CLAM LAKES, BURNETT COUNTY

2021-25 AQUATIC PLANT MANAGEMENT PLAN

WDNR WBIC: 2656200 & 2655300

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CLAM LAKEPROTECTION&
REHABILITATION DISTRICT
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Table of Contents

Figures

Tables

Appendices

AQUATIC PLANT MANAGEMENT PLAN-CLAM LAKES

PREPARED FOR THE CLAM LAKES PROTECTION & REHABILITATION DISTRICT

INTRODUCTION

In 2009, the Clam Lakes Protection and Rehabilitation District (CLPRD) applied for and received a multi-phase lake management planning grant to address the need for a revised Aquatic Plant Management Plan (APMP) originally focused on their on-going curly-leaf pondweed (CLP) large scale harvesting program; and to gather information pertaining to the state of the water quality in Lower and Upper Clam Lakes.

Data collection began in 2009 with full point-intercept aquatic plant surveys including early season CLP and mid-season all plant surveys on both lakes. Dense infestations of CLP were identified on Lower Clam Lake and to a lesser degree in Upper Clam Lake. Native plants were present and diverse, but sparse in density, confirming anecdotal observations by the local lake community that over the previous 3-5 years dense native plant beds were disappearing. Also noted in this plant survey were large schools of young carp that "…were everywhere in both lakes" leading the plant survey specialist to characterize the state of the aquatic plant community in 2009 as being "under siege by invasive species", most notably CLP and carp (1). Perhaps most impacted was the high quality wild rice beds historically and commonly present in Upper Clam Lake. Not only had there been a noticeable decline in total acreage of wild rice, additional CLP survey work to estimate the number of CLP turions in the sediment noted little to no wild rice seed in the bottom sediments where these large beds previously existed. This was confirmed by survey work later in 2009, specifically to look at wild rice seed in the lakes, indicating that the observed multi-year decline in wild rice was more than just natural variance, and may not be able to correct itself.

In 2010 and 2011, the CLPRD, working with the Wisconsin Department of Natural Resources (WDNR) and St. Croix Tribal Environmental Services (SCTES), and with assistance from two different consulting firms and the University of Minnesota, embarked on several projects to determine the extent of the noticeable carp population increase. It was documented that the population of carp had indeed exploded in the lakes with a huge year class of young carp. Also documented in 2010 was a severe decline in CLP. Management of CLP that had previously dominated large areas of both lakes became unnecessary as the carp severely curtailed its growth and reproduction. Wild rice and other native aquatic plants were almost completely wiped out in 2010 and 2011. Water quality worsened as there was little aquatic vegetation to absorb nutrients in the system, and turbidity levels increased as carp stirred up and re-suspended bottom sediments in both lakes. At the same time, fisherman and resort owners noticed significantly fewer panfish being caught in the lakes. As a result, the final goals of the 2009 project were put on hold, pending the outcome of management efforts spear-headed by SCTES to protect and enhance the remaining wild rice and to reduce the carp population. Because of the direct impact of carp on both aquatic plants and water quality, management of both was considered secondary until the carp population was brought under control.

Between 2010 and 2014, many actions were implemented to reduce the carp population and to protect and enhance the wild rice population. In 2014, the initial 2009 project was picked up again and a management plan that was in large part a summary of the data gathered, actions taken, and results achieved through 2014 was completed. The plan made recommendations for both aquatic plant and water quality management actions to consider as the CLPRD and other partners moved forward.

Between 2014 and 2019, carp control measures that had continued past 2014 began to pay dividends. The amount of aquatic vegetation in the two lakes began to increase and water quality/clarity improved. So much so, that large-scale mechanical harvesting of aquatic vegetation (both CLP and native vegetation began again in 2018. In 2019, the CLPRD contracted with Matt Berg of Endangered Resource Services, LLC to complete another whole-lake, point-intercept, aquatic plant survey that included both early season CLP survey work and summer all plant survey work. The CLPRD in discussion with the WDNR also determined it was time to update the interim management plan with a new Aquatic Plant Management Plan. This document, considered a new Aquatic Plant Management Plan to cover the years 2021-25, is the result of that project.

PUBLIC PARTICIPATION AND STAKEHOLDER INPUT

This project started back in September 2019 with a tour of both Upper and Lower Clam lakes with several members of the CLPRD Board. During this tour, problem areas of both lakes were viewed and issues discussed. Concerns were raised about both the spread of CLP earlier in the year, and dense growth native vegetation that started causing navigation issues in 2019. The meeting was held after Matt Berg has completed his summer PI survey, so maps of existing vegetation were available for review.

During the meeting one of the operators of the Clam Lakes harvesters commented that the amount of vegetation and the areas where vegetation causes nuisance and navigation issues changes every year. He felt it was important for any management plan to be flexible enough to accommodate annual changes in vegetation. He stated that harvesting may not occur in all locations, but the plan should reflect possible management in those locations making harvesting possible if needed in any given year.

In June 2020, more time was spent with members of the CLPRD to review management actions for the 2020 season. During this discussion, concern was brought up about the large areas of dense growth CLP in Lower Clam Lake. The existing 2020 harvesting permit from the WDNR only recognized opening navigation lanes along the shoreline. It did not specifically allow for harvesting in a larger capacity to remove large areas of CLP. After a modified CLP harvesting plan that included larger areas of removal was drafted and shared with the WDNR and Tribal Resources, several comments were made regarding minimizing large-scale removal in order to protect juvenile bluegill habitat. WDNR Fisheries did support some level of larger scale removal, but not what was initially proposed in the modified plan for 2020.

In August 2020, a draft of the new APM Plan and proposed CLP and nuisance and navigation harvesting maps was sent to the CLPRD Board, St. Croix Tribal Resources, and the WDNR. On August 27, 2020 a meeting was held at the Burnett County Government Center to discuss the Clam Lakes plan. At the same time, a draft form of the APM Plan and the proposed Goals, Objectives, and Actions was posted on the CLPRD webpage for public review. As of December 2020, no specific feedback to the plan has been obtained beyond the comments from the August 2020 meeting.

A more complete draft of the 2021-25 APM Plan and its appendices has since been posted on the webpage (www.leapsllc.com) of the consultant used by the CLPRD for public review. The most current draft of the plan will also be posted on the website hosted by the CLRPD at www.clamlakeprd.com. It is expected that the entire plan will be presented to the CLPRD constituency during its first constituent meeting in 2021.

OVERALL MANAGEMENT GOAL

The overall management goal for the Clam Lakes is to maintain and enhance the positive gains in native aquatic plant growth, water quality, fisheries management, and control of aquatic invasive species that have been experienced since 2010 when the negative impacts of an over-abundant carp population were first recognized and addressed. The last Aquatic Plant Management Plan for the Clam Lakes was completed in 2014, but was really only intended to be an interim guide to management that would support efforts being made by the Clam Lake Protection and Rehabilitation District (CLPRD), St. Croix Tribal Environmental Services (SCTES), the Wisconsin Department of Natural Resources (WDNR), and other entities to restore the health of the lakes.

The efforts made have brought the lakes back from thoroughly impaired state to a much more desirable state that is reflected in better water clarity/quality, a more diverse and healthy native aquatic plant community, and a healthier fishery. It has also opened the door for greater distribution and density of curly-leaf pondweed (CLP) and nuisance level growth of native aquatic plants in some places. This plan attempts to keep the more desirable changes happening, while at the same time limiting the less desirable changes.

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 growing concern over the spread of Aquatic Invasive Species (AIS), such as Eurasian water milfoil (EWM). These two forces have been behind more recent changes in Wisconsin's aquatic plant management laws and the evolution of stronger support for the control of invasive plants.

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

The impacts of humans on 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.

SHALLOW LAKE MANAGEMENT CONSIDERATIONS

Lake management requires consideration of the differences between deep and shallow lakes. Shallow lakes are those lakes with a maximum depth of less than 20 feet or with an average depth of less than 10 feet which clearly describes both Upper and Lower Clam Lakes (Cooke, Welch, Peterson, & and Nichols, 2005). Shallow lakes generally exist in one of two alternative states: the algae-dominated turbid water state and the plant-dominated clear water state (Figure 1). The turbid water state is characterized by dense algae (phytoplankton) populations, an undesirable bottom feeding fish community, and few aquatic plants whereas the clear water state is characterized by abundant aquatic plant growth, a greater number of zooplankton, and a diverse and productive gamefish community (Moss, Madgwick, & and Phillips, 1996).

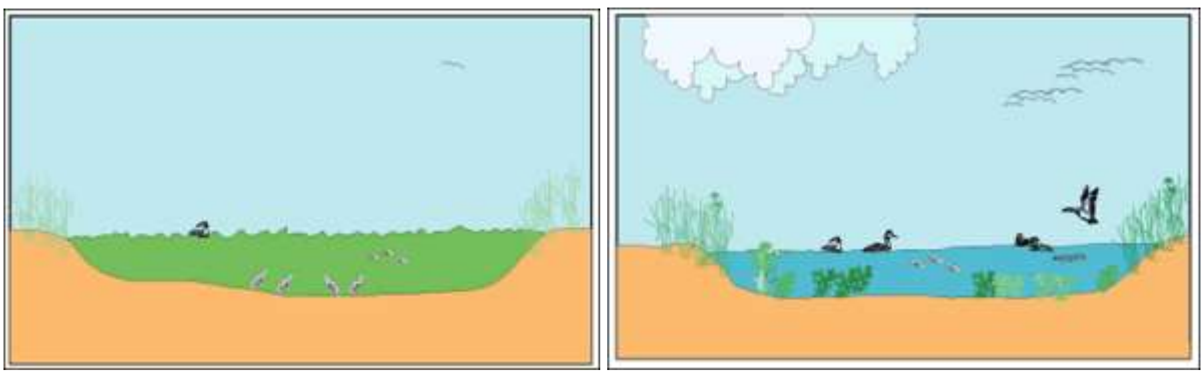


Figure 1: Alternative stable states in a shallow water lake (Scheffer, 1998)

SHALLOW LAKE ALTERNATIVE STATES AND STABILIZING MECHANISMS

Aquatic plants are the key to clear water in shallow lakes. A shallow lake that is free of both aquatic plants and algae is uncommon and it is unrealistic to expect such a lake to occur without a large investment of money and energy. Shallow lakes are more susceptible to internal nutrient loading (e.g. lake sediment phosphorus release) and biomanipulation (additions or removals of fish that affect the entire aquatic food web) than deep lakes, which are more responsive to changes in the external nutrient load from the watershed.

The addition or removal of nutrients can change the composition of an aquatic plant community, but can't displace aquatic plants altogether. A mechanism that displaces the plants and allows for algae to take over is called a forward switch (Moss, Madgwick, & and Phillips, 1996). Forward switches include the direct loss of plants through harvesting or herbicide use, repeated boat passage damaging the plants beyond recovery, runoff of herbicides from the surrounding watershed, static water levels, the introduction of carp, and a fish community that favors zooplanktivorous (fish that eat the Daphnia that eat the algae).

A reverse switch is a process or management option that restores and stabilizes the plant community by overcoming the buffers stabilizing the algae (Moss, Madgwick, & and Phillips, 1996). The most common techniques are biomanipulation, which is a manipulation of the fish community to reduce the number of zooplanktivores (often by adding piscivorous fish), and by re-establishing plants under conditions in which they can thrive. An important aspect of plant restoration is the re-establishment of wetland fringes (cattails, rushes, water lilies) that utilize nutrients, buffer wave action, provide refuge for daphnia and other algae grazers, and add to the lake's aesthetic appeal.

Each alternative state can persist over a wide range of nutrient concentrations. Aquatic plants can dominate without threat at total phosphorus concentrations below about 0.025 to 0.050mg/L. At total phosphorus levels greater than about 0.050mg/L, such as found in the Clam Lakes, either plant- or algae-dominated systems can exist, though at these higher nutrient levels there is a greater risk of the system switching from plant to algae dominance. Plant diversity also decreases at higher nutrient levels and filamentous algae can be common. Native plants can become a nuisance at high nutrient concentrations as highly adaptable species such as coontail, water celery, and water lilies become dominant.

If the goal of management is to return a lake from an algae-dominated state to an aquatic plant dominated state, there are several steps that can be undertaken to begin that restoration (Moss, Madgwick, & and Phillips, 1996):

- Identify the "forward switch" and remove it;
- Implement external and internal nutrient control measures;
- Restructure the ecosystem by a "reverse switch" (biomanipulation);
- Reestablish the aquatic plant community, including wetland fringe; and
- Stabilize and manage the restored system to keep it that way.

Identifying the historic forward switch that moved a lake from the plant-dominated to algae-dominated state can be difficult. It is more important to identify the switch mechanisms currently in operation. Once forward switches have been identified and removed, over-fertilization can be addressed through nutrient management strategies. External and internal nutrient sources should be reduced as much as possible to buffer against a forward switch and to establish conditions favorable for the next steps: biomanipulation and plant re-establishment (Moss, Madgwick, & and Phillips, 1996). A well-established plant community can withstand moderate impacts without further active management; however, the lakes and watershed should be monitored for changes and activities that might destabilize the system.

FORWARD AND REVERSE SWITCHES IN THE CLAM LAKES

Aquatic vegetation was once very abundant throughout Clam Lake. Historically, the lakes supported diverse, dense aquatic plant communities including large stands of wild rice. Aquatic vegetation often reached nuisance levels for recreation, leading to mechanical and chemical controls in 1960s through early 2000s.

In 2006, aquatic plant densities dropped dramatically. Wild rice beds saw an 80 percent reduction between 2001 and 2010 (Johnson J. A., 2010). In addition to wild rice/aquatic vegetation decline, Clam Lake's common carp population increased dramatically in 2005 (an identifiable forward switch). Common carp have been present in the system since 1940 or earlier (DNR correspondence 1980). The 2005 carp population increase led to dramatic shifts in the fish community (Wendel, 2011). The most notable changes were corresponding increases in the walleye and channel catfish populations. At the same time, there were dramatic decreases in bluegill and northern pike. The main driver in these shifts was common carp altering the aquatic vegetation density and increasing the turbidity within the lakes (Roberts, 2017).

Beginning in 2011 and continuing through 2017, WDNR permits allowed the removal of an estimated 656,378 lbs. of carp from the two lakes (Roberts, 2017). The large amount of carp removed acted as a reverse switch enabling the lakes to revert back to what they were prior to the forward switch caused by an increased carp population. Since 2017, this reverse switch has also reestablished the same issues with nuisance growth of aquatic vegetation and the increased presence of the invasive species curly-leaf pondweed such that there is again a need for aquatic plant management.

The Clam Lakes clearly has shown it has two states: clearer/abundant aquatic vegetation and turbid/without vegetation. The state it resides in affects the ecosystem in many ways. Currently, the Clam Lakes likely reside somewhere between a clear, vegetated state and a turbid, non-vegetated state.

It is an important goal of this plan to recommend management actions that will prevent the conditions that may have led to the dramatic forward switch to a turbid state between 2005 and 2010, but at the same time manages aquatic vegetation in the lakes in a manner that improves or maintains lake usability.

WATERSHED CHARACTERISTICS

A drainage basin or watershed is an area of land where surface water from rain and melting snow or ice converges to a single point at a lower elevation where those waters join another waterbody, such as a river, lake, reservoir, estuary, wetland, sea, or ocean. Defined more fully, a watershed describes an area of land that contains a common set of streams and rivers that all drain into a single larger body of water, such as a larger river, a lake or an ocean. A watershed can cover a small or large land area. Small watersheds are usually part of larger watersheds. All the streams flowing into small rivers, larger rivers, and eventually into the ocean, form an interconnecting network of waterways.

Homes, farms, ranches, forests, small towns, big cities and more can make up watersheds. Some cross county, state, and even international borders. Watersheds come in all shapes and sizes. Some are millions of square miles and others are just a few acres. As water drains from these areas, it picks up many different types of pollution including soils eroded from farm lands, and deposits it in streams and rivers, and eventually lakes and other larger bodies of water. Water that filters through the soil can also become contaminated with pollution that is left over from agricultural, industrial, commercial, and other types of human activity.

LAND USE

The Clam Lakes have a nearly 200,000 acre watershed in parts of four different counties. There are many different land uses within this watershed (Table 1, Figure 2). Fortunately, it remains largely undeveloped with nearly 70 % of it undeveloped. Approximately 25% is agricultural land, but most of this is pasture or hay, not row crops like corn and soybeans that often contribute large amount of eroded soil. Three main tributaries drain the Clam Lakes Watershed: Sand Creek, Clam River, and the North Fork of the Clam River.

Table 1: Land use in the Clam Lakes Watershed

Land Use/Cover	Acres
Developed, Open Space	8,601.9
Developed, Low Intensity	335.2
Developed, Medium Intensity	31.0
Developed, High Intensity	14.0
Deciduous Forest	104,194.8
Evergreen Forest	3,238.4
Mixed Forest	9,574.1
Pasture/Hay	40,767.2
Cultivated Crops	9,593.4
Shrub/Scrub	620.3
Grassland/Herbaceous	1,545.1
Open Water	8,829.9
Woody Wetlands	4,650.4
Emergent Wetlands	5,526.9
TOTAL	**197,522.7**

Source: NLCD, 2006

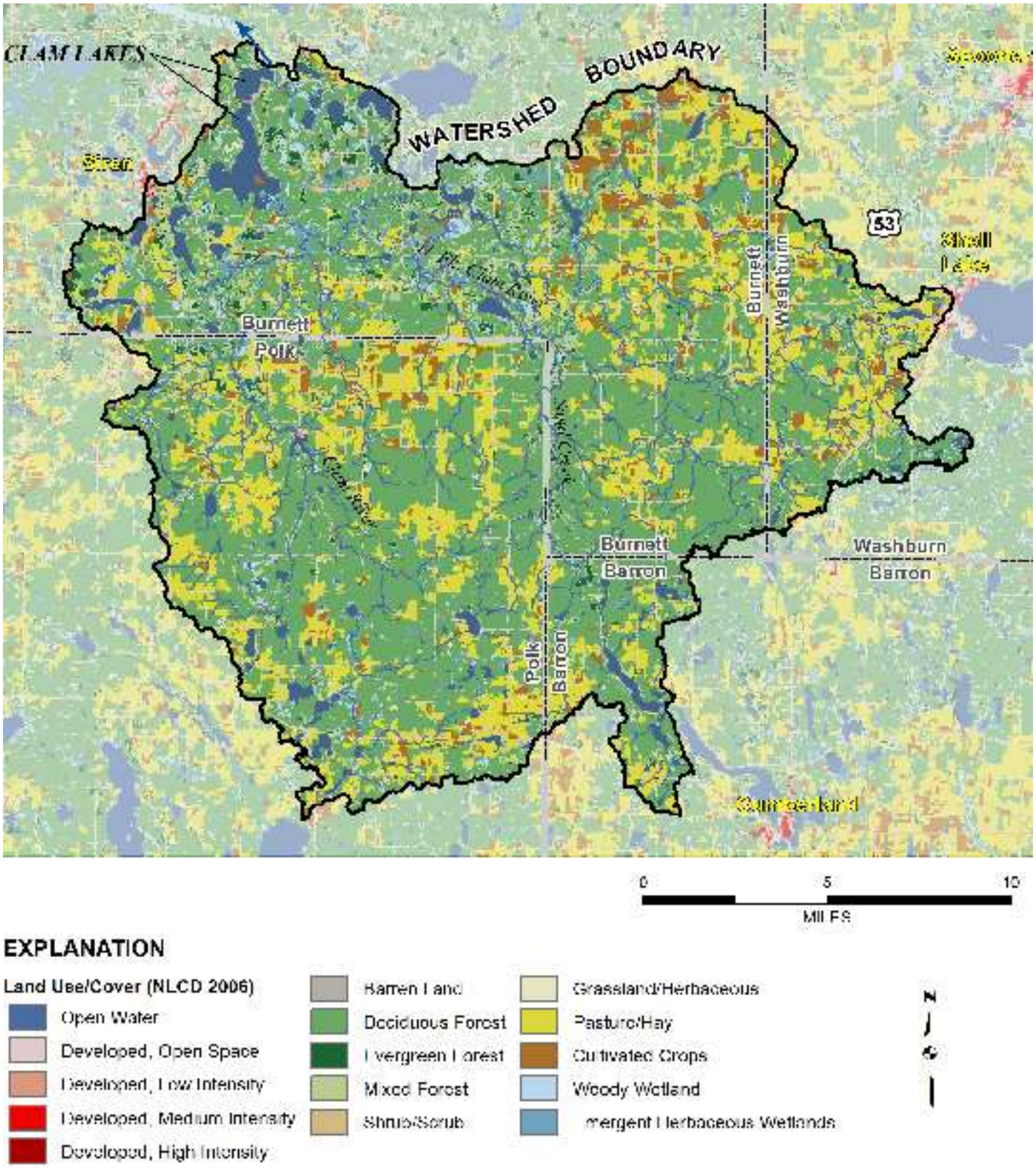


Figure 2: Land use in the Clam Lakes Watershed (3)

WETLANDS

In Wisconsin, a wetland is defined as 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 (Wisconsin Statue 23.32(1)). Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes. Wetlands are protected under the Clean Water Act and state law and in some places by local regulations or ordinances. Landowners and developers are required to avoid wetlands with their projects whenever possible; if the wetlands can't be avoided, they must seek the appropriate permits to allow them to impact wetlands (for example, fill, drain or disturb soils).

According to the National Wetland Inventory, emergent, forested/shrub and freshwater, emergent wetlands are present in the Clam Lakes watershed. The majority of the wetland borders the lakes and tributary streams and have a direct hydrologic connection to the lakes (Figure 3). Emergent wetlands (light green) are wetlands with saturated soil and are dominated by grasses such as redtop and reed canary grass, and by forbs such as giant goldenrod. Forested/shrub wetlands (darker green) are wetlands dominated by mature conifers and lowland hardwood trees. Forested/shrub wetlands are the dominant form of wetlands in the watershed and are important for stormwater and floodwater retention and provide habitat for various wildlife.

Figure 3: Clam Lakes wetlands (4)

Wetlands serve many functions that benefit the ecosystem surrounding the Clam Lakes. Wetlands support a great 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. Contrary to popular belief, healthy wetlands reduce mosquito populations; natural enemies of mosquitoes (dragonflies, damselflies, backswimmers, and predacious diving beetles) need proper habitat (that is, healthy wetlands) to survive.

Wetlands provide flood protection within the landscape by retaining stormwater from rain and melting snow and capturing floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands 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.

Wetland plants and soils provide water quality protection by storing and filtering pollutants ranging from pesticides to animal wastes. Wetlands also provide shoreline protection by acting as buffers between the land and water. Wetland plants protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This is important in waterways where high boat traffic, water currents, and wave action may cause substantial damage to the shore.

Although some small (two acres or less) wetlands may not appear to provide significant functional values when assessed individually, they may be very important components of a larger natural system. Not only do small wetlands provide habitat functions, they also store phosphorus and nitrogen and trap pollutants such as heavy metals and pesticides. Draining these small wetlands, which often do not appear on maps, not only requires the proper permits, but can also release the once-stored pollutants and nutrients into lakes and streams.

CRITICAL HABITAT

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

The WDNR mapped sensitive areas on the Clam Lakes in 1997 (Figure 4). The full report is included in Appendix C. The Sensitive Area survey identified three areas on Upper Clam Lake and one area on Lower Clam Lake. These areas of aquatic vegetation on Clam and Lower Clam Lake offer critical or unique fish and wildlife habitat. These habitats provide the necessary seasonal or life stage requirements of the associated fisheries, and the aquatic vegetation offers water quality or erosion control benefits to the body of water.

The data and recommendations from the Sensitive Area Report were reviewed and incorporated into this management plan. In addition to site-specific recommendations, the report recommends that aquatic vegetation should be protected and any removal or control should be minimized. In sensitive areas, it is important to maintain vegetated shoreland buffers. Stumps and woody habitat, which provide fish cover, should not be removed from sensitive areas.

Although restrictions are in place to protect these areas during plant management operations, in some cases, short-term disruptions to habitat during the removal of monotypic stands of aquatic invasive species may lead to positive long-term improvements to the habitat of the lake. Disruptions to the sensitive areas may be warranted when responding to the discovery of a new invasive species.

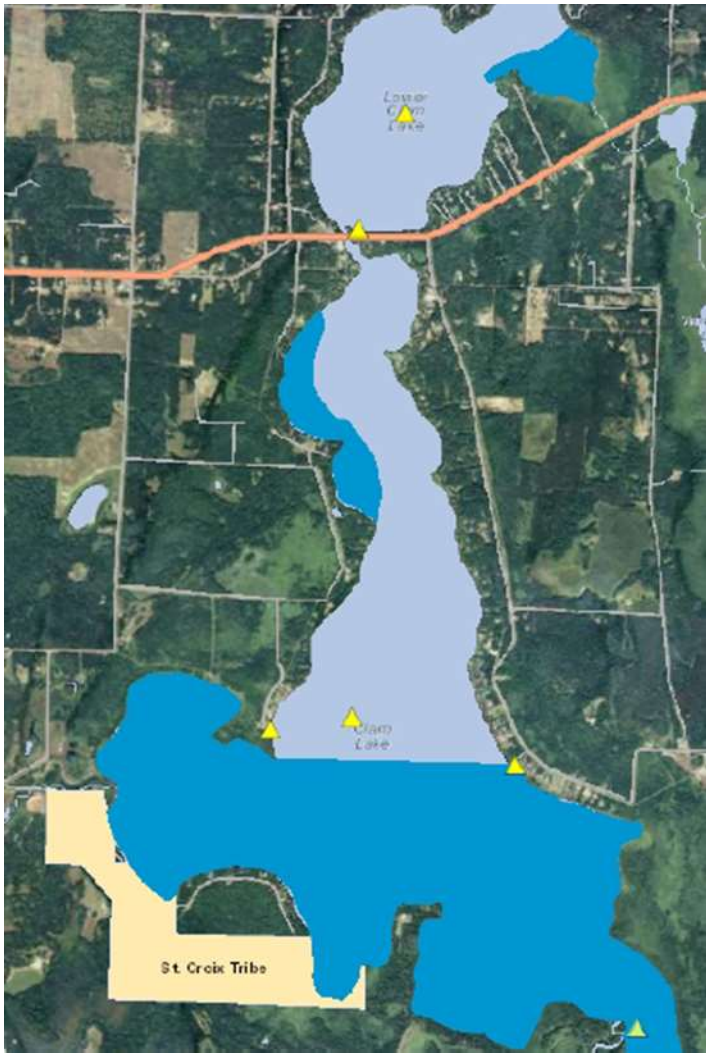


Figure 4: Sensitive areas (dark blue) in Upper and Lower Clam lakes (5)

RARE AND ENDANGERED SPECIES AND HABITAT

The Wisconsin Natural Heritage Inventory (NHI) program is part of an international network of programs that focus on rare plants and animals, natural communities, and other rare elements of nature. Each species has a state status including Special Concern, Threatened, or Endangered. Species are listed by township: Lower Clam Lake is situated in T39, R16W and Upper Clam Lake is in T38, R16W. It is important for lake managers to consider impacts to these valuable species, nearly all of which can be directly affected by aquatic plant management. Choosing the proper management techniques and the proper timing of management activities can greatly reduce or prevent negative impacts.

Two threatened (Blanding's turtle, and Pugnose shiner) and five special concern species are listed for T39, R 16W (Bald eagle, Lake sturgeon, Karner blue butterfly, Torrey's bulrush, and a Riffle beetle). One threatened species (Pugnose shiner), one endangered species (Sand violet), and four species of special concern are listed for T38, R16W (Bald eagle, Trumpeter swan, the Sylvan hygrotus diving beetle, and Torrey's bulrush).

Descriptions of these species can be found at:
http://dnr.wi.gov/topic/EndangeredResources/biodiversity.html/ (last accessed 2014-1-2).

The Natural Heritage Inventory Program tracks examples of all types of Wisconsin's natural communities that are deemed significant because of their undisturbed condition, size, what occurs around them, or for other reasons. Natural communities listed for the T39, R16W include the northern sedge meadow. Natural communities listed for T38, R16W include: alder thicket, lake—hard bog, and lake—shallow hard seepage.

Full descriptions of these communities including current threats can be found on the WDNR website at: http://dnr.wi.gov/topic/endangeredresources/communities.asp (last accessed 2014-1-2).

The Natural Heritage Inventory Program also tracks other natural features that provide important habitat for certain plants and animals and are places where a catastrophic event could have an impact on a large number of common and/or rare species. Potential range for the Karner Blue Butterfly, a federally endangered species, is one such natural feature listed for T38, R16W and T39, R16W.

A full description of a potential range for the Karner blue can be found on the WDNR website at: http://dnr.wi.gov/topic/endangeredresources/OtherElements.asp (last accessed 2014-1-2).

CLAM LAKE WILDLIFE AREA

The Clam Lake Wildlife Area is 285 acres on the south side of Upper Clam Lake. The wildlife area consists of a 20-acre peninsula on the west side of the lake, two large sedge/brush islands, 10 acres on the eastern shore, and over 200 acres on the southern shore including a mile of the Clam River. A map is included in Appendix D. The area includes wetlands, old fields, northern hardwoods, and riparian areas of lake shore and river. The WDNR manages the area for waterfowl nesting and the wild rice beds at the mouth of the Clam River. Recreational opportunities include birding, canoeing, cross country skiing, fishing, hiking, hunting, snowmobiling, trapping, foraging, and wildlife viewing.

WATERFOWL

The Clam Lakes have traditionally been an important stopping point for waterfowl during their normal migration patterns. In 2010-2011 waterfowl surveys on Clam and Long Lakes identified a total of 10 waterfowl species and 3,416 individual ducks were counted (6). In addition, observations of 6 other species were recorded. Species recorded include Canada goose, trumpeter swan, wood duck, gadwall, mallard, ring-neck, blue-winged teal, bufflehead, hooded merganser, common merganser, great blue heron, scaup, common loon, double-crested cormorant, American white pelican, and bald eagle.

