Aquatic Plant Management Plan

Connors Lake, Lake of the Pines, and Papoose Lake
Sawyer County Wisconsin

June 2017

Sponsored By:
Co/Pa/Pi Voluntary Lake Association

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Ecological Integrity Service

Funded By:
Co/Pa/Pi Voluntary Lake Association
A Wisconsin Department of Natural Resources Grant

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Introduction

This Aquatic Plant Management Plan for Connors Lake, Lake of the Pines, and Papoose Lake in Sawyer County Wisconsin presents a strategy for managing aquatic plants by protecting native plant populations, controlling the growth of Eurasian water milfoil (EWM), and preventing establishment of additional invasive species. The plan includes data about the plant community, watershed, and water quality of the lakes. Based on this data and public input, goals and strategies for the management of aquatic plants in the lake are presented. This plan will guide the Co/Pa/Pi Voluntary Lake Association and the Wisconsin Department of Natural Resources in aquatic plant management for the lakes over the next five years (from 2017 through 2021).

Public Input for Development

The Co/Pa/Pi Voluntary Lake Association Aquatic Plant Management Committee provided input for the development of the original aquatic plant management plan in 2007. The 2017 update was drafted by board representatives and consultants with guidance from WDNR, then reviewed by the full Co/Pa/Pi board and released for public review prior to the July 2017 membership meeting. No comments were received from the public, although the current herbicide applicator did express disagreement with the proposed strategy.

Lake Management Concerns

The 2007 APM Committee expressed a variety of concerns that are reflected goals and objectives for aquatic plant management in this plan. Aquatic plant management concerns include the following:

- Best treatment methods for Eurasian water milfoil in Connors Lake
- Preventing establishment of Eurasian water milfoil in Lake of the Pines
- Protecting existing native plants for various reasons
    - Preventing shoreline erosion
    - Maintaining/improving fishery
    - Preventing spread of invasive species
- Need for resident and lake user education

Other identified concerns were listed but deferred to a comprehensive lake management planning process in the future. These include:

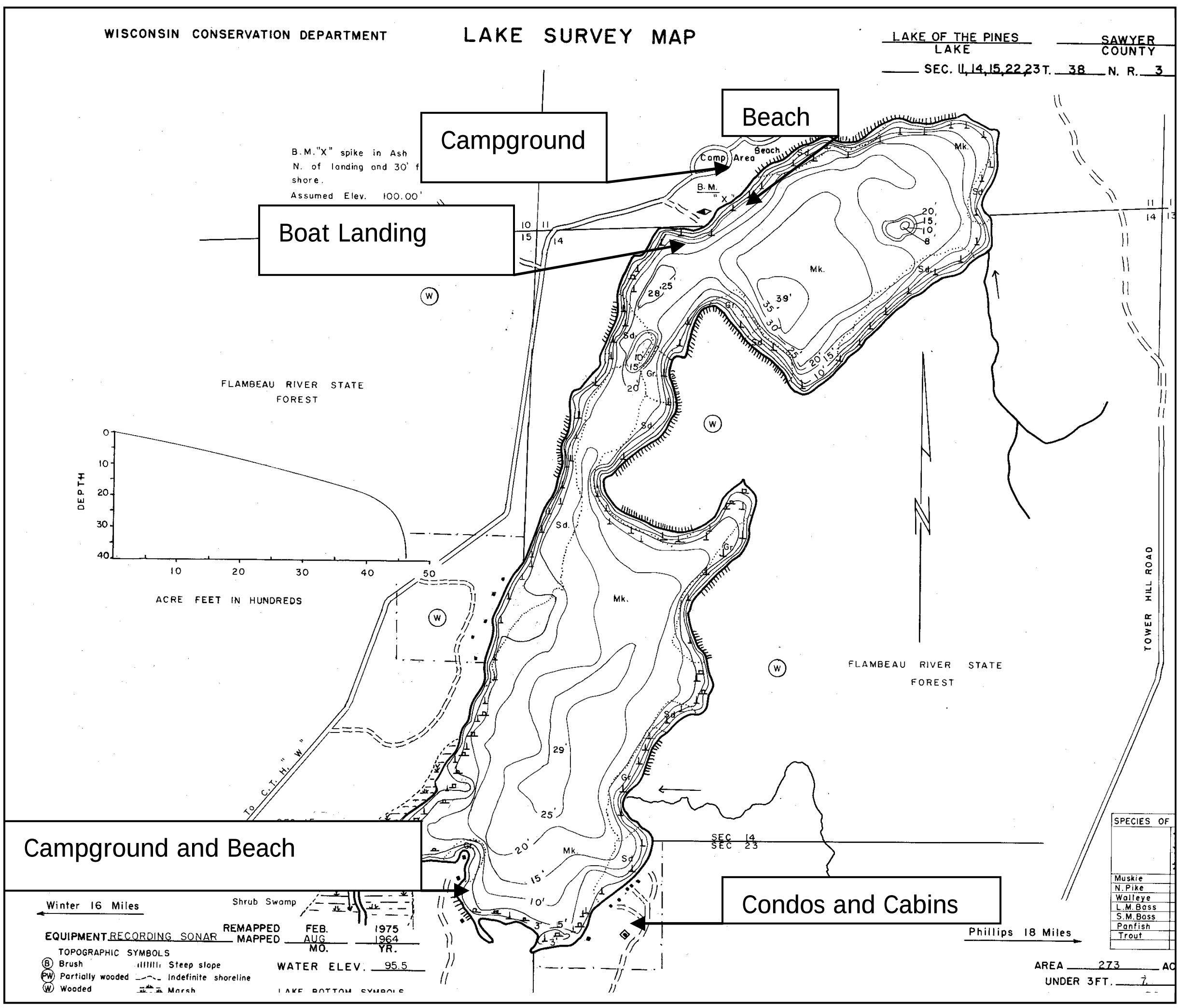
- Water levels
- Fisheries
- Loading from septic systems
- Encouraging lake association membership

Lake Information[2]

Lake of the Pines is a 273-acre deep lowland lake with a water body identification code of 2275300. The maximum depth is 39 feet. Lake of the Pines is a drainage lake with unnamed tributaries flowing into the lake and Connors Creek flowing from the lake to Connors Lake. Lake of the Pines is shown as Figure 1.

Connors Lake is a 429-acre deep lowland lake. Its water body identification code is 2275100. The maximum depth is 82 feet. Connors Lake is a drainage lake with Connors Creek flowing both into the lake, from Lake of the Pines, and out of the lake at the south end of Connors Lake. A two-foot rock roller dam is located on the outlet. Connors Lake and Papoose Lake are shown in Figure 2. Papoose Lake is a 2.9-acre widening of Connors Creek found between the two lakes. It has a maximum depth of 14 feet.

The lakes are located in Sawyer County in the Town of Winter (T38N, R03W). Connors Lake is in Section 28. Lake of the Pines is in Section 22.



[2] From Wisconsin DNR Lakes Pages http://dnr.wi.gov/water

Figure 1. Map of Lake of the Pines

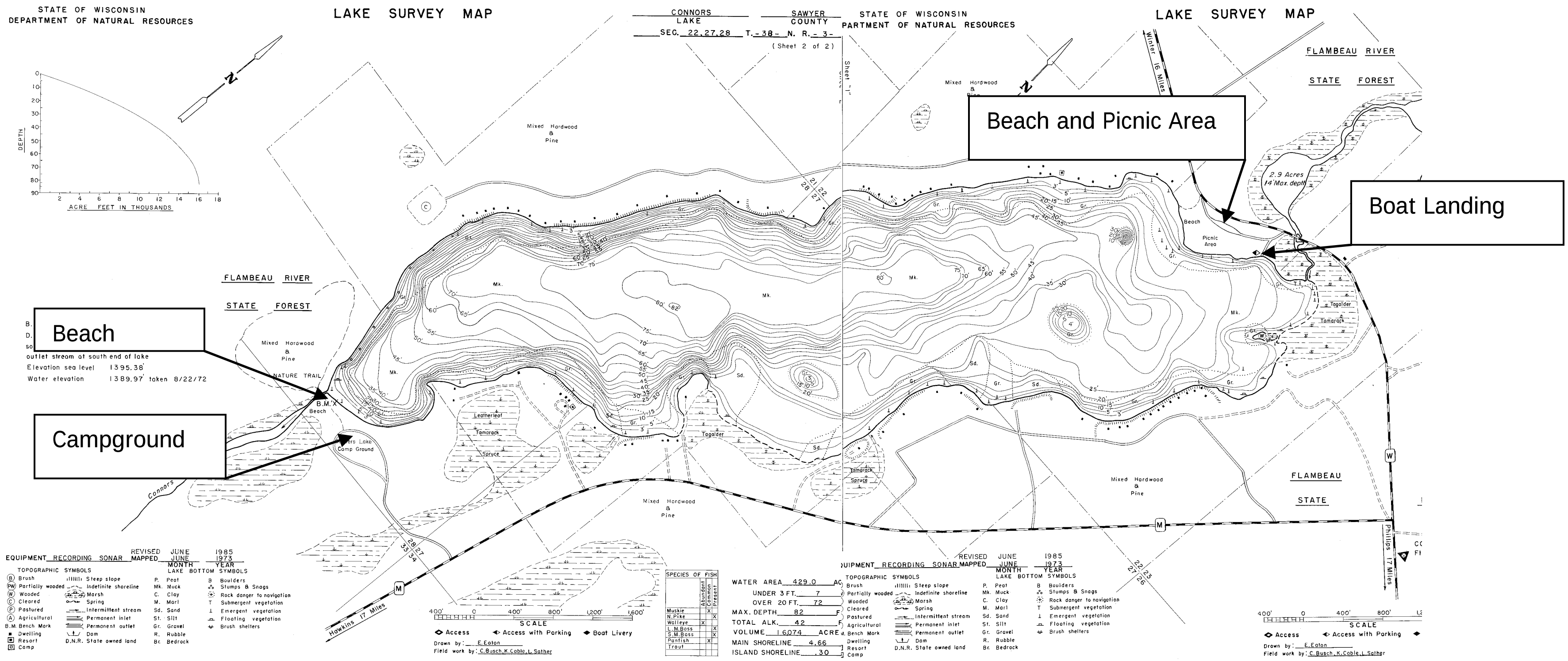


Figure 2. Map of Connors Lake and Papoose Lake

Water Quality

Water quality is frequently reported by the trophic state or nutrient level of the lake. Nutrient rich lakes are classified as eutrophic. These lakes tend to have abundant aquatic plant growth and low water clarity due to algae blooms. Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms. Oligotrophic lakes are nutrient poor with little growth of plants and algae.

Secchi depth readings are one way to assess the trophic status of a lake. The Secchi depth reported is the depth at which the black and white Secchi disk is no longer visible when it is lowered into the water. Greater Secchi depths occur with greater water clarity. It is important to note that factors other than nutrient status (such as tannins in the water) may reduce water clarity and influence Secchi depth results.

Secchi depth readings, phosphorus concentrations, and chlorophyll measurements can each be used to calculate a Trophic State Index (TSI) for lakes.[3] TSI values range from 0 – 110. TSI values from 40 to 50 characterize mesotrophic lakes. Lakes with TSI values greater than 50 are considered eutrophic, and lakes with TSI values below 40 are considered oligotrophic.

Volunteers have monitored Lake of the Pines water quality through the WDNR Citizen's Lake Monitoring Program since 2010.[4] Lake of the Pines is a mesotrophic to eutrophic lake as shown in Figure 3 below. Water quality measures from 2016 are shown in Table 1.

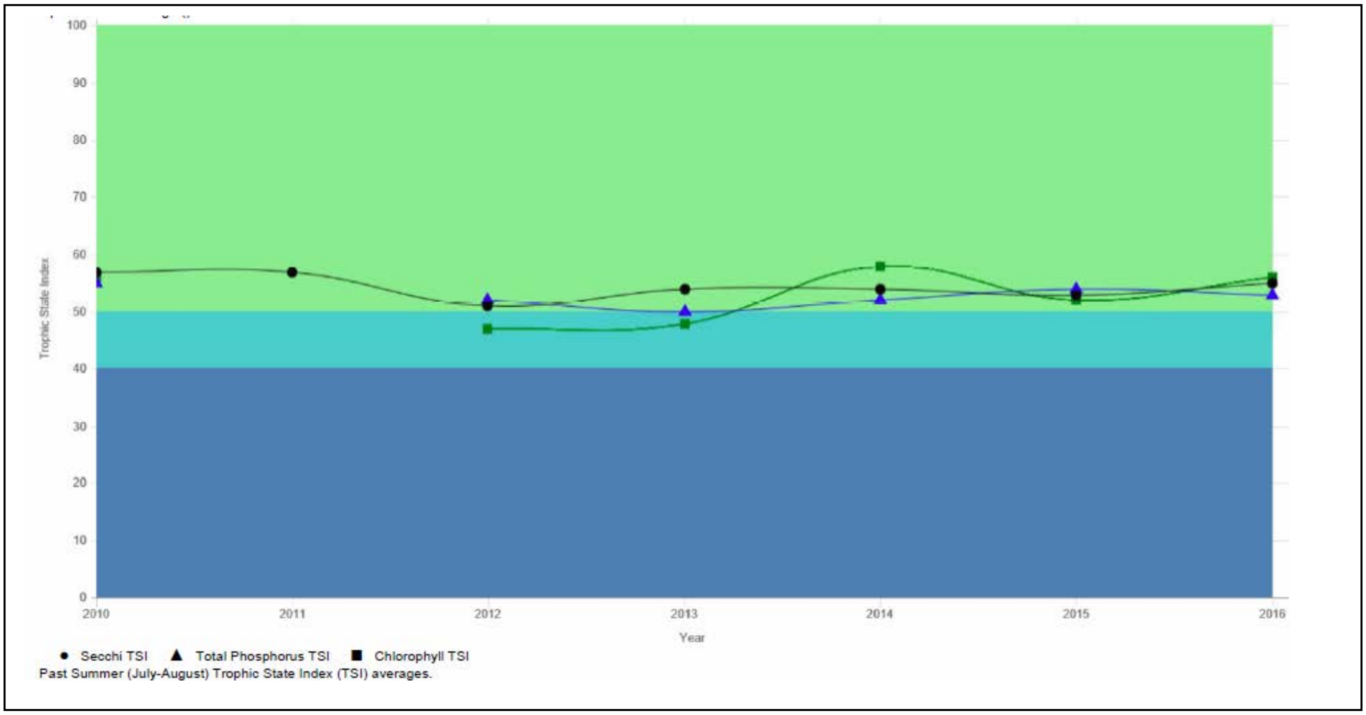


Figure 3. Lake of the Pines Trophic State Index 2010-2016

[3] TSI = 60 – 14.41 (ln * Sechhi depth in meters)
[4] Monitoring results are taken from WDNR Citizen Lake Monitoring data at http://dnr.wi.gov/lakes/CLMN/

Table 1. 2016 July/August Water Quality Data

	Lake of the Pines	Connors Lake
Secchi Depth (ft.)	4.5	9.5
Total Phosphorus (ppb)	23.6	21.7
Chlorophyll A (ppb)	17.25	7.3

Volunteers have monitored Connors Lake consistently since 2007. Connors Lake is generally mesotrophic as measured by TSI values for Secchi depth, Chlorophyll A, and total phosphorus shown in Figure 4. Water quality data from July and August 2016 is summarized in Table 1.

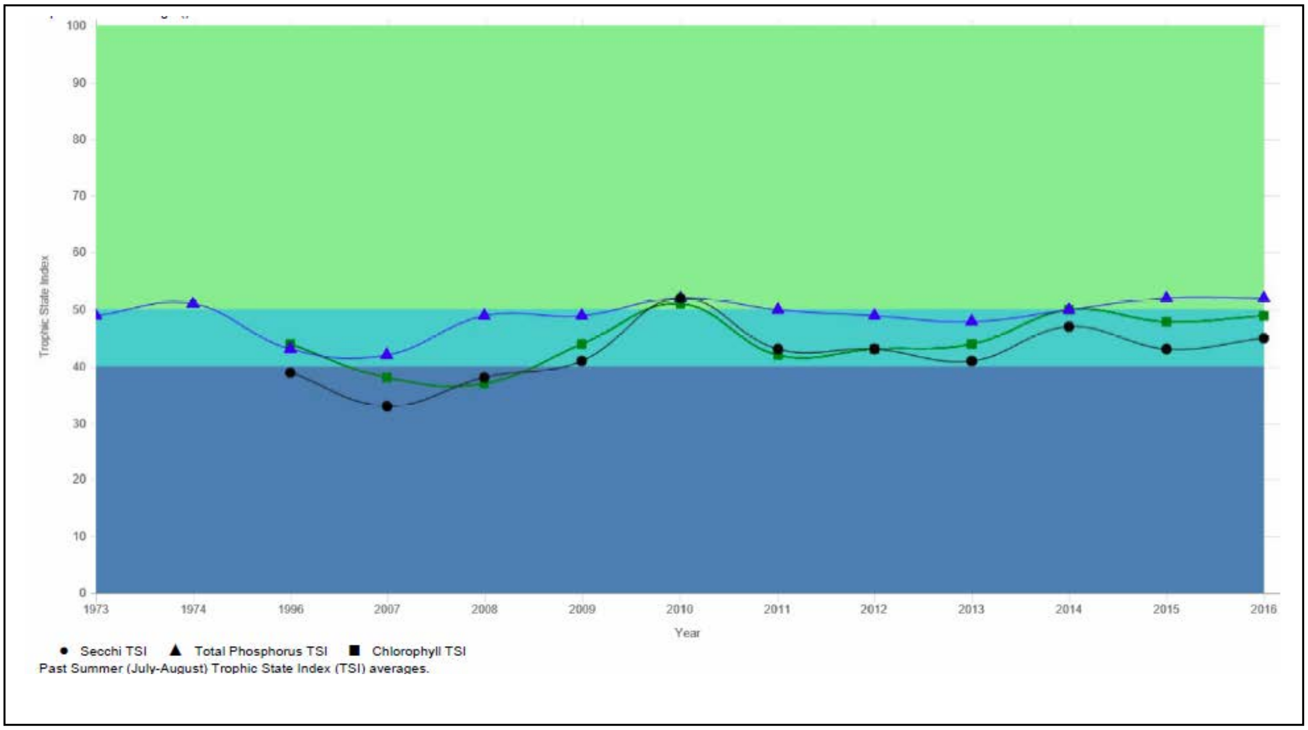


Figure 4. Connors Lake Trophic State Index through 2016

Volunteers also take profile measurements of temperature and dissolved oxygen at the deep hole of each lake as part of the Citizen Lake Monitoring Program. Lake of the Pines generally stratifies with oxygen levels below 1 mg/L at the lake bottom from about mid-June through at least late August. Oxygen levels go below 1 mg/L a bit later on Connors Lake beginning somewhere from mid-June to early August. None of the records which run through mid to late September indicate that fall mixing has occurred on either lake by that time.

Watershed

The lakes' watershed is part of the Lower North Fork of the Flambeau River watershed (Watershed Identification Key UC11) in the Upper Chippewa River Basin. The lakes' watershed area is illustrated in Figure 6.[5] The watershed (or drainage area) of the lakes is approximately nine square miles. The watershed of these lakes is mostly forested with some waterfront development. Land cover area is illustrated in Figure 5. There are a total of only about 80 cabins around both lakes with most on Connors Lake. The watershed forest includes the Flambeau River State Forest.

Phosphorus from Watershed Runoff

Phosphorus is the pollutant that most influences the clarity of the lakes because it is the limited ingredient for algae growth.[6] Phosphorus is found dissolved in runoff water and carried in soil particles that erode from bare soil.

Phosphorus runoff from the watershed is determined by how land is used in the lakes' watershed along with watershed soils and topography. When a watershed is maintained in natural vegetation, there is less runoff of pollutants that impact the lake. Agricultural and residential lands tend to contribute greater amounts of phosphorus in runoff than undeveloped lands. Soil erosion is reduced when there is good vegetative cover. Water flow is slowed by tall vegetation, and forest groundcovers and fallen leaves allow runoff water to soak into the ground. In summary, anything that reduces soil erosion and/or the amount of runoff water flowing from a portion of the watershed reduces pollution to the lake.

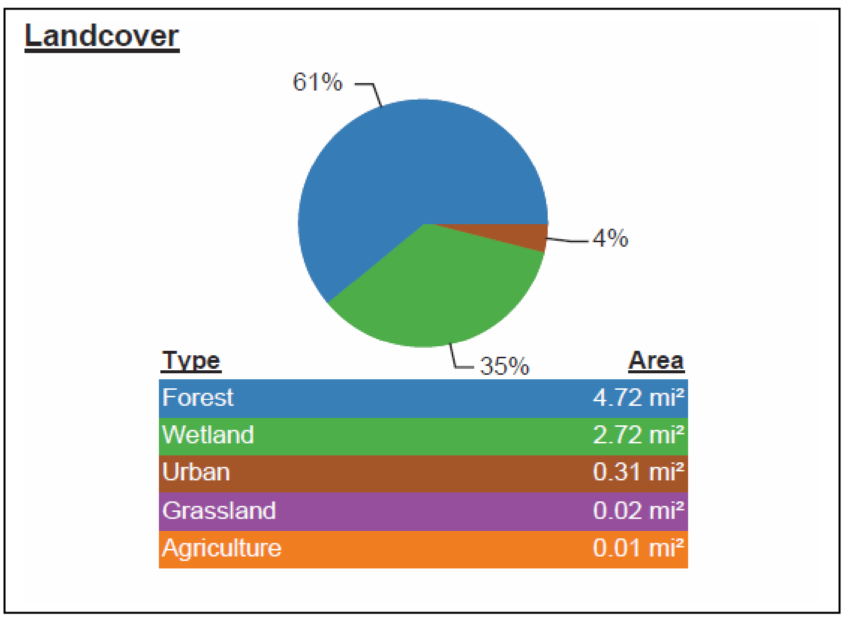


Figure 5. Landcover of the Lakes Watershed

[5] Watershed delineated with WDNR Prestolite tool http://dnr.wi.gov/topic/SurfaceWater/PRESTO.html

[6] Based on data from 1996 sample results (nitrogen and phosphorus ratio) for both lakes.

