2011 Progress Report for Black Otter Lake, Outagamie County, Wisconsin

Project ACEI-052-09

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October 24, 2011

Introduction

In 2008, the Black Otter Lake District received an Aquatic Invasive Species (AIS) Established Population Control Grant from the Wisconsin DNR. This three-year grant has been used to fund control efforts for Eurasian watermilfoil (*Myriphyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) and related activities. The primary control activities have been a full lake drawdown and spring herbicide application. Additionally, annual monitoring of the native and exotic plant communities and the water quality of Black Otter Lake has been carried out. The main focus of this long-term project has been to restore water quality and the biotic communities of Black Otter Lake and to improve recreational use of the lake.

Recent Management Efforts

Over the past eight years, the members of the Black Otter Lake District have actively managed Eurasian watermilfoil and curly-leaf pondweed. Both species have dominated the lake at various times over this period. Treatments for exotic species date back to 2003.

Since 2008 annual reports have been prepared which summarize the year's activities. These reports can be reviewed for more specific details regarding management activities on Black Otter Lake. The following is a brief description of activities since 2008.

On May 5, 2008 a survey of Black Otter Lake was conducted to identify the extent of Eurasian watermilfoil and curly-leaf pondweed. In total approximately 25 acres of Eurasian watermilfoil and 30 acres of curly-leaf pondweed were identified. Chemical treatment of exotics took place on May 6, 2008. This treatment focused primarily on curly-leaf pondweed and covered a total of 30 acres of the lake. This included the area upstream of the railroad trestle. On July 18, 2008, a full point-intercept survey of Black Otter Lake was conducted. The survey identified 14 aquatic plant species including Eurasian watermilfoil and curly-leaf pondweed. Eurasian in the main body of the lake declined however it was still wide-spread in the southern portion of the lake above and below the train trestle.

In 2008 an Adaptive Lake Management Plan was developed for the Black Otter Lake District. This plan included a number of lake management planning activities. These included bathymetric mapping of the lake bed, sediment analysis, a drawdown of the lake and subsequent monitoring. The plan also called for the planting of emergent species at specified locations along shore.

A drawdown of Black Otter Lake took place during the winter of 2008-2009. The lake was drained in September 2008 and refilled in May 2009. The goals of the drawdown were to improve water quality, reduce sediment volumes and control nuisance aquatic plant growth, including native and exotic species. In 2009, following the drawdown, surveys found little Eurasian watermilfoil present but nearly lake-wide curly-leaf pondweed. The abundance of curly-leaf pondweed was unexpected as it was hoped the

freezing conditions would impact both exotic species equally. Pre- and post-drawdown data indicate that Eurasian watermilfoil declined significantly as a result of the drawdown. In addition, sediment depths had decreased and average water depth had increased, as did overall navigation in the lake.

Prior to the 2008-2009 drawdown of Black Otter Lake, fish were captured and moved to a private pond to be held until after the lake was refilled. After the drawdown, the fish were returned and additional fish were stocked in the lake.

The Black Otter Lake District undertook a number of additional projects in 2009 in an effort to improve the overall health and recreational use of Black Otter Lake. In June 2009 an emergent planting effort was conducted. Many lake volunteers including District members and high school students took part in this project which was supervised by Cason & Associates' staff. In total, six emergent and floating-leafed species totaling 800 plants were planted along the lake shore.

The District created eight tree drops around the shore of Black Otter Lake to serve as fish and wildlife habitat. The District also elected two non-voting high school students to the board. This was done to give the students the opportunity to become more involved and educated on lake ecology and management, and to develop future lake leaders.

In 2010, the District installed an osprey/eagle nesting platform at the southeast end of the lake. The District also kicked off a Clean Boats Clean Waters program on Black Otter Lake in the spring 2010. In June 2010, 200 pickerel plants were planted along the east shore of Black Otter Lake. These plants were unavailable in 2009 when the previous planting effort took place.

In April 2010, post-drawdown treatments of curly-leaf pondweed and Eurasian watermilfoil took place. Approximately 57 acres of curly-leaf pondweed in the main body of the lake were treated with Aquathol K® (liquid endothall) at a rate of 1.5 ppm. An additional 5 acres of curly-leaf pondweed located above the train trestle was treated with Aquathol Super K® (granular endothall) at a rate of 1.5 ppm. In addition, 14 acres of Eurasian watermilfoil were treated with DMA4 IVM® (liquid 2,4-D) at a rate of 1.5 ppm. Pre- and post-treatment monitoring was conducted in accordance with the current Aquatic Invasive Species grant awarded to the Black Otter Lake District in 2008.

On May 11, 2011 61 acres of curly-leaf pondweed and 14 acres of Eurasian watermilfoil were treated in the same manner as in 2010.

This report provides a summary of lake monitoring activities in 2011 and presents the results of these studies with management recommendations. This should also be considered the final report to the DNR in regards to the 2008 AIS grant.

Methods

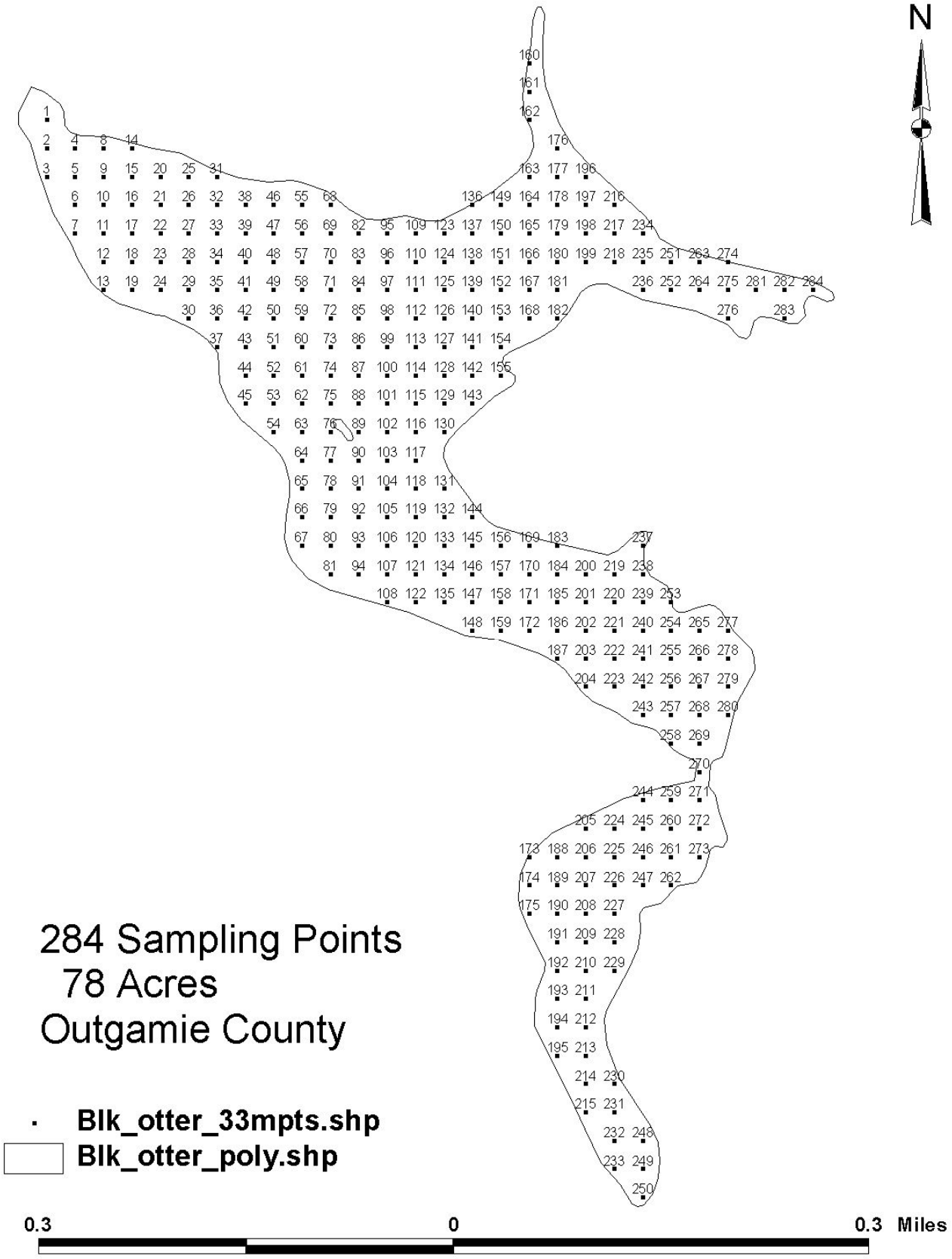
Exotic Plant Distribution Mapping
On May 5, 2011, a survey for exotic species was conducted on Black Otter Lake by Cason & Associates' staff. This survey was used to determine the area and location of curly-leaf pondweed and Eurasian watermilfoil. It utilized the point-intercept aquatic plant survey map as a guide. Surface observations and rake tows were used to determine the extent and locations of exotic species at each location. Abundance ratings were given for each species at each location. The ratings used follow the guidelines established by the Wisconsin DNR for point-intercept plant surveys.