The American white pelican is listed as a species of moderate conservation concern under the Upper Mississippi Valley/Great Lakes Waterbird Conservation Plan. Wood duck, mallard, and blue winged teal are all focal species of the Upper Mississippi Great Lakes Joint Venture. Scaup are the only species showing a decreasing trend according to the 1998 update to the North American Waterfowl Management Plan (NAWMP). They are currently 45% below goal with habitat degradation and loss identified as one of the major reasons for achieving desired recruitment rates. An objective under the NAWMP is to maintain or exceed recent rates of annual increase in populations of trumpeter swans to achieve an autumn index of 2,500. The blue winged teal, lesser scaup, and trumpeter swan are all listed as a species of greatest conservation need under the Wisconsin Wildlife Action Plan.

LAKE INFORMATION

Identifying appropriate aquatic plant and water quality management recommendations for the Clam Lakes requires a basic understanding of its physical characteristics, including its morphology (size, structure, and depth), critical habitat, and the fishery, as well as factors influencing water quality, such as soils and land use. All of these factors have the potential to influence aquatic plant growth. Aquatic plant management activities can impact the lakes water quality, fish and wildlife habitat, and both target and non-target aquatic plants. Plant survey data and water quality data were collected within the lakes during the development of this plan. These data along with data collected in the past and future will provide the information necessary to evaluate the effects of aquatic plant management and other management activities on the lakes and their ecosystem.

PHYSICAL CHARACTERISTICS

Lower and Upper Clam Lakes are natural flowages of the Clam River in Burnett County, Wisconsin. Lower Clam Lake is the smaller of the two with a surface area of 366 acres, a maximum depth of 14 feet and mean depth of 7 feet (Table 2). Upstream and to the south is Upper Clam Lake with a surface area of 1,338 acres, maximum depth of 11 feet and mean depth of 5 feet (Table 2). The water level of both lakes is maintained by a water control structure on Lower Clam Lake (2).

Table 2: Lower and Upper Clam Lakes information

Characteristic – Upper Clam Lake	Data
Waterbody Identification Code	2656200
Surface area	1,338 acres
Volume	6,282 acre-ft
Maximum depth	11 ft
Mean depth	5 ft
Bottom Composition – muck	30%
Bottom Composition – sand	70%
Waterbody Type	Flowage
Hydrologic Lake Type	Drainage
Sub-basin	Upper St. Croix River
Watershed	Clam River
Sub-watershed	Clam Lake
Shoreline Distance	12.5 miles
Boat Landings	2

Characteristic – Lower Clam Lake	Data
Waterbody Identification Code	2655300
Surface area	366 acres
Volume	2,254.3 acre-ft
Maximum depth	14 ft
Mean depth	7 ft
Bottom Composition – muck	10%
Bottom Composition – sand	75%
Bottom Composition – gravel	10%
Bottom Composition – rock	5%
Waterbody Type	Flowage
Hydrologic Lake Type	Drainage
Sub-basin	Upper St. Croix River
Watershed	Clam River
Sub-watershed	Clam Lake
Shoreline Distance	3.8 miles
Boat Landings	1

UPPER CLAM LAKE

Depth soundings at Upper Clam's 668 survey points revealed the deepest areas in the lake occur in the middle of the central basin. This 7-9ft groove follows the river channel to the lake outlet on the north side. The southwest bay is a gently sloping flat that angles uniformly from 2 to 7ft towards the south end of the central basin. The southeast bays are also flats that slowly slope from 2 to 5ft before dropping off more rapidly into the central basin west of the islands. The 7-9ft main basin has steeper sides, midlake, and is generally bowl-shaped with the exception of a sand bar on the eastern shore just north of where the lake narrows. The many north side bays are mostly in the 2-6ft range and tend to slope gradually into the channel (Figure 5).

Bottom sediments in the southwest, south and both southeast bays were dominated by thick organic muck while the main basin was primarily sandy muck. We found pure sugar sand along the big island's shoreline, at the Clam River Inlet, on the midlake bar, and on the margins of the main basin. Of the lake's 668 points 578 (86.5%) were categorized as being muck or sandy muck and 90 (13.5%) as being pure sand (Figure 5).

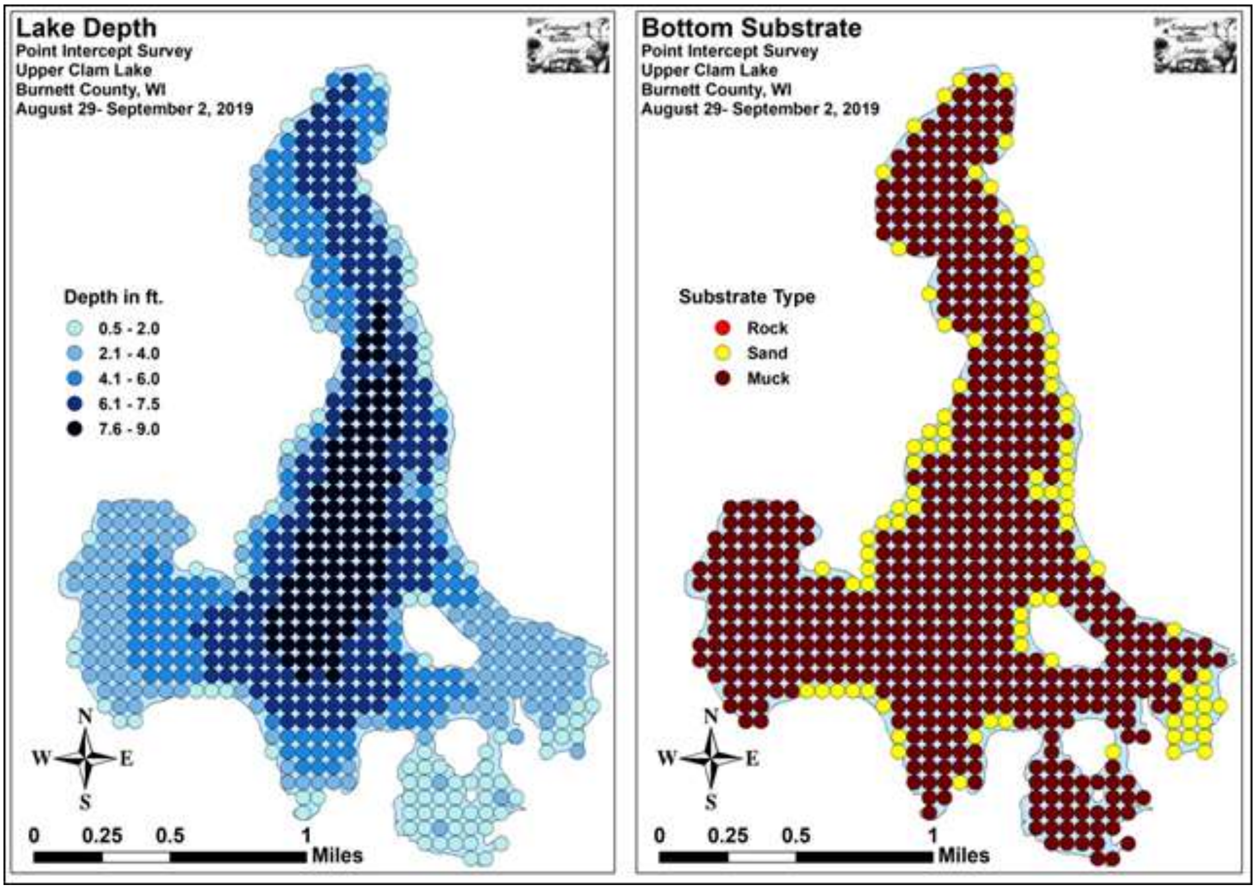


Figure 5: Lake depth and bottom substrate (Berg, 2019)

LOWER CLAM LAKE

Depth soundings at Lower Clam's 350 survey points revealed the deepest areas in the lake occur on the west side where the channel from Upper Clam cuts a 9-13ft furrow along the shoreline before turning to the northeast approximately 400 yards north of the Hwy 70 bridge. The central basin is a generally uniform 6-9ft bowl that gets gradually shallower moving west to east. The far south end of the eastern bay is a shallow 2-5ft flat that slopes towards the 6ft river channel that exits the lake in the northeast corner (Figure 6).

Sand dominated the majority of the nearshore lake bottom on Lower Clam on the north, west and south sides. This quickly transitioned to nutrient poor sandy muck at most depths beyond 4ft. Further to the east, this muck gradually thickened and became more nutrient rich; especially in the south end of the east bay. Of the lake's 350 points, 298 (85.1%) were categorized as being muck or sandy muck, and the remaining 52 (14.9%) as being pure sand (Figure 6).

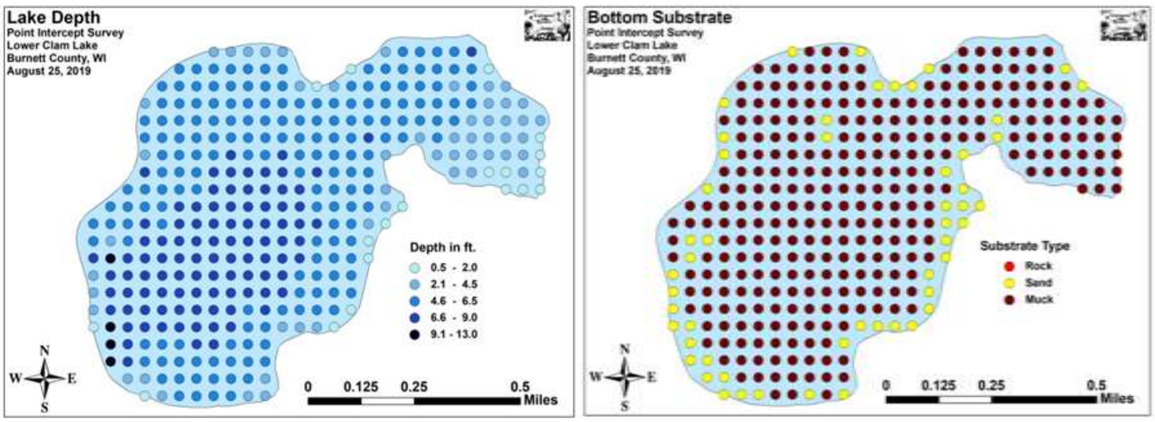


Figure 6: Lake depth and bottom substrate (Berg, 2019)

WATER QUALITY

Water quality data reviewed here was collected by SCTES between 2012 and 2019 on Upper Clam Lake and between 2012-2014. Data of interest are Secchi disk readings of water clarity (Secchi), total phosphorus (TP), chlorophyll-a (CHL), temperature (temp) and dissolved oxygen (DO). The two sites where the data was collected include Site in Upper Clam Lake, and Site 31 in Lower Clam Lake (Figure 7).

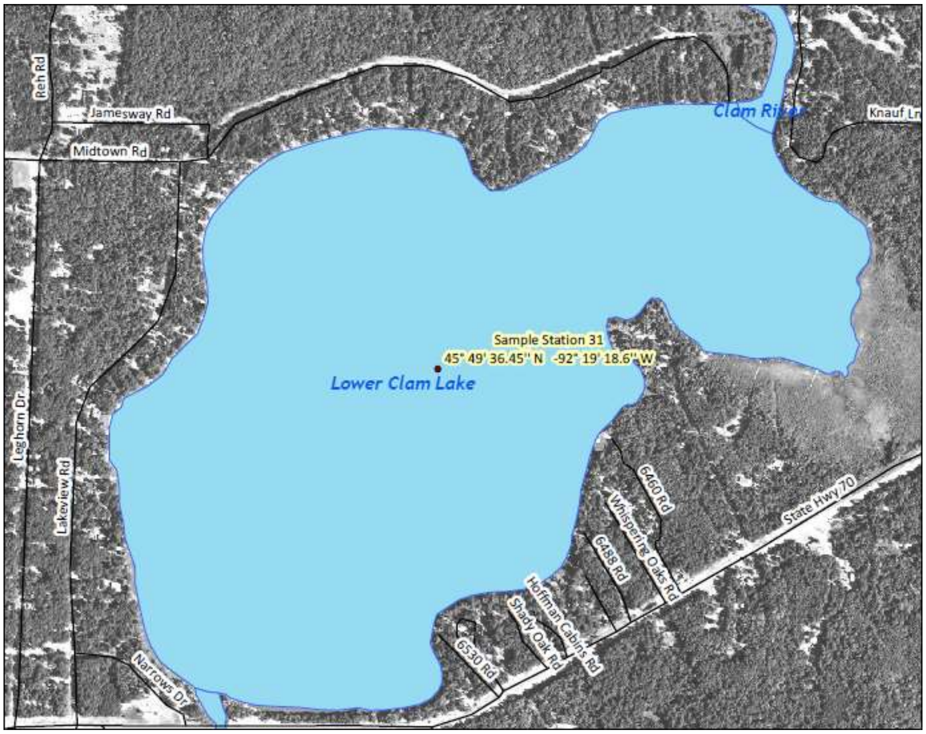


Figure 7: St. Croix Tribal water quality sampling sites on Upper (top) and Lower (bottom) Clam lakes

WATER CLARITY

Water clarity is a measurement of how deep sunlight can penetrate into the waters of a lake. It can be measured in a number of ways, the most common being an 8" disk divided into four sections, two black and two white, lowered into the lake water from the surface by a rope marked in measurable increments (Figure 8). 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.

Secchi depths vary throughout the year, generally with shallower readings in summer when algae become dense and limit light penetration and deeper readings in spring and late fall when algae growth is limited.

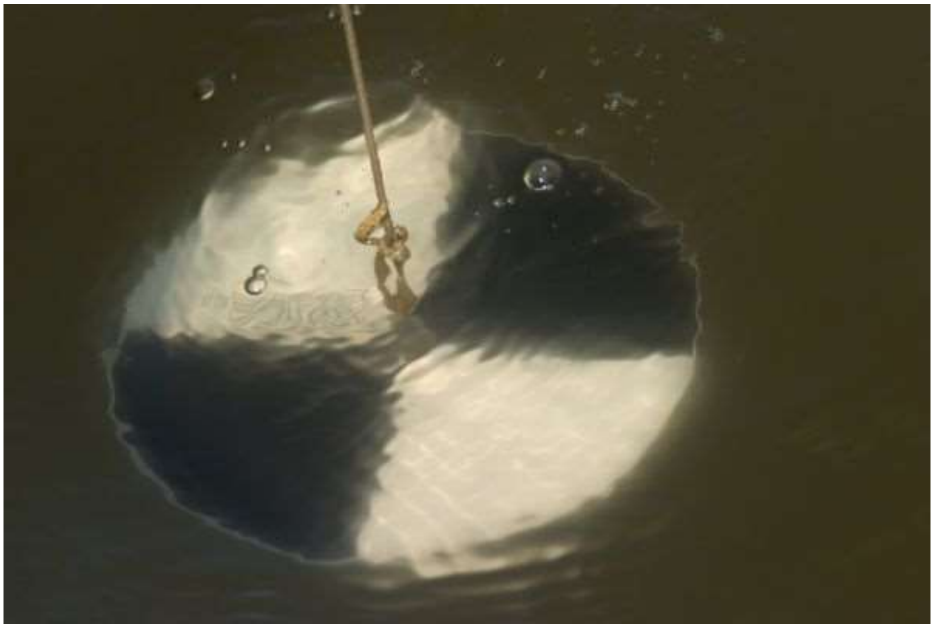


Figure 8: Black and white Secchi disk

Figure 9 reflects the mean summer (July and August) Secchi disk reading of water clarity in Upper Clam Lake from 2012 to 2019. The trend in summer Secchi readings indicates an improvement since 2012. Figure 10 reflects the individual monthly averages for those months where data was collected in every year from 2012 to 2019. The average of all the Secchi readings from 2012 to 2019 was 3.08-ft with a minimum reading of 1.25-ft and a maximum reading of 6.0-ft. Water clarity in 2017 based on all the readings taken, was well above average for the lake at 4.58-ft. At first glance this seems like an anomaly, however, both total phosphorus and chlorophyll-a concentrations were also down in 2017.

As is usually the case, water clarity declines as the summer season progresses. As water temperatures increase more algae grows. Boat traffic typically increases. All these things can reduce water clarity. The worst month for water clarity on Upper Clam Lake is typically August.

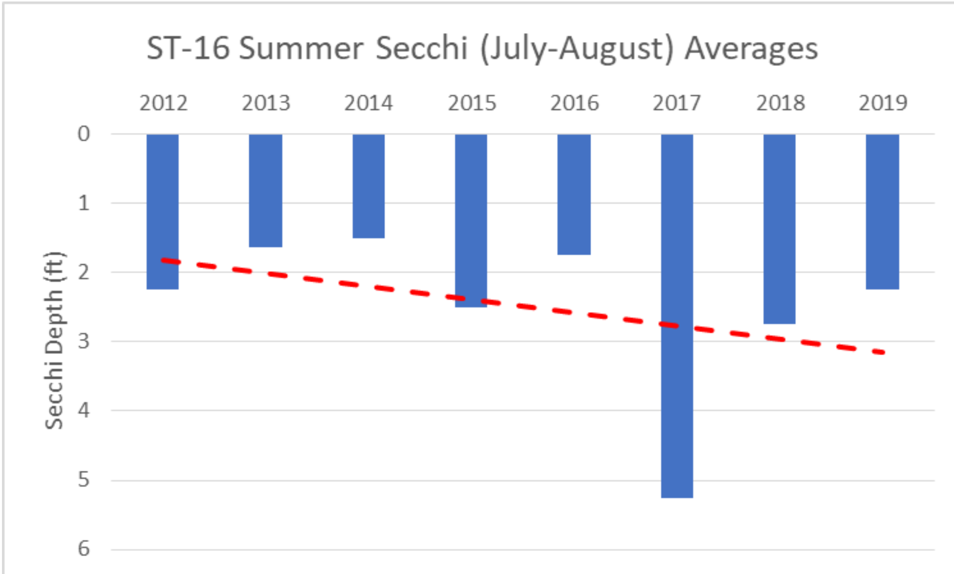


Figure 9: Summer (July and August) Secchi disk readings and trend line (red dash line) from Site 16 on Upper Clam Lake (SCTES)

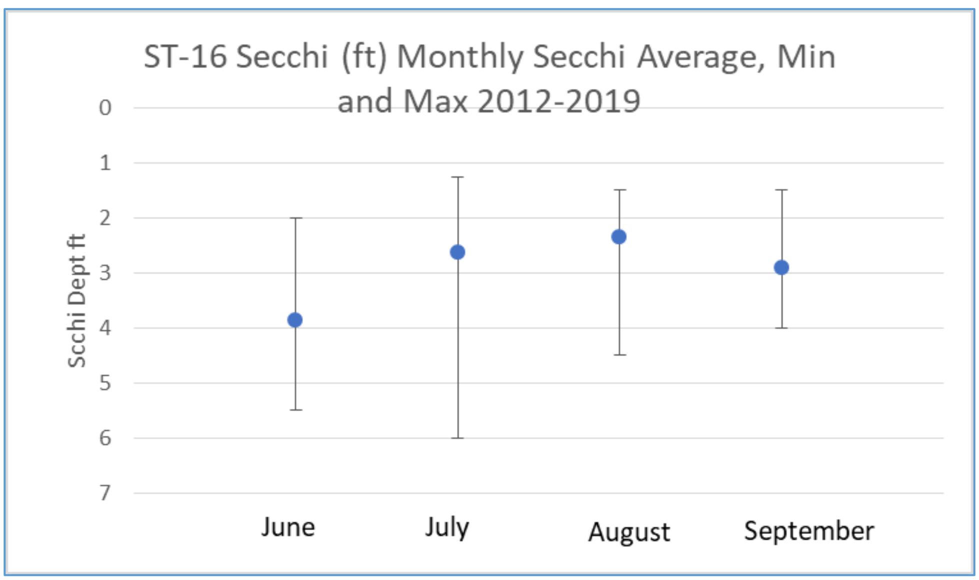


Figure 10: Monthly averages (blue dots) from June through September from 2012 to 2019 with minimum and maximum readings (SCTES)

There is less data available for the water quality monitoring (Site 31) in Lower Clam Lake. Data collected by the SCTES only covers 2012, 2013, and 2014 (Figures 11 & 12). In these three years, water clarity reflected a decreasing trend line. Since Lower Clam Lake is downstream of Upper Clam Lake, it is reasonable to assume that water clarity improved in Lower Clam like it did in Upper Clam after 2014.

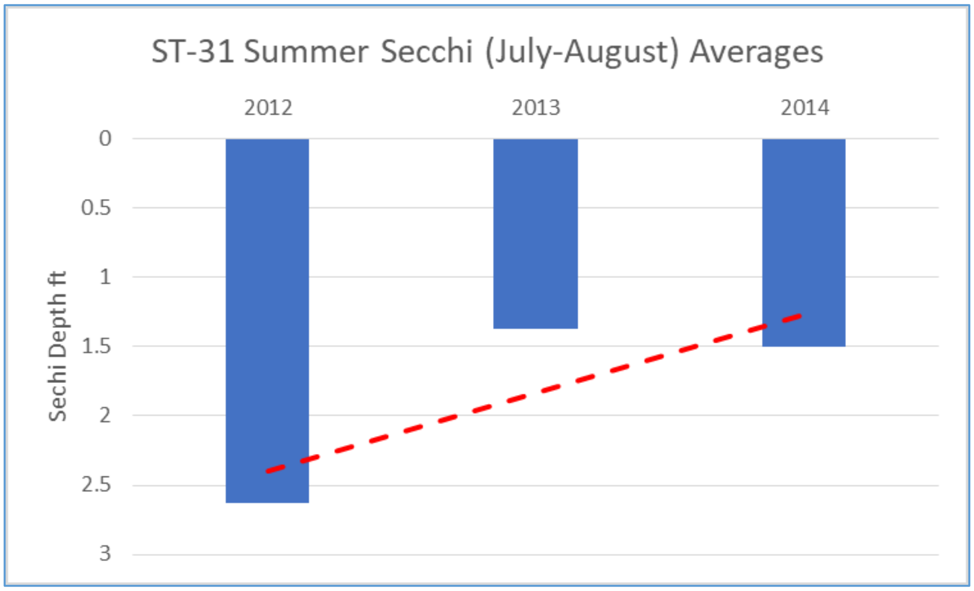


Figure 11: Summer (July and August) Secchi disk readings and trend line (red dash line) from Site 31 on Lower Clam Lake (SCTES)

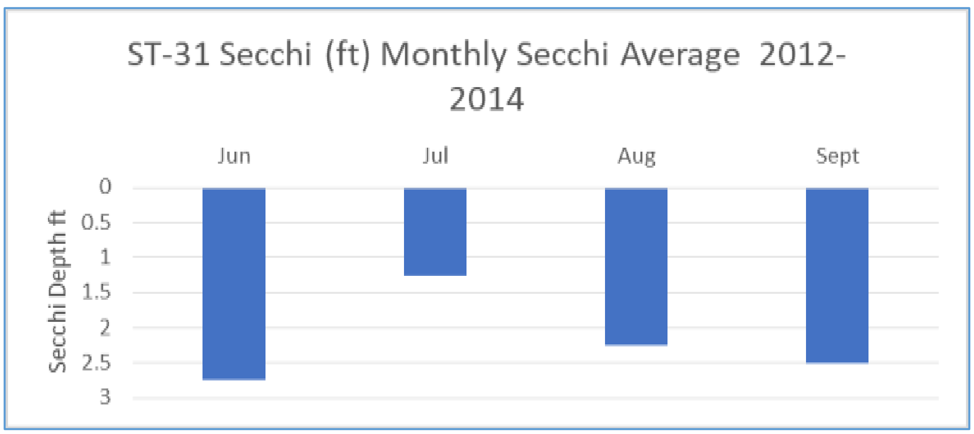


Figure 12: Monthly averages from June through September from 2012 to 2014 (SCTES)

TOTAL PHOSPHORUS AND CHLOROPHYLL-A

Two other water chemistry variables are frequently used to quantify water quality in a lake. Phosphorus is generally the limiting nutrient that is available in a lake that directly impacts the amount of aquatic plant and algae growth that exists in a lake. Total Phosphorus (TP) is a measure of both the phosphorus dissolved in that that is readily available to support algae growth, and the amount of particulate phosphorus found mostly in the sediment or suspended in the water column of the lake. Chlorophyll-a (CHL) is a measurement of the green pigment in the algae suspended in the water, so indirectly it is a measurement of the amount of algae in the water. The higher these two values are, the more eutrophic the lake is. Both TP and CHL are considered more accurate representations of the state of the overall water quality in a lake then Secchi readings alone.

Summer (July and August) TP and CHL averages on Upper Clam Lake from 2021 to 2019 reflect a positive trend of declining concentrations. Lower concentrations typically mean better water quality Figures 13 & 14).

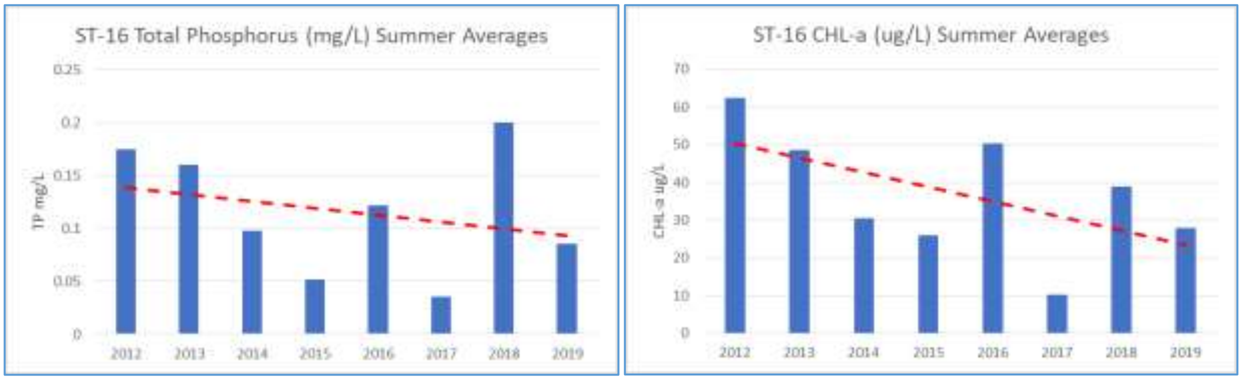


Figure 13: Summer (July-August) averages from 2012 to 2019 for TP (left) and CHL (right) for Upper Turtle Lake (SCTES)

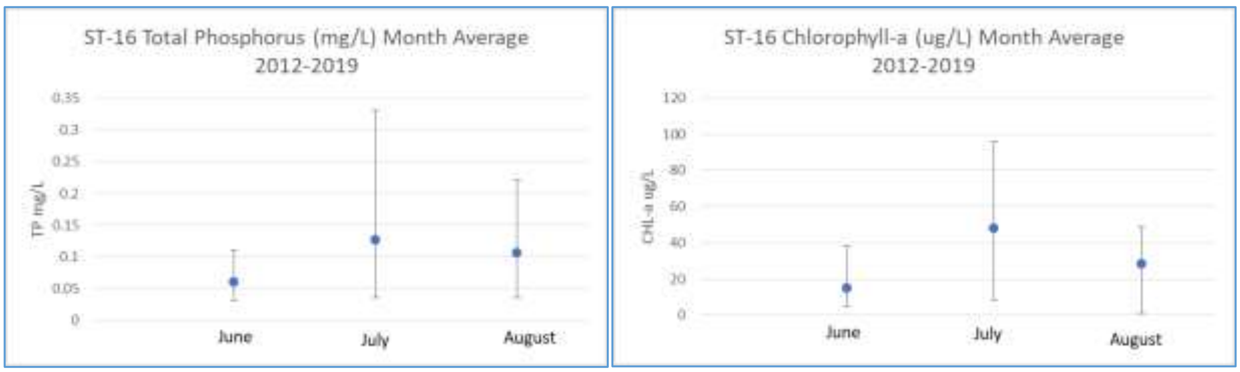


Figure 14: Monthly TP (left) and CHL (right) averages with minimum and maximum values for Upper Clam Lake (SCTES)

Secchi disk readings of water clarity, TP, and CHL data for Lower Clam Lake are limited to only three years in this document. But from 2012 to 2014 the amount of phosphorus and chlorophyll-a in the lake was presenting a decreasing trend (Figure 15). Lower concentrations are generally representative of improving water quality.

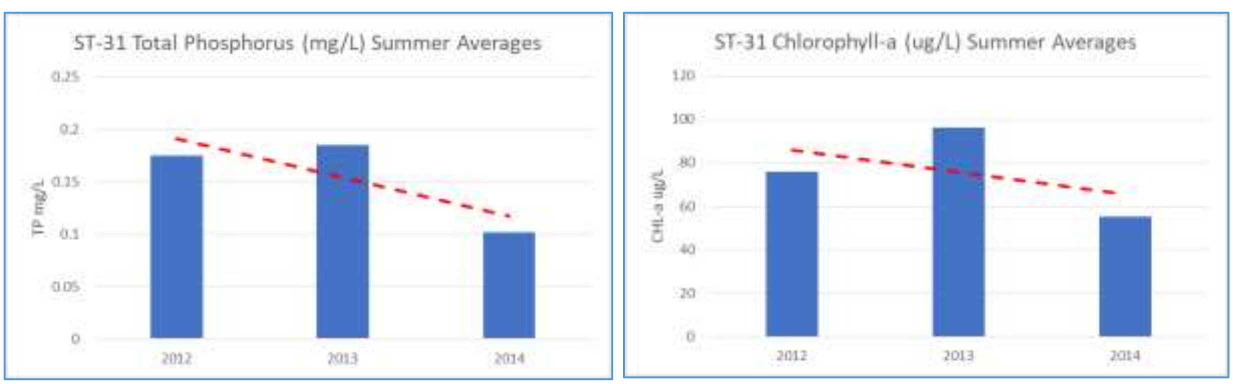


Figure 15: TP and CHL data for Lower Clam Lake

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 of Secchi depth, total phosphorus, and chlorophyll concentration. 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 16). 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.

Water quality data on both Upper and Lower Clam lakes classify them as eutrophic or nutrient-rich lakes.

