and values in the white range are not given any points (Table 5). The points are then summed and the properties prioritized based on the point range for the entire lake.

Table 5: Value ranges for color assignments of each parameter of concern.

Parameter	Red range (2 points)	Yellow Range (1 Point)	White (No points)
Percent canopy cover	0-33%	34-66%	>66%
Percent shrub and herbaceous (undisturbed)	0-33%	34-66%	>66%
Percent lawn, impervious, and other surfaces	>66%	34-66%	0-33%
Number of buildings and other human structures	>1	1	0
Presence/ Absence of lawn or soil sloping to lake	N/A	1 (Present)	0 (Absent)
Presence/Absence of bare soil	1 (Present)	N/A	0 (Absent)

LAKE-WIDE SUMMARY

To establish project potential rankings for Lower Turtle Lake, it was important to consider the entire lake. The maximum possible score was 11 points, but the highest scoring parcel only scored 9 points. From here, four levels of implementation were established: red, orange, yellow, and white. These colors correspond to the possibility of projects to improve shoreland habitat and reduce shoreland runoff. Red properties have multiple opportunities for projects, orange properties have fewer projects, yellow may have only one or two projects; and white represents a property where projects are probably not necessary at this time. However, any property owner who wishes to implement a project that might improve habitat and/or reduce shoreland runoff would be encouraged to do so. Table 6 and Figure 13 summarize the survey results for the entire lake.

Table 6: Score ranges and project potential rankings for the 109 parcels evaluated on Lower Turtle Lake.

Color	Overall Score	Priority	Number of Parcels
Red	7-9 Points	High	15
Orange	5-6 Points	Moderate	23
Yellow	3-4 Points	Low	16
White	0-2 Points	No Concern	55

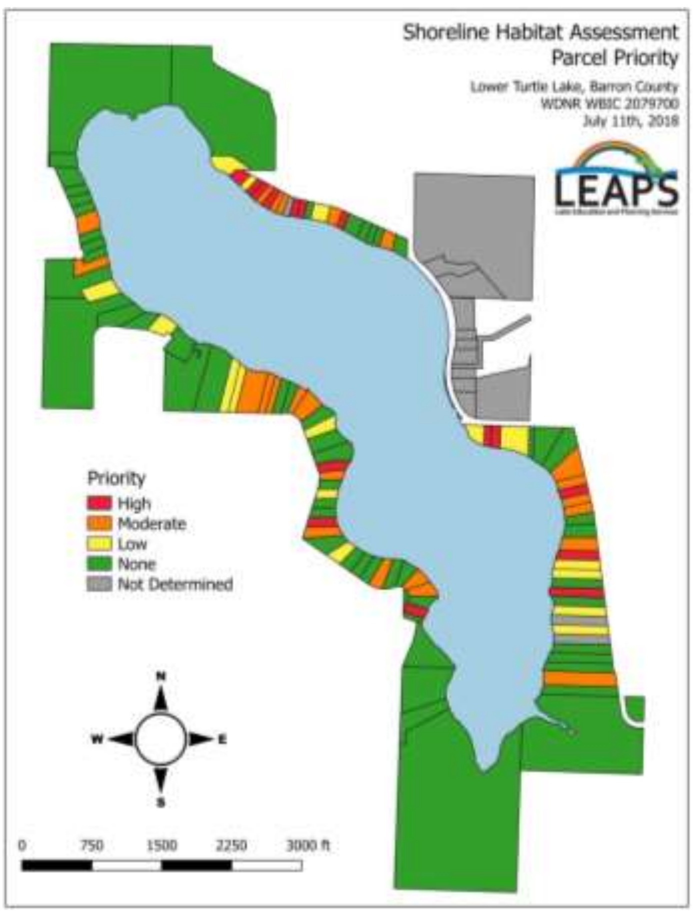


Figure 13: Shoreland habitat assessment results – properties with potential projects

COARSE WOODY HABITAT (WOLTER, 2012)

Coarse woody habitat (CWH) in lakes is classified as trees, limbs, branches, roots, and wood fragments at least 4 inches in diameter that enter a lake by natural (beaver activity, toppling from ice, wind, or wave scouring) or human means (logging, intentional habitat improvement, flooding following dam construction). CWH in the littoral or near-shore zone serves many functions within a lake ecosystem including erosion control, as a carbon source, and as a surface for algal growth which is an important food base for aquatic macro invertebrates. Presence of CWH has also been shown to prevent suspension of sediments, thereby improving water clarity. CWH serves as important refuge, foraging, and spawning habitat for fish, aquatic invertebrates, turtles, birds, and other animals. The amount of littoral CWH occurring naturally in lakes is related to characteristics of riparian forests and likelihood of toppling. However, humans have also had a large impact on amounts of littoral CWH present in lakes through time. During the 1800's the amount of CWH in northern lakes was increased beyond natural levels as a result of logging practices. But time changes in the logging industry and forest composition along with increasing shoreline development have led to reductions in CWH present in many northern Wisconsin lakes.

CWH is often removed by shoreline residents to improve aesthetics or select recreational opportunities (swimming and boating). Jennings et al. (2003) found a negative relationship between lakeshore development and the amount of CWH in northern Wisconsin lakes. Similarly, Christensen et al. (1996) found a negative correlation between density of cabins and CWH present in Wisconsin and Michigan lakes. While it is difficult to make precise determinations of natural densities of CWH in lakes it is believed that the value is likely on the scale of hundreds of logs per mile. The positive impact of CWH on fish communities have been well documented by researchers, making the loss of these habitats a critical concern.

The amount of CWH around Lower Turtle Lake was quantified in the summer of 2018 during the Shoreline Habitat Assessment. This assessment found 31 pieces of CWH around Lower Turtle Lake (Figure 14). The vast majority of this habitat was found along the western shoreline with only four individual pieces of CWH found on the eastern half of the lake. The Lake District could consider implementing a program to work with interested property owners to install fish sticks projects around Lower Turtle Lake.

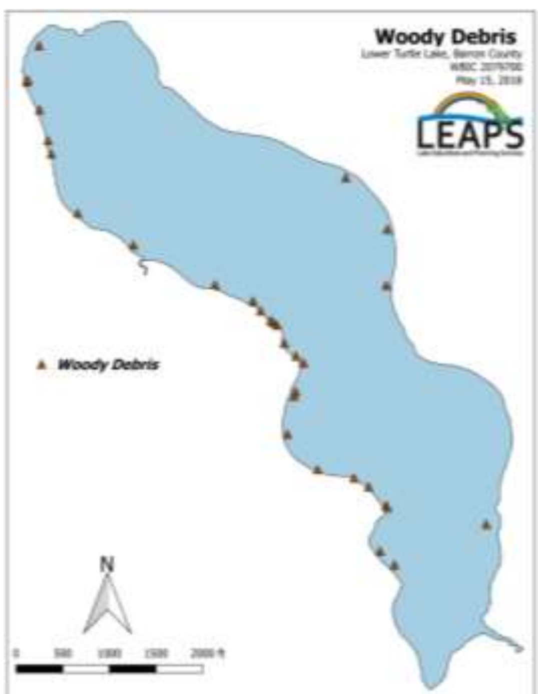


Figure 14: Coarse Woody Habitat around Lower Turtle Lake

Adding coarse woody habitat to a lake is relatively easy to do particularly when private landowners and lake associations are willing to partner with county, state, and federal agencies. Large-scale CWH projects are currently being conducted by lake associations and local governments with assistance from the WDNR where hundreds of whole trees are added to the near-shore areas of lakes. These types of projects are popularly called "fish sticks" (Figure 15).

Figure 15: Coarse woody habitat-Fishsticks projects

HEALTHY LAKES PROJECTS

Fishsticks are one of five shoreland best management practices that are eligible for grant funding through the WDNR Healthy Lakes Initiative. Other projects include installation of native plantings, rain gardens, surface water diversions, and rock infiltration basins. More information on fish sticks and other eligible Healthy Lakes Initiative projects can be found at https://healthylakeswi.com/ (Last accessed: 04/15/2019).

