Aquatic Plant Management Plan

Deer Lake

Polk County Wisconsin

April 2006

Sponsored by:

Deer Lake Association / Deer Lake Conservancy

In-Lake Subcommittee

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Table of Contents

TABLES

FIGURES

APPENDICES

Introduction

This Aquatic Plant Management Plan for Deer Lake presents a coordinated strategy for managing aquatic plants by protecting native plant populations and related ecosystem benefits, managing nuisance plants, and preventing establishment of invasive species. The plan reviews public input, reports existing conditions, discusses management alternatives, and recommends action items. The document may guide Department of Natural Resources permits for aquatic plant management. The Deer Lake Association and lake residents will carry out plan action items and recommended actions.

Public Input for Plan Development

An in-lake committee of Deer Lake Association and Deer Lake Conservancy representatives provided and coordinated public input. A survey of Deer Lake property owners and comments at the annual meeting provided additional input. The survey and lake resident comments clearly identify issues related to aquatic plant and filamentous algae management as priorities for Deer Lake.

In-Lake Committee

The In-Lake Committee guided the development of this plan (including plan recommendations) and the studies and public input that support the plan. The committee consists of members from both organizations. Each organization has a role in management of aquatic plants in Deer Lake. The Deer Lake Association's role is to manage immediate lake concerns such as in-lake water quality. The Deer Lake Conservancy focuses primarily on long-term lake management by working to control watershed sources of phosphorus and sediments. Phosphorus levels control density and amounts of algae in the lake and sediments carry nutrients and create the substrate for rooted aquatic plants.

Deer Lake Owners Survey

The In-Lake Committee conducted a survey of Deer Lake property owners in 2002. The survey was distributed to over 300 households on Deer Lake and had a response of about 200. The survey asked respondents to 'list in order of priority (1, 2, 3), which of the following are most important:'

- Weeds
- Swimmer's Itch
- Algae
- Safety
- Screening of Shoreline & Appearance
- Other

The results, ranked* from greatest to least order of priority, are:

PRIORITY	1	2	3	4	5
Weeds	65	33	28	6	1
Algae	24	46	31	12	5
Swimmer's Itch	22	37	32	8	7
Safety	24	18	19	24	4
Shoreline	7	5	14	10	29

*Ranking order determined by the sum of the first three priorities

The 'other' comments are not reported here.

Weeds, algae, and swimmer's itch received the top three priority rankings by half or more of the respondents.

Deer Lake Improvement Association - 2003 Annual Meeting

The Deer Lake Improvement Association annual meeting was held on July 19, 2003. At that meeting, members expressed concerns with:

- Aquatic plant management
- Curly leaf pondweed
- Copper sulfate treatment for filamentous algae control
- Swimmer's itch control
- Fish kills
- High water levels causing bank erosion and fallen trees

Lake Management Concerns

This aquatic plant management plan addresses the top two concerns of lake residents:

- Excessive Algae - Algae in the lake (planktonic) and filamentous algae (attached to rooted plants)

- Weeds – Curly leaf pondweed control, native plant protection, swimming areas, channels to open water and exotic plant prevention

Lake Information[1]

Deer Lake is an 812-acre lake located in Polk County, Wisconsin in the Towns of St. Croix Falls (S25, T34N, R18W) and Balsam Lake (S30 and S29, T34N, R17W). Its subwatersheds, primarily on the north side of the lake, total almost 5800 acres.

The Deer Lake Conservancy and Deer Lake Association together sponsored a comprehensive in-lake study and aquatic plant survey in 2003 with assistance from Department of Natural Resources planning grant funds. This aquatic plant management plan uses the results of these studies for background information and management recommendations.

The 2003 in-lake studies followed comprehensive implementation of watershed practices recommended in plans sponsored by the Deer Lake Association and supported by Department of Natural Resources planning grant funds in the early 1990's. The Deer Lake Conservancy implemented these watershed practices from 1997 through 2005 with the help of many partners including the Department of Natural Resources and the Polk County Land and Water Resources Department.

Water Quality Summary

The Deer Lake Improvement Association has participated in Wisconsin's Self-Help Lake Monitoring program since 1987 (Secchi disk) and the Expanded Self-Help Lake Monitoring (phosphorus and chlorophyll) since 1991. There are two self- help monitoring sites on Deer Lake: at the deepest location of both the East and West basins. Water quality in 2003, as indicated by phosphorus, chlorophyll and Secchi disk (summer averages), was the best measured in recent years (see Figures 1-3).

Measurements of temperature and dissolved oxygen indicate the mid-summer thermocline depth fluctuates between 17 and 20 feet in both the East and West Basin of Deer Lake.

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[1] Much of this information is taken from previously prepared reports including: *Lake and Watershed Planning and Analysis. Deer Lake Management Plan.* Dick Osgood. February 2004.
Macrophyte Survey. Deer Lake, Polk County Wisconsin. Steve Schieffer and Robert Bursik. Summer 2003.

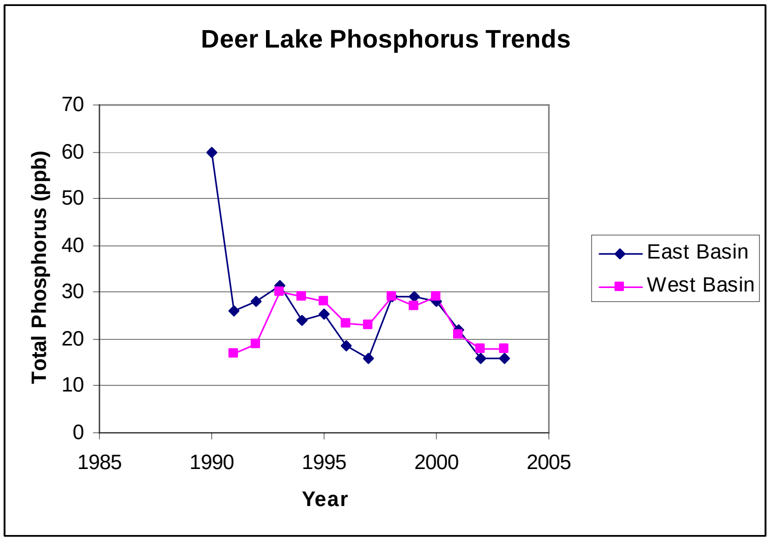

Figure 1. Deer Lake Phosphorus Trends

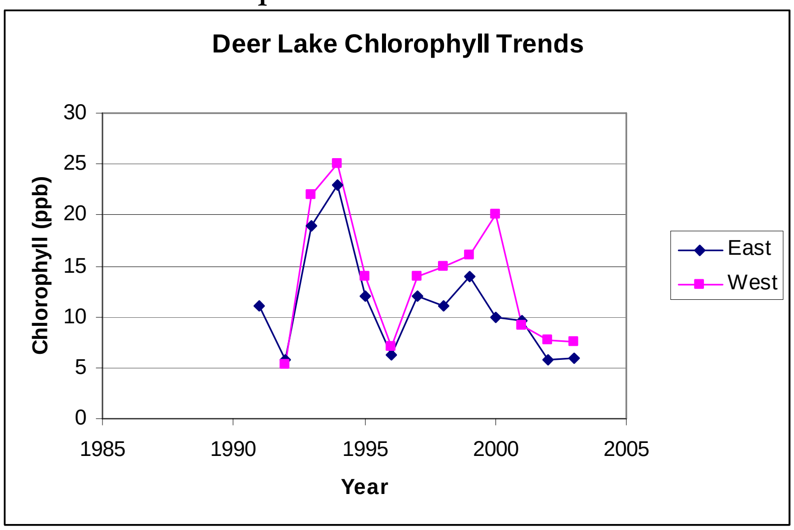

Figure 2. Deer Lake Chlorophyll Trends

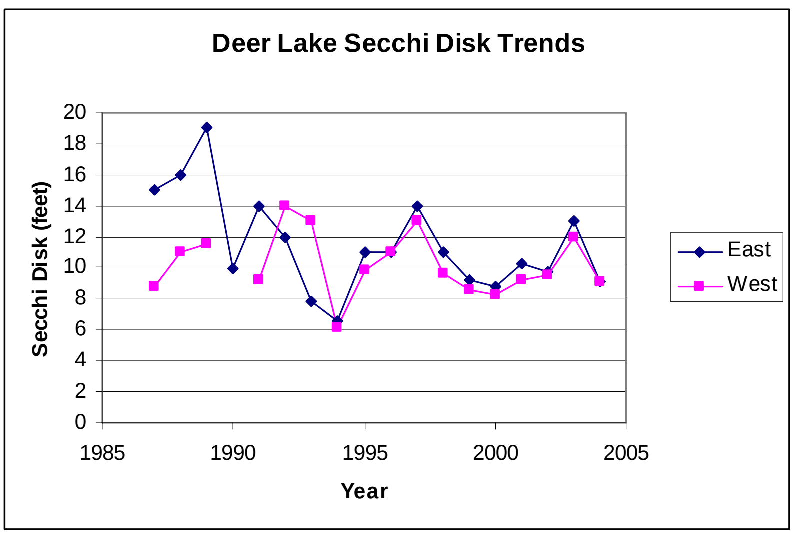

Figure 3. Deer Lake Secchi Disk Trends

Internal Phosphorus Inputs

Sediment samples were collected from six locations in Deer Lake on August 20, 2003 (Figure 4) to determine the magnitude of internal phosphorus loading to the lake's nutrient budget. For Deer Lake, the sediment release rate is estimated to be 6.4 mg P/ m^2/d. When this rate is applied to the anoxic sediments in Deer Lake, the internal phosphorus load is estimated to be 1,833 pounds annually.