Submergent Aquatic Plant Survey
On August 1, 2011, Cason & Associates staff and a district volunteer conducted a point intercept survey of the entire aquatic plant community in Black Otter Lake (**Figure 1**). At each location, aquatic plant samples were collected from a boat with a single rake tow. All plant samples collected were identified to *genus* and *species* whenever possible, and the information was recorded. An abundance rating was also given for each species. In addition to the plant data, depth and bottom substrate composition were recorded for each location. Data collected were used to determine species composition, percent frequency and relative abundance. Results of this survey and surveys conducted in 2008-2010 were compared to assess changes in the plant community as a result of the recent drawdown.

Water Quality Assessment
Dissolved oxygen and temperature data are currently being collected on a regular schedule by District volunteers. Surface-to-sediment data are collected at the lake's deepest point near the dam. Data are collected at three-foot increments in order to develop these profiles. Data from May 25 and July 19, 2011 are currently available.

Water samples for analysis of chlorophyll *a* and total phosphorus were also collected by volunteers in 2011. Samples were sent to the State Lab of Hygiene for analysis. Water transparency (Secchi depth) data have been collected starting in May 2011. Chlorophyll *a*, total phosphorus and Secchi depth data were used to quantify the productivity of the lake (Trophic State Index). To date, only a limited number of results are available.

Figure 1. Black Otter Lake aquatic plant survey map.



Results and Discussion

Exotic Plant Distribution Mapping

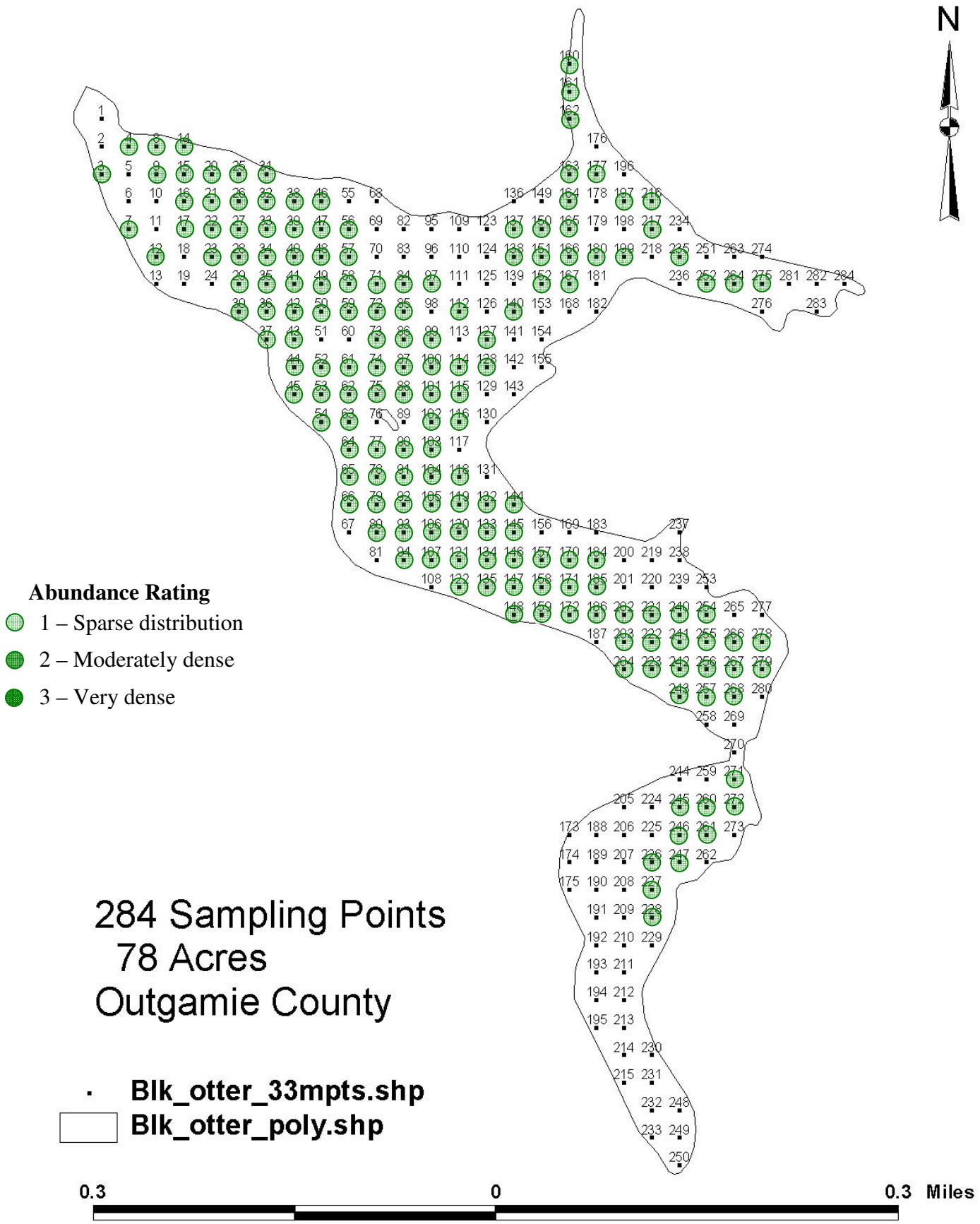
Results of the May 5, 2011 survey for exotic species in Black Otter Lake are shown in **Figure 2**. Eurasian watermilfoil had not begun growing and was not found at the time of the survey. As expected curly-leaf pondweed was found lake-wide.

The results of the May 5, 2011 survey showed curly-leaf pondweed was still widespread in the lake prior to the treatment (**Figure 2**). Following treatment, at the time of the point-intercept survey on August 1, 2011, curly-leaf pondweed was found at only three locations. The treatment appeared to be very effective. Eurasian watermilfoil was not found during the August survey.

Curly-leaf pondweed produces vegetative reproductive structures called turions. These turions fall to the bottom of the lake when the plants die in the summer. Over the winter and into the spring, turions begin to sprout. Turions can survive chemical treatment and can remain viable in the sediment for up to five years.

