Aquatic Plant Management Plan

Cranberry Lake/Flowage (WBIC: 2693100)

Douglas County, Wisconsin

2021

Sponsored by

Cranberry Lake/Flowage Association

Prepared by

Ecological Integrity Service, LLC and Cranberry Lake/Flowage Association Plant Management Committee

Advisor

Pamela Toshner, Wisconsin Department of Natural Resources

Funded by

Cranberry Lake/Flowage Association

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DEPT. OF NATURAL RESOURCES

January 4, 2021

Mr. Tom Franta
Cranberry Lake Flowage Association
PO Box 74
Wascott, Wisconsin 54890

Subject: Cranberry Lake/Flowage 2021 Aquatic Plant Management Plan (Plan) Approval

Dear Mr. Franta:

Thank you for your efforts to understand, protect, and improve Cranberry Lake and Flowage. Aquatic Plant Management Coordinator Tyler Mesalk and I both reviewed the Plan. We appreciate the effort that went into the it and are pleased with the changes made since August. This letter is to notify you the DNR has approved the Plan with the following conditions:

1. *(what is?)*, *(What may be),* and *(what would)* show up in the text repeatedly. If possible, please send an updated pdf without this language.
2. Page 46, Section 1.2, there is a statement "*Regardless of herbicide type used, the early season application will continue in the future with the application occurring while water temperatures range from 50-60 degrees F."* This statement is a little confusing in that it implies herbicide applications will occur regardless of DNR approval. If herbicide control is permitted, early season treatment will likely be required. It may be that herbicide control is not approved by DNR every year, though.
3. Lastly on page 48, Section 2.3, 1.25 is suggested as a mean Eurasian watermilfoil (EWM) density to engage management. This is a low density for EWM itself and may mean in certain circumstances there are abundant native plants. After reviewing other approved APM Plans, I couldn't find any current examples with a similar low-density criterion. We suggest editing this measurement to a 1.5 within the Plan and will require the EWM density be a 1.5 in order to be eligible for surface water grant funding of herbicide control efforts.

Approved management recommendations, incorporating the conditions above, are eligible for funding under the Surface Water Grant program (NR 193), subject to the application requirements.

Please append this approval letter to the final Plan into the future. Your patience with this approval is much appreciated. Thanks to you and the lake community for continuing to work hard to protect Cranberry Lake and Flowage and feel free to reach out with any questions.

Sincerely yours,

Pamela Toshner

Lake & Watershed Protection Specialist

CC: Dave Olson, Cranberry Lake Flowage Association
Steve Schieffer, Ecological Integrity Service LLC

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Introduction

This aquatic plant management plan is developed for Cranberry Lake/Flowage for the management of aquatic plants with oversight by the Cranberry Lake/Flowage Association (CFLA). Eurasian water milfoil (EWM) was discovered in Cranberry Lake in 2007. Since then, herbicide treatments and hand-pulling have been implemented to reduce the spread of this invasive plant. The development of this plan has been on-going during this time. This update will provide for an established plan for future management of AIS and prevention of new introductions of AIS, as well enhance education about the lake ecosystem.

This plan will be effective from 2021 until 2026, at which time it should be reevaluated and/or adjusted to reflect effective and ineffective aspects and change those accordingly. The updated plan will begin in 2019-20. A plant management committee was formed to evaluate data and the previous version of the Aquatic Plant Management Plan to evaluate and update this plan. Those committee members were:

Rick Maas-Cranberry Lake
Dave Olson-Cranberry Lake
Paul Seiferth-Cranberry Flowage
Steve Schieffer-Cranberry Lake and Consultant

The committee met four times. First to evaluate plant community and past management of EWM, as well as review past goals. The second, third and fourth meetings were to review and revise objectives and action items.

In June 2007 for management purposes, it was determined that the Cranberry Lake Association would be separate from the Minong Flowage. An agreement was approved by both the Cranberry Lake/Flowage Association and the Minong Flowage Association to use County Highway T as the defined boundary for management and designation of the Cranberry Lake/Flowage Association. All waters north of this location would be managed by the Cranberry Lake/Flowage Association and all waters south by the Minong Flowage Association. This created an issue with aquatic plant surveys, as the Cranberry Flowage has been historically included in the point intercept grid for the Minong Flowage. As a result, the plant survey data from the Cranberry Flowage points within the Minong Flowage point grid was used in this plan.

Figure 1: Aerial photo of Cranberry Lake and Flowage with location ending management area (County T) and location of public boat landing (red dot).

In 2017, this plan was modified to meet grant application requirements. This version (2020), represents a formal re-evaluation and is considered a complete update. This plan was shared with the public for 60 days, opened for comments, and presented at the annual meeting.

Throughout the year, the Cranberry Lake/Flowage Association held four plant management committee meetings. In these meetings, management practice updates are provided to all attendees. In addition, many members are on an email list and receive informational updates.

A draft of this plan was shared with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) and received comments which were implemented into the plan. It has also been shared with the Minong Flowage Association since these bodies are hydrologically connected via the Cranberry Flowage channel. Also, the Wisconsin DNR regional lake manager was consulted in the development of this plan.

No public survey has been completed to date.

Lake Management Concerns

In meetings with the plant committee and annual meeting comments, the major management concern is the EWM. Since Cranberry Lake is a small, shallow lake with many areas conducive to EWM growth habitat, there is major concern of this AIS plant overtaking the native plant community in Cranberry Lake, adversely affecting the fisheries, recreation use, and lake aesthetics. Another high concern is the length and effectiveness in maintaining reduction of the EWM with the travel of boats between Cranberry Lake and the Minong Flowage. Furthermore, the financial burden of managing EWM is of high concern.

The Cranberry Lake/Flowage Association also understands the importance of native aquatic plants. They are interested in maintaining a highly diverse, healthy native plant community.

The following lake health management goals were established reflecting these concerns:

1. *Protect native plant community and fish habitat.*
2. *Limit Eurasian watermilfoil coverage and reduce its impact on the ecosystem.*
3. *Prevent introduction of other invasive species.*
4. *Maintain and enhance native shoreline community.*
5. *Educate citizens about importance of aquatic plants and lake ecology.*
6. *Continue to establish funding mechanisms.*

Functions and Values of Native Aquatic Plants

Naturally occurring native plants are extremely beneficial to the lake and play a vital role in the lake ecosystem. They provide a diversity of habitats, help maintain water quality, sustain fish populations, and support common lakeshore wildlife such as loons and frogs.
Aquatic plants are generally divided into broad categories: Emergent, free floating, floating-leaf, and submersed. Emergent plants, such as cattails, have leaves that stick up above the water surface. Free-floating plants, such as duckweed, float freely on the water surface. Water lily is an example of floating leaf plants (its leaves float on the water surface) but are attached to the bottom via a leaf petiole. Submersed (submergent) plants exist totally submersed in the water. They may reach the surface, but the leaves do not stick above the water surface. Pondweed and milfoils are examples of submergent plants.

Water Quality/Watershed

Aquatic plants can improve water quality by absorbing phosphorus, nitrogen, and other nutrients from the water that could otherwise fuel nuisance algal growth. Some plants can even filter and break down pollutants. Plant roots and underground stems help to prevent re-suspension of sediments from the lake bottom. Stands of emergent plants (whose stems protrude above the water surface) and floating plants help to blunt wave action and prevent erosion of the shoreline. Poor water clarity can restrict aquatic plant growth by limited light penetration.

Shallow lakes typically have two alternative stable states—phytoplankton (algae)-dominated or macrophyte (plant)-dominated (Newton and Jarrell, 1999). In moderate densities, macrophytes are beneficial in these lakes. Macrophytes keep sediment from being resuspended by the wind and therefore help keep the water less turbid. Macrophytes also provide a place for attached algae to grow and remove phosphorus from the water column. If the macrophytes are removed or if external phosphorus inputs increase, the lake can shift from a macrophyte-dominated state to an algal-dominated state. Once a lake is in the algae-dominated state, macrophytes have a difficult time re-establishing themselves, because algae reduce the penetration of light. Of these two conditions, it is commonly believed that the macrophyte-dominated state, which is present in Cranberry Lake (although moderate in amount), is more desirable for human and biological use than the algal-dominated state (Newton and Jarrell, 1999).

Cranberry Lake is contained in the Totagatic watershed as it flows into the Minong Flowage. Only a small portion of this watershed flows into Cranberry Lake as it is at the northern region of this southern flowing watershed. There is one tributary that feeds Cranberry Lake known as Cranberry Springs. As the name implies, this tributary originates from a series of springs found in a wetland area just to the north and west of the lake. The main land use around Cranberry Lake is wooded and wetland. Depending on the nutrients that naturally occur in Cranberry Springs, the most likely human activity that leads to nutrient loading is development on the lake.

The flowage portion of Cranberry Lake occurs between Cranberry Lake and the Minong Flowage. Its water enters from a net flow from Cranberry Lake and the surrounding watershed which is largely forested with limited development. As a result, the nutrient loading is most likely due to natural occurrences.

Historically, Cranberry Lake nutrient loading has never been analyzed. The majority of the nutrients presumably come from Cranberry Springs and the residential development immediately on the lake. Since nearly the entire immediate water shed is forested and wetlands, this loading most likely is not large in mass of phosphorus or nitrogen. The total phosphorus measurements support this speculation.

There are approximately 80 permanent structures on Cranberry Lake/Flowage. Most of these are part-time residents. The age of septic systems and their sizes is unknown. There is one large campground on the northwest end of Cranberry Lake and another on the south end of Cranberry Lake. A third campground is located between Cranberry Lake and Crystal Lake. These campgrounds should have private septic systems that are designed to accommodate the input from campers.

Fishing
Habitat created by aquatic plants provides food and shelter for both young and adult fish. Invertebrates living on or beneath plants are a primary food source for many species of fish. Other fish, such as bluegills, graze directly on the plants themselves. Plant beds in shallow water provide important spawning habitat for many fish species.

Waterfowl
Plants offer food, shelter, and nesting material for waterfowl. Birds eat both the invertebrates that live on plants and the plants themselves.[1]

Protection against Invasive Species
Non-native invasive aquatic species threaten native plants in Northern Wisconsin. The most common are Eurasian water milfoil (EWM) and curly leaf pondweed (CLP). These species are described as opportunistic invaders meaning they take over openings in the lake bottom where native plants have been removed. Without competition from other plants, these invasive species may successfully become established and spread in the lake. This concept of opportunistic invasion can also be observed on land in areas where bare soil is quickly taken over by weeds.

Removal of native vegetation not only diminishes the natural qualities of a lake, but also increases the risk of non-native species invasion and establishment. The presence of invasive species can change many of the natural features of a lake and often leads to expensive annual control plans. Allowing native plants to grow may not guarantee protection against invasive plants, but it can discourage their establishment. Native plants may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm.[2]

Lake Information

(Note: The most recent data available for fisheries is 2002. As a result, the data used in this section is limited and needs updating from the WI DNR).

General characteristics
Cranberry Lake (Douglas County Wisconsin) is a 169-acre drainage lake, with one inlet (Cranberry Springs Creek), which is a cold-water stream, and drains via a "flowage" to the Minong Flowage. This flowage is referred to as the Cranberry Flowage but is technically part of the Minong Flowage. Cranberry Lake has a maximum depth of 19 feet and mean depth of 11 feet. The dominant substrate is comprised of 95% sand and 5% muck. The trophic state for Cranberry Lake is designated as mesotrophic by the Wisconsin DNR.

[1] Above paragraphs summarized from *Through the Looking Glass*. Borman et al. 1997.
[2] *Aquatic Plant Management Strategy. DNR Northern Region.* Summer 2007.

Fisheries

Note: The data available for Cranberry Lake fisheries is limited. This is due to the limited surveys that have been conducted by the Wisconsin DNR on Cranberry Lake. This section reflects the most recent data made available from the Wisconsin DNR.

Cranberry Lake is listed to contain panfish (bluegill, pumpkin seed and black crappie), largemouth bass, northern pike, and walleye. All of these fish are quite common in the lake with the exception of walleye.

Considering fisheries is imperative in plant management, as they rely heavily on plants for recruitment and rearing of young fish as well as feeding areas. The following table outlines spawning needs for the fish in the lake to consider if an early spring herbicide treatment (or some other management tool) is utilized.

Fish Species	Spawning Temp. (Degrees F)	Spawning Substrate / Location	Comments
Northern Pike	Upper 30s – mid 40s (right after ice-out)	Emergent vegetation 6-10 inches of water	Eggs are broadcast
Walleye	Low to upper 40s – (about one week after ice-out)	Rocky shorelines with rubble/gravel 0.5 – 3 feet of water	Eggs are broadcast
Black Crappie	Upper 50s to lower 60s	Nests are built in 1-6 feet of water.	Nest builders
Largemouth Bass Bluegills	Mid 60s to lower 70s	Nests are built in water less than 3 feet deep.	Nest builders

Table 1: Summary of game fish species spawning behavior (those present in Cranberry Lake/Flowage).

In a 2002 fish survey conducted by the Wisconsin DNR (using electrofishing and fyke nets) produced the following results[3]:

[3] Data provided by the Wisconsin DNR through Scott Toshner, Wisconsin DNR Fish Biologist, 2012. This is the most recent data available.

Summary of Combined Gamefish and Panfish Totals Collected during 2002 Spring Electrofishing Events on April 24th and May 30th.					
Species	**# Caught**	**Mean Size (In.)**	**Size Range (In.)**	**# ≥14 inches**	**# ≥ 18 inches**
Walleye	13	17.6	14.4 – 21.6	13	5
Largemouth Bass	88	12.1	5.2 – 18.7	26	4
Smallmouth Bass	1	3.8	3.8	0	0
Species	**# Caught**	**Mean Size (In.)**	**Size Range (In.)**	**# ≥ 26 inches**	**# ≥ 34 inches**
Northern Pike	14	16.0	9.6 – 20.7	0	0
Species	**# Caught**	**Mean Size (In.)**	**Size Range (In.)**	**# ≥ 7 inches**	**# ≥ 10 inches**
Bluegill	797	5.1	1.2 – 8.5	26	0
Yellow Perch	61	2.6	2.2 – 5.2	0	0
Pumpkinseed	29	5.9	3.3 – 7.3	3	0
Black Crappie	22	7.4	3.7 – 10.1	10	1
Rock Bass	24	8.2	2.9 – 11.1	16	9

Table 2: Wisconsin DNR fish survey results, 2002.

In addition to the species listed in the table, the following species were also sampled in the survey: thirty-two spottail shiners, thirteen white suckers, twelve yellow bullheads, nine bluntnose minnows, eight central mudminnows, four bowfin (dogfish), three brook silversides, black bullheads, and golden shiners each, and one shorthead redhorse, common shiner, blacknose shiner, and native lamprey species each.

The results of the survey have led the Wisconsin DNR to manage the fisheries in Cranberry Lake for largemouth bass, panfish, and northern pike. The following statement is taken directly from the survey summary:

Analyses of data collected from baseline monitoring surveys conducted in 2002 appear to warrant the continued approach of managing Cranberry Lake for largemouth bass, northern pike, and panfish species. Habitat types available are also more conducive for reproduction in these fish species, whereas walleye spawning areas are generally considered poor in Cranberry Lake. Good water quality and healthy macrophyte and macroinvertebrate communities provide quality living space, young-of-year habitat, and food items for fish, as well as other animals found within the Cranberry Lake ecosystem. Current daily bag limits for northern pike are five/day, with no minimum size limit; bag limits for bass species are five in total/day, with a minimum size of 14 inches; limits for walleye include any length may be kept, but only one may be over 14" – 3/day bag limit and bag limits for panfish is twenty-five in total, with no size restrictions.

This analysis also advocated to protect vital habitat in and around the lake. These include but are not limited to development of native shoreline buffers to reduce erosion, sedimentation and nutrient loading, leaving large woody debris in the lake as it provides important habitat, and taking precaution with any future human development.

Since the native beds are considered moderate, maintaining a healthy native plant community is important. Many goals put forth in this plan (found later in the management section) should reflect the needs of the Cranberry Lake fishery. This includes native plant preservation, careful control of AIS such as EWM, and reduction of nutrient loading and sedimentation through shoreline restoration.

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

Two species of fish could potentially have newly distributed eggs during an early season herbicide treatment (northern pike and black crappie). One treatment to eradicate AIS, such as EWM, could be justified even if it reduced fish recruitment for that year. However, a series of annual treatments could have a serious impact on fish populations even if it caused only a partial loss of each year's hatch. As a result, herbicide use must be used with caution and to a limited extent in spawning areas and annual dosing of herbicide such as 2,4-D may not be desirable based on potential impact on fish.

Rare, Endangered, or Protected Species Habitat

Cranberry Lake/Flowage is located in the town of Wascott (T43N, R13W) in section 25. Natural Heritage Inventory records are provided to the public by town and range rather than section, so there is no indication if the incidences of these species occur in and immediately surrounding Cranberry Lake.[4]

Species listed in the Town of Wascott (T43N, R13W):

Alasmidonta marginata Elktoe SC/P Mussel
Canis lupus Gray Wolf SC Mammal
Cyclonaias tuberculata Purple Wartyback END Mussel
Emydoidea blandingii Blanding's Turtle THR Turtle
Etheostoma microperca Least Darter SC Fish
Haliaeetus leucocephalus Bald Eagle SC/P Bird
Littorella uniflora var.americana American Shoreweed SC Plant
Moxostoma valenciennesi Greater Redhorse THR Fish
Oeneis chryxus Chryxus Arctic SC Butterfly
Oporornis agilis Connecticut Warbler SC Bird

Note: SC=species of special concern; THR=threatened; END=endangered

The proposed actions within the plan are not anticipated to affect native plants and wildlife including the natural heritage species listed above.

[4] Natural Heritage data for Wisconsin is found at http://dnr.wi.gov/org/land/er/nhi. (data current as of 11/04/11)

No sensitive area survey has been conducted on Cranberry Lake, therefore there are no mapped sensitive areas to consider based upon such survey. Cranberry Lake has locations throughout the lake that contain important aquatic plants and habitats for organisms. The Cranberry Flowage has many sensitive plants and caution should be used in managing plants in these areas.

Plant Community-Cranberry Lake

The plant community was evaluated in July/August 2019 using the point intercept method as directed by the Wisconsin DNR. The most recent survey prior to this was 2007. The survey was used to update the frequency, distribution, and potential bed formation of native and non-native plant species. It was also used to compare to previous surveys in order to evaluate changes occurring in the plant community especially as it relates to management practices such as mitigation of AIS.

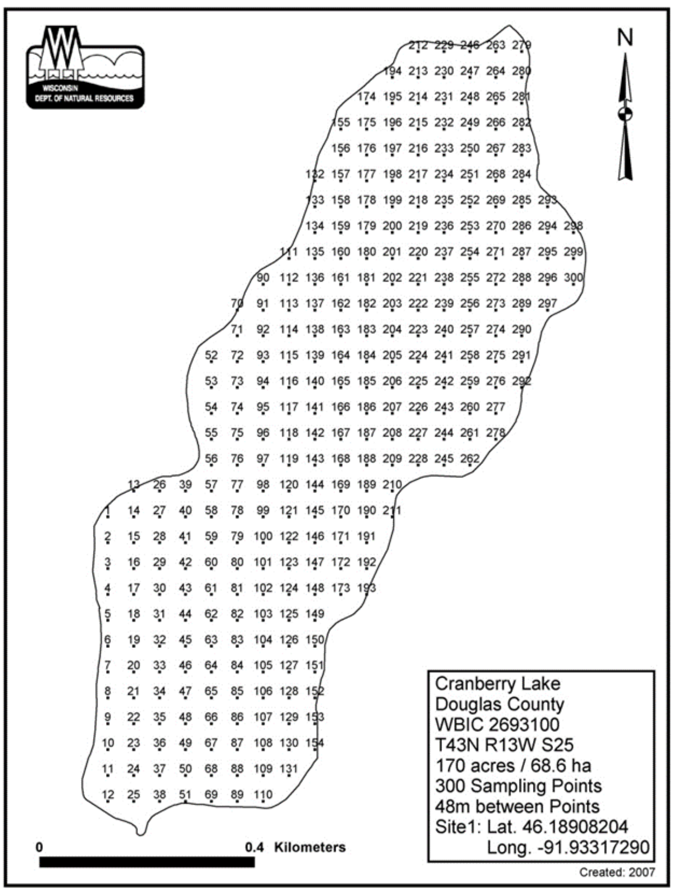


Figure 2: Sample grid for point intercept survey, Cranberry Lake.

The point intercept aquatic macrophyte survey reflects a healthy and diverse native plant community. The species richness was 31 native species sampled on the rake (32 total species including one non-native, invasive species). There was one additional species that was viewed only (not sampled on rake) for a total of 33 species sampled or viewed. The Simpson's diversity index indicates relatively high diversity, indicating an 88% probability of any two samples being different species.

Total sample points in full lake sample grid	300
Total number of sites with vegetation	152
Total number of sites shallower than maximum depth of plants	196
Frequency of occurrence at sites shallower than maximum depth of plants	77.55%
Frequency of occurrence of entire lake	50.7%
Simpson Diversity Index	0.88
Maximum depth of plants (feet)	16.70
Mean depth of plants (feet)	4.7
Average number of all species per site (shallower than max depth)	1.83
Average number of all species per site (veg. sites only)	2.36
Average number of native species per site (shallower than max depth)	1.77
Average number of native species per site (veg. sites only)	2.30
Species Richness	32
Species Richness (including visuals)	33

Table 3: Summary of full lake macrophyte survey statistics-2019.