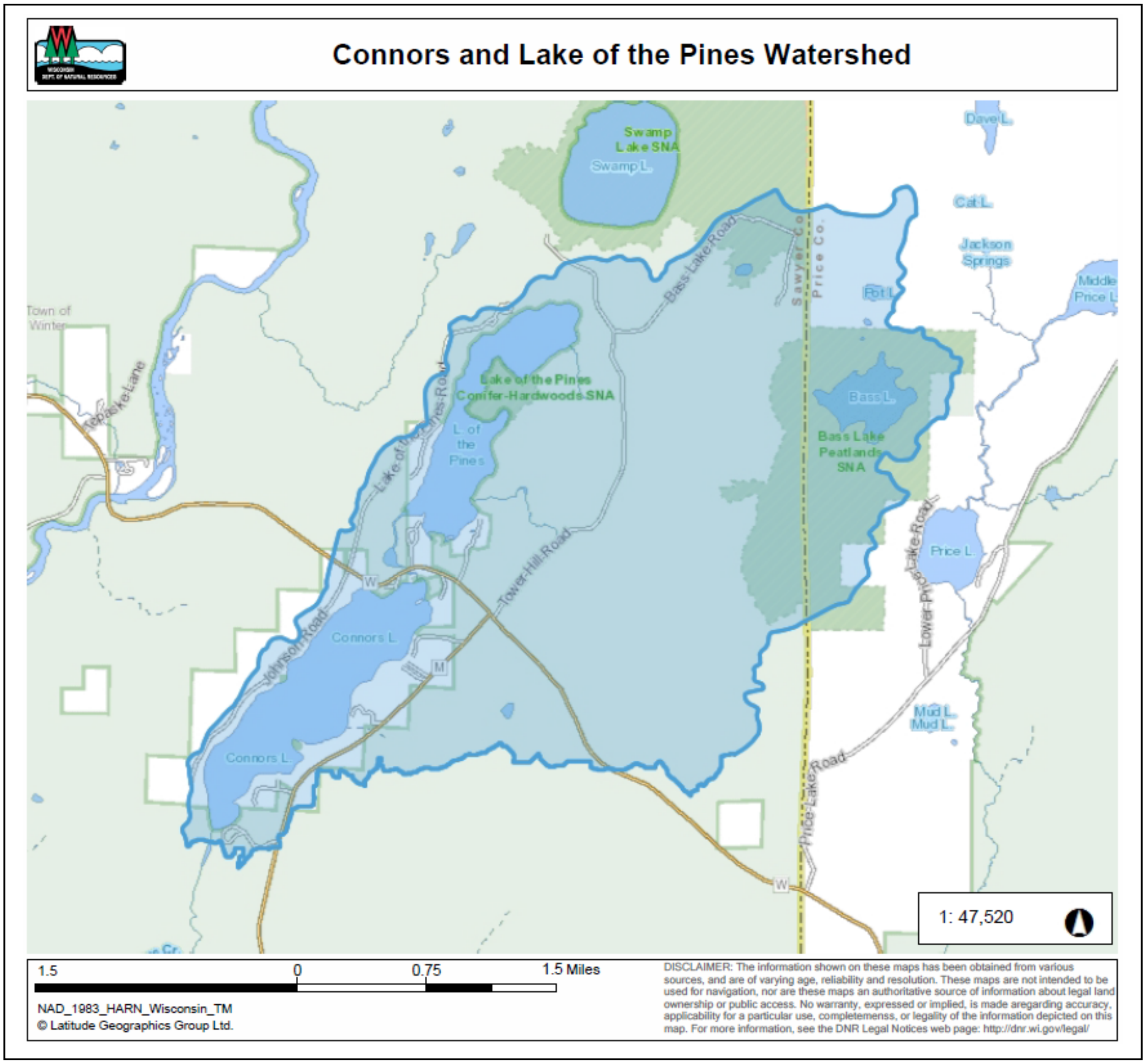


Figure 6. Connors Lake and Lake of the Pines Watershed

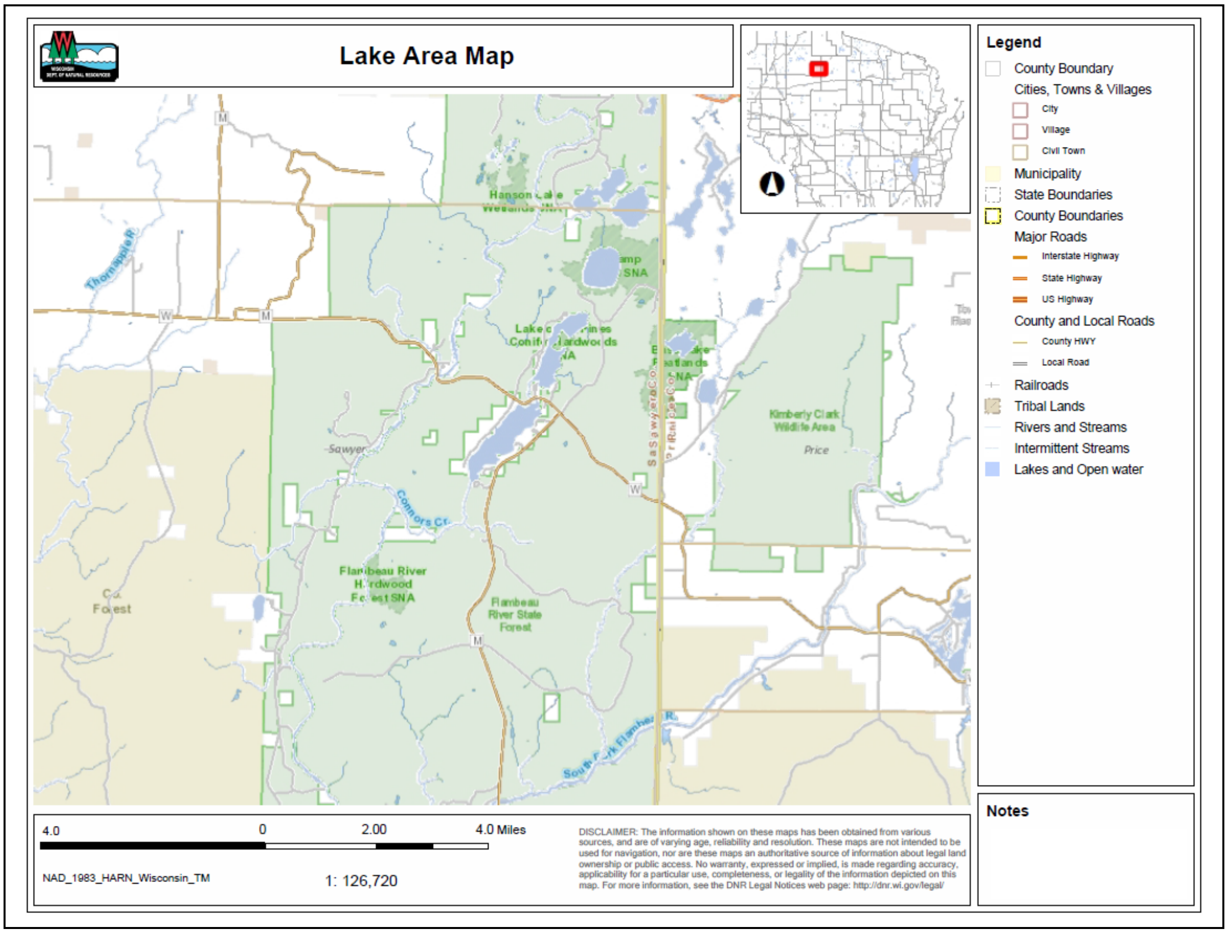


Figure 7. Lake Area Map

Aquatic Use and Habitat

Primary Human Use Areas

The lakes are located within the heart of the Flambeau River State Forest. The Flambeau River State Forest has two major campgrounds, each with a public swimming beach, one on Connors Lake and the other on Lake of the Pines. The state forest also has a picnic area and swimming beach on the northern end of Connors Lake, and public boat access points provide day use at both Lake of the Pines and Connors Lake.

Nearby Water Bodies with EWM Present

The control of Eurasian water milfoil in Connors Lake is critical because of the high use and recreational value of Connors Lake and connected Lake of the Pines. EWM control is also important because these waters flow directly to the Flambeau River and to several impoundments downstream. All of these areas are integral parts of the state forest, and further spread of Eurasian water milfoil in this water system is of great concern to the Flambeau River State Forest management staff. Several water bodies in Sawyer County and Price County already have EWM present.

Table 2. Sawyer Lakes with EWM Present[7]

Waterbody Name	Year Discovered
Callahan Lake	2005
Chippewa Lake (Above CTH B)	2006
Clear Lake	1999
Lake Chippewa (Chippewa Fl.)	1991
Lake Hayward	2011
Little Lac Courte Oreilles	2015
Little Round Lake	1998
Lost Land Lake	2013
Mud Lake	2005
North Fork Chief River	2006
Osprey Lake	2005
Radisson Flowage	2003
Round Lake	1993
Tiger Cat Flowage	2013
Whitefish Lake	2008

[7] Information from WDNR web pages (04/11/2017)
http://dnr.wi.gov/lakes/invasives/AISLists.aspx?species=EWM&location=58

Table 3. Price County Lakes with EWM Present[8]

Waterbody Name	Year Discovered
Duroy Lake	2000
Elk Lake	2002
Grassy Lake	2002
Lac Sault Dore	2004
Long Lake	2002
Wilson Lake	2002

[8] Information from WDNR web pages (04/11/2017) http://dnr.wi.gov/lakes/invasives/AISLists.aspx?species=EWM&location=51

Functions and Values of Native Aquatic Plants

Naturally occurring native plants are extremely beneficial to the lake. They provide a diversity of habitats, help maintain water quality, sustain fish populations, and support common lakeshore wildlife such as loons and frogs.

Water Quality

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. Emergent and floating plants are quite common in Lake of the Pines.

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.[9]

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. This means that 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 it 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.[10]

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

Habitat Areas

The Department of Natural Resources designates *critical habitat areas* that include both *sensitive areas* and *public rights features*. Critical habitat areas have not been designated or proposed for project lakes. While Connors Lake was ranked third on a list for completion of a critical habitat designation in Sawyer County in 2008, new designations have not been initiated since 2011.

The c*ritical habitat area* designation provides a holistic approach to ecosystem assessment and protection of those areas within a lake that are most important for preserving the character and qualities of the lake. These sites are those sensitive and fragile areas that support wildlife and fish habitat, provide the mechanisms that protect the water quality in the lake, harbor quality plant communities, and preserve the places of serenity and aesthetic beauty for the enjoyment of lake residents and visitors.

Critical habitat areas include *sensitive areas* that offer critical or unique fish and wildlife habitat, including seasonal or life stage requirements, or offer water quality or erosion control benefits to the area (Administrative code 107.05(3)(1)(1)). The Wisconsin Department of Natural Resources is given the authority for the identification and protection of sensitive areas of the lake in this code. *Public rights features* are areas that fulfill the right of the public for navigation, quality and quantity of water, fishing, swimming, or natural scenic beauty. Protecting these *critical habitat areas* requires the protection of shoreline and in-lake habitat.

Rare and Endangered Species Habitat[11]

The lakes are located in T38N, R03W. The Wisconsin Natural Heritage Inventory lists the species listed in Table 4 for this town. Bald eagles are not represented, and sensitive species have been removed. The listing does not provide enough detail to know if these species are found on the lakes themselves.

Table 4. Rare and Endangered Species

Scientific Name	Common Name	State Status[12]
DENDROICA CERULEA	CERULEAN WARBLER	THR
BUTEO LINEATUS	RED-SHOULDERED HAWK	THR
FALCIPENNIS CANADENSIS	SPRUCE GROUSE	THR
GLYPTEMYS INSCULPTA	WOOD TURTLE	THR
LITTORELLA UNIFLORA	AMERICAN SHOREWEED	SC

[11] http://dnr.wi.gov/topic/NHI/Data.asp Data current as of May 2016
[12] THR = Threatened, SC = Special Concern

The following communities are also listed in the database for T38N, R03W:
BLACK SPRUCE SWAMP
EMPHEMERAL POND
NORTHERN MESIC FOREST
FORESTED SEEP
LAKE--SHALLOW; SOFT; SEEPAGE
NORTHERN WET-MESIC FOREST
MUSKEG
POOR FEN
NORTHERN TAMARACK SWAMP

Fishery

The Wisconsin Lakes book indicates that largemouth bass, panfish, and muskellunge are present in the lakes with relative abundance shown in Table 5. The current plant community is supporting a desirable fishery. Negative changes to the plant community could adversely impact the fish population. The fish present in the lakes depend upon aquatic vegetation for their survival. Stands of aquatic plants provide cover from predatory fish as well as forage areas for fish to feed on small organisms.

Table 5. Fish Species of Connors Lake and Lake of the Pines

Common Name	**Scientific Name**	**Connors Lake Abundance**	**Lake of the Pines Abundance**
Largemouth bass	*Micropterus salmoides*	Present	Common
Smallmouth bass	*Micropterus dolomieu*	Common	Not mentioned
Panfish	*various*	Common	Common
Muskellunge	*Esox masquinongy*	Common	Present
Walleye	*Sander vitreus vitreus*	Abundant	Common

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 perhaps be reconsidered.(DeQuattro and Karasov, 2015). Musky could have newly distributed eggs during an early season EWM treatment, so caution regarding repeated use may be warranted.

Fish Management

The DNR stocks muskies at a rate of one per acre every other year in Connors and Lake of the Pines. Walleye stocking began on Lake of the Pines in 2014. (Tables 6 and 7) A 1985 report suggests that rusty crayfish should be harvested. It also stresses the importance of maintaining the present fish refuge at Connors Creek between the two lakes because it is a major source of natural reproduction for Connors Lake. This area is referred to as Papoose Lake in this plan.

Table 6. Connors Lake WDNR Muskellunge Stocking[13]

Year	Age Class	Number Stocked	Average Length (in.)
2012	LARGE FINGERLING	429	13.30
2010	LARGE FINGERLING	189	12.70
2008	LARGE FINGERLING	429	10.50
2006	LARGE FINGERLING	235	11.40
2004	LARGE FINGERLING	427	11.10
2002	LARGE FINGERLING	429	10.40
2000	LARGE FINGERLING	215	12.10
1997	LARGE FINGERLING	108	11.70
1996	FINGERLING	429	10.80
1993	FINGERLING	858	11.90
1992	FINGERLING	858	9.00
1991	FINGERLING	818	13.00
1990	FINGERLING	818	9.00
1989	FINGERLING	377	9.00
1988	FINGERLING	818	9.00
1987	FINGERLING	2,454	9.00
1985	FINGERLING	1,218	10.00
1984	FINGERLING	818	11.00
1983	FINGERLING	818	9.00
1981	FINGERLING	400	9.00
1979	FINGERLING	818	11.00
1977	FINGERLING	800	7.00
1976	FINGERLING	1,000	8.00
1975	FINGERLING	349	11.00
1974	FINGERLING	750	11.00
1973	FINGERLING	800	13.00
1972	FINGERLING	400	15.00

[13] http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2275100&page=fishstocking

Table 7. Lake of the Pines WDNR Fish Stocking[14]

Year	Species	Age Class	Number Stocked	Average Fish Length (inches)
2016	WALLEYE	LARGE FINGERLING	4,089	7.10
2015	MUSKELLUNGE	LARGE FINGERLING	147	12.20
2014	WALLEYE	LARGE FINGERLING	4,091	6.30
2013	MUSKELLUNGE	LARGE FINGERLING	137	11.60
2011	MUSKELLUNGE	LARGE FINGERLING	137	11.60
2009	MUSKELLUNGE	LARGE FINGERLING	273	10.20
2007	MUSKELLUNGE	LARGE FINGERLING	182	12.40
2005	MUSKELLUNGE	LARGE FINGERLING	273	11.20
2003	MUSKELLUNGE	LARGE FINGERLING	273	11.10
2001	MUSKELLUNGE	LARGE FINGERLING	273	10.50
2000	MUSKELLUNGE	LARGE FINGERLING	137	11.00
1991	MUSKELLUNGE	FINGERLING	546	12.00
1990	MUSKELLUNGE	FINGERLING	546	11.00
1989	MUSKELLUNGE	YEARLING	941	13.00
1988	MUSKELLUNGE	FINGERLING	1,006	11.00
1987	MUSKELLUNGE	FINGERLING	1,638	9.00
1986	MUSKELLUNGE	FINGERLING	546	9.00
1985	MUSKELLUNGE	FINGERLING	546	11.00
1984	MUSKELLUNGE	FINGERLING	546	11.33
1983	MUSKELLUNGE	FINGERLING	546	9.00
1981	MUSKELLUNGE	FINGERLING	275	7.00
1979	MUSKELLUNGE	FINGERLING	546	11.00
1977	MUSKELLUNGE	FINGERLING	450	13.00
1976	MUSKELLUNGE	FINGERLING	650	8.00

[14] http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2275300&page=fishstocking

The DNR developed a Fishery Management Plan for Connors Lake and Lake of the Pines in 2008 and established goals and measurable objectives for important sportfish species.[15] Goals and recent survey results for walleye are shown in Table 8.

Table 8. Walleye Goals and Measured Results[16]

Lake	Method	Goal	Actual	Year
Connors		3-5 adults/acre	2.5	2013
Connors	Fyke Netting	25-35% =>15”	41%	
Connors	Electrofishing	25-35% =>15”	29%	
Lake of the Pines		3-5 adults/acre	0.3	2013
Lake of the Pines	Fyke Netting	25-35% =>15”	67%	
Lake of the Pines	Electrofishing	25-35% =>15”	20%	

The Department of Natural Resources placed half-log structures in Connors Lake in 1986 to enhance smallmouth bass spawning habitat. Visual observations during annual nesting surveys (1986-1990) demonstrated that smallmouth used the structures, but there was no conclusive evidence of increased recruitment. The DNR Fishery Team has shifted away from promoting fish cribs as fish habitat to produce more or bigger fish. Instead, they now encourage groups and individuals to protect and/or replace the submerged woody structure that shoreland owners often remove from the near-shore zone of lakes for “better” recreational opportunity.[17]

[15] Fishery Management Plan Flambeau River State Forest Lakes Sawyer and Price Counties, Wisconsin. December 2008. Jeff Scheirer and Dave Neuswanger WDNR.

[16] Fishery Status Update. WDNR. Connors Lake and Lake of the Pines. September 2016.

[17] Email communication. Jeffrey Scheirer, WDNR Fisheries Biologist. May 5, 2017.

Plant Survey Results

Lake of the Pines

The Lake Association commissioned an aquatic macrophyte (plant) survey of Lake of the Pines in preparation for developing the 2008 aquatic plant management plan. An early season survey was completed in June 2007, and the full point intercept survey was completed in August 2007. Plant survey results are found in Appendix A with methods found in Appendix B. The Lake of the Pines point intercept survey will be completed again in 2017. Since no active management is planned for Lake of the Pines, the plan update proceeded prior to completion of this survey.

Connors Lake

The Department of Natural Resources completed aquatic plant surveys according to the point intercept method for Connors Lake in 2005 and 2007-2015. Survey results from 2015 are summarized in Table 9. Connors Lake has a diverse plant community with 25 species of macrophytes sampled with a rake and 28 sampled and viewed. Table 10 lists these species along with sampling frequency data.

The coverage of aquatic plants in Connors Lake is limited. At sample points within the depth where plants can grow (13.5 feet and less), 70.75% had plants growing. However, most of the lake is deeper than the depth of plants, so only 12.9% of the lake had plants present. The Simpson's Diversity Index indicates a high diversity of plant species.

Table 9. Connors Lake 2015 Point Intercept Survey Summary

Total number sample points in lake grid	986
Total number of sites with vegetation	127
Total number of sites shallower than maximum depth of plants	177
Frequency of occurrence at sites shallower than maximum depth of plants	71.75%
Frequency of occurrence of all lake sites	12.9%
Simpson Diversity Index	0.91
Maximum depth of plants (ft)	13.50
Average number of all species per site (shallower than max depth)	1.54
Average number of all species per site (veg. sites only)	2.14
Average number of native species per site (shallower than max depth)	1.53
Average number of native species per site (veg. sites only)	2.13
Species Richness	25
Species Richness (including visuals)	28
Floristic Quality Index (FQI)	30.65

The mean rake fullness map (Figure 8) illustrates the limited coverage of aquatic plants in Connors Lake. Most of the plant growth is limited to a few bays. Musky Bay has the most extensive growth and diversity. This is followed by a small bay just south of Musky Bay and the bay on the northeast end of the lake.

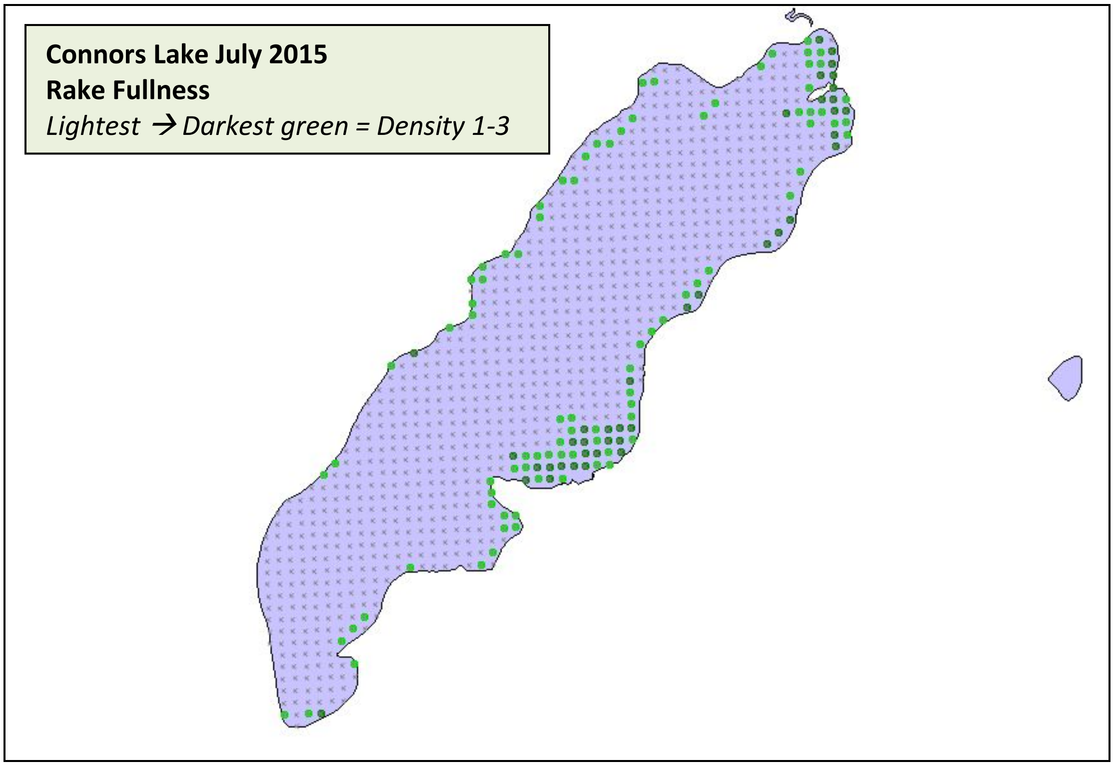

Figure 8. Mean Rake Fullness Connors Lake 2015

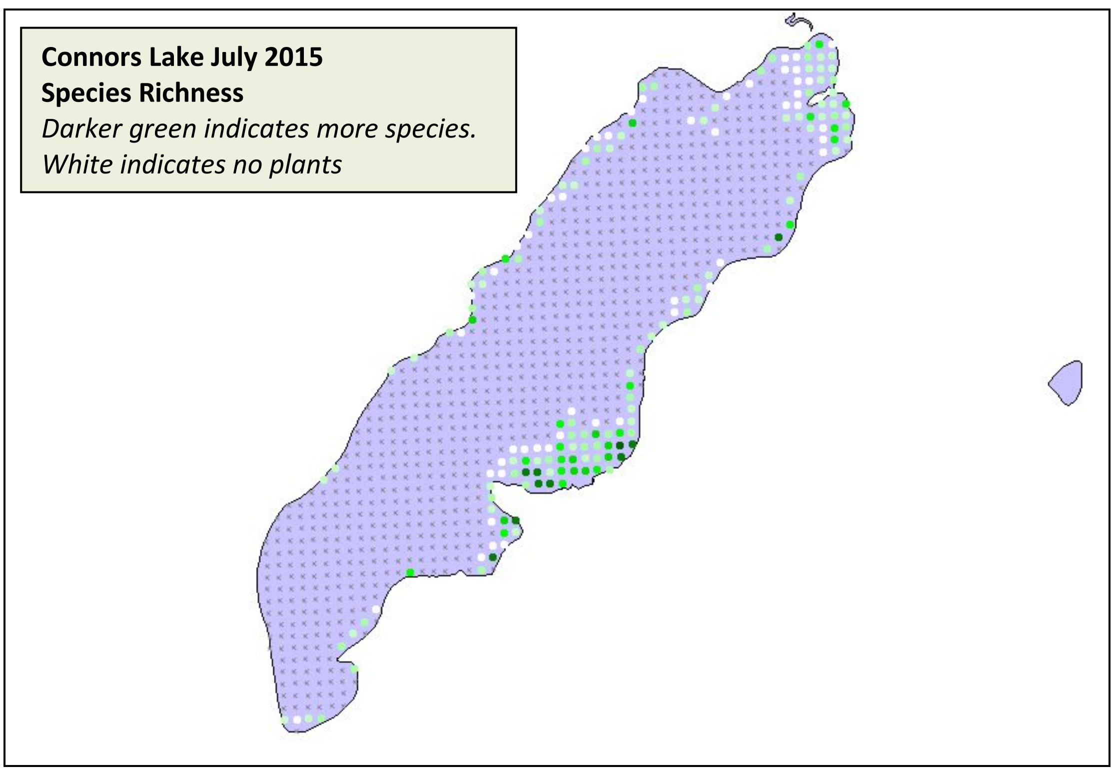

Figure 9. Species Richness Connors Lake 2015

Table 10. Connors Lake Aquatic Plant Species Survey Results[18]

Species	FOO	FOO Littoral	Relative Freq.	Number Sampled	Mean Density	Visual
Potamogeton robbinsii, Fern pondweed	37.80	27.12	17.65	48	1.40	
Potamogeton gramineus, Variable pondweed	32.28	23.16	15.07	41	1.05	4
Ceratophyllum demersum, Coontail	21.26	15.25	9.93	27	1.07	
Najas flexilis, Slender naiad	18.11	12.99	8.46	23	1.00	3
Vallisneria americana, Wild celery	16.54	11.86	7.72	21	1.05	2
Schoenoplectus acutus, Hardstem bulrush	13.39	9.60	6.25	17	1.12	3
Elodea canadensis, Common waterweed	12.60	9.04	5.88	16	1.00	
Myriophyllum sibiricum, Northern water-milfoil	11.02	7.91	5.15	14	1.00	
Potamogeton amplifolius, Large-leaf pondweed	9.45	6.78	4.41	12	1.00	4
Potamogeton richardsonii, Clasping-leaf pondweed	8.66	6.21	4.04	11	1.00	
Heteranthera dubia, Water star-grass	6.30	4.52	2.94	8	1.00	
Potamogeton pusillus, Small pondweed	4.72	3.39	2.21	6	1.00	
Potamogeton zosteriformis, Flat-stem pondweed	3.94	2.82	1.84	5	1.00	
Chara sp., Muskgrasses	2.36	1.69	1.10	3	1.00	
Eleocharis acicularis, Needle spikerush	2.36	1.69	1.10	3	1.00	1
Eleocharis palustris, Creeping spikerush	2.36	1.69	1.10	3	1.00	4
Nuphar variegata, Spatterdock	2.36	1.69	1.10	3	1.00	2
Pontederia cordata, Pickerelweed	2.36	1.69	1.10	3	1.00	
Myriophyllum spicatum, Eurasian water milfoil	1.57	1.13	0.74	2	1.00	2
Equisetum fluviatile, Water horsetail	0.79	0.56	0.37	1	1.00	1
Isoetes sp., Quillwort	0.79	0.56	0.37	1	1.00	
Juncus pelocarpus f. submersus, Brown-fruited rush	0.79	0.56	0.37	1	1.00	
Myriophyllum tenellum, Dwarf water-milfoil	0.79	0.56	0.37	1	1.00	
Nymphaea odorata, White water lily	0.79	0.56	0.37	1	1.00	
Sagittaria sp., Arrowhead	0.79	0.56	0.37	1	1.00	
Freshwater sponge	15.75	11.30		20	1.00	
Filamentous algae	18.90	13.56		24	1.00	
Schoenoplectus pungens, Three-square bulrush	Viewed	only				2
Potamogeton spirillus, Spiral-fruited pondweed	Viewed	only				2
Lobelia dortmanna, Water lobelia	Viewed	only				1

[18] FOO = Frequency of Occurrence

The three most common native plants surveyed in 2015 were fern pondweed (*Potamogeton robbinsii*), variable pondweed (*Potamogeton gramineus*), and coontail (*Ceratophyllum demersum*) respectively. All three of these native plants are common in Wisconsin and are desirable in a lake. They provide good habitat for invertebrates and fish. The extensive coverage of native plants in various areas of Connors Lake will also help keep invasive species such as Eurasian Water Milfoil from dominating the plant community.