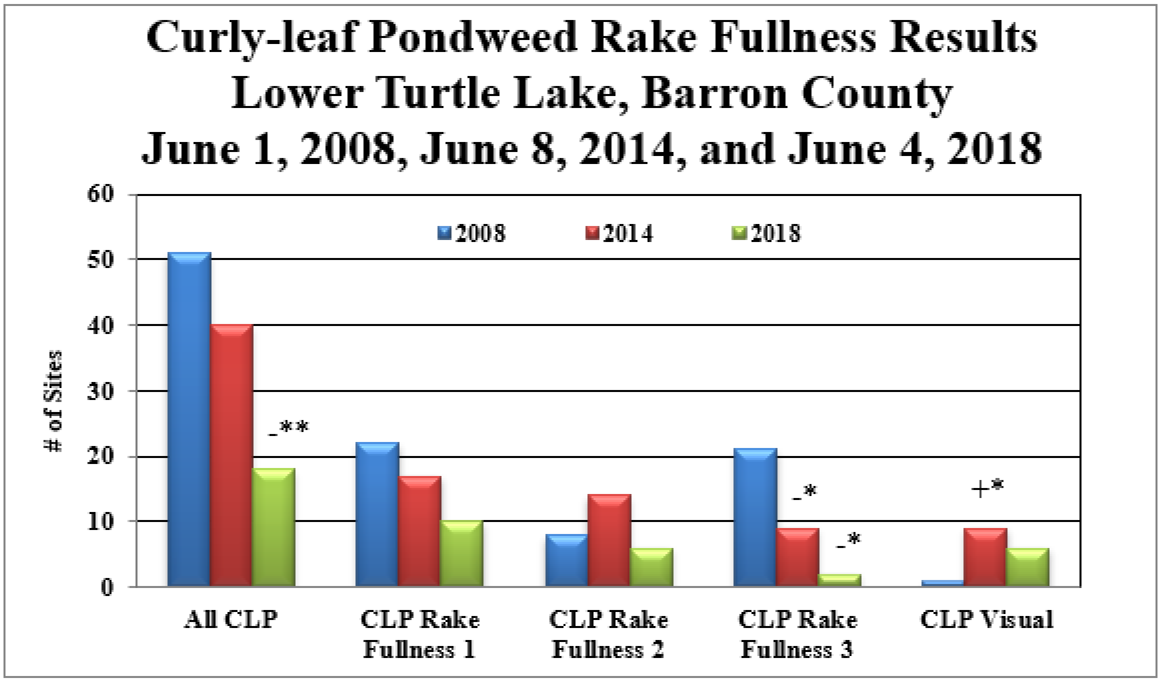
PAST AQUATIC PLANT MANAGEMENT

Other than hand or rake removal completed by residents, the only CLP, a non-native, invasive, aquatic plant species, has been actively managed in Lower Turtle Lake since the 2010 APM Plan and 2016 Addendum were completed. CLP has been present in Lower Turtle Lake since before 1994 when it was first officially documented. The first early-season bedmapping, done in 2004 by Blue Water Science, found CLP throughout the littoral (plant-growing) zone of the lake, but determined it only created nuisance conditions that could impair navigation and potentially interfere with native aquatic plant growth later in the season in about 20 acres, mostly in the southern end of the lake (McComas, 2005)(Figure 16).

Figure 16: Canopied CLP in Lower Turtle Lake, June 2004 (McComas, 2005)

In 2008, CLP was present in about 30 acres of the lake, with 17 acres of that presenting moderate to dense growth CLP (Berg M. , 2008). A 2014 survey found CLP at 49 points, but, for the most part, it occurred at low densities or in a narrow band along the east/west shorelines where the majority of lake residences were found. Lakewide, nine beds totaling 9.42 acres (3.2% of the lake's 294 acres) were mapped in Lower Turtle Lake with the biggest being 4.90 acres (Figure 17). Each of these beds was canopied or near canopy, and, although some of them were scattered to 7.0ft, most growth ended abruptly at 5-6ft forming a hard outer edge. The inner edges often extended to 3ft, but tended to be more fragmented as CLP was almost always mixed with native plants. The densest and largest beds were located next to undeveloped shorelines or well away from shore where they were unlikely to interfere with lake access or most recreational navigation.

Following three years of active management, the 2018 results suggested there was a moderately significant reduction in total CLP and a significant reduction in rake fullness 3 (Figure 17). Expanding the comparison to 2008 and 2018 found a highly significant reduction in total CLP and rake fullness 3.



Significant differences = * p<0.05, ** p<0.01, *** p<0.001

Figure 17: 2008, 2014, and 2018 changes in June CLP rake fullness (Berg M. , 2019)

The 2018 survey found CLP at only 24 points (Figure 18). The total acreage of CLP and the density was also down. This is not entirely surprising given that weather conditions in the spring and early summer of 2018 were not very conducive to the growth of CLP with many lakes in NW Wisconsin experiencing significant declines in CLP, with or without chemical treatment. Post-treatment survey results after each year of chemical management showed that CLP in the treated areas was reduced. Growing conditions for CLP in the spring and early summer of 2017 were some of the best in NW Wisconsin based on explosions of CLP in nearby lakes (including Upper Turtle Lake), but in Lower Turtle Lake, the amount of CLP remained lower than previous years, suggesting that successful control of CLP limited the amount of CLP growth that might otherwise have been expected. CLP mapping in 2019 showed 8 areas of CLP totaling 8.03 acres, the majority of which were only low to moderate in density (Figure 19).

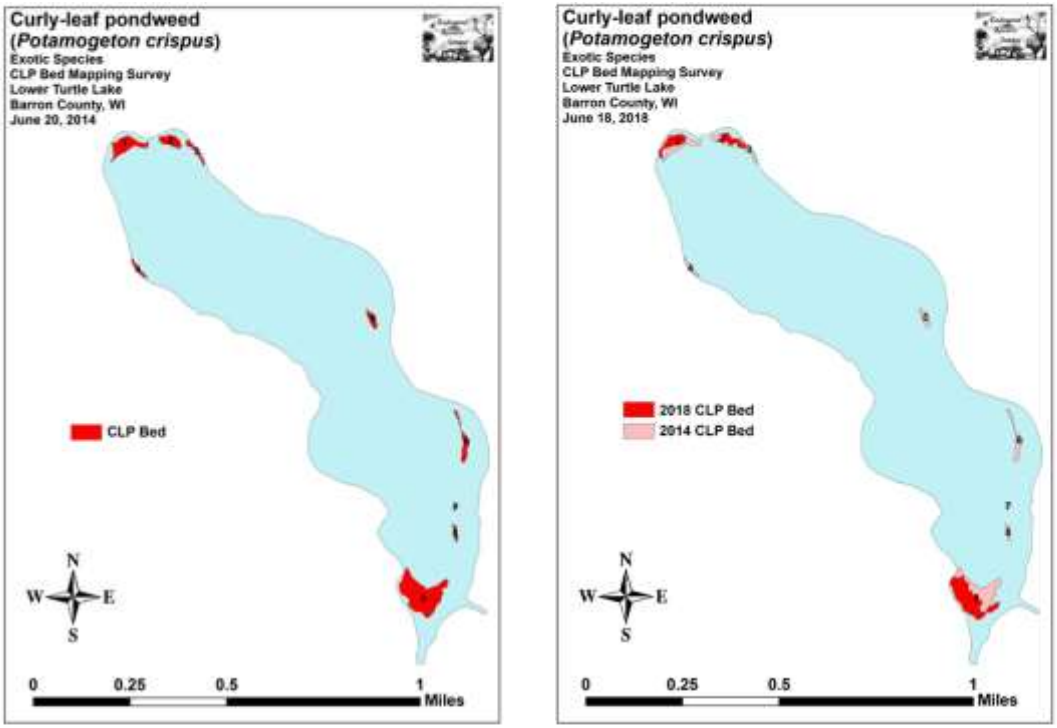


Figure 18: CLP bedmapping in 2014 and 2018 (ERS)

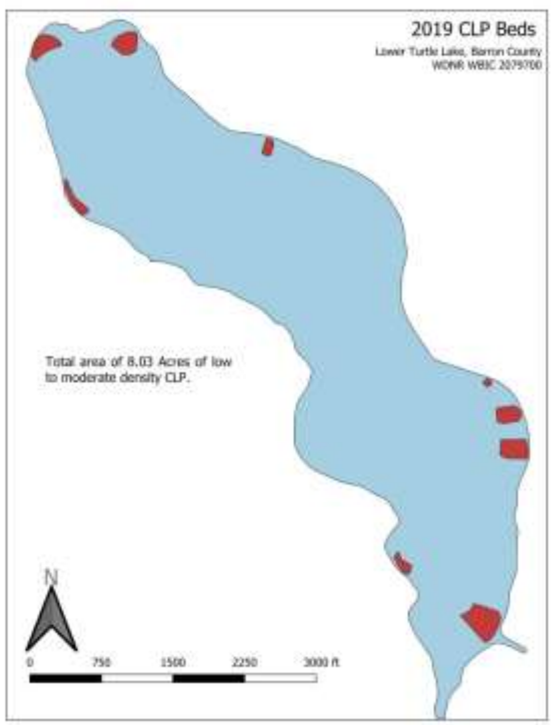


Figure 19: 2019 CLP bedmapping (LEAPS)

CHEMICAL TREATMENT OF CLP

Three years of chemical treatment of CLP were completed in Lower Turtle Lake beginning in 2015 as a part of the recommendations made in the 2015-16 Addendum to the 2010 APM Plan. The initial chemical treatment proposal for 2015 was based on CLP survey results from 2014. Table 7 and Figure 20 reflect what was done. Prior to actual placement of the herbicide in the water, a pre-treatment survey is completed to determine if areas included in each annual proposal should be modified or perhaps eliminated. As previously mentioned, in 2017, while CLP was exploding in nearby lakes, the treated amount in Lower Turtle Lake actually went down from both previous years of management (2015 and 2016).