Greatest depth with plants growing was 16.7 feet and a mean depth of 4.7 feet. The coverage of plants is moderate, with 77.55% of the littoral zone defined by depth of plants had vegetation. In the entire lake, 50.7% of the lake had plants growing (at sample points within grid). The depth of plants indicates the light penetration is moderate due to average water clarity leading to plants growing at the depths observed.

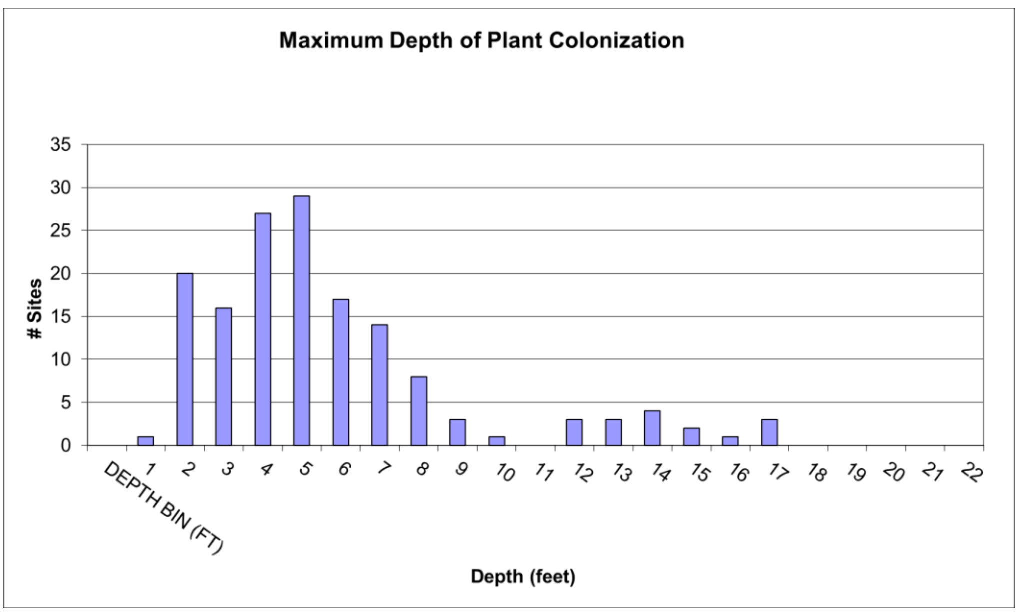


Figure 3: Depth analysis graph for plants growing in Cranberry Lake, 2019.

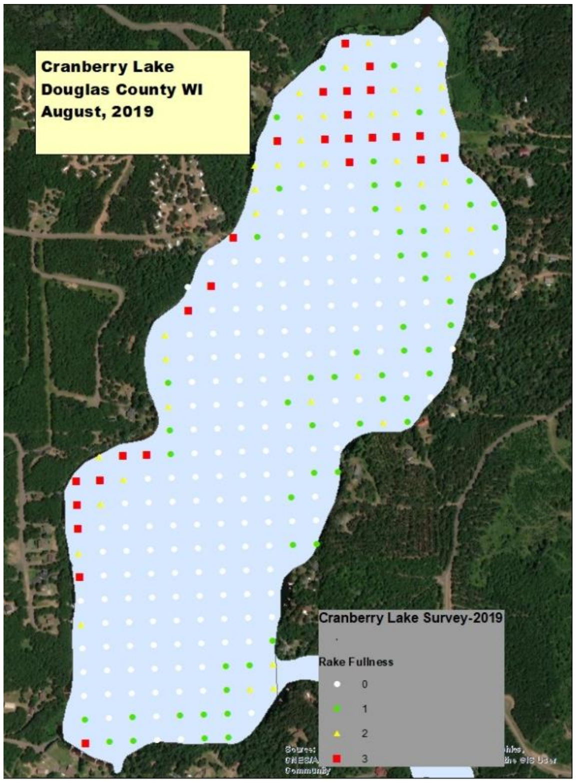


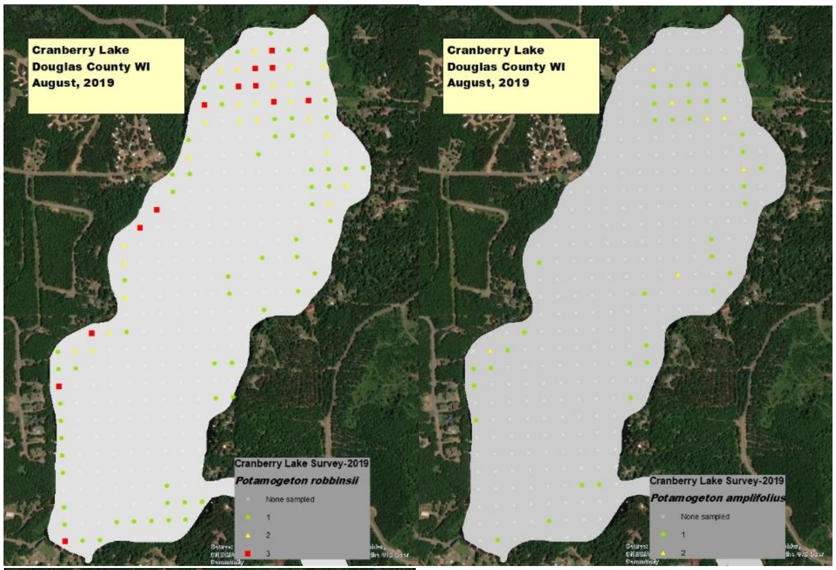
Figure 4: Total rake fullness in Cranberry Lake at each sample site. This shows the locations plants were sampled as well as the density. White shows no plants sampled. Green is least dense, yellow medium density and red the densest with plants.

Species	FOO Vegetated Littoral	FOO Littoral Depth	Relative Freq.	Number Sampled	Mean Density	Number viewed
Potamogeton robbinsii, Fern pondweed	65.79	51.02	27.86	100	1.5	
Potamogeton amplifolius, Large-leaf pondweed	28.95	22.45	12.26	44	1.2	
Vallisneria americana, Wild celery	23.03	17.86	9.75	35	1.0	
Ceratophyllum demersum, Coontail	18.42	14.29	7.80	28	1.1	
Nitella sp., Nitella	15.79	12.24	6.69	24	1.0	
Elodea nuttallii, Slender waterweed	13.16	10.20	5.57	20	1.2	
Najas flexilis, Slender naiad	13.16	10.20	5.57	20	1.0	
Chara sp., Muskgrasses	11.84	9.18	5.01	18	1.2	
Filamentous algae	10.53	8.16		16	1.0	
Nuphar variegata, Spatterdock	9.87	7.65	4.18	15	1.0	
Myriophyllum spicatum,Eurasian water milfoil	7.89	6.12	3.34	12	1.2	
Elodea canadensis, Common waterweed	3.95	3.06	1.67	6	1.0	
Potamogeton friesii, Fries' pondweed	3.29	2.55	1.39	5	1.0	
Potamogeton pusillus, Small pondweed	3.29	2.55	1.39	5	1.2	
Myriophyllum sibiricum, Northern water-milfoil	2.63	2.04	1.11	4	1.0	

Species	FOO Vegetated Littoral	FOO Littoral Depth	Relative Freq.	Number Sampled	Mean Density	Number viewed
Potamogeton richardsonii, Clasping-leaf pondweed	1.97	1.53	0.84	3	1.0	
Utricularia vulgaris, Common bladderwort	1.97	1.53	0.84	3	1.0	
Eleocharis acicularis, Needle spikerush	1.32	1.02	0.56	2	1.0	
Polygonum amphibium, Water smartweed	1.32	1.02	0.56	2	1.0	
Potamogeton praelongus, White-stem pondweed	1.32	1.02	0.56	2	1.0	
Juncus pelocarpus f. submersus, Brown-fruited rush	1.32	1.02	0.56	2	1.0	
Bidens beckii, Water marigold	0.66	0.51	0.28	1	2.0	
Brasenia schreberi, watershield	0.55	0.51	0.28	1	1.0	
Isoetes echinospora, Spiny spored-quillwort	0.66	0.51	0.28	1	1.0	
Nymphaea odorata, White water lily	0.66	0.51	0.28	1	1.0	
Potamogeton epihydrus, Ribbon-leaf pondweed	0.66	0.51	0.28	1	1.0	
Potamogeton gramineus, Variable pondweed	0.66	0.51	0.28	1	1.0	1
Potamogeton illinoensis, Illinois pondweed	0.66	0.51	0.28	1	1.0	
Potamogeton vaseyi, Vasey's pondweed	0.66	0.51	0.28	1	1.0	1
Potamogeton zosteriformis, Flat-stem pondweed	0.66	0.51	0.28	1	1.0	
Sagittaria cristata, Crested arrowhead	0.66	0.51	0.28	1	1.0	
Sagittaria rigida, sessile fruited arrowhead	0.66	0.51	0.28	1	1.0	
Sparganium angustifolium, Narrow-leaved bur-reed	0.66	0.51	0.28	1	1.0	
Aquatic moss	0.66	0.51		1	3.0	
Elatine minima, Waterwort						1

Table 4: Species richness with frequency of occurrence and rake fullness data-2019.

The relative frequency resulted in *Potamogeton robbinsii* (fern pondweed) was the most common plant sampled on the rake (27.86%). This was followed by *Potamogeton amplifolius* (large-leaf pondweed, 12.26%) and *Vallisneria americana* (wild celery, 9.75%) respectively. All three of these aquatic plants are common native species found in Wisconsin lakes. The plants serve important roles in the lake ecosystem including key habitat for invertebrates and fish.



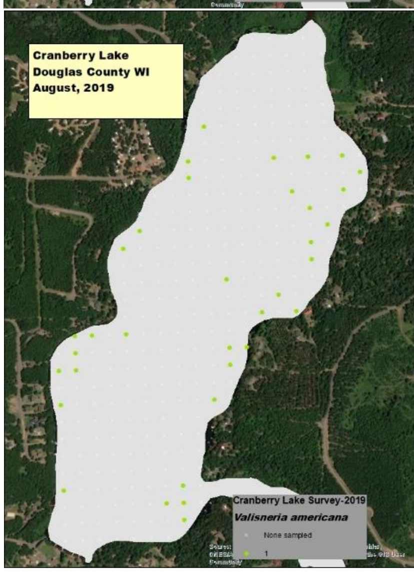


Figure 5: Distribution maps of three most common native plants sampled. Left to right, fern pondweed, large-leaf pondweed, and wild celery.

Invasive species

There was one invasive species sampled in Cranberry Lake, *Myriophyllum spicatum* (Eurasian watermilfoil-EWM). This plant was discovered in Cranberry Lake more than ten years ago and has been managed by use of herbicide. The frequency of EWM has increased since 2007. Figure 6 shows the distribution maps of EWM in 2007 (prior plant survey year) and 2019. In 2007, the frequency of occurrence (FOO) for EWM was 1.9%. In 2019, the EWM FOO was 7.89%. Treatment of EWM with herbicide occurred prior to the point intercept survey taking place in 2019.

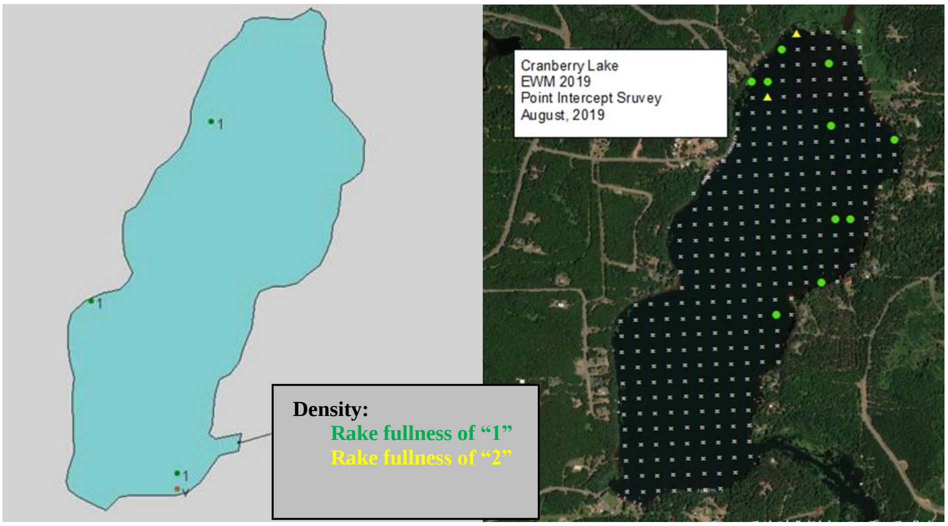


Figure 6: EWM distribution and density in 2007 and 2019.

Bed mapping was completed for EWM in August 2019. Figure 7 shows the bed, which covers 2.36 acres, that was delineated in Cranberry Lake.

Figure 7: Bed map of EWM in Cranberry Lake, August 2019.

Species of special concern

Special concern species are suspected, but not yet proved, to have some problem of abundance or distribution. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.

Cranberry Lake had two species of special concern observed or sampled. *Potamogeton vaseyi* (Vasey's pondweed) was sampled in one location and viewed in a second location. *Najas gracillima* (northern naiad), was observed in boat survey. Table 5 lists the species with frequency.

Species of special concern	Frequency of occurrence	Mean fullness
Najas gracillima-northern naiad	Only observed in boat survey	n/a
Potamogeton vaseyi-Vasey's pondweed	0.66	1.0

Table 5: Species of special concern in Cranberry Lake, 2019.

Floristic quality index

The floristic quality index (FQI) for Cranberry Lake in 2019 resulted all FQI parameters being significantly higher than the eco-region median values. The mean conservatism indicates the susceptibility of plants to habitat changes. This value was 6.77 vs 5.6 for the eco-region median. The overall FQI was 37.06 for Cranberry Lake as compared to 20.7 for the eco-region median. The FQI for Cranberry Lake shows the plant community has several sensitive plants and indicates the habitat in the lake has not changed immensely due to human activity. Table 4 summarizes the FQI data.

FQI Parameter	Cranberry Lake 2019	Eco-region median
Mean conservatism	6.7	5.6
Number of species in FQI	30	14
FQI	36.7	20.9

Table 6: Floristic quality index information for Cranberry Lake, 2019 and eco-region median.

Comparison of 2007 and 2019 surveys-Cranberry Lake

An important aspect of conducting periodic plant surveys on lakes is to compare the results to evaluate changes that may be occurring in the ecosystem. Table 5 outlines some comparison statistics between 2007 and 2019 surveys.

In terms of diversity, the two surveys reflect nearly identical results. The species richness differs by only one species and the Simpson's diversity indexes are different by 0.01. The FQI and mean conservatism values are nearly the same. The coverage changed by only five sample points. These parameters show minimal change to the plant community over the last 12 years in relationship to plant diversity.

Comparison parameter	2007	2019
Species richness	33	32
Simpson's diversity index	0.89	0.88
Mean conservatism	7.0	6.7
FQI	37.7	36.7
Maximum depth of plant growth	16.0	16.7
Points with plants	157*	152*
**decrease not significant (p=0.68)*		

Table 7: Comparison of various parameters from full lake surveys 2007 and 2019.

To evaluate changes in individual species in Cranberry Lake, the FOO is analyzed using a chi-square statistical analysis. There are various sources for the frequency of occurrence change. Those possible sources are as follows:

1. Management practices such as herbicide treatments could cause reductions. Typically, if herbicide treatments of invasive species are utilized, a pretreatment and post-treatment analysis is conducted in those specific areas. To determine if this is a cause of a reduction in the full lake survey, the treatment areas would need to be evaluated using the point-intercept sample grid. Furthermore, if herbicide reduces the native species, the type and concentration of the herbicide is what will determine this reduction. A single species reduction is unlikely, so presumably, multiple species would be affected.

2. Sample variation could also occur. The sample grid is entered into a GPS unit. The GPS allows the surveyor to get close to the same sample point each time, but there is a possible error of 20 feet or more (the arrow icon is 16 feet in real space). Since the distribution of various plants is not typically uniform but usually clumped, sampling variation could result in that plant not being sampled in a particular survey. Plants with low frequency could give significantly different values with surveys conducted within the same year.

3. Each year, the timing for aquatic plants coming out of dormancy can vary widely. A late or early ice-out may affect the size of plants during a survey from one year to the next. For example, a lake with a high density of a plant one year could have a low density another year. The type of plant reproduction can affect this immensely. If the plant grows from seed or a rhizome each year, the timing can be paramount as to the frequency and density are shown in a survey.

4. Identification differences could lead to frequency changes. The small pond weeds such as *Potamogeton pusillus*, *Potamogeton foliosus*, *Potamogeton friesii*, and *Potamogeton strictifolious* can easily be mistaken for one plant or another. Evaluating the overall frequency of all of the small pondweeds to determine if a true reduction has occurred may be the best approach. All small pondweeds collected were magnified and closely scrutinized in the 2017 survey.

5. Habitat changes and plant dominance changes can lead to plant declines. If an area received a large amount of sediment from human activity, the plant community may

respond though unlikely within 5-7 years. If a plant emerges more dominant over time, that plant may reduce another plant's frequency and /or density.

6. Large plant coverage reduction that is not species specific can occur from an infestation in the non-native rusty crayfish or common carp.

Management of Eurasian watermilfoil has been taking place for many years, so any reduction in frequency could be due to herbicide use. There is no conclusive evidence that herbicide is the only source of any reductions, also considering there were numerous frequency increases as well.
The chi-square analysis resulted in showing a statistically significant reduction in 10 native plant species. Three of these species had relatively high FOO in 2007 and much lower FOO in 2019 which could be of concern. The other species had more subtle changes or were low frequency in 2007. Table 8 lists the species with significant decreases in FOO. The largest change was *Elodea sp*. having a significant reduction. *Myriophyllum sibiricum* (northern watermilfoil) also had a significant decrease. Both of these plants decreased after the herbicide treatment in 2019 in the treatment beds. The reduction of these populations in the whole lake from herbicide is unlikely, but is possible. Northern watermilfoil is closely related to the AIS Eurasian watermilfoil and is susceptible to the same herbicides, so its decrease is of concern.

Species with significant reduction	**FOO 2007**	**FOO 2019**	**Significance**
Ceratophyllum demersum	35.7	18.4	P=0.0007
Elodea sp.	70.1	17.1	$P=6.9X10^{-21}$
Vallisneria americana	36.3	23.0	P=0.01
Myriophyllum sibiricum	19.7	2.6	$P=2.1X10^{-6}$
Potamogeton zosteriformis	7.0	0.7	P=0.004
Bidens beckii	9.6	0.7	P=0.0004
Heteranthera dubia	4.4	0.0	P=0.008
Potamogeton illinoensis	5.7	0.7	P=0.01
Brasenia schreberi	2.5	0.0	P=0.05
Potamogeton strictifolius	3.2	0.0	P=0.03

Table 8: Native species with statistically significant reduction from 2007 to 2019 (from chi-square analysis).

Figure 8 shows the distribution of *Elodea sp*. (*E. canadensis* and *E. nutalli* combined). The coverage in 2007 was widespread in the lake. In 2019, the coverage of these plants was much smaller, with most change appearing to be in the north end of the lake.

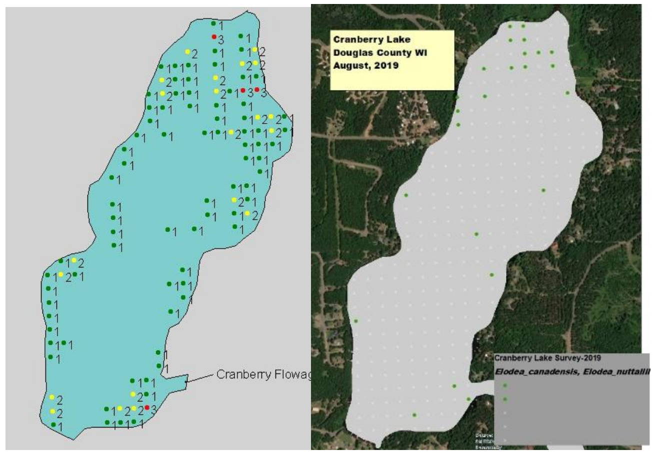


Figure 8: Distribution of Elodea sp. In 2007 (left) and 2019 (right) to show the difference in coverage.

There were increases in three native species from 2007 to 2019. All three had a small FOO in 2007 that increased to FOO's between 10% and 20% (in 2019? Is that when the increase occurred?). There was also a statistically significant increase in the AIS Eurasian watermilfoil from and FOO of 1.9% (in 2007) to 7.9% (in 2019). Table 9 summarizes the significant increased species.

Species with significant increase	**FOO 2007**	**FOO 2019**	**Significance**
Nitella sp.	3.2	15.79	P=0.0001
Najas flexilis	5.7	13.2	P=0.025
Chara sp.	5.1	11.8	P=0.03
Myriophyllum spicatum (AIS)	1.9	7.9	P=0.014

Table 9: Plant species with statistically significant increase between 2007 and 2019.

Discussion

The 2019 aquatic macrophyte survey reflects a moderately diverse plant community with a high floristic quality index. These data indicate that the aquatic plant community in Cranberry Lake appears healthy. This plant community is paramount to the overall lake ecosystem and therefore important to manage Cranberry Lake to maintain a healthy, native plant community.