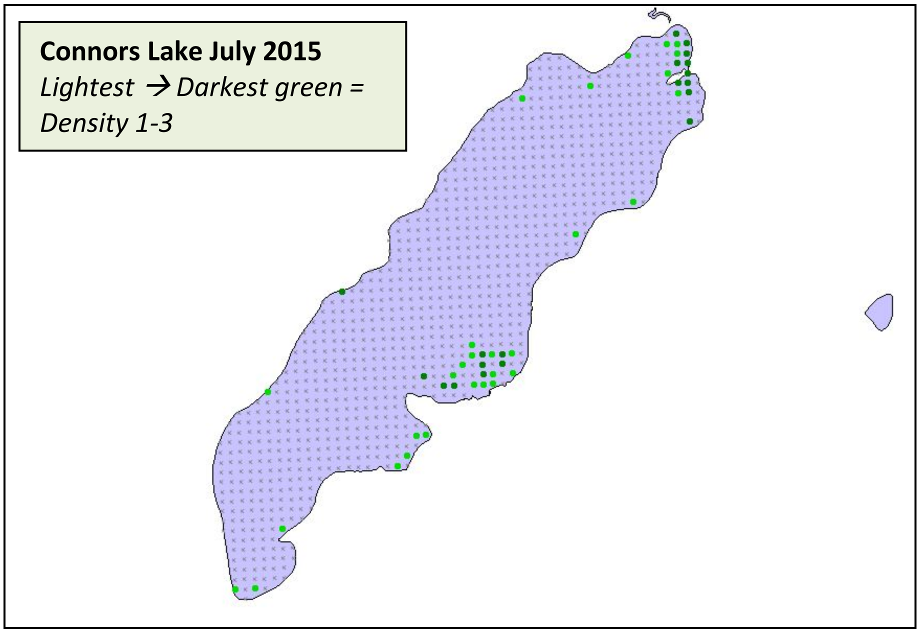

Figure 10. Potamogeton robbinsii – Fern Pondweed Mean Rake Density 2015

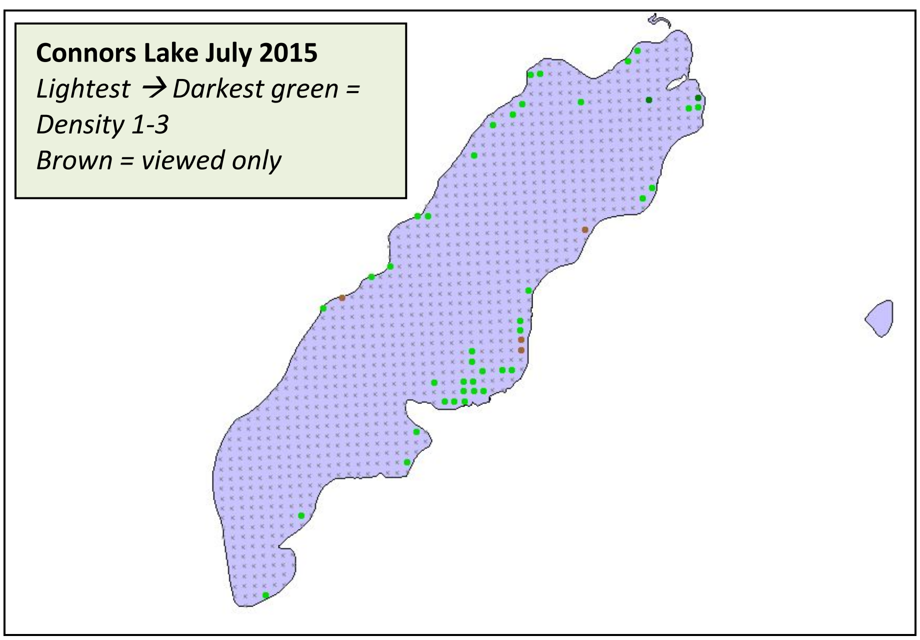

Figure 11. Potamogeton gramineus –Variable Pondweed Mean Rake Density 2015

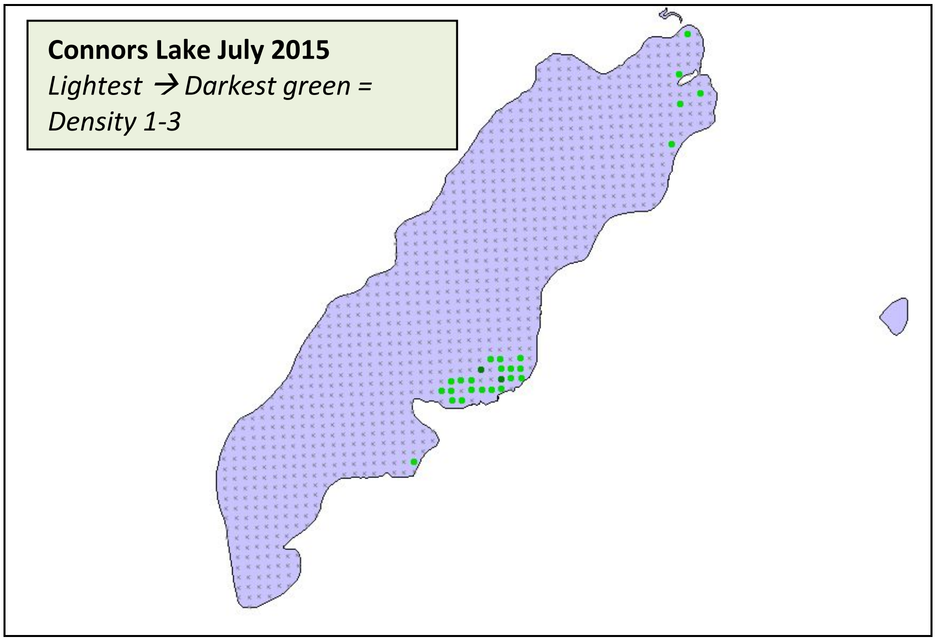

Figure 12. Ceratophyllum demersum – Coontail Mean Rake Density 2015

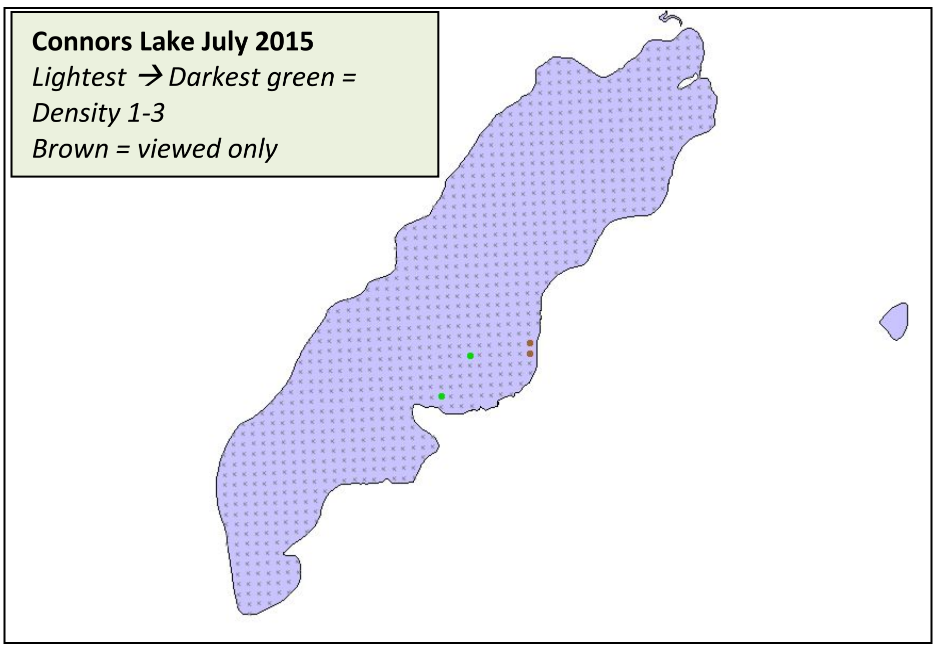

Figure 13. Myriophyllum spicatum – Eurasian Water Milfoil Mean Rake Density 2015

The coverage of EWM in the 2015 survey was limited. There were only two sample points with EWM sampled and two sample points where it was viewed. This resulted in a very low frequency of occurrence of 1.57%. By comparison, the frequency of occurrence of the native milfoil (northern water milfoil) was 11.02%.

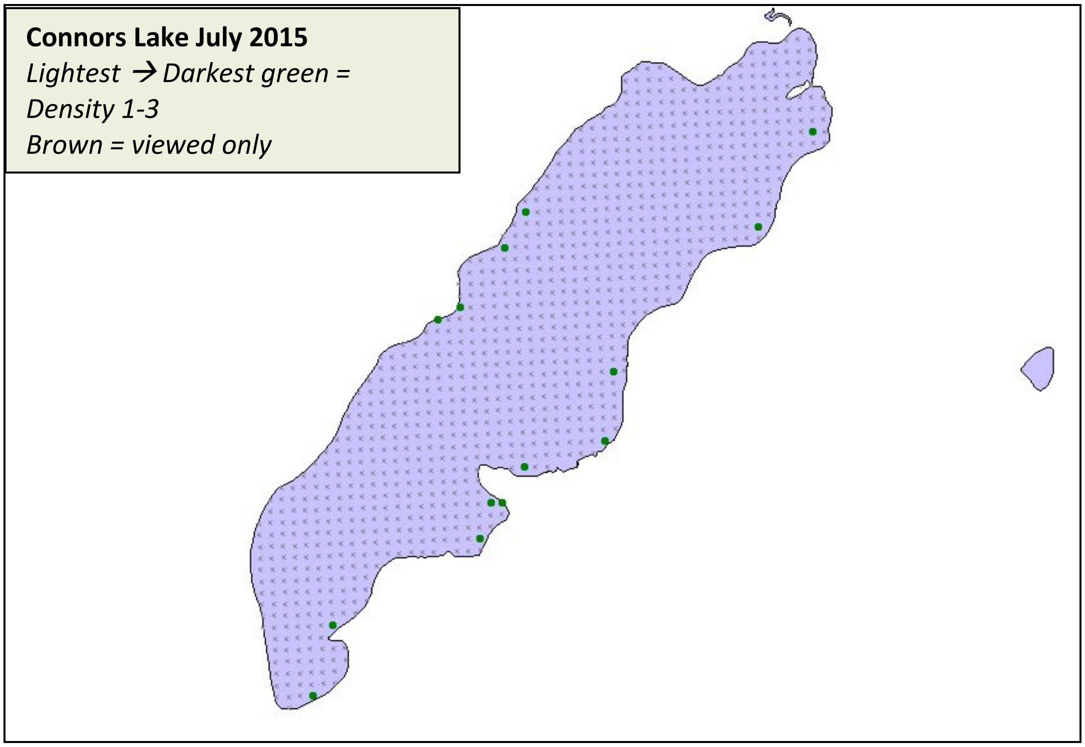

Figure 14. Myriophyllum sibiricum - Northern Water Milfoil Mean Rake Density 2015

A Floristic Quality Index (FQI) calculation is used to assess changes in a plant community. The FQI is based upon the number of species (which indicate quality) and the mean conservatism value (high value = less tolerant plants, lower value = more tolerant plants). A higher FQI implies that human activity has had little impact on the aquatic plant community. Habitat changes and decreased water quality can lower the FQI. In 2015, the survey indicated a much higher FQI than the ecoregion median, but the mean conservatism value was just a bit lower. The higher FQI is largely due to higher species richness.

Table 11. Connors Lake Floristic Quality Index Comparison

	Connors	Ecoregion
Number of species	23	13
Mean conservatism	6.4	6.7
FQI	30.65	24.3

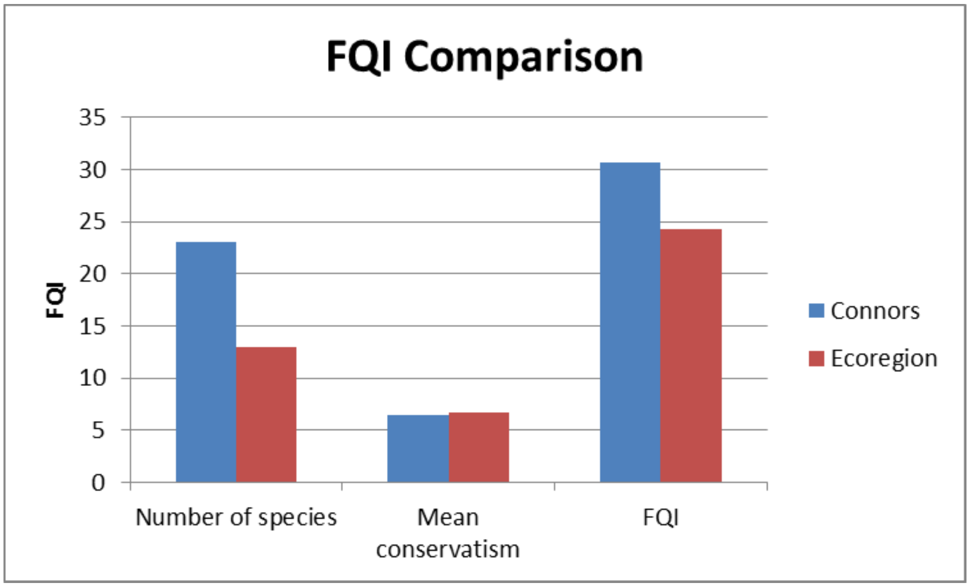

Figure 15. Connors Lake Floristic Quality Index Comparison

Invasive Species

Eurasian water milfoil was first discovered by WDNR staffer Craig Roesler in 2002. The June 2003 EWM survey located a total of about 23 acres with significant amounts of EWM growing at depths between 3 and 10 feet. A map of these areas follows as Figure 16. EWM was not found in the small (2.3 acre) Papoose Lake just to the north of Connors Lake in this survey.

Two non-native, invasive species were located during the 2005 plant survey of Connors Lake. In addition to the Eurasian water milfoil (*Myriophyllum spicatum*) found in 2003, *Potamogeton crispus*, commonly known as curly leaf pondweed (CLP) was also found. Figure 17 and Figure 18 illustrate the distribution of each in 2005. Eurasian water milfoil has been found in each subsequent plant survey and has been the focus of aquatic plant management efforts. Curly leaf pondweed does not appear to be spreading or causing nuisance conditions in Connors Lake.[19]

[19] Schieffer, Steve. Email communication May 2017

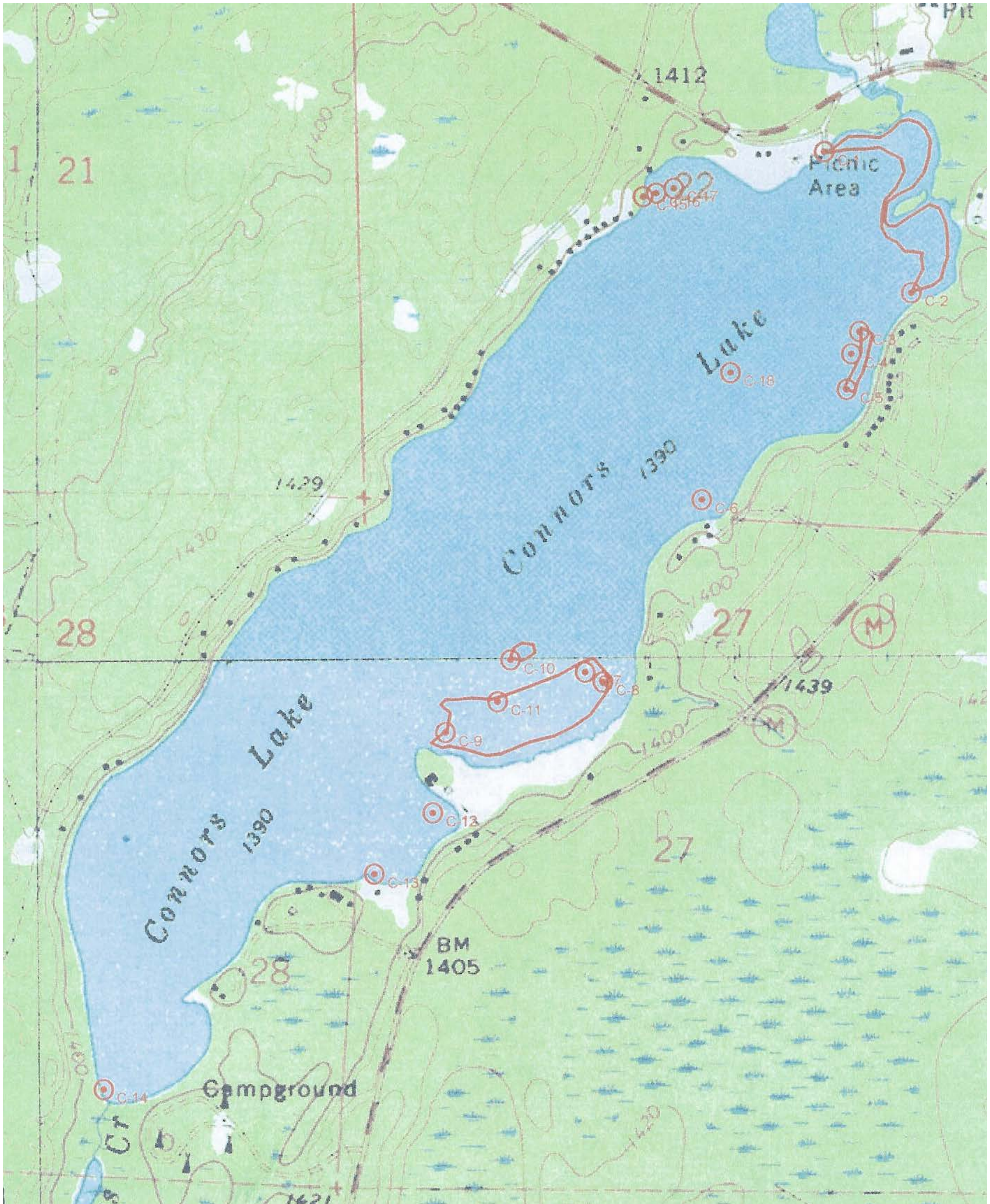

Figure 16. Eurasian Water Milfoil Locations in 2003

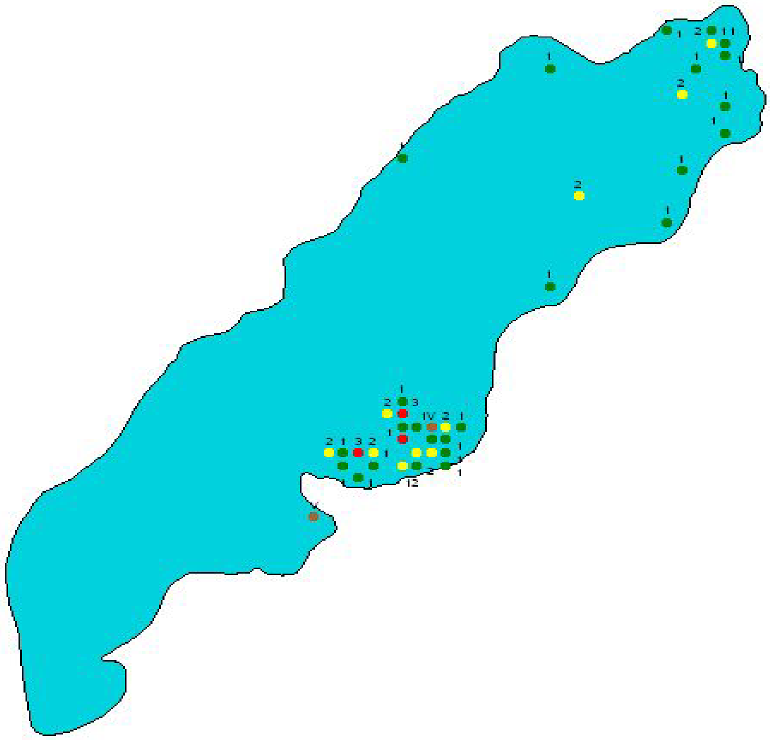

Figure 17. Eurasian Water Milfoil Locations Connors Lake July 2005 Rake Fullness: ● ***1*** ○ ***2*** ● ***3***

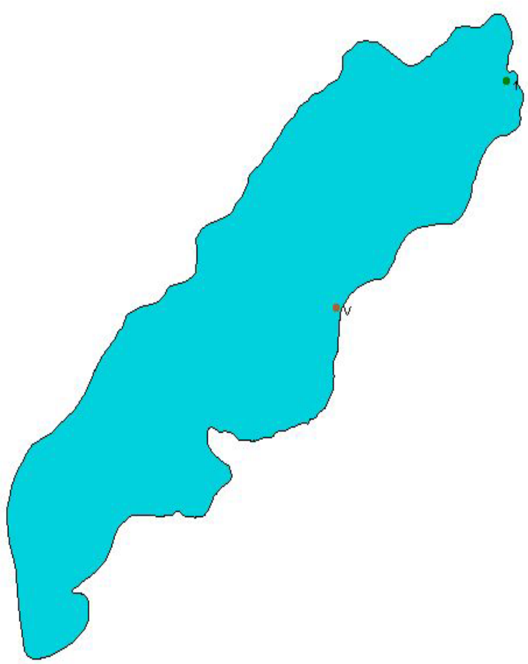

Figure 18. Curly Leaf Pondweed Locations Connors Lake 2015

Point Intercept Results 2005-2015

Results from WDNR Connors Lake point intercept surveys are compared in Table 12. There are small variations in survey results each year. Species richness represents the number of different plants sampled on the rake. Simpson's diversity index reflects the diversity of the plant species. The number of points with plants gives an overview of the changes in plant coverage from year to year.

The floristic quality index (FQI) can change due to changes in habitat. The FQI is used to evaluate changes in the plant community due to human activity from pre-development times. If human activity negatively affects the habitat for plants, the FQI may decrease. The Connors Lake FQI showed little change from 2005-2015.

Table 12. Connors Lake Point Intercept Survey Results 2005-2015

	2005	**2007**	**2008**	**2009**	**2010**	**2011**	**2013**	**2015**
Species richness	27	29	31	26	28	30	28	25
Simpson's diversity	0.92	0.92	0.93	0.92	0.93	0.93	0.93	0.91
Points with plants	140	186	191	201	183	147	140	127
FQI	32.04	33.68	35.42	30.00	32.52	36.7	31.97	30.65

Native Plant Species Changes

Repeated point intercept surveys can be used to evaluate changes in the aquatic plant community over time. Changes in frequency of occurrence for a particular species are tested for statistical significance with a chi-square analysis. This evaluation is completed because of a concern over significant reductions in native species.

There are various factors that can contribute to reduction in native species including:

1. <u>Management practices such as herbicide treatments.</u> Reduction in native species from herbicide application is dependent upon the type, concentration, and timing of herbicide application. Pre and post treatment analysis are completed in treatment areas to assess effectiveness of treatment and impact on native plants. The full point intercept survey can be used to assess impacts lakewide.
2. <u>Variation in sample point location.</u> The sample grid is entered into a GPS unit. The GPS allows the surveyors to get close to the same sample point each time, but there could easily be a difference of 20 feet or more (the arrow icon is 16 feet in real space). Since the distribution of various plants is not typically uniform but more likely clumped, sampling variation could easily result in a plant found in one survey and not in the next. This is especially true with plants with low frequency – even within the same year.
3. <u>Timing of aquatic plant growth.</u> The timing for aquatic plants coming out of dormancy can vary each year. A late or early ice-out can greatly affect the size of plants during a survey. A lake may have high rake density of a plant one year, only to have a very low rake density another year. The type of plant reproduction (whether a plant reproduces from a seed or a rhizome) can affect timing of plant growth and therefore measured frequency of occurrence and rake density of plants.

4. Identification error. The small pondweeds such as *Potamgeton pusillus*, *Potamogeton foliosus*, *Potamogeton friesii*, and *Potamogeton strictifolious* can easily be mistaken for one another. Because of likelihood of identification error, it may be best to look at the overall frequency of all of the small pondweeds to determine if a true reduction has occurred.
5. Habitat and plant dominance changes. For example, sediment deposition from human activity may result in changes to the plant community over a several year period. If a plant increases in dominance, it may reduce another plant's frequency of occurrence and/or rake density.
6. Infestation of non-native rusty crayfish or common carp can result in very large, but non species-specific plant coverage reduction.