Immediately following the drawdown, it was apparent that curly-leaf pondweed had persisted. Because the lake was refilled in May 2009, treatment of curly-leaf pondweed was not permitted that year. Many native species had begun growing and the risk of damaging the native plant community was too high. Unfortunately, a new crop of turions were produced and, as a result, the first post-drawdown treatment of curly-leaf pondweed was postponed until 2010. A second such treatment was conducted on May 11, 2011. It is likely curly-leaf pondweed will again be wide-spread in Black Otter Lake in the spring of 2012. It is anticipated annual treatments will be needed for the next 2-3 years to continue managing curly-leaf pondweed. Each year the density of curly-leaf will decline as plants are treated before turions are able to form. Each year the number of viable turions in the sediment will decline. Although density may decrease, treatment areas may be similar in size.

Figure 2. Locations of curly-leaf pondweed (*Potamogeton crispus*) found on May 5, 2011 on Black Otter Lake.



Point-Intercept survey

Although 284 points were mapped across Black Otter Lake, it was only possible to reach 158 locations at the time of the August 1, 2011 survey. The remaining locations were not navigable due to extremely dense growth of common waterweed (*Elodea candensis*) and shallow water (**Figure 3**). Very little plant growth was found in areas deeper than 7.5 feet. A total of 16 submergent, floating-leafed and emergent aquatic plant species were found during the survey (**Table 1**). This is above the state-wide average of 13 species. Black Otter Lake lies within the Northern Central Hardwood Forests region of Wisconsin[(1)]. The average number of species found in lakes in this region is 14 species. The percent frequency values listed in **Table 1** reflect the relationship between the number of locations where a particular species was found versus the total number of locations sampled. Percent composition values reflect the abundance of a particular species in relation to all other species found. The most abundant plant species encountered in Black Otter Lake in 2011 were common waterweed, coontail (*Ceratophyllum demersum)*, and sago pondweed (*Stuckenia pectinata*). These species have all reached nuisance levels in Black Otter Lake in the past. The data in **Table 1** show some fluctuation in the levels of these three species dating back to before the drawdown in 2008. The level of common waterweed in the lake in 2011 was very concerning to riparian property owners and other lake users. Data show that this species has been on the increase annually since 2009. Whether this trend will continue into 2012 or whether another species will become more dominant is impossible to predict. The raw data for the 2011 submergent aquatic plant survey can be found in **Appendix A**.

Simpson Diversity Index

In order to estimate the diversity of the aquatic plant community, the Simpson Diversity Index takes into account both the number of species identified (richness) and the distribution or relative abundance of each species. With the Simpson Diversity Index (D), 1 represents infinite diversity and 0, no diversity. That is, the bigger the value of D, the higher the diversity. The value of D calculated for Black Otter Lake based on the 2011 data was 0.65. Data from 2010 resulted in a D value of 0.82, down slightly from 2009 when it was 0.88. The value calculated from the 2008 data was 0.79. Although State-wide or regional averages for D are not available, data from lakes surveyed in neighboring counties have yielded values of 0.75 or greater with many lakes with values above 0.85. The data for Black Otter Lake indicate that the drawdown of 2008-2009 stimulated aquatic plant diversity in the lake, but as time has passed the diversity has continued to drop.

[(1)] Nichols. 1999. *Floristic quality assessment of Wisconsin lake plant communities with example applications.* Journal of Lake and Reservoir Management. 15(2):133-141.

Figure 3. Locations of common waterweed (Elodea Canadensis) found on August 1, 2011 on Black Otter Lake.

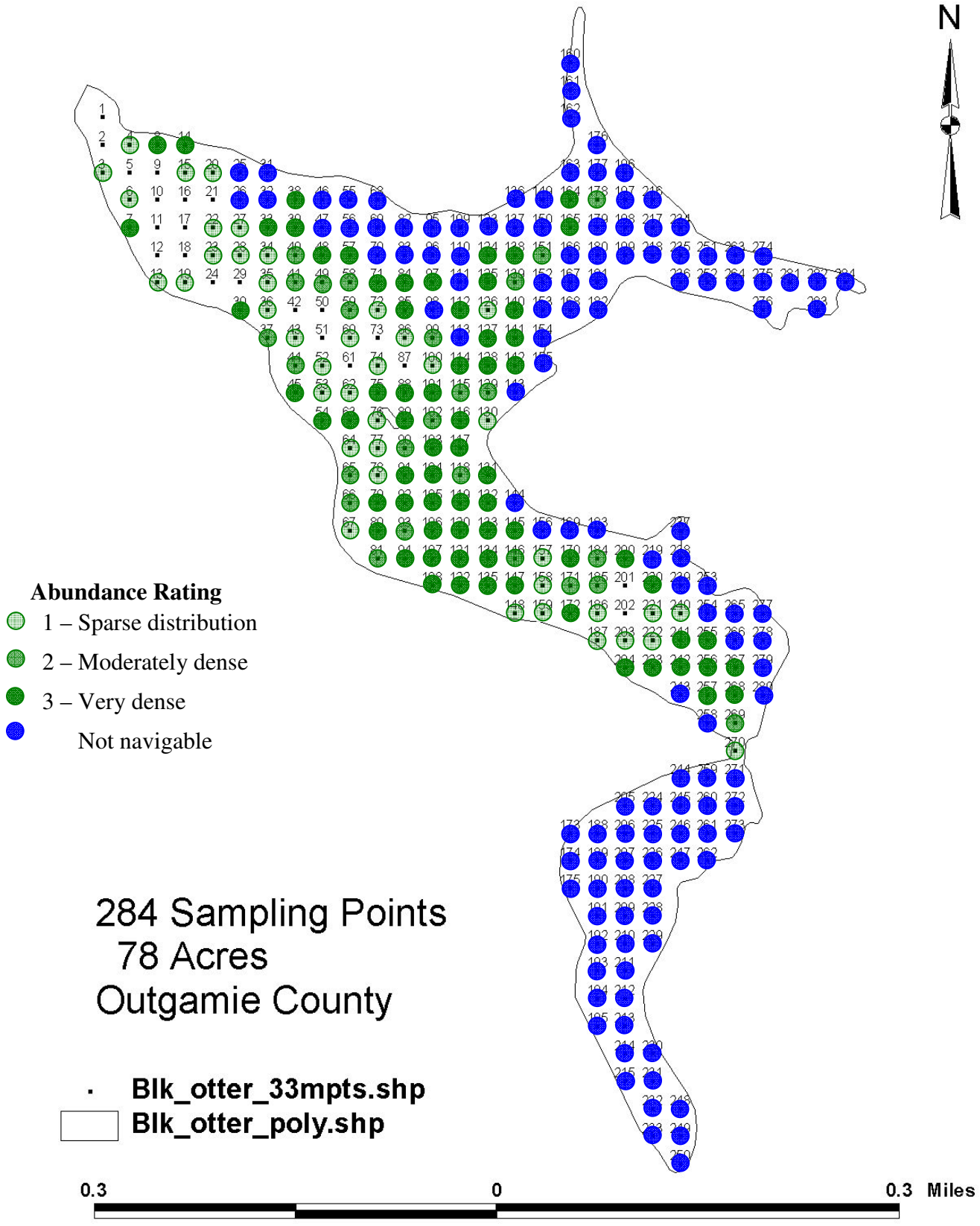


Table 1. Results of the submergent aquatic plant survey conducted on Black Otter Lake on July 18, 2008, July 31, 2009, August 17, 2010 and August 1, 2011.