The comparison of the 2007 and 2019 survey data using chi-square analysis revealed a statistically significant decrease in the frequency of occurrence of 10 native plant species. This is approximately 1/3 of the species sampled in Cranberry Lake. The cause of this decrease is unknown, but since management of EWM using herbicides has been utilized on a near annual basis, considering herbicide as a possible contributor to native plant reductions needs to occur. Native plants are known to compete with AIS, such as EWM, reducing their coverage and spread. The objective for the Cranberry Lake/Flowage Association in managing EWM is therefore to balance using integrated management to minimize EWM while also facilitating the continued health of the native plant communities. Broad spectrum herbicide such as diquat (which has been used in Cranberry Lake) will reduce any actively growing plant and, in theory, will have a greater impact than herbicide that target certain types of plants.

Plant Community-Cranberry Flowage[5]

The sample grid for the Cranberry Flowage is contained within the Minong Flowage Plant survey. However, the Cranberry Flowage is customarily managed by the Cranberry Lake Association, and historically, the survey in the Cranberry Flowage has been completed by the Minong Flowage Association. For this plan, the sample points from the DNR plant survey grid were isolated so that in future surveys, the Cranberry Flowage can be separated from the Minong Flowage.

The most recent Cranberry Flowage data collection was in 2018 The following is a summary of the 2018 data (Minong Flowage with the Cranberry Flowage sample points isolated.

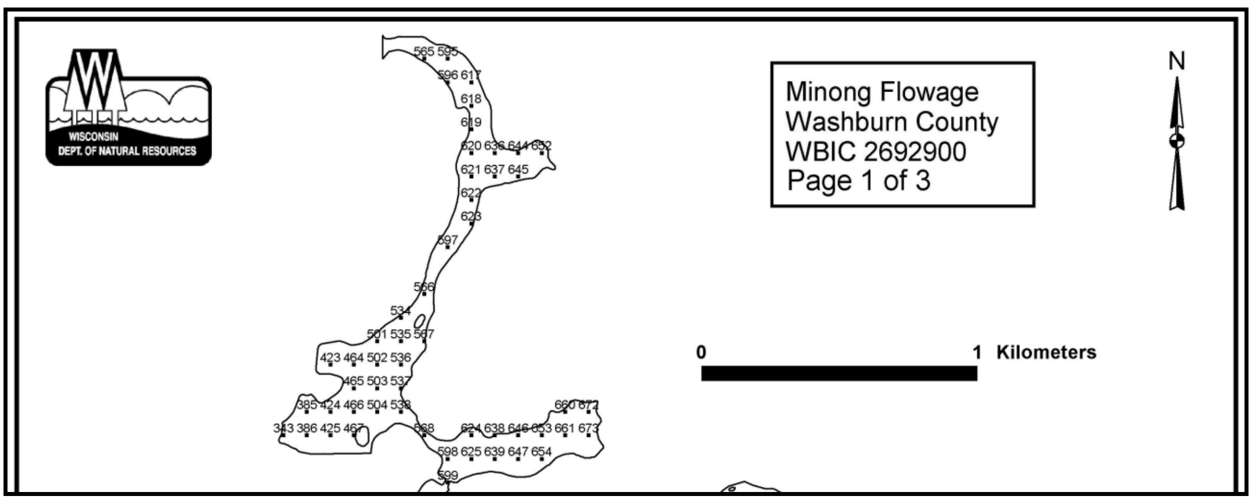


Figure 9: Point intercept grid for aquatic plant survey-Cranberry flowage up to management boundary.

The plant community in the Cranberry flowage is extensive. All but one sampling site had plants present which reflected in 98% coverage of the area with plants. All depths are shallower than the deepest plants were sampled (8 feet).

[5] The Cranberry Flowage survey points are part of the Minong Flowage point grid so these data were extracted from the most recent survey conducted on the Minong Flowage by Endangered Resource Services, LLC. This survey will be updated in 2020.

Total number of sites visited	50
Total number of sites with vegetation	45
Total number of sites shallower than maximum depth of plants	49
Frequency of occurrence at sites shallower than maximum depth of plants	91.84%
Simpson Diversity Index	0.94
Maximum depth of plants (ft)	6.00
Average number of all species per site (shallower than max depth)	4.29
Average number of all species per site (veg. sites only)	4.67
Average number of native species per site (shallower than max depth)	4.29
Average number of native species per site (veg. sites only)	4.67
Species Richness	36
Species Richness (including visuals)	40

Table 10: Aquatic plant survey stats from the 2018-point intercept survey-Cranberry flowage.

The Cranberry Flowage is more diverse than Cranberry Lake. With only 50 sample points, 33 species of plants were sampled resulting in a Simpson's diversity index of 0.94. There were more than four native plants sampled on average at each sample location.

The most common species sampled is a floating leaf plant, white water lily. This was followed by variable pondweed and coontail. All three are common aquatic plants in Wisconsin lakes and serve important roles in the lake ecosystem.

Species	FOO vegetated areas	FOO Littoral depth	Relative freq.	# sampled	Mean rake fullness	# viewed
Elodea canadensis, Common waterweed	55.56	51.02	11.90	25	1.40	
Ceratophyllum demersum, Coontail	46.67	42.86	10.00	21	1.38	
Nymphaea odorata, White water lily	40.00	36.73	8.57	18	2.00	2
Potamogeton robbinsii, Fern pondweed	37.78	34.69	8.10	17	1.76	1
Najas flexilis, Slender naiad	31.11	28.57	6.67	14	1.14	
Nuphar variegata, Spatterdock	22.22	20.41	4.76	10	1.90	2
Utricularia gibba, Creeping bladderwort	22.22	20.41	4.76	10	1.00	
Myriophyllum verticillatum, Whorled water-milfoil	20.00	18.37	4.29	9	1.44	1
Utricularia vulgaris, Common bladderwort	20.00	18.37	4.29	9	1.00	2
Potamogeton gramineus, Variable pondweed	17.78	16.33	3.81	8	1.00	
Potamogeton pusillus, Small pondweed	15.56	14.29	3.33	7	1.00	
Schoenoplectus subterminalis, Water bulrush	15.56	14.29	3.33	7	1.57	
Utricularia intermedia, Flat-leaf bladderwort	15.56	14.29	3.33	7	1.14	1
Filamentous algae	13.33	12.24		6	1.00	
Sparganium emersum, Short-stemmed bur-reed	11.11	10.20	2.38	5	1.60	2
Brasenia schreberi, Watershield	8.89	8.16	1.90	4	1.50	1
Potamogeton amplifolius, Large-leaf pondweed	8.89	8.16	1.90	4	1.00	5

Species	FOO vegetated areas	FOO Littoral depth	Relative freq.	# sampled	Mean rake fullness	# viewed
Potamogeton natans, Floating-leaf pondweed	8.89	8.16	1.90	4	1.00	1
Potamogeton zosteriformis, Flat-stem pondweed	8.89	8.16	1.90	4	1.00	2
Najas gracillima, Northern naiad	6.67	6.12	1.43	3	1.33	
Pontederia cordata, Pickerelweed	6.67	6.12	1.43	3	2.00	2
Chara sp., Muskgrasses	4.44	4.08	0.95	2	1.00	
Eleocharis robbinsii, Robbins' spikerush	4.44	4.08	0.95	2	2.00	
Lemna minor, Small duckweed	4.44	4.08	0.95	2	1.00	
Sparganium natans, Small bur-reed	4.44	4.08	0.95	2	1.50	1
Vallisneria americana, Wild celery	4.44	4.08	0.95	2	1.50	
Dulichium arundinaceum, Three-way sedge	2.22	2.04	0.48	1	1.00	
Elatine minima, Waterwort	2.22	2.04	0.48	1	1.00	
Heteranthera dubia, Water star-grass	2.22	2.04	0.48	1	1.00	
Isoetes echinospora, Spiny spored-quillwort	2.22	2.04	0.48	1	1.00	
Lemna trisulca, Forked duckweed	2.22	2.04	0.48	1	1.00	
Myriophyllum sibiricum, Northern water-milfoil	2.22	2.04	0.48	1	1.00	6
Nitella sp., Nitella	2.22	2.04	0.48	1	1.00	
Potamogeton vaseyi, Vasey's pondweed	2.22	2.04	0.48	1	1.00	
Sagittaria cristata, Crested arrowhead	2.22	2.04	0.48	1	1.00	
Schoenoplectus tabernaemontani, Softstem bulrush	2.22	2.04	0.48	1	1.00	1
Typha sp., Cattail	2.22	2.04	0.48	1	3.00	
Myriophyllum spicatum,Eurasian water milfoil						2
Potamogeton epihydrus, Ribbon-leaf pondweed						1
Typha latifolia, Broad-leaved cattail						1

Table 11: Species list with frequency and rake fullness statistics-Cranberry flowage, 2018.

Three species of special concern was sampled. Northern naiad was found at 6.12% of the sample points, Robbin's pondweed was found at 4.44% of the sample points and Vasey's pondweed at 2.22% of the sample points in the flowage.

Species of special concern	Frequency of occurrence	Mean fullness
Najas gracillima, Northern naiad	6.12	1.33
Eleocharis robbinsii, Robbins' spikerush	4.44	2.0
Potamogeton vaseyi, Vasey's pondweed	2.22	1.0

Table 12: Species of special concern sampled in Cranberry flowage, 2018.

There were no invasive plant species sampled in 2018 including Eurasian watermilfoil, but was viewed near two locations. This indicates the coverage of EWM in the flowage was limited in 2018.

Cranberry Flowage Comparison 2014 to 2018

In comparing the macrophytes survey in the Cranberry Flowage a few small changes occurred. First the species richness was slightly higher in 2018, with three more species sampled. The diversity index was very high in both years at 0.94. The floristic quality index increased slightly from 20014 to 2018. Although there were three less points with plants in 2018, it was not a significant reduction.

Comparison parameter	2014	2018
Species richness	33	36
Simpson's diversity index	0.94	0.94
Mean conservatism	6.5	6.7
FQI	35.6	38.9
Points with plants	48*	45*
**decrease not significant*		

Table 13: Survey comparison of key parameters 2014 to 2018.

In the chi-square analysis, the same number of species saw statistically significant increases as decreases. This indicates that there is no indication that herbicide use in the flowage has adversely affected the native plants long-term.

Species with statistically significant frequency increase	
Elodea canadensis, Common waterweed	P=0.0017
Najas flexilis, Slender naiad	P=0.046
Utricularia gibba, Creeping bladderwort	P=0.0008
Schoenoplectus subterminalis, Water bulrush	P=0.027

Species with statistically significant frequency decreases	
Potamogeton gramineus, Variable pondweed	P=0.023
Nitella sp., Nitella	P=0.014
Utricularia minor, small bladderwort	P=0.0002
Eleocharis acicularis, needle spikerush	P=0.04

Table 14: Chi-square analysis indications of significant increase and decrease in frequency from 2014 to 2018.

Water quality/Watershed Characteristics

Cranberry Lake has a fairly short history of water quality data. However, in more recent years, volunteers have done a respectable job collecting data through the self-help monitoring program.

Available data shows Cranberry Lake is a mesotrophic lake, meaning there is a moderate amount of nutrients. This can lead to moderate plant and algae growth leading to water clarity that is in the mesotrophic level. This indicates that Cranberry Lake does not have excessive nutrient loading but increased nutrient loading could lead to a higher trophic state. Higher trophic state would lead to more algae and plant growth, including invasive species. Since Eurasian water milfoil flourishes in high nutrient environments, nutrient flux into Cranberry Lake should be limited.

Year	*Mean Total P (ppb)*	*Mean Chl-a (ppb)*	*Mean Secchi (ft)*	*Bottom DO (mg/L)*	*Mean TSI indicator*
2007	N/a	N/a	7.66	N/a	Mesotrophic
2008	13	1.9	N/a	5.5	Mesotrophic (chl-a oligotrophic)
2009	18	5.53	N/a	N/a	Mesotrophic
2010	12.6	5.6	N/a	N/a	Mesotrophic
2011	17.25	6.01	5.56	N/a	Mesotrophic (Secchi eutrophic)
2012	12.25	4.39	N/a	N/a	Mesotrophic

Table 15: Summary of historical water quality data (growing season means). Trophic states do not all include all three TSI parameters (total phosphorus, chlorophyll-a, and Secchi depth).

Some volunteer data collection of Secchi depth started again in 2019. The following are data collected:

Date	Secchi depth	Trophic state
May 30	10 feet	Mesotrophic
June 16	10 feet	Mesotrophic
July 23	7 feet	Mesotrophic
August 11	9 feet	Mesotrophic
Mean	**9 feet**	**Mesotrophic**

Figure 12 shows an estimate of the immediate watershed around Cranberry Lake/Flowage. County T is used as a southern boundary. Cranberry Lake and Flowage fall within the northwest most portion of the Totagatatic River watershed. The water from Cranberry Lake and Flowages flows into the Minong Flowage which is an impoundment of the Totagatatic River. Although this is a large watershed, the watershed that directly flows into the Cranberry Lake and then the flowage is quite small (Figure 10).

Cranberry Creek, a cold-water stream, is the main inlet of water into Cranberry Lake. There does not appear to be any historical data as to water quality of flow amounts available. The creek has been listed to harbor brook trout signifying the water quality is quite high as brook trout are intolerant fish. The water quality suggests a small watershed and limited nutrient loading as the water source is likely ground water and passes through a large wetland area.

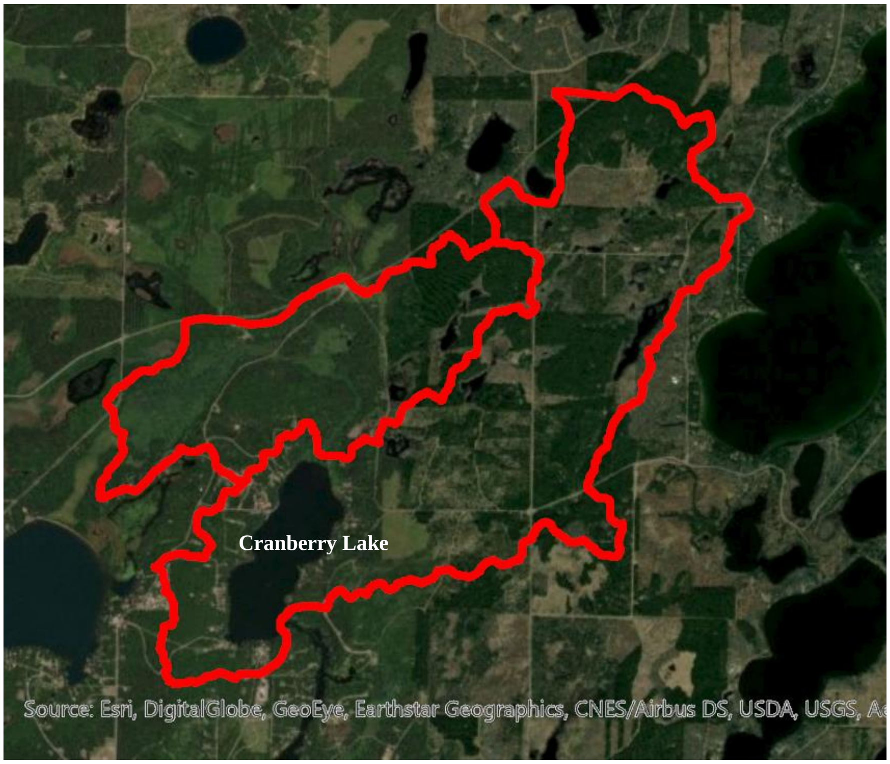


Figure 10: Catchment watershed of Cranberry Lake (from Wisconsin DNR data viewer).

Since much of the land-use around Cranberry Lake is forested and wetland, the nutrient loading from the watershed should be low. This could mean that the residential area around the lake would then have a greater impact on the nutrient loading since this type of land use typically has a higher loading of nutrients. Residential land use tends to have higher runoff and higher nutrients loads than forested areas due to less infiltration of precipitation and possible fertilizer use on lawns. The land cover map available is not precise, so the direct watershed/riparian developed properties area is under- represented in the land cover summary. The residential land use can significantly impact nutrient inputs into a lake. For this reason, the Cranberry Lake/Flowage Association recommends riparian owners develop buffers and institute management practices where possible to reduce the flux of nutrients into Cranberry Lake/Flowage.

The Pollution Load Ratio Estimation Tool (PRESTO) from the Wisconsin DNR predicts an annual load of phosphorus from non-point sources (watershed runoff) at 112 pounds. Using the land use and simple export coefficients estimate the phosphorus load from 303 to a high of 1187 pounds. The PRESTO estimate indicates that the phosphorus load is lower than 303 pounds per year. Reducing runoff and nutrients could help reduce nutrients and help water quality and reduce the added nutrients that help invasive plants thrive.

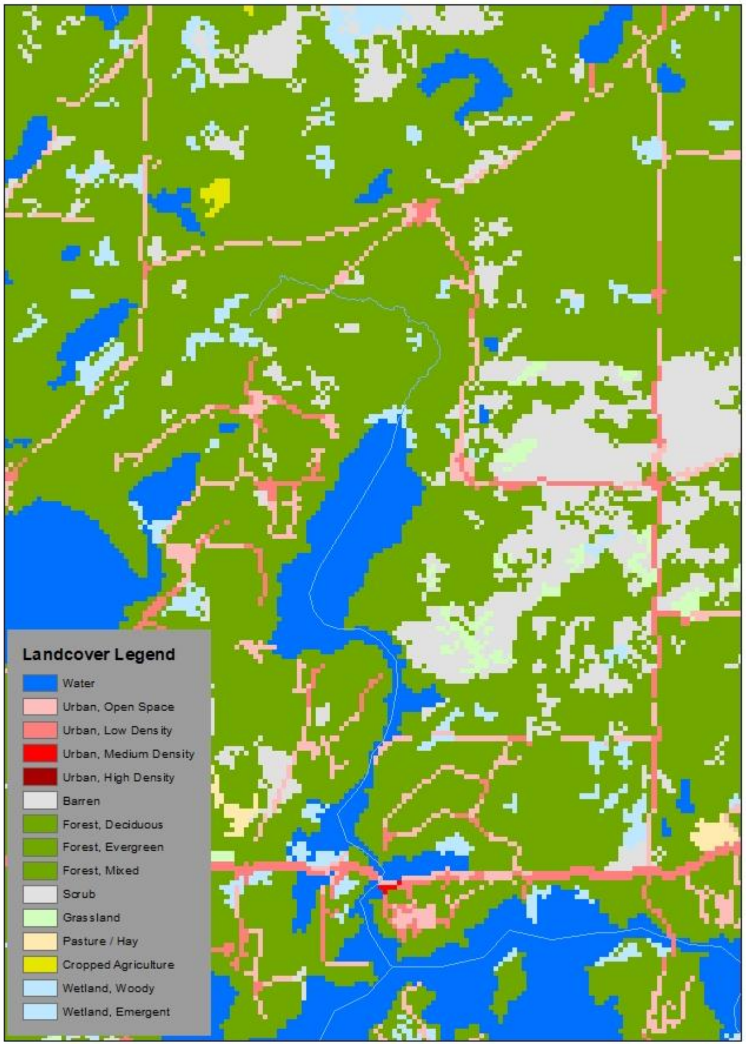


Figure 11: Land use surrounding Cranberry Lake and Flowage.

There are approximately 128 (2019 Douglas County records) residential properties on Cranberry Lake/Flowage and also two large campgrounds. At this time, the septic system design and age is unknown for residential and campgrounds. Septic systems can contribute large amounts of nutrients if not functioning correctly due to age and lack of maintenance.

Land use	**Area (acres)**	**% of watershed area**
Forest	4890	69.3
Pasture/grassland	582	8.2
Rural residential	435	6.2
Row crop	4	0.1
Wetland	241	3.4
Open water	900	12.8
Total	7052	100

Table 16: Summary of land use/type in Cranberry Lake watershed.

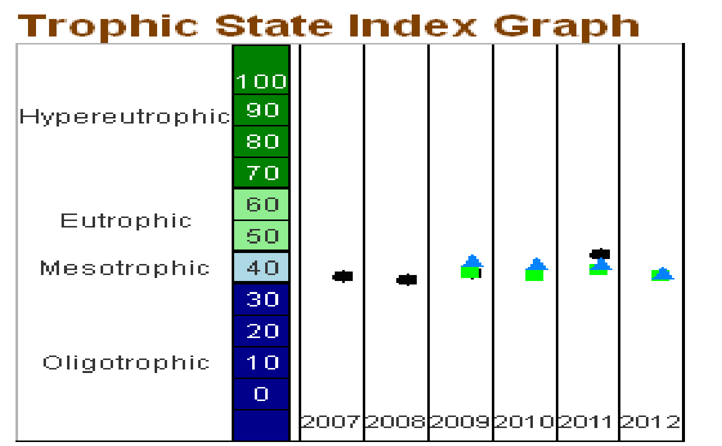


Figure 12: Trophic status graph, 2007 to 2012.

Plant Management Techniques/Options

This section reviews the potential management methods available and reports recent management activities on the lakes.