The native species previously found to be susceptible to 2,4-D herbicide (Nault, 2012) were evaluated from each point intercept plant survey by graphing the frequency of occurrence for each year the surveys were conducted. The frequency of occurrence was analyzed statistically (with chi-square analysis) each year compared to the first aquatic plant survey in 2005. Those reductions that were significant are indicated with red bars. Any treatment that was at least 10% of the littoral zone is approximately marked on the graph with a green vertical line (Figures 19-23).

Table 13. Herbicide Treatment of at Least 10 Percent of the Littoral Zone

Treatment Year	Area (acres)
2005 (June)	32
2005 (Sept)	5
2006 (July)	5
2007 (June)	9.8
2009	28.8
2010	18.7
2013	4.73
2015	3.5

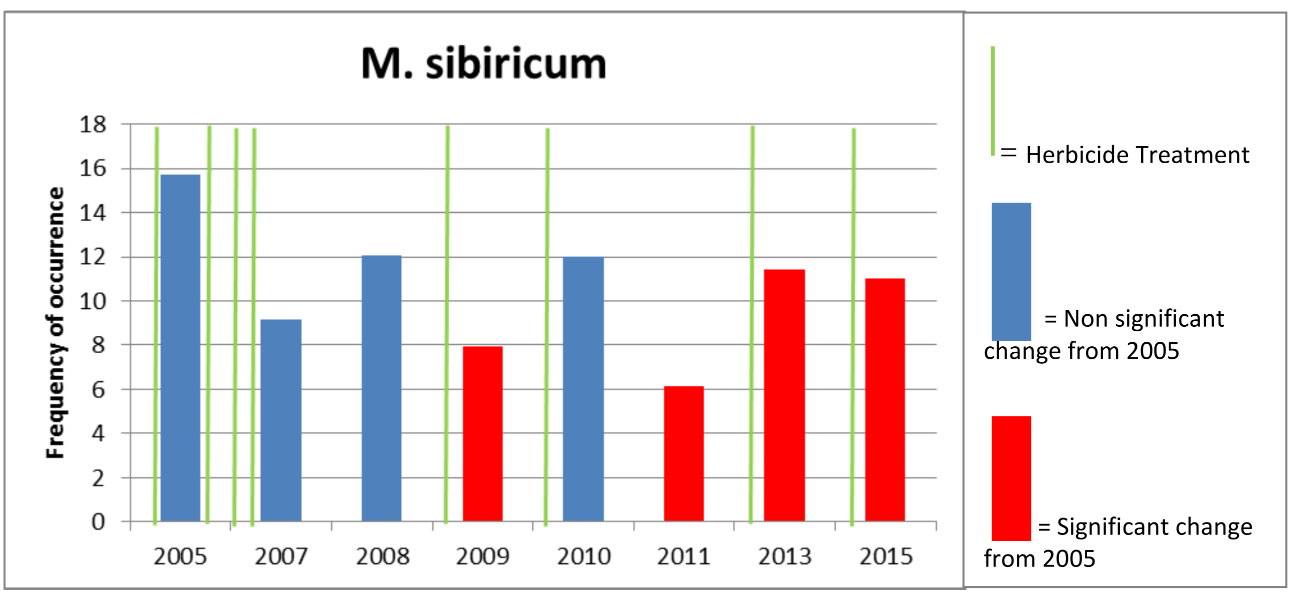

Figure 19. Changes in Northern Water Milfoil 2005 to 2015

Northern water milfoil (*Myriophyllum sibiricum*) showed significant reductions in 2009, 2011-2015 when compared with frequency of occurrence in 2005.

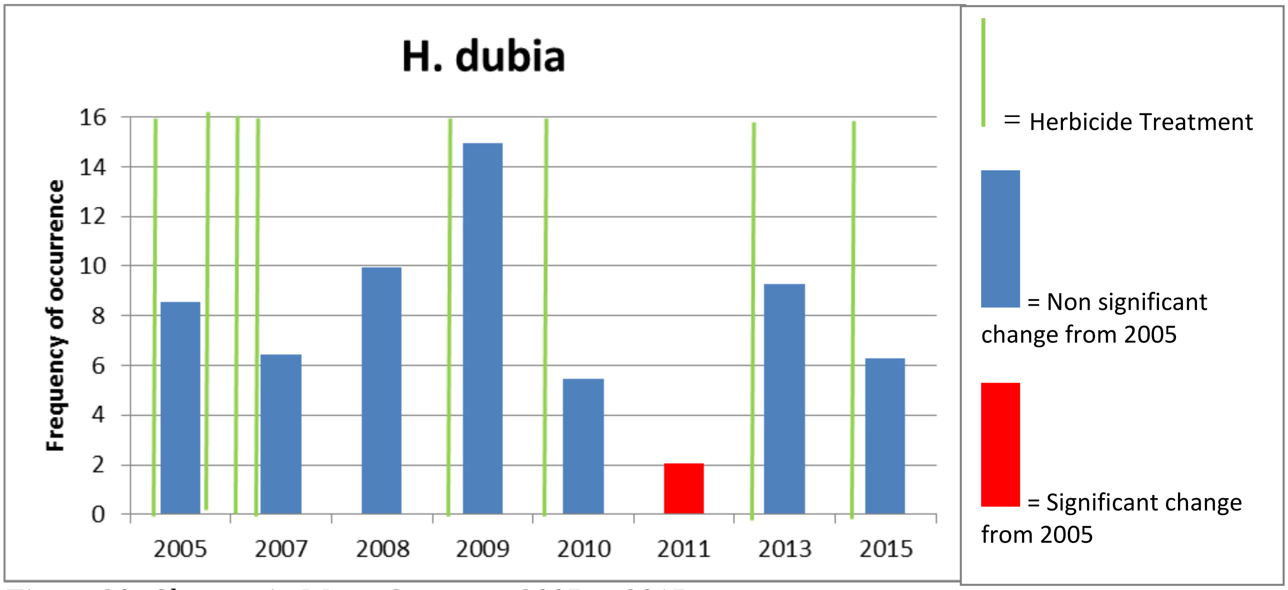

Figure 20. Changes in Water Stargrass 2005 to 2015

Water stargrass (*Heteranthera dubia*) showed a significant reduction only in 2011 when compared with frequency of occurrence in 2005.

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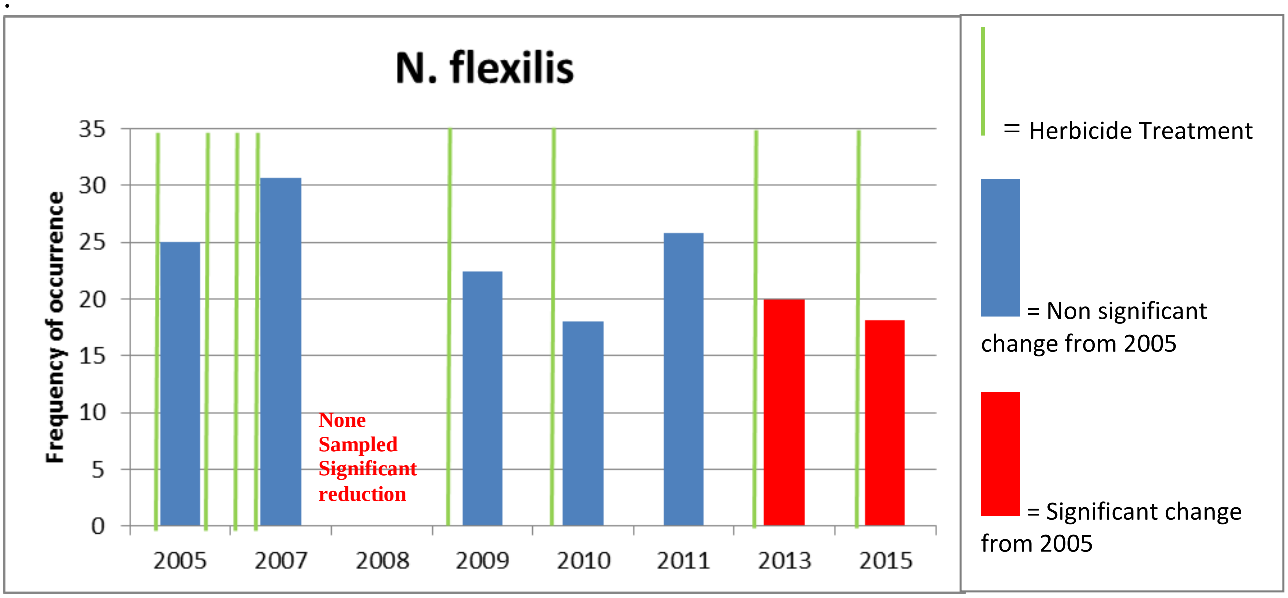


Figure 21. Changes in Slender Naiad 2005 to 2015

Slender naiad (*Najas flexilis*) showed reductions in 2008, 2013 and 2015 when compared with frequency of occurrence in 2005.

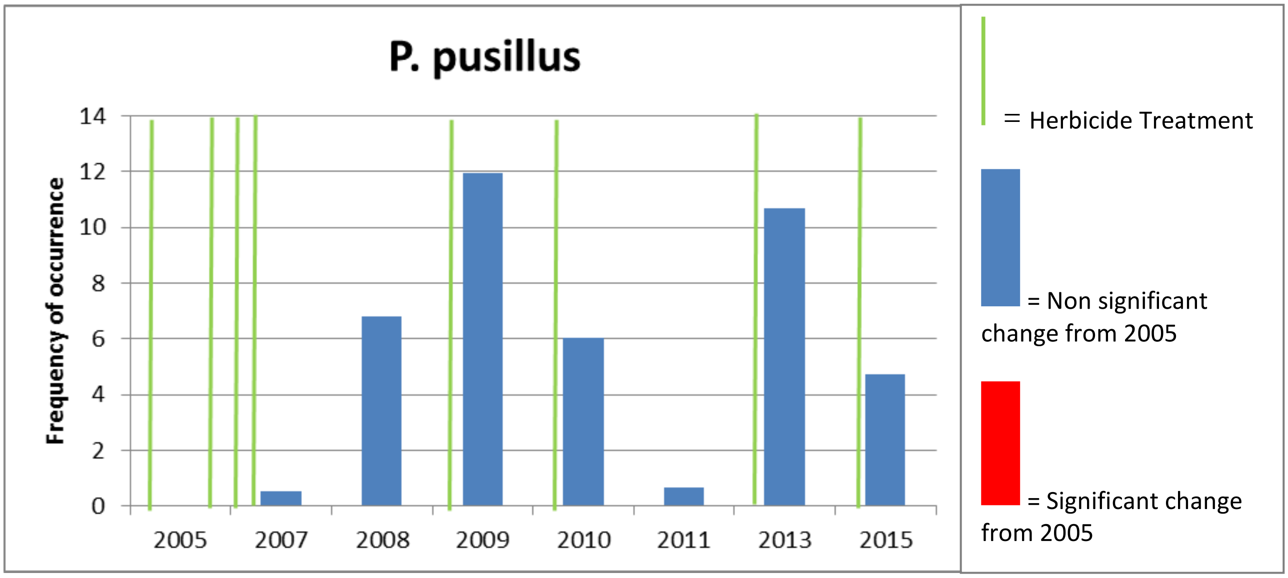


Figure 22. Changes in Small Pondweed 2005 to 2015

Small pondweed (Potamogeton pusillus) did not appear to show any reductions. However, it was not sampled in 2005, so it is not possible to have a reduction. The frequency of occurrence did fluctuate immensely over the years.

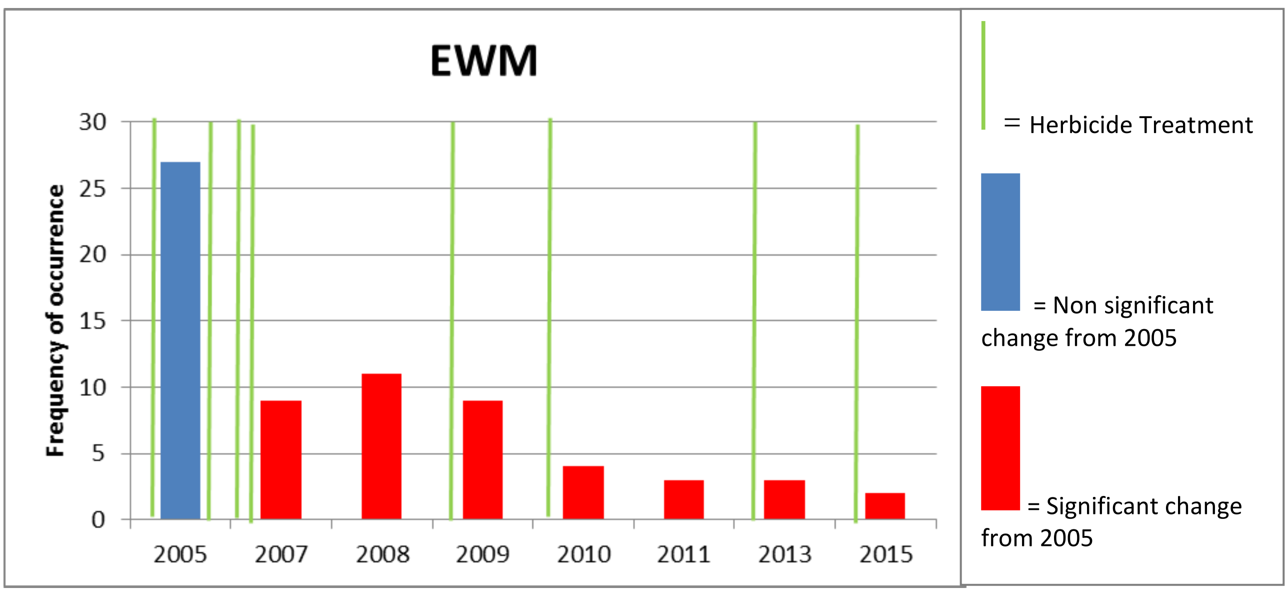


Figure 23. Changes in Eurasian Water Milfoil 2005 to 2015

Eurasian water milfoil (EWM) had its highest frequency in 2005. Based upon information provided, treatment occurred in 2005 both prior to the PI survey data collection and after (there were two treatments that occurred).

Changes in Eurasian water milfoil are further illustrated in point intercept maps prepared by the Wisconsin Department of Natural Resources and shown in Figures 24-26.

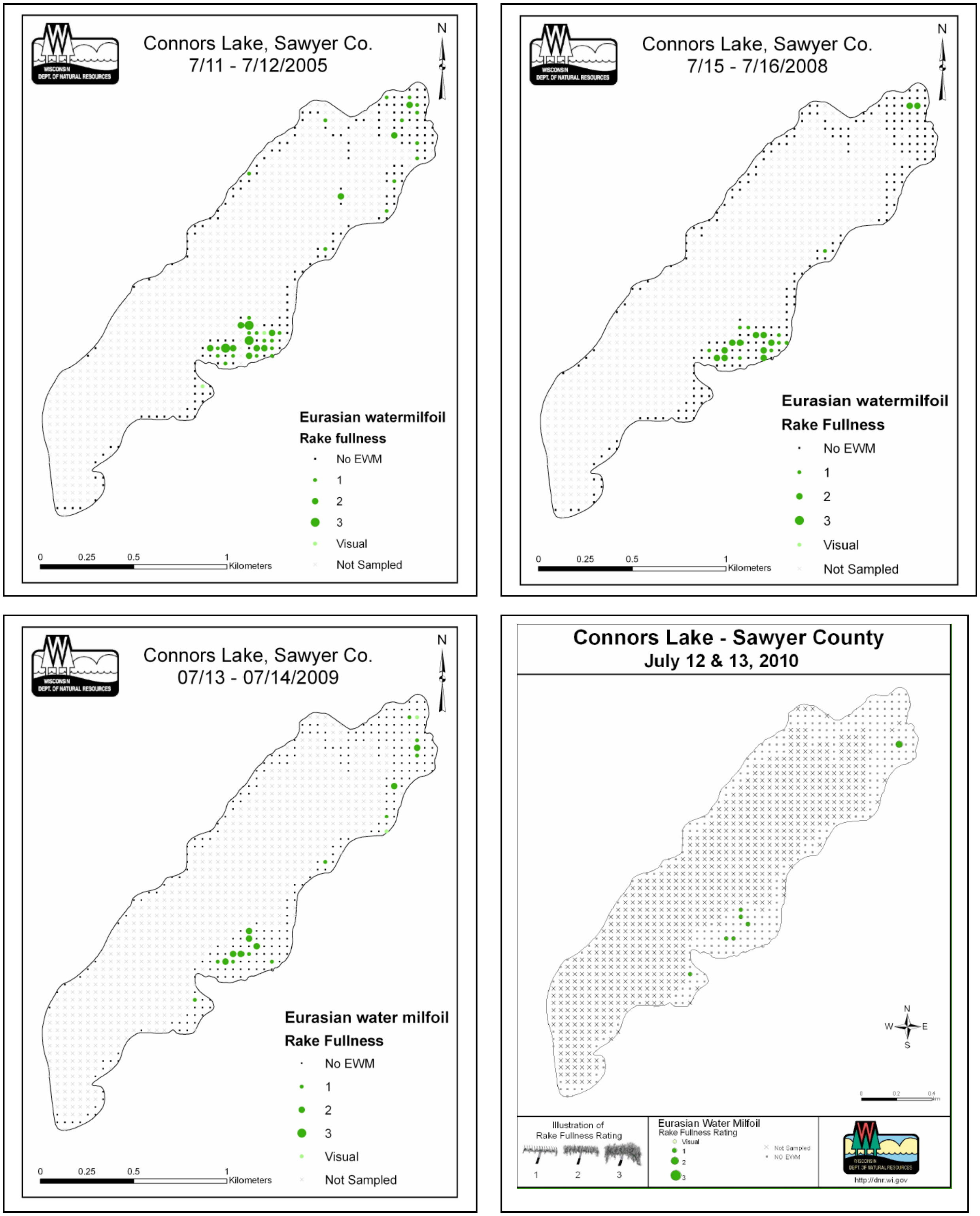


Figure 24. Eurasian Water Milfoil Point Intercept Survey Results 2005, 2008 - 2010

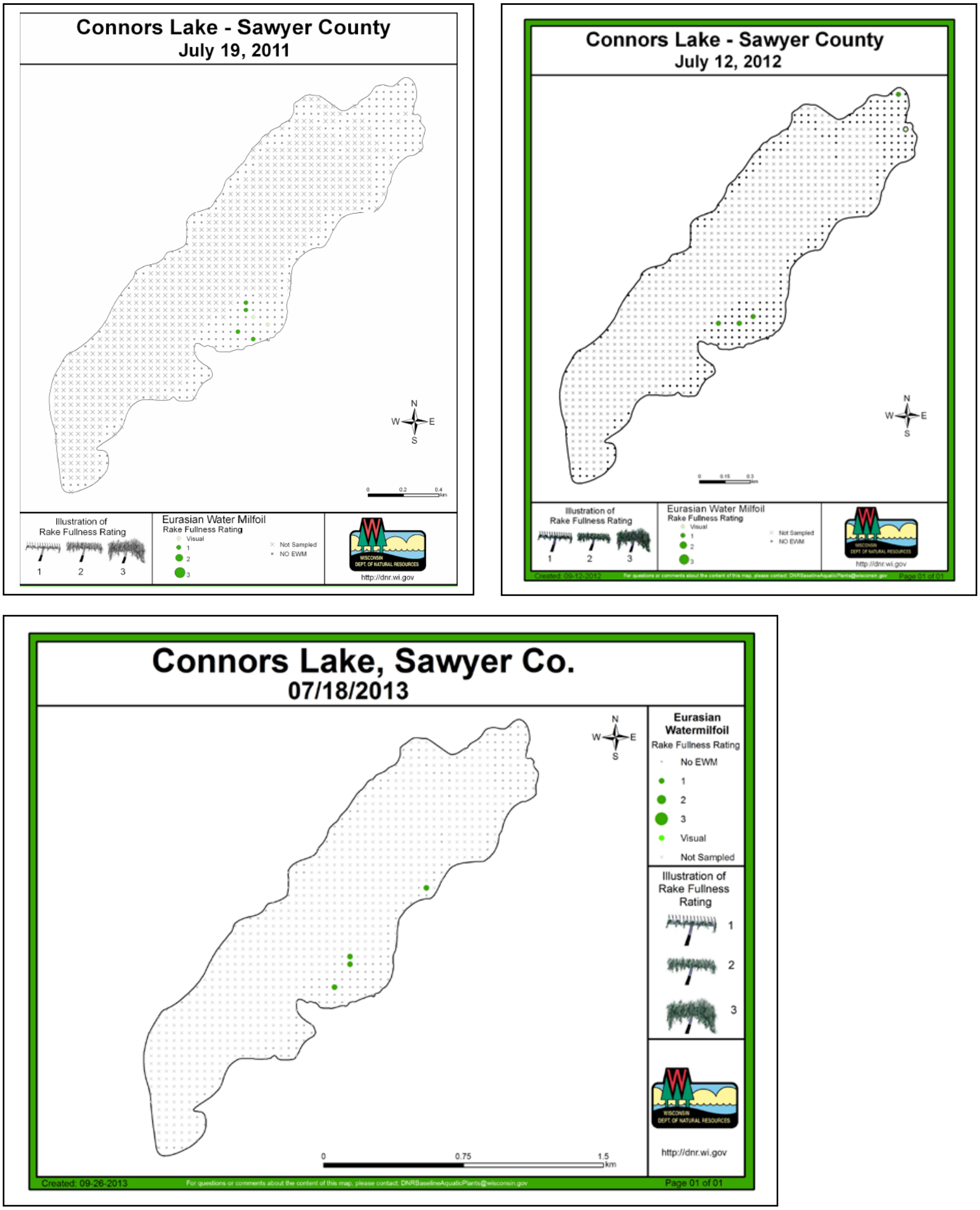
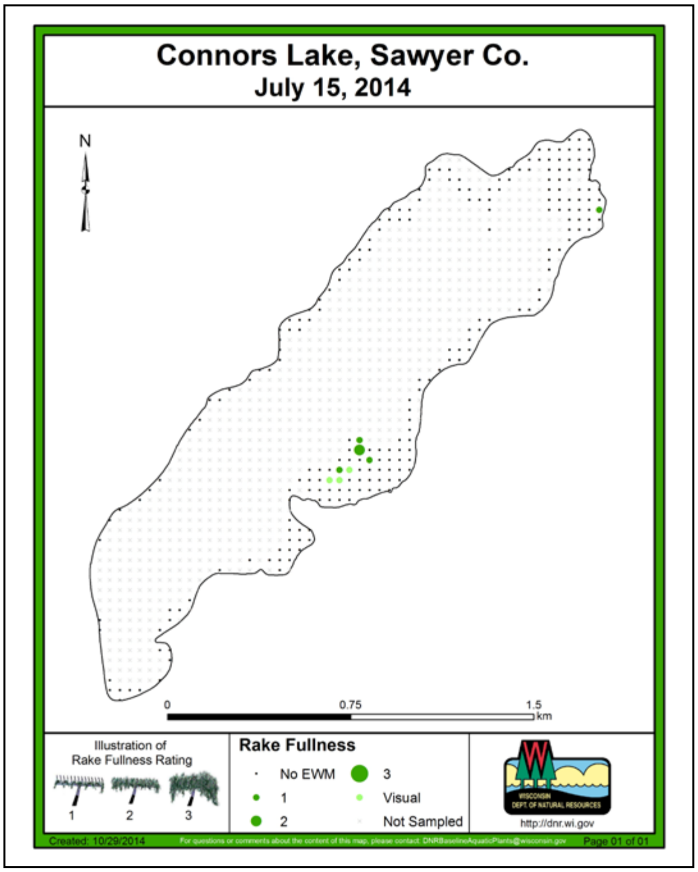


Figure 25. Eurasian Water Milfoil Point Intercept Results 2011-2013



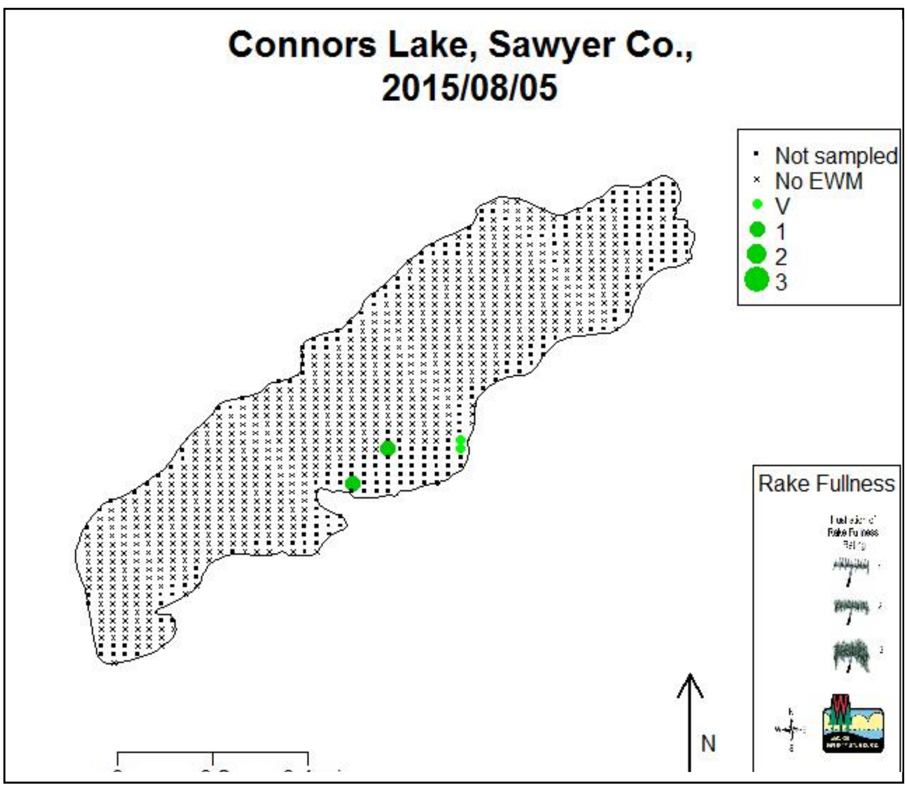


Figure 26. Eurasian Water Milfoil Point Intercept Results 2014-2015

Aquatic Plant Management

This section reviews the potential management methods available to reach plan goals, existing management activities, and presents aquatic plant management goals and strategies for the lakes.