		2011		2010		2009		2008	
Species common name	**scientific name**	**Percent Frequency**	**Relative Frequency**	**Percent Frequency**	**Relative Frequency**	**Percent Frequency**	**Relative Frequency**	**Percent Frequency**	**Relative Frequency**
Common waterweed	*Elodea canadensis*	88.51	54.1	44.22	21.9	19.74	6.3	0.9	0.3
Coontail	*Ceratophyllum demersum*	32.43	19.8	58.17	28.9	47.64	15.3	95.2	36.6
Sago pondweed	*Stuckenia pectinata*	21.62	13.2	3.59	1.8	39.91	12.8	10	3.8
Watermeal	*Wolffia columbiana*	4.73	2.9	--	--	--	--	38.3	14.7
Filamentous algae	--	4.05	2.5	17.93	8.9	14.59	4.7	49.6	19.1
Small duckweed	*Lemna minor*	3.38	2.1	27.89	13.8	3.43	1.1	32.2	12.4
Curly-leaf pondweed	*Potamogeton crispus*	2.03	1.2	1.59	0.8	69.53	22.3	6.5	2.5
Small pondweed	*Potamogeton pusillus*	2.03	1.2	0.4	0.2	36.48	11.7	--	--
Water stargrass	*Heteranthera dubia*	2.03	1.2	23.11	11.5	9.01	2.9	2.6	1
Bushy pondweed	*Najas flexilis*	1.35	0.8	1.2	0.6	25.32	8.1	1.3	0.5
Stonewort	*Nitella* sp.	0.68	0.4	0.4	0.2	--	--	--	--
Common bladderwort	*Utricularia vulgaris*	0.68	0.4	--	--	--	--	--	--
Cattails	*Typha* sp.	visual	--	1.59	0.8	7.73	2.5	--	--
White water lily	*Nymphaea odorata*	visual	--	visual	--	5.15	1.7	visual	--
Softstem bulrush	*Schoenoplectus tabernaemontani*	visual	--	0.8	0.4	0.43	0.1	--	--
Spatterdock	*Nuphar variegata*	visual	--	0.4	0.2	visual	--	visual	--
Muskgrass	*Chara* sp.	--	--	16.73	8.3	11.59	3.7	0.9	0.3
Northern watermilfoil	*Myriophyllum sibiricum*	--	--	--	--	8.58	2.8	0.9	0.3
Eurasian watermilfoil	*Myriophyllum spicatum*	--	--	visual	--	5.15	1.7	16.5	6.4
Floating-leaf pondweed	*Potamogeton natans*	--	--	2.79	1.4	4.29	1.4	5.2	2
Water smartweed	*Polygonum amphibium*	--	--	--	--	1.72	0.6	--	--
Common arrowhead	*Sagittaria latifolia*	--	--	visual	--	0.86	0.3	--	--
Forked duckweed	*Lemna trisulca*	--	--	--	--	0.43	0.1	--	--
Grass-leaved arrowhead	*Sagittaria graminea*	--	--	visual	--	--	--	--	--
	Simpson Diversity Index	0.65		0.82		0.88		0.79	
	Coefficient of Conservatism	4.9		5.0		4.9		5.2	
	Floristic Quality Index	18.4		19.4		20.1		17.9	
	(WI ave. 22.2, Region ave. 20.9)								

Assessment of Floristic Quality

The plant data collected for Black Otter Lake were used to assess the *floristic quality* of the lake. The method used assigns a value to each native plant species called a *Coefficient of Conservatism*. Coefficient values range from 0-10 and reflect a particular species' likelihood of occurring in a relatively undisturbed landscape. Species with low coefficient values, such as sago pondweed, are likely to be found in a variety of habitat types and can tolerate high levels of human disturbance. On the other hand, species with higher coefficient values, such as small pondweed, are much more likely to be restricted to high quality natural areas. By averaging the coefficient values available for the submergent and emergent species found in Black Otter Lake, a lake-wide value of 4.9 was calculated. In 2010, this value was 5.0, in 2009 it was 4.9 and in 2008 it was 5.2. The average value for lakes in Wisconsin is 6.0 while the average in the Northern Central Hardwood Forests region of Wisconsin, which includes Outagamie County, is 5.6 [(1)].

By utilizing the *Coefficients of Conservatism* for the plant species of Black Otter Lake, further assessment of floristic quality can be made. By multiplying the average coefficient values for Black Otter Lake by the square root of the number of plant species found, a *Floristic Quality Index* (FQI) was calculated to be 18.4. In 2010 this value was 19.4, in 2009 it was 20.1 and in 2008 it was 17.9. In general, higher FQI values reflect higher lake quality. The average for Wisconsin lakes is 22.2. The average for lakes in the Northern Central Hardwood Forests region is 20.9 [(1)].

The *Simpson Diversity Index*, the *Coefficient of Conservatism* and the *Floristic Quality Index* values suggest the quality of Black Otter Lake, specifically in terms of the plant community, is slightly below average. This is not surprising for an artificial waterbody such as Black Otter Lake. However, the values for these calculations are now at or below the pre-drawdown levels. The data suggest conditions in the lake improved initially, but have begun to decline. Progress toward reaching lake management goals of improving the quality of the native plant community is no longer being achieved.

Aquatic Planting Sites

Initially in 2009, most of the species which had been planted appeared to be doing well. Geese were observed eating the arrowhead plants along the north shore of the lake. The following season, many of the species planted were not spreading as hoped. The burreed (*Sparganium eurycarpum*) and bulrushes (*Schoenoplectus tabernaemontani*) appeared healthy, but other species were either not found or only found in low numbers. In 2011, the burreed were not found; the bulrushes were sparse and only a few pickerel plants (*Pontederia cordata*) were found. White water lilies (*Nymphaea odorata*), arguably the most tolerant of static water levels, have responded the best.

Water Quality Assessment

Dissolved Oxygen and Temperature
Dissolved oxygen and temperature data collected from Black Otter Lake in 2011 by lake volunteers are found in **Table 2**.

Dissolved oxygen data show that there are sufficient oxygen levels at the surface of the lake. Much of the data since the drawdown also indicates this trend. The ideal level of oxygen needed for fish, such as bass, perch, and sunfish to survive and grow, is 5 mg/L or greater. An aeration system was in operation throughout the season. Oxygen levels in July raise some concerns. Although the surface levels were above 5 mg/L, at six and nine feet deep the lake was nearly void of oxygen. Prior to curly-leaf pondweed management summer anoxia and fish kills occurred. This does not appear to be a threat currently. However, dissolved oxygen conditions could be improved further.

Table 2. 2011 dissolved oxygen and temperature data from the deepest location near the dam on Black Otter Lake, Outagamie County, WI.

Depth	5/25/2011		7/19/2011		9/12/2011	
(feet)	Temp (ºC)	D.O. (mg/l)	Temp (ºC)	D.O. (mg/l)	Temp (ºC)	D.O. (mg/l)
3	17.4	8.12	24.8	6.73	22.3	8.98
6	17.3	7.9	21.7	0.18	21.1	3.76
9	15.4	2.66	19.8	0.14	19.9	0.11

Water Chemistry

The water quality data collected from Black Otter Lake in from 2007 to 2011 are found in **Tables 3 and 4**. In the two years prior to the drawdown in the winter of 2008-2009, water clarity (Secchi depth) was the only water quality parameter assessed. Following the drawdown, water clarity data as well as phosphorus and chlorophyll data were collected.

Table 3. Pre-drawdown (2007-2008) Black Otter Lake water quality analysis and trophic state index (TSI) results.