Table 7: Chemical management of CLP from 2015-2017

2015-2017 Chemical Treatment of CLP in Lower Turtle Lake				
Year	# of Beds	Total Acreage	Herbicide	Concentration
2015	3	5.27	Endothall	2-2.5 ppm
2016	5	6.41	Endothall	2-3 ppm
2017	4	3.28	Endothall	3 ppm

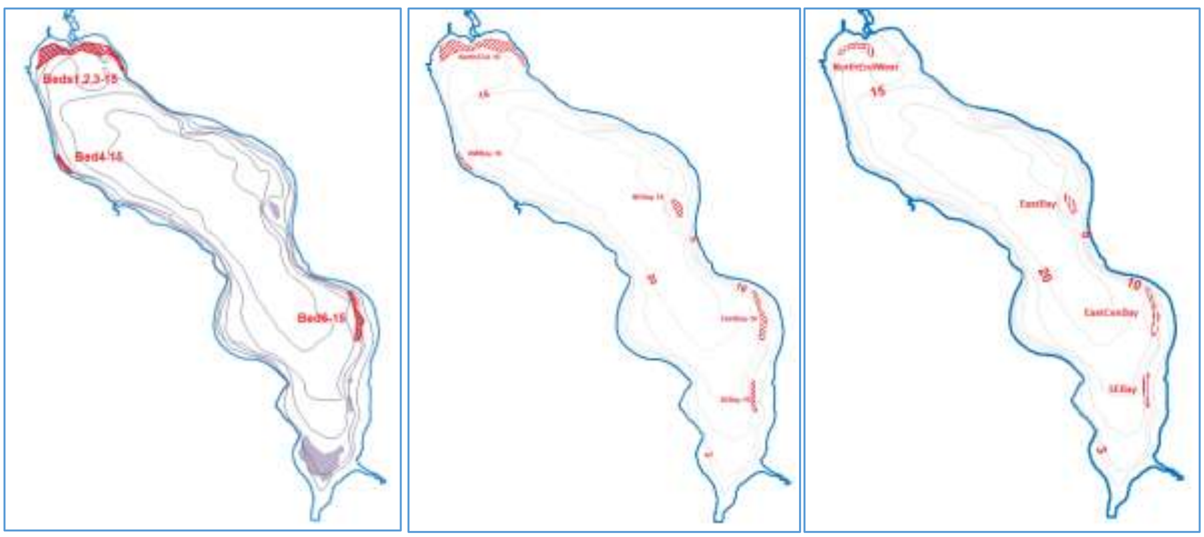


Figure 20: 2015 (left), 2016 (center), and 2017 (right) CLP chemical treatment maps (LEAPS)

LATER SEASON HARVESTING OF NAVIGATION AND ACCESS LANES

Despite recommendations to complete harvesting of native aquatic vegetation made in the 2015-16 Addendum, no mechanical harvesting was completed in Lower Turtle Lake. Aquatic vegetation in general was down in area lakes in 2018, so the Lake District did not pursue harvesting. Nor did it pursue any harvesting in 2019.

NATIVE AQUATIC PLANT SURVEYS

Since 1994, five official aquatic plant surveys have been completed in Lower Turtle Lake. The Blue Water Science (BWS) consulting firm completed surveys in 1994 (McComas & Stuckert, 1995) and 2004 (McComas S. , 2005) using a transect method previously accepted by the WDNR. In 2008, 2014, and most recently in 2018, Endangered Resource Services (ERS) completed aquatic plant surveys using a point-intercept method, which is currently required by the WDNR. All three surveys completed by ERS included early season cold water and mid-season warm water point-intercept survey components.

Aquatic plant management recommendations in the 2010 APM Plan and in the 2015-16 Addendum were based on the 2008 and 2014 surveys. Modifications to those recommendations in this document are based on 2018 aquatic plant survey results documenting changes after three years of active management. Much of the following aquatic plant data is taken from the 2018 Aquatic Plant Survey Report prepared by Endangered Resource Sciences (Berg M. , 2019).

Summary statistics from the all five aquatic plant surveys are presented in Table 8. Statistical data from 2018 seems to be more in alignment with what was documented in 2008. Many of the statistics from the 2014 survey are lower, primarily the result of the change in depth of aquatic plant growth. The maximum depth of aquatic plant growth was a third more (12 vs. 8 feet) in 2014 than it was in either 2008 or 2018. However, the number of points with aquatic vegetation really did not change significantly over the three surveys, making the percentage of points that could have supported aquatic plant growth in 2014 much lower than it was in either 2008 or 2018. It was noted by the aquatic plant surveyor that despite a maximum depth of aquatic plant growth of 12-ft in 2014, most plant growth ended in 7-8ft of water, and was nearly identical to 2008. The recorded 2008 littoral zone only extended to 8.0-ft and resulted in a littoral coverage of 83.2%. Statistics from 2018 survey are nearly the same.

Table 8: Aquatic plant survey statistics – 1994, 2004, 2008, 2014, and 2018

Compiled Summary Statistics from 1994, 2004, 2008, 2014, and 2018					
Statistic	Survey Year				
	July/Aug 1994	7/23/2004	7/18/2008	7/11/2014	7/15/2018
Points sampled	66	75	479	479	479
Number of sites with vegetation	*46	60	112	113	102
Maximum depth of plants (ft)	8	8	8	12	8
Mean depth of plants (ft)	NA	NA	3.8	4.12	3.5
Median depth of plants (ft)	NA	NA	3.5	4	3
Percent of lake bottom coverage	31	NA	23.4	23.6	21.3
Sites shallower than maximum depth of plants	66	75	131	176	127
Frequency of occurrence at sites shallower than maximum depth of plants	88.5	80	85.5	64.2	80.13
Simpson Diversity Index	**0.88	**0.90	0.88	0.9	0.91
Sites sampled using rope rake (R)	0	0	0	0	29
Sites sampled using pole rake (P)	66	75	142	142	171
Average number of all species per site (shallower than max depth)	*2.4	3.32	2.95	2.375	2.87
Average number of all species per site (veg. sites only)	*2.72	4.15	3.46	3.7	3.55
Average number of native species per site (shallower than max depth)	*2.38	3.25	2.82	2.23	2.7
Average number of native species per site (veg. sites only)	*2.7	4.07	3.29	3.5	3.55
Species Richness	17	19	18	19	18
Species Richness (including visuals)	NA	NA	19	21	21
Species Richness (including visuals and boat survey)	NA	NA	27	27	24
Mean rake fullness (veg. sites only)	NA	NA	2.06	1.99	2.06
Type of Survey	Transect	Transect	Point-intercept	Point-intercept	Point-intercept
*Does not include all 1994 transect data.					
**Calculated by ERS, 2010.					

SIMPSONS DIVERSITY INDEX

Plant diversity was very high in 2014 with a Simpson Index value of 0.90 – up from 0.87 in 2008. It was even higher in 2018 at 0.91. The Simpson's diversity index 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 individuals (randomly selected) will be different species. The index values range from 0 to 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.

FLORISTIC QUALITY INDEX

This index 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. Lower Turtle Lake is in the Northern Central Hardwood Forests Region.

In 2008, a total of 16 native index species were identified in the rake during the point-intercept survey. They produced a mean C of 5.5 and a FQI of 22.0. In 2014, a total of 18 native index plants were identified in the rake during the point-intercept survey. They produced a mean C of 5.2 and a FQI of 22.2. In 2018, a total of 18 native index plants were identified in the rake during the point-intercept survey. They produced a mean C of 5.5 and a FQI of 22.6, better than either previous survey. Nichols (1999) reported an average mean C for the Northern Central Hardwood Forests Region of 5.6 identifying Lower Turtle Lake as slightly below average for this part of the state. The FQI was, however, slightly above the median of 20.9 for the Northern Central Hardwood Forests Region (Nichols, 1999).

SPECIES RICHNESS AND LITTORAL ZONE

The total species richness in Lower Turtle Lake continues to be relatively low with only 25 species identified including on the rake and both boat and visual surveys. In 2008 the number of species was 26; in 2014 it was 27. Other values related to species distribution were nearly the same in 2018 as they were in 2008, and slightly up from 2014. Mean total rake fullness declined from a very high 2.49 (estimated) in 2008 to a moderate 1.99 in 2014, and back up to 2.06 in 2018. Figures 21 and 22 show the differences in the littoral zone and aquatic plant diversity at individual survey points from 2008, 2014, and 2018.