Discussion of Management Methods

Techniques to control the growth and distribution of aquatic plants are discussed in Appendix D. Permitting requirements and herbicide use to manage invasive species are discussed below. The application, location, timing, and combination of techniques must be considered carefully because of potential impacts to native plants and aquatic habitats.

Permitting Requirements

The Department of Natural Resources regulates the removal of aquatic plants when chemicals are used, when plants are removed mechanically, and when plants are removed manually from an area greater than 30 feet in width along the shore. The requirements for chemical plant removal are described in Administrative Rule NR 107 – Aquatic Plant Management. A permit is required for any aquatic chemical application in Wisconsin. This includes granular herbicides available through mail order and internet purchase. A Department of Agriculture, Trade, and Consumer Protection pesticide applicator certification (aquatic nuisance control category) is required to apply liquid chemicals in the water.

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 limited to a 30-foot corridor. A riparian landowner may also manually remove the invasive plants Eurasian water milfoil, curly leaf pondweed, and purple loosestrife along his or her shoreline without a permit. Manual removal means the control of aquatic plants by hand or hand–held devices without the use or aid of external or auxiliary power.[20]

[20] More information regarding DNR permit requirements and aquatic plant management contacts is found on the DNR web site www.dnr.wi.gov.

Eurasian Water Milfoil Management

Hand Pulling[21]

Hand pulling is a strategy recommended for rapid response to a Eurasian water milfoil establishment, for private landowners and organizations that wish to remove small areas of growth, and to remove scattered growth following an herbicide treatment. EWM growth is generally deep enough that snorkel or SCUBA gear is required. Recent costs for hand-pulling EWM using divers on Minocqua and Kawaguesaga Lakes in Oneida County were about $28,000 to remove an estimated <4,000 lbs.

Hand pulling requires good enough water clarity to identify plants prior to pulling. In Cedar Lake (St. Croix County) hand pulling of EWM was not an option in 2015 because of poor clarity. In 2016, SCUBA divers hand pulled some plants following the herbicide treatment. However, water clarity was very limited, and plants were difficult to find. Hand pulling with divers is an option for Connors Lake.

Diver Assisted Suction Harvesting (DASH)

With Diver Assisted Suction Harvesting (DASH) divers hand pull aquatic invasive plants from the lake-bed. A suction line transports removed plants to the surface. This method is probably most appropriate for relatively small and less dense areas of invasive plant growth. Poor water clarity would also make it more difficult to use DASH.[22]

The Tomahawk Lake Association (TLA) developed and has used a DASH system for several years, although they call their system a hydraulic conveyor system (HCS). HCS is an automated system that removes, filters, and bags harvested EWM after it has been hand harvested from the lake bed by divers. The TLA HCS includes a floating chassis, a "jet pump" water system, a three tiered separation system, and a Hookah diver air supply system.[23] Use of the TLA HCS began in the summer of 2007. A second generation HCS began operation in 2011. Capital costs for the system are just over $25,000 and annual operating costs are about $31,000. The TLA harvested about 20,000 lbs. each year through 2014.

Because of the mechanical elements of the system, a WDNR aquatic plant management harvesting permit is required. Contracted DASH systems are available. Decontamination of the system is especially important with a contracted DASH system that moves between lakes. A DASH trial might be considered for Connors Lake. A recent estimate for 2017 from a contractor was $2,500/day with harvesting amounts varied with total EWM acreage and density. With high density, the contractor reported removing 3,000 pounds in a single day.[24]

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21 Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005.
22 Wisconsin Lakes Convention Presentation. 2016.
23 Wisconsin Lakes Convention presentation, TLA Hydraulic Conveyor System. Ned Greedy, 2014.
24 TSB Lakefront Restoration Email Communication. January 2017.

Figure 27. TLA Hydraulic Conveyor System (Greedy)

Eurasian Water Milfoil Biocontrol

A potential management method for EWM is the use of the native weevil *Euhrychiopsis lecontei*. This weevil has a larvae stage that feeds on both native milfoils and Eurasian water milfoil. The larvae tunnel into the stem causing the plant to presumably lose the ability to transport nutrients and gases. *E. lecontei* adults swim and climb from plant to plant, feeding on leaflets and stem material. After mating, the female lays an average of 1.9 eggs a day, usually 1 egg per watermilfoil apical meristem (growing tip). One female may lay hundreds of eggs in her lifetime. The eggs hatch, and the larvae first feed on the apical meristem and then mine down into the stem of the plant, consuming internal stem tissue. Weevils pupate inside the stem in the pupal chamber, a swelled cavity in the stem. Adults emerge from the pupal chamber to mate and lay eggs. In the autumn, adults travel to the shore where they over-winter on land. In the laboratory, *E. lecontei* take 20 to 30 days to complete a life cycle, depending on water temperatures. For complete development, weevils require about 310 degree-days with temperatures above 10 degrees C. Two to four generations per year are generally observed in the field.[25]

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

The Minocqua and Kawaguesaga Lakes Protection Association experimented with a weevil program for six areas infested with Eurasian Water Milfoil beginning in 2008. The weevils showed little effect on EWM growth when monitored in 2010. Herbicide treatment began in one

[25] *Euhrychiopsis lecontei* fact sheet. Cornell University Research Ponds Facility.
< http://www.eeb.cornell.edu/ponds/weevil.htm>

of the six beds because of concern for EWM expansion. In 2011 the weevil augmentation results were showing some positive results with small decreases in both frequency and in density of EWM. However, a second bed was switched to herbicide treatment for 2012 because of expansion of EWM growth. Then in 2012, both frequency and density were back to levels seen in 2010 (density) and prior to 2010 (frequency). Beginning in 2012, any bed that met the criteria for herbicide treatment was treated and reliance on the weevil program was discontinued. (Schieffer, 2012). The results reported for Minocqua and Kawaguesaga Lakes are consistent with DNR research that indicated weevils are not an effective solution in Northern Wisconsin.[26]

Results for use of weevils for a St. Croix County lake, Perch Lake were a bit more positive. Milfoil weevils were raised by Beaver Creek Reserve and stocked into Perch Lake in 2013 and 2014 as a biocontrol tool for EWM. During this time, volunteers raised over 20,000 weevils and put them into Perch Lake. Records from 2014 showed weevil damage evident in 22-42% of stem samples collected in EWM beds, depending on bed. Weevils were present at a rate of 0.24 N/stem. Control has been documented (Newman) at as low as 0.22 N/stem. EWM had decreased significantly in Perch Lake in 2014.[27]

Current plans are for WDNR Water Resources staff to continue to conduct aquatic plant surveys on an annual basis in Perch Lake to monitor the effectiveness of the milfoil weevils as a biocontrol of EWM. It is not certain how long this support will continue.

A weevil biocontrol program for EWM might be considered for Connors Lake over the long term.

Control with Herbicides

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies the following herbicides for control of Eurasian water milfoil: complexed copper, 2,4-D, diquat, endothall, fluridone, and triclopyr. Early season treatment of Eurasian water milfoil is also recommended by the Department of Natural Resources to limit the impact on native aquatic plant populations. 2,4-D is frequently used to target EWM (a dicot) over many other native plants (monocots).

However, large-scale treatments can result in significant damage to both monocots and dicots.

- Dicots susceptible to both 2,4-D and fluridone include native watermilfoils (particularly northern), bladderworts, water lilies, and coontail.
- Monocot species such as elodea, several narrow leaf pondweeds, and naiads are also impacted by fluridone and some 2,4-D use.
- Fewer natives are affected at lower dosages of herbicides.[28]

Wisconsin DNR research indicates that larger scale herbicide treatments seem to have more consistent reduction of both EWM and native plants than smaller treatments. These results are

[26] Susan Knight, Personal Communication with Noah Lottig.
[27] Thorstenson, Amy. Golden Sands Resource Conservation & Development Council, Inc. *Email communication.* November 2015.
[28] WDNR. Large Scale Treatment Research in Wisconsin PUB-SS-1077. 2011.

based upon data collection in many Wisconsin lakes where herbicides were used for EWM control. (Nault et al, 2015)[29]

Herbicides can dissipate off of a small treatment site very rapidly. 2,4-D dissipated rapidly after treatment after it was applied to 98 small (0.1-10 acre) treatment areas across 22 study lakes with application rates of 2-4 ppm. The following results were found:

- Initial 2,4-D concentrations detected in the water column were well below application targets.
- Herbicide moved quickly away from treatment sites within a few hours after treatment.
- 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)[30]

Recent studies indicate a need to consider the long-term effects of 2,4-D use. One is the effect of 2,4-D variants on the endocrine system and reproduction of fat head minnows (DeQuattro, 2015). There is also some evidence that hybrid EWM can acquire resistance to 2,4-D (LaRue et al, 2013). Hybrid EWM has not been identified in Connors Lake, but no sample has been submitted for analysis. Testing for hybrid EWM is recommended.

Statewide Eurasian Water Milfoil Management Results[31]

Of the lakes with Eurasian watermilfoil, the majority currently have populations at low frequencies, with relatively few lakes exhibiting very dense EWM growth. Historically, once EWM was first reported in a waterbody, many lake users perceived the waterbody as “infested” or “diseased” and were fearful that the invasive plant would quickly “kill” the lake or make it unusable.

To look at the current frequency of EWM in waterbodies across the state, researchers compiled the most recent aquatic plant point-intercept data on 397 lakes and flowages with EWM populations. Analysis of this data found that the majority of lakes surveyed had very low frequencies (less than 10 percent) of EWM observed in the littoral zone (area of the lake where there is enough light for plants to grow). This low frequency is below the level where most lake users would consider the plant to be a “nuisance.” Many of the waterbodies with very low frequencies were following aquatic plant management plans which included regular monitoring and control to prevent EWM spread.

However, other lakes with very low EWM populations had not undergone any active management, providing evidence that in certain lakes there may be environmental conditions that limit EWM’s ability to spread. In contrast, relatively few lakes had EWM observed as a dominant plant species, which could likely cause recreational and ecological impairments. Examination of lakes with high EWM frequencies revealed that while some of these lakes were not being actively managed, there were other lakes that were. The actively managed lakes with poor results should explore alternative management strategies.

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29 Nault, et. al., Control of Invasive Aquatic Plants on a Small Scale. Lakeline. 2015.
30 Nault, Michelle. Herbicide Treatment in Wisconsin Lakes. Lakeline 32. 2012.
31 Taken entirely from: Nault, Michelle. The Science Behind the So-Called Superweed. Wisconsin Natural Resources. August 2016.

In general, higher EWM populations tended to occur on reservoirs and flowages versus natural lakes, lakes in the south versus the north, and in lakes where EWM had been established longer versus newly established populations in lakes. This statewide data analysis illustrates that while EWM can undoubtedly become a dominant species capable of causing recreational and aesthetic nuisances in certain lakes, more often than not it does not exhibit these tendencies. Interestingly, this trend of nonnative species being "rarely common and commonly rare" has also been documented across many other invasive species, many for which control is not attempted.

Current and Past Plant Management Activities

Eurasian Water Milfoil Management

Eurasian water milfoil (EWM) was first identified in Connors Lake by WDNR Water Quality Specialist Craig Roesler on October 8, 2002. He surveyed the whole lake on June 18, 2003 and found 23 acres of Eurasian water milfoil growth. The CoPaPi (Connors Lake, Papoose Lake, and Lake of the Pines) Lake Association was formed on Labor Day 2003 in part as an effort to rally support for treating the EWM. The Lake Association was officially incorporated February 4, 2004 and became a Qualified Lake Association on August 29, 2006. An appeal to members of the Lake Association for EWM treatment raised approximately $16,500 in early 2004.

Herbicide Treatment

With the help of a matching grant of $8,510 from the Wisconsin Waterways Commission and assistance from the Sawyer County Land and Water Conservation Department, the Lake Association used 2-4-D to treat 32 acres of EWM in June 2005, 5 acres in September 2005, and 6 acres on July 24, 2006. On June 4, 2007 Northern Aquatic Services treated 9.8 acres of scattered beds of EWM with the herbicide 2,4-D at a cost of $5,500.

The Department of Natural Resources requires a pre and post monitoring protocol as a condition of permitting herbicide treatment of invasive aquatic plants.[32] The Sawyer County LWCD surveyed EWM in Connors Lake prior to and following treatment in June 2005. The lake association hired a private consultant to monitor the EWM beds in the fall of 2007. His results are shown in Figure 28 below.[33] Areas of the lake were targeted for monitoring based upon previously known locations of EWM from the point intercept survey DNR staff completed in 2005 and data from Sawyer County. A bed of EWM was identified if there was dense growth of the plant and the area was wide enough to navigate a boat around the perimeter. The conclusion of the survey was that EWM is common throughout Connors Lake. However, there were few dense beds. The total area of beds on Connors Lake was 41,699 ft^2 or 0.957 acres in October 2007. Treatment records indicate that 9.8 acres were ultimately treated in 2007.

[32] DNR Pre and post monitoring strategy. May 2007.
[33] Williamson, Jeremy. October 2007.

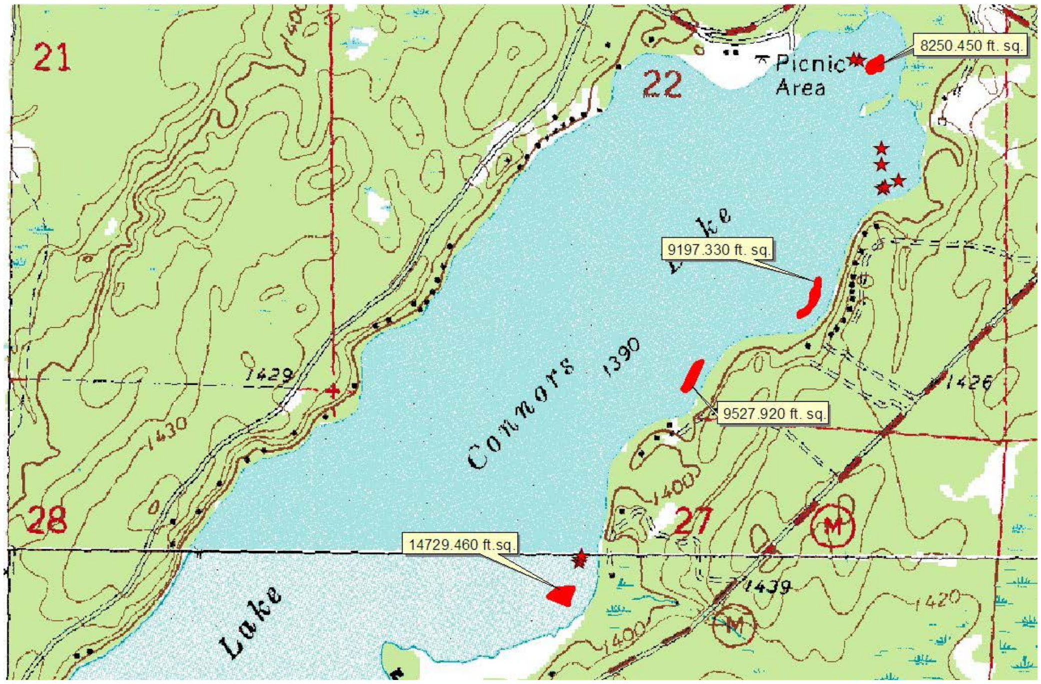


Figure 28. 2007 EWM Treatment Beds

The 2008 Aquatic Plant Management Plan which guided Connors Lake EWM management outlined a treatment strategy for various areas of lake. Each area had a "tolerance" designated for presence of EWM and resulting treatment strategy. The treatment strategy emphasized high levels of EWM removal in low tolerance areas and delaying herbicide treatment until EWM reached specific frequency and density thresholds prior to herbicide treatment. The strategy assumed that treatment as small as 500 square feet could be effective at removing EWM.

The 2008 plan strategy was clearly not followed in plan implementation. In fact, it appears that any amount of EWM was treated in any area of the lake where it was found. For example, in Musky Bay, a designated mid-tolerance area, beds as small as .07 acres with mean density of 1 were treated (2014). In fact, additional smaller "spot" treatments involved sprinkling granular 2,4-D over small clumps of plants in 2014 and other years.

Recommendations from WDNR and Project Consultants (2017)

- Conduct herbicide treatments early in the season prior to extensive native plant growth
- Eliminate any late season treatment of EWM to avoid impacts to natives
- Do not conduct spot herbicide treatments or use 2,4-D for small scale treatments (<3 acres)
- Consider contact herbicides such as diquat and endothall for small treatment areas
- Wait for high density growth prior to herbicide treatment
- Use hand-pulling methods to remove scattered EWM
- Follow treatment standards by zone as recommended in the 2017 plan

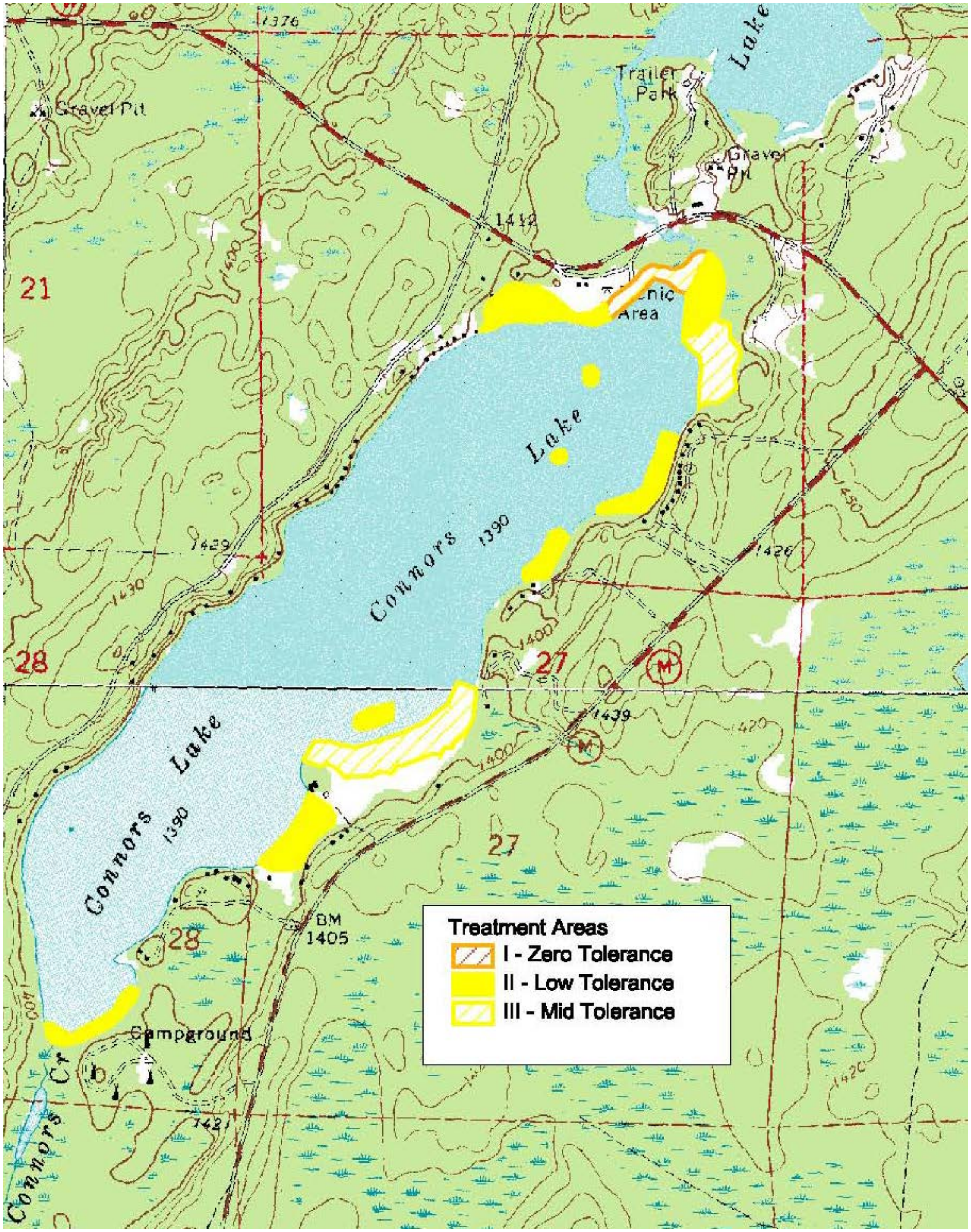


Figure 29. EWM Treatment Areas (from 2008 Aquatic Plant Management Plan)

Areas and Standards for EWM Herbicide Treatment (2008)

Class 1/Zero Tolerance Areas

Treatment standard = any plants visible

A bed of EWM has a EWM density of random rake measurements (according to DNR protocol) >1

Beds of EWM will have density >10% coverage

Treatment method =

- Hand pulling scattered plants in shallow water by lake association volunteers
- Diver pulling small populations (scattered plants and beds up to 500 square feet) – diver to be contracted if available and cost effective
- Herbicide treatment for beds >500 square feet

Class 2/Low Tolerance Areas

Treatment standard = scattered plants in beds to be treated

A bed of EWM has a EWM density of random rake measurements >1

Beds of EWM will have density >30% coverage

Treatment method =

- Residents encouraged to hand pull
- Herbicide treatment for beds >20,000 square feet

Class 3/Mid Tolerance Areas

Treatment standard = dense plants in beds to be treated

A bed of EWM has a EWM density of random rake measurements >2

Beds of EWM will have density >50% coverage

Treatment method =

- Herbicide treatment for beds >2 acres
- Buoys will mark outer boundary of these areas

NOTE – No herbicide treatment will occur until a threshold of area of EWM beds meeting above standards totals at least three to five acres. Note that even if an applicator treats on the lake because the acreage threshold is reached, not all areas will be treated. (If a class 2 or 3 area has small areas with low density growth that fall below the treatment standard, no herbicide would be used in this area).

Zero Tolerance Areas currently total 4.2 acres

Low Tolerance Areas currently total 27.0 acres

Mid Tolerance Areas currently total 18.6 acres

Table 14. Connors Lake EWM Treatments

Year	Acres	Concentration 2,4-D	Comments
2005 (June)	32		WI Waterways Commission grant ($8,510)
2005 (September)	5		
2006 (July)	5		
2007 (June)	9.8		$1,600 per acre
2009	28.8		Treatment not effective – compared to 2007 data
2010	18.74	175 lbs/acre (about 2ppm) granular	Frequency decreased 0.4 to 0.13
2011	0.22		Frequency decreased 1 to 0.31, new EWM areas
5/23/12	2.97		Frequency decreased 0.61 to 0.16, new EWM areas
6/26/12	Spot treat		Not evaluated
2013	4.73	4 ppm	Results not yet available
2013 (late July)	0.14	4 ppm	Spot treatments
7/9/14	0.85	4 ppm	6 spot treatment areas in Musky Bay
7/9/14	0.45	4 ppm	33 small spot treatments
2015 (June)	3.5	4 ppm	6 beds, only found in Musky Bay
2016	3.0		3 acres treated plus spot treatments

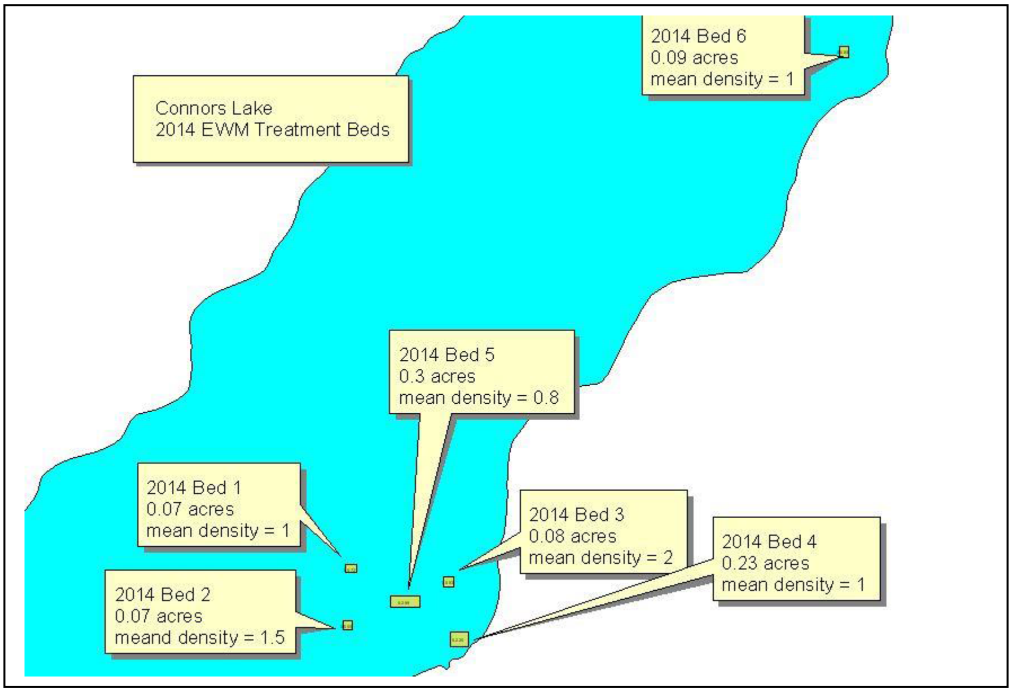


Figure 30. 2014 EWM Treatment Beds

Monitoring and Education

Volunteer Tom Stram monitors EWM growth in Connors Lake regularly (about six times) during the summer and has helped the applicator locate EWM for treatment.