Permitting Requirements

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

The requirements for manual and mechanical plant removal are described in *NR 109 – Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations*. A permit is required for manual and mechanical removal except for when a riparian (waterfront) landowner manually removes or gives permission to someone to manually remove plants, (with the exception of wild rice) from his/her shoreline up to a 30-foot corridor. A riparian landowner may also manually remove the invasive plants Eurasian water milfoil, curly leaf pondweed, and purple loosestrife along his or her shoreline without a permit. Manual removal refers to the control of aquatic plants by hand or hand–held devices without the use or aid of external or auxiliary power.[6]

The *Department of Natural Resources Northern Region Aquatic Plant Management Strategy* (May 2007) requires documentation of impaired navigation or nuisance conditions before native plants may be managed with herbicides. Severe impairment or nuisance will generally mean that vegetation grows thickly and forms mats on the water surface.

[6] More information regarding DNR permit requirements and aquatic plant management contacts is found on the DNR web site: www.dnr.state.wi.us.

Techniques to control the growth and distribution of aquatic plants are discussed in the following text. The application, location, timing, and combination of techniques must be considered carefully. A summary table of Management Options for Aquatic Plants from the WDNR is found in Appendix E.

Manual Removal[7]

Manual removal—hand pulling, cutting, or raking—will effectively remove plants from small areas. Plant removal may need to be repeated more than once during the growing season. The best timing for hand removal of herbaceous plant species is after flowering but before seed head production. For plants with rhizomatous (underground stem) growth, pulling roots is not generally recommended since it may stimulate new shoot production. Hand pulling is a strategy recommended for rapid response to a Eurasian water milfoil establishment and for private landowners who wish to remove small areas of curly leaf pondweed growth. Raking is recommended to clear nuisance growth in riparian area corridors up to thirty feet wide. SCUBA divers may engage in manual removal for invasive species like Eurasian water milfoil. Care must be taken to ensure that all plant fragments are removed from the lake.
Costs for hand pulling EWM using divers on Minocqua and Kawaguesaga Lake in Oneida County were about $28,000 to remove approximately 4000 pounds of EWM.

Mechanical Control

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

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

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).

In some cases, the plants are transported to shore by the harvester itself for disposal, while in other cases, a barge is used to store and transport the plants in order to increase the efficiency of the cutting process. The plants are deposited on shore where they can be transported to a local farm to be used as compost (the nutrient content of composted aquatic plants is comparable to that of cow manure) or to an upland landfill for proper disposal. Most harvesters can cut between 2 and 8 acres of aquatic vegetation per day, and the average lifetime of a mechanical harvester is 10 years.

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[7] Information from APIS (Aquatic Plant Information System). U.S. Army Corps of Engineers. 2005. and the *Wisconsin Aquatic Plant Management Guidelines.*

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

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

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

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

Timing is also important. The ideal time to harvest, in order to maximize the efficiency of the harvester, is just before the aquatic plants break the surface of the lake. For curly leaf pondweed, harvesting should also be before the plants form turions (reproductive structures) to avoid spreading the turions within the lake. If the harvesting is conducted too early, the plants will not be close enough to the surface, and the cutting will not do much damage to them. If too late, turions may have formed and may be spread, and there may be too much plant matter on the surface of the lake for the harvester to cut effectively.

If the harvesting work is contracted, the equipment should be inspected before and after entering the lake. Since these machines travel from lake to lake, they may carry plant fragments with them and facilitate the spread of aquatic invasive species from one body of water to another. Harvesting contractors are not readily available in northern Wisconsin, so harvesting contracts are likely to be expensive. Prevailing winds may also pose issues since cut vegetation can be blown into open areas of the lake or along shorelines.

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

Plant fragments can result from diver dredging, but fragmentation is not as severe a problem when infestations are small. To be effective, diver dredging operations may need to be repeated more than once. When applied to a pioneering infestation, control can be complete. However, periodic inspections of the lake should be performed to ensure that all the plants have been found and collected.

Lake substrates play an important role in the effectiveness of a diver dredging operation. Soft substrates are easy to work in. Divers can remove the plant and root crowns with little difficulty. Hard substrates however, pose more of a problem. Divers may need hand tools to help dig the root crowns out of hardened sediment. Diver dredging will be considered as a rapid response control measure for Eurasian water milfoil as new areas are discovered.

Use of DASH has increased in recent years as a management tool. The most effective use of DASH appears to be for small, sporadic areas of AIS that need to be removed due to boat traffic, piers, or other reasons to reduce the AIS. DASH has also been effective in removing AIS after herbicide use has occurred, and there is a small amount of AIS remaining. Large, dense beds of AIS are not effectively managed by DASH.
The cost of contracting DASH is approximately $2500 per day. The amount of EWM removed in one day varies greatly due to density differences, but one contractor reports removing 3000 pounds per day in dense beds.

Because of the mechanical elements of the DASH system, an aquatic plant management harvesting permit must be obtained from the Wisconsin DNR. Decontamination is an important component with contracted DASH as the system will have been on other lakes.

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

Biological Control[8]

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

The effectiveness of bio-control efforts varies widely (Madsen, 2000). Beetles are commonly and successfully used to control purple loosestrife populations in Wisconsin. Weevils are used as an experimental control for Eurasian water milfoil once the plant is established. Tilapia and carp are used to control the growth of filamentous algae in ponds. Grass carp, an herbivorous fish, is sometimes used to feed on pest plant populations, but grass carp introduction is not allowed in Wisconsin. As a result, grass carp is not a viable bio-control in Wisconsin lakes and will not be utilized.

Weevils[9] have potential for use as a biological control agent against Eurasian water milfoil. There are several documented "natural" declines of EWM infestations with weevil present. In these cases, EWM was not eliminated but its abundance was reduced enough so that it did not achieve dominance. These declines are attributed to an ample population of native milfoil weevils (*Euhrychiopsis lecontei*). Weevils feed on native milfoils but will shift preference over to EWM when it is present. Lakes where weevils can become an effective control have an abundance of native northern water milfoil and fairly extensive natural shoreline where the weevils can over winter. Any control strategy for EWM that would also harm native milfoil may hinder the ability of this natural bio-control agent. Lakes with large bluegill populations are not good candidates for weevils because bluegills feed on the weevils. The presence and efficacy of stocking weevils in EWM lakes is being evaluated in Wisconsin lakes. So far, stocking weevils does not appear to be effective.

Weevils were utilized in six secluded EWM beds on Minocqua and Kawaguesaga Lakes while herbicide was used in less secluded beds. The reduction in EWM by weevils was minimal and after 3 years (released 2009), the program was ceased in 2012[10].

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

[8] Information from APIS (Aquatic Plant Information System). U.S. Army Corps of Engineers. 2005.
[9] *Control of Eurasian Water Milfoil & Large-scale Aquatic Herbicide Use*. Wisconsin Department of Natural Resources. July 2006.
[10] Eurasian watermilfoil (*Myriophyllum spicatum*) Treatment Analysis. Minocqua and Kawaguesaga Lakes, 2012.

specific environmental conditions necessary for success. Biological control is not without risks; new non-native species introduced to control a pest population may cause problems of its own.

Re-vegetation with Native Plants
Another aspect to biological control is native aquatic plant restoration. The rationale for re-vegetation is that restoring a native plant community should be the end goal of most aquatic plant management programs (Nichols 1991; Smart and Doyle 1995). However, in communities that have only recently been invaded by nonnative species, a propagule (seed) bank probably exists that will restore the community after nonnative plants are controlled (Madsen, Getsinger, and Turner, 1994).

Physical Control[11]

In physical management, the environment of the plants is manipulated, which in turn, acts upon the plants. Several physical techniques are commonly used: dredging, drawdown, benthic (lake bottom) barriers, and shading or light attenuation. Because they involve placing a structure on the bed of a lake and/or affect lake water level, a Chapter 30 or 31 WDNR permit would be required. Such permits are not commonly granted.

Dredging removes accumulated bottom sediments that support plant growth. Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, need deepening, or require removal of toxic substances (Peterson 1982). Lakes that are shallow, due to sedimentation, tend to have excess plant growth. Dredging can form an area of the lake too deep for plants to grow, thus creating an area for open water use (Nichols 1984). By opening more diverse habitats and creating depth gradients, dredging may also create more diversity in the plant community (Nichols 1984). Results of dredging can be long term. However, due to the cost, environmental impacts, and the problem of disposal, dredging should not be performed for aquatic plant management alone. Dredging is best used as a lake remediation technique and not for plant management.

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

Although drawdown can be inexpensive and have long-term effects (2 or more years), it also can have significant environmental effects and may interfere with use and intended function (e.g., power generation or drinking water supply) of the water body during the

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

drawdown period. Lastly, species respond in different manners to drawdown and individual species responses can be inconsistent (Cooke 1980a). Drawdowns may provide an opportunity for the spread of highly weedy species, particularly annuals. Drawdown requires a mechanism to significantly lower water levels.

Drawdown has been explored and proposed by the Minong Flowage which would affect Cranberry Lake and Flowage. In 2013/14, a drawdown occurred to repair the dam on the Minong Flowage. This drawdown resulted in little, if any, reduction in EWM on Cranberry Lake, but was not evaluated in the Cranberry Flowage. In 2013, there was 5.42 acres of EWM beds to be treated with herbicide (beds were delineated using the APMP treatment threshold of area, mean density and aerial coverage). Treatment did not occur because the herbicide applicator couldn't access the water in the low water conditions. The beds were checked that spring to verify presence and although a formal evaluation did not occur, qualitatively it appears the beds were unchanged but growing in more shallow water. When the water levels returned to normal, the EWM beds were evaluated for treatment in following year, and there were 5.29 acres delineated for treatment, thus very little change in total coverage. That treatment occurred and was effective, followed by a 4.97-acre treatment in 2015. Therefore, if the drawdown was effective it was minimal and not long-term. This may be due to the higher depths of most all of the areas with EWM, causing the drawdown to be exposed. There has been discussion of future use of drawdown on the Minong Flowage. The effectiveness of drawdown as an EWM management tool in the Minong Flowage may be more effective maybe due to EWM presence in shallower water and the ability to dry/freeze those areas with EWM. Considering the depth of the Cranberry Flowage (channel), it would likely be more effective than on the main lake.

Since the Minong Flowage and Cranberry Lake/Flowage are hydrologically connected, is important that the two entities work together in using this as a management tool. Although it may not be as effective on Cranberry Lake, it should be considered in management decisions/data collection should the Minong Flowage request using this practice. It is possible that if the Cranberry Flowage (channel) EWM gets very dense and herbicide use is not warranted due to negative impact potential, the CLFA may discuss a drawdown event with the Minong Flowage. Regardless, the two entities will need to coordinate EWM management with one another to arrive at the best management tools, including drawdown.

Benthic barriers, or other bottom-covering approaches, are another physical management technique. The basic idea is to cover the plants with a layer of a growth-inhibiting substance. Many materials have been used including sheets or screens of organic, inorganic, and synthetic materials; sediments such as dredge sediment, sand, silt or clay; fly ash; and various combinations of the above materials (Cooke 1980b; Nichols 1974; Perkins 1984; Truelson 1984). The problem with synthetic sheeting is that the gases evolved from plant and sediment decomposition collect underneath and lift the barrier (Gunnison and Barko 1992).
The problem with using sediments is that new plants establish on top of the added layer (Engel and Nichols 1984).

Benthic barriers will typically kill the plants under them within 1 to 2 months after which time they may be removed (Engel 1984). Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively (Carter et al. 1994). Sites from which barriers are removed will be rapidly re-colonized (Eichler et al. 1995). Synthetic barriers, if left in place for multi-year control, will eventually become sediment-covered and will allow colonization by plants. Benthic barriers may be best suited to small, high-intensity use areas such as docks, boat launch areas, and swimming areas. However, they are too expensive to use over widespread areas and heavily affect benthic communities by removing fish and invertebrate habitat. A WDNR permit would be required for a benthic barrier, and these barriers are not recommended.

Shading or light attenuation reduces the amount of light plants have available for growth. Shading has been achieved by fertilization to produce algal growth, application of natural or synthetic dyes, shading fabric, or covers, and establishing shade trees (Dawson 1981, 1986; Dawson and Hallows 1983; Dawson and Kern-Hansen 1978; Jorga et al. 1982; Martin and Martin 1992; Nichols 1974). During natural or cultural eutrophication, algae growth alone can shade aquatic plants (Jones et al. 1983). Although light manipulation techniques may be useful for narrow streams or small ponds, in general, these techniques are only of limited applicability. Physical control is not currently proposed for management of aquatic plants in Cranberry Lake.

Herbicide and Algaecide Treatments

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

An important caveat is that these products are considered safe when used according to the label. The U.S. Environmental Protection Agency (EPA)-approved label gives guidelines protecting the health of the environment, the humans using that environment, and the applicators of the herbicide. WDNR permits under Chapter NR 107 are required for herbicide application.

General descriptions of herbicide classes are included below.[12]

Contact herbicides

Contact herbicides act quickly and are generally lethal to all plant cells they contact. Because of this rapid action, or other physiological reasons, they do not move extensively within the plant and are effective only where they contact plants directly. They are generally more effective on annuals (plants that complete their life cycle in a single year). Perennial plants (plants that persist from year to year) can be defoliated by contact herbicides, but they quickly sprout from unaffected plant parts. Submersed aquatic plants that are in contact with sufficient concentrations of the herbicide in the water for long enough periods

[12] This discussion is taken from: *Managing Lakes and Reservoirs*. North American Lake Management Society.

of time are affected, but regrowth occurs from unaffected plant parts especially plant parts that are protected beneath the sediment. Because the entire plant is not killed by contact herbicides, retreatment is necessary, sometimes two or three times per year. **Endothall, diquat,** and **copper** are contact aquatic herbicides.

Systemic herbicides

Systemic herbicides are absorbed into the living portion of the plant and move within the plant. Different systemic herbicides are absorbed to varying degrees by different plant parts. Systemic herbicides that are absorbed by plant roots are referred to as soil active herbicides, and those that are absorbed by leaves are referred to as foliar active herbicides. **2,4-D, dichlobenil, fluridone, glyphosate and florpyrauxifen-benzyl** are systemic aquatic herbicides. When applied correctly, systemic herbicides act slowly in comparison to contact herbicides. They must move to the site of action within the plant. Systemic herbicides are generally more effective for controlling perennial and woody plants than contact herbicides. Systemic herbicides also generally have more selectivity than contact herbicides.

Broad spectrum herbicides

Broad spectrum (sometimes referred to as nonselective) herbicides are those that are used to control all or most species of vegetation. This type of herbicide is often used for total vegetation control in areas such as equipment yards and substations where bare ground is preferred. **Glyphosate** is an example of a broad-spectrum aquatic herbicide. **Diquat, endothall, and fluridone** are used as broad-spectrum aquatic herbicides but can also be used selectively under certain circumstances.

Selective herbicides

Selective herbicides are those that are used to control certain plants but not others. Herbicide selectivity is based upon the relative susceptibility or response of a plant to an herbicide. Many related physical and biological factors can contribute to a plant's susceptibility to an herbicide. Physical factors that contribute to selectivity include herbicide placement, formulation, timing, and rate of application. Biological factors that affect herbicide selectivity include physiological factors, morphological factors, and stage of plant growth.

Environmental considerations with herbicide use

Aquatic communities consist of aquatic plants including macrophytes (large plants) and phytoplankton (free floating algae), invertebrate animals (such as insects and clams), fish, birds, and mammals (such as muskrats and otters). All of these organisms are interrelated in the community. Organisms in the community require a certain set of physical and chemical conditions to exist such as nutrient requirements, oxygen, light, and space. Aquatic weed control operations can affect one or more of the organisms in the community, and in turn, affect other organisms or weed control operations. These operations can also impact water chemistry which may result in further implications for aquatic organisms.

Brand Name(s)	Chemical	Target Plants
Cutrine Plus, $CuSO_4$, Captain, Navigate, Komeen	Copper compounds	Filamentous algae, coontail, wild celery, elodea, and pondweeds
Reward	Diquat	Coontail, duckweed, elodea, water milfoil, and pondweeds
Aquathol, Aquathol K, Aquathol Super K, Hydrothol 191	Endothall	Coontail, water milfoil, pondweeds, and wild celery as well as other submersed weeds and algae
Rodeo	Glyphosate	Cattails, grasses, bulrushes, purple loosestrife, and water lilies
Navigate, Aqua-Kleen, DMA 4 IVM, Weed-Rhap	2,4-D	Water milfoils, water lilies, and bladderwort
ProcellaCOR[13]	Florpyrauxifen-benzyl	Water milfoils, floating hearts.

Table 17: Herbicides Used to Manage Aquatic Plants

General descriptions of the breakdown of commonly used aquatic herbicides are included below.[14]

Copper

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

2,4-D

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

A study in Tomahawk Lake in Bayfield County, Wisconsin illustrated a much slower breakdown time of 2,4-D than described above. Following a whole lake treatment of 0.5 mg/L 2,4-D, the chemical was still present 160 days after treatment. While there was successful removal of the target plant, Eurasian water milfoil, there were also significant declines in native plant biomass. A potential explanation was the low nutrient conditions in Lake Tomahawk which was described as an oligo-mesotrophic lake. (Nault 2010, Toshner 2010)

[13] From Wisconsin Dept. of Natural resources Florpyrauxifen-benzyl Chemical Fact Sheet.

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

Diquat
When applied to enclosed ponds for submersed weed control, diquat is rarely found longer than 10 days after application and is often below detection levels 3 days after application. The most important reason for the rapid disappearance of diquat from water is that it is rapidly taken up by aquatic vegetation and bound tightly to particles in the water and bottom sediments. When bound to certain types of clay particles, diquat is not biologically available. When diquat is bound to organic matter, it can be slowly degraded by microorganisms. When diquat is applied foliarly, it is degraded to some extent on the leaf surfaces by photodegradation. Because it is bound in the plant tissue, a proportion is probably degraded by microorganisms as the plant tissue decays.
Diquat has been found to be toxic to some invertebrates important to the lake food chain such as Daphnia sp. at the label application rates. It has also been found to be toxic to walleye at the labeled rates (Wisconsin DNR Factsheet-Diquat).

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

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

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

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

Florpyrauxifen-benzyl[15]
The active ingredient is 2-pyridinecarboxylic acid, 4-amino-3-chloro-6-(4-chloro-2-fluro-3-methoxyphenyl)-5-fluoro-, phenyl methyl ester, commercially known as ProcellaCOR™ (manufactured by SePRO Corp.). This is a systemic herbicide that is a synthetic auxin that

[15] From Wisconsin Dept. of Natural resources Florpyrauxifen-benzyl Chemical Fact Sheet.

causes the plant cells to elongate and kills the plant. The herbicide needs to be applied to actively growing plants with more mature plants possibly requiring higher concentration. It has relatively short contact exposure time of 12-24 hours. The efficacy compared to size of treatment area is unknown at this time. There are no restrictions for swimming, fish consumption, or drinking water. There is no restriction on irrigation of turf. The herbicide is broken down quickly in water by light and microbial breakdown. The half-life is 1-6 days. It also binds tightly to sediments, so leaching into groundwater is unlikely. EPA considers this herbicide "practically non-toxic" to bees, birds, reptiles, amphibians, and mammals. Toxicity tests show it is not toxic to rainbow trout, fathead minnow, *Daphnia sp.*, *Gammarus sp.* and *Lymnaea sp.* (snails).

Herbicide Used to Manage Invasive Species

Eurasian Water Milfoil

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies the following herbicides for control of Eurasian water milfoil (EWM): 2,4-D, diquat, endothall, fluridone, and triclopyr.[16] Florpyrauxifen-benzyl was registered with the EPA for aquatic use in 2017. All of these herbicides, with the exception of diquat, are available in both granular and liquid formulations. Targeting invasive species is possible by using the appropriate herbicide and timing of application of the herbicide. Early season treatment of Eurasian watermilfoil is recommended by the Wisconsin DNR to limit the impact on native aquatic plant populations.

The herbicide 2,4-D has been most commonly used to treat EWM in Wisconsin. This herbicide kills dicots including native aquatic species such as northern water milfoil, coontail, water lilies, spatterdock, and watershield. A project in Bayfield County on Lake Tomahawk also found unexpected impacts on pondweeds which are monocots (Nault, 2010). Monocot species such as elodea, several small pondweeds, and naiads are by fluridone and in some cases 2,4-D.

Wisconsin DNR research indicates that larger scale treatments results in more consistent reduction from herbicide than smaller treatments. These are data collected in many Wisconsin Lakes where herbicides were used for EWM control (Nault, 2015).

Herbicides can dissipate off a small treatment site rapidly. In the analysis of 2,4-D applied in 98 small treatment areas (0.1-10 acres) across 22 study lakes with application rates of 2-4 parts per million, the following results were found:

- Initial concentrations detected in the water column were far below the targeted concentration.
- Herbicide moved quickly away from treatment sites within a few hours after treatment.

[16] Additional information provided by John Skogerboe, Army Corps of Engineers, personal communication. February 14, 2008.

- ➢ The rapid dissipation of herbicide indicates that the concentrations in target areas may be lower than what is needed for effective EWM control (Nault, 2012).

Early results for florpyrauxifen-benzyl (ProcellaCOR) appear favorable for EWM control. In 2019, this herbicide was utilized on Cedar Lake in St. Croix County, WI to treat 12.2 acres of EWM in two beds. The frequency of occurrence went from 59.5% to 0% after treatment (chi-square p value < 0.0001). There was a statistically significant reduction in one native species (*Potamogeton pusillus*) and a significant increase in three native species (comparing before and after treatment).