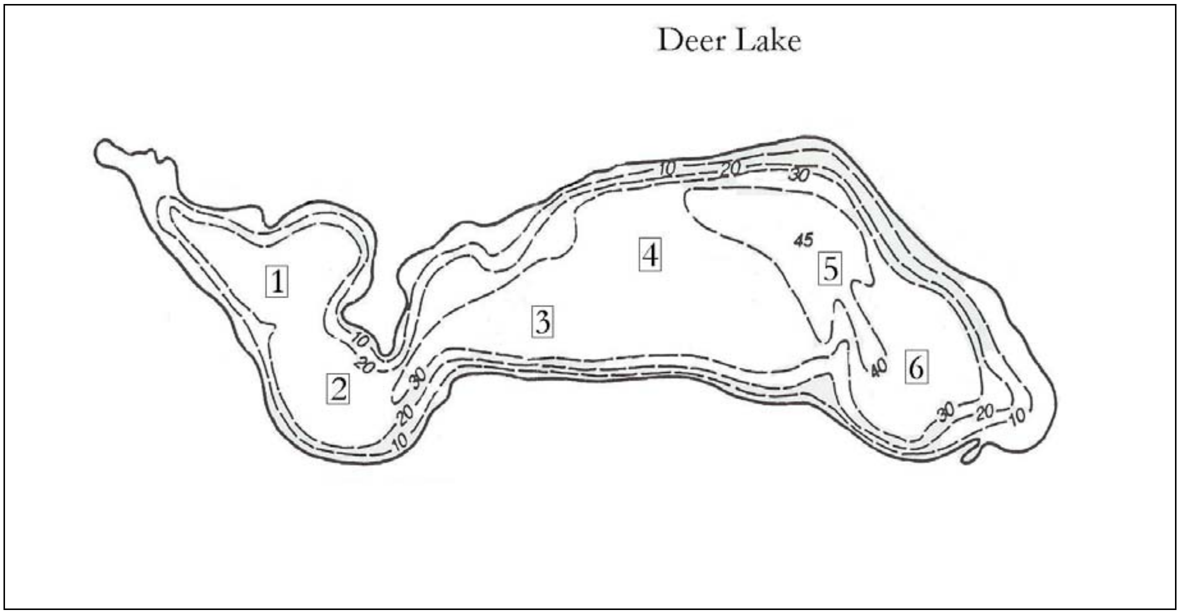

Figure 4. Deer Lake Sediment Sample Locations, August 20, 2003.

Watershed Description

The Deer Lake watershed, primarily on the north side of the lake, totals almost 5,800 acres. The watershed is divided into seven subwatersheds for management purposes. Inflow is through intermittent drainages. The outflow is at the southeast corner of the lake through a small creek.

Land cover and conservation practices effectiveness were recently evaluated in a study by JEO Consulting Group (March 2003). The predominant land cover in 2000 in all Deer Lake Watersheds was cropland, followed by forestland and grassland. Forest cover with residential land use predominates in the watershed area closest to the lake. The phosphorus load from watershed runoff is estimated to be 2,996 pounds annually.

The JEO analysis found a 51 percent reduction in watershed phosphorus loading (or 28 percent total loading) to the lake from 1996 to 2000. The reductions resulted from changing land cover and installation of conservation practices.

The Deer Lake Conservancy is continuing to work on implementation of watershed practices to reach an ambitious goal of 36 percent reduction of total phosphorus loading to the lake. Planned projects include wetland restoration following final acquisition of the Flagstad Farm property in watershed 6 and treatment of or reduction of agricultural runoff to a pond that flows to the lake from watershed 1. A greater emphasis on infiltration practices, buffer zones and correcting gully erosion in the direct drainage area is also planned.