In 2016 volunteers spent 40 hours at the Connors Lake North Access providing boater education under the Clean Boats, Clean Waters (CBCW) program. Former Board member Patty Peloquin managed the CBCW program for Connors Lake for several years and board member Dave Bauer recently assumed her duties. Volunteers from the Lake Association implement the CBCW program on the three major holiday weekends of the summer putting in an average total of 40 - 50 hours. Dave installed a large locked mailbox on the kiosk on Connors Lake to store the materials needed for documenting the boat inspections and handouts for the boaters. In addition, he prepared a special handout in 2017 warning boaters to specifically stay out of or travel at no wake in Muskie Bay where most of the EWM is located. The brochure also contains pertinent CBCW educational information. A few volunteers have stepped forward to start boat inspections on Lake of the Pines, and we are hopeful that they will become a regular occurrence in the near future.

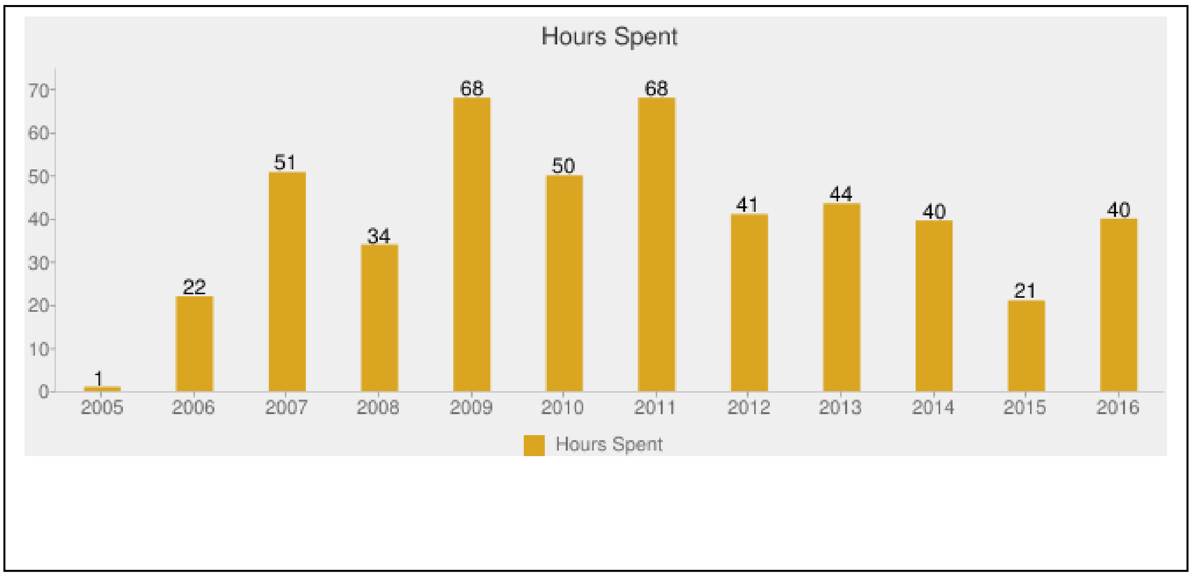


Figure 31. Connors Lake North Landing Clean Boats Clean Waters Hours

Access Corridor Management

There are no reports of herbicide use to maintain access corridors around docks and for swimming areas in front of individual properties on project lakes. Nor does the DNR have any records of complaints of nuisance plant conditions. This plan does not recommend any use of herbicides to manage native plant beds but instead, focuses on control and prevention of invasive species.

The Department of Natural Resources Northern Region Aquatic Plant Management Strategy (May 2007) requires documentation of severely 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.

Plan Goals and Strategies

Aquatic Plant Management Goals

Goal 1) Eurasian water milfoil growth is kept to a minimal level in Connors Lake.

Goal 2) Eurasian water milfoil does not establish and spread into Papoose Lake or Lake of the Pines.

Goal 3) No new aquatic invasive species are introduced and established in our lakes.

Goal 4) The lakes' diverse native plant communities are preserved.

Goal 5) Lake residents understand the importance of native aquatic plants, the means to protect them, and the threat of aquatic invasive species.

Goal 6) Aquatic plant management efforts are carried out in an efficient, cost effective manner.

Implementation for each goal is described on following pages. This includes objectives and actions to achieve each objective. An implementation plan that describes timeline, cost estimate, and responsible parties for each action item follows.

Goal 1) Eurasian water milfoil growth is kept to a minimal level in Connors Lake.

Objectives and Actions

Note that treatment areas mentioned below are shown on the map in Figure 33.

<u>Objective A. No detectable EWM near areas of high public use such as boat launches and high-use resorts.</u>

<u>Action.</u> Conduct treatment according to standards and methods outlined for Class 1/Zero Tolerance Areas.

<u>Action.</u> Contracted hand pulling methods such as DASH or SCUBA may be employed.

Objective B. Contain the growth of EWM in moderate and low public use areas of the lake with a less aggressive treatment approach.

Action. Conduct treatment according to standards and methods outlined for Class 2/Low Tolerance Areas and Class 3/Mid Tolerance Areas.

Action. Residents will be instructed regarding proper hand-pulling techniques: a) remove plant fragments: b) net or second person to collect; c) pull EWM: d) remove plant fragments and dispose of far away from the lake (composting is fine).

Objective C. Use the best available treatment technology for Eurasian water milfoil for effective treatment while minimizing impacts to native aquatic plants.

Action. Treat Eurasian water milfoil beds as identified in Objective A and B above only early in the season before significant native plant growth has begun.

Action. Treat EWM early in the day when the winds are calm.

Objective D. Identify location of EWM plants and beds and monitor effectiveness of treatment.

Action. Monitor EWM location and treatment effectiveness according to DNR recommended pre and post AIS monitoring methods.

Action. Use an establish grid of monitoring points in the Class 3/Mid Tolerance Areas.

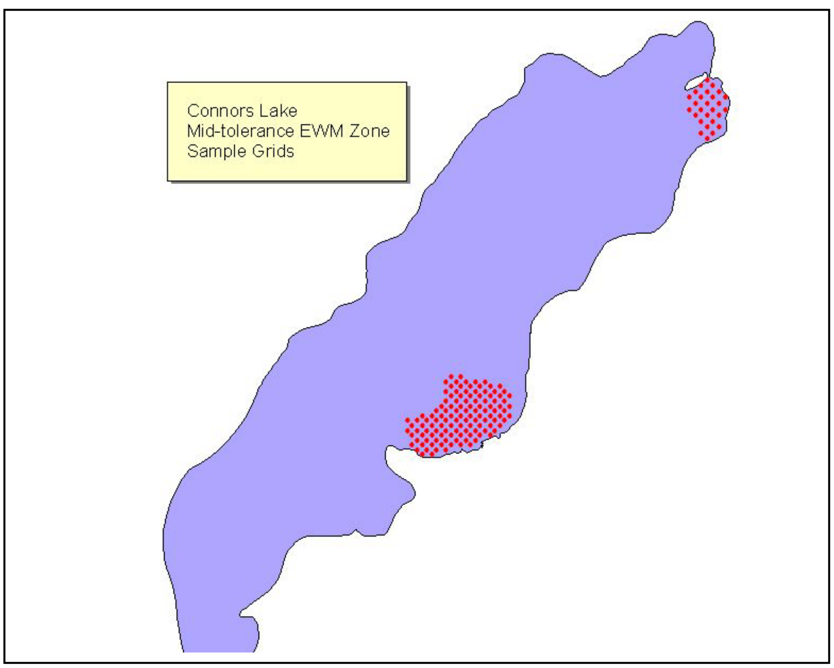


Figure 32. Class 3/ Mid Tolerance Area Monitoring Grids

Objective E. Co/Pa/Pi Lake Association will utilize lake association and public resources effectively and efficiently.

Action. Volunteers will regularly (every two weeks) monitor areas of high public use (Class 1/Zero Tolerance Areas) in Connors Lake and mark where EWM plants are located. *(Water quality volunteer might monitor when water chemistry samples are taken)*

Action. Volunteers or contractors will hand pull EWM in shallow areas of high public use in Connors Lake.

Action. Volunteers will monitor known locations of EWM in Connors Lake the first three weeks of May (approximately one month after ice-out) and one month following treatment, noting locations of EWM on a map and recording GPS points.

Action. Consultants will be hired to perform tasks that are beyond the ability or time commitment of volunteers.

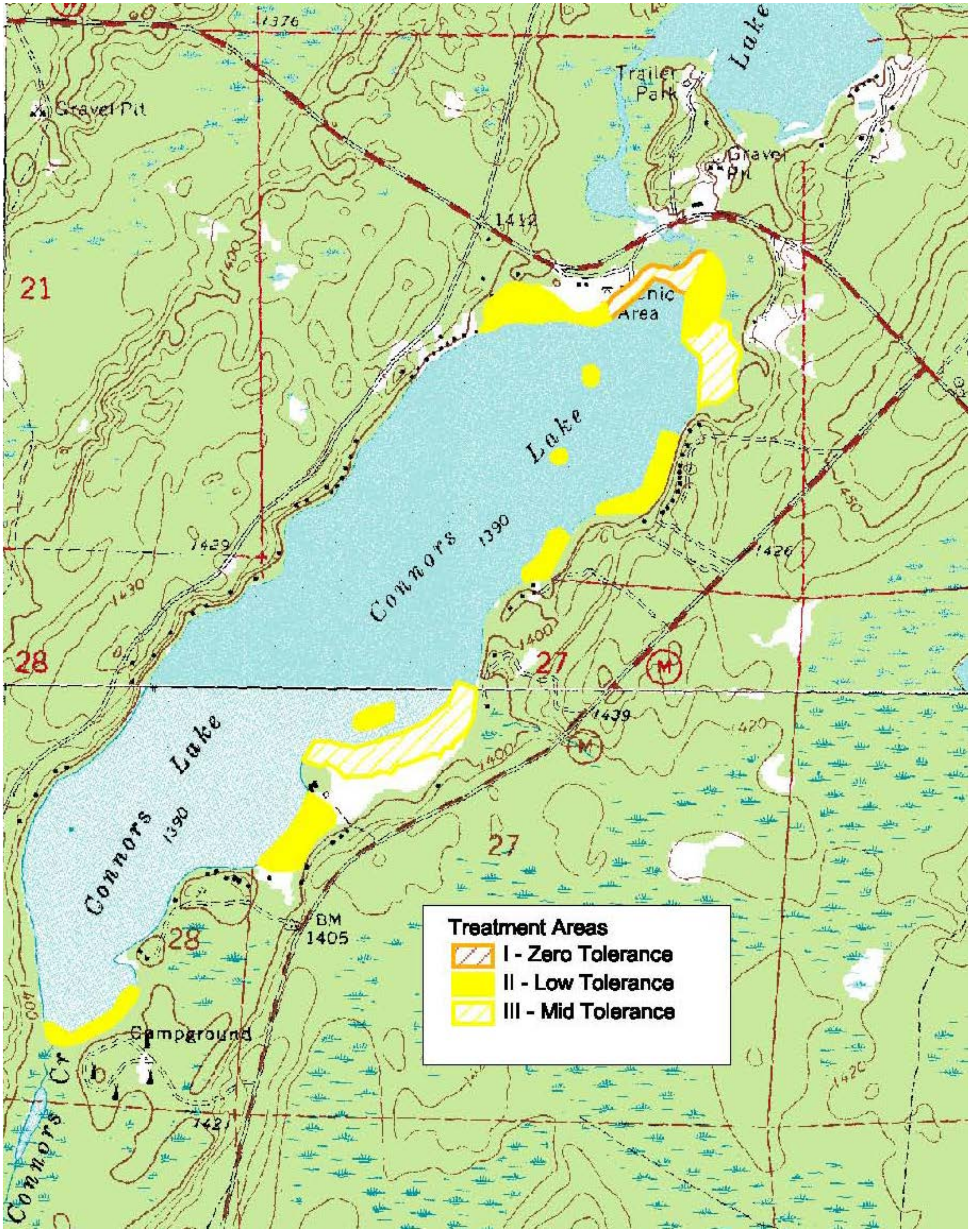


Figure 33. Eurasian Water Milfoil Treatment Areas (2017)

Areas and Standards for EWM Herbicide Treatment

Class 1/Zero Tolerance Areas
Treatment standard = any plants visible
A bed of EWM has a EWM mean rake density (according to DNR protocol) >1
Beds of EWM will have >10% frequency of occurrence
Treatment method =

- Diver pulling small populations (scattered plants and beds up to ½ acre) – divers to be contracted if available and cost effective. Use DASH or SCUBA.
- Herbicide treatment for beds >1/2 acre
- Contact herbicide such as diquat or diquat/endothall combination

Class 2/Low Tolerance Areas
Treatment standard = scattered plants in beds to be treated
A bed of EWM has a EWM mean rake density >1
Beds of EWM will have >30% frequency of occurrence
Treatment method =

- Diver pulling small populations (scattered plants and beds up to ½ acre) – divers to be contracted if available and cost effective. Use DASH or SCUBA.
- Herbicide treatment (2,4-D) for beds >3 acres

Class 3/Mid Tolerance Areas (Whole Bay Treatments)
Treatment standard = dense plants in beds to be treated
A bed of EWM has a EWM mean rake density of >1.5
Beds of EWM will have >50% frequency of occurrence
Treatment method =

- Herbicide treatment (2,4-D) for beds >14 acres (Musky Bay) or >7 acres (northeast bay)

Zero Tolerance Areas currently total 4 acres
Low Tolerance Areas currently total 27 acres
Mid Tolerance Areas currently total 24 acres

Schedule and roles for herbicide treatments[34]

Feb/March preceding treatment
Lake Association Board: Contract with herbicide applicator. Apply for aquatic plant management permit from DNR. Permit will be based upon potential acreage mapped in late summer of preceding year using standards for treatment of EWM areas listed previously.

Spring preceding treatment (First three weeks of May)
Volunteers: Check for presence of EWM in suspected locations and note GPS locations. Volunteers to notify Lead AIS volunteer of locations via email or telephone. Lead AIS volunteer to turn results into Monitoring Consultant.

Prior to treatment (late May)
Monitoring Consultant: check treatment areas that were mapped the previous late summer (with assistance of lead AIS volunteer) and provide specific treatment area and locations to herbicide applicator, lake association, and DNR permit staff.

Early season treatment (late May to early June)
Herbicide applicator: apply herbicide according to permit conditions prior to significant native aquatic plant growth. No late season herbicide treatments will be conducted.

Lead AIS volunteer: supervise herbicide applicator, notifying applicator when new EWM growth reaches one inch and overseeing permit conditions such as location and timing of treatment, and wind conditions that preclude treatment.

Four weeks following treatment (late June to early July)
Volunteers: mark suspected locations of remaining EWM with GPS points. Volunteers to notify Lead AIS volunteer of locations via email or telephone. Lead AIS volunteer to turn results into Monitoring Consultant.

Monitoring Consultant: Measure effectiveness of treatment according to DNR monitoring protocol (Monitoring Consultant).

Late Summer (with no herbicide treatment)
Volunteers: Identify additional potential EWM treatment locations using a map of previous EWM – note where EWM is present/suspected with GPS points.

Monitoring Consultant: Map EWM beds and location of individual plants along with species rake fullness at each sample point. Compare results to treatment standard and prepare potential treatment area for next season.

[34] All monitoring to be completed according to DNR pre and post treatment monitoring protocol which identifies 4-10 points per acre with aquatic plant species measured by rake fullness at a scale of 0-3. Outer boundaries of beds mapped with GPS points to create polygons.

Goal 2) Eurasian water milfoil does not establish and spread into Papoose Lake or Lake of the Pines.

Objective A. Prevent the introduction of EWM into Papoose Lake or Lake of the Pines.

Action. Ensure that public education efforts are in place to prevent the spread of EWM from Connors Lake and other nearby lakes – see goal # 5.

Action. Establish rapid response to identification of EWM in Papoose Lake or Lake of the Pines.

Objective B. Monitor Lake of the Pines regularly to rapidly identify any areas where EWM becomes established.

Action. Establish regular volunteer monitoring in areas of high public use and in areas where Northern water milfoil is present (Monitor once a month). High public use areas include the campgrounds, boat landings, and resorts mapped in Figure 1.

Action. Hire a consultant to complete an AIS Meandering Survey emphasizing areas of high public use and in areas where Northern water milfoil is present (annually).

Action. Complete point intercept survey of Papoose Lake when area is navigable and to coincide with a Connors Lake or Lake of the Pines point intercept survey.

Objective C. Remove any detectable EWM plants found in Papoose Lake or Lake of the Pines.

Action. Conduct treatment according to standards and methods outlined for Class 1/Zero Tolerance Areas.

Adaptive Management Approach

The EWM treatment areas, standards, and methods will be reviewed each year to see if they are effective and cost efficient. Changes may be made to the treatment approach based upon project results. Significant changes will be documented as brief addendums to the aquatic plant management plan to be reviewed by the Co/Pa/Pi board and the Department of Natural Resources.

Goal 3) No new aquatic invasive species are introduced and established in our lakes.

Objective A. Lake residents understand the threat of new invasive species and take action to minimize their spread.

Objective B. Lake residents can identify potential invasive species and/or know who to contact for identification.

Actions to be detailed under Goal #5.

Goal 4) The lakes' diverse native plant communities are preserved.

Objective A. Herbicide use selectively targets invasive species avoiding impacts to native plants.

Action. See Goals 1 and 2.

Objective B. Limit removal of native plants in waterfront corridors.

Action. Recommend hand removal only (not herbicides) if needed to maintain access for swimming and navigation.

Action. Limit hand clearing to a 30 foot access corridor except that invasive species may be removed along the entire shoreline by hand.

Objective C. Increase residents' and lake users' understanding about the role and importance of native plants and the means to preserve them.

Action. See Goal #5

Goal 5) Lake residents understand the importance of native aquatic plants, the means to protect them, and the threat of aquatic invasive species.

Audience

A. Lake residents
B. Lake users
C. Resort visitors

Messages

1. Include messages regarding the long-term nature of lake management.
2. Discuss the importance of native aquatic plants to the lakes and residents.
3. Describe how lake residents and users can best preserve native plants – no wake near shore, only limited clearing/raking for dock access and swimming, preventing introduction of invasive species, etc.
4. Lake residents may remove EWM from their entire shoreline without a permit using hand removal techniques like hand pulling or raking.
5. Be sure to remove all plant fragments when raking or hand pulling EWM. A second person to pick up or net plant fragments is recommended.
6. Dispose of EWM plant fragments well away from the water. It is fine to compost these plants.
7. A permit is required to use herbicides in the water. Fines may result if herbicides are applied in the water without the appropriate permit.
8. Affirm that lakes are public resources.
9. How to identify and prevent introduction of other aquatic invasive species. Explain which species are potential threats to our lakes. Include pictures for identification.
10. Volunteers are needed to help with aquatic plant management education and monitoring.
11. An aquatic plant management plan guides our plant management efforts.
12. It is not possible to eradicate Eurasian water milfoil once it is established in a lake. Our plan is geared to minimize the growth and spread of this invasive plant.
13. Explain past EWM treatment methods and results and how native plants are recovering where EWM was treated.
14. Encourage lake association membership to support aquatic plant management.

Actions

Newsletter articles (Co/Pa/Pi Lake Association)
Direct mail
Clean Boats, Clean Waters public landing monitoring and education
Kiosks at boat landings and campgrounds
Distribute DNR and UWEX publications.
Flambeau Forest newsletter (annually)
Annual and special meetings
Workshops/instruction (for hand pulling invasive species)

Table 15. Education Methods, Audience, and Messages

Method	Audience	Message
Newsletter articles	A	1-14
Direct mail	A	10, 14
Clean Boats, Clean Waters	A, B, C	1-14
Kiosks	A, B, C	1-14
DNR UWEX publications	A, B, C	1-14
Flambeau Forest newsletter	A, B, C	1-14
Annual and special meetings	A	1-14
Workshops/instruction	A	4, 5, 6, 9, 10

Goal 6) Aquatic plant management efforts are carried out in an efficient, cost effective manner.

Objective: Volunteer resources are used whenever feasible.

Action: Seek volunteers from lake residents.

Action. Provide appropriate training for lake volunteers.

Action: Acknowledge volunteer efforts through recognition in newsletter, thank you notes, and small gifts of appreciation.

Objective: Donations from lake residents supplement lake management funds.

Action: Solicit donations for EWM control efforts annually, summarizing control efforts and success to date.

Objective: Seek Department of Natural Resources Aquatic Invasive Species Grants.

Action. Apply for AIS control grant by February 1 if control efforts are identified.

Action. Apply for AIS education grant by December 10.

Implementation Plan

Action Items[35]	Timeline	Cost	Volunteer Hours	Responsible Parties
Eurasian Water Milfoil Management (Connors Lake)				
Apply for APM Permits	Feb/March Each treatment year	$150 - $500	5	Volunteers Contractor
Mark locations with EWM present	May/June August/Sept.		60	Volunteers
Conduct pre and post treatment monitoring	May July	$1,200		Consultant
Treat EWM according to plan standards	Late May/ Early June	$700 - $1,000/acre		Contractor
Notify contractor re: plant growth Supervise contractor	Late May/ Early June		8	Volunteers
Monitor high public use (Class 1) areas	Every 2 weeks		50	Volunteers
Hand pull EWM in Class 1 areas	June – August Every 2 weeks		40	Volunteers
Eurasian Water Milfoil Prevention (Lake of the Pines)				
Monitor high public use areas	June-August Every 2 weeks		50	Volunteers
Complete AIS Meander Survey	Annually	$1,000		Consultant

[35] See previous pages for action item detail.

Action Items[35]	Timeline	Cost	Volunteer Hours	Responsible Parties
Complete point intercept survey Papoose Lake	When navigable along with Connors (DNR survey date?) or LOP survey (2017)			Consultant DNR
Implement Educational Activities				
Lake association newsletter (email)	2 issues per year	$50		Volunteers
Clean boats, clean waters monitoring	Holiday weekends		50	Volunteers
Workshops	One per year		8	Volunteers AIS Coord.
Annual meeting			8	Volunteers
Direct mail distribution	As needed	$50	?	Volunteers
Funding Plan Activities				
Apply for DNR AIS grant	February and December deadlines	Up to $1,000		Consultant
Seek donations for AIS activities	Ongoing			Volunteers

Aquatic Invasive Species Grants

Department of Natural Resources Aquatic Invasive Species Grants are available to assist in funding the action items in the implementation plan. Grants provide up to 75 percent funding. AIS Education, Prevention, and Planning (AEPP), and Clean, Boats Clean Waters (CBCW) grants are due December 10 of each year. AIS Control (ACEI) grants are due February 1 of each year.

The CoPaPi Voluntary Lake Association currently has a 75 percent Planning and Education AIS grant. Grant AEPP 411-14 provides $18,482 from October 1, 2013 through December 31, 2017. The grant project scope includes monitoring for the EWM control program, a plant survey for Lake of the Pines, and the update of the aquatic plant management plan. Volunteer outreach and the Clean Boats Clean Water program provides grant match.

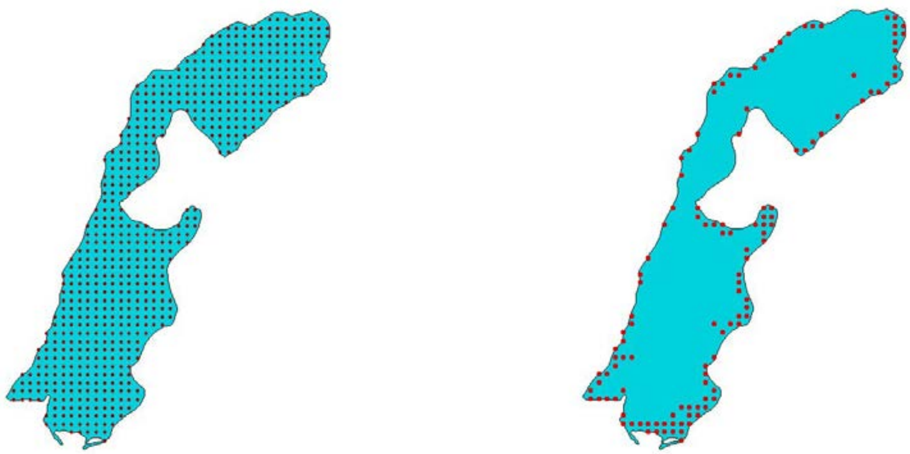
Previous Grants

The Lake Association received an education and planning AIS grant in 2007 and completed an aquatic plant management plan by May 2008. The Department of Natural Resources approved the aquatic plant management plan July 3, 2008. An AIS Control grant was awarded in 2008. The control grant ended December 31, 2013.