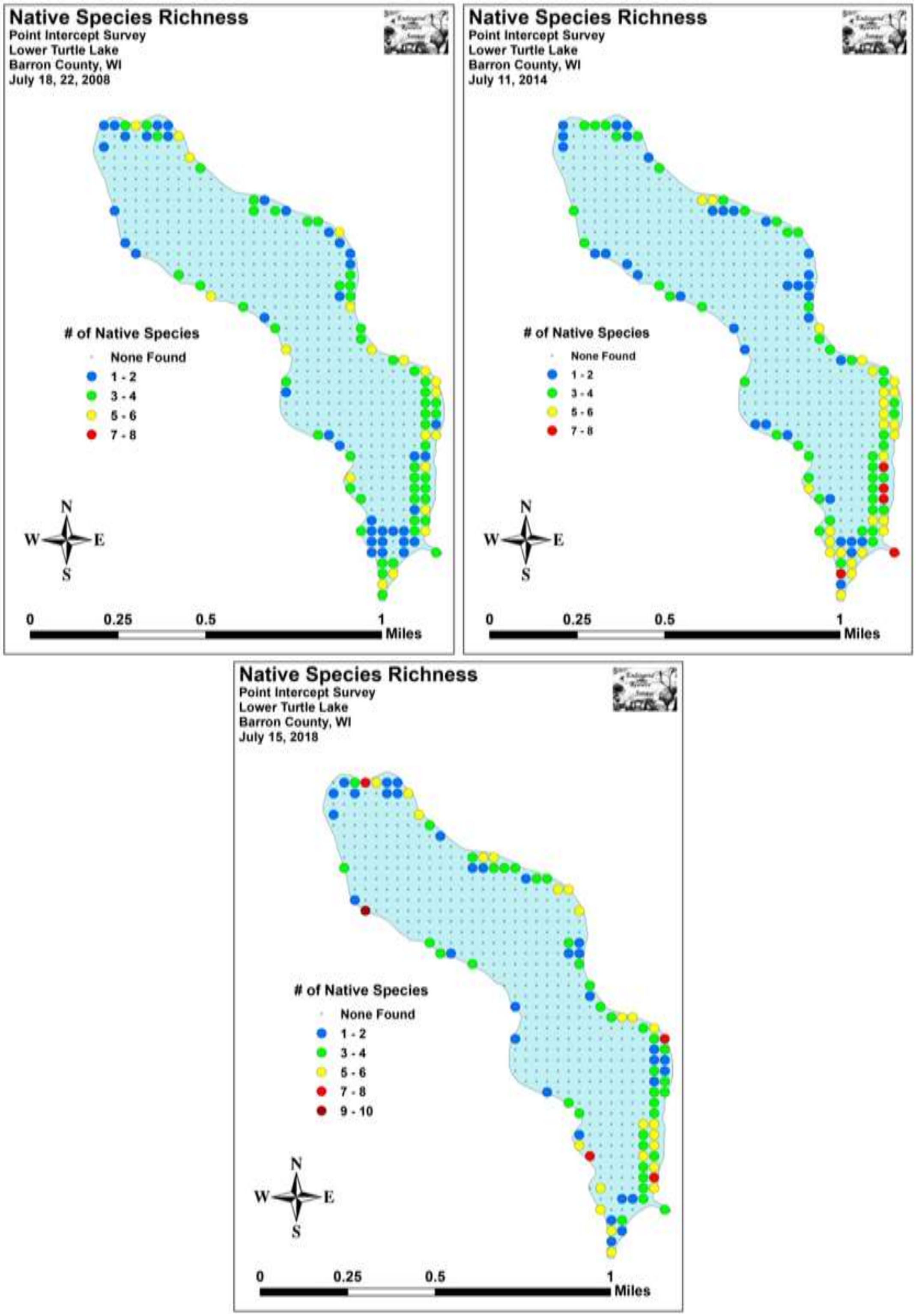


Figure 21: Native species richness 2008, 2014, and 2018 (Berg M. , 2019)

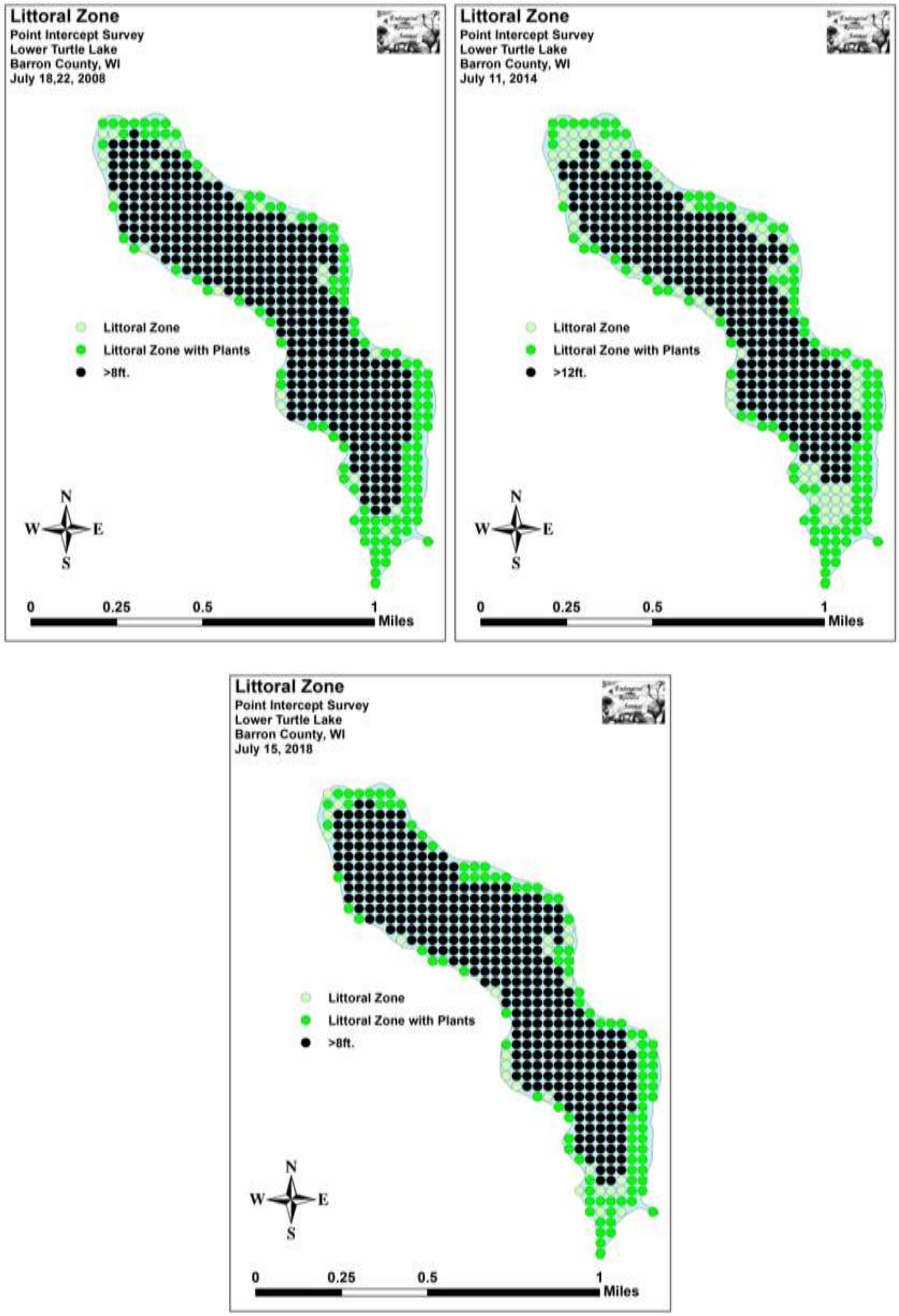


Figure 22: Littoral zone 2008, 2014, and 2018 (Berg M. , 2019)

Despite the decrease in native species richness at each of the survey sites, only four individual plant species showed significant decreases lakewide while filamentous algae actually showed a significant increase (Figure 23). Flat-stem pondweed (Potamogeton zosteriformis) and small pondweed (Potamogeton pusillus) suffered highly significant declines, but, conversely, filamentous algae, slender naiad (Najas flexillus), and muskgrass (Chara sp.) enjoyed highly significant increases. As flat-stem pondweed and small pondweed are known to be sensitive to Endothall, their declines are potentially at least partially tied to the chemical treatment program. It's also possible that slender naiad and muskgrass, two species that regrow each spring and are unlikely to be affected by an early-spring treatment, may be expanding into areas that were left open by the declines of other species.

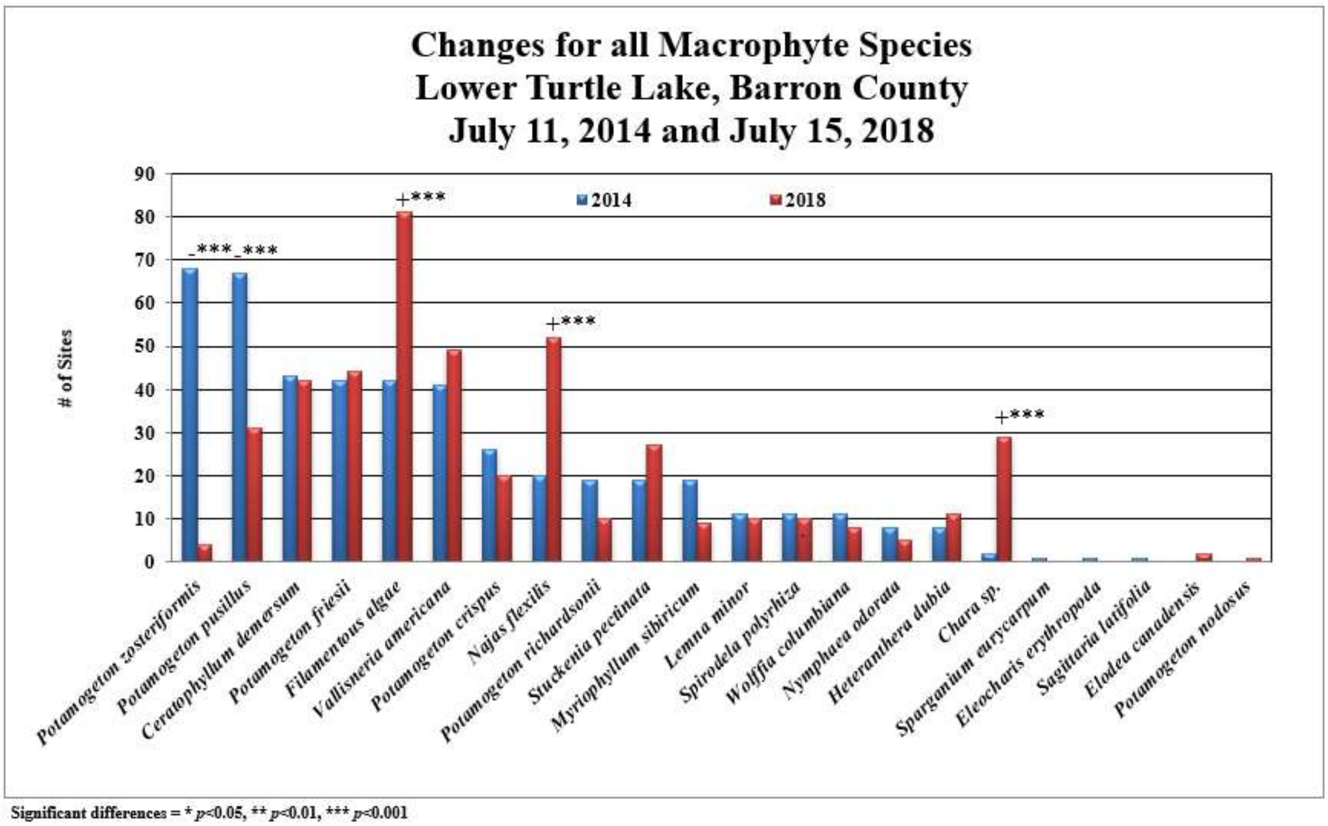


Figure 23: Species that showed significant changes between 2014 and 2018 (Berg M. , 2019)

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 Surface Water Data Viewer, Lower Turtle Lake is not wild rice water. The whole-lake point-intercept surveys completed on the lake since 2008 have confirmed this.