Sample Date	Phosphorus (µg/l)	Phosphorus TSI	Chlorophyll a (ug/l)	Chlorophyll a TSI	Secchi Depth (feet)	Secchi (m)	Secchi TSI	Average TSI
9/12/2007	--	--	--	--	9.0	2.7	45.46	45.46
9/19/2007	--	--	--	--	9.0	2.7	45.46	45.46
9/28/2007	--	--	--	--	9.5	2.9	44.68	44.68
10/3/2007	--	--	--	--	9.2	2.8	45.14	45.14
10/12/2007	--	--	--	--	7.2	2.2	48.67	48.67
10/20/2007	--	--	--	--	9.0	2.7	45.46	45.46
11/7/2007	--	--	--	--	7.0	2.1	49.08	49.08
4/20/2008	--	--	--	--	4.3	1.3	56.10	56.10
4/27/2008	--	--	--	--	4.0	1.2	57.14	57.14
5/1/2008	--	--	--	--	4.8	1.5	54.52	54.52
5/8/2008	--	--	--	--	5.4	1.6	52.82	52.82
5/15/2008	--	--	--	--	4.0	1.2	57.14	57.14
5/23/2008	--	--	--	--	6.1	1.9	51.06	51.06
5/28/2008	--	--	--	--	10.1	3.1	43.80	43.80
6/5/2008	--	--	--	--	8.6	2.6	46.11	46.11
6/13/2008	--	--	--	--	9.1	2.8	45.30	45.30
6/18/2008	--	--	--	--	8.6	2.6	46.11	46.11
6/26/2008	--	--	--	--	7.2	2.2	48.67	48.67
7/4/2008	--	--	--	--	5.4	1.6	52.82	52.82
7/12/2008	--	--	--	--	5.0	1.5	53.93	53.93
7/20/2008	--	--	--	--	5.0	1.5	53.93	53.93
7/27/2008	--	--	--	--	3.2	1.0	60.36	60.36
8/9/2008	--	--	--	--	2.8	0.9	62.28	62.28
8/25/2008	--	--	--	--	3.7	1.1	58.27	58.27
8/31/2008	--	--	--	--	3.7	1.1	58.27	58.27
9/6/2008	--	--	--	--	3.7	1.1	58.27	58.27

Table 4. Post-drawdown (2009-2011) Black Otter Lake water quality analysis and trophic state index (TSI) results.

Sample Date	Phosphorus (µg/l)	Phosphorus TSI	Chlorophyll a (ug/l)	Chlorophyll a TSI	Secchi Depth (feet)	Secchi (m)	Secchi TSI	Average TSI
6/13/2009	--	--	--	--	5.8	1.8	51.79	51.79
7/6/2009	--	--	--	--	5.0	1.5	53.93	53.93
8/12/2009	--	--	--	--	5.5	1.7	52.56	52.56
8/26/2009	--	--	--	--	5.8	1.8	51.79	51.79
8/27/2009	122	73.42	33.3	64.99	5.3	1.6	53.09	63.83
9/1/2009	--	--	--	--	4.8	1.5	54.52	54.52
9/22/2009	149	76.31	28.9	63.60	4.7	1.4	54.82	64.91
10/13/2009	--	--	--	--	5.5	1.7	52.56	52.56
11/1/2009	--	--	--	--	4.4	1.3	55.77	55.77
4/11/2010	36	55.82	6.93	49.59	5.7	1.7	52.04	52.49
4/19/2010	--	--	--	--	5.5	1.7	52.56	52.56
4/26/2010		--	--	--	5.3	1.6	53.09	53.09
5/2/2010	37	56.22	--	--	5.4	1.6	52.82	54.52
5/9/2010	--	--	--	--	6.0	1.8	51.30	51.30
5/15/2010	--	--	--	--	7.0	2.1	49.08	49.08
5/24/2010	--	--	--	--	7.6	2.3	47.89	47.89
6/1/2010	--	--	--	--	6.3	1.9	50.60	50.60
6/9/2010	--	--	--	--	7.0	2.1	49.08	49.08
6/15/2010	30	53.2	4.73	45.84	7.3	2.2	48.48	49.17
7/7/2010	--	--	--	--	6.1	1.9	51.06	51.06
7/26/2010	23.4	49.61	1.37	33.69	6.3	1.9	50.60	44.63
8/16/2010	22.2	48.85	8.8	51.93	5.1	1.6	53.64	51.48
9/13/2010	--	--	--	--	5.1	1.6	53.64	53.64
11/9/2010	--	--	--	--	5.6	1.7	52.30	52.30
11/22/2010	--	--	--	--	5.0	1.5	53.93	53.93
5/25/2011	84	68.04	--	--	5.1	1.6	53.64	60.84
6/29/2011	82	67.69	3.49	42.86	--	--	--	55.28
7/19/2011	95	69.82	29.9	63.93	5.1	1.6	53.64	62.46
9/12/2011	--	--	--	--	8.5	2.6	46.28	46.28

Phosphorus

Total phosphorus is one of the most important water quality indicators. Because phosphorus is often the limiting factor in aquatic systems, phosphorus levels determine the amount of plant and algae growth in a lake. Phosphorus can come from external sources within the watershed (fertilizers, livestock, septic systems) or to a lesser extent, from groundwater. Phosphorus can also come from within the lake. Internal loading occurs when plants and chemical reactions release phosphorus from the lake sediments into the water column.

The average phosphorus concentration for natural lakes in Wisconsin is 25 µg/L.[(2)] Values above 50 µg/L are indicative of poor water quality. Data from 2011 indicate

phosphorus levels were high in Black Otter Lake. Levels have fluctuated in the past two to three years. In 2010 levels were typical for Wisconsin Lakes. In 2009, levels in August and September were 122 and 149 µg/L, respectively. This was likely due to nutrient release from untreated curly-leaf pondweed which died back and decomposed in the summer. The early season treatment for curly-leaf pondweed in 2010 and 2011 targeted small plants with low biomass. The amount of nutrients released from decomposing plants after these treatment would have been much less. It is unclear what the source of phosphorus in 2011 has been.

Chlorophyll

Chlorophyll is the pigment that makes plants and algae green. Measuring chlorophyll levels indicates the level of algae in a lake. Generally speaking, the more nutrients there are in the water and the warmer the water, the higher the production of algae and consequently chlorophyll. Chlorophyll concentrations below 10 µg/L are most desirable for lakes. Results from the first two sampling events in 2011 varied. In June, levels were well below 10 µg/L, while levels in July were well above. In 2010, levels were consistently below 10 µg/L. In 2009, levels were high; again likely due to nutrient release from untreated curly-leaf pondweed.

Secchi Transparency

Water clarity (Secchi depth) is often used as a quick and easy test for a lake's overall water quality, especially in relation to the amount of algae present. There is an inverse relationship between Secchi depth and the amount of suspended matter, including algae, in the water column. The less suspended matter, the deeper the Secchi disc is visible. Secchi depths deeper than six feet are generally indicative of good water quality. Clarity in May and July 2011 were both 5.1 feet; in September it was 8.5 feet. Clarity in 2010 averaged 6.0 while in 2009 it averaged 5.2. The annual average clarity in 2008, prior to the drawdown, was 5.5 feet. Only fall data from 2007 are available. No data are available from 2003 to 2006. The data suggest the clarity of Black Otter Lake varies throughout a given season but the overall average clarity form year to year has not changed significantly as a result of the drawdown.

(2) Shaw, Bryon, Christine Mechenich, and Lowell Klessig. 2004. *Understanding lake data.* University of Wisconsin – Extension. RP-03. 20 pp.