Appendix A. Lake of the Pines Point Intercept Survey Results August 2007

Plant Coverage

The full point intercept survey in August 2007 found that the plant coverage of Lake of the Pines was low (19.48 % with plants) with a fairly small littoral zone. Figure A-1 below shows the point grid for sampling as well as all points where plants were sampled.



Sample points Points with vegetation

Figure A-1. Lake of the Pines Sample Points and Points with Vegetation

Within the littoral zone, the coverage was fairly high, with 72.5 percent of the points below maximum depth of plants (11.3 feet) containing plants. The water clarity was relatively low and may explain the rather shallow depth where plants occurred. Table A-1 below contains data summarizing the survey.

Table A-1. Lake of the Pines Plant Survey Data Summary

Total points in grid	621
Points with vegetation	121
Points in littoral zone	167
Percentage of points with vegetation	19.48%
Frequency of plants in littoral zone	72.50%
Maximum depth with plants	11.6 ft
Simpson's diversity index	0.91
Average number of species/point	3.34

Plant Diversity

The survey reflected high plant diversity in Lake of the Pines. There were 32 species of macrophytes sampled and 4 species viewed for a total of 36. All species were native with 33 vascular plants and 3 species of algae. Table A-2 shows the list of species, the number of points where each species was sampled, and its frequency data. The Simpson's Diversity Index was

0.91, which indicates that two randomly sampled plants have a 91 percent probability of being different.

Plant diversity is reflected by the frequency statistics. Of the 32 species sampled, none dominated the lake. The most common plant, *Potamogeton robbinsii* (Robbins pondweed) is a desirable plant to have in a lake. With a relative frequency of 18.1 percent, it was the most common plant in Lake of the Pines, but only made up a rather small percentage of all the plants sampled.

Table A-2. Aquatic Macrophytes in Lake of the Pines

Species-Common Name	Sites	Frequency of Occurrence	Relative Frequency
Potamogeton robbinsii-Robbins pondweed	73	60.33	18.1
Potamogeton zosteriformis-Flat-stem pondweed	60	49.59	14.9
Najas flexilis-Bushy pondweed	50	41.32	12.4
Vallesneria americana-Wild celery	38	31.4	9.4
Schoenoplectus acutus-Hardstem bulrush	23	19.01	5.7
Nuphar variegata-Spatterdock	20	16.53	5
Myriophyllum sibiricum-Northern water-milfoil	19	15.7	4.7
Chara sp.-Muskgrass	17	14.05	4.2
Elodea canadensis-Common waterweed	17	14.05	4.2
Potamogeton gramineus-Variable pondweed	16	13.22	4
Potamogeton amplifolius-Large-leaf pondweed	13	10.74	3.2
Heteranthera dubia-Water star-grass	11	9.09	2.7
Nitella sp.-Nitella	7	5.79	1.7
Filamentous algae	5	4.13	1.2
Nymphaea odorata-White water lily	4	3.31	1
Pontederia cordata-Pickerelweed	3	2.48	0.7
Potamogeton foliosus-Leafy pondweed	3	2.48	0.7
Potamogeton richardsonii-Clasping-leaf pondweed	3	2.48	0.7
Brasneria schreberi-Watershield	2	1.65	0.5
Ceratophyllum demersum-Coontail	2	1.65	0.5
Juncus pelocarpus f submerse –Brown fruited rush	2	1.65	0.5
Potamogeton epihydrous-Ribbon-leaf pondweed	2	1.65	0.5
Potamogeton praelongus-White-stem pondweed	2	1.65	0.5
Potamogeton pusillus-Small pondweed	2	1.65	0.5
Potamogeton spirillus-Spiral-fruited pondweed	2	1.65	0.5
Sagittaria cuneata-Arum leaved arrowhead	2	1.65	0.5
Dulichium anundinaceum-3-way sedge	1	0.83	0.2
Equisetum fluviatile-Water horsetail	1	0.83	0.2
Aquatic moss	1	0.83	0.2
Polygonum amphibium-Water smartweed	1	0.83	0.2
Ranunculus aquatilis-Stiff water crowfoot	1	0.83	0.2
Schoenoplectus tabemaemontani-Softstem bulrush	1	0.63	0.2
Carex sp. -Sedge	6	viewed only	
Potamogeton illinoensis-Illinois pondweed	1	viewed only	
Sagittaria latifolia-Common arrowhead	1	viewed only	
Potentilla palustris-Marsh cinquefoil	1	viewed only	

The diversity at each point was high in Lake of the Pines at 3.34 species per point. The number of species at each point ranged from one to seven with a range of diversity scattered throughout the lake. Figure A-2 below shows the location and number of species at each point where plants were sampled.

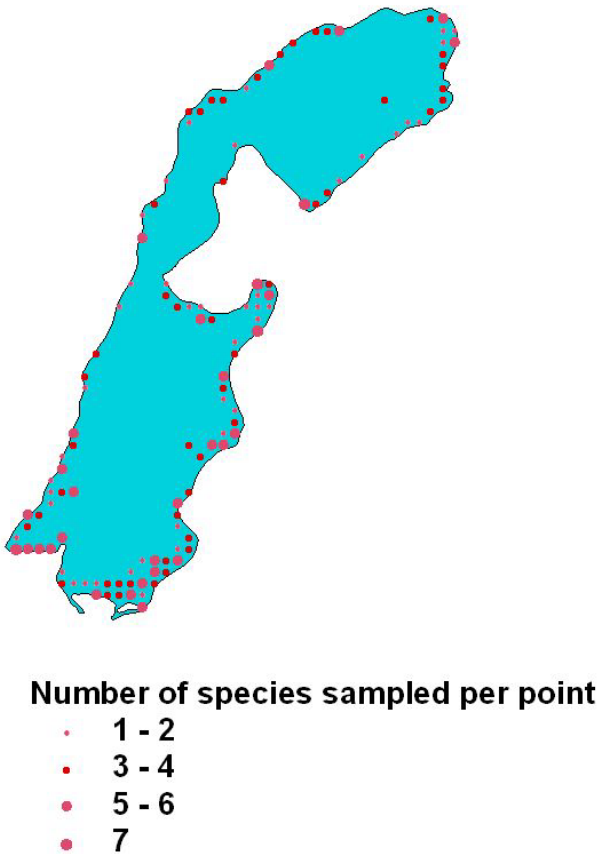


Figure A-2. Number of Species per Sample Point Lake of the Pines

Overview of Common Plant Species

Potamogeton robbinsii (Robbins pondweed) was the most common plant, followed by *Potamogeton zosteriformis* (flat-stem pondweed) and *Najas flexilis* (bushy pondweed) repectively. Robbins pondweed is a desirable plant, as it provides good habitat for fish and invertebrates. It is a rather intolerant to human disturbance, so its presence may indicate a relatively undisturbed plant community. Flat-stem pondweed provides good habitat and cover for fish as well as being an important food source for waterfowl and other wildlife. Bushy pondweed is also an important food source for waterfowl, and its fine leaves provide great cover for invertebrates.

Robbins pondweed

Flat-stem pondweed

Bushy pondweed

Figure A-3. Common Plants of Lake of the Pines

Hardstem bulrush

Spatterdock

White water lily

Watershield

Figure A-4. Emergent and Floating Plants

Emergent Plant Species in Lake of the Pines

Emergent plants such as cattail and bulrush have stems that protrude above the surface of the water and floating plants such as lily pads float on the surface. Emergent and floating plants provide cover and shade for aquatic organisms in the lake. Emergent and floating plants are quite common in Lake of the Pines, including the floating leaved plants *Nuphar variegata* (spatterdock) and *Nymphaea odorata* (white water lily). *Brasenia schreberi* (watershield) is another floating leaf plant present. The emergent plant *Schoenoplectus acutus* (hardstem bulrush) has a high frequency and borders nearly the entire shoreline. Hardstem bullrush plays an important role in holding substrate in place as well as reducing wave energy, thereby protecting the shoreline from erosion. It also provides nesting material for birds and muskrats, as well as great habitat for fish such as northern pike. Figure A-5 shows the location of all floating or emergent plant sampled or viewed. Because these plants provide very important habitat elements for many organisms in the lake, their protection is paramount.

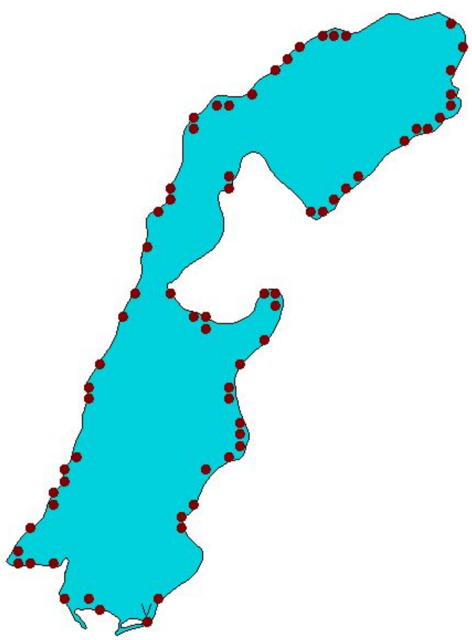


Figure A-5. Lake of the Pines Emergent and/or Floating Plant Locations

Floristic Quality Index

The floristic quality index reflects the reaction various plants may have had to disturbances that resulted in lower water quality and substrate changes, and therefore habitat changes. The higher the floristic quality, the less disturbed the lake is likely to be. If many of the plants present are intolerant to disturbance, the lake plant habitat is similar to pre-settlement conditions, and therefore has experienced little human disturbance. Table A-3 contains the floristic quality data for Lake of the Pines.

Table A-3. Floristic Quality Index Lake of the Pines

Floristic Quality Index Data	Lake of the Pines	Eco-region median
Number of species	33	13
Mean conservatism	6.33	6.7
FQI	36.38	24.3

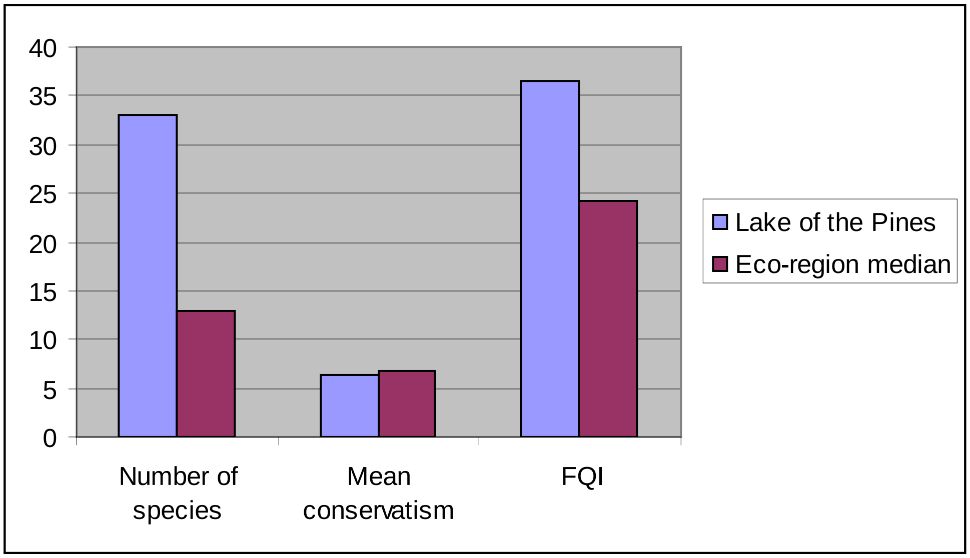


Figure A-6. FQI Comparison: Lake of the Pines and Median Lake in Eco-region

Lake of the Pines has a higher diversity and a higher FQI than the median for lakes in the same eco-region. The mean conservatism, which reflects the lake plants' tolerance to disturbance, is slightly below the mean for lakes in the eco-region. This may indicate some reaction to disturbance but could also be based on natural characteristics of the lake. Without previous baseline data, it is invalid to speculate about these values, especially when the differences are small. Increased diversity of plants increases the FQI value. The high value for Lake of the Pines supports the idea that the plant community is diverse with no significant indications of a declining plant ecosystem.

Invasive Species

No invasive species were located during the early season survey conducted in June 2007 for Lake of the Pines. This survey was conducted early in the summer to monitor for *Potamogeton crispus*, commonly known as curly leaf pondweed. The survey included viewing down to depths where plants are present from the surface with the aid of a viewfinder at 200 random points along the entire littoral zone.

No Eurasian water milfoil was found in Lake of the Pines. Special attention was made to locate this non-native plant during the survey because Connors Lake has EWM.

All milfoil sampled was northern water milfoil (*Myriophyllum sibiricum*) which is native to Wisconsin. The locations of the native northern water milfoil should be noted and monitored because EWM has very similar habitat needs and will often occupy areas northern water milfoil is growing or was once growing. Figure A-7 shows that northern milfoil distribution is quite widespread and may indicate that EWM could potentially have widespread distribution if it should enter Lake of the Pines.

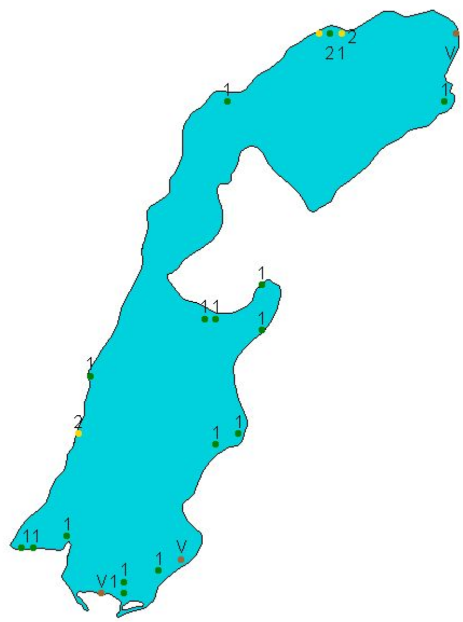


Figure A-7. Northern Water Milfoil (Myriophyllum sibiricum) Distribution (number denotes rake fullness rating at each point).

Recommendations

Lake of the Pines aquatic macrophyte community is healthy, diverse and composed only of native species. A good variety of macrophyte species were sampled at many points.

Preserving the native plant community should be considered during any management practice. Plants provide invaluable habitat and food for fish and wildlife as well as protection of lake water quality. Therefore, it is important to maintain a healthy, diverse plant community in Lake of the Pines. The lake ecosystem will continue to thrive if this quality plant community is managed responsibly. Small stands of diverse, emergent, and floating plants provide crucial habitat for wildlife and fish in addition to stabilizing bottom and shoreline sediments.

Appendix B. Aquatic Plant Survey Methods

Introduction

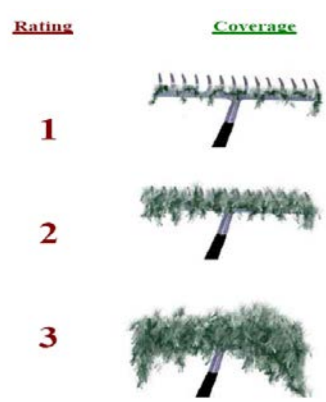
In June and August 2007, a macrophyte survey was conducted on Lake of the Pines (WBIC: 2275300) in Sawyer County, Wisconsin. Lake of the Pines is a 237-acre lake with a maximum depth of 39 feet. Development around the lake is limited with most all of the lakeshore being natural and wooded.

This report presents a summary and analysis of data collected in a baseline aquatic macrophyte survey. The primary goal of the survey is to establish a baseline for long-term monitoring of aquatic plant populations and allow for the evaluation of any changes that may occur long-term. This survey is acceptable for aquatic plant management purposes.

Field Methods

A point intercept method was employed for the macrophyte sampling. The Wisconsin Department of Natural Resources (Wisconsin DNR) generated the sampling point grid of 621 points. Only points shallower than 25 feet were initially sampled until the maximum depth of plants could be established. If no plants were sampled at a specific depth, one sample point beyond that depth was sampled for plants. In areas such as bays that appear to be under-sampled, a boat survey was conducted. This involved going to the area and surveying that area for plants, 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 six feet of the boat was recorded. 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-foot resolution and the location arrow touching the point.

At each sample location, a double-sided fourteen-tine rake was used to rake a one meter tow off the bow of the boat. All plants contained on the rake and those that fell off of the rake were identified and rated as to rake fullness. The rake fullness value was used based on the criteria contained in the diagram and table that follow. Those plants that were within six feet were recorded as “viewed,” but no rake fullness rating was given.



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 bottom type was also recorded for each sample point. All plants needing verification were bagged and cooled for later examination. Each species was mounted and pressed for a voucher collection. 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.

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 sample points
- 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 number of total sites. There can be two values calculated for this. The first is the percentage of all sample points that this plant was sampled at depths less then maximum depth plants were found (littoral zone), regardless if vegetation was present. The second is the percentage of sample points where the plant was sampled out of only points containing vegetation. The first value shows how often the plant would be encountered in the defined littoral zone, while the second value considers only points that contain plants. In either case, the greater this value, the more frequent the plant is in the lake. If one wants to compare plants within the littoral zone, we look at the frequency of all points below maximum depth with plants. This frequency value allows the analysis of how common plants are where they could grow. If one wants to focus only on where plants are actually present, then one would look at 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% within 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 where plants actually grow. Generally the second will have a higher frequency.

Relative frequency

This value shows, as a percentage, 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 allows us to see which of the plants are the dominant species in the lake. The higher the relative frequency, the more common the plant is compared to the other plants.

Total sample points

This is the total number of points created for sampling on the lake. This may not be the same as the actual points sampled. When doing a survey, we do not sample at depths outside of the littoral zone (the area where plants can grow). Once the maximum depth of plants is established, many of the points deeper than this are eliminated to save time and effort.

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

So one can see that Plant D is the most frequently sampled at all points with 60% (6/10) of the sites having plant D. However, the relative frequency allows us to see what the frequency is compared the other plants, without taking into account the number of sites. It is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. If we add all frequencies (3+5+2+6), we get a sum of 16. We can 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%

Now we can compare the plants to one another. Plant D is still the most frequent, but the relative frequency tells us 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 we sampled Plant D at 6 of 10 sites, we were sampling many other plants too, thereby giving a lower frequency when compared to those other plants. This then gives a true measure of the dominant plants present.

Sample sites with vegetation

The number of sites where plants were actually sampled. This gives a good idea of the plant coverage of the lake. If 10% of all sample points had vegetation, it implies about a 10% coverage of plants in the whole lake, assuming an adequate number of sample points have been established. We also look at 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

Simpson's diversity index is calculated to measure the diversity of the plant community. This value can run from 0 to 1.0. The greater the value, the more diverse the plant community is in a particular lake. 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 more diverse the plant community, the better the lake ecosystem.

Simpson's diversity example:

If one sampled a lake and found just one plant, the Simpson's diversity would be "0." This is because if we randomly sampled two plants, 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 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. Results include 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 found 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 high 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. The FQI is calculated using the number of species and the average conservatism value of all species used in the index. The formula is:

$$FQI = \text{Mean } C \cdot \sqrt{N}$$

Where C is the conservatism value and N is the number of species.

Therefore, a higher FQI, indicates a healthier aquatic plant community. This value can then be compared to the mean for other lakes in the assigned eco-region. There are four ecoregions used throughout Wisconsin. These are Northern Lakes and Forests, Northern Central Hardwood

Forests, Driftless Area, and Southeastern Wisconsin Till Plain. Lake of the Pines is in the Northern Lakes and Forest eco-region.

Summary of Northern Lakes and Forest Median Values for Floristic Quality Index:

Mean species richness = 13

Mean conservatism = 6.7

Mean Floristic Quality = 24.3*

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

Floristic Quality Index

The floristic quality index reflects the reaction the plant community may have had to disturbances leading to lower water quality, substrate changes, and therefore habitat changes for various plants. The higher the floristic quality, the less disturbed the lake is likely to be. If many of the plants present are intolerant species, the lake plant habitat should reflect pre-settlement conditions and little human disturbance. Table B-1 contains the floristic quality data for Lake of the Pines.

Table B-1. List of Species used for FQI and Conservatism Values

Species	Common Name	C
Dulichium arundinaceum	**Three-way sedge**	9
Pontederia cordata	**Pickerelweed**	9
Juncus pelocarpus f. submersus	**Brown fruited rush**	8
Potamogeton epihydrus	**Ribbon-leaf pondweed**	8
Potamogeton praelongis	**White-stem pondweed**	8
Potamogeton robbinsii	**Robbins pondweed**	8
Potamogeton spirillus	**Spiral-fruited pondweed**	8
Sagittaria cuneata	**Arum leaved arrowhead**	7
Brasenia schreberi	**Watershield**	7
Chara sp.	**Muskgrasses**	7
Equisetum fluviatile	**Water horsetail**	7
Myriophyllum sibericum	**Northern water-milfoil**	7
Nitella sp.	**Nitella**	7
Potamogeton amplifolius	**Large-leaf pondweed**	7
Potamogeton gramineus	**Variable pondweed**	7
Potamogeton pusillus	**Small pondweed**	7
Ranunculus aquatilis	**Stiff water crowfoot**	7
Najas flexilis	**Bushy pondweed**	6
Nuphar variegata	**Spatterdock**	6
Nymphaea odorata	**White water lily**	6
Potamogeton foliosus	**Leafy pondweed**	6
Potamogeton illinoensis	**Illinois pondweed**	6
Potamogeton zosteriformis	**Flat-stem pondweed**	6
Vallisneria americana	**Wild celery**	6
Zosterella dubia	**Water star-grass**	6
Carex comosa	**Bottle brush sedge**	5
Polygonum amphibium	**Water smartweed**	5
Potamogeton richardsonii	**Clasping-leaf pondweed**	5
Schoenoplectus acutus	**Hardstem bulrush**	5
Schoenoplectus tabernaemontani	**Softstem bulrush**	4
Ceratophyllum demersum	**Coontail**	3
Elodea canadensis	**Common waterweed**	3
Sagittaria latifolia	**Common arrowhead**	3

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Appendix C. Invasive Species Information

Curly Leaf Pondweed

Curly leaf pondweed is specifically designated as an invasive aquatic plant (along with Eurasian water milfoil and purple loosestrife) to be the focus of a statewide program to control invasive species in Wisconsin. Invasive species are defined as a "non-indigenous species whose introduction causes or is likely to cause economic or environmental harm or harm to human health (23.22 c)."

The Wisconsin Comprehensive Management Plan for Aquatic Invasive Species describes curly leaf pondweed impacts as follows:

> It is widely distributed throughout Wisconsin lakes, but the actual number of waters infested is not known. Curly-leaf pondweed is native to northern Europe and Asia where it is especially well adapted to surviving in low temperature waters. It can actively grow under the ice while most plants are dormant, giving it a competitive advantage over native aquatic plant species. By June, curly-leaf pondweed can form dense surface mats that interfere with aquatic recreation. By mid-summer, when other aquatic plants are just reaching their peak growth for the year, it dies off. Curly-leaf pondweed provides habitat for fish and invertebrates in the winter and spring when most other plants are reduced to rhizomes and buds, but the mid-summer decay creates a sudden loss of habitat. The die-off of curly-leaf pondweed also releases a surge of nutrients into the water column that can trigger algal blooms and create turbid water conditions. In lakes where curly-leaf pondweed is the dominant plant, the summer die-off can lead to habitat disturbance and degraded water quality. In other waters where there is a diversity of aquatic plants, the breakdown of curly-leaf may not cause a problem.[36]

The state of Minnesota DNR web site explains that curly leaf pondweed often causes problems due to excessive growth. At the same time, the plant provides some cover for fish and some waterfowl species feed on the seeds and winter buds.[37]

The following description is taken from a Great Lakes Indian Fish and Wildlife Commission handout.

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[36] Wisconsin's Comprehensive Management Plant to Prevent Further Introductions and Control Existing Populations of Aquatic Invasive Species. Prepared by Wisconsin DNR. September 2003.
[37] Information from Minnesota DNR (www.dnr.state.mn.us/aquatic_plants).

Curly Leaf Pondweed (*Potamogeton crispus*)[38]

Identification

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 one to three 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 two 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 vegetatively. 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, they germinate in the fall, over-wintering as a small plant. The next summer they 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.

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.

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

Curly leaf pondweed 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[39]

The control of Eurasian water milfoil in Connors Lake is critical because of the high use and recreational value of Connors Lake and connected Lake of the Pines. EWM control is also important because these waters flow directly to the Flambeau River and to several impoundments downstream. All of these areas are integral parts of the state forest, and further spread of Eurasian water milfoil in this water system is of great concern.

Department of Natural Resource scientists have found Eurasian water milfoil in other Sawyer County lakes including Callahan, Clear, Little Round, Mud, Osprey, Round, and Lake Chippewa and the Raddison flowage. Other lakes with EWM present in nearby counties include in Bayfield (Eagle Lake, Hart Lake, Sand Bar Lake, Tomahawk Lake, Twin Bear Lake, and the Washburn Harbor of Lake Superior), in Ashland (Chequamegon Bay of Lake Superior), in Washburn (Nancy Lake and the Totagatic River), and in Price County (Duroy Lake, Elk Lake, Grassy Lake, Lac Sault Dore, Long Lake, and Wilson Lake).