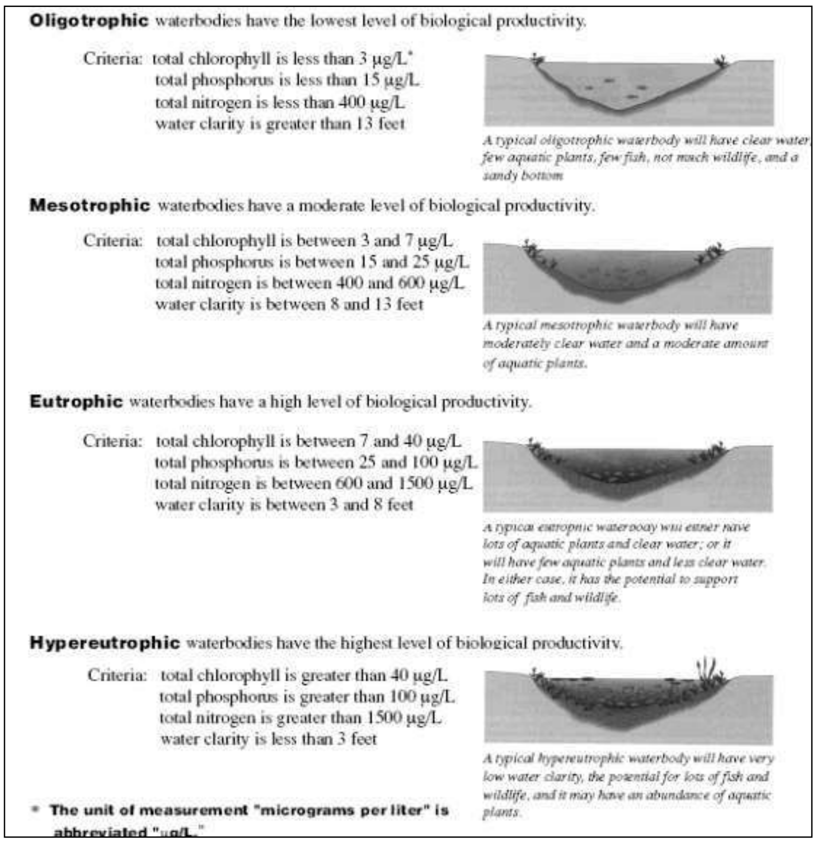


Figure 16: Trophic status in lakes

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, called stratification. When measuring oxygen and temperature at different depths in a stratified lake it becomes very evident that the top and bottom layers of the lake water are different. Shallow lakes like Upper and Lower Clam do not stratify during the summer months. Instead they remain mixed and when oxygen and temperature is measured at different depths they pretty much remain constant top to bottom. Figure 17 shows how mixing and stratification are different in shallow and deep lakes. Research conducted by (Boqiang, et al., 2020) shows that eutrophication (nutrient enrichment) is favored in shallow lakes, and while not the focus of this management document, if nutrient reduction were necessary to improve water quality, both phosphorus and nitrogen would likely need to be addressed.

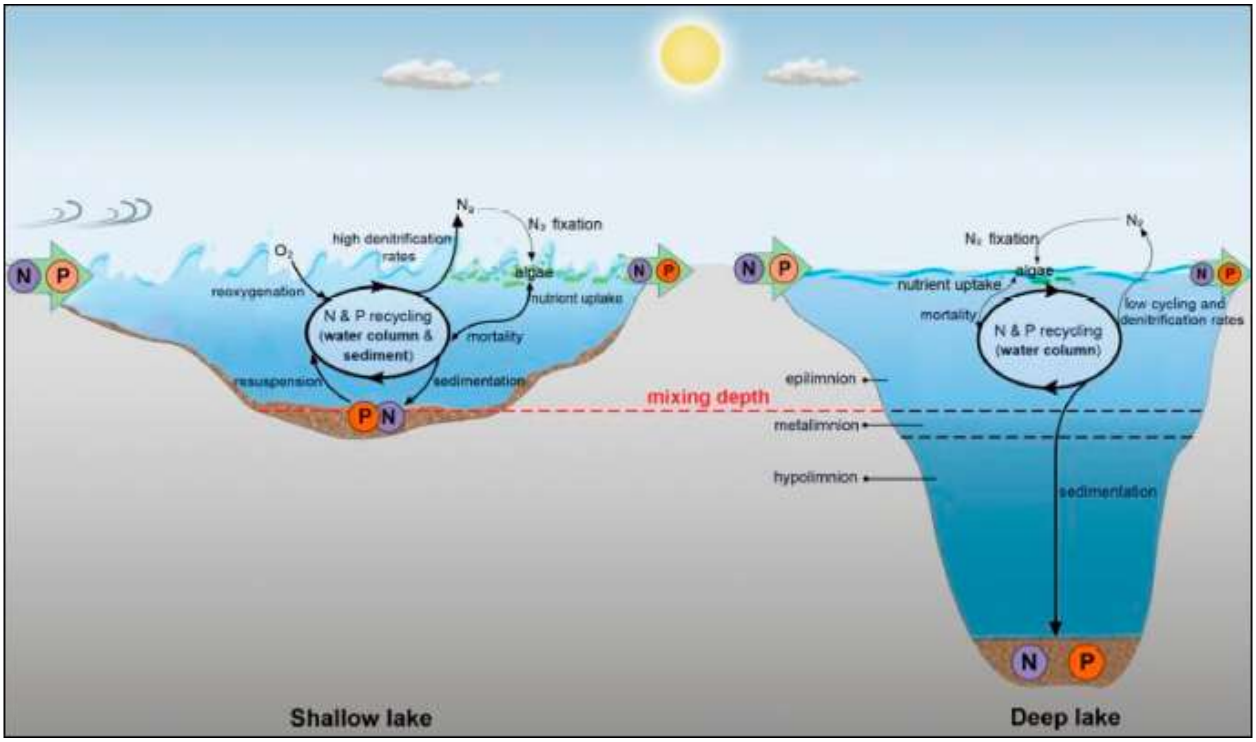


Figure 17: Shallow, summer, mixed lakes verses deep, summer, thermally stratified lakes (Boqiang, et al., 2020)

FISHERY

The Clam Lakes are generally considered a warm water fishery and historically has and continues to support a diverse fish community. WDNR and Tribal comprehensive fish surveys were completed in 1995, 2004, 2011, and 2017. Other smaller, more targeted surveys have been completed during that time frame as well. The Clam Lakes have not been stocked with any fish species since 1989.

The Clam Lakes fish community and ecosystem has shown that it can be very dynamic with drastic changes happening in a relatively short timeframe. This fact has been demonstrated by the large shifts in the fish, wildlife, and aquatic vegetation from 2005 to present. The Clam Lakes are considered eutrophic or highly productive lakes but can shift between two common states (turbid, algae-dominated water and clearer plant-dominated water) very quickly. The most recent survey in 2017 focused on assessing the gamefish and panfish populations in the lakes. A secondary goal was to assess the population of invasive common carp (Roberts, 2017).

The following paragraphs are taken from the 2017 Comprehensive Fishery Survey Report written by the WDNR (Roberts, 2017).

While the 2017 survey focused on the fisheries in the Clam Lakes, the implications of the data collected can suggest ecosystem changes that may occur in other parts of the system. The 2017 survey was the second survey since the common carp population increased dramatically in the Clam Lakes and drastically reduced the bluegill and wild rice densities. It was also the first survey following the large carp removals.

Walleye *in the Clam Lakes have shown that they can survive/thrive in a shallow turbid system. The population has naturally improved since common carp abundance increased in 2005 and seems to benefit from the high levels of turbidity. This scenario makes sense since walleye are low light predators and adapt well to lakes associated with a river (Bozek et al. 2011).*

Northern pike *densities have rebounded since the 2011 fish survey and they are now the most abundant piscivore in the lake. Their relative abundance increased by 64%. This dramatic increase suggests that aquatic vegetation used by northern pike for habitat/spawning has improved. If the amount of aquatic vegetation in the lake continues to improve, it is expected that the pike will increase or remain stable into the future.*

Largemouth bass *remain at low densities in the Clam Lakes. Bass catch rates were low prior to carp establishment based on the 2004 survey. However, the adult abundance appears to be at its lowest during 2017. Low numbers of bluegill, high turbidity, and poorer reproduction may explain the lower numbers of largemouth bass in the Clam Lakes. Bluegill are a very important prey item for largemouth bass and bass/bluegill densities effect the abundance and size structure of each species. Low bluegill abundance may be causing lowered bass abundance also. Turbidity is another potential issue, bass are sight predators so higher turbidity may limit their capability to feed. Common carp likely impact nest success by either predating on bass eggs, or reducing egg hatching with bottom disturbance.*

Smallmouth bass *appear to be at low densities in Clam Lake based on the past three surveys. They are likely transient in the lakes moving in/out of the Clam River.*

Channel catfish *abundance is difficult to estimate in the Clam Lakes. Electrofishing gave the best sample, even though it is generally considered less effective for channel catfish sampling than tandem hoop nets (Bodine et al. 2013). Based on the data collected, they appear to be at low densities in Clam Lake. Wendel (2011) noted approximately 1,000 catfish in a seine haul during a spring carp removal in 2011. It is possible that the catfish densities have decreased since that time.*

Bluegill *relative abundance has improved since 2011. This increase in abundance is fragile, with most bluegill being two years old. The bluegill have likely benefitted from a recent increase in aquatic vegetation (i.e. bluegill habitat). However, the bluegill catch is still lower than pre-carp densities, especially for bluegill 6 in or greater. Bluegill growth continues to be very good in Clam Lake, with fish growing to 6 in in three growing seasons. This excellent growth is tied to high productivity, but also suggests that bluegill densities are still low in Clam Lake. Bluegill are the most important panfish in the lake for potential carp control. Bajer et al. (2012) have documented the importance of bluegill for controlling common carp populations in the Upper Midwest. For Clam Lake to reach a full recovery, it will require a healthy and abundant bluegill population.*

Black crappie *abundance decreased since 2011. This change indicates that conditions are becoming less favorable for crappie. Rypel (et al. 2018) found that black crappie can do well in a dark/turbid system in Wisconsin. Recent reduced crappie electrofishing and fyke net CPEs may support a recent shift toward clearer water/more aquatic vegetation.*

Yellow perch *densities have increased greatly since 2011. This response may be tied to more available vegetation for spawning habitat.*

The current instability of clear/turbid states in the Clam Lakes makes black crappie and yellow perch population trends difficult to predict.

The adult ***common carp*** *population appears to be at low levels based on the 2017 fisheries survey of the Clam Lakes. This decline is a large shift from 2011, where carp were prevalent in netting and electrofishing samples. Based on aging data, the 2005-year class continues to be the most common in Clam Lake, suggesting this one year-class is still having a strong impact 12 years later (in 2017). It also appears that the remaining adults have produced a very large year class in 2017. The DNR mini-fyke CPE of 33.2 carp/net night is the highest that has been recorded since the first DNR mini-fyke net survey in 1995. In addition, experimental mini-fyke sets placed by SCE recorded CPEs as high as 400 fish/net night in 2017 (SCE unpublished data). These findings suggest that common carp will likely/could become abundant again in Clam Lake.*

Despite the presence of common carp, the Clam Lakes continue to support a very diverse fish community. Gamefish include: walleye, northern pike, largemouth bass, smallmouth bass, channel catfish, lake sturgeon, and brown trout (present during winter season). Panfish include: bluegill, black crappie, yellow perch, pumpkinseed, and rock bass. Other common species include: bowfin, redhorse species, bullhead species, and white sucker. Fishing regulations in the Clam Lakes have generally followed statewide regulation (Table 3).

Table 3: General fishing regulations for Upper and Lower Clam Lake in 2016 (Roberts, 2017)

Fish Species	Daily Limit	Minimum Length (in)
Walleye	3	15, 20-24 protected, 1 fish > 24
Largemouth and Smallmouth Bass	5	NONE
Northern Pike	5	NONE
Channel Catfish	10	NONE
Panfish	25	NONE

Based on the findings in the 2017 fisheries survey, the following fisheries management recommendations were made (Roberts, 2017). The exact verbiage of these recommendations may have been modified by the author of this plan, but the intent of the original verbiage is still intact.

- Work with St Croix Tribe, Resorts, Anglers, and other interested stakeholders to develop a Clam Lakes Fisheries Management Plan.
- Maintain the current Ceded territory regulation for walleye harvest in the Clam Lakes.
- Promote the increased presence of northern pike as a new harvest opportunity for anglers.
- Make no regulation changes for largemouth and smallmouth bass.
- Because bluegill densities have improved, but their recovery is still in a fragile state, manage the lakes in a way that will protect and improve their recovery.
- No special recommendations need to be made as result of decreased black crappie densities, increases in perch densities, or the population of channel catfish in the lakes.
- Adult common carp appear to be at a low density, management activities should strive to maintain this low density.
- Habitat preservation/reestablishment should be encouraged.
- Preventing the establishment of new invasive species and monitoring of established invasive species should continue.

BLUEGILLS AND CARP RECRUITEMENT

In the Clam Lakes it appears that the population of bluegills is directly related to the success of carp recruitment in them, and is one key to maintaining a healthy lake system that is never again impacted by carp the way it was between 2005 and 2011. Dr. Przemek Bajer, a carp researcher at the University of Minnesota has played a major role in research that supports how bluegills can be used to control common carp. Bluegills are voracious feeders on both carp eggs and larvae and their abundance in a lake can be a significant factor is keeping carp populations in check. Though Dr. Bajer, and others like him, have done extensive research on the relationship between carp and bluegills, none of his work is referenced here. But it should be mentioned that the Clam Lakes have been a part of his research since the late 2000's when the first issues with carp were documented.

DEVELOPMENT OF A FISHERIES MANAGEMENT PLAN FOR THE CLAM LAKES

The idea of developing a fisheries management plan for the Clam Lakes has been discussed several times during this project. But when asked about it, the WDNR felt that the Aquatic Plant Management plan was going to be more integral to the lakes' management than the fisheries. Further, the WDNR agreed that common carp are a driving factor in the aquatic plants and their density, but some aspect of the fisheries remains good in either the clear or turbid state. During the clear state, the lake was excellent for panfish. More recently, in the turbid state, the lake became good for walleye and channel catfish. The Fisheries Manager for the Clam Lakes realizes anglers and shore owners want a happy medium, but did not think that this was a realistic goal. So, due to the complexities related to Clam Lake, it was the opinion of the WDNR that they would not be drafting a fisheries management plan for the lakes.

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 changes over time 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.

Fortunately, remediation of this habitat type is attainable on many waterbodies, particularly where private landowners and lake organizations are willing to partner with county, state, and federal agencies. Large-scale CWH projects are currently being conducted by lake groups and local governments with assistance from the WDNR where hundreds of whole trees are added to the near-shore areas of lakes. For more information on this process visit: http://dnr.wi.gov/topic/fishing/outreach/fishsticks.html (last accessed on 1-4-2018). These types of projects are more formally called "tree drops" but are popularly are called "fish sticks" (Figure 18).

Figure 18: Coarse woody habitat-Fishsticks projects

Since the decline of aquatic plants, correlating with a decline of panfish in the lakes, more attention is being paid to CWS in the Clam Lakes. In 2013, twelve "Fishsticks" structures at four different sites were installed by SCTES, the WDNR, and the CLPRD. These entities should continue focusing on protecting existing CWS in the lakes and adding it through Fishsticks and similar projects. Individual property owners should be encouraged to leave CWS in the lakes, unless it is causing hardship.

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 19 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 3-15-2019).

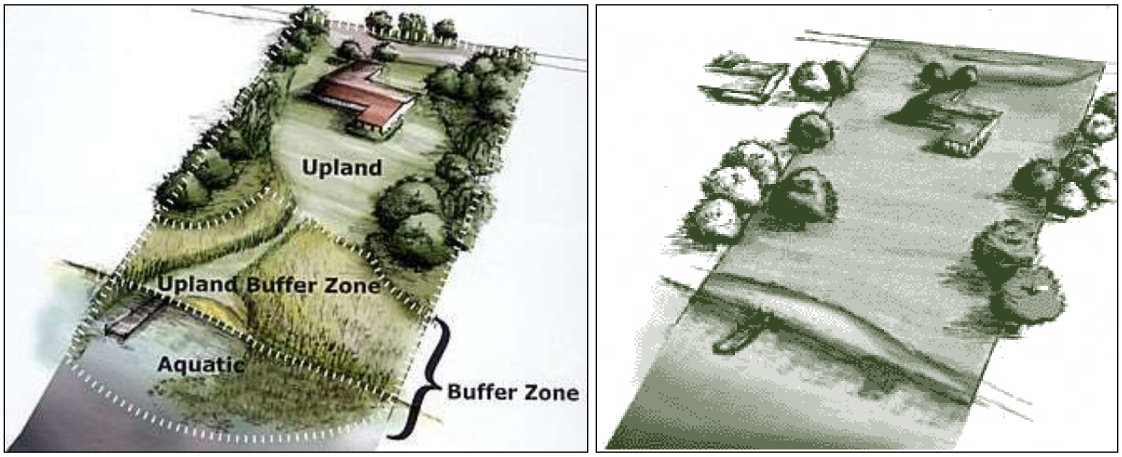


Figure 19: Healthy, AIS Resistant Shoreland (left) vs. Shoreland in Poor Condition

SHORELINE INVENTORY

In the summer of 2010, a shoreline inventory survey was completed on the Clam Lakes. During the survey the entire shoreline was patrolled with a small craft, placing GPS points at the beginning and end of several designated shoreline uses. Disturbed shoreline was divided into lawn and impervious surface sub categories; natural shoreline was divided into forest, prairie, shrub, wetland, and open water subcategories. In addition, the existence of buffer strips and rip rap; the presence of emergent aquatic vegetation, and sites with substantial erosion were all documented. GIS mapping was then used to place these points on a map of the lakes. Shoreline status was determined for Upper, Lower, and the two miles of river outlet.

Table 4 shows the breakdown of this shoreline survey. More than 35% (7.25 miles out of nearly 21 miles) of the shoreline of the entire system is mowed lawn or impervious surface right to the water's edge. Approximately 6% (1.2 miles) of the shoreline has rip rap in place. More than 60% of the property around Lower Clam is mowed to the water's edge, much higher than the 28% and 30% on Upper Clam and in the river respectively. Emergent vegetation was identified as being present around 61% of the entire shoreline.

A little more than 71% of the shoreland on Upper Clam Lake is natural; 68% of the river outlet is natural; and only 38% of the shoreland on Lower Clam Lake is in a natural state. Wetlands make up the largest piece of the natural shoreline on Upper Clam; shrubs are the largest part of the natural shoreline on Lower Clam, and forests make up the largest piece of the natural river shoreline.

Table 4: Shoreline status categories: % coverage and miles of shoreline on the Clam Lakes. Note: The Other category overlaps with the Disturbed and Natural categories (e.g. a shoreline segment may have Lawn and Riprap).

Land Use		Upper (%)	Miles	Lower (%)	Miles	River (%)	Miles
Disturbed	Impervious	0.4%	0.05	0.7%	0.03	1.6%	0.06
	Lawn	28.2%	3.68	60.3%	2.43	29.5%	1.10
Natural	Forest	12.1%	1.58	10.7%	0.43	45.6%	1.71
	Prairie	0.1%	0.01	0.0%	0.00	0.0%	0.00
	Shrub	24.0%	3.13	14.3%	0.58	17.8%	0.67
	Wetland	35.1%	4.59	13.0%	0.52	4.6%	0.17
	Open Water	0.3%	0.03	1.1%	0.04	0.8%	0.03
Other	Buffer	8.6%	1.13	10.7%	0.43	6.4%	0.24
	EAV	69.1%	9.04	45.6%	1.84	50.7%	1.89
	Erosion	1.3%	0.16	3.2%	0.13	13.9%	0.52
	Rip rap	4.2%	0.55	15.1%	0.61	1.2%	0.05

EAV: Emergent Aquatic Vegetation

Source:2010 Shoreline Survey, SEH

NEARSHORE AREA LAND USE

In addition to the shoreline survey, a band of the nearshore area from the water's edge inland 200-ft was evaluated for land use. The land use was assessed using recent high resolution (6-inch) ortho-photos and GIS. Land use was classified as disturbed (lawn, impervious surface) or natural (forest, wetland). More than 500 acres was evaluated around Upper and Lower Clam Lakes and the river outlet.

Wetlands make up the largest piece of the nearshore area at 38%, most of which is located on the southern third of Upper Clam Lake. Mowed lawn makes up the second largest piece at 31%. When combined with impervious surfaces including roads, rooftops and driveways 37% of the nearshore area is in a disturbed state. Natural forest cover and open water make up the remaining 25% of the total land use in the nearshore area. Figure 20 shows the distribution of land use in the 200-ft nearshore area. The majority of mowed lawn is on the east and west shores of Upper Clam, and essentially all the way around Lower Clam.

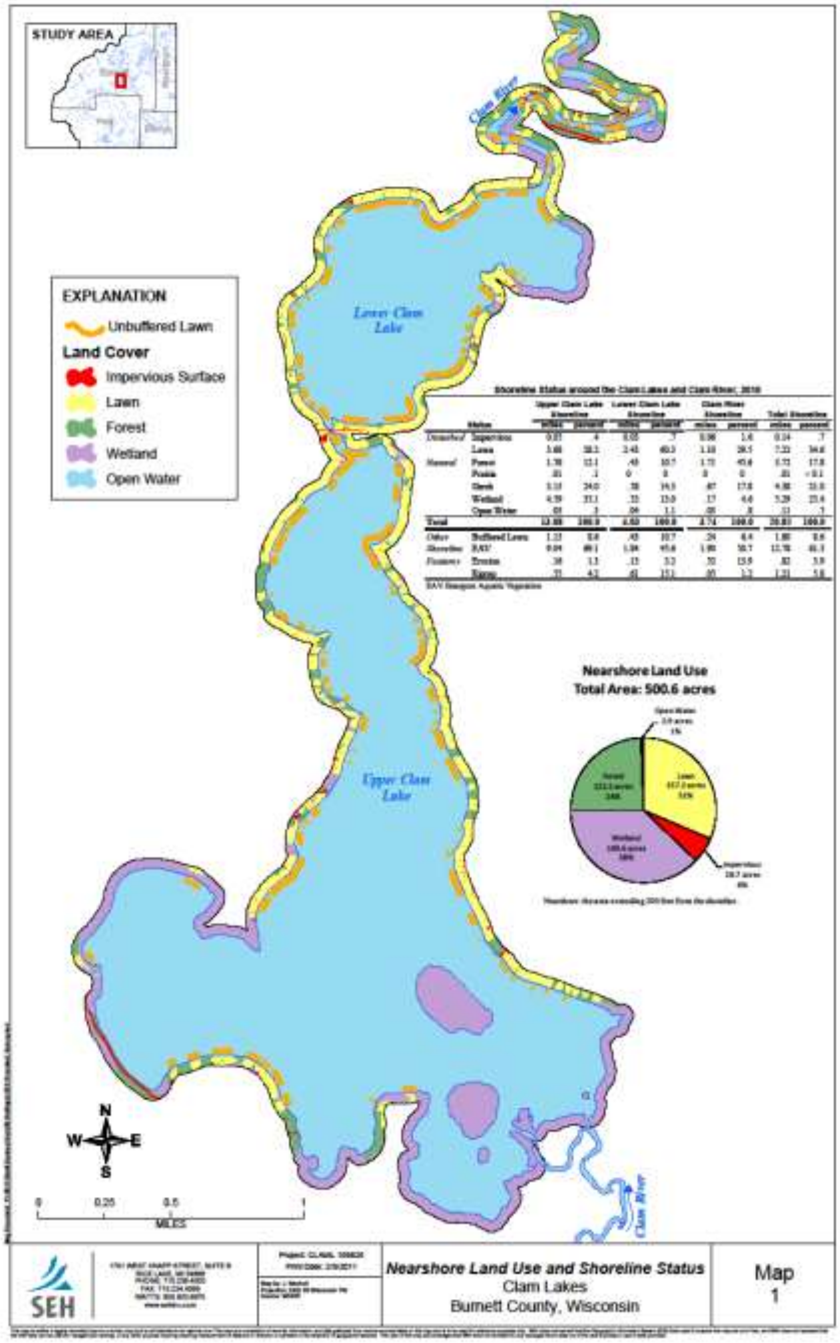


Figure 20: Nearshore land use in a 200-ft band around the Clam Lakes (SEH, 2010)

Property owners should be encouraged to participate in the Burnett County Shoreland Incentive Program and/or a Lakeshore Education Specialist could be employed by the CLPRD to identify and work with shoreline property owners interested in shoreland improvement planning and possible implementation of restoration plans on their properties. Planning and implementation could be expedited if money was made available to hire a shoreland consultant to complete planning for these landowners and if there were incentives to implement the projects once the planning was complete. This service should be made available to any property included in the boundaries of the CLPRD.

BURNETT COUNTY SHORELINE INCENTIVES PROGRAM

The Burnett County Land and Water Conservation Department provides incentives to encourage restoring or preserving waterfront as natural shoreline. Over 600 parcels have been enrolled in the Burnett County Shoreline Incentives Program since it began in 2000. Owners of these parcels receive and annual property tax credit in return for ensuring permanent protection for the shoreline zone. Incentives provided for each parcel enrolled in the Shoreline Incentives Program are as follows:

- An annual property tax credit of $50
- An enrollment payment of $250
- A free visit with a natural landscape expert
- Planting plans to restore a natural shoreline
- Payments that cover 70% of the cost of plants and materials
- An exclusive shirt or cap that identifies you as a Shoreline Incentives participant
- An optional sign to post at the water's edge

There are currently 15 parcels on the Clam Lakes already enrolled in the Burnett County Program, and another 14 parcels along the Clam River (Burnett County, personal communication, Feb. 2014). New property owners interested in being a part of this program can find more information at https://www.burnettcounty.com/index.aspx?NID=1123 (last accessed on August 8, 2020).

AQUATIC PLANTS

Aquatic plants are an often misunderstood and under-valued part of lakes and rivers. Though many people would rather not have them in their favorite swimming spot or fishing hole, native aquatic plants provide varied environmental benefits to many lakes. Aquatic plants are a food source for many animals. Aquatic plants provide important habitat for small animals like aquatic insects, snails and freshwater shrimp, which in turn supply food for fish and waterfowl. Young fish and amphibians use aquatic plants for cover from predatory fish and birds. Aquatic plants provide important nurseries for young fish, frogs and salamanders. Sturdy emergent plants provide many birds and mammals with material for nests and dens. Humans construct baskets, mats, boats and even dwellings from cattail, rush and bulrush stems. Submersed and emergent plants protect shorelines from erosive wave action or currents. They also help keep sediment on the lake bottom, which increases water clarity. Aquatic plants are a vital part of the complex system of chemical cycling in a lake, and can influence oxygen supply in the water. Aquatic plants can also soak up pollutants from contaminated water. And, if all of that wasn't enough, a diverse healthy native plant community is better able to repel invasion by opportunistic exotic weeds like Eurasian watermilfoil.

In a review of fish and aquatic plant literature completed by the Food and Agricultural Organization (FAO) of the United Nations in 2000, entitled *Interactions between Fish and Aquatic Macrophytes in Inland Waters, A Review* (Petr, 2000) the following list of aquatic plant characteristics which make them important to fish was referenced:

- Water purification,
- Nutrient recycling,
- Physical link between water and air for many invertebrates,
- Refuge for zooplankton,
- Cover for invertebrates,
- Cover for fish,
- Spawning areas and sites of oviposition (egg laying),
- Direct food source,
- Affect flow patterns favorable for fish, and
- Create discrete habitat and physical structure.

Problems with Aquatic Plants

The native aquatic plant community in the Clam Lakes has staged a comeback after nearly complete devastation by an over-abundant carp population a few years back. This comeback benefits the Clam Lakes for all the reasons above, but it is not all positive. Issues become apparent when plant density/growth impedes recreational activities like general lake access, boating, and swimming. When growth becomes very thick, the density can also harm some fish by contributing to low dissolved oxygen levels at night, or by hampering the search for food or avoidance of predators.

Very dense native plant growth is usually caused by an overabundance of nutrients from multiple sources. Increased nutrient levels can accelerate the natural process of lake aging (eutrophication), increasing plant and algal growth. Once nutrients are in a lake, they can persist for decades before being flushed out, fueling plant and algae growth even after nutrient sources outside the lake have been addressed.

Additional problems arise when non-native, invasive plant species get introduced and established in a lake. This often happens when recreational users unknowingly carry plants from one waterbody to another, or when someone discards aquarium plants into a lake. Exotic species like Curly-leaf pondweed and Eurasian watermilfoil are aggressive; creating large mats of vegetation that can crowd out more desirable native vegetation and create greater nuisance conditions.

AQUATIC PLANT SURVEYS – UPPER CLAM LAKE

Using a standard formula that takes into account the shoreline shape and distance, water clarity, depth, and total acreage, Jennifer Hauxwell (WDNR) generated the original 668 point sampling grid used for Upper Clam Lake aquatic plant surveys in 2009, 2012, 2014, 2015, and 2016. This same grid was used by Endangered Resource Services (ERS) in 2019 for a cold-water CLP survey and a warm-water summer PI survey of all aquatic plants. During each survey, all survey points were located using a handheld mapping GPS unit (Garmin 76CSx) and a rake was used to sample an approximately 2.5ft section of the bottom. When found, CLP and other aquatic plants were assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 21). Visual sightings of CLP and aquatic plants within six feet of the sample point were also noted.

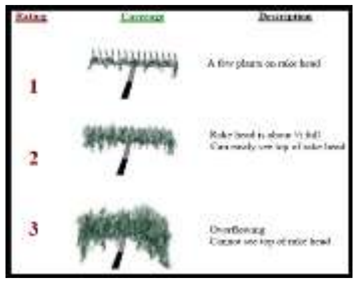


Figure 21: Rake fullness rating (UWEX 2010)

CURLY-LEAF PONDWEED POINT-INTERCEPT SURVEY

During the 2019 early-season point-intercept survey all 668 points were rake-sampled with CLP found at 8 sites. This extrapolated to 1.0% of the entire lake and 1.1% of the 9.5ft spring littoral zone having at least some CLP present. Of the 8 sites with CLP, none rated a rake fullness value of 3, 1 was a 2, 6 were a 1, and 1 was just a visual, for a combined mean rake fullness of 1.14 (Figure 22). The single point with a rake fullness of a 2 or a 3 suggested 0.1% of the entire lake and 0.2% of the spring littoral zone had a significant infestation.