SENSITIVE AREAS

In 1993 the WDNR completed a "sensitive areas" survey on Lower Turtle Lake. This survey was again revisited in 2001. During the initial survey, four areas that merit special protection of the aquatic habitat due to the critical or unique fish and wildlife habitat they provide were identified (Figure 24). All four of these areas are considered sensitive because they contain aquatic plant communities which provide important fish and wildlife habitat and important shoreline stabilization functional values (Koshere, Sundeen, Roblek, Darkow, & Cahow, 1993). The sensitive area report suggests the following guidelines for protecting the lake:

- Limit aquatic vegetation removal to navigation channels no greater than 25-ft wide where necessary, the narrower the better
- Prohibit littoral zone alterations covered by Wisconsin Statutes Chapter 30 unless there is clear evidence that such alterations would benefit the lake's ecosystem
- Leave large woody debris, logs, trees, and stumps in the littoral zone to provide habitat for fish, wildlife, and other aquatic organisms
- Leave an adequate shoreline buffer of un-mowed natural vegetative cover and keep access corridors as narrow as possible
- Prevent erosion, especially at construction sites
- Strictly enforce zoning ordinances
- Eliminate nutrient inputs to the lake caused by lawn fertilizers, failing septic systems, and other sources
- Control exotic species

All of these guidelines are incorporated into this new Aquatic Plant Management Plan for Lower Turtle Lake.

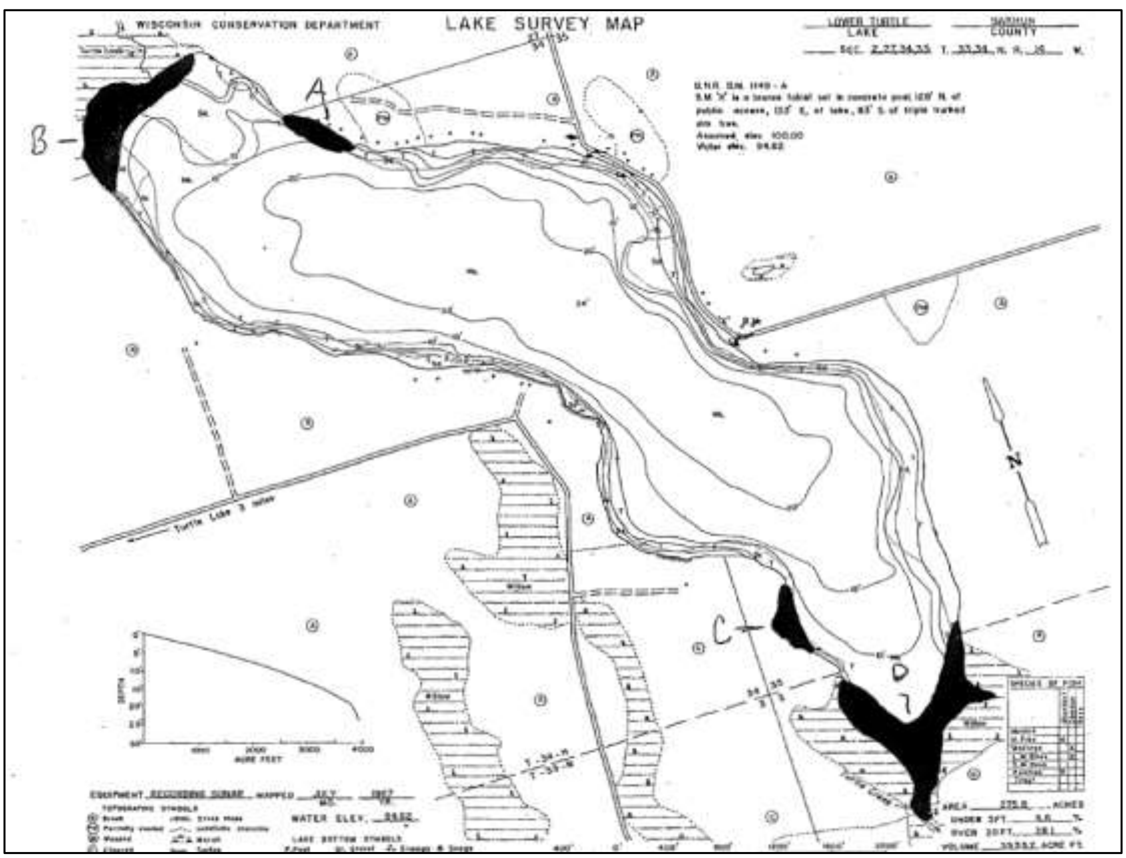


Figure 24: 1993 WDNR Sensitive areas on Lower Turtle Lake, Barron County

AQUATIC INVASIVE SPECIES

Currently there are several invasive species within or around Lower Turtle Lake: curly-leaf pondweed, Chinese mystery snails, and reed canary grass.

NON-NATIVE, AQUATIC INVASIVE PLANT SPECIES

CLP is the only known aquatic invasive plant species in Lower Turtle Lake, but there are several more that could arrive in the lake at any time. Reed canary grass is found in some of the wetlands surrounding Lower Turtle Lake and in places along the shore. 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 25). 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 an annual with new plants growing from burr-like winter buds called turions (Figure 23) deposited on the lake bottom when the water is cool, even under the ice in winter. It is one of the first nuisance aquatic plants to emerge in the spring, growing rapidly as sunlight becomes more available. Dense mats of early growth vegetation often interfere with or out-compete native aquatic plant growth that begins a little later when water temperatures rise. At peak growth, mats of CLP at and just under the surface can interfere with aquatic recreation. CLP usually completes its annual life cycle in June depositing new turions on the bottom of the lake. By early July the plant dies, dropping to the bottom to decompose, releasing nutrients back into the water as it does so. Large-scale die-offs may result in a critical loss of dissolved oxygen. Floating mats of dead and dying CLP can inundate shallow water areas and foul shorelines and beaches. In the fall, when water temperature begins to cool, turions start to sprout again.

Figure 25: CLP Plants and Turions (not from Lower Turtle Lake)

EURASIAN WATERMILFOIL

EWM (Figure 26) is a submersed aquatic plant native to Europe, Asia, and northern Africa. It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts, and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter, and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, 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.

Figure 26: A complete example of a growing EWM plant and a floating fragment with new roots

EWM has not been found within Lower Turtle Lake. However, there are several nearby lakes including Beaver Dam, Echo, Horseshoe, and Lower Vermillion which all have EWM or the a hybridized version of it. Prevention and education should remain a top priority for the LTLMD to prevent EWM from entering Lower Turtle Lake.

PURPLE LOOSESTRIFE

Purple loosestrife (Figure 27) 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 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. Currently, more than 20 states, including Wisconsin have laws prohibiting its importation or distribution because of its aggressively invasive characteristics.

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 has not been found around Lower Turtle Lake, but it has been found in several nearby wetlands including those surrounding the Echo and Horseshoe Lakes as well as many of the smaller wetlands along Highway 8 near Lower Turtle Lake. Monitoring efforts should include purple loosestrife.

Figure 27: Purple Loosestrife (not from Lower Turtle Lake)

REED CANARY GRASS

Reed canary grass (Figure 28) 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 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 a few locations along the shoreland of Lower Turtle Lake, but these have not become monotypic stands that impair the normal function of wetlands. While this should be monitored with other AIS, this is not considered an issue at this time.

Figure 28: Reed Canary Grass (not from Lower Turtle Lake)

NON-NATIVE AQUATIC INVASIVE ANIMAL SPECIES

Currently, there is only one non-native aquatic animal species, Chinese mystery snails, that has been found within Lower Turtle Lake. There are several other non-vegetative, aquatic, invasive species are in nearby lakes and streams, that have not been identified in Lower Turtle Lake. 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 Lower Turtle Lake.

CHINESE AND BANDED MYSTERY SNAILS

Chinese mystery snails were found and verified within Lower Turtle Lake in 2012.

Chinese mystery snails and banded mystery snails (Figure 29) 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 and less susceptible to pesticides.

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.

Figure 29: Chinese Mystery Snails (left) and Banded Mystery Snails (right) (not from Lower Turtle Lake)

RUSTY CRAYFISH

Rusty crayfish have not been identified in Lower Turtle Lake, but they can be found in several nearby bodies of water including Rice Lake and the Red Cedar River

Rusty crayfish (Figure 30) 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 Rhode 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.