Florpyrauxifen-benzyl was also used to treat a small bed of EWM on North Twin Lake in Polk County, WI. The bed was only 0.51 acres and the frequency of occurrence fell from 90+% to 0%. There was no reduction in any native plant species. This is only one application in a small bed but may indicate effectiveness of this herbicide for use in smaller beds.

Factors affecting herbicide effectiveness

The Wisconsin DNR has collected extensive data to evaluate the effectiveness of herbicides on EWM reduction, related to the use of the common herbicide 2,4-D for EWM reduction (Nault, et al, 2015). In extensive data analysis of various lakes by the Wisconsin DNR, it was found that 2,4-D did not reach the necessary concentration exposure time (CET) in any of the lakes studied. It was concluded that increasing the treatment area is likely to increase the likelihood of achieving CET resulting in better EWM control. There does not appear to be a definitive size that makes treatments effective or not effective.

The type of herbicide is can also be a factor in effectiveness. 2,4-D is slow acting and therefore needs a longer CET. As a result, small scale, spot treatments with 2,4-D don't tend to be very effective. Using a faster acting herbicide may achieve the necessary CET[17]. The manufacturers of Aquathol-K® (a fast-acting herbicide) recommends only applying herbicide on areas greater than 5 acres to enhance to probability of reaching the adequate CET. Treating areas greater than 5 acres does not guarantee herbicide success. The data from the 2,4-D study states that treatments less than 10 acres were considered successful (significant reduction of >50% in EWM a few months after treatment) in about half of the lakes studied. In contrast, large (assume to be greater than 10 acres) or whole lake treatments had 80% to 100% control.

The data on herbicide effectiveness also suggests that protected treatment areas have a higher concentration of herbicide achieved and takes longer to dissipate than exposed treatment areas. Although the study does not define protected or exposed treatment areas, it does discuss the treatment area being more prone to water flow and wind currents. This would imply that treatment areas in secluded bays or near shore (or any location that reduces wind currents and/or water flow) would increase the CET compared to areas where currents could carry herbicide away from the site. A few lakes have begun using

[17] Michelle Nault, Wisconsin DNR. Personnel communication, 2020.

curtains (limno-barriers) that contain the herbicide in the treatment area. This will presumably increase CET to make the herbicide treatment area isolated.

Historical Plant Management on Cranberry Lake and Flowage

Historically, the invasive species *Myriophyllum spicatum*-Eurasian watermilfoil (EWM) has been managed through herbicide application. Treatments with herbicide were first utilized in 2009 after discovery in 2007. These treatments occurred in both the main lake basin and the flowage connecting the lake to the Minong Flowage. Table 16 summarizes the acreage treated each year.

Year of treatment	Total acres treated	Herbicide utilized	Significant EWM reduction in all beds combined?(based upon FOO)	Significant native species reduction?(based upon FOO)
2009	0.8	2,4-D	Yes	No
2011	5.89	2,4-D	Yes	No
2012	14.74	2,4-D	Yes	No
2014	5.29	2,4-D	Yes	No
2015	4.97	2,4-D	Yes	No
2016	16.15	2,4-D	Yes	No
2018	12.97	2,4-D	Yes	No
2019	9.7	Diquat	Yes	Yes-2 species *Elodea canadensis* and *Myriophyllum sibiricum*

Table 18: Summary of historical EWM treatment in Cranberry Lake and flowage.

Area in Cranberry that has had herbicide applied at some point since 2009 (entire areal coverage of beds considering overlap) = 31.77 acres.

Area in Cranberry Flowage that has had herbicide applied at some point since 2009 = 10.33 acres.

In 2012 and 2013, SCUBA was used to hand pull EWM from an area in the southern bay (in front of Chipmunk Bar) immediately out from the pier to reduce spreading. Two volunteer divers were assisted by three people in boats with nets and rakes to clean up fragmentation. No formal evaluation of removal quantities was conducted, but the effort did open corridors for boat travel and likely reduced fragmentation from boat traffic. Hand pulling efforts have not been utilized since this time, largely due to no available volunteer divers.

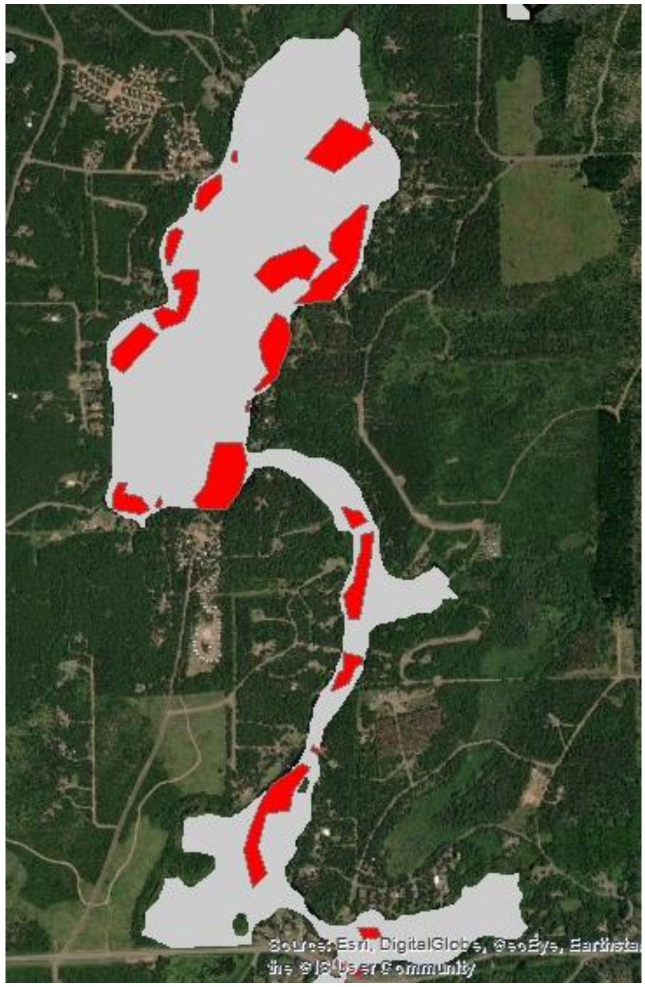

Figure 13: Map showing areas that herbicide has historically been applied since 2009. Many of these areas have been treated in more than one year. This map is the culmination of all treated beds that may overlap or are lone beds.

Although the pre/post treatment surveys show effective reduction in EWM, this reduction has not been long-term. Typically, the beds of EWM treated in any given year shows substantially less EWM present after treatment (later in summer of treatment year). However, EWM tends to return within a year or two after treatment, usually resulting in established beds again within three years. This shows that the reduction is more short-term than long-term.

Aquatic Plant Management Goals and Objectives

The main concerns that the plant committee has expressed during re-revaluation of this plan were as follows:

- **Eurasian watermilfoil management issues and funding.**
- **Zebra mussel infestation.**
- **Water clarity/water quality.**
- **Boat traffic from Minong Flowage and AIS impact.**

The Cranberry Lake/Flowage Association is committed to managing the aquatic plant community to reduce EWM, reduce other AIS infestations and protect the native plant community. The Association is concerned about management difficulties due to extensive lake use by boaters.

The goals from previous plan were reviewed and the adjusted. The new goals are as follows:

Cranberry Lake/Flowage Management Goals

1. ***Protect and enhance native plant community and fish habitat.***
2. ***Limit Eurasian watermilfoil coverage and reduce its impact on the ecosystem through long-term control.***
3. ***Prevent introduction of other invasive species.***
4. ***Maintain and enhance native shoreline community.***
5. ***Educate citizens about importance of aquatic plants, lake ecology, and native shoreline community.***
6. ***Develop/implement sustainable funding mechanisms to manage AIS.***

Management Objectives and Actions

Goal 1: Protect and enhance native plant community and fish habitat

1.1-Encourage the protection of plants in littoral zone adjacent to riparian owners.

Riparian owners can hand pull aquatic vegetation from an area 30 feet wide without a permit. Since native plants are paramount for competing with EWM (and other AIS plants) potentially reducing its spread, maintaining the integrity of the native plant community is important.
Riparian owners are encouraged in this plan (and through public education in newsletters and at meetings) to leave native plant community intact with no removal physically or chemically (which would require a permit from the Wisconsin DNR).

1.2-Manage AIS with early season methods to allow reduction of target species only and minimal effect on native plants.

Historically, the EWM has been treated with 2,4-D in an early season time period. This is in the early spring when water temperatures range from 50 to 60 degrees F. Early application allows targeting the AIS, with limited adverse effects on the native species, since they are generally still in dormancy. Also, 2,4-D typically targets dicot plant species only and therefore will not affect the monocot species such as those in the genus *Potamogeton.*

The newly approved herbicide Florpyrauxifen-benzyl (ProcellaCOR®) will be explored and potentially utilized as an alternative to 2,4-D. This could help reduce potential resistance development to 2,4-D.

If herbicide use is deemed necessary based upon listed criteria, and the Wisconsin DNR authorizes a permit to use herbicide, the application of any herbicide will follow an early season time schedule. This application would occur when the plant level lake water temperature is between 50°F and 60°F.

1.3-No reduction of native plant species by Lake Association efforts will be conducted.

The Cranberry Lake/Flowage Association will not embark on any management efforts that result in the reduction of native plant species. The Association recognizes the importance of native aquatic plant species. As a result, they will take safeguards to preserve this important community. Any changes in the native community will be monitored through periodic full lake point intercept macrophyte surveys.

Action A-A full lake, point-intercept macrophyte survey will be conducted in 2025 and approximately every 5-7 years if EWM herbicide application continues.

1.4- Evaluate the management plan every 5 years.

Management practices can sometimes adversely affect native plant communities. Furthermore, over time, various management practices may be ineffective or not cost effective. Evaluation management plans every 5 years to make sure the management practices are effective and sustainable and reflect data collected from Cranberry Lake and Flowage is important.

Action B- An evaluation of this plan will begin in 2026, with the plan updated in 2027.

Goal 2: Limit Eurasian watermilfoil coverage and reduce its impact on the ecosystem

Eradication of EWM is not realistic. The emphasis on EWM management is to control EWM in coverage and reduce spreading. During any given growing season, there will likely be clumps of EWM in Cranberry Lake, but management is designed to avoid large, dense beds of EWM. These objectives, if implemented correctly and with diligence, EWM can successfully be controlled at this level.

Cranberry Lake/Flowage Association plans to take an integrated approach to management of EWM. This will range from hand removal/DASH (diver assisted suction harvest) removal of small, less dense areas of EWM, differentiation of herbicide use based upon size, density and location of EWM beds, and education to reduce spread. The objectives outline each of the integrated portions of EWM management that will be implemented based upon EWM monitoring.

All EWM management will be coordinated with the Minong Flowage Association. The two water bodies are connected hydrologically and so management tools such as drawdown may affect both waterbodies. Communication will occur with the Minong Flowage before any management decision are made annually.

2.1-Utilize an adaptive management scheme for the management of EWM in Cranberry Lake and Flowage.

The objectives and actions in relationship to EWM will be evaluated each year along with any new technology or methods that may emerge from literature and/or the Wisconsin DNR. An example may be a new herbicide that is found to be more effective. The methods may be adjusted based upon new information available over the next 5 years.

2.2-Maintain an overall aerial bed coverage of EWM in Cranberry Lake that is less than 8.6 acres (less than 10% of littoral zone area) and no EWM beds within travel channel in the flowage.

The decision to reduce EWM with herbicide will be first based upon objective 2.2. If more than 10% of the littoral zone area (by acres) is covered by EWM beds, then reduction will be potentially conducted to lower this aerial coverage. If there is less than 10% coverage in the littoral zone, individual beds may be considered based upon objective 2.3.
Based upon the 2019 plant survey, the littoral zone is 86.5 acres. 10% of this area is 8.56 acres.

2.3 -Consider herbicide application for reduction of EWM beds within Cranberry Lake and Flowage to keep the EWM below the goal stated (<10% of littoral zone of lake and out of travel channel in flowage) within the lake and the flowage.

An EWM bed is defined as an area that have a border delineated by sight (EWM observed from surface, has a frequency of occurrence greater than 50% (20-meter square point grid), and a mean density (in sample grid) of 1.5 or greater.
These thresholds will be evaluated annually by the CLFA based upon how effective management is and the status of EWM in the lake and flowage.

2.4-Improve long-term control of EWM through evaluation of latest management tools available.

Historically EWM reduction in most areas of Cranberry Lake/Flowage has lasted on a year or two before the EWM returns. A focus will be to evaluate and implement the latest available methods/herbicide to improve the long-term reduction.

The following recommendations will be followed when considering herbicide application to improve long-term reduction:

1. Beds greater than 5 acres will have a greater degree of effectiveness so beds should be larger and small beds in close proximity combined to increase coverage.
2. Beds smaller than 5 acres need to have high density and/or a large portion with EWM canopying/matting at the surface.
3. Beds smaller than 5 acres need to show evidence of adversely affecting lake use and/or having an ecological impact on other plant species (monotypic EWM) to warrant herbicide use for immediate and possibly short-term reduction. Examples would be a thick bed canopying near docks with boat travel or a dense EWM bed not allowing native plants to thrive.
4. Treatment should be conducted in early morning and when winds are forecast for <10 mph over a 24-hour period.
5. Use of a containment curtain (limno barrier) may be explored for use if very small beds are considered (< 1 acre or portions of a larger bed).

Early season herbicide application will be used to reduce/contain EWM in beds chosen for herbicide application. The herbicide 2,4-D typically has been used to target the EWM along with early spring application to reduce the chance native species are out of dormancy.

The common target concentration (as of 2015) has been 4.0 parts per million (ppm) in the treatment beds. This concentration may need to be adjusted depending on effectiveness or adverse effects on native species. 2,4-D should only be used in beds greater than 5 acres in coverage. Otherwise the contact time/concentration will be too limited for effective reduction results. A combination formulation could be considered (such as 2,4-D and endothall) to increase efficacy.

Should beds less than 5 acres established as absolutely necessary to treat, a faster acting herbicide should be utilized. These could include: ProcellaCOR, endothall or diquat (as examples) or another recommendation from licensed applicator or Wisconsin DNR APM professional.

A more recent herbicide available is ProcellaCOR. This has been found to be effective in smaller beds as it needs less contact time (based upon limited data thus far, but the Wisconsin DNR is studying data results at this time). Endothall, ProcellaCOR or diquat should be considered in beds less than 5 acres in area. Diquat was used in the 2019 Cranberry Lake/Flowage herbicide treatment, and there was significant reduction of two native plants species[18]. Also, there is concern on the toxicity of Diquat on other organisms such as Daphnia sp. and walleye. This may cause ProcellaCOR to be a better choice if future reductions occur when using Diquat, however ProcellaCOR is more expensive. In small beds (< 5 acres) either ProcellaCOR or Diquat will be utilized with expense and effectiveness being considered. The herbicide 2,4-D will only be considered for beds >5 acres, with ProcellaCOR also being an option. The data for long-term effectiveness of ProcellaCOR has not been established at this writing. Short-term effectiveness looks promising, but more data is needed to determine long-term effectiveness.

Monitoring/treatment evaluation surveys

Effectiveness of reduction from herbicide application will be determined using the Wisconsin DNR pre and post monitoring protocol. The pre-treatment survey will be conducted in late summer the year prior to the treatment year. A chi-square analysis of the EWM and native species frequencies will be compared before and after treatment. Any potential reduction will be deemed statistically significant if $p<0.05$.

Action B -After delineation and a pre-treatment survey, EWM beds will be treated with herbicide. The herbicide used will be based upon Wisconsin DNR recommendations and from plant management researchers. A post treatment survey will be conducted in late summer following an early spring treatment and compared to the pre-treatment survey that is conducted in the previous summer.

Action C- The Cranberry Lake/Flowage Association will communicate annually with the Minong Flowage Association about EWM management. Since they are managing EWM in connected waters, this communication is important.

[18] The pre/post treatment analysis from 2019 showed a statistically significant (using chi-square analysis) reduction in *Elodea canadensis* and *Myriophyllum sibiricum* in the treatment beds.

2.4-Monitor EWM in lake and flowage and record any new growth with GPS bed mapping. This will utilize a volunteer monitoring team with professional oversight (or only by a professional if a volunteer team cannot be assembled).

One important element to managing EWM is to keep an updated inventory as to where the plant is growing and the density. This monitoring needs to occur on many occasions beyond the pre and post survey work. A volunteer monitoring team will need to be established and trained to implement a monitoring program. Their data will then be shared with the consultant that delineates the EWM beds for treatment. Monitoring on a semi-weekly basis from late June to mid-August is recommended.

Action D - A monitoring team of volunteers plan be established and trained. They will monitor as often as they can with a goal of once per month. If volunteers cannot complete, a professional will be hired to evaluate the EWM in late summer. All EWM will be marked with GPS coordinates resulting in bed mapping of EWM. A sampling grid will be established to evaluate frequency and mean density in any bed delineated.

2.5-In small areas or areas with scattered EWM, and/or not meeting the criteria listed in objective 2.2, use of hand removal EWM using SCUBA (hand pulling) or DASH (suction mechanism) may be utilized.

Herbicide use in small beds is not typically effective, since the area is too small to apply very precisely and the concentration can be reduced so quickly, making it difficult to reach an effective concentration to kill the plants. In areas smaller than the threshold, hand pulling (using SCUBA if necessary) will be used to remove as much EWM as possible. Since EWM can spread through fragmentation, it is imperative that safeguards be taken to remove EWM fragments during this practice. Volunteers should be present during hand pulling exercises to remove any fragments during the process.

Action E-Volunteer divers may remove EWM by hand and/or rake if the decision is made to utilize this method. Care will be used to remove plants in their entirety including roots. Volunteers will be utilized as needed to remove any fragments while hand removal is occurring. If financial resources are available, contracting DASH may be considered.

Goal 3: Prevent introduction of other invasive species and respond if new introduction occurs.

3.1-Maintain AIS education materials and monitor boat landing.

Future introductions of AIS into Cranberry Lake/Flowage need to be avoided. One method is to disseminate information at the boat landing on Cranberry Lake. Education materials about Cranberry Lake/Flowage as well as information on AIS present in the lake, and methods to reduce future infestations will be made available.

The Cranberry Lake/Flowage Association will coordinate training volunteers for the Clean Boats/Clean Waters Program. This will allow volunteers to monitor the boat landing especially at key, busy times of lake use. This program has proven to be beneficial on lakes statewide. At minimum, the Cranberry Lake/Flowage Association would like to monitor boat landings during high use times such as July 4.

Action F-A kiosk has been constructed. The Association will maintain the kiosk and materials available at the kiosk.

3.2-Monitor Cranberry Lake and Flowage for AIS each summer.

Action G-Collect a water sample and test for hardness as calcium carbonate and total hardness to determine susceptibility to zebra mussels.

Action H-Cranberry Lake/Flowage Association plan place a minimum of four plate samplers during summer months to monitor for zebra mussels. They will also communicate with residents to check their docks periodically and when they remove them in the fall.

The key to the management of AIS is early detection and a rapid response. To address this, Cranberry Lake/Flowage Association will follow a rapid response plan (Appendix I) if AIS is detected.

Action I-Cranberry Lake/Flowage Association volunteers plan to monitor Cranberry Lake/Flowage early and late summer (two monitoring sessions) minimum. If volunteers not available, a professional may be hired to fulfill this survey.

Action J-Should AIS be suspected/detected, the established rapid response will be implemented. The rapid response plan is in appendix.

3.2-Distribute annual newsletter with information about AIS, and update EWM management. Communication is imperative in the managing of EWM.

The Cranberry Lake/Flowage Association has historically provided written publication of their meeting minutes as well as provided newsletter information. This communication will continue annually at least. The understanding of EWM management practices by lake residents and users is important. Maps will be provided showing the most up-to-date locations of EWM beds and smaller clumps of plants. The maps will be labeled accordingly as well as dated.

See appendix J for a sample of a newsletter published by the Cranberry Lake/Flowage Association.

3.3-Should new AIS species be observed/detected in Cranberry Lake and/or Cranberry Flowage, the rapid response plan will be followed (see Appendix D for this plan).

Goal 4: Maintain and enhance native shoreline community

4.1-Discuss the opportunity for a shoreline restoration and use a showcase for others riparian owners.

Native shoreline buffers are important to create and maintain on lakes. This practice can limit nutrient loading a large amount. They also provide excellent wildlife habitat for lake and near lake organisms.

Since EWM grows well in high nutrient sediment, reducing the sedimentation process in lakes that have EWM is important. As a result, Cranberry Lake/Flowage Association will consider working with the Douglas County Land and Water Conservation Dept. to try and restore one residential shoreline that is identified as a desirable location. Also, this location will need the residents' commitment as well. With one showcase restoration, the Association can try and demonstrate how restorations look and how they function.

In addition, the Association will explore the Healthy Lakes Initiative that has funds and support materials for shoreline restoration projects.

Action K- The Cranberry Lake/Flowage Association will (with assistance from the Douglas County Land/Water Conservation Dept) evaluate residential properties that would be a good candidate for restoration and communicate opportunities for restoration with those residents.

4.2-Diseminate educational materials on native shoreline benefits.

Action L- Material available from the Douglas County (or others) on shoreline restoration will be sent to all riparian owners on Cranberry Lake/Flowage.

Goal 5: Educate citizens about importance of aquatic plants, lake ecology, and native shoreline community.

5.1-Distribute educational materials on lake ecology information.

