A Survey of Aquatic Plants in Long Lake, Waushara County, with recommendations for management and improvement

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Sponsored by: **The Long Lake Association and the Wisconsin Department of Natural Resources**

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Introduction

Long Lake is 272 acre lake located in northern Waushara County, Wisconsin, near the village of Saxeville. The Long Lake Association is the principle management unit representing the interests of lakefront property owners. In 2004, the Long Lake Association retained Aquatic Biologists, Inc. to conduct aquatic plant surveys of the lake, and to draft an aquatic plant management plan for the association.

Specific project objectives were to 1) survey both emergent and submergent plant communities, 2) map the locations and distribution of any exotic aquatic plant species encountered, 3) research management options, and develop contingency plans for dealing with exotic species invasion, and 4) to research management options for lake habitat improvement. This report presents the findings of these efforts.

Lake Characteristics

Long Lake is a deep, clear lake of glacial origin surrounded by forested hills. The lake's 272 acres lie in an east-west axis comprised of two basins (Figure 1). The west basin has a maximum depth of 71 feet. The east basin has a maximum depth of 60 feet. Long Lake has an average depth of 22 feet and a volume of 5,984 acre-feet (approximately 2 billion gallons). The lake has no inlets or outlets, and is primarily fed by groundwater seepage. Hydraulic residence time has been calculated at 4.9 years. Long Lake experiences both thermal and oxygen stratification. Mid summer thermoclines were found beginning from 15 to 25 feet deep. Mid summer oxyclines began at 25 to 35 feet, with anoxic conditions occurring below a depth of 40 to 45 feet (R.A. Smith, 1996).

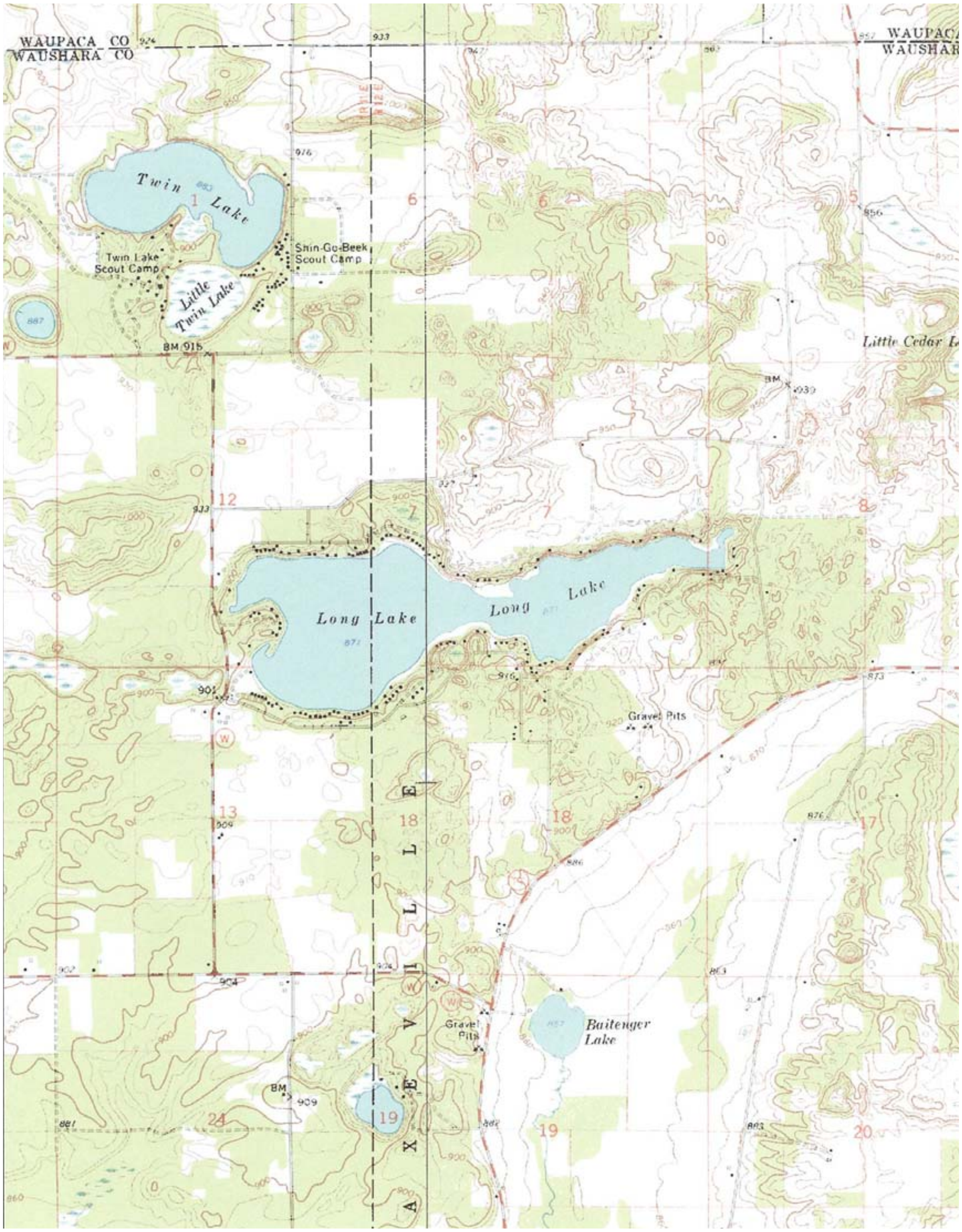
Water quality indicators categorize Long Lake as early mesotrophic – a classification typical of natural lakes of this size found in Central Wisconsin. The good water quality, sandy shores and depth found in Long Lake make the lake very appealing for boaters and swimmers. Not-surprisingly, the lake is entirely surrounded by cottages and year-around homes. A well-maintained boat launch located on the south shore of the lake provides access to the public.