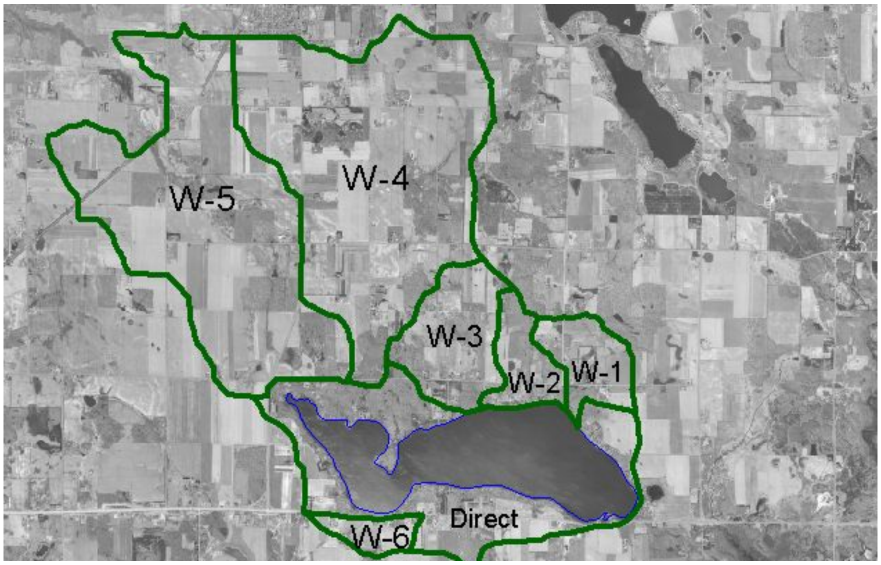

Figure 5. Deer Lake Watersheds

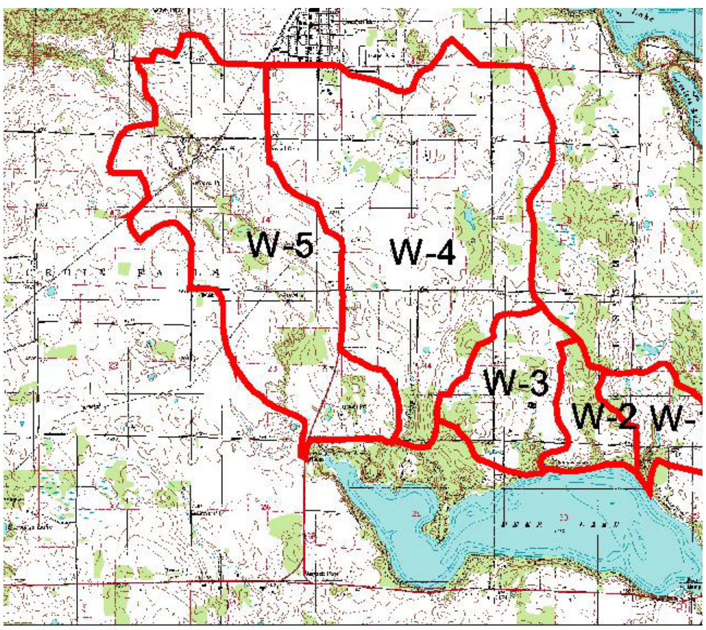

Figure 6. Deer Lake North Watersheds on Topographic Map

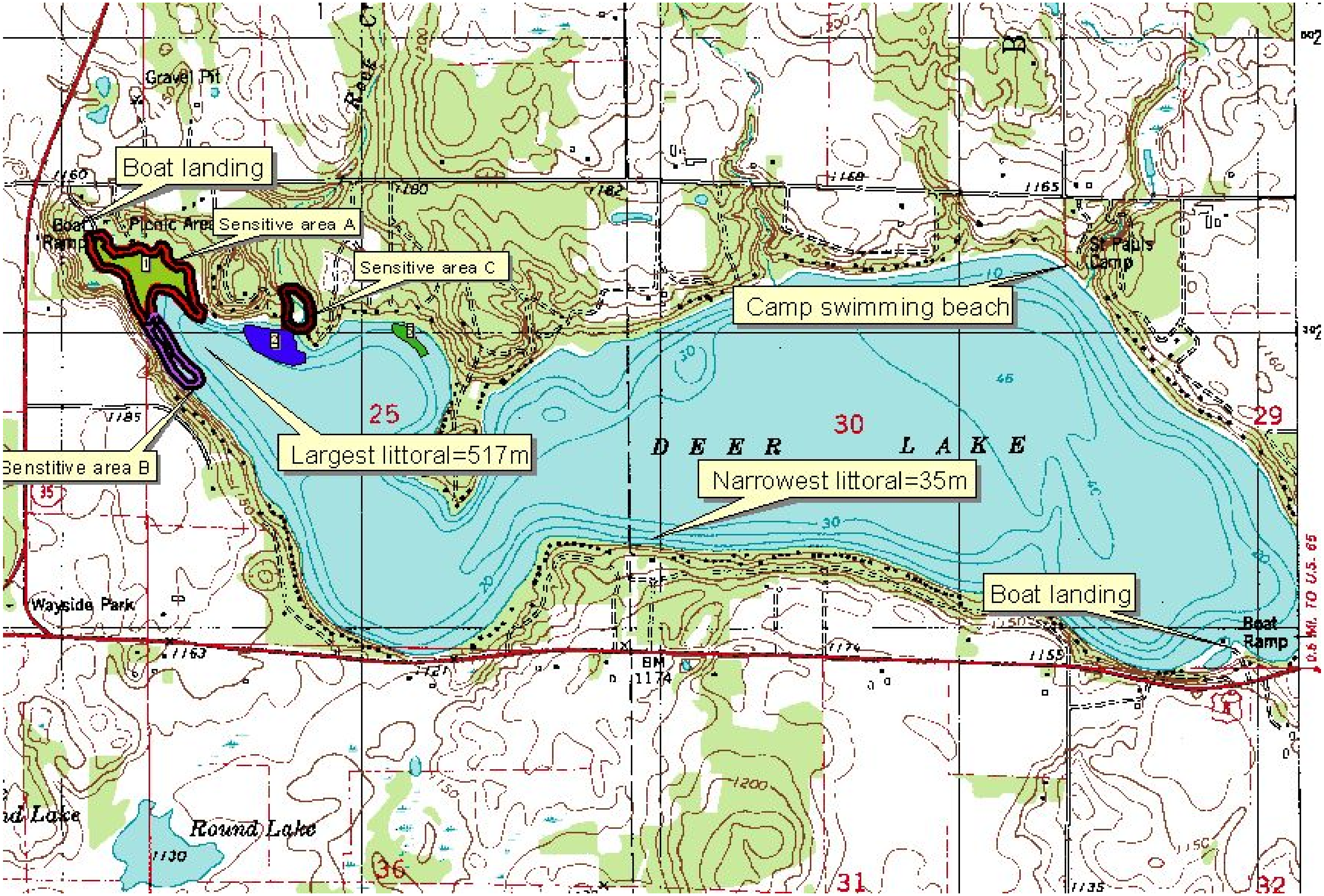

Figure 7. Sensitive areas and primary use areas of Deer Lake.

Intensity of Water Use

The various use areas are shown in the Deer Lake map in Figure 7. The map shows the location of homes around the lake as small black squares along the shoreline.

Primary human use areas

A public boat landing owned by the Town of St. Croix Falls is located at the northwest corner of the lake. The boat landing includes space for parking 25 vehicles and trailers. Many anglers travel from the Twin Cities, Minnesota metropolitan area, and access the lake at this boat landing. According to Heath Benike, DNR fisheries biologist, "Deer Lake is one of the most important and popular muskie fisheries in the state of Wisconsin. Many resident as well as non-residents anglers use Deer Lake, and this is the only public landing on the lake." The Town of St. Croix Falls boat landing on Deer Lake is used extensively throughout the year. While there are only 25 parking spots on the lake, a busy weekend brings an estimated use by over 200 vehicles. Daily weekday use is about 15 – 25 vehicles.

A private boat launch is located at the southeast corner of the lake near the outlet. There is a swimming beach owned by a private church camp at the northeast corner of the lake near the outlet of watershed 1.

The shoreline of Deer Lake is largely developed for residential use with 330 residences, many are large homes constructed for year-round use. Lake residents use focuses around their docks placed in the relatively shallow, littoral zone of the lake.

Habitat areas for fish, waterfowl and other wildlife

The littoral, or plant supporting, zone of the lake provides critical habitat for fish, waterfowl and other wildlife. It is found in a narrow band around Deer Lake at depths up to about 20 feet. This depth extends horizontally from the shore to approximately 115 to 1700 feet into the lake.

Sensitive area study

The DNR sensitive area study (1992) identified three areas that merit special protection of aquatic habitat. In the same report, they describe all of Deer Lake as unique. "Areas of aquatic vegetation provide the necessary seasonal or life stage requirements of the associated fisheries, and the aquatic vegetation offers water quality or erosion control benefits to the body of water." In the designated sensitive areas, aquatic vegetation removal is limited to navigational channels no greater than 25 feet wide. Chemical treatments are discouraged and if navigational channels must be cleared, pulling by hand is preferable.

<u>Resource Value of Site A</u>

Sensitive area A is located at the northwestern end of Deer Lake and includes the public boat launch. This area encompasses approximately 2,500 feet of shoreline. The area provide important habitat for centrarchid (bass and panfish) and esocid (northern pike and muskellunge) spawning and nursery areas. This area also provides important habitat for forage species. Wildlife also are reliant upon this area for habitat. Eagles, loons, herons, waterfowl, songbirds, furbearers, turtles, and amphibians benefit from this valuable habitat.

Resource Value of Site B

Sensitive area B is located adjacent to Area A, extending along the western shoreline of Deer Lake. This area encompasses approximately 1,200 feet of shoreline.

The habitat values of Site B mirror those described for site A above.

Resource Value of Site C

Sensitive area C encompasses a small bay at the northwestern corner of Deer Lake. This bay comprises the entrance of Rock Creek. Approximately 600 feet of shoreline are located in this sensitive area.

The habitat values of Site C mirror those described for site A above.

Deer Lake Fishery[2]

Deer Lake's fish community consists of northern pike, muskellunge, walleye, largemouth bass, bluegill, black crappie, yellow perch, and white sucker as well as various species of minnows. Deer Lake has an exceptional muskellunge fishery, however the fishery is dependent on stocking; no known natural reproduction is present. However, all other fish species present in Deer Lake are reproducing on their own and do not require supplemental stocking.

Table 1. Fish Spawning Times and Considerations

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

[2] Fisheries information provided by Heath Benike, DNR Fish Biologist. March 2006.

Rare, endangered, or protected species habitat

The east half of Deer Lake is in Sections 25 and 34 of the Town of St. Croix Falls. The west half is located in Sections 29 and 30 in the Town of Balsam Lake. Rare species are noted in the Town of St. Croix Falls (T34N, R18W) and in the Town of Balsam Lake (T34N, R17W). Records are provided to the public by Town rather than section, so there is no indication if the incidences of these species occur in and immediately surrounding Deer Lake.

<u>Species listed in the Town of St. Croix Falls:</u>

Red Shouldered Hawk	*Buteo lineatus*	Threatened
Lake Sturgeon	*Acipenser fulvescens*	Special Concern
Blue Sucker	*Cycleptus elongates*	Threatened
Western Sand Darter	*Etheostoma clarum*	Special Concern
Banded Killifish	*Fundulus diaphanous*	Special Concern
River Redhorse	*Moxostoma carinatum*	Threatened

<u>Species listed in the Town of Balsam Lake:</u>

Bald Eagle	*Haliaeetus leucocephalus*	Special Concern
Osprey	*Pandion haliaetus*	Threatened
Banded Killifish	*Fundulus diaphanous*	Special Concern

No plant species are listed on the DNR Natural Heritage Inventory database for Deer Lake towns. However, water-thread pondweed (*Potamogeton diversifolius)* a Wisconsin special concern species, was found in 5 percent of the Deer Lake sample sites in June 2003.

Plant Community

Aquatic species in Deer Lake were characterized with a baseline survey in June and August 2003. The survey used the point intercept method for macrophyte sampling. Methods and results are described in Appendix A. Figure 8 illustrates the 192 sampling points located in the survey with a Global Positioning System (GPS).

Aquatic Plant Survey Results

The survey indicates that Deer Lake has a healthy, diverse native plant community found in a narrow zone along the water's edge. One invasive, non-native aquatic species, curly leaf pondweed (*Potamageton crispus*) was found. Eurasian watermilfoil, an invasive, nonnative species of concern, was not located in this survey or any previous surveys of Deer Lake.