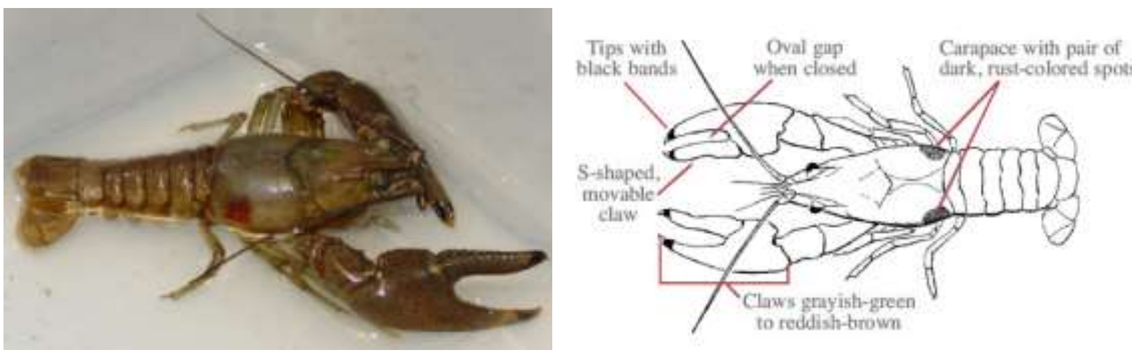


Figure 30: Rusty Crayfish and identifying characteristics

ZEBRA MUSSELS

Zebra mussels have not been identified in Lower Turtle Lake but are present in feeder waters of Lake Superior, Big and Middle Mckenzie lakes in Washburn County, Deer Lake in Polk County, and in Bass Lake in St. Croix County.

Zebra mussels (Figure 31) 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.

Figure 31: Zebra Mussels

While zebra mussels have not been identified in Lower Turtle Lake, they have were found in western Washburn County in 2016. This was the first time that zebra mussels had been found in inland waters of Northwestern Wisconsin. This has increased awareness, but also the risk of zebra mussels being moved throughout the state. Prevention efforts should remain a top priority for the LTLMD.

AIS PREVENTION STRATEGY

Lower Turtle Lake currently only has two established AIS, but there are many more that could be introduced to the lake. The LTLMD has and will continue to implement a watercraft inspection and AIS Signage program at the public boat landing on the lake. It also has an Early Detection and Rapid Response Plan in place in the event a new AIS is found. Information is shared with lake residents and users in an effort to expand the watercraft inspection message. In addition to the watercraft inspection program, an in-lake and shoreland AIS monitoring program has been and will continue to 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 control existing AIS and to keep new non-native AIS from entering the lake. To foster this, the LTLMD should host and/or sponsor 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.

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. Even though not all management alternatives are appropriate for consideration in Lower Turtle Lake, a brief description of each is given in the following sections.

NO MANAGEMENT

When evaluating the various management techniques, the assumption is erroneously made that doing nothing is environmentally neutral. In dealing with 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, 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, 2000).

In Lower Turtle Lake, the current levels of CLP are low enough that the LTLMD could elect to forego active management strategies for several years, but the CLP levels would still need to be regularly monitored.

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, swimrafts 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 32)
- Removal of nonnative or invasive aquatic plants as designated under s. NR 109.07 is unlimited if 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.

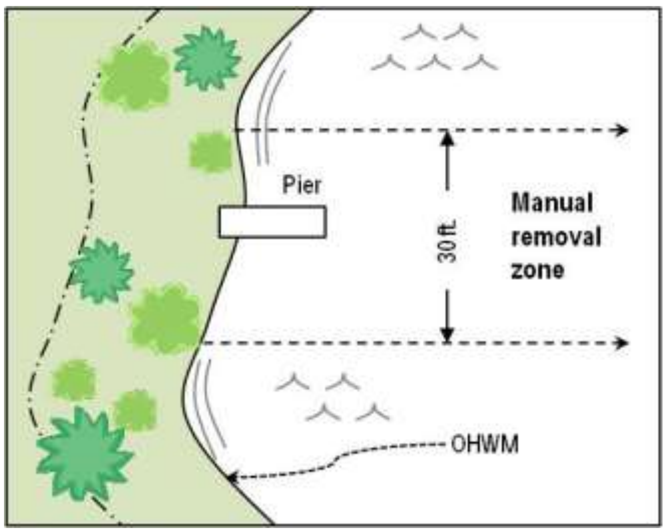


Figure 32: Aquatic vegetation manual removal zone

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. Physical removal of aquatic plants requires a permit if the removal area is located in a "sensitive" or critical habitat area previously designated by the WDNR. 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.

In Lower Turtle Lake, many of the areas of CLP may be best managed by hand-pulling/manual removal, primarily the areas adjacent to resident docks. The LTLMD should work with residents on the lake to teach them how to identify non-native aquatic plant species and how to properly remove them from around their docks and in their swimming areas.

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 weeds 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. 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).

In Wisconsin and Michigan, suction harvesting of unwanted aquatic plants is gaining popularity as a treatment method. There are several companies in the mid-west that are offering DASH services. Some of these companies are also building equipment that lake organizations and consultants can purchase to start up their own DASH program. Aquacleaner Environmental, out of Lancaster, NY sells DASH systems of different sizes based on the needs of a given lake.

DASH removal is not recommended for CLP control on Lower Turtle Lake. Like most active CLP management options, this would need to be repeated for several years. The costs associated with multiple years of DASH would likely outweigh the amount of CLP relief it would provide.

MECHANICAL REMOVAL

Mechanical management involves the use of devices not solely powered by human as a 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

Large-scale mechanical harvesting is more traditionally used for control of CLP, but can be an effective way to reduce EWM biomass in a water body. It is typically used to open up channels through existing beds of EWM to improve access for both human related activities like boating, and natural activities like fish distribution and mobility on lakes in maintenance mode where EWM is well-established and restoration efforts have been discontinued.

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water. 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.

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. There is currently only one harvesting contractor in Northwestern Wisconsin, so there is little flexibility in terms of scheduling.

Contracted harvesting, or purchase and operation of a smaller mechanical harvester by the LTLMD remains a good alternative to the use of herbicides to maintain use of the lake and protect water quality and native plants.

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 (Figure 33) 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.

Figure 33: Aquatic Mower & Weedshear Weed Cutter (weedersdigest.com)

Small-scale harvesting could be used effectively to manage CLP and nuisance native vegetation on Lower Turtle Lake. For a small investment to purchase a boat mounted type weed cutter and some volunteer time, the areas of greatest impact to navigation could be improved. Kirby Lake is located just north of Cumberland, WI about 30 miles north of Lower Turtle Lake. A few years ago, the Kirby Lake District purchased a boat-mounted weed cutter and used it to open channels to maintain access from property owners to open water. They required participating land owners to provide some of the volunteer labor needed to remove the vegetation once cut. If the LTLMD elected to purchase a small-scale weed cutter, this could be used in place of or along with the use of aquatic herbicides.

BOTTOM BARRIERS AND SHADING

Physical barriers, fabric or other, placed on the bottom of the lake to reduce plant growth may provide temporary relief, but also inhibits fish spawning, affects 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 vegetation 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.

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. Bottom barriers and attempts to further reduce light penetration in Lower Turtle Lake are not recommended.

DREDGING

Dredging is the removal of bottom sediment from a lake. Its success as an aquatic plant management strategy 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 at any level must be permitted by the WDNR. It should not be performed for aquatic plant management alone. It is best used as a multipurpose lake remediation technique (Madsen, 2000).

Dredging is not a recommended management action for Lower Turtle Lake.

DRAWDOWN

Drawdown, like dredging, alters the plant environment, in this case by removing water in a water body to a certain depth, exposing bottom sediments to seasonal changes including temperature and precipitation. A winter drawdown is a low cost and effective management tool for the long-term control of certain susceptible species of nuisance aquatic plants. A winter drawdown controls susceptible aquatic plants by dewatering a portion of the lake bottom over the winter, and subsequently exposing vascular plants to the combined effect of freezing and desiccation (drying). The effectiveness of drawdown to control plants hinges first on being able to draw the water down far enough to dewater the areas of most concern; and then on the combined effect of the freezing and drying. If freezing and dry conditions are not sustained for 4-6 weeks, the effectiveness of the drawdown may be reduced. Winter drawdowns are most effective for plants like EWM and lilypads that reproduce from rhizomes and vegetative runners under the sediment. They are much less effective for controlling plants that grow annually from seeds or turions like CLP and other pondweeds. In some cases, pondweed species may actually benefit from a winter drawdown, as competition with other plants species may be reduced following a drawdown. This can aide certain native species like wild rice, but it could also result in CLP doing better in a lake.

It is not possible to lower the water level in Lower Turtle Lake far enough to impact areas with CLP growth. Because CLP has turions that grow annually, a drawdown would likely do limited damage to CLP populations within Lower Turtle Lake and would likely harm several native species. As such, this is not a recommended management option for Lower Turtle Lake.

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.

Currently, there are no biological controls available for CLP. It was thought at one time that the introduction of plant eating carp could help control CLP and EWM. It has since been shown that these carp have a preference list for certain aquatic plants. CLP 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 CLP 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 Lower Turtle Lake.

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 be used 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 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 characteristics 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 other 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 watermilfoil, will be affected by selective herbicides whereas monocots, such as certain broad-leaf pondweeds 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 photosynthesis. 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®, 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. Presently, triclopyr based herbicides are more expensive than 2, 4-D based herbicides, but could be used in a similar fashion to control undesirable AIS.

Research done with triclopyr in 2014 (Vassios, Nissen, Koschnick, & Heilman, 2014) suggest that there is a difference between how the target plant is affected when using liquid or granular formulations of triclopyr. In short, liquid applications of triclopyr tend to build up quicker in the meristem or growing tip of EWM, while granular applications tend to build up more in the root crown of EWM. The indication was that perhaps treating a body of water with both the granular and liquid formulation of the herbicide would affect a greater area of the plant providing better results than either formulation alone. This research was only completed using triclopyr, but it may have some application with 2,4-D as well, and it would be interesting to complete a test treatment using this method.