The Cranberry Lake/Flowage Association is concerned about residents and lake users not understanding basic lake ecology. To help facilitate better understanding the Association will obtain and distribute education materials pertaining to lake ecology. This will include water quality and the importance the lake ecosystem and native plants have on water quality, fisheries, and the lake ecosystem as a whole.

These materials will be made available at the annual meeting, and possibly mailed to residents, depending on annual meeting attendance.

5.2-Invite guest speaker(s) to annual meeting to discuss the importance of aquatic plants and proper management.

The importance of aquatic plants and management practices for EWM have been presented in past meetings. In the future, more speakers will be used to further educate residents and interested lake users about these important organisms. The speakers may include DNR personnel, Douglas County Water Quality Specialists, or private consultants.

Action M-Education materials will be gathered and distributed at the annual meetings. An attempt will be made to secure a speaker for each annual meeting to talk about lake ecology and/or aquatic plants. Target audience will be lake residents and lake users that may attend the annual meeting.

Goal 6: Develop/implement sustainable funding mechanisms to manage AIS.

6.1-The finance committee will continue to evaluate revenue sources and marketing options.

Management of EWM can be expensive. Even though the Wisconsin DNR has a history of being financially supportive for the AIS management through Rapid Response and AIS Grants, these grants are a cost share arrangement. Since the Cranberry Lake/Flowage Association has a small membership, financing management projects can be a burden. In order to reduce the chance of having management postponed due to lack of money, the Association will continue to plan in advance by reviewing all revenue sources.

Since the last update of this plan, the Association implemented some marketing tools to enhance membership and collection of financial resources. See appendix F for an example of one of these practices (most recent fundraising campaign).

Action N-Fund raising/marketing will continue to secure more membership and thus more funding for lake management practices. Lake residents will be targeted for this effort.

6.2-Implement annual fundraisers (has been ongoing).

An effort to increase funds from residents/lake users began in 2018. Some activities included promotions and recommendations to raise money. This has resulted in a positive balance for the Cranberry Association. The Association will continue to promote contributions from lake users to have the financial resources to conduct management practices and match potential future grants.

Monitoring and Assessment

Aquatic Plant Surveys

An aquatic plant (macrophyte) survey using the point intercept method will be completed prior to the update of the aquatic plant management plan. The estimated time would be in 2025 or 2026. The whole lake survey will be conducted in accordance with the guidelines established by the Wisconsin DNR. Voucher specimens will be collected and submitted for verification of any new species not sampled in previous surveys.

In-Lake Monitoring

At the minimum, monthly Secchi depth measurements will be collected by volunteers. The goal is to complete phosphorus and chlorophyll-a analysis as well which will be based upon fund availability. The water collection would be completed by volunteers as well.

Table 19: Implementation plan

Implementation Plan/Information			
Action	**Timeline**	**Estimated costs**	**Volunteer hours (est)**
A-Full lake PI survey every 5 years if herbicide application occurs during that time span.	2019 (completed) Repeated 2025-26	$4000	n/a
B-EWM beds treated with 2,4-D at 4.0 ppm with pre (where delineated and post monitoring to determine effectiveness	Annually in delineated beds; Spring treatment before water 60 degrees F at a rate of 1.5 ppm with 2,4-D	$1400 per acre foot plus $300 trip fee[19]. Pre/post survey approx. $1500-$2500.	3-4 hours for permit application
C-Communicate/coordinate with the Minong Flowage Association	Annually	$0	2-10 hours assuming meeting attendance.
D-Monitor for EWM and other AIS	Semi-weekly from late June to Mid-August by volunteers. Once in August by professional	$0 if trained by County or $500 if trained by consultant. $800 if survey completed in whole professional	Approximately 3 hours each session (total of 12 hours)
E-Diver removal of EWM in less dense stands DASH	Annually as needed after treatment; Mid July-August	$800-$2200 if by consultant (depending on area size) $2500 per day for DASH	2-6 hours for fragment removal (for each volunteer)
F-Maintain kiosk	Annually from first weekend in May until September	$0	2
G-Collect water sample and submit to SLH and test for calcium and total hardness	Summer 2020	$45 for sample run and $15 for shipping for total of $60	2
H-Place four mussel plate samplers in Cranberry Lake May-Sept.	Annually beginning 2020	$0	4
I-Monitor boat landing	Two time periods during high landing use such as July 4.	$0	16-32
J-Rapid response	Upon discovery	$0 but $$ for implementation involves consultant ($500-$1500)	4
K-Evaluate APMP and Update.	2017 Update complete 2018	Consultant assistance $3000	10-12 hours of meetings
L-Obtain shoreline restoration materials	2020-21	$0 (from Douglas County)	4
M-Distribution of education materials	Annually-annual meeting and via electronic delivery	$0-$50 (depending on source of materials)	6-8 annually
N-Fund raising efforts	Various efforts led by Board	$0 (unless marketing materials cost)	20

[19] Based upon 2020 pricing of herbicide applicator used in 2020.

Defined potential CLFA coordinator positions

These positions will act as intermediaries between the CLFA board and the stated independent group

1) CLFA grant applicant writer and reimbursement coordinator.
2) Primary interface between CLFA and Minong Flowage regarding EWM activities.
3) Lead CLFA EWM monitoring team – trained in EWM identification; coordinate semi-weekly surveys of the lake and flowage to monitor growth of EWM.
4) Water quality sampling and assessment: clarity, phosphorous and Chlorophyll A; provide samples to state lab for testing and documentation of results.
5) Lake public landing boat inspection coordinator. Recruit volunteers, arrange funding and interact with DNR possibly with grants from the Clean Boats/Clean Waters Program.
6) Communication of CLFA activities around EWM management to the entire lake homeowner list via annual or more frequent mailings. Also provide annual educational materials regarding healthy lake ecology to all homeowners.
7) Arrange partnership between an interested homeowner, along with Douglas County Land and Conservation Dept. and the Wascott Township, to develop a showcase shoreline restoration project.

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Appendix A. Invasive Plant Species Information

Curly Leaf Pondweed (*Potamogeton crispus*)[3] (not observed or sampled in most recent plant survey)

Curly leaf pondweed is an invasive aquatic species found in a variety of aquatic habitats including permanently flooded ditches and pools, rivers, ponds, inland lakes, and even the Great Lakes. Curly leaf pondweed prefers alkaline or high nutrient waters 1 to 3 meters deep. Its leaves are strap-shaped with rounded tips and undulating and finely toothed edges. Leaves are not modified for floating, and are generally alternate on the stem. Stems are somewhat flattened and grow to as long as 2 meters. The stems are dark reddish-green to reddish-brown with the mid-vein typically tinged with red. Curly leaf pondweed is native to Eurasia, Africa, and Australia and is now spread throughout most of the United States and southern Canada.

Characteristics
New plants typically establish in the fall from freed turions (branch tips). The winter form is short with narrow, flat, relatively limp, bluish-green leaves. This winter form can grow beneath the ice and is highly shade-tolerant. Rapid growth begins with warming water temperatures in early spring – well ahead of native aquatic plants.

Reproduction and Dispersal
Curly leaf pondweed reproduces primarily vegetative. Numerous turions are produced in the spring. These turions consist of modified, hardened, thorny leaf bases interspersed with a few to several dormant buds. The turions are typically 1.0 – 1.7 cm long and 0.8 to 1.4 cm in diameter. Turions separate from the plant by midsummer and may be carried in the water column supported by several leaves. Humans and waterfowl may also disperse turions. Stimulated by cooler water temperatures, turions germinate in the fall over-wintering as a small plant. The next summer plants mature producing reproductive tips of their own. Curly leaf pondweed rarely produces flowers.

Ecological Impacts
Rapid early season growth may form large, dense patches at the surface. This canopy overtops most native aquatic plants shading them and significantly slowing their growth. The canopy lowers water temperature and restricts absorption of atmospheric oxygen into the water. The dense canopy formed often interferes with recreational activities such as swimming and boating.

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[3] Information from GLIFWC Plant Information Center (http://www.glifwc.org/epicenter).

In late spring, curly leaf pondweed dies back releasing nutrients that may lead to algae blooms. Resulting high oxygen demand caused by decaying vegetation can adversely affect fish populations. The foliage of curly leaf pondweed is relatively high in alkaloid compounds possibly making it unpalatable to insects and other herbivores.

Control
Small populations of curly leaf pondweed in otherwise un-infested water bodies should be attacked aggressively. Hand pulling, suction dredging, or spot treatments with contact herbicides are recommended. Cutting should be avoided because fragmentation of plants may encourage their re-establishment. In all cases, care should be taken to remove all roots and plant fragments to keep them from re-establishing.

Control of large populations requires a long-term commitment that may not be successful. A prudent strategy includes a multi-year effort aimed at killing the plant before it produces turions thereby depleting the seed bank over time. It is also important to maintain, and perhaps augment, native populations to retard the spread of curly leaf and other invasive plants. Invasive plants may aggressively infest disturbed areas of the lake such as those where native plant nuisances have been controlled through chemical applications.

Eurasian Water Milfoil ***(Myriophyllum spicatum)****-present in Cranberry Lake/Flowage since 2007*

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

Distribution and Habitat
Eurasian milfoil first arrived in Wisconsin in the 1960's. During the 1980's, it began to move from several counties in southern Wisconsin to lakes and waterways in the northern half of the state. As of 1993, Eurasian milfoil was common in 39 Wisconsin counties (54%)

and at least 75 of its lakes including shallow bays in Lakes Michigan and Superior and Mississippi River pools.

Eurasian water milfoil 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.

Life History and Effects of Invasion

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

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lakebed). As an opportunistic species, Eurasian water milfoil 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 Eurasian milfoil provide only a single habitat and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of Eurasian water milfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by Eurasian water milfoil may lead to deteriorating water quality and algae blooms of infested lakes. [4]

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[4] Taken in its entirety from WDNR, 2008 (http://www.dnr.state.wi.us/invasives/fact/milfoil.htm)

Reed Canary Grass (*Phalaris arundinacea*)-some scattered locations observed in Cranberry Lake/Flowage

Reed canary grass 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. The vast majority of our reed canary grass is derived from the Eurasian ecotype. Agricultural cultivars of the grass are widely planted.

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

Distribution and Habitat
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.

Life History and Effects of Invasion
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 then spreads laterally. Growth peaks in mid-June and declines in mid-July. 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 less than 12 years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, 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.[5]

Purple Loosestrife (*Lythrum salicaria*)[6]-not observed in Cranggery Lake/Flowage.

Purple loosestrife is a non-native plant common in Wisconsin. 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 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 vary from purple to magenta, possess 5-6 petals aggregated into numerous long spikes, and bloom from July to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes (underground stems) that form a dense mat.

Characteristics
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, about 24 states

5 Taken from WDNR, 2008. (http://www.dnr.state.wi.us/invasives/fact/reed canary.htm).

6 Wisconsin DNR invasive species factsheets.(http:/dnr.wi.gov/invasives).

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. This plant's optimal habitat includes marshes, stream margins, river 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.

Reproduction and Dispersal

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. 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 disturbance is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. Locating non-flowering plants is difficult, 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. When the right disturbance occurs, loosestrife can spread rapidly eventually taking over the entire wetland.

Ecological Impacts

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.

Mechanical Control

Purple loosestrife (PL) can be controlled by cutting, pulling, digging, and drowning. Cutting is best done just before plants begin flowering. Cutting too early encourages more flower stems to grow than before. If done too late, seed may have already fallen. Since lower pods can drop seed while upper flowers are still blooming, check for seed. If none, simply bag all cuttings (to prevent them from rooting). If there is seed, cut off each top while carefully holding it upright, then bend it over into a bag to catch any dropping seeds. Dispose of plants/seeds in a capped landfill, or dry and burn them. Composting will not kill the seeds. Keep clothing and equipment seed-free to prevent its spread. Rinse all equipment used in infested areas before moving into non-infested areas, including boats, trailers, clothing, and footwear.

Pulling and digging can be effective, but can also create disturbed bare spots, which are good sites for PL seeds to germinate, or leave behind root fragments that grow into new plants. Use these methods primarily with small plants in loose soils, since they do not usually leave behind large gaps nor root tips, while large plants with multiple stems and brittle roots often do. Dispose of plants as described above.

Mowing has not been effective with loosestrife unless the plants can be mowed to a height where the remaining stems will be covered with water for a full 12 months (year?). Burning has also proven largely ineffective. Mowing and flooding are not encouraged, because they can contribute to further dispersal of the species by disseminating seeds and stems.

Follow-up treatments are recommended for at least 3 years after removal.

Chemical Control

This is usually the best way to eliminate PL quickly, especially with mature plants. The chemicals used have a short soil life. Timing is important. Treat in late July or August but before flowering to prevent seed set. Always back away from sprayed areas as you go to prevent getting herbicide on your clothes. The best method is to cut stems and paint the stump tops with herbicide. The herbicide can be applied with a small drip bottle or spray bottle which can be adjusted to release only a small amount. Try to cover the entire cut portion of the stem but not let the herbicide drip onto other plants since it is non-selective and can kill any plant it touches.

Glyphosate herbicides**:** Currently, glyphosate is the most commonly used chemical for killing loosestrife. Roundup and Glyfos are typically used, but if there is any open water in the area use Rodeo, a glyphosate formulated and listed for use over water. Glyphosate must be applied in late July or August to be most effective. Since you must treat at least some stems of each plant and they often grow together in a clump, all stems in the clump should be treated to be sure all plants are treated.

Another method is using carefully targeted foliar applications of herbicide (NOT broadcast spraying). This may reduce costs for sites with high densities of PL, since the work should be easier and there will be few other plant species to hit accidentally. Use a glyphosate formulated for use over water. A weak solution of around 1% active ingredient can be used, and it is generally necessary to wet only 25% of the foliage to kill the plant.

A permit must be obtained from WDNR before applying any herbicide over water. The process has been streamlined for control of purple loosestrife, and there is no cost. Contact your regional Aquatic Plant Management Coordinator for permit information.

Biological Control
Conventional control methods like hand pulling, cutting, flooding, herbicides, and plant competition have only been moderately effective in controlling purple loosestrife.
Biocontrol is now considered the most viable option for more complete control for heavy infestations. The WDNR, in cooperation with the U.S. Fish and Wildlife Service, is introducing several natural insect enemies of purple loosestrife from Europe. A species of weevil (*Hylobius transversovittatus*) has been identified that lays eggs in the stem and upper root system of the plant; as larvae develop, they feed on root tissue. In addition, two species of leaf eating beetles (*Galerucella calmariensis* and *G. pusilla*) are being raised and released in the state, and another weevil that feeds on flowers (*Nanophyes marmoratus*) is being used to stress the plant in multiple ways. Research has shown that most of these insects are almost exclusively dependent upon purple loosestrife and do not threaten native plants although one species showed some cross-over to native loosestrife. These insects will not eradicate loosestrife but may significantly reduce the population so cohabitation with native species becomes a possibility.

Zebra Mussels (*Dreissena plymorpha*) (not a plant but an AIS of great concern)-not observed in Cranberry Lake/Flowage.

Zebra mussels are tiny bottom-dwelling clams native to Europe and Asia. Zebra Mussels were introduced into the Great Lakes in 1985-1986 and have been spreading throughout these lakes 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 2 inches long, but most are under 1 inch. Zebra mussels usually grow in clusters containing numerous individuals.

Zebra mussels were first found in Wisconsin waters of Lake Michigan in 1990. They are now found in a number of inland Wisconsin waters. Zebra mussels are the only freshwater mollusks that can attach themselves to objects. They are typically found in 6-30 feet of water depth and algae-rich water.

Zebra mussels feed by pumping water into their bodies and filtering out suspended microscopic plants, animals, and other debris for food. This process can lead to increased water clarity and a depleted food supply for fish and other organisms. The higher light penetration can increase growth of rooted aquatic plants. This can affect larger fish by providing more cover for smaller fish. The thicker plant growth can also interfere with boaters, anglers, and swimmers. Zebra mussel infestations may also promote the growth of blue-green algae, since these mussels avoid consuming that type of algae, but not others.

Control
No selective method has been developed that succeeds in controlling zebra mussels in the wild without also harming other aquatic organisms. Ducks and fish will eat small zebra mussels but not to the point of effectively controlling their populations. At this point in time, no practical and effective controls exist. There is a high need for research, and prevention is the best measure.

Appendix B. Rapid Response Strategy for invasive species

If a plant or other potential AIS is observed contact a Cranberry Lake Association Board Member. The Cranberry Lake/Flowage Association Board is responsible to carry out this protocol.

If a suspected AIS is observed, the following should be conducted:

2. Contact AIS lead (in 2020 the lead is: Dave Olson) or another Board member.
3. If AIS is tentatively confirmed, then the Board AIS lead will contact the Board chair, the Douglas County AIS Coordinator, and the Wisconsin DNR.
4. Mark the location of the suspected AIS and confirm AIS.

    Within 48 hours of the credible report, the location will be marked with GPS coordinate and entered.

    Within 72 hours of a credible report, the Douglas County AIS coordinator or the Wisconsin DNR will examine the suspected AIS to confirm ID.

    <u>If the AIS is a plant</u>:

    Take a digital photo of the plant in the setting where it was found. Collected five to ten intact specimens (if possible). Attempt to get the root system, leaves and any flowers and/or seed heads when present. Place into a plastic, sealed bag with no water added, label with data and GPS coordinates (if possible). Place in refrigeration or on ice. The specimens should be delivered to the Wisconsin DNR (810 W Maple St., Spooner WI 54801).

    <u>If the AIS is an animal (other than fish):</u>

    Take digital photo of the animal in the setting where it was found. Collect up to five specimens. Place into a jar with water, and refrigerate or place on ice. Transfer specimen to jar with rubbing alcohol (50-70%) except if jellyfish leave in water. Deliver to same DNR address above.

5. Communicate result of examined specimens with the Cranberry Lake/Flowage Association Board, Douglas County AIS Coordinator, and the Wisconsin DNR.
6. Residents nearest location will be contacted with 48 hours after specimen verified.
7. A public notice will go out to all lake association members (via email/phone) within 5 days of AIS verification.
8. Sign will be posted at landing within 7 days upon verification of AIS.
9. A whole specimen will be bagged and sent to UW Stevens Point Herbarium.
10. Evaluation of a need for control measures will be evaluated with AIS Coordinator, DNR, and consultant (if needed) within 72 hours. At this time, the extent of the AIS will be evaluated.
11. Implement control measures. The goal will be for eradication of the new AIS. Control methods may include hand pulling, divers, herbicide application, or other methods available for AIS plants.
12. If herbicide/other chemical application is best, control method will not take place until proper permits have been granted by Wisconsin DNR.
13. Apply for rapid response grant with the Wisconsin DNR.
14. After mitigation efforts are utilized, the location of AIS in the lake will be inspected frequently to determine the efficacy of the control measures and determine if additional control is necessary.
15. A meander survey will be completed in the entire Cranberry Lake/Flowage basin to visually inspect for more AIS locations.

Contacts:

Dave Olson AIS Lead 651-402-3234

Douglas County, Ashley Vande Voort, Land Conservationist, (715) 395-1266.

Wisconsin DNR Jeremy Bates (Rapid Response Coordinator) 715-392-0807 **jeremy.bates@wisconsin.gov**

Pamela Toshner, Wisconsin DNR Regional Lakes Mgr. (715) 635-4073 pamela.toshner@wi.gov

Consultant/Diver Steve Schieffer 715-554-1168 ecointegservice@gmail.com

Appendix C
Aquatic Macrophyte Survey Point Intercept Methods

A point intercept method was employed for the aquatic macrophyte sampling. The Wisconsin Department of Natural Resources (Wisconsin DNR) generated the sampling point grids for each lake. All points were initially sampled for depth only. Once the maximum depth of plant growth was established, only sample points at that depth (or less) were sampled. If no plants were sampled, one sample point beyond that was sampled for plants. In areas such as bays that appear to be under-sampled, a boat or shoreline survey was conducted to record plants that may have otherwise been missed. The survey involved surveying that area for plants and recording the species viewed and/or sampled. The type of habitat is also recorded. These data are not used in the statistical analysis nor is the density recorded. Only plants sampled at predetermined sampled points were used in the statistical analysis. In addition, any plant within 6 feet of the boat was recorded as "viewed." A handheld Global Positioning System (GPS) located the sampling points in the field. The Wisconsin DNR guidelines for point location accuracy were followed with an 80 feet resolution window and the location arrow touching the point. A June survey was conducted to determine if *Potamogeton crispus* was present.