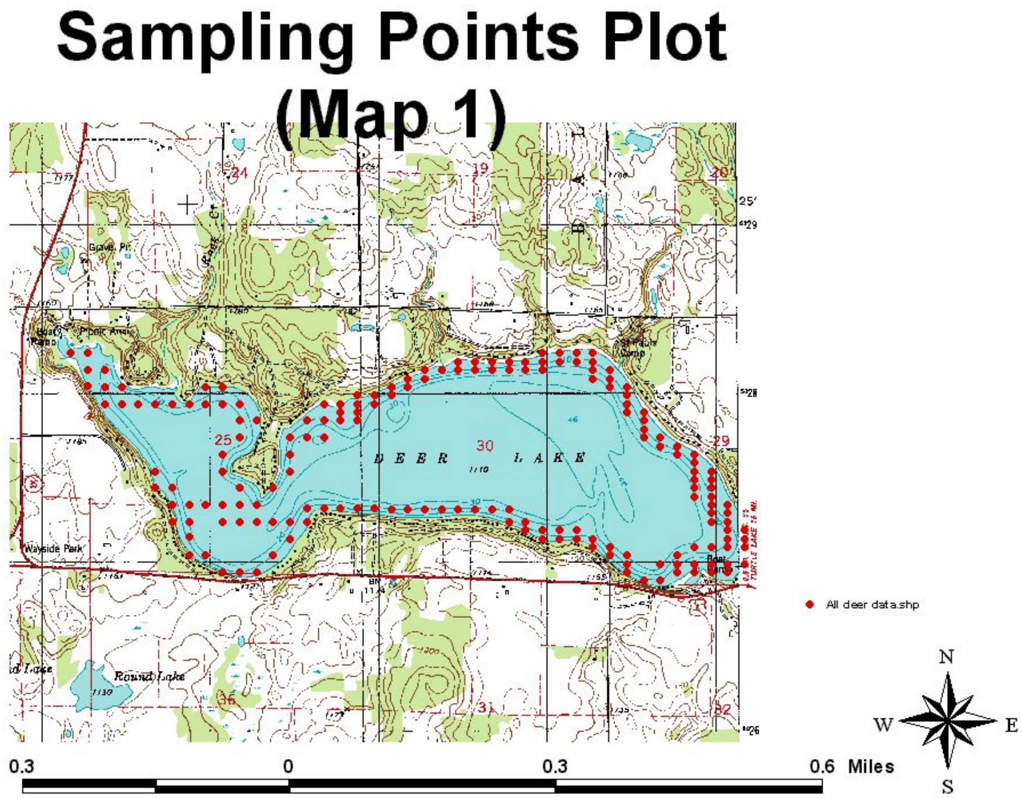

Figure 8. Whole Lake Survey Sampling Points

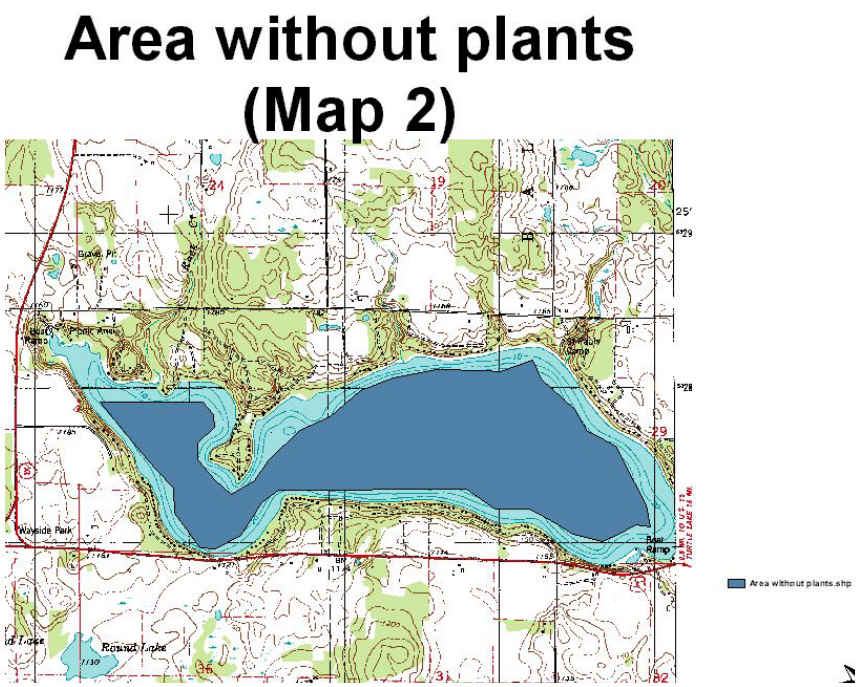

Figure 9. Deer Lake Area Without Plants

Deer Lake has an abundance of high quality aquatic vegetation in its littoral regions. Forty-one percent of Deer Lake is littoral, with a water depth that allows the growth of rooted aquatic vascular plants. The littoral zone is found as a continuous band around the margin of the lake. This zone extends toward the center of the lake in water greater than six meters deep in some areas, another indication of high water quality and an overall healthy ecosystem. Figure 9 shows the portions of the lake that are too deep to support rooted aquatic plant growth.

June 2003 sampling results
Seventeen vascular plant species and two categories of algae (filamentous algae and *Chara* sp.) were recorded during the mid-June survey (Table 2). White-stem pondweed (*Potamogeton praelongus*) and coontail *(Ceratophyllum demersum*) were the most frequently found species (46%). Northern milfoil (*Myriophyllum sibericum*), curly leaf pondweed (*Potamogeton crispus*), flat-stemmed pondweed (*Potamogeton zosteriformis*) and water celery (*Vallisneria americana*) also had high frequencies.[3] *Potamogeton* (the pondweeds) was the most diverse vascular plant group by far, containing nearly half of the aquatic vascular plant flora found in Deer Lake (eight species). Curly leaf pondweed was the only non-native species documented in Deer Lake during this study (there was no Eurasian watermilfoil found).

The Floristic Quality Index for Deer Lake was 25.73, significantly higher than the 20.9 average for other lakes within the Northcentral Hardwoods Ecoregion (NCHE). Four of the aquatic species found in Deer Lake have Coefficents of Conservatism of eight, including *Potamogeton praelongus, P. robbinsii, P. diversifolius, and Bidens beckii.* As a result, Deer Lake has an exceptionally high average Coefficient of Conservativism of 6.24 compared with an average of 5.6 for lakes in the NCHE.[4]

August 2003 sampling results
Nineteen species were found during the mid-August sampling, including 15 vascular species documented during the mid-June sampling as well as the filamentous algae and *Chara* sp. . No diverse-leaf pondweed (*Potamogeton diversifolius*) or sago pondweed (*Potamogeton pectinatus*), which were found in June, were found during the mid-August survey. Two species, wild rice (*Zizania palustris*) and greater duckweed (*Spirodela polyrhiza*) were found in mid-August but not during mid-June sampling. The increase in frequencies of coontail, flat-stemmed pondweed, and water celery are notable from mid-June to mid-August while there was a profound decrease in frequency of curly leaf pondweed from 28% to 1%. This decrease is expected, as this plant dies back in late-June.

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[3] Frequency means the percentage of the sample points where the particular species was found.
[4] For more information about the Floristic Quality Index and Coefficient of Conservativism, see Appendix A data analysis methods beginning on page 1.

Table 2. Species Found During Mid-June Sampling

Species	Number of points sampled	Frequency[5]
1. *Potamogeton praelongus*	67	0.46 or 46%
2. *Potamogeton amphlifolius*	17	0.12 or 12%
3. *Potamogeton crispus**	41	0.28 or 28%
4. *Myriophyllum sibiricum*	45	0.31 or 31%
5. *Potamogeton zosteriformis*	56	0.39 or 39%
6. *Vallisneria americana*	54	0.37 or 37%
7. Filamentous algae	96	0.66 or 66%
8. *Ceratophyllum demersum*	16	0.11 or 11%
10. *Potamogeton robbinsii*	10	0.07 or 7%
11. *Potamogeton diversifolius*	8	0.055 or 5.5%
12. *Nymphaea odorata*	1	0.006 or 0.6%
13. *Potamogeton pectinatus*	2	0.013 or 1.3%
14. *Chara spp.*	5	0.034 or 3.4%
15. *Potamageton pusillus*	4	0.028 or 2.8%
16. *Najas flexilis*	5	0.034 or 3.4%
17. *Bidens beckii*	2	0.013 or 1.3%
18. *Wolfia columbiana*	1	0.006 or 0.6%
19. *Lemna minor*	1	0.006 or 0.6%

Brief descriptions of plant species present in Deer Lake are found in Appendix B.

2005 Curly leaf pondweed mapping

Survey efforts in 2005 focused on identifying and mapping the extent of curly leaf pondweed beds and assessing species composition, density, relative density, and percent coverage in these beds. These areas where surveyed in June when vegetative growth was at its peak and in August after curly leaf pondweed plants died back. Methods and results of these surveys are included as Appendix C.

Fourteen curly leaf pondweed beds were surveyed. They ranged in size from 0.26 to 14 acres. The total coverage was 23.79 acres. In June, the average coverage of curly leaf pondweed in these beds was 60%. In all plots sampled, curly leaf had a higher density than any other plant present. In some plots, curly leaf dominated all plant samples. Plots #1, #2, and #5 shown in Figure 10 showed nuisance levels of curly leaf pondweed. In these areas, curly leaf was the only plant visible at the surface. These areas were very difficult to navigate with a boat because of high plant density at the surface.

[5] Frequency of each species equals number of samples that the species was found in / total number of samples that contained aquatic plants (146 samples contained aquatic plants in the mid-June survey).