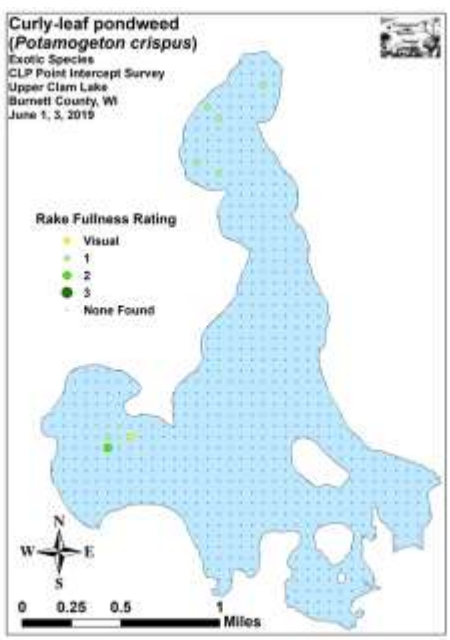


Figure 22: 2019 Early-season CLP density and distribution (Berg, 2019)

Comparisons of CLP in 2009, 2014, and 2019

The 2009 spring Curly-leaf pondweed point-intercept survey found CLP at 33 sites which approximated to 4.9% of the entire lake and 5.0% of the estimated spring littoral zone. Of these, a rake fullness value of 3 at 3 points, a 2 at 10 points, and a value of 1 at 20 points were recorded for a mean rake fullness of 1.48 (Figure 23). The combined 13 points with a rake fullness of 2 or 3 extrapolated to 1.9% of the entire lake and 2.0% of the estimated littoral zone having a significant infestation.

In June of 2014, CLP wasn't present in the rake at any point. The declines in total density and distribution; rake fullness 3 and 2; and the increase in rake fullness 1 were either moderately or highly significant (Figure 23).

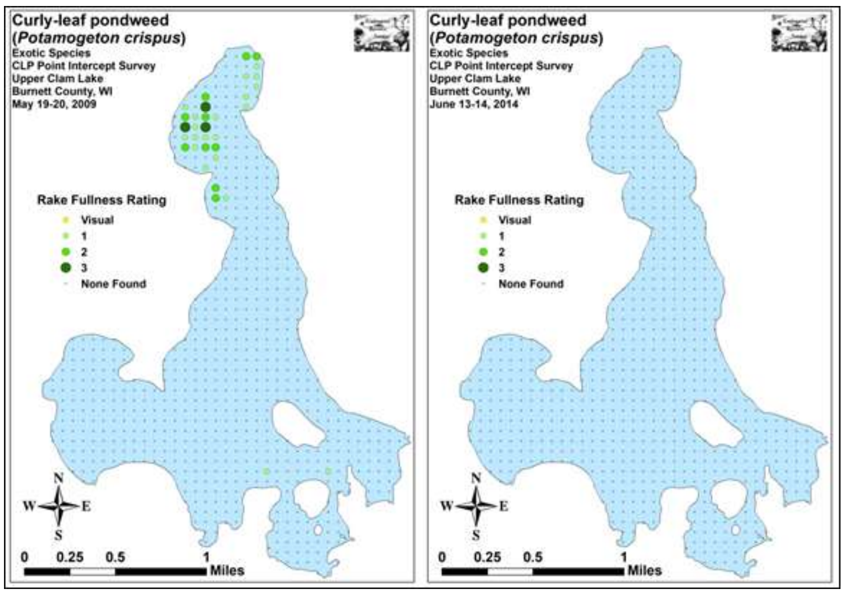


Figure 23: 2009 and 2014 early-season CLP density and distribution (Berg, 2019)

Compared to 2014, the 2019 survey represented a highly significant increase in mean density; a moderately significant increase in total distribution; and a significant increase in rake fullness 1. However, when compared to 2009, the 2019 results show total CLP sustained a highly significant decline in distribution; a moderately significant decline in rake fullness 2 and 1; and a significant decline in mean density. Collectively, the 2019 data suggests CLP is still both less widely distributed and less abundant than it was in 2009 (Figure 24).

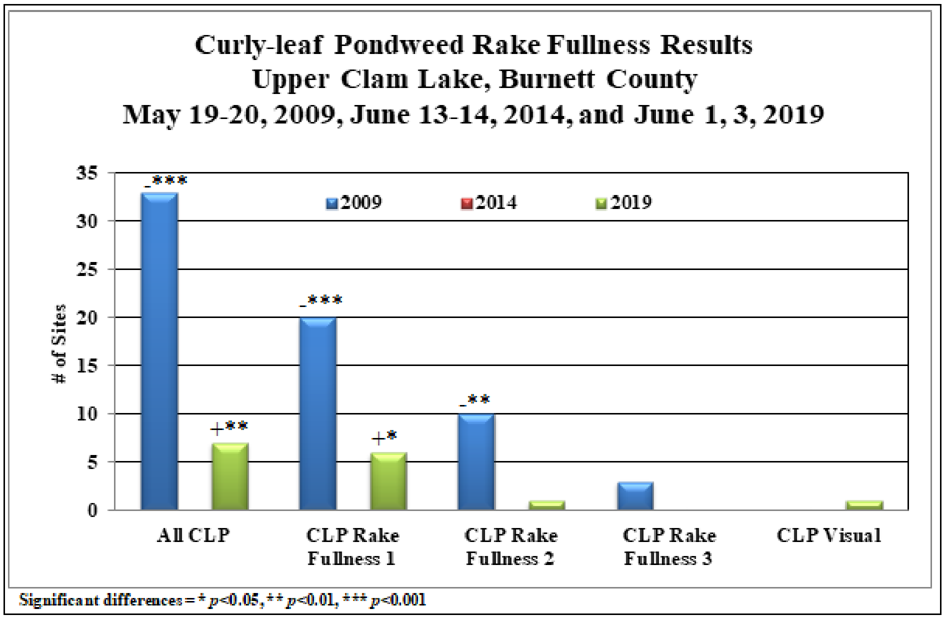


Figure 24: 2009, 2014, and 2019 changes in early-season CLP rake fullness (Berg, 2019)

CURLY-LEAF PONDWEED BED MAPPING SURVEY

CLP bed mapping was also completed in 2009, 2014, and 2019 during mid-June when CLP is usually canopied at the surface of the lake. During abed mapping survey, the lake's entire visible littoral zone is searched for the target species. By definition, a "bed" is determined to be any area where CLP is visually estimated to make up >50% of the area's plants, is generally continuous with clearly defined borders, and is canopied, or close enough to being canopied that it would likely interfere with boat traffic.

In 2009, two beds of CLP were mapped in the lake's northeast bay (Figure 25). Although they covered 2.62 acres (0.2% of the lake's 1,338 acres), it was noted that few of the plants in the beds were truly canopied, and neither bed seemed likely to cause significantly navigation impairment.

Following a dramatic reduction in CLP levels, neither the 2014 point-intercept or the shoreline bed mapping surveys found any evidence of CLP in the lake (Figure 25). However, by 2015, scattered plants started reappearing near the river inlet, and the 2019 bed mapping survey located ten beds totaling 5.19 acres (0.4% of the lake's surface area) – a 98.1% increase over 2009. Despite this, most of these "beds" were better described as patches because all but one was <0.50 acre, they had large numbers of native plants mixed in, and they likely caused no or only minor impairment over the majority of the area.

While no bed mapping was completed in 2020, CLP was present in similar levels of density and distribution based on observations by members of the Lake District and their consultant.

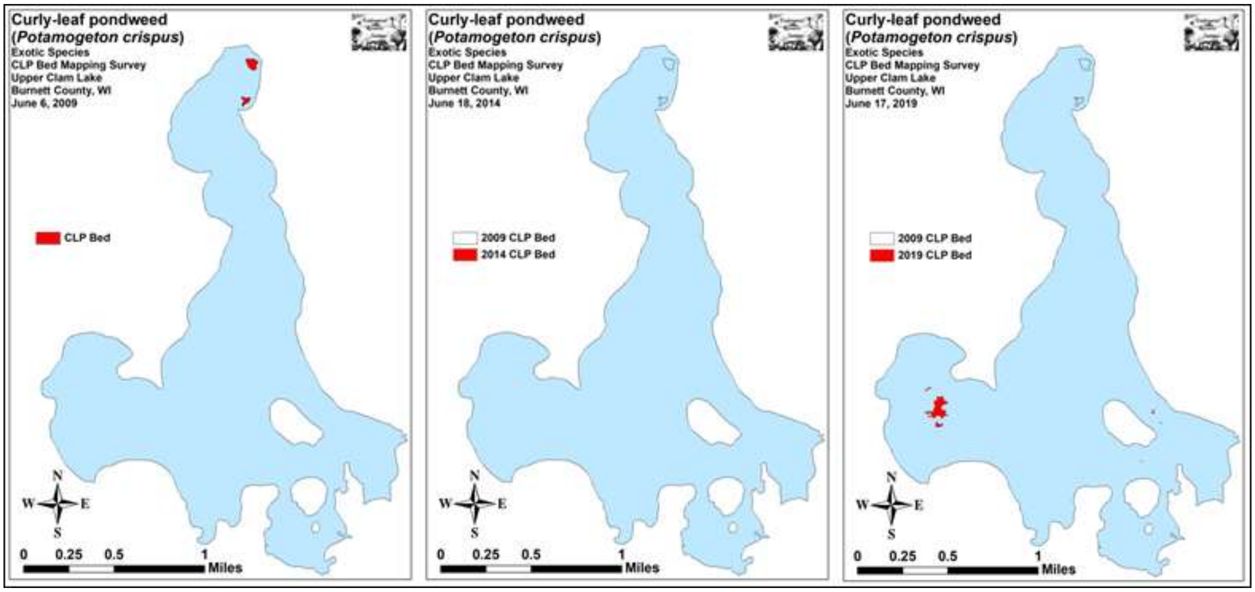


Figure 25: 2009, 2014, and 2019 early-season CLP Beds

WARM-WATER FULL POINT-INTERCEPT MACROPHYTE SURVEY – UPPER CLAM

At the time of the 2019 survey, water clarity readings were in the 2-3ft range. This very poor water clarity produced a littoral zone that extended to 8.5ft and included 667 of the lake's 668 survey points (Figure 26). This was a highly significant increase compared to the 523 littoral points in 2016's 7.5ft littoral zone and 2009's 8.0ft littoral zone, which prior to the 2019 survey, had the most littoral points.

In the 2019 survey, plants were found at 605 points (90.6% of the bottom and 90.7% of the littoral zone). This was a highly significant increase over any of the previous survey results including 2009, when 218 points had aquatic plants on the rake. Growth in 2019 was slightly skewed to shallow water as the mean plant depth of 5.2ft was less than the median depth of 5.5ft. Both of these values were higher than in any other survey dating back to 2009, suggesting that vegetation is spreading back into deeper water, a trend that would be nice to continue, but is at risk with the increase in CLP.

Plant survey statistics from the 2019 and all previous surveys are shown in Table 5.

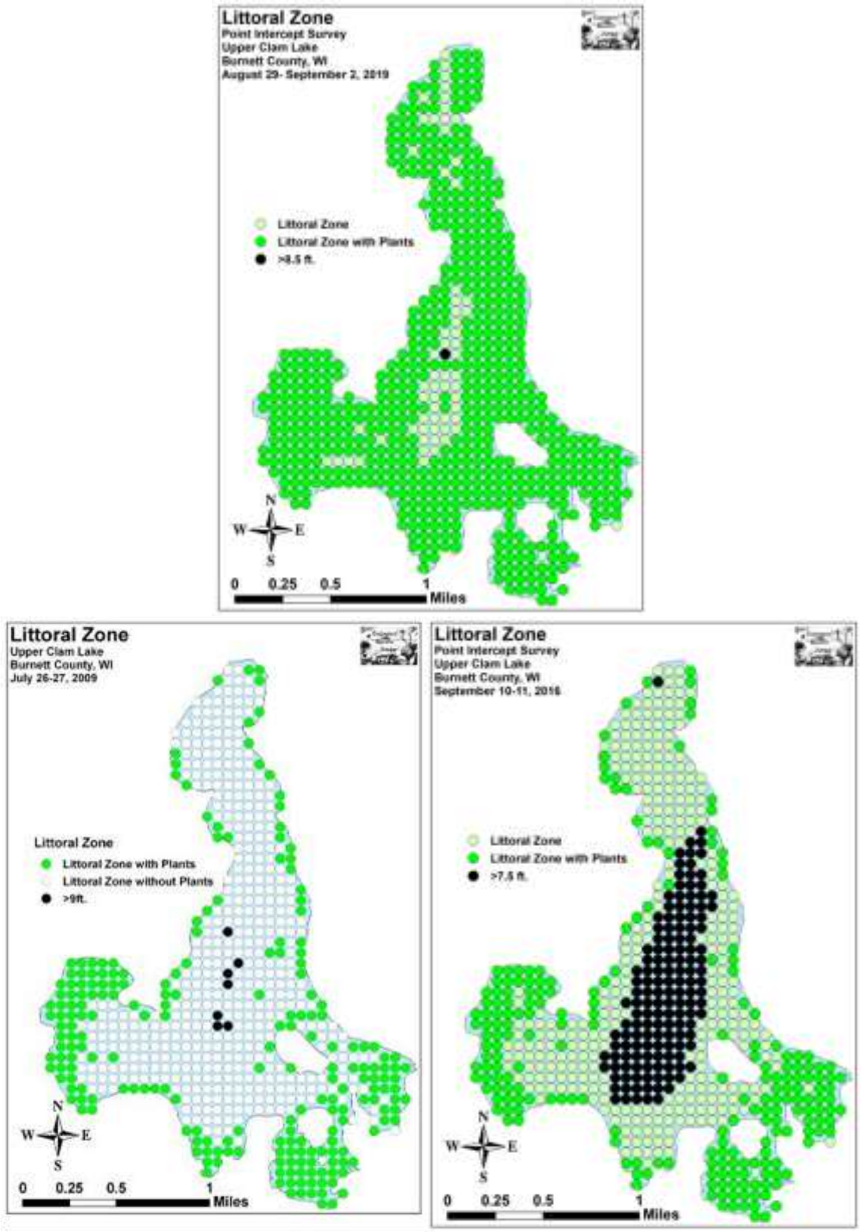


Figure 26: Predicted littoral zone in Upper Clam Lake in 2009, 2016, and 2019 (Berg, 2019)

Table 5: Comparison of aquatic plant survey statistics from 2009 to 2019 on Upper Clam Lake (Berg, 2019)

Summary Statistics:	2009	2012	2014	2015	2016	2019
Total # of points sampled	668	668	668	668	668	668
Total # of sites with vegetation	218	197	153	187	213	605
Total # of sites shallower than the max. depth of plants	661	650	305	439	523	667
Freq. of occur. at sites shallower than max. depth of plants	32.98	30.31	50.16	42.60	40.73	90.70
Simpson Diversity Index	0.90	0.91	0.92	0.93	0.92	0.90
Maximum depth of plants (ft)	9.00	8.00	5.00	6.50	7.50	8.50
Mean depth of plants (ft)	3.30	2.67	2.53	2.73	3.00	5.02
Median depth of plants (ft)	3.50	3.00	2.50	3.00	3.00	5.50
Ave. # of all species per site (shallower than max depth)	0.88	0.93	1.28	1.49	1.33	3.36
Ave. # of all species per site (veg. sites only)	2.68	3.07	2.54	3.50	3.25	3.70
Ave. # of native species per site (shallower than max depth)	0.88	0.93	1.28	1.49	1.32	3.36
Ave. # of native species per site (sites with native veg. only)	2.69	3.06	2.54	3.50	3.24	3.70
Species richness	37	33	29	30	38	36
Species richness (including visuals)	39	34	32	35	39	39
Species richness (including visuals and boat survey)	43	38	38	40	44	45
Mean total rake fullness (veg. sites only)	1.76	2.09	1.89	2.34	2.36	2.17

Plant diversity was high in 2019 with a Simpson Index value of 0.90 – down slightly from 0.92 in 2016. A 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 individual plants (randomly selected) will be different species. The index values range from 0 -1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Perhaps most importantly, plant communities with high diversity also tend to be more resistant to invasion by exotic species.

Total richness was moderate with 36 species found in the rake – down from 38 in 2016. This total increased to 45 species when including visuals and plants seen during the boat survey – an increase from 44 in 2016 and the highest total ever recorded on the lake. Mean native species richness at sites with native vegetation was showed a moderately significant increase from 3.24 species/site in 2016 to 3.70 in 2019. This was also the highest value for any of the six surveys (Figure 27).

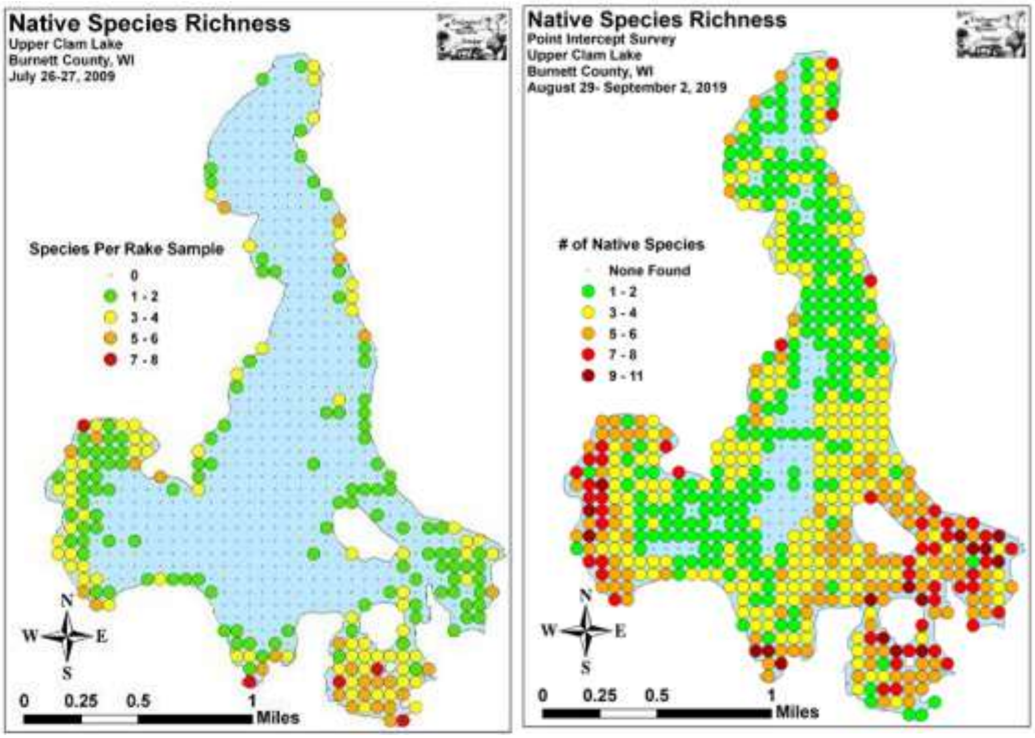


Figure 27: 2009 and 2019 native species richness

Total rake fullness experienced a moderately significant decline from a moderately high 2.36 in 2016 to a moderate 2.17 in 2019. Visual analysis of the maps showed this average decline was due to low density expansion in deeper areas throughout the lake rather than the obvious loss of density in any area. In southern bays, vegetation density actually increased sharply (Figure 28).

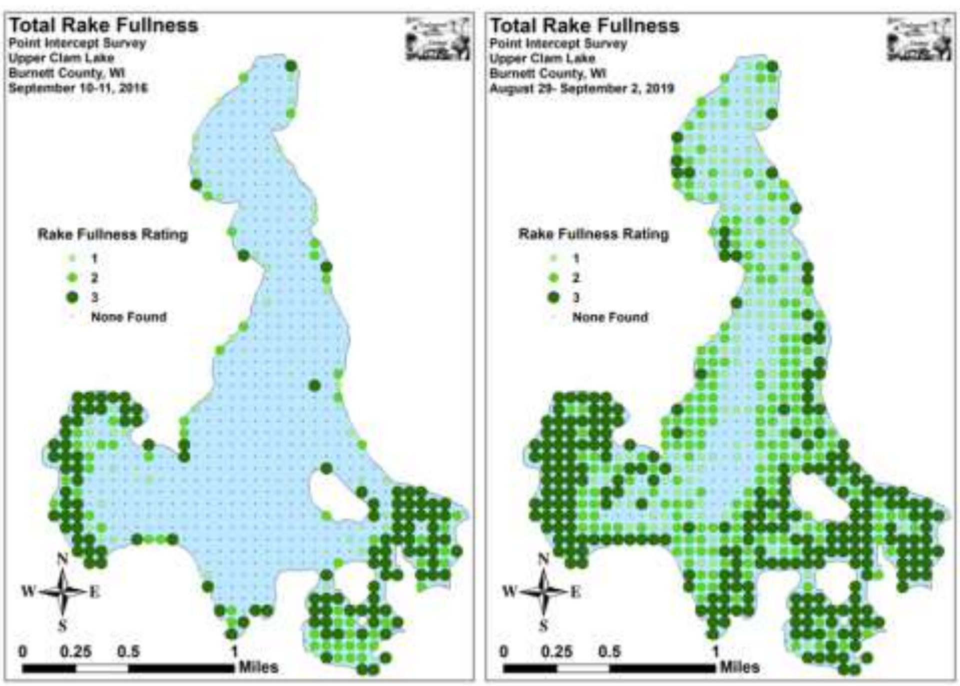


Figure 28: 2009 and 2019 total rake fullness

Comparison of Native Aquatic Plant Species in 2016 and 2019

In 2016 common waterweed, coontail, wild celery and northern wild rice were the most common species. Present at 46.01%, 39.91%, 38.50%, and 24.88% of survey points with vegetation, they accounted for 45.89% of the total relative frequency. Large duckweed (6.93%), water star-grass (6.78%), slender naiad (5.05%), and white waterlily (4.91%) were the only other species that had relative frequencies over 4.0%. In 2009, bushy pondweed, coontail, muskgrass, and small pondweed were the most common species in Upper Clam Lake accounting for 48.86%, 44.29%, 42.01%, and 22.83% of survey points with vegetation respectively. Together, they combined for over 59% of the total relative frequency. Several other species in 2009 were widely distributed, but none had relative frequencies over 5%.

During the 2019 survey, coontail, small pondweed, common waterweed and water star-grass were the most common species. They were found at 72.56%, 59.50%, 44.96%, and 22.64% of sites with vegetation accounting for 53.95% of the total relative frequency. Northern wild rice (6.12%), wild celery (4.73%), large duckweed (4.69%), and northern water-milfoil (4.11%) also had relative frequencies over 4.0%

Lakewide, 18 species showed significant changes in distribution from 2016 to 2019 (Figure 29). Common waterweed, coontail, northern wild rice, large duckweed, water star-grass, filamentous algae, northern water milfoil, white waterlily, small duckweed, small pondweed, common watermeal, sago pondweed, flat-stem pondweed, forked duckweed, and clasping-leaf pondweed all showed highly significant increases; and whorled water-milfoil experienced a significant increase. Conversely, Water marigold suffered a significant decrease.

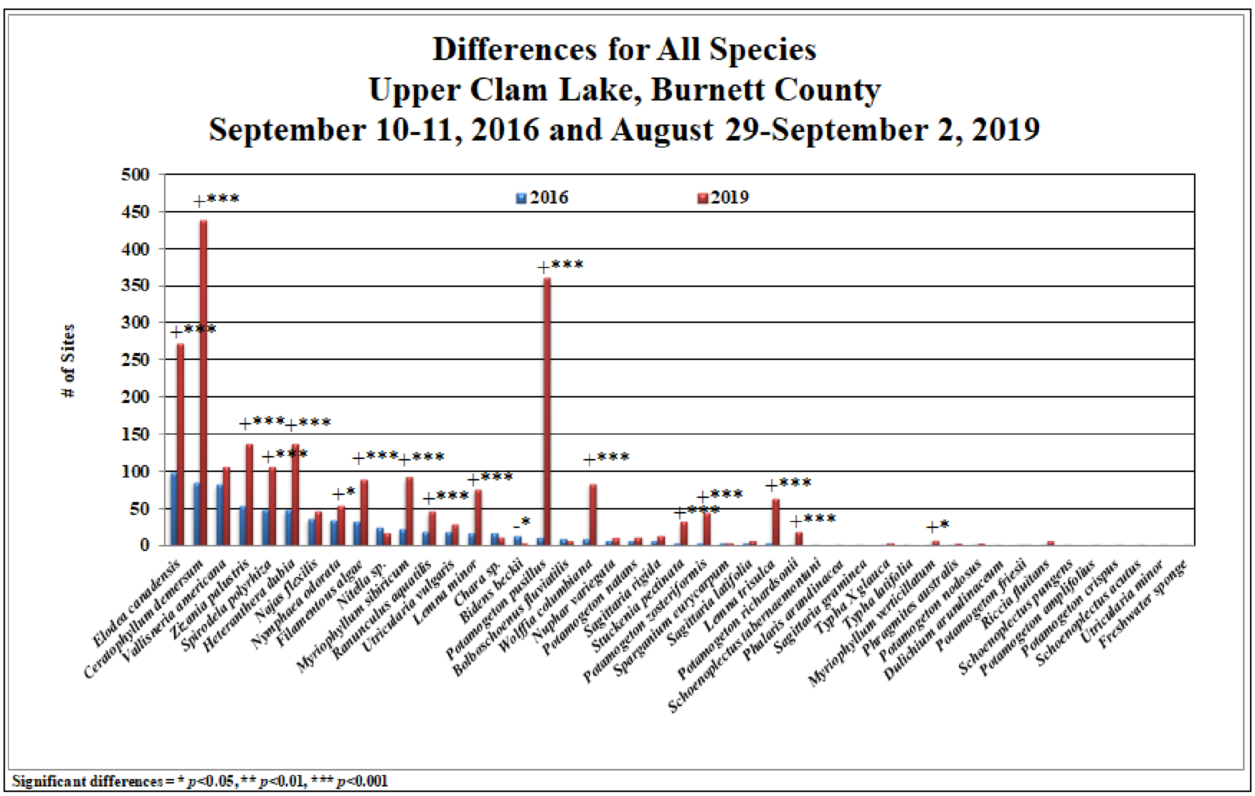


Figure 29: Plant species showing significant changes from 2016-2019

Floristic Quality Index (FQI)

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. Poskin Lake is in the Northern Central Hardwood Forests Region.

In 2019, a total of 36 native index species were found in the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 5.8 and a Floristic Quality Index of 35.0. All of these values were nearly identical to 2016 totals, but they continue to be sharply higher than during any of the previous surveys (30-species/meanC-5.6/FQI-30.5 in 2015; 29-species/meanC-5.5/FQI-29.5 in 2014; 31-species/meanC-5.3/FQI- 29.5 in 2012; 35-species/meanC-5.7/FQI-33.8 in 2009). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Ecoregion of 6.7 meaning Upper Clam Lake continues to be well below average. The FQI was, however, well above the median FQI of 24.3 for this part of the state.

AQUATIC PLANT SURVEYS – LOWER CLAM LAKE

Using a standard formula that takes into account the shoreline shape and distance, water clarity, depth, and total acreage, Jennifer Hauxwell (WDNR) generated the original 350 point sampling grid used for Lower Clam Lake aquatic plant surveys in 2009, 2012, 2014, 2015, and 2016. This same grid was used by Endangered Resource Services (ERS) in 2019 for a cold-water CLP survey and a warm-water summer PI survey of all aquatic plants. During each survey, all survey points were located using a handheld mapping GPS unit (Garmin 76CSx) and a rake was used to sample an approximately 2.5ft section of the bottom. When found, CLP and other aquatic plants were assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 21). Visual sightings of CLP and aquatic plants within six feet of the sample point were also noted.

CURLY-LEAF PONDWEED POINT-INTERCEPT SURVEY

During the 2019 early-season point-intercept survey all 350 points were rake-sampled with CLP found at 132 sites. This extrapolated to 37.7% of the entire lake and 38.7% of the 9.5ft spring littoral zone having at least some CLP present. Of the 132 sites with CLP, 43 rated a rake fullness value of 3, 34 were a 2, and the remaining 55 were a 1 for a combined mean rake fullness of 1.91 (Figure 30). The 77 points with a rake fullness of a 2 or a 3 suggested 22.0% of the entire lake and 22.6% of the spring littoral zone had a significant infestation.

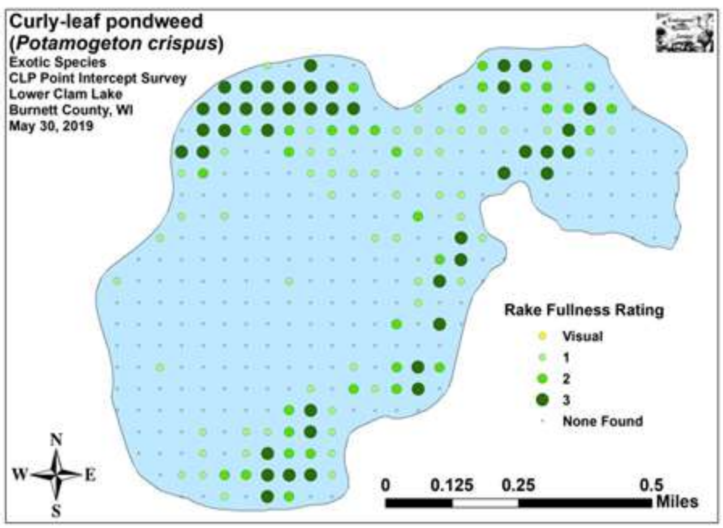


Figure 30: 2019 Early-season CLP density and distribution (Berg, 2019)

Comparisons of CLP in 2009, 2014, and 2019

The 2009 spring Curly-leaf pondweed point-intercept survey found CLP at 231 sites which approximated to 66.0% of the entire lake and 67.3% of the estimated 8.5ft spring littoral zone. Of these, a rake fullness value of 3 at 163 points, a 2 at 44 points, and a value of 1 at 27 points were recorded for a mean rake fullness of 2.58 (Figure 3). The combined 204 points with a rake fullness of 2 or 3 extrapolated to 58.3% of the entire lake and 59.5% of the estimated littoral zone having a significant infestation.