Trophic State

There is a strong relationship between levels of phosphorus and chlorophyll and water clarity in lakes. As a response to rising levels of phosphorus, chlorophyll levels increase and transparency values often decrease. The effect of this is viewed as an increase in the productivity of a lake. This productivity can be quantified by calculating the Trophic State Index (TSI) of a lake. The formulas for calculating the TSI values for Secchi disk, chlorophyll, and total phosphorus are as follows[3]:

$$TSI = 60 - 14.41 \ln \text{Secchi disk (meters)}$$

$$TSI = 9.81 \ln \text{Chlorophyll } (\mu g/L) + 30.6$$

$$TSI = 14.42 \ln \text{Total phosphorus } (\mu g/L) + 4.15$$

Typically the higher the TSI value calculated for a lake, the more productive the lake is. Often higher productivity translates to impaired water quality and nuisance plant growth. TSI values below 50 are most desirable for lakes. The values calculated from data collected in 2011 averaged 56. In 2010 the average was 51 and in 2009 the average was 56. In 2008, prior to the drawdown, the average was 54. Overall, the trophic values calculated before and after the drawdown have been above the desired level. However, appeared conditions in Black Otter Lake improved some in 2010 after the drawdown but have begun to decline since.

Conclusions and Recommendations

Conditions in Black Otter Lake prior to the 2008-2009 drawdown were problematic. Water quality was poor and the lake had lake-wide Eurasian watermilfoil and curly-leaf pondweed. Following the drawdown, changes were observed. Water quality improved particularly in 2010, sediment testing indicated decomposition and desiccation occurred, and the diversity of the native aquatic plant community improved. However, curly-leaf pondweed survived the drawdown and was found wide-spread in 2009. In addition, in the months since the drawdown, emergent plantings sponsored by the lake district have not flourished as hoped and in 2011 the lake was overrun with common waterweed. A recent meeting was held at Black Otter Lake to discuss future management of the lake. Attendees included representatives from the Wisconsin DNR, the Village of Hortonville, the Black Otter Lake District and Cason & Associates, LLC. The following summaries and recommendations are, in part, a direct result of the discussions and decisions made during this meeting. Additional District activities have been summarized at the request of the District.

Aquatic plant community

From 2008 to 2009, the number of aquatic plant species in Black Otter Lake increased from 13 to 19. The increased level of diversity and floristic quality continued into 2010. However, the quality of the plant community declined again in 2011 due to wide-spread growth of common waterweed which was found at nearly 90% of the locations sampled. District members indicated common waterweed was at nuisance levels for seven to eight weeks during the summer. Curly-leaf pondweed was also wide-spread in the spring but was successfully treated along with Eurasian watermilfoil. Eurasian watermilfoil has not been identified in the lake since the spring treatment.

Continued aquatic plant management should result in eventual declines in curly-leaf pondweed. Research and experience has shown that a multi-year treatment strategy is required to effectively manage curly-leaf pondweed. This is due to the persistence of viable turions in the sediment of a lake. These vegetative reproductive structures are produced by mature curly-leaf pondweed plants. As the plants die back in the summer, the turions fall to the bottom of the lake and can remain dormant for a number of years. Each year many turions sprout and can grow into mature, turion-producing plants.

It is recommended that curly-leaf pondweed and Eurasian watermilfoil be actively managed as they have been in the past. Early season treatments with endothall and 2,4-D should again be used to target both species. For greatest effectiveness, treatments should target all known locations of these species and take place when the plants are actively growing. Curly-leaf pondweed is expected to be found growing throughout the lake in the spring of 2012. Approximately 54 acres of the lake are less than 7.5 feet deep and are expected to contain curly-leaf pondweed. The District should expect to treat these areas in the spring with Aquathol K® (liquid endothall) at a rate of 1.5 ppm. An additional 5 acres of curly-leaf pondweed located above the train trestle should again be treated with Aquathol Super K® (granular endothall) at a rate of 1.5 ppm. In addition, spot treatment of Eurasian watermilfoil, *if found*, should be conducted with Navigate® at rates between

150-200 lbs/acre. Continued annual treatments are in line with the 2008 management plan developed for the lake.

If common waterweed continues to be a nuisance, chemical treatment of navigation lanes should be considered. The use of endothall and 2,4-D is not expected to have an impact on common waterweed. Instead, it is recommended that the herbicide diquat be used to open predetermined lanes for navigation. As a broad spectrum herbicide, diquat can have an impact to other plant species and should be used with caution to minimize effects on non-target species.

It will be critical to continue to monitor plant growth in Black Otter Lake particularly in relation to chemical treatments. As planned in the 2008 grant, pre- and post-treatment mapping surveys of the lake will be necessary to determine the efficacy of treatment and further treatment needs. A pre-treatment survey should again take place in mid-April. The first post-treatment survey should take place in the summer, approximately eight weeks following treatment. This survey can also serve as the full point-intercept survey. As exotic species are actively managed, it will be important to continue to monitor the native plant community to assess possible impacts from the treatments. A third and final survey should be scheduled for the fall (October) when water temperatures have cooled and Eurasian watermilfoil begins to regrow. This survey, in particular, will help determine future treatment needs for Eurasian watermilfoil.

The AIS grant awarded in 2008 will come to an end this year. The District plans to use the remaining funds to offset treatment costs in 2012 by pre-purchasing the herbicides. The AIS grant application ranked high in 2008. It is recommended a similar project focusing on lake restoration and specifically management of aquatic invasive species be proposed to begin in 2012. The deadlines for submission to the AIS Established Population Control grant program are February 1st and August 1st of each year. Consensus of the content of the proposal should be reached before a proposal is submitted.

Emergent plants

Following the 2009 and 2010 emergent planting efforts, survival of the species planted has been less than expected. It is believed that the relatively constant water depth since the drawdown has not allowed for healthy emergent plant growth because many emergent plant species are accustomed to fluctuating water levels.

It is recommended that before additional emergent plantings are planned, previous planting locations be monitored. It will be important to determine which species survived and could be planted in other areas.

Clean Boats Clean Waters

District volunteers Mark Voight, Mason Arnold and Bill Curtis have conducted boat launch monitoring to discourage the movement of exotic species into or out of Black Otter Lake. Fishing pressure on the lake is low due to post-drawdown conditions and perceptions. As a result, there has been little fishing activity; perhaps 5-6 boats per week.

The District wishes to increase the pool of volunteers participating in this monitoring program, however, with such low boating pressure on the lake, it has been a challenge to convince potential volunteers of its importance.

Water level control

The District has discussed again manipulating the water level of Black Otter Lake. The best results in terms of improvements to the plant community and sediment compaction/desiccation come from a growing season drawdown rather than a winter drawdown. The District has the option of drawing the water down by a small margin in the winter in order to minimize damage from ice shoves. Due to the decline in the native plant community, the District is strongly considering a more extensive but still partial drawdown during the growing season of 2012. The beginning of this drawdown would take place in May 2012 after the spring curly-leaf pondweed treatment has taken effect. The lake would then be refilled in the fall. There are benefits to a partial drawdown that a full drawdown would not include. The fishery has a better chance of remaining intact and recreational use of the lake can continue. A partial drawdown would also be able to improve conditions of the emergent and submergent plant communities in the area drawn down. As previously discussed, it is recommended a two to four foot drawdown be conducted every two to three years. This will encourage emergent plant growth, while deterring the growth of exotics and other nuisance submergent plant growth in the shallow locations of the lake.

Water quality assessment

Phosphorus, chlorophyll and Secchi depth data for Black Otter Lake in 2011 indicate fair to poor water quality. In 2010, conditions appeared to be improving. This had been attributed to the management of curly-leaf pondweed. This species did not experience a lake-wide die-off in 2010, as it did in 2009 when water quality was poor. Because water quality can be affected by management activities on the lake, continued water quality monitoring is recommended. The frequency to which volunteer monitoring took place in 2010 and 2011 should continue in 2012 and beyond. This data will be valuable in determining what impact the management of exotics, in particular, has on the water quality of the lake.