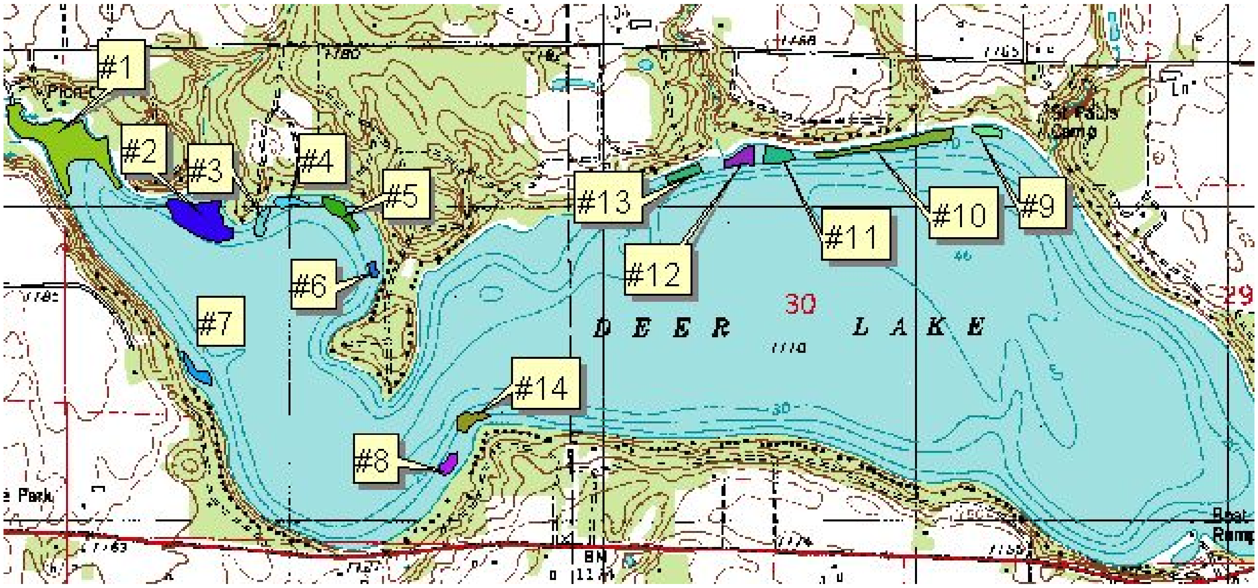

Figure 10. Curly Leaf Pondweed June Sample Plots

Sediment characteristics were noted in each sample location, and curly leaf pondweed appears to grow preferentially on sites with mucky sediments. All sites with curly leaf pondweed present were characterized by at least four inches of muck. Although, sediment at sites without curly leaf pondweed was not characterized as part of this study, mucky sediment is not generally present throughout the littoral zone of Deer Lake. The whole lake survey in 2006 will include an assessment of sediment characteristics at each sample point to assess the relationship between mucky sediments and curly leaf pondweed presence.

The August 2005 plant survey revealed a significant change in curly leaf pondweed. The relative density declined from 35 percent in June to 0.8 percent in August. The plots identified as having nuisance levels of curly leaf pondweed in June had diverse native plant populations by August.

Nuisance stands of aquatic plants

Few portions of the littoral zone of Deer Lake have what the plant surveyors deemed nuisance stands of aquatic plants. The exceptions are the two areas mentioned above supporting dense stands of curly leaf pondweed in late June and the extremely dense stands of aquatic vegetation on the western end of the lake near the public boat landing (site #1 above). During the early survey in June and the late survey in August this bay had nuisance plant growth thick enough to hinder boat use, swimming, and fishing.

Filamentous Algae

Filamentous algae was noted at 66 percent of the sample sites in June 2003. Filamentous algae are masses of long, stringy, hair-like strands that attach to plants, rocks, and docks. They are usually green in color, but may become yellow grayish or brown. Individual filaments are a series of cells joined end to end, which give them a thread-like appearance.

Nuisance growth of filamentous algae may indicate that a lake has excessive nutrients, although some amounts of algae will grow in low nutrient conditions. The long-term management strategy for filamentous algae is to reduce nutrient flow into the lake. Short-term management methods may include raking to physically remove algae; biological control by introducing algae eaters such a grass carp and tilapia (although this is more practical and acceptable in ponds); and chemical controls such as copper sulfate.

Invasive Species of Concern

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 "nonindigenous 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.[6]

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.[7]

[6] Wisconsin's Comprehensive Management Plan To Prevent Further Introductions and Control Existing Populations of Aquatic Invasive Species. Prepared by: Wisconsin Department of Natural Resources. September 2003.

[7] Information from Minnesota DNR (www.dnr.state.mn.us/aquatic_plants)

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

Curly leaf pondweed (*Potamogeton crispus*)[8]

<u>Identification:</u>
Curly leaf pondweed is an invasive aquatic species found in a variety of aquatic habitats, including permanently flooded ditches and pools, rivers, ponds, inland lakes, and even the Great Lakes. Curly leaf pondweed prefers alkaline or high nutrient waters 1 to 3 meters deep. Its leaves are strap-shaped with rounded tips and undulating and finely toothed edges. Leaves are not modified for floating, and are generally alternate on the stem. Stems are somewhat flattened and grow to as long as 2 meters. The stems are dark reddish-green to reddish-brown, with the midvein 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.

<u>Characteristics:</u>
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.

<u>Reproduction and dispersal:</u>
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.

<u>Ecological impacts:</u>
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

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

fish populations. The foliage of curly leaf pondweed is relatively high in alkaloid compounds possibly making it unpalatable to insects and other herbivores.

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 when new curly leaf infestations occur. 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[9] requires a long-term commitment that may or 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 back 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 will aggressively infest disturbed areas of the lake, such as those where native plant nuisances have been controlled through chemical applications.

Eurasian watermilfoil[10]

The ecological risks associated with an infestation of Eurasian water milfoil appear to surpass those associated with curly leaf pondweed. This plant is also not yet present in Deer Lake. However, there is a high risk that Eurasian watermilfoil may become established in Deer Lake.

A public boat landing owned by the Town of St. Croix Falls is located at the northwest corner of the lake. Deer Lake is a popular lake for muskellunge fishing. Many fisherman travel from the Twin Cities, Minnesota metropolitan area, and access the lake at this boat landing. With Eurasian watermilfoil present in many urban Twin Cities lakes, such as White Bear Lake and Lake Minnetonka, the danger of transporting plant fragments on boats and motors is very real. The lake is also situated on a major highway, providing easy access to the Twin Cities. According to the Minnesota Sea Grant Office:

> *Eurasian watermilfoil can form dense mats of vegetation and crowd out native aquatic plants, clog boat propellers and make water recreation difficult. Eurasian watermilfoil has spread to over 150 lakes [in Minnesota], primarily in the Twin Cities area.*

Department of Natural Resource scientists have also found Eurasian watermilfoil in the nearby counties of Burnett (Ham Lake and Round Lake) Washburn (Nancy Lake and the Minong Flowage), Barron (Beaver Dam, Sand, Kidney, Shallow, Duck, and Echo Lakes) and Polk (Long Trade) in Wisconsin.

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[9] "Large" is not defined in this factsheet. According to Frank Koshere, Aquatic Plant Management Coordinator, a large-scale herbicide treatment is any area greater than 10 acres. Under this definition, Deer Lake certainly has a "large" infestation with 50 to 70 acres containing curly leaf pondweed.
[10] Wisconsin DNR Invasive Species Factsheets from www.dnr.state.wi.us.

The following Eurasian watermilfoil information is taken from a Wisconsin DNR fact sheet. Both Northern milfoil and coontail, mentioned below as frequently mistaken for Eurasian watermilfoil, are present in Deer Lake.

<u>Identification</u>

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

<u>Characteristics</u>

Eurasian watermilfoil 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 opportunitistic 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.

<u>Reproduction and dispersal:</u>

Unlike many other plants, Eurasian watermilfoil 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 watermilfoil is adapted for rapid growth early in spring.

Ecological impacts:
Eurasian watermilfoil'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 watermilfoil 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 watermilfoil may lead to deteriorating water quality and algae blooms of infested lakes.

Control methods:
Preventing a Eurasian watermilfoil 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 reduces nutrients reaching the lake and thereby 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 watermilfoil 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.

Because Eurasian watermilfoil is found in nearby lakes, it is prudent to provide a contingency plan to be best prepared to control milfoil, should it be found in the lake. A contingency plan should include a systematic monitoring program and a fund to provide timely treatments.

Aquatic Plant Management

This section presents aquatic plant management goals for Deer Lake, the potential management methods available to reach these goals, and selection of action items for plant management.

Deer Lake's Goals for Aquatic Plant Management

1) Protect and restore healthy native aquatic plant communities.

2) Prevent the introduction of Eurasian watermilfoil and other invasive, non-native aquatic species.

3) Rapidly respond to eliminate any newly introduced invasive, non-native aquatic plant species.

4) Reduce filamentous algae density.

5) Reduce levels of nuisance aquatic plants to allow safe, enjoyable recreation such as swimming and boating.

Discussion of Management Methods

Techniques to control the growth and distribution of aquatic plants are discussed in following text. In most cases, a combination of techniques must be used to reach plan goals. 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 and when plants are removed mechanically, or when plants are removed manually from an area greater than thirty feet in width along the shore. The requirements for chemical plant removal are described in Administrative Rule NR 107 – Aquatic Plant Management. A permit is required for any aquatic chemical application in Wisconsin.