Aquathol whose active ingredient is endothall; Reward whose active ingredient is diquat; and Cutrine whose active ingredient is a form of copper 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. None of these three are considered selective and have 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 plants 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 but can provide substantial nuisance relief from a variety of aquatic plants.

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.

EFFICACY OF AQUATIC HERBICIDES

The efficacy of aquatic herbicides is dependent on both application concentration and exposure time, and these factors are influenced by two separate but interconnected processes - dissipation and degradation. Dissipation is the physical movement of the active herbicide within the water column both vertically and horizontally. Dissipation rates are affected by wind, water flow, treatment area relative to untreated area, and water depths. Degradation is the physical breakdown of the herbicide into inert components. Depending on the herbicide utilized, degradation occurs over time either through microbial or photolytic (chemical reactions caused by sunlight exposure) processes.

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). Micro treatments are as well, but may be used as follow-up spot treatments after an early season application, or in instances where a new infestation has been identified in a lake with EWM already or a in a completely new lake. 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 dissipation and degradation 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 be effective, or in some manner contain the herbicide in the treated area by artificial means, like installing a curtain around the treated area. 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.

Small-scale treatments have been and will, likely, continue to be the main method of CLP control on Lower Turtle Lake. While small-scale treatments will be a part of this plan, micro-treatments will not be a recommended management option.

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 EWM and 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. Due to the small-scale nature of CLP within Lower Turtle Lake, large-scale applications will not likely be necessary in the foreseeable future.

PRE AND POST TREATMENT AQUATIC PLANT SURVEYING

When introducing 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 protocol for pre and post treatment survey is applicable for chemical treatment of CLP and EWM.

The WDNR protocol assumes that an Aquatic Plant Management 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. 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.

Unless a treatment exceeds ten acres, pre- and post-treatment surveys will not need to be conducted on Lower Turtle Lake.

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.

Chemical concentration testing has never been done on Lower Turtle Lake, and it is not recommended unless at some future point management efforts exceed 10% of the littoral zone.

MANAGEMENT DISCUSSION

CURLY-LEAF PONDWEED

Dense beds of CLP that prevent native plant species from becoming established and have the potential to negatively impact water quality should be managed. Harvesting is not target plant specific and would have to occur later in the spring to accommodate maximum CLP growth and removal. By itself, CLP doesn't really have a large enough presence in Lower Turtle Lake to justify buying large-scale harvesting equipment or purchasing harvesting services unless the harvesting program also includes management of native aquatic plants later in the season to reduce nuisance and navigation issues. If the LTLMD choses to purchase small-scale harvesting equipment, any relatively small areas of CLP could likely be completed with this small-scale equipment, if the Lake District chooses.

For control of dense areas of CLP, early season application of the chemical endothall would provide the most benefit to the lake in lieu of the use of harvesting. Eliminating CLP early in the season prevents it from producing turions for later growth and may allow other plants that previously had been out-competed by CLP to grow more vigorously. Early season application of herbicides also reduces the amount of plant material that is killed and left to decay on the bottom of the lake.

The 2010 APMP recommends chemically treating all of the CLP in the lake to gain the most benefit. However, because there are concerns about losing water level if vegetation in the south end or outlet area of the lake is somehow removed; and because dense growth CLP is for the most part, not interfering with navigation or open water access in this area of the lake, no management of CLP is recommended in this area.

Other areas where dense beds of CLP exist should be the focus of management in the early season if aquatic herbicides are used. Harvesting of dense beds of CLP and native vegetation that causes nuisance or navigation issues should be the focus of management later in the season. If aquatic herbicides are used to control CLP, planning should include treating the same areas for at least three consecutive seasons to get the best results. Later season harvesting should be based on the vegetation that exists each season, although a general plan identifying potential harvesting areas should guide implementation.

Establishing an annual spring CLP bed mapping program will help to determine the extent of CLP to treat each year. CLP control strategies need to focus on both reducing growth and promoting the re-establishment of native aquatic plants. Establishing a baseline condition before beginning a CLP control program is vital for guiding decisions on the level of management required, prioritizing areas of the lake for treatments, and selecting the specific tools and strategies to be implemented. Depending on the size of the areas chemically treated pre and post management aquatic plant monitoring will help track the success of management actions. In addition, it may be beneficial to sample turion density at a limited number of points within a treated area prior to three years of planned management, and again at the end of three years of management.

NATIVE AQUATIC PLANTS

The main focus of native aquatic plant harvesting on Lower Turtle Lake would be to provide navigation relief by opening designated navigation and access lanes to improve access to open water. The most problematic area of the lake is the fully developed southeast shoreline where a large shallow (1-5 feet) flat extends 200-300 feet out into the lake before dropping off to 10 feet or more (Figure 34). It is on this flat that dense growth native aquatic vegetation creates navigational impairments for lake users throughout July and August. These impairments are exacerbated when water levels in the lake are low due to weather conditions.

To provide navigational relief and access to open water, navigation and access lanes 10-20 feet wide, covering 1.5 - 3.0 acres of total surface area could be opened and maintained. Harvesting depth in the channels would not exceed 2/3 of the water depth. Harvesting will not be implemented in water less than 3 feet deep. Harvesting would only occur in those areas identified ahead of time and included in a WDNR harvesting permit. Final approval of the harvesting permit will be dependent on verification by WDNR Staff or an approved contractor of nuisance/navigation impairment conditions. It would be expected that once the navigation and access lanes were opened, that regular use would maintain them, and additional harvesting would not be necessary. However, harvesting permits are typically written to allow repeated harvesting in the same year if necessary. No clear cutting of native aquatic vegetation would be completed, and any proposed cutting in sensitive areas would be kept at a minimum. Additionally, there should be no chemical control of native plants within Lower Turtle Lake.

Limited harvesting of native aquatic plants in the summer months would likely not negatively impact the overall abundance and diversity of native aquatic vegetation in the lake. Within the channels, rooted vegetation would not be removed, only cut deep enough to allow unimpeded navigation to open water.

Secondary benefits of native aquatic plant harvesting would be improving fishing access in the shallow flats, possibly improving the fishery, and reducing nutrient loading from decaying vegetation.

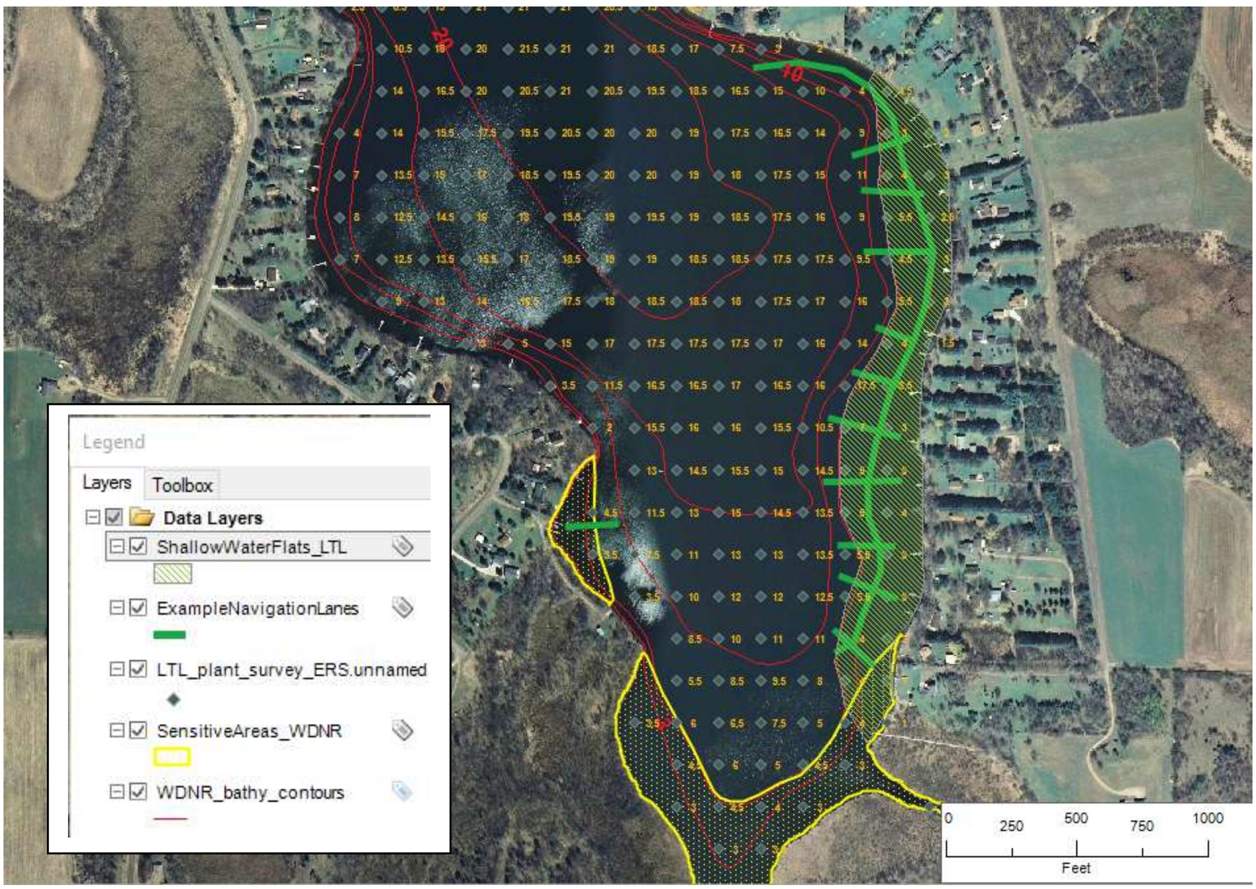


Figure 34: Southern half of Lower Turtle Lake showing the "shallow water flat" along the southeast shoreline (LEAPS, 2016)