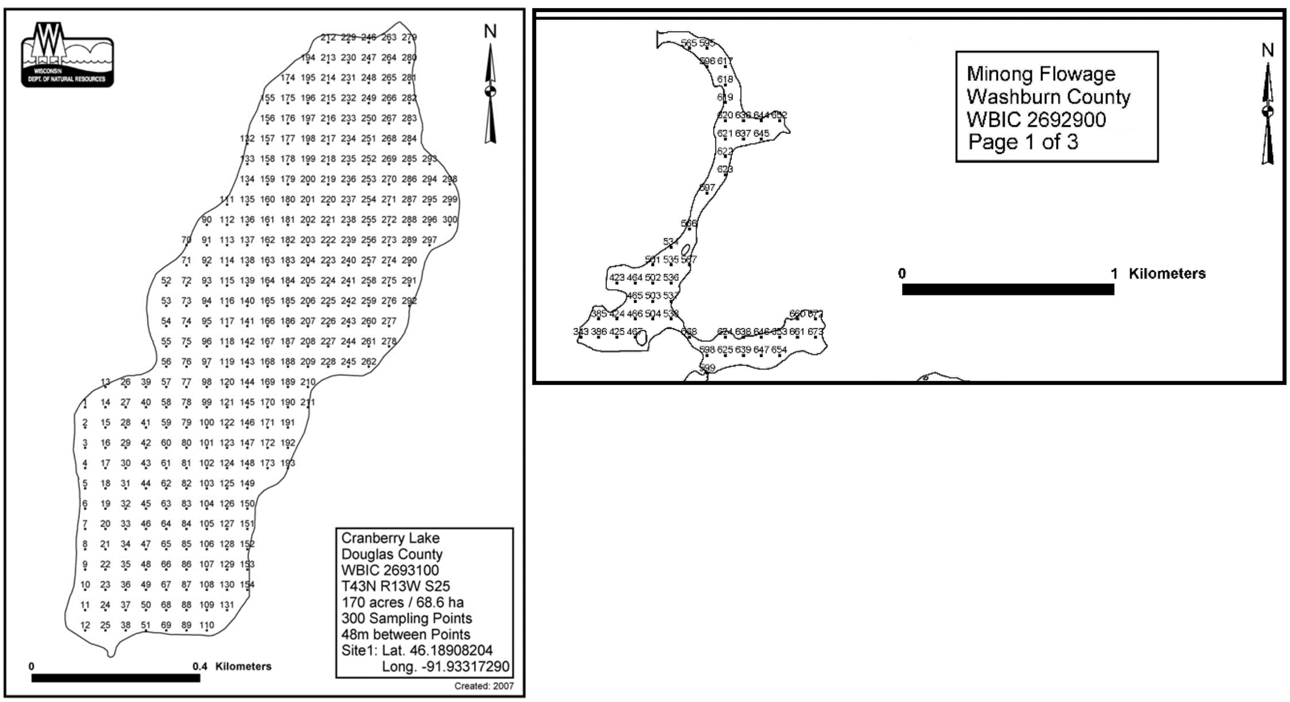
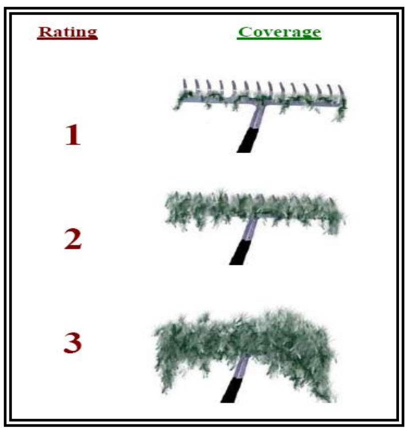


Figure 2: Point intercept sample grids for Cranberry Lake and management portion of Minong Flowage.

At each sample location, a double-sided fourteen-tine rake was used to rake a 1 meter tow off the bow of the boat. All plants present on the rake, and those that fell off the rake, were identified and rated for rake fullness. The rake fullness value was used based on the criteria contained in the diagram and table below. Those plants that were within 6 feet were recorded as "viewed," but no rake fullness rating was given. Any under-surveyed areas such as bays and/or areas with unique habitats were monitored. These areas are referred to as a "boat survey or shoreline survey."

The rake density criteria used:



Rake fullness rating	Criteria for rake fullness rating
1	Plant present, occupies less than ½ of tine space
2	Plant present, occupies more than ½ tine space
3	Plant present, occupies all or more than tine space
v	Plant not sampled but observed within 6 feet of boat

The depth and predominant sediment type were also recorded for each sample point. Caution must be used in determining the sediment type in deeper water as it is difficult to discern between muck and sand with a rope rake. All plants needing verification were bagged and cooled for later examination. Each species was mounted and pressed for a voucher collection and submitted to the Freckmann Herbarium (UW-Stevens Point) for review. On rare occasions, a single plant may be needed for verification not allowing it to be used as a voucher specimen and may be missing from the collection.

An early season, aquatic invasive species (AIS) (emphasis on *Potamogeton crispus*-curly leaf pondweed) survey is completed to pick up any potential growth before native plants are robust. Curly leaf pondweed grows in the spring only to senesce in early July before the main survey is typically conducted.

Data analysis methods

Data collected was entered into a spreadsheet for analysis. The following statistics were generated from the spreadsheet:

- Frequency of occurrence in sample points with vegetation (littoral zone)
- Relative frequency
- Total points in sample grid
- Total points sampled
- Sample points with vegetation
- Simpson's diversity index
- Maximum plant depth
- Species richness
- Floristic Quality Index

An explanation of each of these data is provided below.

Frequency of occurrence for each species- Frequency is expressed as a percentage by dividing the number of sites the plant is sampled by the total number of sites. There can be two values calculated for this. The first value is the percentage of all sample points that a particular plant was sampled at depths less then maximum depth plants (littoral zone) regardless if vegetation was present. The second is the percentage of sample points that a particular plant was sampled at only points containing vegetation. The first value shows how often the plant would be encountered in the defined littoral zone (by depth) while the second value shows how frequent the plant is where plants grow. In either case, the greater this value, the more frequent the plant is present in the lake. When comparing frequency in the littoral zone, observe the frequency of all points below maximum depth with plants. This frequency value allows the analysis of how common plants are and where they could grow based upon depth. When focusing only where plants are actually present, observe frequency at points in which plants were found. Frequency of occurrence is usually reported using sample points where vegetation was present.

> **Frequency of occurrence example**:
>
> Plant A sampled at 35 of 150 littoral points = 35/150 = 0.23 = 23%
> Plant A's frequency of occurrence = 23% considering littoral zone depths.
>
> Plant A sampled at 12 of 40 vegetated points = 12/40 = 0.3 = 30%
> Plant A's frequency of occurrence = 30% in vegetated areas.
>
> These two frequencies can tell us how common the plant was sampled in the littoral zone or how common the plant was sampled at points plants actually grow. Generally, the second will have a higher frequency since that is where plants are actually growing as opposed to where they could grow. This analysis will consider vegetated sites for frequency of occurrence only.

<u>Relative frequency</u>-This value, as a percentage, shows the frequency of a particular plant relative to other plants. This is not dependent on the number of points sampled. The relative frequency of all plants will add to 100%. This means that if plant A had a relative frequency of 30%, it occurred 30% of the time compared to all plants sampled or makes up 30% of all plants sampled. This value demonstrates which plants are the dominant species in the lake. The higher the relative frequency, the more common the plant is compared to the other plants and therefore, more frequent in the plant community.

Relative frequency example:

Suppose we were sampling 10 points in a very small lake and got the following results:

	Frequency sampled
Plant A present at 3 sites	3 of 10 sites
Plant B present at 5 sites	5 of 10 sites
Plant C present at 2 sites	2 of 10 sites
Plant D present at 6 sites	6 of 10 sites

Plant D is the most frequent sampled at all points with 60% (6/10) of the sites having plant D. However, the relative frequency demonstrates what the frequency is compared to the other plants without taking into account the number of sites. Relative frequency is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. Adding all frequencies (3+5+2+6) shows a sum of 16. Calculate the relative frequency by dividing by the individual frequency.

Plant A = 3/16 = 0.1875 or 18.75%
Plant B = 5/16 = 0.3125 or 31.25%
Plant C = 2/16 = 0.125 or 12.5%
Plant D = 6/16 = 0.375 or 37.5%

Comparing the plants to one another, Plant D is still the most frequent, but the relative frequency shows that of all plants sampled at those 10 sites, 37.5% of them are Plant D. This is much lower than the frequency of occurrence (60%), because although Plant D was sampled at 6 of 10 sites, many other plants were also sampled, thereby giving a lower frequency when compared to those other plants. This then gives a true measure of the dominant plants present.

Total points in sample grid- The Wisconsin DNR establishes a sample point grid that covers the entire lake. Each GPS coordinate is mapped and used to locate the points.

Sample sites less than maximum depth of plants-The maximum depth at which a plant is sampled is recorded. This defines the depth plants can grow (potential littoral zone). Any sample point with a depth less than, or equal to this depth, is recorded as a sample point less than the maximum depth of plants. This depth is used to determine the potential littoral zone and is referred to as the littoral zone.

Sample sites with vegetation- This is the number of sites where plants were actually sampled and gives a good projection of plant coverage on the lake. For example, having 10% of all sample points with vegetation implies about 10% coverage of plants in the whole lake assuming an adequate number of sample points have been established. Observe the number of sample sites with vegetation in the littoral zone. If 10% of the littoral zone had sample points with vegetation, then the plant coverage in the littoral zone would be estimated at 10%.

Simpson's diversity index-To measure the diversity of the plant community, Simpson's diversity index is calculated. This value can run from 0 to 1.0. The greater the value, the more diverse the plant community. In theory, the value is the chance that two species sampled are different. An index of "1" means that the two will always be different (very diverse) and a "0" would indicate that they will never be different (only one species found). The higher the diversity in the native plant community, the healthier the lake ecosystem.

Simpson's diversity example:

If a lake was sampled and found just one plant, the Simpson's diversity would be "0." This is because if two plants were randomly sampled, there would be a 0% chance of them being different, since there is only one plant.

If every plant sampled were different, then the Simpson's diversity would be "1." This is because if two plants were randomly sampled, there would be a 100% chance they would be different since every plant is different.

These are extreme and theoretical scenarios, but they demonstrate how this index works. The greater the Simpson's index is for a lake, the greater the diversity since it represents, and a greater chance of two randomly sampled plants being different.

Maximum depth of plants-This depth indicates the deepest that plants were sampled. Generally, more clear lakes have a greater depth of plants while lower water clarity limits light penetration and reduces the depth at which plants are found.

Species richness-The number of different individual species found in the lake. There is a number for the species richness of plants sampled and another number that takes into account plants viewed but not actually sampled during the survey.

Floristic Quality Index-The Floristic Quality Index (FQI) is an index developed by Dr. Stanley Nichols of the University of Wisconsin-Extension. This index is a measure of the plant community in response to development (and human influence) on the lake. It takes into account the species of aquatic plants sampled and their tolerance for changing water quality and habitat quality. The index uses a conservatism value assigned to various plants ranging from 1 to 10. A higher conservatism value indicates that a plant is intolerant while a lower value indicates tolerance. Those plants with higher values are more apt to respond adversely to water quality and habitat changes largely due to human influence (Nichols, 1999). The FQI is calculated using the number of species and the average conservatism value of all species used in the index.

The formula is: **FQI = Mean C ·√N**

Where C is the conservatism value and N is the number of species (only species sampled on rake).

Therefore, a higher FQI indicates a healthier aquatic plant community which is an indication of better plant habitat. This value can then be compared to the median for other lakes in the assigned eco-region. There are four eco-regions used throughout Wisconsin: Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area, and Southeastern Wisconsin Till Plain. The 2006 and 2008 values from past aquatic plant surveys will also be compared in this analysis.

Summary of Northern Lakes and Forests and Flowages Median Values for Floristic Quality Index:
(Nichols, 1999)

	Northern Lakes	Flowages
Median species richness	13	23.5
Median conservatism	6.7	6.2
Median Floristic Quality	24.3	28.3

*Floristic Quality has a significant correlation with area of lake (+), alkalinity(-), conductivity(-), pH(-) and Secchi depth(+). In a positive correlation, as that value increases, so will FQI, while with a negative correlation, as a value decreases, the FQI will decrease.

Appendix D

AQUATIC PLANT MANAGEMENT STRATEGY

Northern Region WDNR
Summer, 2007

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

ISSUES

- Protect desirable native aquatic plants.
- Reduce the risk that invasive species replace desirable native aquatic plants.
- Promote “whole lake” management plans.
- Limit the number of permits to control native aquatic plants.

BACKGROUND

As a general rule, the Northern Region has historically taken a protective approach to allow removal of native aquatic plants by harvesting or by chemical herbicide treatment. This approach has prevented lakes in the Northern Wisconsin from large-scale loss of native aquatic plants that represent naturally occurring high quality vegetation. Naturally occurring native plants provide a *diversity of habitat* that *helps maintain water quality*, helps *sustain the fishing* quality known for Northern Wisconsin, supports common lakeshore wildlife, from loons to frogs, and helps to provide the *aesthetics* that collectively create the “up-north” appeal of the northwoods lake resources.

In Northern Wisconsin lakes, an inventory of aquatic plants may often find 30 different species or more whereas a similar survey of a Southern Wisconsin lake may often discover less than half that many species. Historically, similar species diversity was present in Southern Wisconsin but has been lost gradually over time from stresses brought on by cultural land use changes (such as increased development, and intensive agriculture). Another point to note is that while there may be a greater variety of aquatic vegetation in Northern Wisconsin lakes, the vegetation itself is often *less dense*. This is because northern lakes have not suffered as greatly from nutrients and runoff as have many waters in Southern Wisconsin.

The newest threat to native plants in Northern Wisconsin is from invasive species of aquatic plants. The most common include Eurasian Water Milfoil (EWM) and Curly Leaf Pondweed (CLP). These species are described as *opportunistic invaders*. This means that these “invaders” benefit where an opening occurs from removal of plants, and without competition from other plants, may successfully become established in a lake. Removal of native vegetation not only diminishes the natural qualities of a lake, it *may increase the risk that an invasive species can successfully invade onto the site where native plants have been removed*. There, it may more easily establish itself without the native plants to compete against. This concept is easily observed on land where bared soil is quickly taken over by replacement species (often weeds) that crowd in and establish themselves as new occupants of the site. While not a providing a certain guarantee against invasive plants, protecting and allowing the native plants to remain may reduce the success of an invasive species becoming established on a lake. Once established, the invasive species cause far more inconvenience for all lake users, riparian and others included, can change many of the natural features of a lake and often lead to *expensive annual control plans*. Native vegetation may cause localized concerns to some users, but as a natural feature of lakes, they generally do not cause harm.

To the extent of maintaining the normal growth of native vegetation, Northern Wisconsin lakes can continue to offer the water resource appeal and benefits they have historically provided. A regional position on removal of aquatic plants that carefully recognizes how native aquatic plants benefit lakes in Northern Region can help prevent a gradual decline in the overall quality and recreational benefits that make these lakes attractive to people and still provide abundant fish, wildlife, and northwoods appeal.

GOALS OF STRATEGY:

1. Preserve native species diversity, which in turn, fosters natural habitat for fish and other aquatic species from frogs to birds.
2. Prevent openings for invasive species to become established in the absence of the native species.
3. Concentrate on a "whole-lake approach" for control of aquatic plants, thereby fostering systematic documentation of conditions and specific targeting of invasive species as they exist.
4. Prohibit removal of wild rice. WDNR – Northern Region will not issue permits to remove wild rice unless a request is subjected to the full consultation process via the Voigt Tribal Task Force. We intend to discourage applications for removal of this ecologically and culturally important native plant.
5. To be consistent with our WDNR Water Division Goals (work reduction/disinvestment) established in 2005, to "not issue permits for chemical or large-scale mechanical control of native aquatic plants – develop general permits as appropriate or inform applicants of exempted activities." This process is similar to work done in other WDNR Regions although not formalized as such.

BASIS OF STRATEGY IN STATE STATUTE AND ADMINISTRATIVE CODE

State Statute 23.24 (2)(c) states:

"The requirements promulgated under par. (a) 4. may specify any of the following:

1. The **quantity** of aquatic plants that may be managed under an aquatic plant management permit.
2. The **species** of aquatic plants that may be managed under an aquatic plant management permit.
3. The **areas** in which aquatic plants may be managed under an aquatic plant management permit.
4. The **methods** that may be used to manage aquatic plants under an aquatic plant management permit.
5. The **times** during which aquatic plants may be managed under an aquatic plant management permit.
6. The **allowable methods** for disposing or using aquatic

plants that are removed or controlled under an aquatic plant management permit.

7. The requirements for plans that the department may require under sub. (3) (b). "

State Statute 23.24(3)(b) states:
"The department may require that an application for an aquatic plant management permit contain a plan for the department's approval as to how the aquatic plants will be introduced, removed, or controlled."

Wisconsin Administrative Code NR 109.04(3)(a) states:
"The department may require that an application for an aquatic plant management permit contain an aquatic plant management plan that describes how the aquatic plants will be introduced, controlled, removed or disposed. Requirements for an aquatic plant management plan shall be made in writing stating the reason for the plan requirement. In deciding whether to require a plan, the department shall consider the potential for effects on protection and development of diverse and stable communities of native aquatic plants, for conflict with goals of other written ecological or lake management plans, for cumulative impacts and effect on the ecological values in the body of water, and the long-term sustainability of beneficial water use activities."

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

APPROACH

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

2. Control of aquatic plants (if allowed) in documented sensitive areas will follow the conditions specified in the report.

3. Invasive species must be controlled under an approved lake management plan with two exceptions (these exceptions are designed to allow sufficient time for lake associations to form and subsequently submit an approved lake management plan):
   a. Newly discovered infestations. If found on a lake with an approved lake management plan, the invasive species can be controlled via an amendment to the approved plan. If found on a lake without an approved management plan, the invasive species can be controlled under the WDNR's Rapid Response protocol (see definition), and the lake owners will be encouraged to form a lake association and subsequently submit a lake management plan for WNDR review and approval.
   b. Individuals holding past permits for control of *invasive* aquatic plants and/or "mixed stands" of native and invasive species will be allowed to treat via individual permit until January 1, 2009 if "impairment of navigation" and/or "nuisance conditions" is adequately documented; unless, there is an approved lake management plan for the lake in question.

4. Control of invasive species or "mixed stands" of invasive and native plants will follow current best management practices approved by the Department and contain an explanation of the strategy to be used. Established stands of invasive plants will generally use a control strategy based on Spring treatment (typically, a water temperature of less than 60 degrees Fahrenheit, or approximately May 31st, annually).

5. Manual removal (see attached definition) is allowed (Admin. Code NR 109.06).

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* *Exceptions to the Jan. 1, 2009 deadline will be considered only on a very limited basis and will be intended to address unique situations that do not fall within the intent of this approach.*

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

DOCUMENTATION OF IMPAIRED NAVIGATION AND/OR NUISANCE CONDITIONS

Navigation channels can be of two types:

- Common use navigation channel. This is a common navigation route for the general lake user. It often is offshore and connects areas that boaters commonly would navigate to or across and should be of public benefit.

- Individual riparian access lane. This is an access lane to shore that normally is used by an individual riparian shore owner.

Severe impairment or nuisance will generally mean vegetation grows thickly and forms mats on the water surface. Before issuance of a permit to use a regulated control method, a riparian will be asked to document the problem and show what efforts or adaptations have been made to use the site (which is currently required in NR 107 and on the application form, but the following helps provide a specific description of what impairments exist from native plants).

Documentation of *impairment of navigation* by native plants must include:

a. Specific locations of navigation routes (preferably with GPS coordinates).
b. Specific dimensions in length, width, and depth.
c. Specific times when plants cause the problem and how long the problem persists.
d. Adaptations or alternatives that have been considered by the lake shore user to avoid or lessen the problem.
e. The species of plant or plants creating the nuisance (documented with samples or a from a Site inspection).

Documentation of the *nuisance* must include:

a. Specific periods of time when plants cause the problem, e.g. when does the problem start and when does it go away.
b. Photos of the nuisance are encouraged to help show what uses are limited and the severity of the problem.
c. Examples of specific activities that would normally be done where native plants occur naturally on a site but cannot occur because native plants have become a nuisance.

AQUATIC PLANT MANAGEMENT STRATEGY
Northern Region WDNR

DEFINITIONS

Manual removal:	Removal by hand or hand-held devices without the use or aid of external or auxiliary power. Manual removal cannot exceed 30 feet in width and can only be done where the shore is being used for a dock or swim raft. The 30 foot-wide removal zone cannot be moved, relocated, or expanded with the intent to gradually increase the area of plants removed. Wild rice may not be removed under this waiver.
Native aquatic plants:	Aquatic plants that are indigenous to the waters of this state.
Invasive aquatic plants:	Non-indigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health.
Sensitive area:	Defined under s. NR 107.05(3)(i) (sensitive areas are areas of aquatic vegetation identified by the department as offering critical or unique fish and wildlife habitat, including seasonal or life stage requirements, or offering water quality or erosion control benefits to the body of water).
Rapid Response protocol:	This is an internal WDNR document designed to provide guidance for grants awarded under NR 198.30 (Early Detection and Rapid Response Projects). These projects are intended to control pioneer infestations of aquatic invasive species before they become established.

Appendix E

The Cranberry Lake and Flowage Association Newsletter, Spring 2019 v. 5

The Cranberry Lake and Flowage Association (CLFA) is committed to protecting our lake and your investments through the proactive management of Eurasian Water Milfoil and monitoring water quality in our lake.

In this Issue:

1) Welcome back to summer on the lake

2) Membership Update and Meeting Dates & Times

3) Eurasian Water Milfoil Removal Grant Information

4) Facebook

1) **Welcome back to summer on the lake.**
The ice is out, the docks are going in. Can boating, swimming, fishing and fun be far behind? The association has been working hard this winter to enhance the quality of our lake. There is a new kiosk at the landing with information about loon nests, invasive species, and more. Be sure to take a look. Thanks to Rick Haugen for all his hard work in making the kiosk and to Rick H., Rick Maas and Dave Olson for getting it in place.