Dissolved oxygen data from 2011 suggest the current aeration system may not be providing sufficient oxygen to the lake during the warmest times of the year. It is recommended an assessment of the current system be made to assure it is working at full capacity. An expansion of the system may be warranted following this assessment.

Fish stocking

Since the 2008-2009 drawdown, District members have indicated the bluegills (*Lepomis macrochirus*) appear to have done well in the lake with hatches in 2010 and 2011. In 2019 large number of northern pike (*Esox lucius*) hatched and became overabundant in the lake. Many were caught in 2010, however, very few have been observed or caught in 2011. Anglers have been encouraged to keep northern pike and releasing largemouth bass (*Micropterus salmoides*) and panfish.

Over 8,000 yellow perch (*Perca flavescens*) were stocked in Black Otter Lake following the drawdown. Several large perch have been caught since. Large black crappies (*Pomoxis nigromaculatus*) have also been caught recently. No young of the year crappies or perch were observed in 2011. Much of these observations are anecdotal in nature. The Wisconsin DNR plans to conduct a boomshocking survey of the lake in the fall of 2011. Results should help determine the current condition of the fishery of Black Otter Lake and assess the natural reproduction in the lake since 2009.

DNR staff have indicated surplus fish, primarily panfish, from federal hatcheries may be available in the future to stock in Black Otter Lake. Specific types and numbers are not known. Black Otter Lake will be placed on a waiting list to receive surplus fish when they become available.

Restoration of island

Over time, the island on Black Otter Lake has experienced significant erosion. In 2010, a large tree on the island fell during a wind storm, further revealing the condition of the island. The District would like to restore the shoreline of the island and reverse the effects of erosion. A combination of physical stabilization and emergent plantings should be able to help the District reach this goal. The DNR has discouraged the District from using riprap. However, midsized rocks may be used. There are also options like coconut fiber logs which slowly break down over time, but allow for bank stabilization. Emergent plants can also be planted in and around the island to reduce the impacts from wave action. If muskrat damage is occurring on the island as well, it may be possible to include chicken wire into the restoration plan to limit this damage.

Tree drops

With the success and positive response from the previous tree drop event, the District is interested in continuing with this effort. The DNR is also encouraged by the results and supports the District's plans to drop more trees into the lake. The District will need to identify the trees they wish to include in this effort and contact the appropriate riparian owners.

Watershed study

The District recently applied and received a lake planning grant for a comprehensive watershed study. This study will look at both point and non-point sources of nutrients entering the lake and the effect this has on water quality. Results will be used to develop actions which the Village, District and individual property owners can take to improve conditions in the watershed and lake as a whole. Data collection will begin in the winter and fieldwork will take place next year.

Recreational use of the lake

The District is working to improve the recreational use of the lake. In recent years, the District has sponsored several fund-raising events in order to raise $23,000 which was used to build a new boat landing and handicap-accessible dock at the main public access point on the western shore of Black Otter Lake.

In addition, the District plans to work with the Hortonville High School, which owns several canoes to make them accessible to visiting lake users. This would be a positive step toward promoting Black Otter Lake as a recreational destination for people in the Fox valley. The District is also considering purchasing kayaks that can also be made available. Businesses in Hortonville could also benefit from having an increase in visitors in town. The logistics of canoe and kayak rentals have not yet been worked out.

Appendix A

Point-intercept plant survey data from August 1, 2011 on Black Otter Lake, Outagamie County, Wisconsin.

sampling point	Depth (ft)	comments	*Potamogeton crispus*,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum*,Coontail	*Elodea canadensis*,Common waterweed	*Heteranthera dubia*,Water star-grass	*Lemna minor*,Small duckweed	*Najas flexilis*,Bushy pondweed	*Nitella* sp.,Nitella	*Potamogeton pusillus*,Small pondweed	*Stuckenia pectinata*,Sago pondweed	*Utricularia vulgaris*,Common bladderwor	*Wolffia columbiana,Common watermeal*	Freshwater Sponge
1	9.4	No Plants													
2	9.6	No Plants													
3	4		1	v		1									
4	6.7			v		1									
5	9.8	No Plants													
6	8.2					1									
7	4			v		3									
8	6.1			v	1	3						1		v	
9	8.3			v	1							v			
10	9.3	No Plants													
11	9.1	No Plants													
12	7	No Plants													
13	3.7			1		1	1								
14	2					3		v				v		v	
15	7.2		v			1						1			
16	8.8	No Plants													
17	9.1	No Plants													
18	9.3	No Plants													
19	8.2					1									
20	7.6					v									
21	6.1			v	1			v			1	1			
22	8					1									
23	8.3				1	1									
24	7.6	No Plants													
25		Not Navigable													
26		Not Navigable													
27	5		1			1									
28	7.4		v			v									
29	9.1	No Plants													
30	5.1					3									
31		Not Navigable				v									
32		Not Navigable				v									
33	4					3		v				2			
34	6.5					1						1			
35	7.7		v			1				1					
36	7.3				1	1									
37	4			v		2						v			

sampling point	Depth (ft)	comments	*Potamogeton crispus*,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum*,Coontail	*Elodea canadensis*,Common waterweed	*Heteranthera dubia*,Water star-grass	*Lemna minor*,Small duckweed	*Najas flexilis*,Bushy pondweed	*Nitella* sp.,Nitella	*Potamogeton pusillus*,Small pondweed	*Stuckenia pectinata*,Sago pondweed	*Utricularia vulgaris*,Common bladderwor	*Wolffia columbiana,Common watermeal*	Freshwater Sponge
38	3.2					3									
39	2.9				1	3						1			
40	8.4					2					1				
41	6.5					2						v			
42	8.7	No Plants													
43	7.2					v						v			
44	5.2				v	2						1			
45	4.4					3									
46		Not Navigable													
47		Not Navigable													
48	4					3		v				1		v	
49	7.1				1	2					1				
50	8.9		v												
51	8.2	No Plants													
52	7.3					1									
53	7.5				1	1									
54	3.2			2		3	v							v	
55		Not Navigable													
56		Not Navigable													
57	3.8					3						v		v	
58	6.7				1	2						2			
59	7.8		v			2									
60	8.7					1									
61	10.4	No Plants													
62	5.3					v									
63	4.7				1	3									
64	4.8					1						v			
65	5.5					2						1		v	
66	5.2					2						v		v	
67	5.7					1								v	
68		Not Navigable													
69		Not Navigable													
70		Not Navigable													
71	4.3					3						2			
72	7.7					1									
73	8.2	No Plants													
74	8					1									

sampling point	Depth (ft)	comments	*Potamogeton crispus*,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum*,Coontail	*Elodea canadensis*,Common waterweed	*Heteranthera dubia*,Water star-grass	*Lemna minor*,Small duckweed	*Najas flexilis*,Bushy pondweed	*Nitella* sp.,Nitella	*Potamogeton pusillus*,Small pondweed	*Stuckenia pectinata*,Sago pondweed	*Utricularia vulgaris*,Common bladderwor	*Wolffia columbiana,Common watermeal*	Freshwater Sponge
75	4.4					3						3			
76	7.4					1						1			
77	7					1						1		v	
78	6					1						2			
79	6.2				v	3								v	
80	6.6					3								v	
81	5.5				1	2									
82		Not Navigable													
83		Not Navigable													
84	4.5					3						1			
85	7.2				1	3								v	1
86	7.7				1	1									
87	8.6	No Plants													
88	4					3									
89	3			1	1	3		v				2		v	
90	5				v	3						1			
91	6					2									
92	6.4				1	3									
93	7.2				2	2									
94	6					3								v	
95		not navigable													
96		not navigable													
97	3				v	3									
98	4.5					3						v			
99	7.2		1		1	2									
100	8.6				v	v									
101	7.1		v		1	3									
102	8.2					2									
103	6.1				1	3								v	
104	7.1					3									
105	5.2					3									
106	6.2				1	3									
107	4.4					3						2			
108	6				v	3	1					v		v	
109		not navigable													
110		not navigable													
111		not navigable													