AQUATIC PLANT MANAGEMENT GOALS, OBJECTIVES, AND ACTIONS

1. Goal One: Support and propagate aquatic plant management efforts that minimize negative impacts to the native plant communities.
    a. Objective One: Monitor the distribution of CLP in Lower Turtle Lake annually
        i. Action 1: CLP bed mapping surveys
            1. Conducted the spring prior to the proposed treatment.
            2. Conducted on an annual basis each spring to determine changes in CLP levels and the efficacy of any management actions.
    b. Objective Two: Prevent the expansion of CLP in Lower turtle Lake
        i. Action 1: The LTLMD will implement a 3-yr chemical treatment plan that in areas that meet or exceed the conditions below.
            1. Conditions:
                a. Areas must be ≥ 1 acre in size
                b. Areas must have an average rake head density of 3
                c. The above conditions must persist for two or more consecutive years.
                d. Areas must be located outside of the outlet area
                e. Areas surveyed by volunteers that meet conditions above will be re-surveyed by a professional plant surveyor prior to the submission of a chemical application permit.
                f. Pre- and post-treatment aquatic plant survey work and herbicide concentration/dispersion monitoring will be completed as instructed by the WDNR.
    c. Objective Three: Maintain or improve current (2018) measurements of native aquatic plant community health in Lower Turtle Lake.
        i. Action 1: Compare measurements of the health of the native aquatic plant community in Lower Turtle Lake prior to and after a multi-year aquatic plant management project.
            1. The LTLMD 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 2018, 2014, and 2008.

2. Goal Two: Maintain summer and late season access to open water
    a. Objective One: Open up navigation and open water access lanes through areas of dense, summer vegetation
        i. Action One: Harvest up to 3 acres of aquatic vegetation from predetermined navigation and open water access channels totaling no more than 1.25 miles in length.
            1. Assumes that either the LTLMD owns its own mechanical harvester, or contracts with a provider of aquatic plant harvesting
            2. Conditions
                a. Harvesting areas are identified ahead of time in a WDNR aquatic plant harvesting permit
                b. Areas to be harvested must have an average rake head density of 3
                c. Navigation and access lanes will be no wider than 20-ft in any area of the lake
                d. Harvesting will remove aquatic vegetation from up to 2/3 of the water column in water 3-ft or greater in depth
        ii. Action Two: Aquatic plant harvesting using small-scale cutting equipment that can be mounted to a boat, and requires physical removal of cut vegetation as a separate action.
            1. Conditions

                a. Cutting areas are identified ahead of time in a WDNR aquatic plant harvesting permit
                b. May be completed in water less than 3-ft deep
                c. All cut vegetation is removed from the lake immediately after cutting
        iii. Action Three: Physical removal of native aquatic vegetation by land owners
            1. Conditions
                a. Limited by provisions in NR 109

3. Goal Three: AIS education and prevention.
    a. Objective 1: Prevent new AIS from entering and becoming established within Lower Turtle Lake
        i. Action 1: Implement Clean Boat Clean Waters
            1. 200 hours annually with grant funding
            2. Volunteer hours only without grant funding
    b. Objective 2: Support an AIS education and information program for lake property owners and lake users
        i. Action 1: Develop and distribute at least two newsletters updating AIS and other LTLMD activities
        ii. Action 2: Host at least one annual meeting and maintain open LTLMD Board meetings
        iii. Action 3: Host an Annual Lake Fair to promote public involvement in lake activities
            1. Can be combined with the Annual Picnic or other planned event, or with another entity
        iv. Action 4: Maintain a Lower Turtle Lake Association webpage and/or social media page
    c. Objective 3: Establish and maintain AIS monitoring efforts
        i. Action 1: Install, maintain, and/or improve AIS signage at both public access points
        ii. Action 2: Establish and maintain an in-lake and shoreline AIS monitoring program following CLMN guidelines
        iii. Action 3: Follow established AIS early detection and response plan
            1. See AIS Rapid Response Plan (Appendix C)

4. Goal Four: Monitor changes is water quality
    a. Objective One: Continue to participate in the CLMN Water Quality Monitoring Program
        i. Action 1: The LTLMD will continue to participate in the expanded level of the Citizen Lake Monitoring Network (CLMN).

2. Goal Five: Promote and support nearshore, riparian, and watershed best management practices that will improve fish and wildlife habitat, reduce runoff, and minimize nutrient loading into Lower Turtle Lake.
    a. Objective 1: Adopt State of Wisconsin Healthy Lakes Initiative
        i. Action 1: Officially adopt the Wisconsin Healthy Lakes Initiative during the next annual meeting of the LTLMD.
        ii. Action 2: Install two Healthy Lakes Best Management Practices each year and 5 fish sticks projects within the next 5 years
            1. Apply for Healthy Lakes grant funding to support these projects

3. Goal Six: Implement the Lower Turtle Lake Management Plan effectively and efficiently with a focus on community and constituent education, information, and involvement.
    a. Objective 1: Complete annual project activity and assessment reports
        i. Action 1: Use reports to make recommendation for annual revisions and updates to the APM Plan

b. Objective 2: Complete an End-of-project Summary Report
    i. Action 1: Overall review of project successes and failures.
    ii. Action 2: Complete early and mid-season whole-lake point-intercept survey of all plants.
    iii. Action 3: Revise or rewrite APM Plan as needed.

c. Objective 3: Develop partnerships to support management implementation
    i. Action 1: Communicate with local, county, and state entities; schools and local business; clubs and organizations, etc. to generate support for management actions.
    ii. Action 2: Share results with partners from Action 1

IMPLEMENTATION AND EVALUATION

This plan is intended to be a tool for use by the LTLMD to move forward with aquatic plant management actions that will maintain the health and diversity of Lower Turtle Lake 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 LTLMD funds is highly recommended. An Implementation and Funding Matrix is provided in Appendix B.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES GRANT PROGRAMS

The Aquatic Invasive Species (AIS) Prevention and Control grants are a cost-share effort by the DNR to provide information and education on types of existing and potential aquatic invasive species in Wisconsin, the threats that invasive species pose to the state's aquatic resources, and available techniques for invasive species control. These grants also assist in the planning and implementation of projects that will prevent the introduction of invasive species into waters where they currently are not present, controlling and reducing the spread of invasive species from waters where they are present, and restoring native aquatic communities.

There are five AIS Prevention and Control grants subprograms:

- Education, Prevention and Planning Projects (including Clean Boats Clean Waters)
- Early Detection and Response Projects
- Established Population Control Projects
- Maintenance and Containment Projects
- Research and Demonstration Projects

Several of these subprograms are applicable to Lower Turtle Lake and the Lower Turtle Lake Association.

EDUCATION, PREVENTION AND PLANNING PROJECTS

Education projects are intended to broaden the public's awareness and understanding of, and ability to identify, AIS; the threats that AIS pose to the health of aquatic ecosystems; the measures to prevent the spread of AIS; and the management practices used for control of AIS. Prevention projects are intended to prevent the introduction of new AIS into a waterbody/wetland, or prevent the spread of an AIS population from one waterbody to another unpopulated waterbody/wetland. Planning projects are intended to assist in the development of plans for the prevention and control of AIS. Eligible projects include:

- Educational programs including workshops, training sessions, or coordinated volunteer monitors. Projects will be reviewed for consistency with the DNR's statewide education strategy for controlling AIS including the use of existing publications and outreach materials.
- Development of AIS prevention and control plans
- Monitoring, mapping, and assessing waterbodies for the presence of AIS or other studies that will aid in the AIS prevention and control.
- Watercraft inspection and education projects following the guidelines of the DNR's Clean Boats, Clean Waters program.

This subprogram is not intended to provide support for any management action that may be taken.

ESTABLISHED POPULATION CONTROL PROJECTS

Established population control grants are intended to assist applicants in eradicating or substantially reducing established populations of AIS to protect and restore native species communities. Established populations are defined as substantial reproducing populations of AIS that are not pioneer populations. Eligible projects include activities recommended in a DNR-approved control plan including monitoring, education, and prevention activities. Ineligible projects include the following:

- Dredging

- Chemical treatments or mechanical harvesting of aquatic plants to provide single season nuisance or navigational relief.
- Maintenance and operation of aeration systems and mechanical structures used to suppress aquatic plant growth.
- Structural facilities for providing boat washing stations. Equipment associated with boat washing facilities is eligible if included in a management plan.

MAINTENANCE AND CONTAINMENT PROJECTS

Maintenance and containment grants are intended to provide sponsors limited financial assistance for the ongoing control of established AIS population without the assistance of an Established Population Control grant. These projects are intended for waters where management activity has achieved the target level of control identified in an approved plan that meets the criteria of s. NR 198.43, Wis. Adm. Code. Ongoing maintenance is needed to contain these populations so they do not re-establish throughout the waterbody, spread to other waters, or impair navigation and other beneficial uses of the waterbody.

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Appendix A

Lower Turtle Lake Aquatic Plant Management Goals, Objectives, and Actions

Appendix B

Lower Turtle Lake Funding and Implementation Matrix

Appendix C

Lower Turtle Lake AIS Response Plan