2) **Membership Updates and Meeting Dates & Times:**
We now have 47 active members in the association. This number is down from past highs, but is higher than the last several years. Joining the association supports the efforts to protect our lake from further increases of invasive species and helps us raise money for EWM treatments, water quality testing, and upkeep of the information at the kiosk. Most importantly, it allows us better access to grants from the Wisconsin DNR as they look at association membership numbers when deciding which lakes get grant monies. Please join using the membership form that will soon be available on our facebook page or talk with one of the association members as they meet land-owners this spring and summer.

Meeting Dates & Times:
The association meets at the 4 Seasons Rec Club in Wascott (by the ballfields) on the third Saturday of the summer months (May through September). Our May meeting is from 8 a.m. to 9 a.m. The June and July meetings start at 9 a.m. and in August we have our annual meeting and picnic which starts at 11 a.m. The picnic will be held at the picnic shelter at the ball fields. The association provides the brats, buns, paper goods and cups. We ask that you bring a dish to share and your own beverages. More information will be available closer to the date of the picnic.

3) **Eurasian Water Milfoil Removal Grant Information**

Management of Eurasian Water Milfoil (EWM) continues to be the priority for the CLFA. This effort is a collaborative effort between the CLFA, Steve Schieffer (lake aquatic specialist who generously volunteers his expertise in mapping the EWM) and the DNR. Using primarily DNR grant money, we have been treating the lake's EWM invasive species for the past ten years with the chemical 2,4-D. We again treated in 2018 with the remainder of the 2016 DNR grant money.

This past winter an application to the DNR was successfully made to receive 15% of the 2016 grant; this $4119.88 will be used on an experimental May 2019 treatment using an alternative herbicide (diquat). A second application to the DNR was also successfully made to obtain an aquatic education prevention and planning (AEPP) grant. This $4388 grant will be used to fund Steve Schieffer to write an updated Cranberry Lake APMP (aquatic plant management plan) and PIS (point intercept survey) during the summer of 2019. With these current documents in hand we will again be able to apply next winter for new DNR AIS treatment grants.

4) **Facebook: Like us!**

The association has created a facebook page where we all can share information about the lake, learn about the activities of the association, join the association, and see what is going on around the lake and flowage.

You can find this page by entering "Cranberry lake and flowage association" in the search bar on facebook.

Alternatively, the direct URL is: https://www.facebook.com/pg/Cranberry-Lake-and-flowage-association-1097263360449645/posts/?ref=page_internal

Ultimately, we'd like to use this page as a communication tool for all the property owners in and around Cranberry and the flowage. We'll do our best to keep it updated with information not only about the association, but events and updates on the entire area.

PLEASE GO TO THE PAGE AND LIKE US AND FOLLOW US! Feel free to post pictures, comments or anything relevant to the page. This page is a learning experience for all of us. Our hope is that in time, this will be a valuable information resource for all property owners and friends.

Cranberry Lake & Flowage Association
Board Members:

President: Larry Carlson
cranbolson@gmail.com

Vice President: Stan Blom
cranbolson@gmail.com

Treasurer: Brad White
bwhite@nomadonline.com

Secretary: Marla Olson
cranbolson@gmail.com

Member at Large: Paul Seiferth
Plbtrmail@gmail.com

It was a beautiful winter at the lake, but we're ready for spring!

Appendix F

Cranberry Lake Flowage Association (CLFA) is a 501(c)3, non-profit organization. Membership dues and donations for CLFA are tax deductible and 100% dedicated to the preservation and protection of Cranberry Lake/Flowage. The primary emphasis of CLFA is costly treatments to control invasive Eurasian milfoil that crowds out native species, impacts boating and reduces property values. In addition, the association works to improve water quality and diminish the introduction of other invasive species, such as zebra mussels.

As a member, you will be helping to preserve and protect Cranberry Lake for future generations. Members will receive a plaque that can be hung on a dock or post to prominently display their support of Cranberry Lake. Please see the reverse side of this flyer for membership levels and rates.

If you have questions or comments, feel free to reach out to any of the CLFA board members identified in the newsletters. For immediate inquiries, please call Brad White, CLFA Treasurer, at 612-875-5521(cell).

gofundme

Support Cranberry Lake Flowage Association with your donations to our gofundme fundraising account.

Search gofundme.com by entering "CLFA" or go directly to our page at https://www.gofundme.com/6qaqyt .

Your support of Cranberry Lake Flowage Association is greatly appreciated.

Become a Member Today!

Name(s): ______________________________

Email: ______________________________

Note: email addresses help us reduce postal costs, send newsletters, and contact members about timely issues. We guard your email address very carefully and do not share our email list.

Address on the Lake:
Address: ______________________________
City/St/Zip: ______________________________
Phone: ______________________________

Primary residence (if different from Address on the Lake):
Address: ______________________________
City/St/Zip: ______________________________
Phone: ______________________________

Membership: ☐ New ☐ Renewal
Membership Level : ☐ CLFA Basic Member ☐ CLFA Supporter ☐ CLFA Sponsor — See descriptions on reverse side
Payment Information: ☐ Check enclosed ☐ PayPal

Memberships run from 5/1 to 4/30 each year. CLFA Tax ID#: 56-2594439

Membership Levels

	**CLFA Basic Member** Annual contribution of $25. You will receive a plaque that can be displayed on your dock or property.
	**CLFA Supporter** Suggested annual contribution of $100, plus $50 for each motorized watercraft you own. (i.e., Property $100 + Pontoon $50 + Wave runner $50 = $200) You will receive a plaque that can be displayed on your dock or property. For an additional $25, receive your name on the plaque, which is ***waived*** in 2019. Stars will be included with your name if you contribute more than the suggested annual amount.
	**CLFA Sponsor** For every $2 donated by a member, as a sponsor, you agree to match with an additional $1 contribution, up to an agreed upon amount. You will receive a plaque that includes your name and stars that can be displayed on your dock or property.

Signage and materials are provided courtesy of Nomad AV Systems to allow 100% of your support dollars to go toward the activities and mission of the CLFA.

Please return to:

Cranberry Lake Flowage Assn.
P.O. Box 74
Wascott, WI 54890

Appendix G: 2019 herbicide treatment analysis using diquat.

Abstract

The herbicide diquat was applied in seven *Myriophyllum spicatum*-Eurasian watermilfoil (EWM) beds on June 4, 2019 in Cranberry Lake, Douglas County Wisconsin. Comparing the frequency of occurrence (FOO) from the pretreatment survey in Sept. 2019 to the post treatment survey in August 2019 showed a statistically significant reduction in EWM (based on chi-square analysis). The FOO decreased from 88.1% to 13.6%. There was a statistically significant reduction in two native plant species out of 12 native species sampled (*Myriophyllum sibiricum* and *Elodea canadensis*). EWM bed mapping resulted in two beds of EWM that could be considered for 2020 management. The two beds totaled 2.53 acres.

Introduction

On June 4, 2019 the herbicide diquat was applied to seven EWM beds on Cranberry Lake, Douglas County Wisconsin. The beds totaled 9.7 acres, with beds ranging in size from 0.3 to 3.5 acres. Figure 1 shows the locations of the EWM beds and table 1 summarizes the bed parameters as well as conditions at time of treatment.

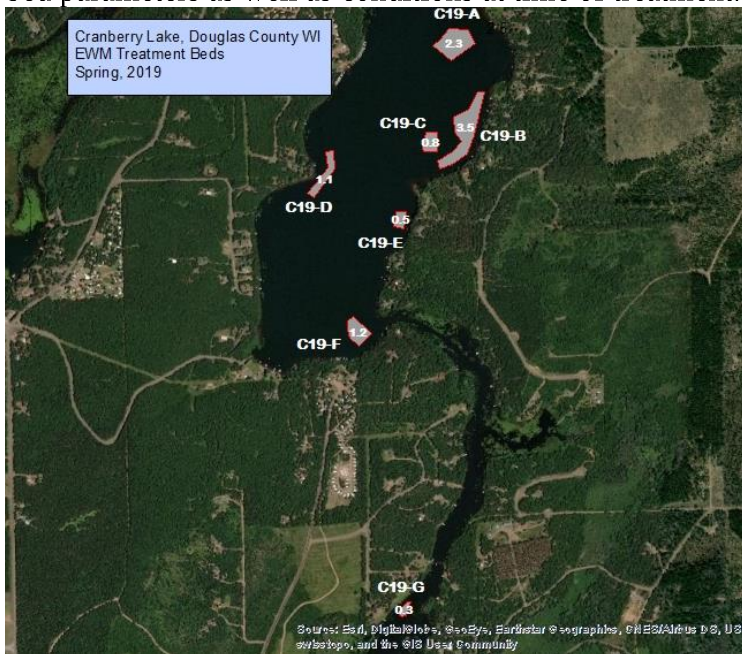


Figure 1: Herbicide treatment beds, Cranberry Lake and Flowage 2019.

Bed	Area	Mean Depth	Acre-feet	Water temp	Wind(mph) /dir
C19-A	2.3	6	13.8	63	3-5/S
C19-B	3.5	5.3	18.55	63	3-5/S
C19-C	0.8	6.6	5.28	63	3-5/S
C19-D	1.1	7.2	7.92	63	3-5/S
C19-E	0.5	5.9	2.95	63	3-5/S
C19-F	1.2	6.9	8.28	63	3-5/S
C19-G	0.3	4.6	1.38	63	3-5/S
Total	**9.7**		**58.16**	**63**	3-5/S

Table 1: Treatment bed data, Cranberry Lake 2019.

Methods

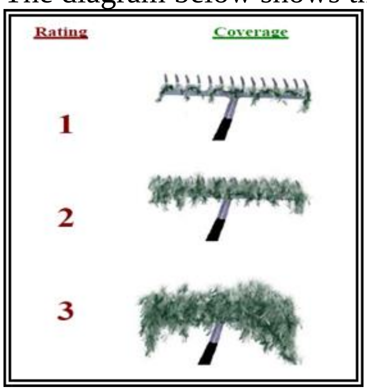
The beds of EWM were delineated in Sept. 2018. The sample grid was created within the beds and the presence and density of EWM was recorded in the pretreatment survey. Native plants were also recorded in regard to presence and density within all EWM beds. This was used as the pretreatment survey.

In May 2019, the EWM were checked to verify EWM growth and presence. This is not a pretreatment survey, but is verification to check bed borders and to evaluate growth to communicate timing with the herbicide applicator.

Several weeks after application, the EWM beds were surveyed again. Waiting allows for an evaluation that EWM has been reduced. If they EWM is not killed, there is time for it to regrow to better determine density and frequency. The native plants also have time to rebound if adversely affected by the herbicide. The density of EWM and native plants were recorded at the same sample points used in the pretreatment survey.

The frequency of occurrence (FOO) is determined within the EWM treatment beds for both EWM and native plants. The FOO is used to evaluate any reductions using a chi-square analysis. The lower the p-value (when less than 0.05), the more statistically significant the reduction is and likely due to herbicide application.

The diagram below shows the criteria for density determination:



Results

In comparing the pretreatment frequency with the post treatment survey frequency, the herbicide treatment was successful in 2019 at reducing the frequency of EWM. The reduction was statistically significant according to a chi-square analysis (p= 1.1 X 10^{-16}). Figure 2 shows the maps before and after treatment occurred.

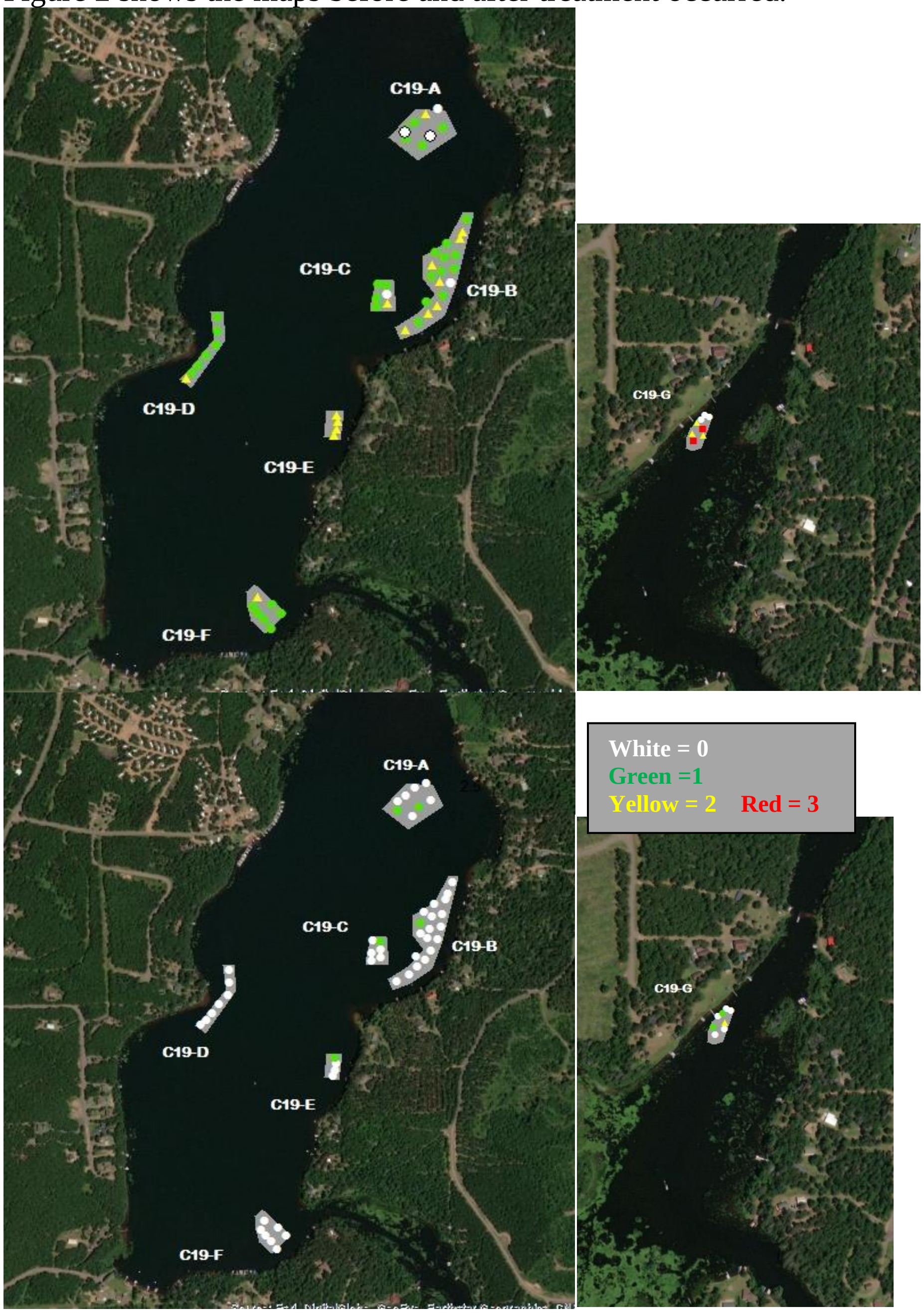


Figure 2: Before and after treatment EWM density at sample points within treatment beds.

Table 2 shows the frequency of EWM within each bed and all beds combined from the pretreatment and post treatment surveys. Figure 3 graphically compares the frequency of occurrence before and after treatment.

Bed	Pre treat EWM FOO	Post treat EWM FOO	Reduction	
A	71.4	28.6	yes	
B	94.4	5.6	Yes	
C	83.3	16.7	Yes	
D	100.0	0.0	Yes	
E	100.0	25.0	Yes	
F	100.0	0.0	Yes	
G	62.5	37.5	Yes	
ALL BEDS	88.1	13.6	Yes (significant)	$P=1.1X10^{-16}$

Table 2: Frequency of occurrence for EWM before and after treatment with diquat.

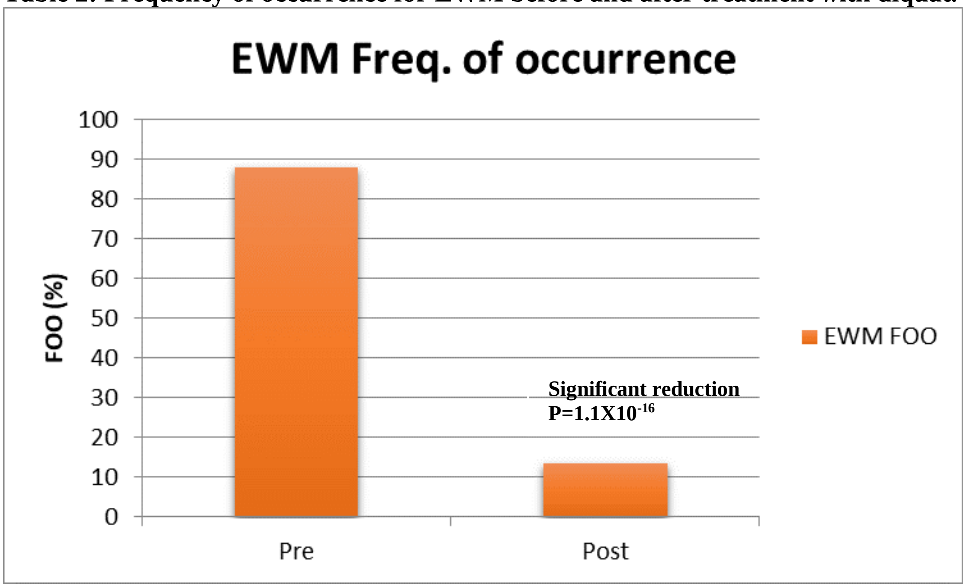


Figure 3: Graph showing the frequency change after treatment, Cranberry Lake 2019.

Native species evaluation

For an herbicide application to be deemed fully successful, the native plants within the treatment beds should not be adversely affected. The frequency of occurrence for each native species found within the treatment beds was analyzed using a chi-square analysis. The desire is for there to be no reductions that are statistically significant. There were two native plants with statistically significant reduction in frequency. These two plants were *Elodea canadensis* and *Myriophyllum sibiricum*. This is not a desirable outcome. Diquat is a broad-spectrum herbicide, so any growing plants contacted by this herbicide are susceptible to the herbicide. Table 3 summarizes the FOO for the native species and table 4 has the chi-square analysis results. There were 12 native species sampled and the other 10 were not adversely affected by the herbicide.

Native Species	**Pre Sept. 2018**	**Post August 2019**	**Change**	**Significant reduction**
Potamogeton robbinsii	0.66	0.76	+	No
Potamogeton amplifolius	0.50	0.41	-	No
Vallisneria americana	0.61	0.43	-	No
Elodea canadensis	0.56	0.06	-	**Yes**
Chara sp.	0.06	0.22	+	No
Ceratopyllum demersum	0.33	0.15	-	No
Myriophyllum sibiricum	0.28	0.00	-	**Yes**
Najas flexilis	0.11	0.11	**n/c**	No
Potamogeton pusillus	0.06	0.04	-	No
Potamogeton gramineus	0.06	0.04	-	No
Elodea nutalli	0.06	0.04	-	No
Najas gracillima	0.00	0.02	+	No
Nymphaea odorata	0.00	0.02	+	No

Table 3: Native species frequency of occurrence before and after treatment.

Native Species Reduction (12 native species sampled)	FOO Pre	FOO Post	Significant reduction p value
***Elodea canadensis*-common waterweed**	55.6	6.0	P =1.8 X 10^{-6}
***Myriophyllum sibiricum*-northern water milfoil**	27.8	0.0	P=6.0 X 10^{-5}

Table 4: Native species with statistically significant reduction after treatment 2019.

There were 12 native species sampled in the pretreatment survey and 11 sampled in post-treatment survey.

After the post treatment survey, the EWM was evaluated in Cranberry Lake. The observations were used to bed map the EWM. Figure 4 shows the beds present for potential management in 2020.

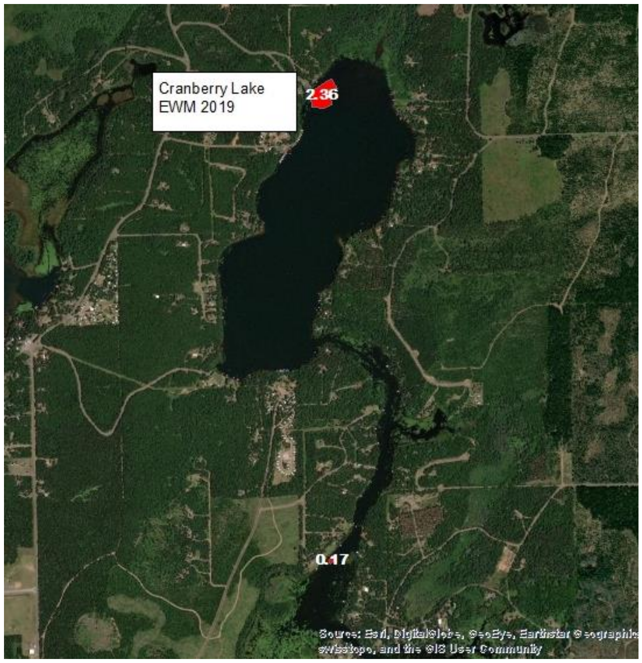


Figure 4: Bed map from EWM evaluation in August, 2019.

The 2.36 acre bed in the main lake is likely large enough to use 2,4-D. Diquat appears to have reduced two native species and may not be warranted for use in larger beds of EWM. Another option is the relatively new herbicide ProcellaCOR, which has been found to be effective on large and small beds. The bed in the flowage (0.17 acres) is likely too small for 2,4-D, so an alternative would be recommended for this bed (or handpulling). There is some boat traffic near this bed so it should be managed.