sampling point	Depth (ft)	comments	*Potamogeton crispus*,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum*,Coontail	*Elodea canadensis*,Common waterweed	*Heteranthera dubia*,Water star-grass	*Lemna minor*,Small duckweed	*Najas flexilis*,Bushy pondweed	*Nitella* sp.,Nitella	*Potamogeton pusillus*,Small pondweed	*Stuckenia pectinata*,Sago pondweed	*Utricularia vulgaris*,Common bladderwor	*Wolffia columbiana,Common watermeal*	Freshwater Sponge
112	3.4					3									
113	9				3	3						v			
114	7.6				1	3									
115	7.1					2									
116	5.1					3									
117	4					3						1		v	
118	6.2				2	2									
119	6.8				v	3								v	
120	6.5				1	3								v	
121	7.1			v	2	3								v	
122	4.2				v	3								v	
123		not navigable													
124	3.2			v		3						2		v	
125	5.5			v	1	3									
126	8.1				1	1									
127	6.5					3									
128	5					3						2			
129	4				v	2						2		v	
130	2.9			v		v	1		v					v	
131	3				1	3						2		v	
132	5.2					3						2		v	
133	6.6			v	2	3								v	
134	7.2					3						v			
135	6.1			v	1	3								v	
136		not navigable													
137		not navigable													
138	4					3						1			
139	7.5				1	2									
140	5.5				v	3									
141	4.9					3									v
142	4.4					3						2		v	
143		not navigable													
144		not navigable													
145	3.2					3						1		v	
146	5.8				1	2							1		
147	6.6					3								v	
148	2			v	1	1									

sampling point	Depth (ft)	comments	*Potamogeton crispus*,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum*,Coontail	*Elodea canadensis*,Common waterweed	*Heteranthera dubia*,Water star-grass	*Lemna minor*,Small duckweed	*Najas flexilis*,Bushy pondweed	*Nitella* sp.,Nitella	*Potamogeton pusillus*,Small pondweed	*Stuckenia pectinata*,Sago pondweed	*Utricularia vulgaris*,Common bladderwor	*Wolffia columbiana,Common watermeal*	Freshwater Sponge
149		not navigable													
150		not navigable													
151	5			v	2	2								v	
152		not navigable													
153		not navigable													
154		not navigable													
155		not navigable													
156		not navigable													
157	4.7				1	1									
158	6.4				1	1								v	
159	5.8			v	v	1								v	
160		not navigable													
161		not navigable													
162		not navigable													
163		not navigable													
164	6.7			v		3			1					v	
165	4.6				1	3			v						
166		not navigable													
167		not navigable													
168		not navigable													
169		not navigable													
170	3.7					3								v	
171	5.6					2								v	
172	6					3									
173		not navigable													
174		not navigable													
175		not navigable													
176		not navigable													
177		not navigable													
178	4.7			v	1	2			2					v	
179		not navigable													
180		not navigable													
181		not navigable													
182		not navigable													
183		not navigable													
184	2					2								v	
185	6.8					2								v	

sampling point	Depth (ft)	comments	*Potamogeton crispus*,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum*,Coontail	*Elodea canadensis*,Common waterweed	*Heteranthera dubia*,Water star-grass	*Lemna minor*,Small duckweed	*Najas flexilis*,Bushy pondweed	*Nitella* sp.,Nitella	*Potamogeton pusillus*,Small pondweed	*Stuckenia pectinata*,Sago pondweed	*Utricularia vulgaris*,Common bladderwor	*Wolffia columbiana,Common watermeal*	Freshwater Sponge
186	6.6				1	1						1			
187	2			2	1	1	v								
188		not navigable													
189		not navigable													
190		not navigable													
191		not navigable													
192		not navigable													
193		not navigable													
194		not navigable													
195		not navigable													
196		not navigable													
197		not navigable													
198		not navigable													
199		not navigable													
200	2.5			1	1	3						1		1	
201	8.6	No Plants												1	
202	9.2	No Plants													
203	5.3				v	1								v	
204	3			1	1	3	v							1	
205		not navigable													
206		not navigable													
207		not navigable													
208		not navigable													
209		not navigable													
210		not navigable													
211		not navigable													
212		not navigable													
213		not navigable													
214		not navigable													
215		not navigable													
216		not navigable													
217		not navigable													
218		not navigable													
219		not navigable													
220	5.2					3									
221	7.5				2	1								v	
222	6.9				v	1								v	

sampling point	Depth (ft)	comments	*Potamogeton crispus*,Curly-leaf pondweed	filamentous algae	*Ceratophyllum demersum*,Coontail	*Elodea canadensis*,Common waterweed	*Heteranthera dubia*,Water star-grass	*Lemna minor*,Small duckweed	*Najas flexilis*,Bushy pondweed	*Nitella* sp.,Nitella	*Potamogeton pusillus*,Small pondweed	*Stuckenia pectinata*,Sago pondweed	*Utricularia vulgaris*,Common bladderwor	*Wolffia columbiana*,Common watermeal	Freshwater Sponge
223	3.6				v	3								1	
224		not navigable													
225		not navigable													
226		not navigable													
227		not navigable													
228		not navigable													
229		not navigable													
230		not navigable													
231		not navigable													
232		not navigable													
233		not navigable													
234		not navigable													
235		not navigable													
236		not navigable													
237		not navigable													
238		not navigable													
239		not navigable													
240	6.1				1	1		1						v	
241	3.4				1	3		1						v	
242	3.8				v	3		v						v	
243		not navigable													
244		not navigable													
245		not navigable													
246		not navigable													
247		not navigable													
248		not navigable													
249		not navigable													
250		not navigable													
251		not navigable													
252		not navigable													
253		not navigable													
254		not navigable													
255	3.2					3		1						1	
256	3.3					3		v				v		v	
257		not navigable													
258		not navigable													
259	3.5				1	3						2		v	

284	283	282	281	280	279	278	277	276	275	274	273	272	271	270	269	268	267	266	265	264	263	262	261	260	sampling point
														3.5	2.7	4.7	3.4								Depth (ft)
not navigable	not navigable	not navigable	not navigable	not navigable	not navigable	not navigable	not navigable	not navigable	not navigable	not navigable	not navigable	not navigable	not navigable					not navigable	not navigable	not navigable	not navigable	not navigable	not navigable	not navigable	comments
																									Potamogeton crispus, Curly-leaf pondweed
																									filamentous algae
															2	1									*Ceratophyllum demersum*, Coontail
														1	2	3	3								*Elodea canadensis*, Common waterweed
																									Heteranthera dubia, Water star-grass
															1	V	1								*Lemna minor*, Small duckweed
																									Najas flexilis, Bushy pondweed
																									Nitella sp., Nitella
																									Potamogeton pusillus, Small pondweed
																2									*Stuckenia pectinata*, Sago pondweed
																									Utricularia vulgaris, Common bladderwort
															1	V	1								*Wolffia columbiana, Common watermeal*
																									Freshwater Sponge