In June of 2014, CLP was present in the rake at 75 points which extrapolated to 21.4% of the entire lake and 22.2% of the 8.0ft spring littoral zone. Of these, a rake fullness value of 3 at one point, a 2 at 15 points, and a value of 1 at 59 points for a mean rake fullness of 1.23 was recorded. This suggested 4.6% of the lake had a significant infestation (rake fullness of 2 or 3) (Figure 31). The declines in total density and distribution; rake fullness 3 and 2; and the increase in rake fullness 1 were all highly significant (Figure 4). Collectively, they represented a greater than 67.5% reduction in total CLP coverage, also well as a 92.2% reduction in areas where the infestation was significant enough to be considered a nuisance.

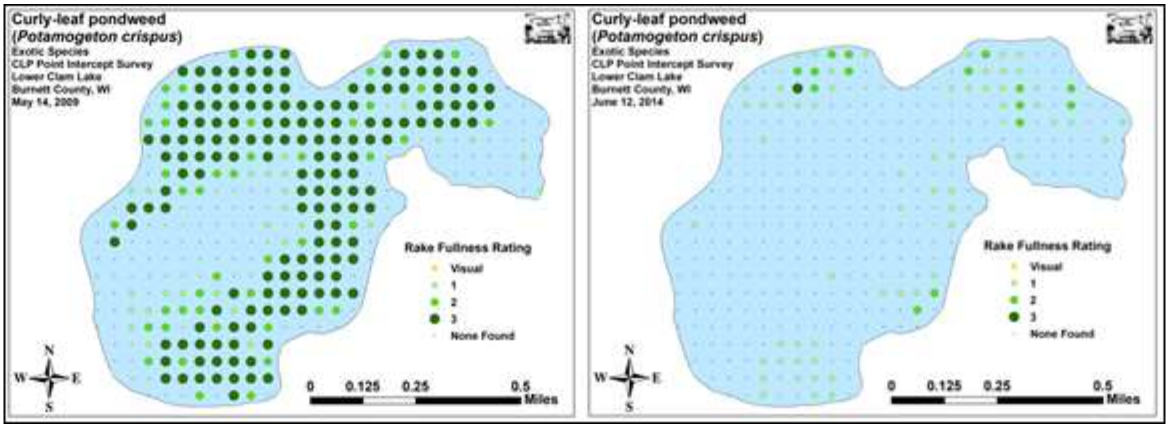


Figure 31: 2009 and 2014 early-season CLP density and distribution (Berg, 2019)

Compared to 2014, the 2019 survey represented a highly significant increase in density, distribution and rake fullness 3; and a moderately significant increase in rake fullness 2 (Figure 32). However, when compared to 2009, the 2019 results suggest total CLP distribution, rake fullness 3, and mean rake fullness have all undergone highly significant declines. The only increase was rake fullness 1 which saw a highly significant increase. Collectively, the 2019 results suggest CLP is still both less widespread and less abundant than it was in 2009, but based on an increase in low-level reestablishment, it could be back to 2009 level within a year or two.

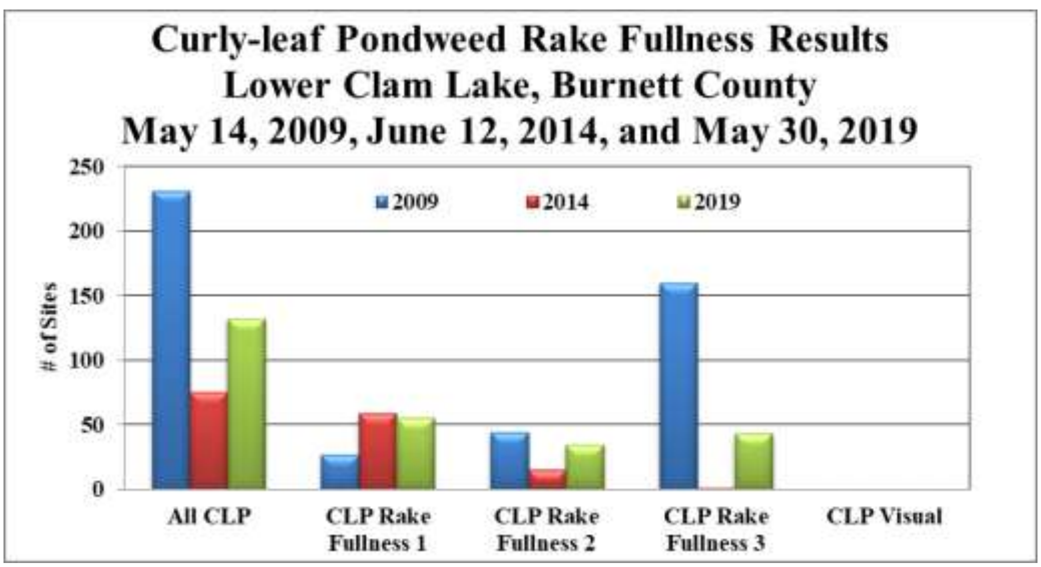


Figure 32: 2009, 2014, and 2019 changes in early-season CLP rake fullness (Berg, 2019)

CURLY-LEAF PONDWEED BED MAPPING SURVEY

CLP bed mapping was also completed in 2009, 2014, and 2019 during mid-June when CLP is usually canopied at the surface of the lake. During abed mapping survey, the lake's entire visible littoral zone is searched for the target species. By definition, a "bed" is determined to be any area where CLP is visually estimated to make up >50% of the area's plants, is generally continuous with clearly defined borders, and is canopied, or close enough to being canopied that it would likely interfere with boat traffic.

In 2009 a single canopied bed of CLP that dominated the majority of the lake's spring littoral zone was mapped (Figure 5). It covered 220.18 acres (60.2% of the lake's 366 acres), was almost monotypic, and, based on the numerous prop trails crisscrossing it, caused severe navigation impairment.

Following a dramatic reduction in CLP levels, the 2014 survey didn't find any canopied CLP anywhere in the system (Figure 5). Of the few CLP plants that were found by raking, most showed evidence of carp herbivory.

The 2019 bed mapping survey located five beds totaling 57.75 acres, 15.8% of the lake's surface area. Although it was a large increase when compared to 2014, it still represented a 162.44 acre decline (-73.8%) from the original 2009 bed mapping survey (Figure 33). While no bed mapping was completed in 2020, CLP was present in similar levels of density and distribution based on observations by members of the Lake District and their consultant.

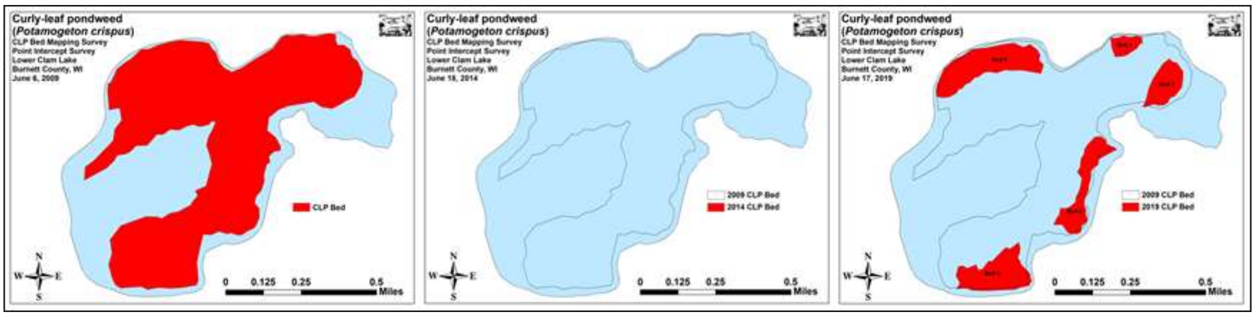


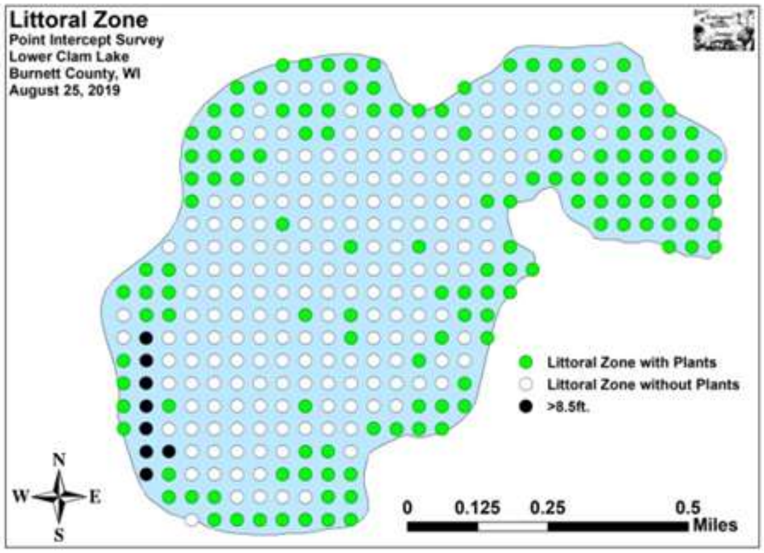
Figure 33: 2009, 2014, and 2019 early-season CLP Beds

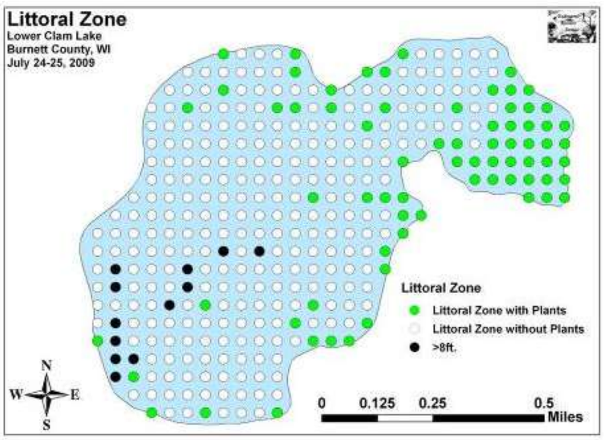
WARM-WATER FULL POINT-INTERCEPT MACROPHYTE SURVEY – LOWER CLAM

At the time of the 2019 survey, water clarity readings were in the 2-3ft range. This very poor water clarity produced a littoral zone that extended to 8.5ft and included 342 of the lake's 350 survey points (Figure 34). This was a highly significant increase compared to the littoral points in 2016's 5.5ft littoral zone and 2009's 8.0ft littoral zone, which prior to the 2019 survey, had the most littoral points. Despite this, most growth in 2019 still ended in 6-7ft.

In the 2019 survey, plants were found at 141 points (40.3% of the bottom and 41.2% of the littoral zone). This was a highly significant increase over any of the previous survey results including 2009, when 69 points had aquatic plants on the rake. Growth in 2019 was slightly skewed to shallow water as the mean plant depth of 4.4ft was less than the median depth of 5.0ft. Both of these values were higher than in any other survey dating back to 2009, suggesting that vegetation is spreading back into deeper water, a trend that would be nice to continue, but is at risk with the increase in CLP.

Plant survey statistics from the 2019 and all previous surveys are shown in Table 6.





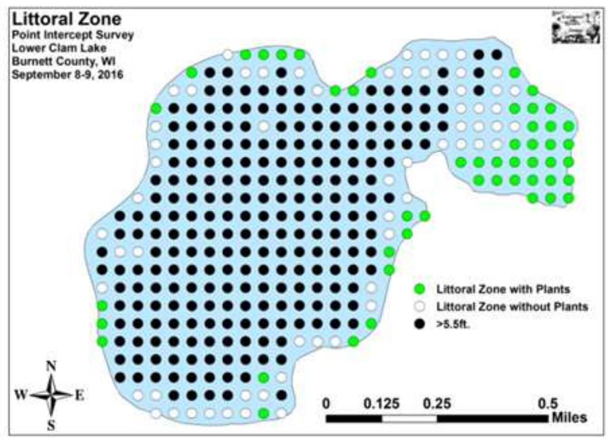


Figure 34: Predicted littoral zone in Lower Clam Lake in 2009, 2016, and 2019 (Berg, 2019)

Table 6: Comparison of aquatic plant survey statistics from 2009 to 2019 on Lower Clam Lake (Berg, 2019)

Summary Statistics:	2009	2012	2014	2015	2016	2019
Total # of points sampled	350	350	350	350	350	350
Total # of sites with vegetation	69	42	30	57	49	141
Total # of sites shallower than the max. depth of plants	338	122	71	142	109	342
Freq. of occur. at sites shallower than max. depth of plants	20.41	34.43	42.25	40.14	44.95	41.23
Simpson Diversity Index	0.91	0.91	0.86	0.90	0.92	0.88
Maximum depth of plants (ft)	8.0	5.5	4.5	5.5	5.5	8.5
Mean depth of plants (ft)	3.9	2.9	2.6	3.1	3.2	4.4
Median depth of plants (ft)	3.5	3.0	3.0	3.5	3.5	5.0
Ave. # of all species per site (shallower than max depth)	0.45	0.88	0.89	0.94	1.31	1.23
Ave. # of all species per site (veg. sites only)	2.22	2.55	2.10	2.33	2.94	2.97
Ave. # of native species per site (shallower than max depth)	0.41	0.88	0.87	0.92	1.29	1.22
Ave. # of native species per site (sites with native veg. only)	2.34	2.55	2.14	2.38	2.96	2.96
Species richness	25	19	17	23	23	30
Species richness (including visuals)	27	22	21	27	27	33
Species richness (including visuals and boat survey)	29	33	28	32	32	40
Mean total rake fullness (veg. sites only)	1.71	1.86	2.00	2.00	2.06	1.67

Plant diversity was moderately high in 2019 with a Simpson Index value of 0.88 – down slightly from 0.92 in 2016. A 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 individual plants (randomly selected) will be different species. The index values range from 0 -1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Perhaps most importantly, plant communities with high diversity also tend to be more resistant to invasion by exotic species.

Total richness was moderate with 30 species found in the rake – up from 23 in 2016 and the highest total of any of the six surveys. This total increased to 40 species when including visuals and plants seen during the boat survey – also an increase from 32 in 2016 and the highest total ever recorded on the lake. Mean native species richness at sites with native vegetation was unchanged at 2.96 species/site in both 2016 and 2019 but was still the highest value for any of the six surveys (Figure 35).

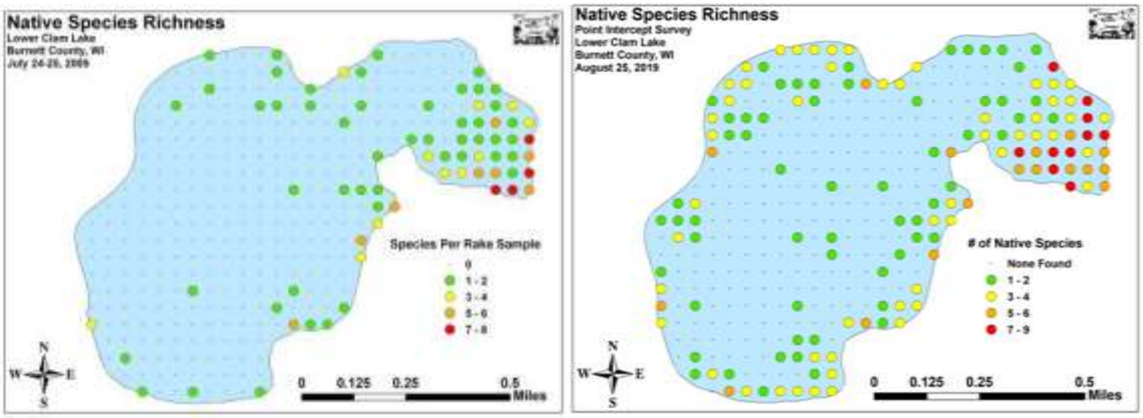


Figure 35: 2009 and 2019 native species richness

Total rake fullness experienced a moderately significant decline from a moderate 2.06 in 2016 to a moderately/low 1.67 in 2019. Visual analysis of the maps showed this average decline was due to low density expansion throughout the lake rather than the obvious loss of density in any area (Figure 36).

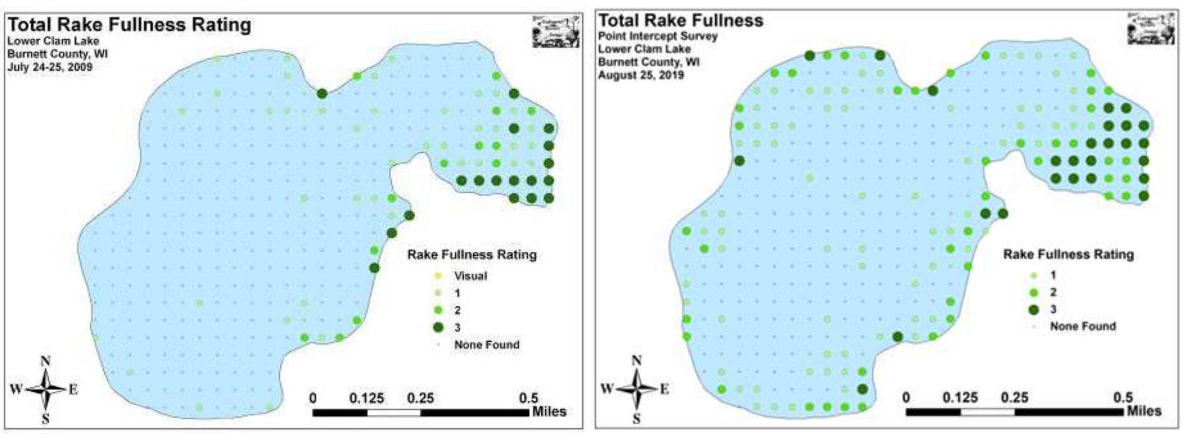


Figure 36: 2009 and 2019 total rake fullness

Comparison of Native Macrophyte Species in 2016 and 2019

In 2016 common waterweed, coontail, whitewater lily, and slender naiad were the most common species. Present at 51.02%, 36.73%, 32.65%, and 22.45% of survey points with vegetation, they accounted for 48.61% of the total relative frequency. Wild celery (6.94%), Floating-leaf pondweed (6.25%), Northern wild rice (5.56%), and Water star-grass (4.86%) were the only other species that had relative frequencies over 4.0%. In 2009, coontail, bushy pondweed, muskgrass and CLP were the most common species. They were present at 34.29%, 31.43%, 22.86%, and 21.43% of survey points with vegetation respectively and together, accounted for 47.5% of the total relative frequency. White water lily (8.64) was the only other species we found with a relative frequency over >5.0.

During the 2019 survey, common waterweed, coontail, small pondweed, and wild celery were the most common species. They were found at 60.28%, 58.87%, 51.06%, and 16.31% of sites with vegetation accounting for 62.77% of the total relative frequency. Flat-stem pondweed (4.53%) and large duckweed (4.06%) also had relative frequencies over 4.0%.

Lakewide, nine species showed significant changes in distribution from 2016 to 2019 with all of them being increases (Figure 37). Common waterweed, coontail, and small pondweed had highly significant increases; large duckweed, flat-stem pondweed, filamentous algae, and common bladderwort saw moderately significant increases; and wild celery and northern water-milfoil experienced significant increases.

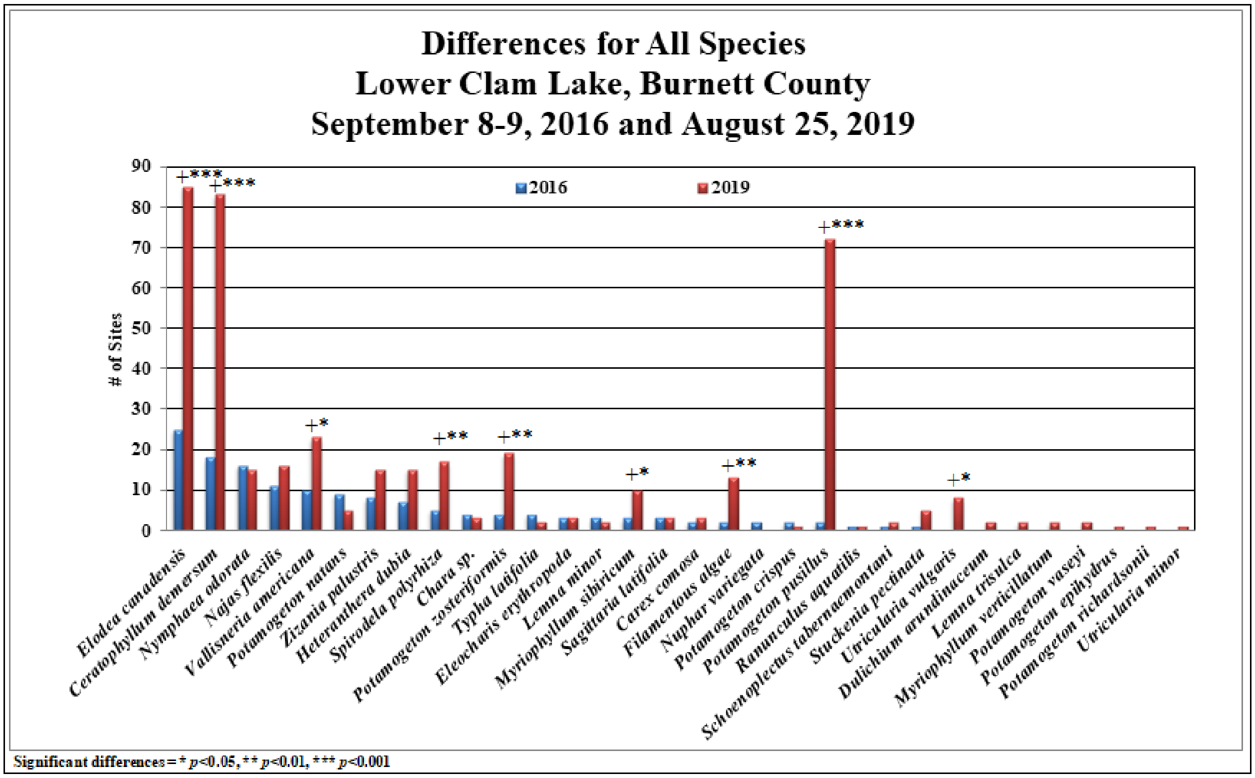


Figure 37: Plant species showing significant changes from 2016-2019

Floristic Quality Index (FQI)

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. Poskin Lake is in the Northern Central Hardwood Forests Region.

In 2019, a total of 29 native index species were found in the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 5.8 and a Floristic Quality Index of 31.2. All of these values represented a sharp increase from 2016 totals. They were also the highest values found during any of the previous surveys (22 species/mean C 5.2/FQI 24.5 in 2015; 16 species/mean C 4.8/FQI 19.3 in 2014; 19 species/mean C 4.9/FQI 21.3 in 2012; 24 species/mean C 5.3/FQI 26.1 in 2009). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Ecoregion of 6.7 meaning Lower Clam Lake continues to be well below average. The FQI was, however, well above the median FQI of 24.3 for this part of the state. (Nichols, 1999).

WILD RICE

Wild rice is an annual aquatic grass that produces seed that is a nutritious source of food for wildlife and people (Figure 38). As a native food crop, it has a tremendous amount of cultural significance to the Wisconsin and Minnesota Native American Nations. Wild rice pulls large amounts of nutrients from the sediment in a single year and the stalks provide a place for filamentous algae and other small macrophytes to attach and grow. These small macrophytes pull phosphorous in its dissolved state directly from the water. Wild rice can benefit water quality, provide habitat for wildlife, and help minimize substrate re-suspension and shoreland erosion.

In Wisconsin, wild rice has historically ranged throughout the state. Declines in historic wild rice beds have occurred statewide due to many factors, including dams, pollution, large boat wakes, and invasive plant species. Renewed interest in the wild rice community has led to large-scale restoration efforts to reintroduce wild rice in Wisconsin's landscape. Extensive information is available on wild rice from GLIFWC and the WDNR.

In Wisconsin, wild rice is highly protected under DNR Rule NR 19.09 Wild Rice Conservation (Appendix G).

Figure 38: Wild rice

HISTORIC WILD RICE IN LOWER CLAM LAKE

Although Upper Clam Lake is well known for its expansive rice beds, the smaller beds on Lower Clam tend to be overlooked. The rice on Lower Clam is largely limited to the bay east of the outlet which is visible at the upper right in the photo in Figure 39. There are anecdotal reports that these beds were seeded by local residents fairly recently. They are located in an area with little lakeshore development. It remains to be seen if these beds are facing the same decline that has been witnessed on the Upper Clam beds, whose most recent appreciable crop was in 2006. The Tribal Watch Status for Lower Clam is high due to decline concerns.

Figure 39: Wild rice in the bay east of the outlet on Lower Clam Lake in 2008 (GLIFWC, 2010)

HISTORIC WILD RICE IN UPPER CLAM LAKE

Upper Clam Lake has been one of the most significant rice waters in Wisconsin, with expansive rice beds occurring primarily on the large lobes on the southern half of the lake. Through the 20 years prior to 2008, Upper Clam Lake consistently supported large areas (250 to 300 acres) of northern wild rice. The photos in Figure 40 give a sense of the kind of beds Upper Clam Lake is capable of supporting. Unfortunately, in the years since the photos in Figure 28 were taken, the rice beds on Upper Clam have experienced an unusually sudden and drastic decline.

However, only very small beds have been observed in the 6-8 years since these photos were taken. Wild rice harvest records (Figure 41) show that Upper Clam Lake was a consistent high-quality source of wild rice from 1992 through 2006, with anecdotal accounts that this was also typical of most years prior to 1992. The lake has experienced a dramatic decline in the extent and density of wild rice growth in subsequent years. This decline is also evident in the harvesting records, with no reported harvest of rice from the lake between 2007 and 2009 (Figure 41).

Through 2010, after four years of documented decline, only a few sparse remnant stands of wild rice remained in the isolated shallow bays of Upper Clam Lake, less than 80 acres of very sparse rice. Due to this decline, very little new wild rice seed was produced in Upper Clam Lake from 2007 to 2010. Consequently, the bank of seeds remaining from previous years of rice growth is likely severely reduced, possibly limiting a natural recovery of rice beds (21).

Wild rice beds may experience periodic natural declines, and high variability in seed production. However, even after substantial declines, rice beds are typically able to reestablish from seeds remaining in lake sediments. The decline of rice beds in Upper Clam Lake coincided with a documented increase in common carp, suggesting that carp feeding and spawning activities reduced the survival and growth of wild rice in the lake. Furthermore, carp may have reduced the abundance of wild rice seeds by directly consuming them or by uprooting young rice plants before new seeds could be produced (21).

This lake has tremendous significance to the St. Croix Tribe, whose land includes frontage on the lake. The tribe harvests, monitors, and helps manage this water. It is critically important that the extensive rice beds on this body of water be preserved. The Tribal Watch Status for Upper Clam Lake is extremely high and much has been done since 2010 to protect, preserve, and enhance the remaining wild rice beds.

Figure 40: Wild rice in the SW bay in 2006 and 2007 (top) and in the SE bay in 2007 (bottom) on Upper Clam Lake (GLIFWC, 2010)

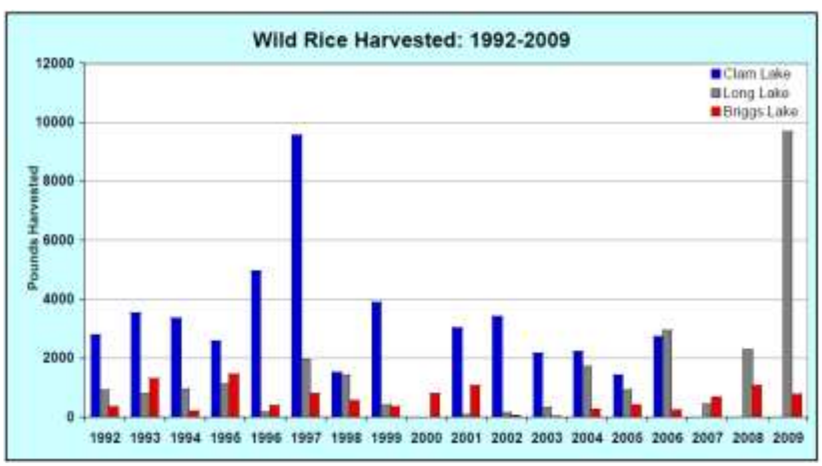


Figure 41: Wild rice harvest on Upper Clam, Long, and Briggs lakes from 1992-2009 (GLIFWC, 2010)

EFFORTS TO PROTECT, PRESERVE, AND ENHANCE REMAINING WILD RICE BEDS IN UPPER CLAM LAKE

The documented abundance and survival of large carp in Upper Clam Lake suggested that there was a high potential for impacts on aquatic plants, particularly during spring spawning when the carp concentrated in shallow areas. A 2 year-old gravid female carp was captured during the 2009 survey, suggesting that the large group of carp born in 2005 may have begun spawning in shallow areas as early as 2007, when they reached 2 years of age. This timing coincides with the first year of major wild rice decline in the lake.

A meeting was held on January 19, 2010 at the Tribal Resources Office in Hertel, WI to discuss 2009 findings on the Clam Lakes and what to do in 2010. The local WDNR Fish Manager, SCTES biologists, GLIFWC Biologists, Clam CLPRD representatives, SEH, and others were in attendance. Additional carp studies were completed in 2010 by both the WDNR and Tribal Resources. SCTES also completed a more comprehensive wild rice survey of the system in 2010. In another study completed in 2010 (22), a system of carp exclusion cages were set up by SCTES and WDNR resources in Upper Clam Lake in an attempt to determine what impact the carp may be having in the system. Several of the cages were seeded with rice (Figures 42 & 43).