The requirements for manual and mechanical plant removal are described in NR 109 – Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations. A permit is required for manual and mechanical removal except for when a riparian (waterfront) landowner manually removes or gives permission to someone to manually remove plants, (with the exception of wild rice) from his/her shoreline limited to a 30 foot corridor. A riparian landowner may also manually remove the invasive plants Eurasian watermilfoil, 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.[11]

Watershed conservation practices

The ultimate goal of Deer Lake watershed conservation practices is the reduction of total annual phosphorus loading by 36% from when watershed studies were conducted in the early 1990's. This reduction is projected to bring summer in-lake phosphorus concentrations to 20 ppb. This level of phosphorus concentration will result in increased water clarity through a decrease in suspended algae and potentially filamentous algae growth. The Deer Lake Conservancy continues to pursue watershed conservation practices to meet the phosphorus reduction goal.

Alum treatment

The 2004 Lake Management Report recommends an alum treatment to control release of phosphorus from bottom sediments. This treatment is projected to reduce summer phosphorus concentrations to 18 ppb without additional watershed practices and to 14 ppb with planned watershed practices. Either level will significantly increase water clarity and aid in achieving plan goals by reducing suspended and filamentous algae growth in Deer Lake. The In-Lake Committee has not recommended proceeding with an alum treatment at this time.

Biological control[12]

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 (i.e., pathogenic microorganisms). With the introduction of native pests to the target invasive organism, the exotic invasive species may be maintained at lower densities.

While this theory has worked in application 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.

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 control times of years

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

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

instead of weeks, lack of available agents for particular target species, and relatively strict environmental conditions for success.

Biological control is not without risks; new non-native species introduced to control a pest population, may cause problems of its own. Biological control is not currently proposed for management of aquatic plants in Deer Lake.

Re-vegetation with native plants

Another aspect to biological control is native 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 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 Deer Lake because a healthy, diverse native plant population is present.

Physical control[13]

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 DNR 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 excess plant growth. Dredging forms an area of the lake too deep for plants to grow, thus opening 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 very 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. Deer Lake has a very narrow shallow shelf that supports vegetation along with good nutrient levels, so dredging is not appropriate.

Drawdown, or significantly decreasing lake water levels can be used to control nuisance plant populations. With drawdown, the water body has all of the 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 1 month long to ensure thorough drying and effective removal of target plants (Cooke 1980a). In northern areas, a drawdown in the winter that will ensure freezing of sediments is also effective. Although drawdown may be effective for control of hydrilla for 1 to 2 years (Ludlow 1995), it is most commonly applied to

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

Eurasian watermilfoil (Geiger 1983; Siver et al. 1986) and other milfoils or submersed evergreen perennials (Tarver 1980). Drawdown requires a mechanism to lower water levels.

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. Drawdown is not a feasible option for Deer Lake.

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 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 1 to 2 months, after which they maybe removed (Engel 1984). Sheet color is relatively unimportant; opaque (particularly black) barriers work best, but even clear plastic barriers will work effectively (Carter et al. 1994). Sites from which barriers are removed will be rapidly re-colonized (Eichler et al. 1995). Synthetic barriers if left in place for multi-year control will eventually become sediment-covered and will allow colonization by plants. Benthic barriers may be best suited to small, high-intensity use areas such as docks, boat launch areas, and swimming areas. However, they are too expensive to use over widespread areas, and heavily affect benthic communities by removing fish and invertebrate habitat. A Department of Natural Resources permit would be required.

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 Deer Lake.

Manual removal

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 seedhead 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 infestation and for private landowners who wish to remove small curly leaf pondweed infestations. Raking is recommended to clear nuisance growth in riparian area corridors up to twenty-five feet wide.

Mechanical control

Larger-scale control efforts require more mechanization. Mechanical cutting, mechanical harvesting, diver-operated suction harvesting, and rotovating (tilling) are the most common forms of mechanical control available. 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 that generally cut from one to six feet deep. A conveyor belt on the cutter head brings the clippings onboard the machine for storage. Once full, the harvester travels to shore to discharge the load of weeds off of the vessel. Because large-scale mechanical control tends to be nonselective and leaves plant fragments in the lake, this method is not recommended for Deer Lake.

Diver dredging operations use pump systems to collect plant and root biomass. The pumps are mounted on 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 infestations of submersed invasive plant species. When a weed is discovered in a pioneering state, this methodology should 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.

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.

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 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. Herbicides must be applied only by licensed applicators.

General descriptions of herbicide classes are included below.[14]

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 annual (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.

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

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 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 a herbicide. Many related physical and biological factors can contribute to a plant's susceptibility to a herbicide. Physical factors that contribute to selectivity include herbicide placement, formulation, and rate of application. Biological factors that affect herbicide selectivity include physiological factors, morphological factors, and stage of plant growth.

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, otters, and manatees). 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 it can affect water chemistry that in turn affects organisms.

General descriptions of the breakdown of commonly used aquatic herbicides are included below.[15]

<u>Copper</u>
Copper is a naturally occurring element that is essential at low concentrations for plant growth. It does not break down in the environment, but it forms insoluble compounds with other elements and is bound to charged particles in the water. It rapidly disappears from water after application as a herbicide. Because it is not broken down, it can

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

accumulate in bottom sediments after repeated high application rates. Accumulation rarely reaches levels that are toxic to organisms or significantly above background concentrations in the sediment.

<u>2,4-D</u>
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 3 weeks in water and can be as short as 1 week. 2,4-D breaks down into naturally occurring compounds.

<u>Diquat</u>
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 it 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, and because it is bound in the plant tissue a proportion is probably degraded by microorganisms as the plant tissue decays.

<u>Endothall</u>
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 2 weeks in water and 1 week in bottom sediments.

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

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

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 invasive species

Curly leaf pondweed

The Army Corps of Engineers Aquatic Plant Information System (APIS) identifies three 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:[16]
Studies have demonstrated that curly leaf can be controlled with Aquathol K (a formulation of Endothall) in 50 - 60 degree F water, and that treatments of curly leaf this early in its life cycle can prevent turion formation. Staff from the Minnesota Department of Natural Resources and the U.S Army Engineer Research and Development Center are conducting further trials of this method. Balsam Lake (Polk County, Wisconsin) treated two sites totaling 13 acres in early June of 2004 and 2005, and will follow up with ongoing treatment and monitoring of the effectiveness of this method.

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.[17]

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. Herbicide use may be necessary to rapidly respond to an infestation if discovered in Deer Lake.

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[16] Research in Minnesota on Control of Curly Leaf Pondweed. Minnesota Wendy Crowell, Minnesota Department of Natural Resources. Spring 2002.
[17] Personal communication, Frank Koshere. March 2005.

Deer Lake Historical Plant Management Activities

Aquatic plant management permitted actions have changed little in the past five years. The Deer Lake Association contracts with an herbicide applicator to conduct inspections for the presence of Eurasian watermilfoil near the boat landing and for filamentous algae along the littoral zone. Nuisance levels of filamentous algae are treated with copper compounds. Up to 15 acres of treatment area is allowed at any one time. From 1993 – 2000 up to five acres at a time were treated for filamentous algae control.

In 2003 the boat landing area was treated with herbicides with the express purpose of preventing the introduction of Eurasian watermilfoil in this area. The Department of Natural Resources permitted the treatment for the purpose of allowing boats to pass each other and navigate from the boat landing. Individual access corridors (limited to a 25 foot width) are treated with herbicide only at a landowner's request and expense. Many years ago the treatments were allowed for the entire riparian frontage.

Management Recommendations

Action items are described in following text for each Deer Lake Aquatic Plant Management Plan goal. Education and Information activities will be critical for many of the plan goals. One of the first tasks is to raise awareness about the plan itself.

Aquatic plant management plan outreach

Plan Action Item
Deer Lake residents will be aware of this aquatic plant management plan and its recommendations through newsletter articles and handouts and presentations at annual meetings.

Goal 1: Protect and restore healthy native aquatic plant communities.

Protection of native plant communities

Deer Lake supports healthy and diverse plant communities that are well-above average when compared to other lakes within the North Central Hardwoods Ecoregion of Wisconsin. However, the littoral zone, which supports all of the aquatic vegetation occurs in a relatively narrow band around the lake margins (covering 41% of the lake area total). If a waterfront property owner sprays even a narrow region in front of their property, it could have very significant negative effects on healthy, desirable native stands of plants. Herbicide use can result in removal of the native aquatic plants that are responsible for the lake's high water quality and excellent fisheries habitat, while potentially hastening the spread of undesirable non-native plants such as curly pondweed or even Eurasian watermilfoil (if introduced). In evaluation and selection of management options, care must be taken to protect native plant communities. Public information and education will be important for successful native plant protection.