The following Eurasian water milfoil information is taken from a Wisconsin DNR fact sheet.

Identification

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

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

surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, Eurasian water milfoil is nearly impossible to distinguish from Northern water milfoil. Eurasian water milfoil has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.

Characteristics

Eurasian water milfoil grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lakebeds, lakes 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.

Reproduction and dispersal

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

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

Ecological impacts

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

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

Control methods

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

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

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

Purple Loosestrife (*Lythrum salicaria*)[40]

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 4-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 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

[40] Wisconsin DNR Invasive Species Factsheets from http:/dnr.wi.gov/invasives.

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. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. 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 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 uninfested 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. Large plants with multiple stems and brittle roots often do. Dispose of plants as described above.
Follow-up treatments are recommended for at least three years after removal.

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. 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.

Chemical Control

This is usually the best way to eliminate PL quickly, especially with mature plants. 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. Generally, the formula designed for use on wet sites should be used. 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: 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. Currently, glyphosate is the most commonly used chemical for killing loosestrife. 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 very carefully targeted foliar applications of herbicide (NOT broadcast spraying). This may reduce costs for sites with very 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.

You must obtain a permit 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 a permit. He will want to know about your site, may make control suggestions, and will issue the permit.

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 DNR, 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 marmoratu*s) 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.

Appendix D. Management Methods

Discussion of Management Methods

Techniques to control the growth and distribution of aquatic plants are discussed in following text. The application, location, timing, and combination of techniques must be considered carefully.

Permitting Requirements

The Department of Natural Resources regulates the removal of aquatic plants when chemicals are used, when plants are removed mechanically, and when plants are removed manually from an area greater than 30 feet in width along the shore. The requirements for chemical plant removal are described in Administrative Rule NR 107 – Aquatic Plant Management. A permit is required for any aquatic chemical application in Wisconsin. This includes granular herbicides available through mail order and internet purchase. A Department of Agriculture, Trade, and Consumer Protection pesticide applicator certification (aquatic nuisance control category) is required to apply liquid chemicals in the water.

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 limited to a 30-foot corridor. A riparian landowner may also manually remove the invasive plants Eurasian water milfoil, curly leaf pondweed, and purple loosestrife along his or her shoreline without a permit. Manual removal means the control of aquatic plants by hand or hand–held devices without the use or aid of external or auxiliary power.[41]

Manual Removal[42]

Manual removal involving hand pulling, cutting, or raking plants will effectively remove plants from small areas. It is likely that plant removal will need to be repeated during the growing season. The best timing for hand removal of herbaceous plant species is after flowering but before seed head production. For plants that possess rhizomatous (underground stem) growth, pulling roots is not generally recommended since it may stimulate new shoot production. Hand pulling is a strategy recommended for rapid response to a Eurasian water milfoil establishment and for private landowners who wish to remove small areas of curly leaf pondweed growth. Raking can be used to clear nuisance growth in riparian area corridors up to 30 feet wide. Recent costs for hand-pulling EWM using divers on Minocqua and Kawaguesaga Lakes in Oneida County were about $28,000 to remove an estimated <4,000 lbs.

Hand pulling requires good enough water clarity to identify plants prior to pulling. In Cedar Lake (St. Croix County) hand pulling of EWM was not an option in 2015 because of poor clarity. In

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[41] More information regarding DNR permit requirements and aquatic plant management contacts is found on the DNR web site www.dnr.wi.gov.

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

2016, SCUBA divers hand pulled some plants following the herbicide treatment. However, water clarity was very limited, and plants were difficult to find. Hand pulling with divers is an option for Connors Lake.

Mechanical Control

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

Aquatic plant harvesters are floating machines that cut and remove vegetation from the water. The cutter head uses sickles similar to those found on farm equipment, and generally cut to depths from one to six feet. A conveyor belt on the cutter head brings the clippings onboard the machine for storage. A harvester can also be used to gather dislodged, free-floating plant fragments such as from coontail or wild celery. 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.

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

Aside from the obvious effort and expense of harvesting aquatic plants, there are 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. Sediment suspension and shoreline erosion may therefore increase. Other organisms such as fish, reptiles, and insects are often displaced or removed from the lake in the harvesting process. This may have adverse effects on these organisms' populations as well as the lake ecosystem as a whole.

While the results of harvesting aquatic plants may be short term, the negative consequences are not so short lived. Much like mowing a lawn, harvesting must be conducted numerous times throughout the growing season. Although the harvester collects most of the plants that it cuts, some plant fragments inevitably persist in the water. This may allow the invasive plant species such as Eurasian water milfoil 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 cost and time efficiency of the operation.

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, it 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 it enters the lake. Since contracted 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. One must also consider prevailing winds, since cut vegetation can be blown into open areas of the lake or along shorelines. Harvesting is not recommended for Connors Lake at this time.

Diver dredging operations use pump systems to collect plant and root biomass. The pumps are mounted on a barge or pontoon boat. The dredge hoses are from 3 to 5 inches in diameter and are handled by one diver. The hoses normally extend about 50 feet in front of the vessel. Diver dredging is especially effective against 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 be formed from this type of operation. Fragmentation is not as great a problem when infestations are small. Diver dredging operations may need to be repeated to be effective. When applied toward a pioneering infestation, control can be complete. However, periodic inspections of the lake should be performed to ensure that all the plants have been found and collected.

Lake substrates can play an important part in the effectiveness of a diver dredging operation. Soft substrates are very easy to work in. Divers can remove the plant and root crowns with little problem. Hard substrates, however, pose more of a problem. Divers may need hand tools to help dig the root crowns out of hardened sediment.

Diver Assisted Suction Harvesting (DASH)

With Diver Assisted Suction Harvesting (DASH) divers hand pull aquatic invasive plants from the lake-bed. A suction line transports removed plants to the surface. This method is probably most appropriate for relatively small and less dense areas of invasive plant growth. Poor water clarity will make it more difficult to use DASH.[43]

The Tomahawk Lake Association (TLA) developed and has used a DASH system for several years, although they call their system a hydraulic conveyor system (HCS). HCS is an automated system that removes, filters, and bags harvested EWM after it has been hand harvested from the lake bed by divers. The TLA HCS includes a floating chassis, a “jet pump” water system, a three tiered separation system, and a Hookah diver air supply system.[44] Use of the TLA HCS began in the summer of 2007. A second generation HCS began operation in 2011. Capital costs for the system are just over $25,000 and annual operating costs are about $31,000. The TLA harvested about 20,000 lbs. each year through 2014.

D-1. TLA Hydraulic Conveyor System (Greedy)

Because of the mechanical elements of the system, a WDNR aquatic plant management harvesting permit is required. Contracted DASH systems are available. Decontamination of the system is especially important with a contracted DASH system that moves between lakes. A DASH trial might be considered for Connors Lake. A recent estimate for 2017 from a contractor

43 Wisconsin Lakes Convention Presentation. 2016.
44 Wisconsin Lakes Convention presentation, TLA Hydraulic Conveyor System. Ned Greedy, 2014.

was $2,500/day with harvesting amounts varied with total EWM acreage and density. With high density, the contractor reported removing 3,000 pounds in a single day.[45]

Rotovation involves using large underwater rototillers to remove plant roots and other plant tissue. Rotovators can reach bottom sediments to depths of 20 feet. Rotovating may significantly affect non-target organisms and water quality as bottom sediments are disturbed. However, the suspended sediments and resulting turbidity produced by rotovation settles fairly rapidly once the tiller has passed. Tilling sediments that are contaminated could possibly release toxins to the water column. If there is any potential of contaminated sediments in the area, further investigation should be performed to determine potential impacts from this type of treatment. Tillers do not operate effectively in areas with many underwater obstructions such as trees and stumps. 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[46]

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 native pests to the target invasive organism, the exotic invasive species may be maintained at lower densities.

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, as well as plant-specific control. On the other hand, there are several disadvantages to consider, including very long control times of years instead of weeks, lack of available agents for particular target species, and relatively narrow environmental conditions for success.

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

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45 TSB Lakefront Restoration Email Communication. January 2017.

46 Information from APIS (Aquatic Plant Information System) U.S. Army Corps of Engineers. 2005 except as otherwise noted.

Eurasian Water Milfoil Biocontrol

A potential management method for EWM is the use of the native weevil *Euhrychiopsis lecontei*. This weevil has a larvae stage that feeds on both native milfoils and Eurasian water milfoil. The larvae tunnel into the stem causing the plant to presumably lose the ability to transport nutrients and gases. *E. lecontei* adults swim and climb from plant to plant, feeding on leaflets and stem material. After mating, the female lays an average of 1.9 eggs a day, usually 1 egg per watermilfoil apical meristem (growing tip). One female may lay hundreds of eggs in her lifetime. The eggs hatch, and the larvae first feed on the apical meristem and then mine down into the stem of the plant, consuming internal stem tissue. Weevils pupate inside the stem in the pupal chamber, a swelled cavity in the stem. Adults emerge from the pupal chamber to mate and lay eggs. In the autumn, adults travel to the shore where they over-winter on land. In the laboratory, *E. lecontei* take 20 to 30 days to complete 1 life cycle, depending on water temperatures. For complete development, weevils require about 310 degree-days with temperatures above 10 degrees C. Two to four generations per year are generally observed in the field.[47]

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

The Minocqua and Kawaguesaga Lakes Protection Association experimented with a weevil program for six areas infested with Eurasian Water Milfoil beginning in 2008. The weevils showed little effect on EWM growth when monitored in 2010. Herbicide treatment began in one of the six beds because of concern for EWM expansion. In 2011 the weevil augmentation results were showing some positive results with small decreases in both frequency and in density of EWM. However, a second bed was switched to herbicide treatment for 2012 because of expansion of EWM growth. Then in 2012, both frequency and density were back to levels seen in 2010 (density) and prior to 2010 (frequency). Beginning in 2012, any bed that met the criteria for herbicide treatment was treated and reliance on the weevil program was essentially discontinued. (Schieffer, 2012). The results reported for Minocqua and Kawaguesaga Lakes are consistent with DNR research that indicates weevils are not an effective solution in Northern Wisconsin.[48]

Results for use of weevils for a nearby St. Croix County lake, Perch Lake are more positive. Milfoil weevils were raised by Beaver Creek Reserve and stocked into Perch Lake in 2013 and 2014 as a biocontrol tool for EWM. During this time, volunteers raised over 20,000 weevils and put them into Perch Lake. 2014 records showed weevil damage evident in 22-42% of stem samples collected in EWM beds, depending on bed. Weevils were present at a rate of 0.24 N/stem. Control has been documented (Newman) at as low as 0.22 N/stem. EWM had decreased significantly in 2014.[49]

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[47] *Euhrychiopsis lecontei* fact sheet. Cornell University Research Ponds Facility. < http://www.eeb.cornell.edu/ponds/weevil.htm>

[48] Susan Knight, Personal Communication with Noah Lottig.

[49] Thorstenson, Amy. Golden Sands Resource Conservation & Development Council, Inc. *Email communication.* November 2015.

Current plans are for WDNR Water Resources staff to continue to conduct aquatic plant surveys on an annual basis in Perch Lake to monitor the effectiveness of the milfoil weevils as a biocontrol of EWM. It is not certain how long this support will continue.

A weevil biocontrol program for EWM might be considered for Connors Lake over the long term.

Purple Loosestrife Biocontrol[50]

Biocontrol may be the most viable long term control method for purple loosestrife control. The WDNR and University of Wisconsin-Extension (UWEX), along with hundreds of citizen cooperators, have been introducing natural insect enemies of purple loosestrife from its home in Europe to infested wetlands in the state since 1994. Careful research has shown that these insects are dependent on purple loosestrife and are not a threat to other plants. Insect releases monitored in Wisconsin and elsewhere have shown that these insects can effectively decrease purple loosestrife size and seed output, thus letting native plants reduce its numbers naturally through enhanced competition.

A suite of four different insect species has been released as biological control organisms for purple loosestrife in North America and Wisconsin. Two leaf beetle species called "Cella" beetles that feed primarily on shoots and leaves were the first control insects to be released in Wisconsin, and are the insects available from WDNR for citizens to propagate and release into their local wetlands. A root-mining weevil species and a type of flower-eating weevil have also been released and are slowly spreading naturally. The Purple Loosestrife Biocontrol Program offers cooperative support, including free equipment and starter beetles from WDNR and UWEX, to all state citizens who wish to use these insects to reduce their local purple loosestrife.

The length of time required for effective biological control of purple loosestrife in any particular wetland ranges from one to several years depending on such factors as site size and loosestrife densities. The process offers effective and environmentally sound control of the plant, not elimination, in most cases. It is also typically best done in some combination with occasional use of more traditional control methods such as digging and herbicide use. Biocontrol with beetles may be appropriate at some point in time should purple loosestrife become established around Connors Lake.

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). Re-vegetation following plant removal is probably not necessary on Connors Lake because a healthy, diverse native plant population is present.

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[50] http://dnr.wi.gov/topic/Invasives/loosestrife.html

Physical Control[51]

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.

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 very 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. It is best used as a lake remediation technique.

Dredging is not suggested for Connors Lake as part of the aquatic plant management plan.

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. It 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 one to two 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). Drawdown requires a mechanism to lower water levels. Drawdown is not a viable option for Connors Lake.

Although drawdown is inexpensive and has long-term effects (2 or more years), it also has significant environmental effects and may interfere with use and intended function (e.g., power generation or drinking water supply) of the water body during the drawdown period. Lastly, species respond in very different manners to drawdown and often not in a consistent fashion (Cooke 1980a). Drawdowns may provide an opportunity for the spread of highly weedy species, particularly annuals.

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

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

decomposition of plants and sediment decomposition collect under and lift the barrier (Gunnison and Barko 1992). Benthic barriers will typically kill plants under them within one to two months, after which 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, benthic barriers are too expensive to use over widespread areas, and they heavily affect benthic communities by removing fish and invertebrate habitat. A Department of Natural Resources permit would be required for a benthic barrier which is not recommended for Connors Lake.

Shading or light attenuation reduces the light plants need to grow. Shading has been achieved by fertilization to produce algal growth, by application of natural or synthetic dyes, shading fabric, or covers, and by establishing shade trees (Dawson 1981, 1986; Dawson and Hallows 1983; Dawson and Kern-Hansen 1978; Jorga et al. 1982; Martin and Martin 1992; Nichols 1974). During natural or cultural eutrophication, algae growth alone can shade aquatic plants (Jones et al. 1983). Although light manipulation techniques may be useful for narrow streams or small ponds, in general, these techniques are of only limited applicability. Physical control is not currently proposed for management of aquatic plants in Connors 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. Wisconsin Department of Natural Resources permits under Chapter NR 107 are required for herbicide application. **Aquatic herbicides must be applied only by licensed applicators.**

General descriptions of herbicide classes are included below.[52]

Contact Herbicides

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

Systemic Herbicides

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

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

Environmental Considerations

Aquatic communities consist of aquatic plants including macrophytes (large plants) and phytoplankton (free floating algae), invertebrate animals (such as insects and clams), fish, birds, and mammals (such as muskrats 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 that can, in turn, affect other organisms. Or, weed control operations can affect water chemistry that, in turn, affects organisms.

General descriptions of the breakdown of commonly used aquatic herbicides are included below.[53] Chemicals commonly used in Wisconsin lakes are listed and described in Table D-1 below.

Table D-1. Herbicides Used to Manage Aquatic Plants in Wisconsin

Brand Name(s)	Chemical	Target Plants
Captain, Nautique, Cutrine Plus	Copper compounds	Free floating and filamentous algae, coontail, curly leaf pondweed, water celery, pondweeds
Aquathol K, Hydrothal	Endothall	Curly leaf pondweed, and other submergent plants: coontail, milfoil, pondweed, water celery
Reward	Diquat	Pondweeds, coontail, Eurasian water milfoil
Aquakleen, Navigate	2,4-D	Eurasian and other milfoils

Copper[54]

Copper is an essential trace element that tends to accumulate in sediments and can be toxic to aquatic life at elevated concentrations (United States Environmental Protection Agency, June 2008).

A study completed by MacDonald et al. (2000) developed consensus based numerical sediment quality guidelines for metals in freshwater ecosystems. This study provides guidelines for metals in freshwater ecosystems that reflect threshold effect concentrations (TECs, below which harmful effects are unlikely to be observed) and probable effect concentrations (PECs, above which harmful effects are likely to be observed). The consensus based TEC for copper is 31.6 mg/kg and the consensus based PEC for copper is 149 mg/kg.

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

54 Copper background information is from the Long Lake Management Plan prepared by the Polk County Land and Water Resources Department March 2013.

2,4-D

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

Recent WDNR studies contradict the above information. Under certain conditions, residual concentrations of 2,4-D above 100 ug/L may be present well past label irrigation restriction guidelines of 21 days. Degradation takes longer in some lakes:

- Oligotrophic (low-nutrient) lakes
- Low alkalinity lakes
- Lakes with no history of herbicide usage
- When water temperatures are cool. (WDNR 2011)

Granular formulations of 2,4-D and other herbicides dissipate at about the same rate as liquid formulations of herbicides (WDNR 2011).

Some recent studies indicate a need to consider the long-term effects of 2,4-D use. One is the effect on the endocrine system and reproduction of fat head minnows (DeQuattro, 2015). There is also some evidence that hybrid EWM can acquire resistance to 2,4-D (LaRue et al, 2013).

Diquat

When applied to enclosed ponds for submersed weed control, diquat is rarely found longer than 10 days after application and is often below detection 3 days after application. The most important reason for the rapid disappearance of diquat from water is that it is rapidly taken up by aquatic vegetation and 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.

Endothall

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

Fluridone

Dissipation of fluridone from water occurs mainly by photodegradation. Metabolism by tolerant organisms and microbial breakdown also occurs. 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 three months but can remain up to nine months. It may remain in bottom sediment between four months and one year.

Glyphosate

Glyphosate is not applied directly to water for weed control. However, 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.

Algaecide Treatments for Filamentous Algae

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

Herbicide Use to Manage Aquatic Invasive Species

Curly Leaf Pondweed

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

Early season herbicide treatment:[55]

Studies have demonstrated that curly leaf can be controlled with Aquathol K (a formulation of endothall) in 50 - 60 degree F water, and treatments of curly leaf this early in its life cycle can prevent turion formation. Since curly leaf pondweed is actively growing at these low water temperatures and many native aquatic plants are yet dormant, this early season treatment selectively targets curly leaf pondweed.

Because the dosage is at lower rates than dosage recommended on the label, a greater herbicide residence time is necessary. To prevent drift of herbicide and allow greater contact time, application in shallow bays is likely to be most effective. Herbicide applied to a narrow band of vegetation along the shoreline is likely to drift, rapidly decrease in concentration, and be rendered ineffective.[56]

Eurasian Water Milfoil

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies the following herbicides for control of Eurasian water milfoil: complexed copper, 2,4-D, diquat, endothall, fluridone, and triclopyr. Early season treatment of Eurasian water milfoil is also recommended by the Department of Natural Resources to limit the impact on native aquatic plant populations. 2,4-D is frequently used to target EWM (a dicot) over many other native plants (monocots).

However, large-scale treatments can result in significant damage to both monocots and dicots.

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

[56] Personal communication, Frank Koshere. March 2005.

- Dicots susceptible to both 2,4-D and fluridone include native watermilfoils (particularly northern), bladderworts, water lilies, and coontail.
- Monocot species such as elodea, several narrow leaf pondweeds, and naiads are also impacted by fluridone and some 2,4-D use.
- Fewer natives are affected at lower dosages. (WDNR 2011)

Wisconsin DNR research indicates that larger scale treatments seem to have more consistent reduction from herbicide use than smaller treatments. These results are based upon data collection in many Wisconsin lakes where herbicides were used for EWM control. (Nault 2015)

Herbicides can dissipate off of a small treatment site very rapidly. 2,4-D dissipated rapidly after treatment after it was applied to 98 small (0.1-10 acre) treatment areas across 22 study lakes with application rates of 2-4 ppm. The following results were found:

- Initial 2,4-D concentrations detected in the water column were well below application targets.
- Herbicide moved quickly away from treatment sites within a few hours after treatment.
- 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)

Native Plant Aquatic Plant Management

The WDNR Northern Region released an Aquatic Plant Management Strategy in the summer of 2007 to protect the important functions aquatic plants provide in lakes. As part of this strategy, the WDNR prohibited management of native aquatic plants in front of individual lake properties after 2008 unless management is designated in an approved aquatic plant management plan.[57] Permits for waterfront corridors were issued in 2008 only for formerly permitted sites where impairment of navigation and/or nuisance conditions were demonstrated. Because of the importance of the native plant population for habitat, protection against erosion, and as a guard against invasive species infestation, plant removal with herbicides as an option for individual property owners is carefully reviewed. The WDNR has not allowed removal after January 1, 2009 unless the “impairment of navigation” and/or “nuisance” conditions are clearly documented.

The WDNR recommends (and may require) that residents who wish to maintain an opening for boating and swimming use rakes or other hand methods.

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[57] Aquatic Plant Management Strategy. DNR Northern Region. Summer 2007.

Appendix E. Early Detection and Rapid Response to AIS

CoPaPi Voluntary Lake Association

Purpose

The purpose of this procedure is to provide guidance to the CoPaPi Voluntary Lake Association on how to identify and respond to introduction of Eurasian water milfoil (EWM) or other aquatic invasive species. Connors Lake already has both Eurasian water milfoil (EWM) and curly leaf pondweed (CLP) present, so the risk of establishment of these species in Lake of the Pines and Papoose Lake is high. New invasive species also may be introduced into the lakes.

Wisconsin DNR grants are available to control pioneer infestations of invasive species. *Pioneer infestation* means a small population of aquatic invasive species in the early state of colonization or re-colonization. For rooted aquatic plants like EWM or CLP, a pioneer infestation is a localized bed that has been present less than 5 years and is less than 5 acres in size or less than 5 percent of the lake area whichever is greater.

Procedure

1. The CoPaPi Voluntary Lake Association, will work together with the Sawyer County and the Department of Natural Resources Aquatic Plant Management and grant staff to implement this procedure.

2. Lake residents and visitors will be informed of whom to contact if they see a plant in Lake of the Pines or Papoose Lake they suspect might be Eurasian water milfoil (EWM) or another invasive species. The lake contact for AIS is currently: Tom Stram (715-332-5388).

3. If the tentative AIS identification is credible, the lake contact will mark the location with a uniquely identified small float, and a GPS waypoint will be entered for the float. The lake contact will then inform the Sawyer County and the Wisconsin Department of Natural Resources (WDNR) of suspected AIS.

4. Within 72 hours of notification, the lake contact or Sawyer County will collect and bag two entire intact rooted adult specimens of the suspect plants and deliver them to WDNR.

5. The DNR will verify if a pioneer infestation of an invasive species is found and rapid response is appropriate.

6. If an AIS infestation is identified, the DNR will work together with the lake association and the Sawyer County to develop an appropriate control method including pre and post monitoring and follow-up control and reporting requirements. If appropriate, already established standards and procedures for EWM control and monitoring on Connors Lake Class 1 areas will be followed for consistency.

Control methods may include hand pulling, use of divers to manually or mechanically remove the AIS from the lake bottom, application of herbicides, and/or other methods.

7. Lake association will notify lake residents of AIS presence and provide guidance for individual action. DNR will post signs at boat landings.

8. DNR will notify lake association contact verbally and via email when control project is authorized. Follow-up written notification will include conditions and procedures for the project, APM permit applications, and grant applications.

9. Lake contact or his/her designee then completes an APM permit application if required.

10. Contractor or volunteers carry out control measures as authorized by the DNR. (e.g., herbicide application by contractor, divers or volunteers to hand pull). Consultants may be hired to complete pre and post monitoring requirements. The lake association may borrow money and/or solicit donations in order to carry out control measures. Consider a reserve fund for EWM rapid response treatment on Lake of the Pines/Papoose.

11. Lake association completes rapid response application and submits to DNR.

12. Lake association reports results of the completed project and requests reimbursement from DNR.

13. Lake association will continue ongoing pre and post monitoring and treatment according to Class 1 EWM standards developed for Connors Lake unless areas are otherwise designated. Other monitoring methods to be completed by DNR, Sawyer County, and/or the lake association as deemed appropriate and necessary.

AIS Contacts

CoPaPi Voluntary Lake Association

Lake AIS Contact	Tom Stram, 715-897-6323 (cell) 715-384-8348 (home) twcstram@frontier.com

Sawyer County Land Conservation Department

AIS Coordinator	invasives@sawyercountygov.org
Zoning and Conservation Administrator	Dale Olson, 715-634-8288

Wisconsin Department of Natural Resources

AIS Notice, Grants, Permits	Alex Smith, 715-635-4124 Alex.smith@Wisconsin.gov
APM Permits	Mark Sundeen, 715-635-4074 Mark.sundeen@Wisconsin.gov

Herbicide Contractor

Northern Aquatic Services	Dale Dressel, 715-755-3507 ddressel@centurytel.net

Monitoring and Divers

Ecological Integrity Services	Steve Schieffer, 715-554-1168 ecointegservice@gmail.com

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