Figure 42: Seeded and fenced (left) and unseeded and fenced (right) wild rice enclosures installed in 2010

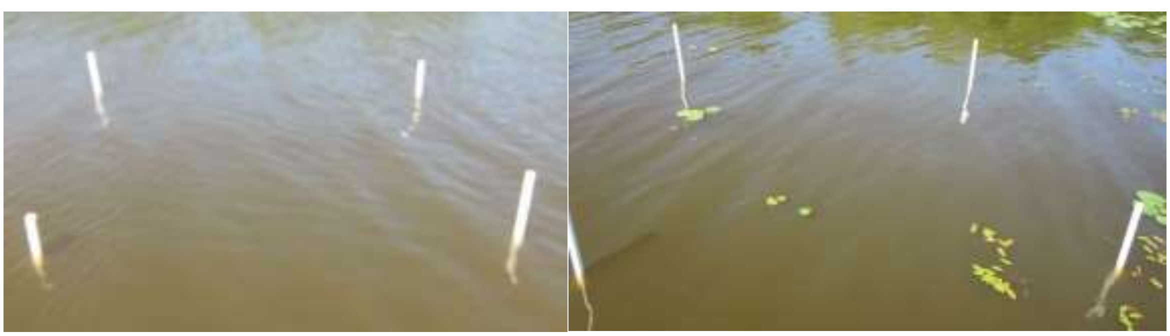


Figure 43: Seeded and unfenced (left) and unseeded and unfenced (right) wild rice enclosures installed in 2010

The study clearly showed that direct carp effects severely limited wild rice survival, growth, and reproduction in Upper Clam Lake. The high survival and growth of rice inside the fenced plots with seeding, which were subject to the same water conditions as the other plots that were not seeded, suggested that indirect carp effects (increased turbidity and nutrients) did not substantially impact wild rice (22). Previous studies have shown that abundant carp can severely reduce submersed aquatic vegetation in shallow areas through direct uprooting or herbivory. Findings in this study strongly suggest that these direct carp effects can also impact wild rice, despite being an emergent plant.

Although wild rice survival and growth can also be reduced by high water levels in June and July, study results clearly show that water level did not substantially affect wild rice survival or growth, as evidenced by the lush rice growth in seeded plots. Water elevation in Upper Clam Lake fluctuated somewhat during the period from April through July 2010, but there was no evidence of "drowning" rice (22).

The study found that direct carp effects severely reduced wild rice during its early stages of growth, as indicated by the near complete lack of young wild rice shoots in open plots during the May survey. However, the study could not determine whether carp had eaten the seeds, eaten young shoots, or merely uprooted new shoots before the end of May. Regardless of whether carp eat wild rice seeds and shoots or merely uproot young plants, carp damage to rice during its early-season growth period likely represents a bottleneck that limits the amount of rice that reaches the emergent growth stage (22).

In addition to showing the strong impact of direct carp effects on wild rice, the study clearly showed that the abundance of wild rice seeds remaining in sediments of Upper Clam Lake from past years was not sufficient to produce substantial rice growth in the absence of carp. The abundance of rice growth in non-seeded, fenced plots was very low throughout the study, and was not significantly greater than what was observed in any of the open plots. Based upon the 4-year duration and longer of the current rice decline in Upper Clam Lake; the low number of seeds found during the 2009–2010 seed enumeration study, and the lack of rice growth in non-seeded fenced plots during this study, the failure of rice in Upper Clam Lake does not appear to be a typical natural decline.

INSTALLATION AND EFFECTIVENESS OF CARP BARRIERS

In an effort to protect and preserve the remaining wild rice beds in the southern most bay of Upper Clam Lake, in April 2011 staff from SCTES installed carp barriers that consisted of two nets with surface floats and bottom weights stretched across the two narrow channels that connect the southern bay of Upper Clam Lake to the main basin of the Lake (Figure 44). These barriers were in place before carp moved into shallow areas to spawn, but carp were not removed from behind the barrier.

Figure 44: Wild rice protection barriers on the SE Bay of Upper Clam Lake

Despite the installation of the carp barrier, the density of wild rice in the southern bay did not increase in 2011. However, increased native aquatic plant growth in the bay suggested that the nets successfully reduced carp activity in the bay in 2011. The abundance and diversity of aquatic plants generally appeared to be greater than in previous years, and were dramatically greater in the enclosed bay than in the areas immediately outside of the carp barrier. In 2011, dense growth of native aquatic plants covered roughly 80% of the bay, with many areas supporting a fairly diverse assemblage of plant species. These dramatic differences were very similar to what was observed during the carp enclosure plot experiment conducted in 2010 (22).

WILD RICE MANAGEMENT IMPLICATIONS

The 2010 carp enclosure plot experiment clearly indicated that exclusion of carp alone did not result in rice growth; seeding of rice was also necessary (23). In that study, it appeared that the wild rice seed bank in lake sediments had been severely depleted by carp. This suggests that similar seed depletion may have occurred in the southern bay over the past 10 years, and likely explains why we did not see a recovery of dense rice growth in the bay after only one season of carp exclusion.

The dramatic recovery of dense rice growth in the southern bay after 2 to 3 years of carp exclusion without supplemental manual seeding strongly suggests that rice beds may naturally recover in the rest of the lake if carp abundance can be reduced. In fact, a few areas in the open portion of the lake (particularly the shallow southeastern portion of the lake) clearly supported low to moderate density rice growth in 2013 after several years of carp removal. This suggests that the carp population may have been suppressed sufficiently by recent nettings to allow natural recovery of rice in the lake. However, the abundance of rice seeds in most of the lake is likely extremely low (23). Consequently, in the first few years of recovery, rice growth will likely be sparse and very susceptible to grazing by the remaining carp. Accordingly, the recovery of dense rice beds in the open lake would almost certainly be enhanced by manual seeding with seed collected from the fully recovered southern bay. Furthermore, the carp-barrier nets should continue to be installed at the same locations each spring to maintain the current "nursery stock" of rice seed in the southern bay until large-scale rice bed recovery is achieved in the rest of the lake (24).

POSITIVE IMPACTS OF THE CARP BARRIERS MAINTAINED THROUGH 2013

The recommendation to keep the carp barrier across the southeast bay of Upper Clam Lake was heeded and in each of the last two years they have been reinstalled in the spring of the year before carp have a chance to move into the area. Survey work done in 2012 and again in 2103 show that by keeping carp out of the SE Bay, the wild rice has rebounded nicely (Figure 45). Further consideration should be given to fencing carp out of other areas of both lakes to help restore wild rice and other native plants.

Figure 45: Wild rice in the SE Bay of Upper Clam Lake in 2012 (left, ERS) and 2013 (right, GLIFWC)

COMPARISONS OF WILD RICE IN UPPER CLAM LAKE FROM 2009-2019

ERS first surveyed the wild rice in both lakes in 2009. The amount of wild rice in the lakes had already been documented as crashing over a period of a couple of years. Additional survey work was done in 2012, 2014, 2015, 2016, and 2019 as a part of the carp removal and wild rice restoration project.

The 2009 survey found northern wild rice in the rake at just five points all of which had a rake fullness value of 1. Following the placement of the carp exclosure nets, in 2012 a highly significant increase in rice distribution (34 sites) and density (mean rake fullness of 2.21) was documented (Figure 46).

In 2014, the number of points with rice increased again to 46 sites. Although this was not significant, the decline in density to a mean rake fullness of 1.80 was. Most of the 2014 increases in distribution occurred near the river inlet on either side of the channel. Interestingly, the rice inside the exclosures was much reduced in density; especially on the west side where broad areas had open water with almost no rice at all.

The 2015 survey found rice in the rake at 56 points – another non-significant increase in distribution. It was also recorded as a visual at 15 points. Density jumped to a mean rake fullness of 2.52 – a highly significant increase from 2014.

In 2016, rice was found at 53 points with five additional visual sightings. Although this decline in distribution wasn't significant, the decline in density to a mean rake fullness of 2.15 was moderately significant. Rice was again present throughout the entire southeast bay behind the carp exclosure. Although patchier and somewhat less dense than in 2015 (Figure 46), there was still so much rice that the only way survey points could be accessed was by canoe/push pole. Even this was especially difficult near the southeast entrance to the bay where the rice was denser than anywhere else and nearly as dense as the levels seen in 2015. Elsewhere, the majority of the bay was moderately dense, but with occasional gaps of open water.

Outside the exclosure and extending back towards the Clam River inlet, rice was still present, but was both less common and less dense than in 2015. This was especially true along the shoreline north and east of the inlet. The other southern bays again had just a scattering of plants in shallow water near the shoreline.

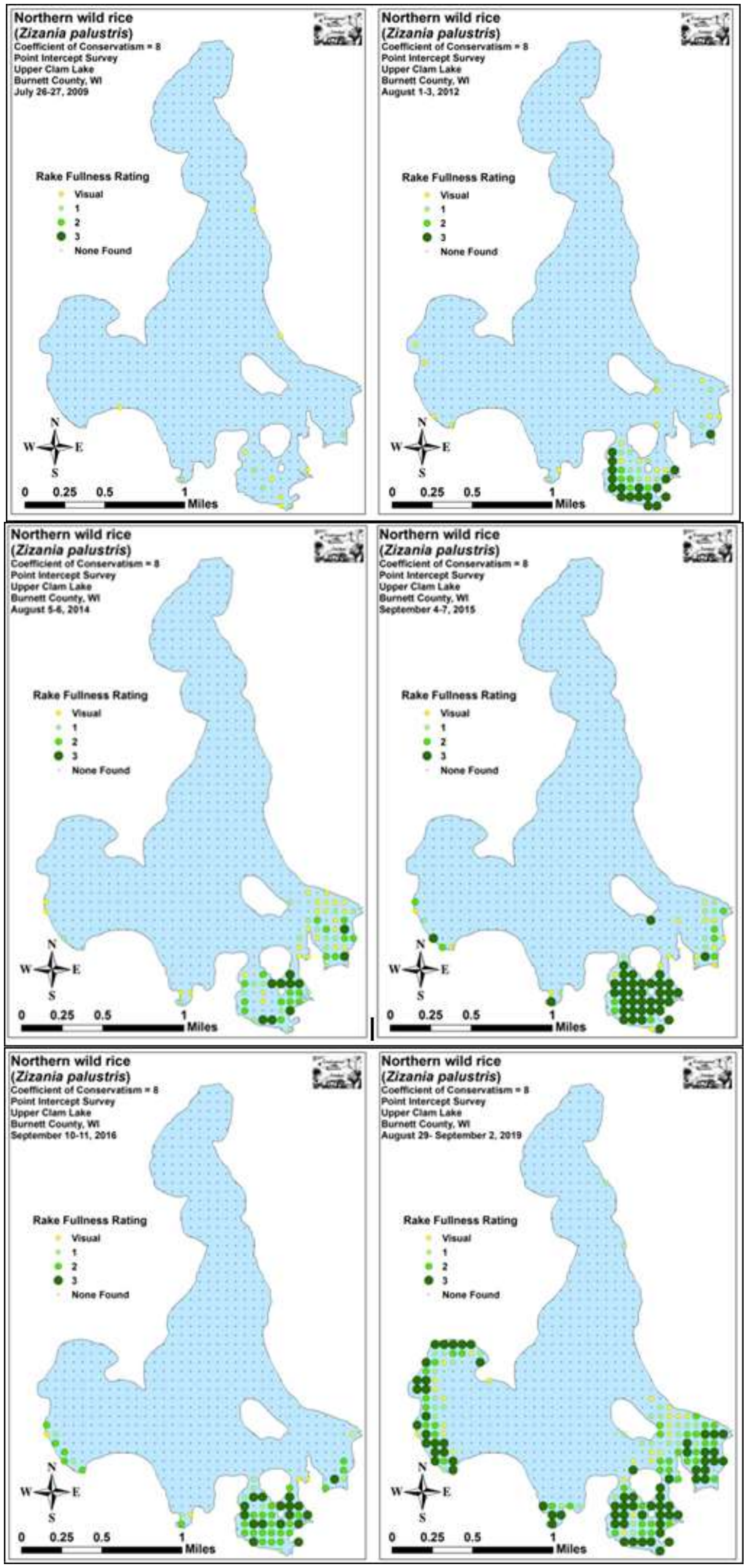


Figure 46: 2009, 2012, 2014, 2015, 2016, and 2019 northern wild rice density and distribution (Berg, 2019)

In 2019, rice underwent a highly significant expansion in distribution. Present at 137 points with 24 additional visual sightings, it was tied for water star-grass as the fourth most widely distributed species (22.64% of points with plants present/20.54% of the littoral zone). Of these, 68 were rated a rake fullness of 3, 39 a 2, and the remaining 30 a 1 for a mean rake fullness of 2.28 (Figure 46). Although this was also an increase in density from 2016, it was not significant. Most of the beds offered significant human harvest potential, and many places found were so dense that using a canoe and pole was impossible. Although wonderful for wildlife and those harvesting, these dense areas of rice clearly made things difficult for those accessing the lake from their shorelines in these southern bays; especially if they were doing so infrequently.

Broken out by region, the southwest bay had more rice than at any point since the first survey in 2009. Viewed from Lone Star Road on the bay's southwest side, a wall of rice extended out from shore (Figure 47). On the open water margin, the rice was more fragmented, but the majority of areas were still extremely dense (Figure 20), and harvest trails crisscrossed the bed.

Figure 47: Panorama of northern wild rice in the SW bay facing southwest 8/31/19 (Berg, 2019)

The south-central bay also had harvestable density. A nearly continuous wall of plants reached the landing on the southwest side of the bay and stretched almost uninterrupted back up the creek inlet (Figure 48).

Figure 48: Panorama of northern wild rice in the south-central bay 8/30/19 (Berg, 2019)

In the southeast bay, much of the river inlet was impassable by canoe and nearly so by kayak as it took an entire day to survey 50 points in this area. Along the north shoreline, residents seemed to be having significant difficulty keeping a path open as both the patchy rice and submergent vegetation made motor travel difficult (Figure 49).

Figure 49: Panorama of north shoreline in the SE bay facing east towards the river inlet 8/31/19 (Berg, 2019)

Wild rice created an almost impenetrable wall that was only accessible by kayak in the entrance to the SE bay south of the river inlet. This area is in the former carp exclosure area (Figure 50). Density was high throughout most of the bay, but a sizable area of open water was found in the southwest corner of the bay (Figure 51).

Figure 50: Panorama of northern wild rice from SE side of former exclosure facing south 9/2/19 (Berg, 2019)

Figure 51: Panorama of northern wild rice from the SW end of the exclosure facing north 9/2/19 (Berg, 2019)

COMPARISONS OF WILD RICE IN LOWER CLAM LAKE FROM 2009-2019

The 2009 and 2012 surveys found a very limited number of wild rice plants growing along the margins of the east bay (Figure 52). By 2014, the number and density of plants appeared to be much increased albeit not covering a wide enough area to be quantified by the survey as it was only found in the rake at two points (mean rake fullness of 2.00) with two additional visual sightings. In 2015, rice was found in the rake at five points (mean rake fullness of 2.00) with five additional visuals sightings (Figure 52). The 2016 survey documented a continued spread and thickening as rice was in the rake at eight points (mean rake fullness of 2.50) with an additional visual sighting.

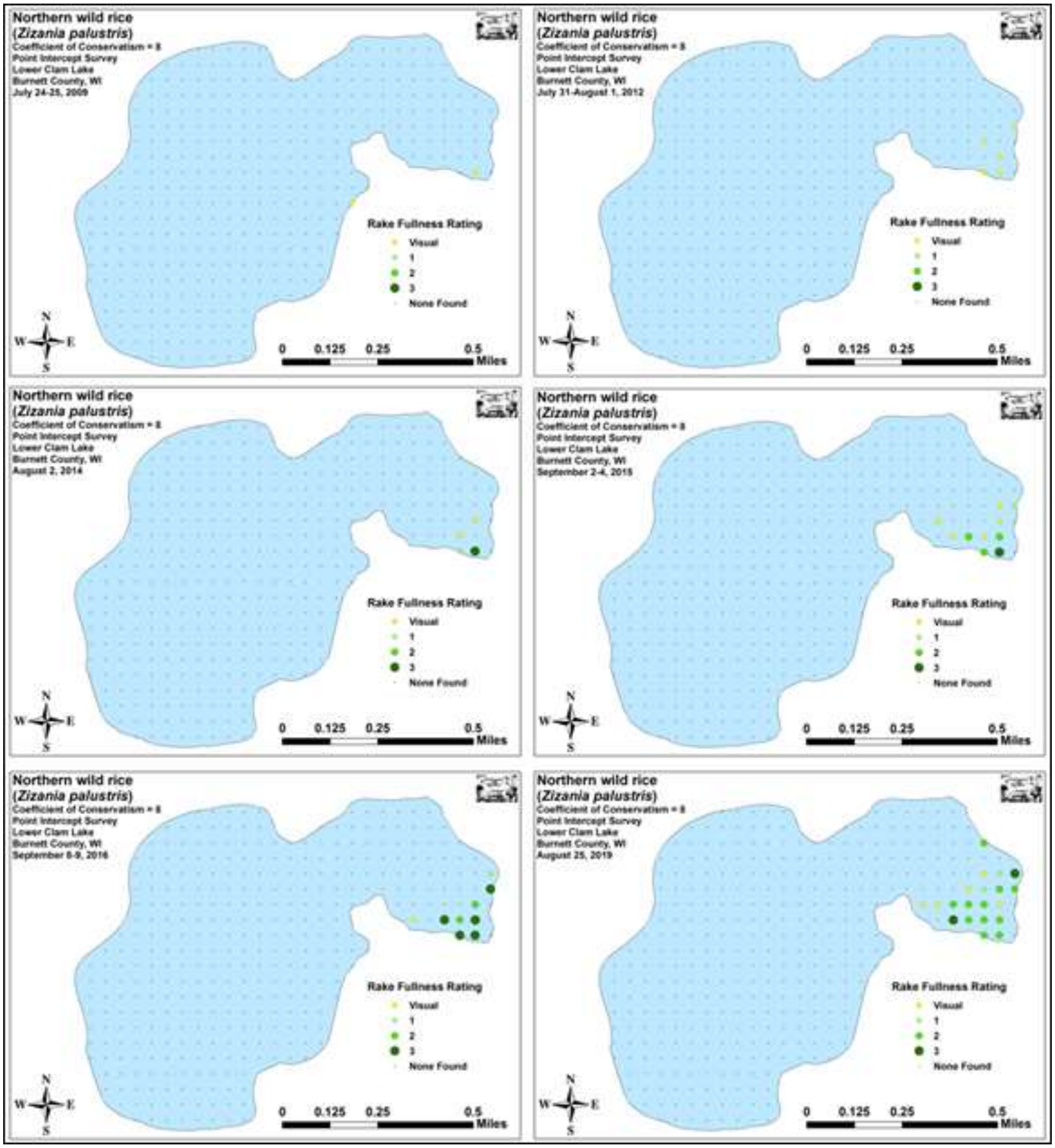


Figure 52: 2009, 2012, 2014, 2015, 2016, and 2019 northern wild rice density and distribution (Berg, 2019)

In 2019, rice underwent a further non-significant expansion to 15 points with five additional visual sightings. Conversely, its density saw a nearly significant decline to a mean rake fullness of 2.00 (Figure 52). The west side of the bay (Figure 53) continued to be somewhat patchy, but the eastern side was so dense that the beds offered significant human harvest potential, albeit over a relatively small area (Figure 54).

Figure 53: Panorama of northern wild rice in SE corner of east bay facing SE - 8/25/19 (Berg, 2019)

Figure 54: Panorama of northern wild rice from SE corner of east bay facing NW - 8/25/19 (Berg, 2019)

AQUATIC INVASIVE SPECIES

At least four different aquatic invasive species (AIS) have been identified in the Clam Lakes: common carp, curly-leaf pondweed, Chinese mystery snails, and purple loosestrife. Two of these species, carp and CLP, have caused tremendous changes to the lakes over time. Other AIS that have the potential to cause significant changes including Eurasian watermilfoil (EWM) and zebra mussels (ZM) have not been identified in the lakes at this time, but do threaten them.

NON-NATIVE, AQUATIC INVASIVE PLANT SPECIES

Curly-leaf pondweed (CLP) and purple loosestrife are the only known aquatic invasive plant species in the lakes. CLP is a submerged vegetation species (rooted to the bottom of the lake and growing under the surface of the water) that has already had significant impacts on the lakes. Purple loosestrife is less prevalent, but does exist on the shores and in adjacent wetlands to the lakes. 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 55). It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. The plant usually drops to the lake bottom by early August. CLP is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures. It has been reported in all states but Maine.

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

Figure 55: CLP plants and turions

EURASIAN WATERMILFOIL

Eurasian water milfoil (EWM) (Figure 56) 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 56: EWM fragment with adventitious roots and EWM in a bed

EWM has not been found in either lake, but should still be monitored for regularly.

PURPLE LOOSESTRIFE

Purple loosestrife (Figure 57) is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers that vary from purple to magenta possess 5-6 petals aggregated into numerous long spikes, and bloom from August to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

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

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

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

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

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

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

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

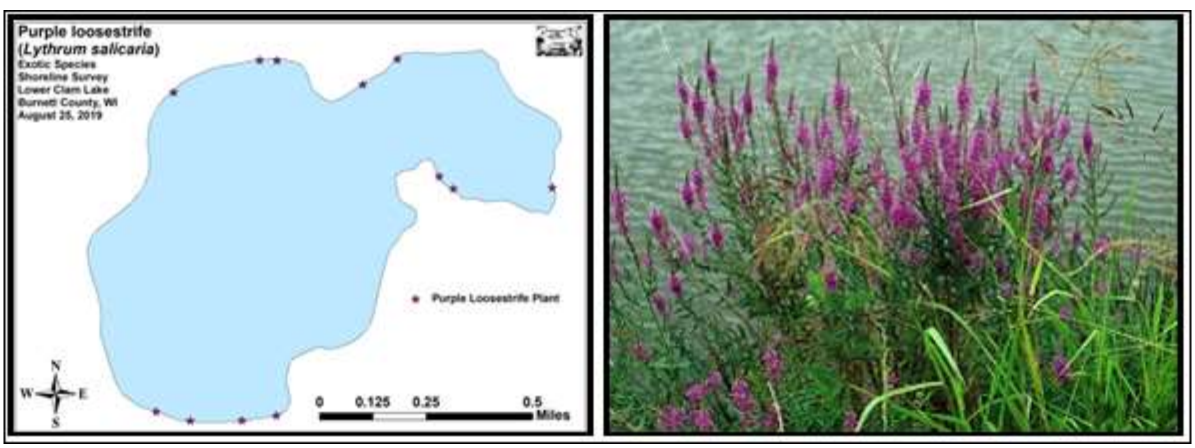


Figure 57: Purple loosestrife

REED CANARY GRASS

Reed canary grass (Figure 58) 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.

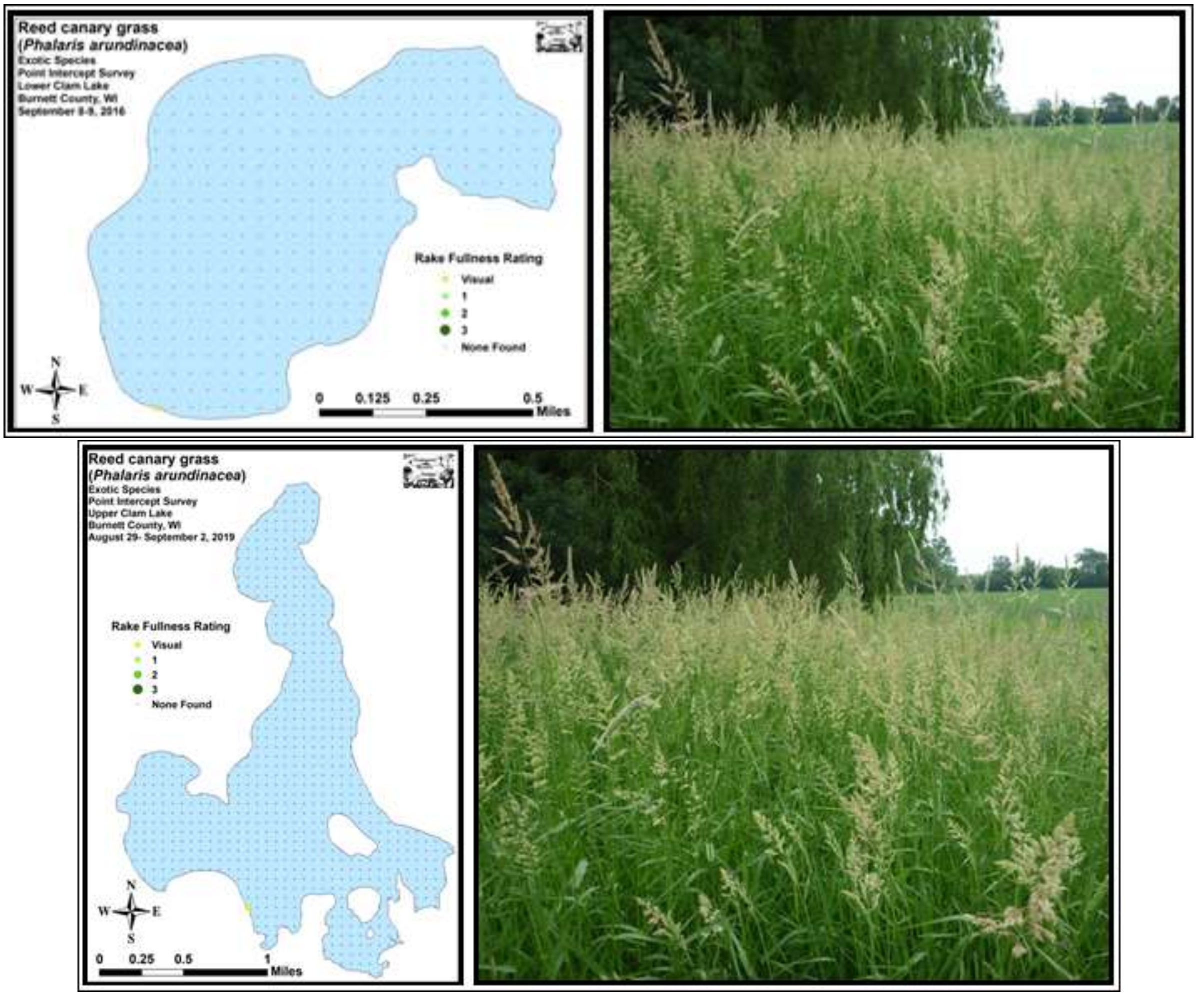


Figure 58: Reed canary grass

NON-NATIVE AQUATIC INVASIVE ANIMAL SPECIES

Currently, there are two non-native animal species in the Clam lakes: common carp and Chinese mystery snails. Several additional non-vegetative, aquatic, invasive species are in nearby lakes, but have not been identified in Clam Lakes. 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 the Clam Lakes.

COMMON CARP

The common carp (Figure 59) is a large omnivorous fish. It has large scales, a long dorsal fin base, and two pairs of long barbels (whiskers) in its upper jaw. Native to Europe and Asia, it was intentionally introduced into Midwest waters as a game fish in the 1880s. Common carp may cause many negative impacts in a lake. Common carp are one of the most damaging aquatic invasive species due to its wide distribution and severe impacts in shallow lakes and wetlands. Their feeding disrupts shallowly rooted plants muddying the water, which in turn releases phosphorus that may increase algae abundance, which can cause water quality to deteriorate, and cause a loss of aquatic plants needed by other fish and waterfowl.

A large expansion of carp after an extremely successful 2005 spawning and recruitment season has been documented as the cause of the crash of wild rice in the Clam Lakes that was first identified in 2007. By 2010, there was almost no wild rice or other vegetation in the Clam Lakes. A large-scale, carp removal project began in 2011 with multiple seasons of fish removal. In 2017 nearly 11,000 individual fish totaling more than 135,000-lbs were removed.

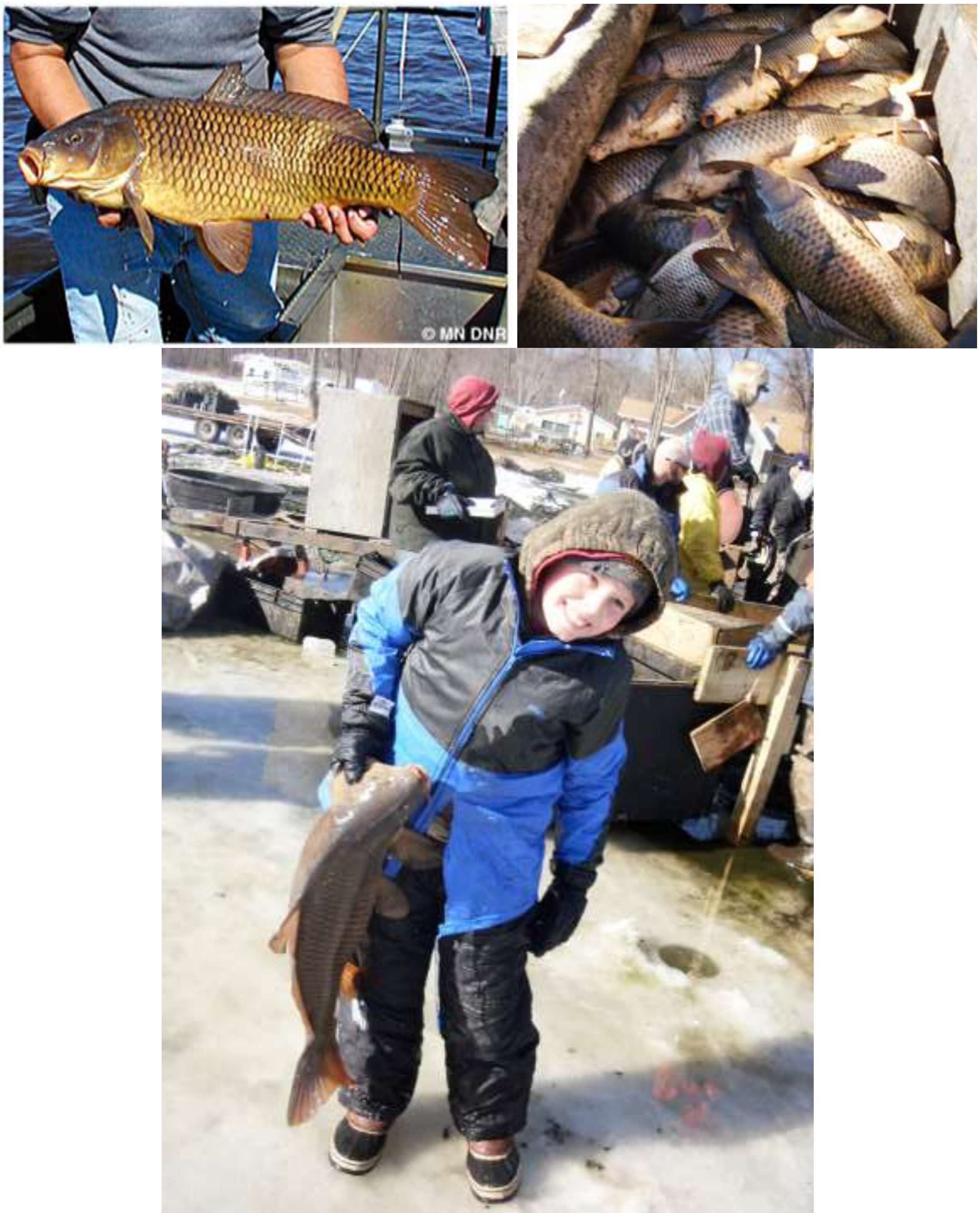


Figure 59: Common carp, carp removal from Upper Clam Lake in 2012, and 10-yr old Logan Blumer holding a large carp

RUSTY CRAYFISH

Rusty crayfish (Figure 60) live in lakes, ponds and streams, preferring areas with rocks, logs and other debris in water bodies with clay, silt, sand or rocky bottoms. They typically inhabit permanent pools and fast moving streams of fresh, nutrient-rich water. Adults reach a maximum length of 4 inches. Males are larger than females upon maturity and both sexes have larger, heartier, claws than most native crayfish. Dark "rusty" spots are usually apparent on either side of the carapace, but are not always present in all populations. Claws are generally smooth, with grayish-green to reddish-brown coloration. Adults are opportunistic feeders, feeding upon aquatic plants, benthic invertebrates, detritus, juvenile fish and fish eggs.