Aquatic plant habitat and ecosystem values

The management challenge for Deer Lake will be to control the aquatic plant nuisances without unduly damaging the native plants and their attendant benefits in the lake. For this to occur, residents must understand the values of aquatic plants in Deer Lake. An important educational message will be communicating the distinction between "good plants" and "bad plants." Most plants are good: in fact, a diverse native plant community is essential for a healthy lake ecosystem. Others are bad: invasive species may displace native plants and their benefits.

Waterfront activities

Another important message will be to discourage boating disturbance within 200 feet of the shoreline. Although this is a no-wake zone according to state regulation, many boaters still travel close to the shoreline. This activity is strongly discouraged for the following reasons:

- Boats may uproot native plants and break aquatic plants into fragments
- Bare substrate is more likely to be colonized by non-native species
- Plant fragments contribute phosphorus to the water as they decay
- Curly leaf pondweed fragments broken up by boat propellers may root and encourage further spread of this invasive plant.

Waterfront residences can also negatively affect native plant communities by causing disturbance of existing plant beds and altering sediment characteristics. Regular waterfront use like boating, swimming, and clearing removes native aquatic plants. Healthy native plant populations prevent colonization by invasive plants. Erosion and runoff from waterfront property may alter sediment characteristics and encourage the spread of invasive plants.

Plan Action Item

Provide residents with written materials and present information regarding aquatic plant values, and methods to limit impacts to them at annual meetings and in newsletters.

Large-scale management of curly leaf pondweed
At first glance, large-scale herbicide treatment of curly leaf pondweed may seem warranted to protect native plant communities. However, while identified as an invasive species of concern, its ecological impacts and likelihood of continued spread are uncertain. A large-scale herbicide treatment may damage native plant communities, opening the lake up to a Eurasian watermilfoil infestation. In addition, the low-dose early season herbicide application discussed earlier for curly leaf pondweed control may not be appropriate throughout the lake because much of the vegetation is found in a narrow band along the shoreline. Herbicide applied in these areas to attempt to control curly leaf pondweed is likely to drift, decreasing herbicide concentration and making the treatment ineffective.

Rather than wholesale treatment, targeted treatments on identified nuisance areas and a close surveillance of remaining curly leaf populations is recommended. Whole lake surveys every three years will assess if new populations of curly leaf pondweed are becoming established. Annual measurements in June will monitor the extent and density (and therefore any spread) of existing curly leaf pondweed beds.

Curly leaf pondweed awareness
Resident understanding of the distinction between curly leaf pondweed and aquatic native plants is critical. With a better understanding of curly leaf pondweed's growth characteristics and negative impacts to the lake, residents may be encouraged to change their purpose from removing all aquatic plants (weeds) to a desire to control the invasive curly leaf pondweed. Poorly informed lake residents may chose wholesale control of "weeds" if unable to distinguish between aquatic plant nuisances of invasive plants from the relative values of native aquatic plants. Better understanding and promotion of reasons for controlling curly leaf pondweed may reduce the desire for complete plant removal in navigation corridors.

Plan Action Item
The curly leaf pondweed strategy will be clearly communicated to lake residents. The Deer Lake Association will provide residents with the information needed to accurately identify curly leaf pondweed. Residents will be encouraged to hand-pull small stands adjacent to their property. The importance of positive identification and removal of plant fragments will be emphasized. The need to notify the Deer Lake Association so that their site may be monitored will also be communicated.

Goal 2: Prevent the introduction of Eurasian watermilfoil and other invasive, non-native aquatic species.

Although the threat of invasion by exotic species is present, a coordinated prevention effort on Deer Lake has not occurred to date. Lakeshore resident education and access inspections will reduce the risk of an unwanted invasive species introduction to Deer Lake with the implementation of this plan. There are many educational materials available from public sources. Eurasian watermilfoil prevention signs are already posted at the public boat landing.

A Department of Natural Resources Aquatic Invasives Species grant to the Town of Saint Croix Falls will support this work from 2006 through 2008. The project includes hiring an intern to implement a watercraft inspection program. Project activities include inspecting watercraft at public access sites; educating residents and visitors regarding identification, threats, and control of aquatic invasive species; and monitoring for the presence of Eurasian Watermilfoil. The grant project also includes a whole lake survey for 2006.

Plan Action Item
Gather and assemble public information materials about Eurasian watermilfoil prevention for distribution to Deer Lake residents. Residents will be provided with written materials and presented with information at annual meetings and in newsletters.

Plan Action Item
Develop an access inspection program to 1) educate boaters entering Deer Lake, 2) provide a voluntary inspection and 3) allow for boat and trailer cleaning when contamination is observed or suspected.

Plan Action Item
Monitor for the presence of Eurasian Watermilfoil and other aquatic invasive species. The public boat landing at the northwest corner of the lake and the private landing on the southeastern shore will be the focal points for monitoring. Introduction is most likely here. Deer Lake inflows are not connected to other lake systems, so these areas will not be targeted. Instead, lake residents will be encouraged to learn to identify Eurasian watermilfoil and purple loosestrife, and a contact for positive identification of potential specimens will be made available.

Goal 3: Rapidly respond to eliminate any newly introduced invasive, non-native aquatic plant species.

Plan Action Item
A Eurasian watermilfoil monitoring program will continue for detection and rapid response if an invasion is discovered. The Deer Lake Association will maintain a reserve budgets to respond to a Eurasian watermilfoil infestation. A file with rapid response steps will be held by the Lake Association president and Environmental Committee chair.

Plan Action Item
Have a rapid response action plan in place. This plan will consist of the following steps.

1. Positive identification of invasive species (contact designated local plant identification expert and DNR)
2. Notify DNR aquatic plant management specialists of positive identification.
3. Carry out response plan using one or more of the following methods.
    a. Hand pulling (w/diver if needed)
    b. Herbicide use (permits required)
4. Notify residents of positive invasive species identification and location.
5. Carefully monitor infested area and nearby for effectiveness of control methods.
6. Repeat controls as needed.

Goal 4: Reduce filamentous algae density.

The long-term strategy for filamentous algae management is to reduce watershed inputs of phosphorus. In the meantime, the plan recommends continuing to treat nuisance levels of filamentous algae with copper compounds.

Whole lake surveys will differentiate filamentous algae species beginning in 2006. This identification may assist with filamentous algae management strategies in the future.

Plan Action Item
Maintain recreational and aesthetic values of Deer Lake using algaecide treatments to alleviate the impacts of nuisance algae blooms. Filamentous algae treatments will be used to control nuisances in the near-term. Reducing lake phosphorus may reduce these nuisances in the long-term.

Identifying nuisance growth of filamentous algae:
100% of rake samples have filamentous algae present
Floating mats exceed 1000 square feet in aerial coverage

Plan Action Item
Assess inorganic material levels in Deer Lake sediments. Take sediment samples in at least 12 locations around the lake.

Goal 5: Reduce levels of nuisance aquatic plants to allow safe, enjoyable recreation such as swimming and boating.

Access Corridor Management

Aquatic plants create nuisances for residents attempting to swim and boat from the shoreline. However, it is important that residents are aware of the risks of complete clearing of access corridors. Native aquatic plants provide critical habitat for fish and other aquatic creatures. Corridors cleared of native plants may provide sites for colonization by invasive, non-native species.

Guidance for Deer Lake Property Owners

1. General herbicide spraying of nuisance aquatic plants for boat access and swimming is discouraged because of potential damage to this critical habitat zone.
2. DNR currently restricts control activity in the littoral zone (area where plants grow) adjacent to private residences to a width of no more than 25 feet.
3. Residents wishing to control curly leaf pondweed with hand pulling may do so throughout their shoreline area, but must be confident of plant identification and remove all plant fragments.
4. Residents who pull curly leaf pondweed should notify the Deer Lake Association by June 1 of the same year, so that these sites can be noted in the plant survey. An annual mailing from the lake association will remind residents of the desired control methods and request notification.
5. Nuisance aquatic plant growth in July and August should be controlled in the access corridors using manual means such as plant rakes. Plant fragments should be removed from the lake and placed on an upland area such as a garden or compost pile.
6. Herbicide treatment of access corridors should be used as a last resort.

Curly Leaf Pondweed Nuisance Control

<u>Plan action item</u> Control curly leaf pondweed, with early season Endothall treatments in areas where nuisance levels are reached, including the public boat landing and along the north shore. Annual treatments are planned, and the treatment areas will be modified using information from detailed annual June plant inventories.

Defining nuisance curly leaf pondweed beds May/June mean density = 4.5 or greater May/June mean percent coverage = 80 percent or higher May/June curly leaf pondweed stem growth reaches surface and is thick enough to impede navigation (stem height > 1 meter)

Site-specific Management / Aquatic Invasive Species Control
The actual size of the treatment area will be refined following an early May pretreatment survey. Three nuisance areas were identified in 2005. Nuisance sites are shown as site #2, site #5, and site #7 in Figure 10. Complete survey results are found in Appendix C.

Table 3. Nuisance Curly Leaf Pondweed beds

Plot #	Mean density	Mean % Coverage	Area
2	4.5	85	4.138
5	5	93.3	0.26
7	4.5	82.5	0.61

The objectives of the treatment are to <u>1) reduce the density of curly leaf pondweed below nuisance levels</u>. The ultimate objective is to remove curly leaf pondweed from these areas. Interim success will be attained when June mean density of curly leaf pondweed is <3 and mean coverage <50% and <u>2) to facilitate the growth of native species.</u> If curly leaf pondweed control is successful, native species will be managed only to control growth that impedes navigation.

The Endothall treatment will occur when water temperatures are approximately 55 degrees Fahrenheit or greater to target this invasive species before significant native plant growth has occurred, and following spawning times for yellow perch. To limit impacts on black crappie that nest in shallow waters, spraying will occur only at depths greater than 1 meter. Treatment locations will be located using GPS equipment, and herbicide application amounts and concentrations will be recorded. The concentration of herbicide is 1 ppm Endothall. Treatment will be preceded and followed by monitoring as described in the monitoring and assessment section that follows. Herbicide treatments and pre- and post-treatment monitoring will occur for minimum of three years. Monitoring results and research results from other projects will guide potential additional treatments of nuisance curly leaf pondweed areas.

Public Boat Landing Navigational Channels

A navigation channel will be maintained at the public boat landing that allows two large boats to safely pass. Because curly leaf pondweed growth is significant in the northwest bay where the boat landing is located, the first treatment at the boat landing will be an early season Endothall treatment as described above. In June of 2005, the relative density of curly leaf pondweed in this 8.4-acre bay was 4.5 and the mean percent coverage was 66.25 percent. The entire area is not targeted for early season Endothall treatment because the bay is identified as a sensitive area.

Monitoring and Assessment

Aquatic Plant Surveys

Aquatic plant (macrophyte) surveys are the primary means to track achievement toward plan goals. Plan goals are to: 1) Protect and restore healthy native aquatic plant communities; 2) Prevent the introduction of Eurasian watermilfoil and other invasive, non-native aquatic species; 3) Rapidly respond to eliminate any newly introduced invasive, non-native aquatic plant species; 4) Reduce filamentous algae density; and 5) Reduce levels of nuisance aquatic plants to allow safe, enjoyable recreation such as swimming and boating.

Plan Action Item
Conduct whole lake aquatic plant surveys every three years to track plant species composition and distribution. Whole lake plant surveys will include identification and measurement of relative abundance of filamentous algae at each sample point. An assessment of sediment characteristics at each sample point will assess the relationship between mucky sediments and curly leaf pondweed presence included beginning in 2006.

Whole lake surveys

The 2003 survey serves to document whole lake baseline conditions. Applicator and DNR data provided additional historical information. Whole lake surveys will be conducted using a point intercept method using the 192 data points developed for the 2003 survey. The 2003 survey results and methodology are included as Appendix A. Results will be used to evaluate the change in the plant community including any change in native plant diversity (number of species per point) and any measurable change in curly leaf pondweed distribution.

Points will also be collected to map the extent of large beds of curly leaf pondweed visible from the lake surface each year in June. Areas of nuisance growth will be compared between survey periods. Any change in area of nuisance growth will be noted. Nuisance growth of curly leaf pondweed is defined as a relative density of 4.5 or greater and a percent coverage greater than 80 percent. Costs of control methods will be tracked per area of nuisance controlled.

More frequent and more detailed surveys as described in following sections will be used to gauge effectiveness of treatment strategies.

Curly leaf pondweed annual assessments

Curly leaf pondweed assessments will measure density, relative density, and percent coverage. Sampling methods and results from 2005 are described in Appendix C. The methods below will be used for nuisance areas to be treated. Additional curly leaf beds will be monitored as described below for early June and August. The beds will be monitored to watch for changes in curly leaf and native plant densities and coverage.

Pre-treatment Survey – early May
Identify the extent of observable curly leaf pondweed growth in potential treatment areas with GPS coordinate points. At pre-selected random sample points within and outside the potential treatment area, note aquatic plant species present and their density (1 (low) to 5 (heavy)). Sediment characteristics will be noted at each sample point. At least one sample point will be chosen per acre of treatment area. Additional sample points may be added for small irregularly shaped sites.

At time of treatment
Sample points will be selected to provide at least one sample point per acre in treatment area. For each sample point the following will be recorded:

- Surface water temperature
- Mid-depth water temperature.

Five curly leaf pondweed specimens will be collected (if present) at each sample site. The following data will be collected for each plant:

- total plant length (root to terminal apex),
- number of stem nodes,
- number of axial and root turions, and
- aerial coverage.

Post-treatment – early June
Survey must be completed before curly leaf has died back. This survey will help to assess the effectiveness of the treatment and to target next year's spray points (if additional treatment sites are to be added). All identified curly leaf beds will be sampled at this time.

Sample sites randomly chosen in the pre-treatment surveys will be resurveyed both within the treatment areas and outside the treatment areas (as control samples) from sites with positive curly leaf pondweed identification. A list of all aquatic plant species present and their density (1 (low) to 5 (heavy)) will be recorded for each sample site.

Post-treatment survey – August
This survey will assess how well native species persist and move-in following early season treatment. The sample sites randomly chosen in the pre-treatment surveys will be resurveyed both within the treatment areas and outside the treatment areas (as control samples). A list of all aquatic plant species present and their density (1 (low) to 5 (heavy)) will be recorded for each sample site using a standardized list of all species identified on Deer Lake to date.

Subsequent seasons

Pre-treatment monitoring will provide data for assessing the effectiveness of treatment the previous year. Follow-up monitoring at a given sample and control site will occur for a minimum of three years following herbicide application.

Plan Action Item
Complete detailed pre- and post-monitoring preceding and following early season Endothall treatment of curly leaf pondweed nuisance areas.

Plan Action Item
Map extent of curly leaf beds in June of each year. Measure relative density of all aquatic plant species and percent coverage of curly leaf pondweed to assess changes in curly leaf pondweed distribution and growth over time.

Eurasian Watermilfoil

Plan Action Item
The Deer Lake Association intern and the applicator will continue to check for the presence of Eurasian watermilfoil and other invasive plants. Volunteer and intern boat landing monitors will check boats and clean boats if necessary and provide information to lake users at the public boat landing.

Plan Action Item
Trained lake resident volunteers will check for presence of Eurasian watermilfoil and other invasive aquatic species along their shorelines.

Filamentous Algae Monitoring

Plan Action Item
The applicator will continue to check for the presence of filamentous algae and use GPS equipment to map locations of nuisance occurrence prior to chemical (copper compound) applications. Extent of nuisance occurrence will be related to in-lake phosphorus levels as collected by self-help monitor volunteers.

Plan Action Item
Monitor effectiveness of chemical filamentous algae treatment. Rake samples will be collected to assess abundance of filamentous algae and the aerial extent of floating mats in treatment and nearby control areas also identified with nuisance conditions. Effectiveness will be measured at two days and one week following treatment.

In-Lake Self-Help Monitoring

Plan Action Item
Expanded self-help monitoring including at least monthly summer and fall measurements of chlorophyll, total phosphorus, transparency (Secchi depth) along with temperature and dissolved oxygen profiles will continue.

Implementation Plan

Action Items	Timeline	Annual Cost Estimate[18]
Early season curly leaf pondweed treatment	May 2006, 2007, 2008	$2,000
Resident information and education	Ongoing July annual meetings	*$1,500
Public boat launch inspection	June – September	*$3,600
Boat landing navigation channel treatment	May - September	
Filamentous algae survey and treatment	June – September	$10,000
Whole lake aquatic plant surveys	2006 and 2009	*$3,500[19]
Curly leaf pondweed treatment monitoring	May, June, August	$4,175
Expanded self-help monitoring	April - September	

Responsible Party for Implementation

Activity	**Responsible Party**
Overall aquatic plant management planning	Deer Lake Association (In-lake Comm.)
Expanded self-help monitoring	DLA Volunteers
Lake Resident Education	DLA Intern and Consultant
Contract with applicator	Chair, DLA Env. Committee
Apply for herbicide permit	Applicator
Supervise herbicide application	Chair, DLA Env. Committee
Pre and post survey filamentous algae	Consultant
Pre and post survey curly leaf pondweed and natives	Consultant
Eurasian watermilfoil monitoring	Applicator, Intern, and Consultant
Whole lake aquatic plant survey	Consultant (not applicator)
Public boat launch inspection	DLA (Intern and Volunteers)
Rapid response for EWM	Chair, DLA Env. Committee
Apply for individual corridor permits	Riparian Landowners (applicator)

[18] Costs marked with an asterisk are currently covered by a DNR aquatic invasive species grant to the Town of St. Croix Falls.
[19] Note that this cost applies only every third year.

The Deer Lake Association currently contracts with Lake Management, Inc. for herbicide and algaecide applications and screening for Eurasian watermilfoil introduction. Harmony Environmental conducts aquatic plant monitoring and other consultant activities.

The Town of St. Croix Falls received an Aquatic Invasive Species Grant to cover activities on Deer Lake from October 1, 2005 to December 31, 2008. The 50% match will be paid by the Deer Lake Association.

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