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

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

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

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

Rusty Crayfish were first documented in Lower Clam Lake in 2017.

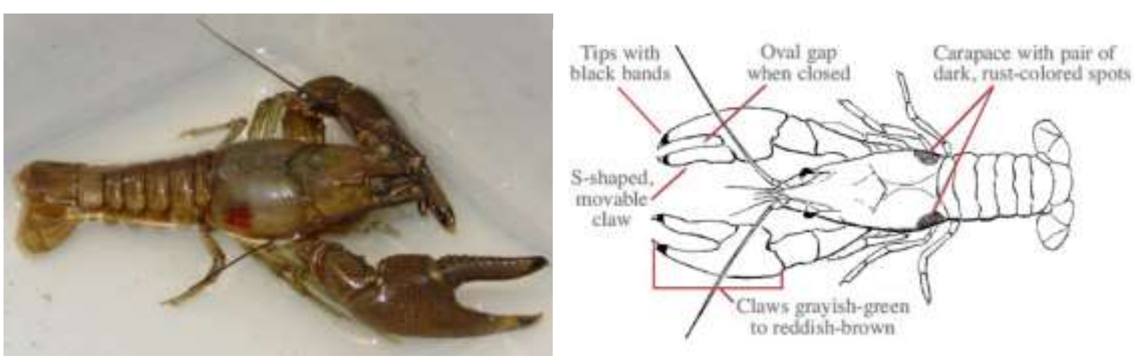


Figure 60: Rusty Crayfish and identifying characteristics

MYSTERY SNAILS

The Chinese mystery snails and the banded mystery snails (Figure 61) are non-native snails that have been found in a number of Wisconsin lakes. There is not a lot yet known about these species, however, it appears that they have a negative effect on native snail populations. The mystery snail's large size and hard operculum (a trap door cover which protects the soft flesh inside), and their thick hard shell make them less edible by predators such as rusty crayfish.

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

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

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

Figure 61: Chinese mystery snails

ZEBRA MUSSELS

Zebra mussels have not been identified in the Clam Lakes.

Zebra mussels (Figure 62) 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 62: Zebra mussels in Big McKenzie Lake, Burnett County July 4, 2019

While zebra mussels have not been identified in the Clam Lakes, they were found in western Washburn County in 2016 on Big McKenzie Lake. This was the first time that zebra mussels had been found in

Northwestern Wisconsin. This discovery heightens the importance of monitoring and prevention activities for all northwestern Wisconsin lakes.

AIS PREVENTION STRATEGY

The Clam Lakes currently have some established AIS, but there are many more that could be introduced to the lake. The CLPRD needs to implement a watercraft inspection and AIS Signage program at all of the public access points on the lakes. AIS information needs to be 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 needs to be implemented. There are UW-Extension Lakes and WDNR protocol through the Clean Boats, Clean Waters program and the Citizen Lake Monitoring Network Aquatic Invasive Species Monitoring program available to support these programs.

Additionally, having an educated and informed lake constituency is the best way to keep non-native aquatic invasive species at bay in the Clam Lakes. To foster this, the CLPRD needs to 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.

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is an ecosystem-based management strategy that focuses on long-term prevention and/or control of species of concern or their damage. IPM considers all the available control practices such as: prevention, biological control, biomanipulation, nutrient management, habitat manipulation, substantial modification of cultural practices, pesticide application, water level manipulation, mechanical removal and population monitoring (Figure 63). Integrated pest management projects should be informed by current, comprehensive information on pest life cycles and the interactions among pests and the environment.

Groups should focus their efforts to keep the species of concern from becoming a problem by looking into the environmental factors that affect the species and its ability to thrive. Once groups understand the species of concern, they can create conditions that are either unfavorable or less beneficial for it.

Monitoring means checking the waterbody to identify what species are present, how many there are and what their impacts are on each other and on water use. Correctly identifying the species of concern as well as all other species in the waterbody is key to knowing whether a species is likely to become a problem and determining the best management strategy.

After monitoring and considering the information about the target species' life cycle and environmental factors, groups can decide whether the species' impacts can be tolerated or whether those impacts warrant control. If control is needed, the data collected on the species and the waterbody will also help groups select the most effective management methods and the best time to use them.

The most effective, long-term way to manage species of concern is by using a combination of methods that work better together than separately. Approaches for managing pests are often grouped in the following categories:

- **Assessment** – is the use of learning tools and protocols to determine a waterbodies' biological, chemical, physical and social properties and potential impacts. Examples include: point-intercept (PI) surveys, water chemistry tests and boater usage surveys. This is the most important management strategy on every single waterbody.
- **Biological Control** – is the use of natural predators, parasites, pathogens and competitors to control target species and their impacts. An example would be beetles for purple loosestrife control.
- **Cultural controls** – are practices that reduce target species establishment, reproduction, dispersal, and survival. For example, a Clean Boats, Clean Waters program at boat launches can reduce the likelihood of the spread of species of concern.
- **Mechanical and physical controls** – can kill a target species directly, block them out, or make the environment unsuitable for it. Mechanical harvesting, hand pulling, and diver assisted suction harvesting are all examples.
- **Chemical control** – is the use of pesticides. In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Groups should use the most selective pesticide that will do the job and be the safest for other organisms and for air, soil, and water quality.

IPM isn't a single solution to species of concern problems. It's a process that combines common-sense methods and practices to provide long-term, economic pest control. Over time, a good IPM program should adapt whenever new information is provided on the target species or monitoring shows changes in control effectiveness, habitat composition and/or water quality.

While each situation is different, eight major components should be established in a group's IPM program:

1. Identify and Understand the species of concern
2. Prevent the spread and introduction of the species of concern
3. Continually Monitor and Assess the species' impacts on the waterbody
4. Prevent species of concern impacts
5. Set Guidelines for when management action is needed
6. Use a combination of biological, cultural, physical/mechanical and chemical management tools
7. Assess the effects of target species' management
8. Change the management strategy when the outcomes of a control strategy create long-term impacts that outweigh the value of target species control.

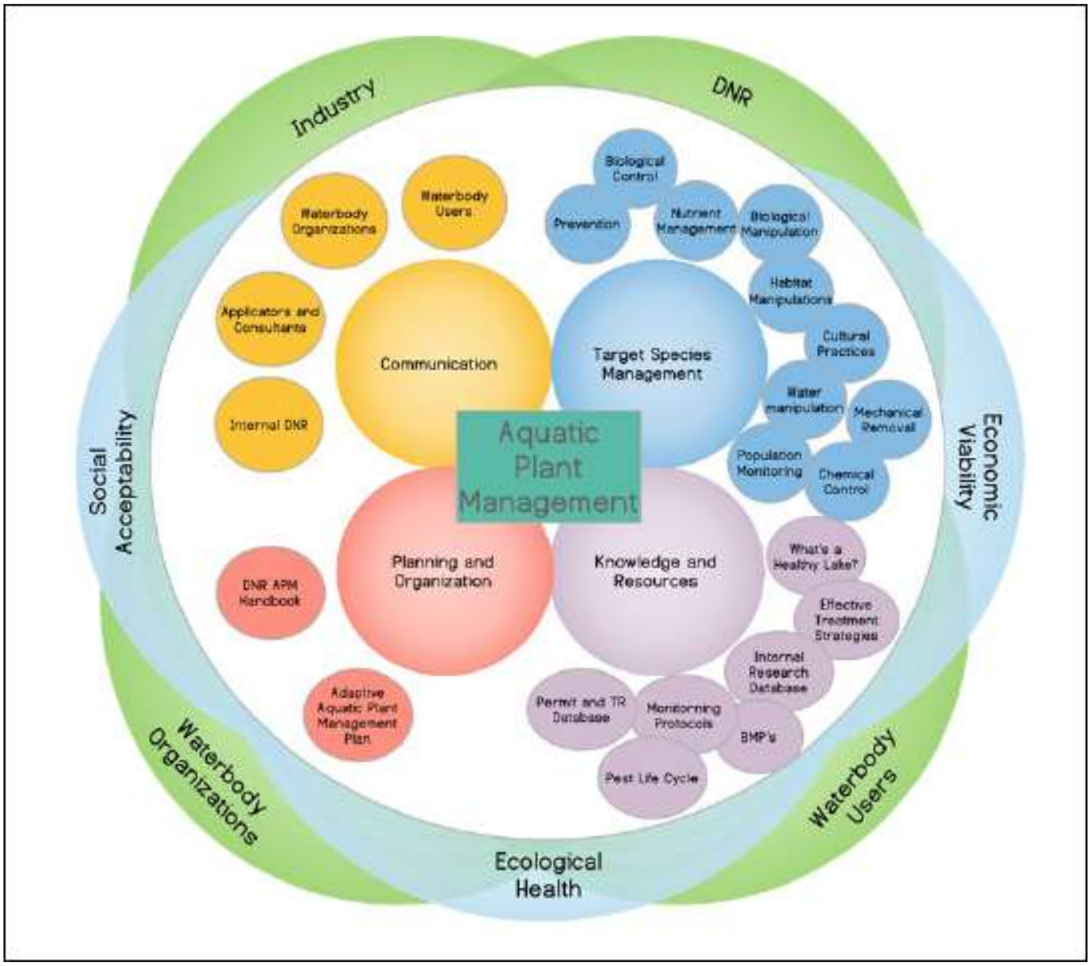


Figure 63: Wisconsin Department of Natural Resources: Wisconsin Waterbodies – Integrated Pest Management March 2020

MANAGEMENT ALTERNATIVES

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

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

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

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

NO MANAGEMENT

When evaluating the various management techniques, the assumption is erroneously made that doing nothing is environmentally neutral. In dealing with nonnative aquatic invasive species like CLP, 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).

Foregoing any management of CLP in the Clam Lakes is not a recommended option. The 2019 survey clearly showed that CLP was once again expanding its distribution and density within both lakes, but more rapidly in Lower Clam Lake. As it continues to do so native aquatic vegetation and water quality could be negatively impacted once again.

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 64)
- Removal of nonnative or invasive aquatic plants as designated under s. NR 109.07 is performed in a manner that does not harm the native aquatic plant community
- Removal of dislodged aquatic plants that drift on-shore and accumulate along the waterfront is completed.
- The area of removal is not located in a sensitive area as defined by the department under s. NR 107.05 (3) (i) 1, or in an area known to contain threatened or endangered resources or floating bogs
- Removal does not interfere with the rights of other riparian owners
- If wild rice is involved, the procedures of s. NR 19.09 (1) are followed (Appendix A).

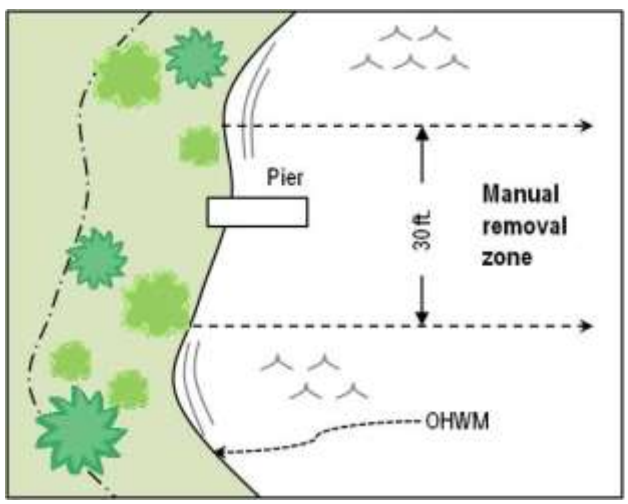


Figure 64: Aquatic vegetation manual removal zone

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 habits, 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.

Larger scale hand or diver removal projects have had positive impacts in temporarily reducing or controlling aquatic invasive species. Typically hand or diver removal is used when AIS has been newly identified and still exists as single plants or isolated small beds, but at least in one lake in New York State, it was used as a means to control a large-scale infestation of EWM. Kelting and Laxson (2010) reported that from 2004 to 2006 an "intensive management effort" which involved "the selective removal of Eurasian water milfoil using diver hand harvesting of the entire littoral zone of the lake at least twice each summer for three years" followed by three years of maintenance management successfully reduced the overall distribution of EWM in the lake.

The extent of CLP in the Clam Lakes is already at a level where physical removal would barely make a dent in it. However, if property owners were to remove individual CLP plants and small clusters that show up in new areas before they have an opportunity to create more turions it would help.

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 (Figure 65). 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. There is one local company out of the Chippewa Falls, WI area that offers contracted DASH services.

Figure 65: DASH - Diver Aided Suction Harvest (Chuck Druckery, 2016 Wisconsin Lakes Convention Presentation)

Any form of CLP management has to be completed several years in a row in order to reduce the turion supply within the treated areas. Because of this, the cost of contracting DASH services or purchasing DASH equipment would likely outweigh the level of CLP control it offers. As such, DASH is not a recommended management option for the Clam Lakes.

MECHANICAL REMOVAL

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

Large-Scale Mechanical Harvesting

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water (Figure 66). 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. The average lifetime of a mechanical harvester is 10 years, but this can be extended with proper operation, maintenance, and storage.

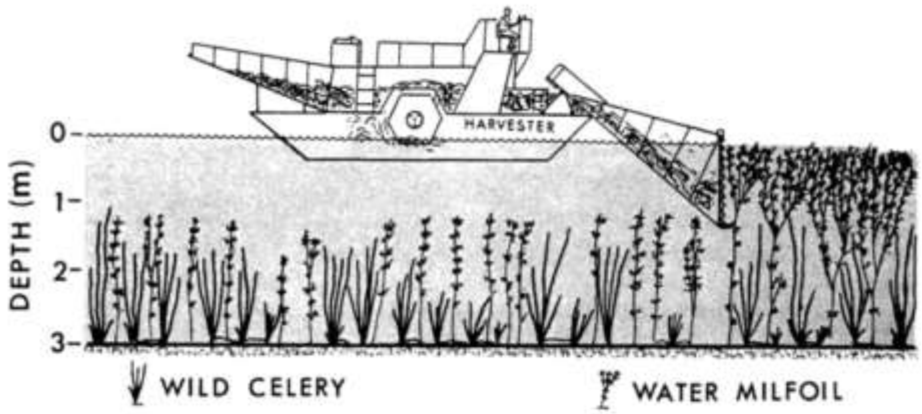


Figure 66: Harvesting of aquatic plants (Engle, 1987)

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 build-up or organic material that would normally occur as a result of dying and decaying plant matter is reduced. Additionally, repeated cuts may result in thinner, more scattered growth.

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

While the results of harvesting aquatic plants may be short term, the negative consequences are not so short lived. Harvesting aquatic plants is a little like mowing the lawn. Some plants may grow back quickly and have to be harvested again in the same season. This is usually dependent on the amount of use a harvested area gets once harvesting has been completed, particularly when harvesting access channels. If these channels are used frequently by boaters, then they will likely be kept open. If they are not frequented by boaters, the plants will likely grow back. Although the harvester collects most of the plants that it cuts, some plant fragments inevitably persist in the water. This may allow invasive plant species to propagate and colonize in new, previously unaffected areas of the lake. Harvesting may also result in re-suspension of sediments and the pollutants they may 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 or waterways. 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, particularly when harvesting invasive species like CLP. The ideal time to harvest CLP is just before the plant sets turions (reproductive structures) as this will reduce the risk of spreading new turions within the lake, remove the most biomass, and has the most potential for removing excess nutrients added from decaying CLP. Harvesting can begin sooner, but may have to be repeated in those early areas. 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/seeds/turions with them, and facilitate the spread of aquatic plant 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.

The Clam Lake Protection and Rehabilitation District currently owns and operates two mechanical harvesters with 10-ft wide cutting heads (Figure 67). These machines are capable of clearing an 8-10-ft path in one pass. Cutting heads can be lowered to as much as 4-ft but are seldom used to cut more than 2-3-ft down into the water column. The Lake District also owns several elevators that help unload the harvested plant material. Harvested plant material is disposed of at two sites near the lake. The harvesters are used for the removal of CLP in May and early June, and to open and maintain navigation channels along the shorelines of both lakes for the remainder of the summer season.

The CLPRD has been set up to harvest nuisance aquatic vegetation for several decades. Based on this, mechanical harvesting of both CLP and nuisance native aquatic vegetation is main management recommendation in this plan.

Figure 67: Two harvesters owned and operated by the CLPRD

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 68) 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 68: Aquatic Mower & Weedshear Weed Cutter (weedersdigest.com)

Given that the CLPRD currently owns its own harvesters, there is little need for one of these other cutters. That said, a rake or cutter that is run by human power could help property owners clear areas of dense growth vegetation alongside docks and other structures that the harvester are not allowed to cut. They could also be used in areas of shallow water less than 3-ft deep.

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 the Clam Lakes is not recommended.

DREDGING

Dredging is the removal of bottom sediment from a lake. Its success is based on altering the target plant's environment. It is not usually performed solely for aquatic plant management but rather to restore lakes that have been filled in with sediment, have excess nutrients, inadequate pelagic and hypolimnetic zones, need deepening, or require removal of toxic substances (Peterson, 1982). In shallow lakes with excess plant growth, dredging can make areas of the lake too deep for plant growth. It can also remove significant plant root structures, seeds turions, rhizomes, tubers, etc. In Collins Lake, New York the biomass of CLP 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. Very limited dredging is allowed without a permit if certain requirements are met.

Normally, dredging 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 the Clam Lakes.

DRAWDOWN

Drawdown, like dredging, alters the plant environment 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.

Using a winter drawdown to control CLP in the Clam Lakes is not recommended for several reasons. It may not be effective against CLP, the depth of the Clam Lakes is already minimal and reducing it further in the winter could cause greater harm.

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 control other than what was evidenced during the crash of aquatic plants from 2005-2010. The havoc wreaked by an over-population of common carp in the Clam Lakes is something that should be prevented from happening again. 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 the Clam Lakes.

Purple loosestrife is another invasive species that has been identified in and around the Clam Lakes. Biological control in the form of a beetle (Figure 69) that eats purple loosestrife and that can be raised and distributed locally is a recommended management action, particularly if the distribution and density of purple loosestrife expands in the lakes. Individual plants and small infestations of purple loosestrife can be controlled manually by pulling and/or cutting. Selective application of herbicides by dabbing cut stems can also be used.

Figure 69: Galerucella beetles that eat purple loosestrife and a "backyard" beetle rearing station

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 WDNR 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 WDNR frequently places conditions on a permit to require that a minimal amount of herbicide is needed and to reduce potential non-target effects, in accordance with best management practices for the species being controlled. For example, certain herbicide treatments are required by permit conditions to be in spring because they are more effective, require less herbicide and reduce harm to native plant species. Spring treatments also means that, in most cases, the herbicide will be degraded by the time peak recreation on the water starts.

The WDNR encourages minimal herbicide use by requiring a strategic Aquatic Plant Management Plan for management projects over 10 acres or 10% of the water body or any projects receiving state grants. The 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 WDNR also supervises treatments, requires that adjacent landowners are notified of a treatment and are given an opportunity to request a public meeting if they want, requires that the water body is posted to notify the public of treatment and usage restrictions, and requires reporting after treatment occurs.

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

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

HERBICIDE USE IN THE CLAM LAKES

Certain aquatic herbicides are used or control of CLP in some lakes. However due to the high concentration of wild rice in the Clam Lakes system, application of herbicides to control CLP is not recommended.

Herbicides may be considered for control of purple loosestrife provided it is "dabbed" on to the cut stem of the plant (Figure 70). This method is carried out by cutting stems of target species within two to four inches of the ground followed by application of herbicide, usually a Glyphosate based solution, to the cut surface. When treating larger stumps (>2 in.) herbicide should be applied to the outer edge of the stump, while smaller stumps (<2 in.) should be treated across the entire top surface. Treatment should occur immediately following cutting to ensure proper absorption of herbicide. A colored dye is usually added to the solution so that it is clear where the herbicide has been applied.

Figure 70: Cut stem or herbicide "dabbing" to control AIS (

Another method of herbicide use that could be considered is hand wicking. Hand wicking involves spraying an herbicide solution on an absorbent glove and carefully wiping the herbicide onto the surface of a leaf (Figure 71). It's important to wear an herbicide resistant glove beneath the absorbent glove, to protect your hand from the herbicide. This method is appropriate when controlling small populations of invasive species that are growing in a high-quality area, or when controlling invasive species in close proximity of endangered or threatened native species (https://muskegonlake.org/habitat-management-plan/invasive-species-control/, last accessed on August 6, 2020)

Figure 71: Hand wicking invasive species with herbicide

Herbicides can be a useful tool, and in some cases the only effective control method for certain invasive species. Herbicides fall into two broad categories; selective meaning they are only effective on certain types of plants (ex. Triclopyr based solution), and non-selective meaning they are effective on any plant they come in contact with (ex. Glyphosate based solution). The choice of herbicide depends on the target population, stage of growth, presence of desirable species, and the proximity of water resources. Herbicide treatments should be performed by certified pesticide applicators and applied in accordance with the chemical manufacturer label instructions. Use of herbicides near standing water requires a chemical application permit from the WDNR.

MANAGEMENT DISCUSSION

The 2014 Interim Aquatic Plant Management Plan completed by SEH Inc. was based on data collected, conversations with the CLPRD, St. Croix Tribal Environmental Services, and the Wisconsin Department of Natural Resources, during a time frame when the lakes were severely impacted by common carp. In that plan, the following eight general lake management and management related goals were established. Each goal had an associated list of objectives, and the actions necessary to reach the objective, and ultimately the goals.

1) Protect, preserve, and enhance native aquatic plant communities in the Clam Lakes
2) Complete annual monitoring and management of aquatic invasive species currently identified in the Clam Lakes
3) Complete aquatic invasive species education, monitoring, and prevention
4) Improve in-lake habitat for fish and wildlife and for reducing available nutrients
5) Reduce nutrient loading to the Clam Lakes
6) Provide property owner and lake user education and awareness of issues impacting the Clam Lakes
7) Collect lake related data to enhance and support current and future lake management planning and implementation

These goals for the most part were reached through the many projects, mostly associated with the removal of carp that were completed by the WDNR, SCTES, and the CLPRD. The population of carp is down, CLP density and distribution was down through 2017 but is again creeping back up to where it had been before the crashed caused by carp, the distribution and density of wild rice is up, water clarity has improved, and the native aquatic plant community has improved. Goals and objectives in the new APM Plan will focus on maintaining the positive changes that have occurred throughout the system.

To do this, aquatic plant management will be focused on reducing recently expanding CLP density and distribution, protecting native aquatic plants and wild rice, and being mindful of how plant management affects the fishery.

AQUATIC PLANT MANAGEMENT IN THE CLAM LAKES

The Clam Lakes are considered shallow water, eutrophic lakes currently in a plant dominated state. Between roughly 2007 and 2015 they were in an algae dominated state with little aquatic vegetation (due to carp disturbances) and very turbid water. After several years of successful carp removal beginning in 2011, the lakes are now showing positive trends toward improved water clarity and quality, but at the same time, nuisance aquatic vegetation in the form of increased CLP distribution and density early in the open water season (particularly in Lower Clam Lake) and increasing density of native aquatic vegetation in the mid to late summer, has become more of a problem. The density of CLP in the spring of the year (Figure 73), and the general summer aquatic plant density (Figure 72) was documented in both lakes in 2019 survey work completed by ERS. In the extreme northeast bay of Lower Clam, and the two southeast bays and the southwest bay in Upper Clam, plant density is the result of abundant wild rice.

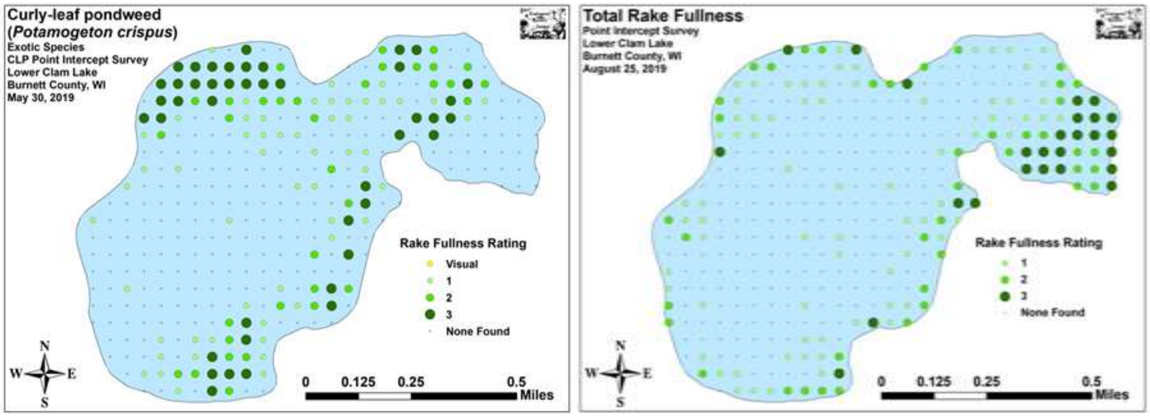


Figure 72: CLP and native aquatic plant density in Lower Clam Lake (Berg, 2019)

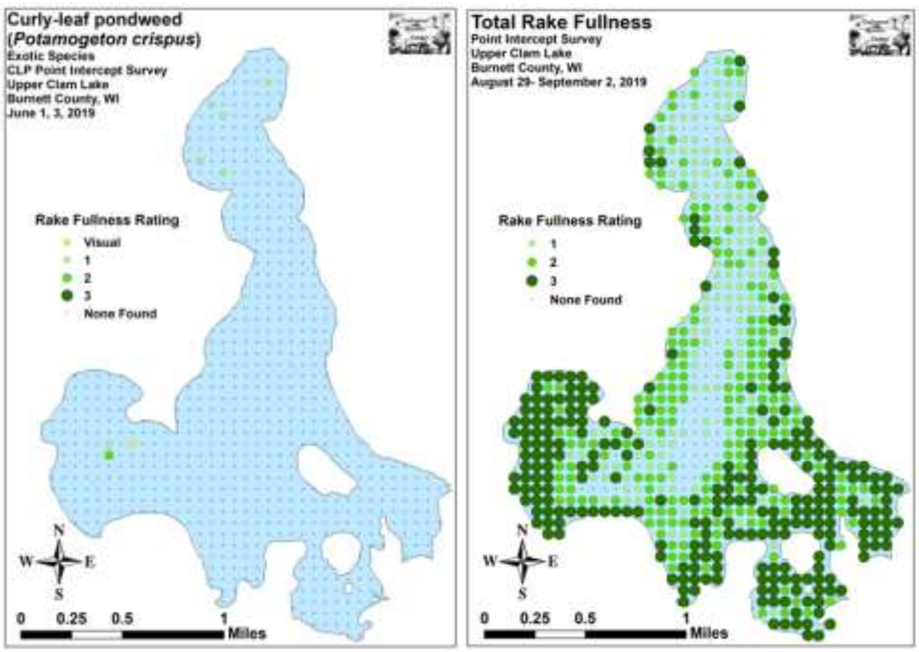


Figure 73: CLP and native aquatic plant density in Upper Clam Lake (Berg, 2019)

CLP MANAGEMENT IN LOWER CLAM LAKE

While it is recognized that CLP provides an important early season nursery for fish species like bluegill and bass that are vital to maintaining the overall health of the lakes, there is concern that CLP will continue to increase both its distribution and density in the lake. CLP often grows to full canopy and spreads rapidly by turions, so it is likely that the springtime beds documented in 2019 will continue to expand to previous levels documented in 2009 (Figure 74). At that time, CLP dominated the majority of the lake's littoral zone, possibly shading out native aquatic plant growth, interfering with lake use, and perhaps even adding to the internal nutrient load in the lakes. Consequently, harvesting in many areas of the lake is once again likely to be needed on an annual basis. The goal is to harvest CLP in a way that reduces its negative impacts, but maintains the benefits it provides to the bluegill nursery in the lake. One way to do this without clear-cutting the CLP would be to open several boating/fish cruising lanes parallel to shore through these large beds. Determining a limit to the expansion of CLP into to deeper water and removing any CLP that exceeds that limit will help prevent it from becoming the dominant plant species it was in 2009.

There is a fair amount of research that suggests in the spring, fish tend to associate with aquatic plants that can overwinter in full form or that emerge early from the substrate (Petr, 2000). CLP is one of the species that does that. More research suggests that many fish associate with the water's surface immediately above plants, the periphery of dense stands of plants, in holes formed in plant beds, or near the bottom directly below the dense canopies. Creation of strips of intermediate vegetation or opening lanes within dense vegetation is thought to enhance the fishery by creating more of these spaces, and improves access to that fishery by fishermen. A couple of studies even showed that bluegill and bass substantially increased growth rates in some age classes as a result of this type of management (Petr, 2000).

Conversely, there is research that shows when dense stands of aquatic plants occupy large areas of a water body, a reduction in fish condition can occur resulting in stunted fish populations (Petr, 2000).

Over time, there has been some concern as to what large-scale mechanical harvesting has on fish directly – not just by changing the makeup of the vegetation. Several studies have shown that harvesting does have an incidental take of several fish species. One study showed an estimated 32% loss of fish numbers and an 18% loss in fish biomass. Another study showed only a 3% estimated loss in fish numbers due to harvesting (Petr, 2000). In both of these referenced studies, bluegills were one of the species experiencing loss. A study in MN concluded that selectively cutting deep channels throughout dense plant beds in lakes was less impactful to the fishery than clear-cutting large surface mats, and in fact, it might actually be more beneficial for fish and those who fish for them (Petr, 2000).

It should be noted that other studies have concluded that the impact of harvesting is likely to vary tremendously between lakes due to the differences in aquatic plant species, their densities, and different fish stocks present (Petr, 2000).

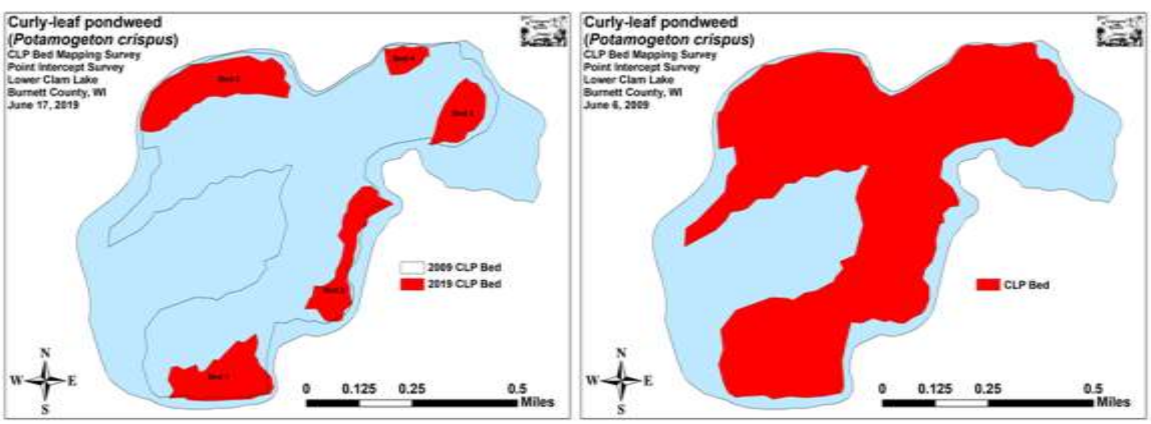


Figure 74: CLP distribution in Lower Clam Lake 2019 & 2009 (Berg, 2019)

NATIVE AQUATIC VEGETATION MANAGEMENT IN LOWER CLAM LAKE

In Lower Clam Lake, the most abundant native aquatic plant species in 2019 were common waterweed, coontail, small pondweed, and water celery (Figures 75). All four of these species, while considered part of a healthy native plant community, can cause nuisance conditions and navigational impairments by entangling around boat props, anchors, and fishing lures; and interfere with swimming and other recreational uses. Common waterweed was found in almost all nearshore areas in 2019. Coontail distribution nearly mirrored that of common waterweed. Small pondweed was also present along the shoreline throughout the entire lake.

While not as widespread in 2019, because of it long stringy nature, wild celery creates similar nuisance conditions.

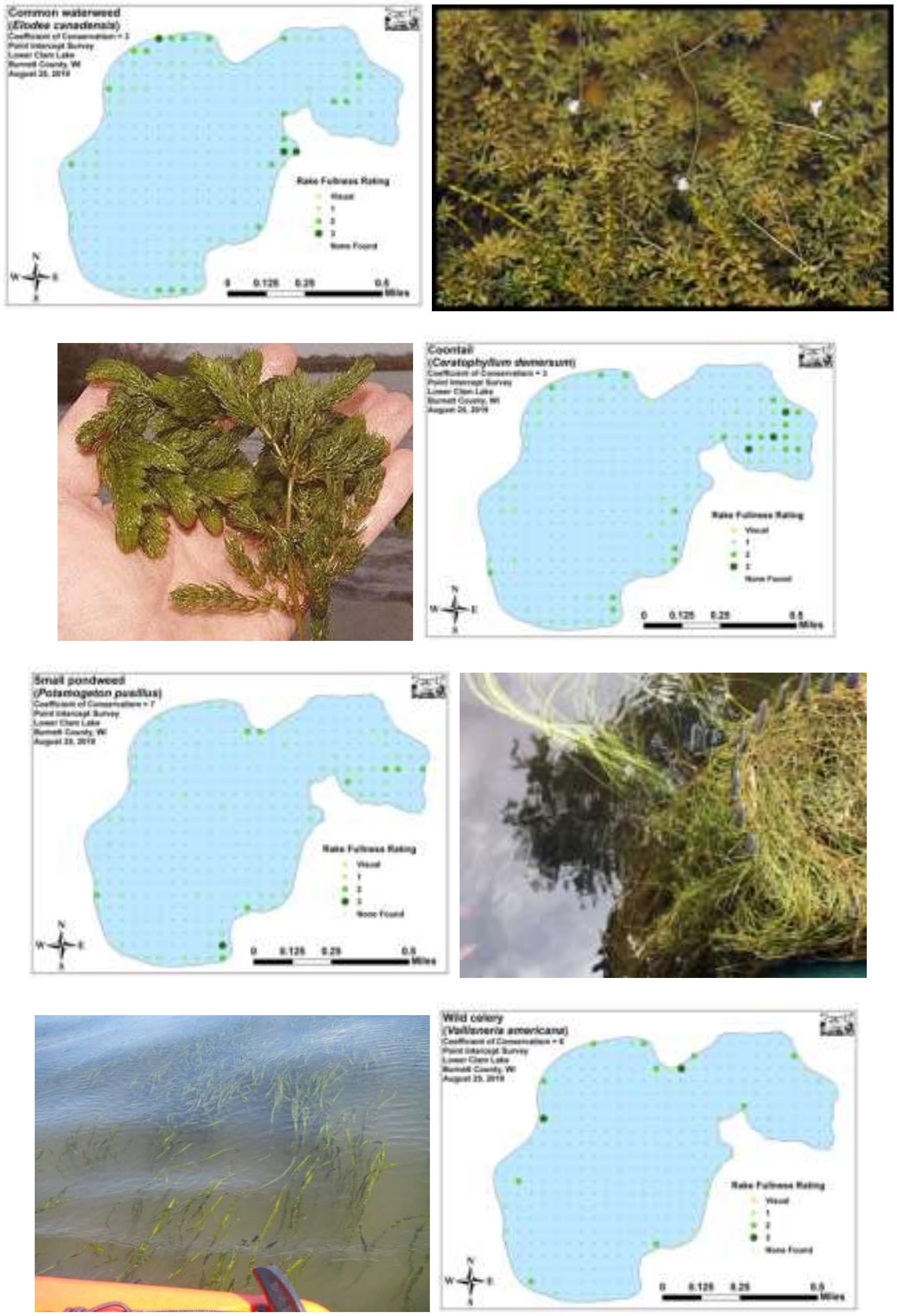


Figure 75: Distribution and density of common waterweed, coontail, small pondweed, and water celery (Berg, 2019)

Management of these species is needed only to open navigation lanes that will maintain access to open water for the numerous property owners adjacent to large beds of these species. Cutting fairly wide navigation channels parallel to the shore at a distance from shore that coincides with the ends of docks; and cutting several access lanes perpendicular to shore through dense beds of vegetation to open water is recommended.

It may also be beneficial to the fishery and fishermen, to cut/harvest lanes through some of the more dense beds throughout the lake.

CLP MANAGEMENT IN UPPER CLAM LAKE

Similar concerns to those discussed for Lower Clam Lake are also in place in Upper Clam Lake. Fortunately, the density and distribution of CLP in Upper Clam Lake has never reached the dominance it did in Lower Clam (Figure 76). As such, in this management plan, it is only recommended that the density and distribution of CLP be monitored each year to document changes. No harvesting of CLP is recommended unless certain criteria are met. Those criteria are based on the extent of distribution, acreage, and density of the CLP within those areas that are documented.

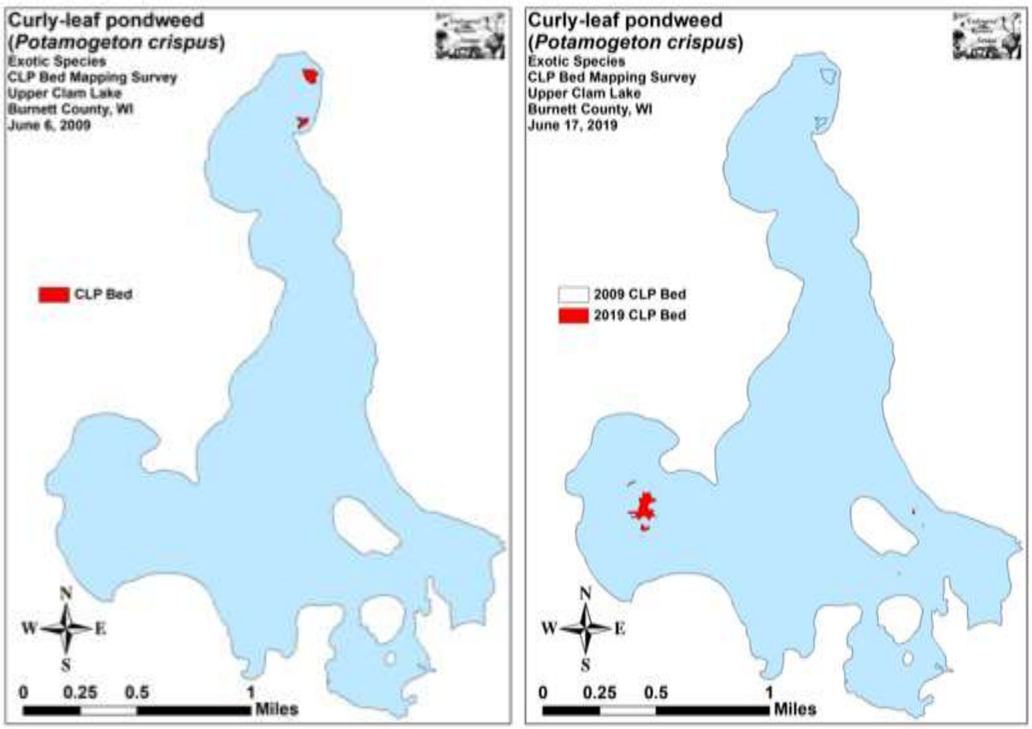
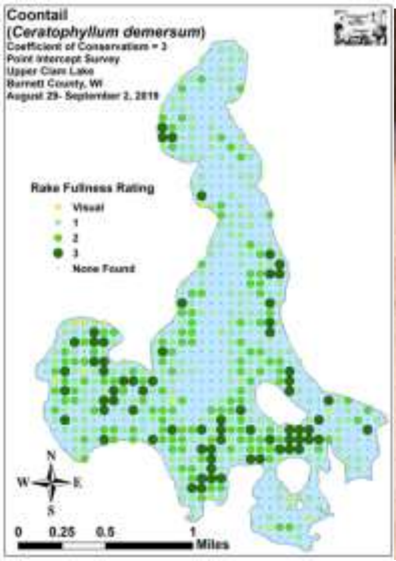


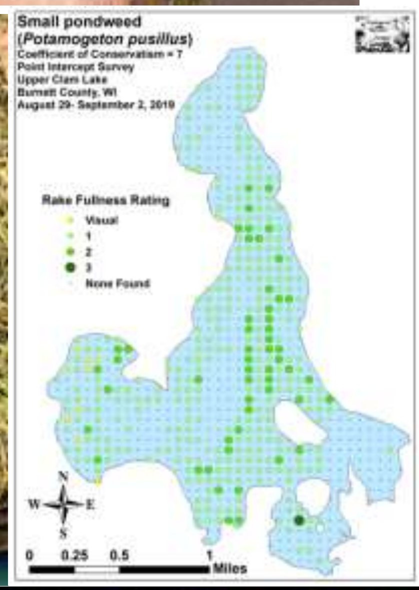
Figure 76: CLP distribution in 2009 and 2019 (Berg, 2019)

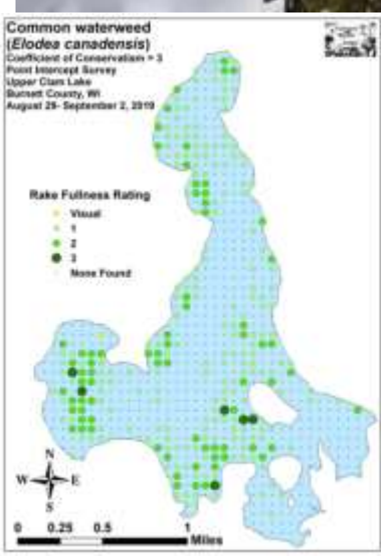
NATIVE AQUATIC VEGETATION MANAGEMENT IN UPPER CLAM LAKE

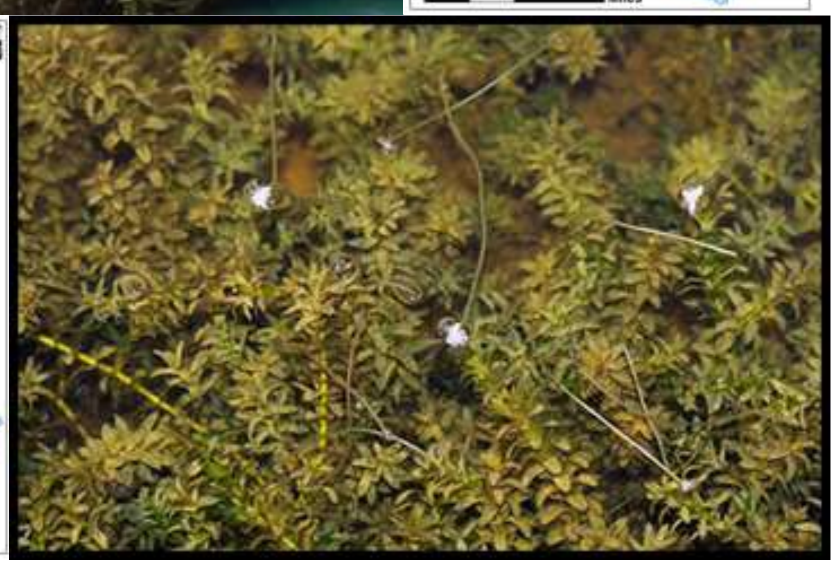
In Upper Clam Lake, the most abundant native aquatic plant species in 2019 were coontail, small pondweed, common waterweed, water star-grass, and water celery (Figures 77). All five of these species, while considered part of a healthy native plant community, can cause nuisance conditions and navigational impairments by entangling around boat props, anchors, and fishing lures; and interfere with swimming and other recreational uses. All of these species are located throughout the lake but they are particularly dense along the southeast shore, and in the two bays on the northwest side of the lake. Like Lower Clam Lake, management of these species is needed only to open navigation lanes that will maintain access to open water for the numerous property owners adjacent to large beds of these species. Cutting fairly wide navigation channels parallel to the shore at a distance from shore that coincides with the ends of docks; and cutting several access lanes perpendicular to shore through dense beds of vegetation to open water is recommended.

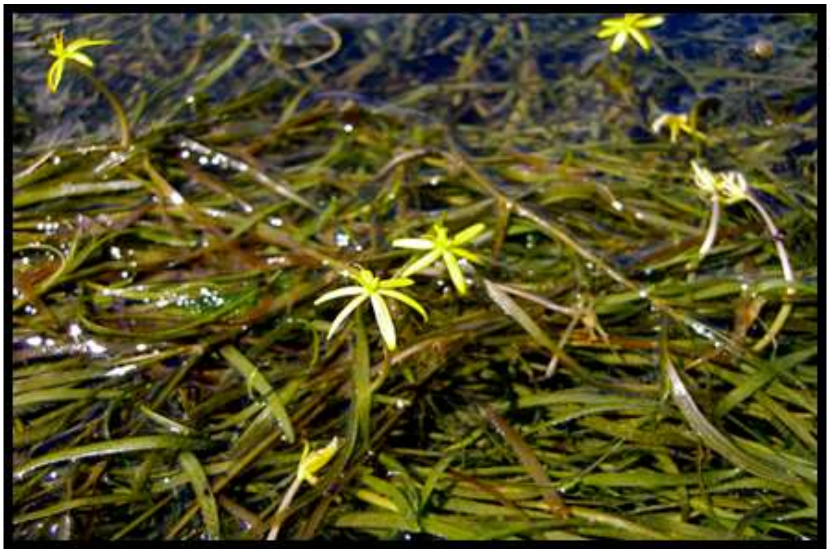
It may also be beneficial to the fishery and fishermen, to cut/harvest lanes through some of the more dense beds throughout the lake.

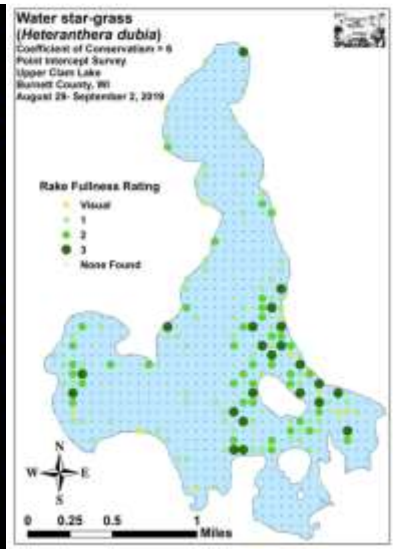

Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0 0.25 0.5 1
Miles


Small pondweed
(Potamogeton pusillus)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0 0.25 0.5 1
Miles


Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0 0.25 0.5 1
Miles







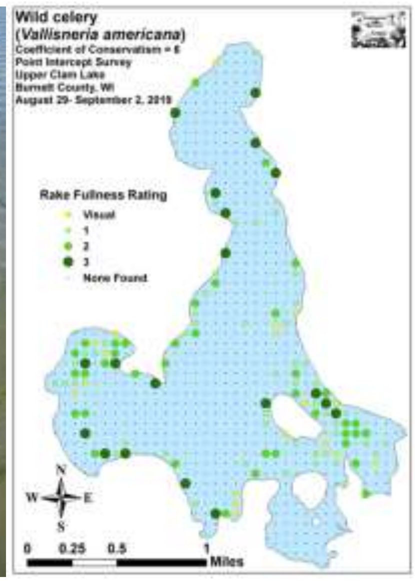


Figure 77: Distribution and density of coontail, small pondweed, common waterweed, water star-grass, and water celery (Berg, 2019)

HARVESTING OF CURLY-LEAF PONDWEED

Harvesting of CLP or any other aquatic plant is considered a maintenance management activity – not intended to provide long-term, multi-year control of the target species. While this is in part true, harvesting of CLP can be done in a manner that may actually reduce the population over time. CLP grows early, often greening up under the ice. The success of this early growth is somewhat dependent on the amount of ice, snow cover, and sunlight that is experienced during the winter season. More ice and snow generally means less early CLP growth. Once the ice goes out, and sunlight exposure is at its greatest, CLP can quickly become dense beds at or near the surface of the lake by mid to late spring, early summer. If the water in the lake stays cool all season long, or there are portions of a lake where cooler tributary or spring water comes in, CLP may persist throughout the open water season. Generally however, when water temperatures warm up in late June early July, CLP completes its growing cycle, but not before setting turions in mid to late June that drop off to the bottom and become the seed for the next season's growth (Figure 78). The window between when CLP has reached its maximum growth stage and before it sets turions is the best time to harvest. This time period typically last only 2-3 weeks, but if harvesting is completed during this window, the number of turions in the sediment can be reduced over time, also reducing future CLP growth.

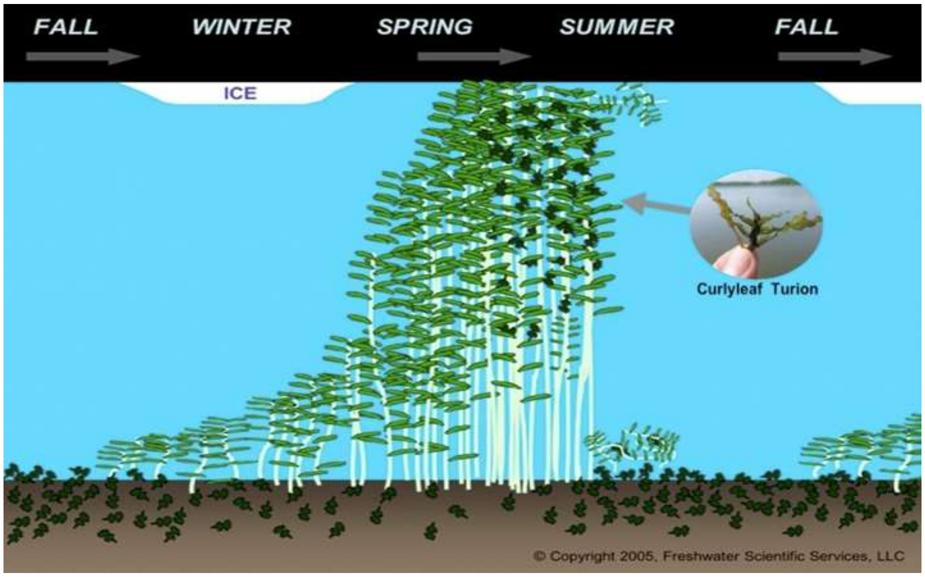


Figure 78: Typical CLP growing season and life cycle

APPLICATION OF AQUATIC HERBICIDES

As previously mentioned, other than the potential use of aquatic herbicides dabbed on cut stems or wicked on to the leaves and stems of purple loosestrife, herbicides are not recommended for use on the Clam Lakes.

AQUATIC PLANT SURVEYING

CLP is thriving once again in Lower Clam Lake, and to a lesser degree in Upper Clam Lake. Just how much area CLP could take over in Lower Clam is easily estimated based on the results of 2009 spring CLP bedmapping. A single bed of CLP covering more than 220 acres was mapped in early June 2009 in Lower Clam Lake. On June 17, 2019 a similar bedmapping survey documented five individual beds of CLP ranging from 3 to nearly 20 acres in size and totaling nearly 60 acres. All of these beds were within the footprint of the single large bed documented in 2009. It is reasonable to assume that if CLP is not managed effectively and efficiently that it will again reach the level it was in 2009. Based on the 2019 CLP survey results on Upper Clam Lake, CLP is not in the same locations as it was documented in 2009. Whether this is because of the carp issues or some other parameter is unknown. What is important for both lakes is to monitor the expansion of CLP on an annual basis. CLP bedmapping is probably the best way to do this, other than completing a PI survey each year. Bedmapping can be done by members of the lake group using handheld GPS units and a pontoon or other boat.

CURLY-LEAF PONDWEED BED MAPPING SURVEY

During a bed mapping survey, the lake's entire visible littoral zone is searched. The definition of a "bed" used by ERS, who completes many of these surveys each year, is any area where it is visually estimated that CLP makes up >50% of the area's plants, is generally continuous with clearly defined borders, and is canopied, or close enough to being canopied that it would likely interfere with boat traffic. After a bed is located, the surveyor motors around the perimeter of the area taking GPS coordinates at regular intervals. The density of the bed is estimated based on a 1-3 rakehead fullness rating. The maximum depth of the bed, whether it is canopied, and the impact it is likely to have on navigation (**none** – easily avoidable with a natural channel around or narrow enough to motor through/**minor** – one prop clear to get through or access open water/**moderate** – several prop clears needed to navigate through/**severe** – multiple prop clears and difficult to impossible to row through) is also estimated. Results from mapping will be transferred to the consultant they are working with and maps made.

MEANDERING SURVEYS

There is continually a threat that non-native, invasive plants like EWM could get introduced into the Clam Lakes. At present they have a healthy and diverse native aquatic plant community with CLP already well-known and managed. Meandering surveys of the littoral zone looking for a specific plant species like EWM are important as they generally are the first indicator that there is something that does not belong. Meandering surveys help find target plant species, document the location where target plants are found using GPS technology or general mapping, and provides an opportunity to physically remove the target plant or make it a part of another management action.

PRE AND POST-TREATMENT POINT-INTERCEPT SURVEYS

Pre and post-treatment, point-intercept surveys are more quantifiable and document short-term changes in those areas under management. They consist of a set of points that can be surveyed at multiple times, usually before and after a chemical treatment. Statistical information can be gathered from the data collected during one of these surveys. The WDNR only requires pre and post-treatment, point-intercept aquatic plant surveying when greater than 10 acres of the littoral zone are proposed for treatment, or if a chemical treatment is grant funded. Currently, it is unlikely that any chemical treatment will occur in the Clam Lakes. Pre and post-treatment surveys are not required for harvesting; therefore, it is not recommended that pre and post surveys be completed in the Clam Lakes.

WHOLE-LAKE, POINT-INTERCEPT, AQUATIC PLANT SURVEYS

Whole-lake, point-intercept surveys are intended to track changes to the aquatic plant community over time. Typically in a lake where management of aquatic plants (non-native or native) takes place, whole-lake surveys are recommended at least every five years using the same set of pre-designated points each time. The first time a whole-lake point-intercept survey is completed, the results serve as a baseline for future comparisons. After the first survey, the results from any future surveys can be compared to the first survey for changes. If any changes are identified, it is then possible to analyze what might have caused the changes. While changes naturally occur in most lakes from one year to another, management actions including management of CLP can also be a reason for change.

The last whole-lake, point-intercept survey of the Clam Lakes was completed in 2019. The next whole-lake point-intercept survey will need to be completed in 2024 at the end of this current plan.

OTHER AIS MONITORING AND MANAGEMENT

In addition to monitoring and managing CLP in the Clam Lakes the CLPRD will participate in Citizen Lake Monitoring Network Aquatic Invasive Species Monitoring Program annually looking for EWM, purple loosestrife, and zebra mussels. Purple loosestrife is already found along the shores of the lakes. Annual survey work along with removal of individual plants easily accessible by volunteers will help keep purple loosestrife from spreading. If larger areas of purple loosestrife are identified, volunteers can get involved in rearing and releasing Gallerucella beetles as a biological control agent.

COARSE WOODY HABITAT

Coarse woody habitat has never been formally quantified within the Clam Lakes. Given the concern over the population of bluegills, the installation of "fishsticks" projects with funding support from WDNR Healthy Lakes grants would benefit the lake. A coarse woody habitat survey could help identify areas of the shoreline that might be suitable for installation of fishsticks projects. These installations are a great way to increase fisheries and wildlife habitat, and help reduce shoreline erosion from wave action.

CLAM LAKES AQUATIC PLANT MANAGEMENT GOALS, OBJECTIVES, AND ACTIONS

There are eleven general aquatic plant management goals for the Clam Lakes. Associated with the eleven goals are 20 objectives and numerous actions to help meet the objectives. The goals, objectives, and actions are intended to act as a guide for the CLPRD to follow in at least the next five years to maintain positive gains achieved through the large-scale carp removal project that began in 2011. The carp management actions improved the fishery, water quality, and the health of the aquatic plant community. But with the positive changes comes a few negative changes including the expansion of CLP, a non-native aquatic invasive species, to levels where it may cease to be a beneficial parameter in the health of the lakes; and an increase in the growth of nuisance level native aquatic vegetation that interferes with lake access and lake use. All of the goals, objectives, and actions are included in Appendix A.

- Protect, preserve, and enhance native aquatic plant communities in the Clam Lakes including wild rice.
- Prevent CLP in Upper Clam Lake from expanding to levels where it might cause navigation issues or hinder native aquatic plant growth.
- Prevent CLP in Lower Clam Lake from taking over the littoral zone.
- Improve access to open water through dense growth native aquatic vegetation for property owners along the Clam Lakes.
- Prevent purple loosestrife from taking over any of the shoreline or wetlands around the Clam Lakes.
- Minimize negative impacts to the existing bluegill fishery caused by aquatic plant management actions in the Clam Lakes.
- Minimize opportunities for new AIS to enter and become established in the Clam Lakes.
- Reduce pollutant loading into the Clam lakes.
- Provide property owner and lake user education and awareness of issues impacting the Clam Lakes.
- Collect lake related data to enhance and support current and future lake management planning and implementation in the Clam Lakes.
- Implement this plan following Integrated Pest Management guidelines from the WDNR.

Additional management discussion is included in Appendix A: Goals, Objectives, and Actions for Clam Lakes Aquatic Plant Management.

IMPLEMENTATION AND EVALUATION

This plan is intended to be a tool for use by the CLPRD to move forward with aquatic plant management actions that will maintain the health and diversity of the Clam Lakes and their 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, CLPRD funds, and other entities is highly recommended. An Implementation and Funding Matrix is provided in Appendix B. A Calendar of Actions is provided in Appendix C. Sample harvesting plans for CLP and summer nuisance aquatic vegetation is included in Appendix D.

Annual review of management actions and the results obtained is essential to the effective implementation of this plan. Annual reports summarizing all management actions and the results, as well as the efforts made by the CLPRD and their partners to educate and inform their constituency about plant management and other action items mentioned in this plan will be completed.

Management actions will be proposed based on as current data that exists and be discussed with all partners for approval before implementation.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES GRANT PROGRAMS

There are many Wisconsin State Surface Water grant programs that can aide the CLPRD as it moves forward with implementation of the actions included in this plan. Appendix E is a quick synopsis of surface water grant programs as they exist at the present time. The CLPRD is encouraged to discuss implementation of this plan with their Regional WDNR Lakes Coordinator to see how and where the grant programs can assist.

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Appendix A

Clam Lakes APM Plan Goals, Objectives, and Actions

Appendix B

Clam Lakes APM Plan Implementation Matrix

Appendix C

Clam Lakes APM Plan Calendar of Actions

Appendix D

CLP and Nuisance Aquatic Plant Harvesting Plans

Appendix E

WDNR Surface Water Grants Program

Appendix F

Burnett County Shoreland Incentives Program

Appendix G

Wisconsin Wild Rice Conservation Rule – NR 19.09