Recent Management

Lake assessment activities occurring in the last twenty years have included periodic fishery surveys conducted by the Wisconsin Department of Natural Resources (WDNR) and a comprehensive lake survey commissioned by the Long Lake Association and conducted by R.A. Smith and Associates, Inc. in 1993 and 1994. The R.A. Smith study assessed lake water quality, aquatic plants, hydrology, and nutrient inputs.

Lake management activities have primarily involved periodic fish stocking to maintain a sport fishery. Since 1993 Long Lake has been used by the WDNR as a rearing facility for spotted musky (*Esox masquinongy*) brood stock.

Figure 1. Long Lake, located in the Townships of Saxeville and Springwater, Waushara County, Wisconsin.



Methods

Submergent Plant Survey

The submergent plant survey involved plotting a series of 23 transects (labeled A through W) at approximately even distances around the lake shoreline. (The coordinates of each transect starting point are given in Appendix A.) These transects extended at 90 degree angles from shore to a depth of twenty feet, or to the maximum depth possible (Figure 2). Where sufficient depths existed, sampling plots were established along each transect at 2.5, 5, 10 and 20 foot depth contours. At each plot a 10-foot diameter circle was estimated around the anchored boat. The circle was divided into four quarters, with each quarter representing a quadrant. Plants were collected in each quadrant with a tethered short-toothed rake. From each rake tow, all plants collected were identified to genus and species. Data was recorded separately for each quadrant. A total of 336 quadrants were sampled. Bottom substrate data were also collected at each sample plot. Although this survey was designed primarily to target submergent species, all plant species encountered were recorded, including emergent and floating leaf plants and macrophytic algae.

Emergent Plant Survey

During the emergent plant survey only, emergent and floating leaf species were recorded. Of these species, only those plants having roots underwater were counted (plants growing on the bank, out of the water, were not considered.) The emergent plant survey consisted of 23 evenly-spaced transects running parallel to the lake shoreline. These transects were located in between the starting points of the submergent plant survey transects (Figure 2, Appendix A). Thus, the shoreline transect located between emergent transects A and B was labeled AB; the transect located between B and C was labeled BC, etc.

Plant observations were recorded on a data sheet. For each transect, each species encountered was given a ranking based on its abundance, as follows:

0	*Absent*	not found along transect
1	*Rare*	found along less than 5% of transect
2	*Present*	found along 5 – 25% of transect
3	*Common*	found along 25 – 50% of transect
4	*Abundant*	found along more than 50% of transect

From this data, percent frequency and percent composition were calculated.

Exotic Species Mapping

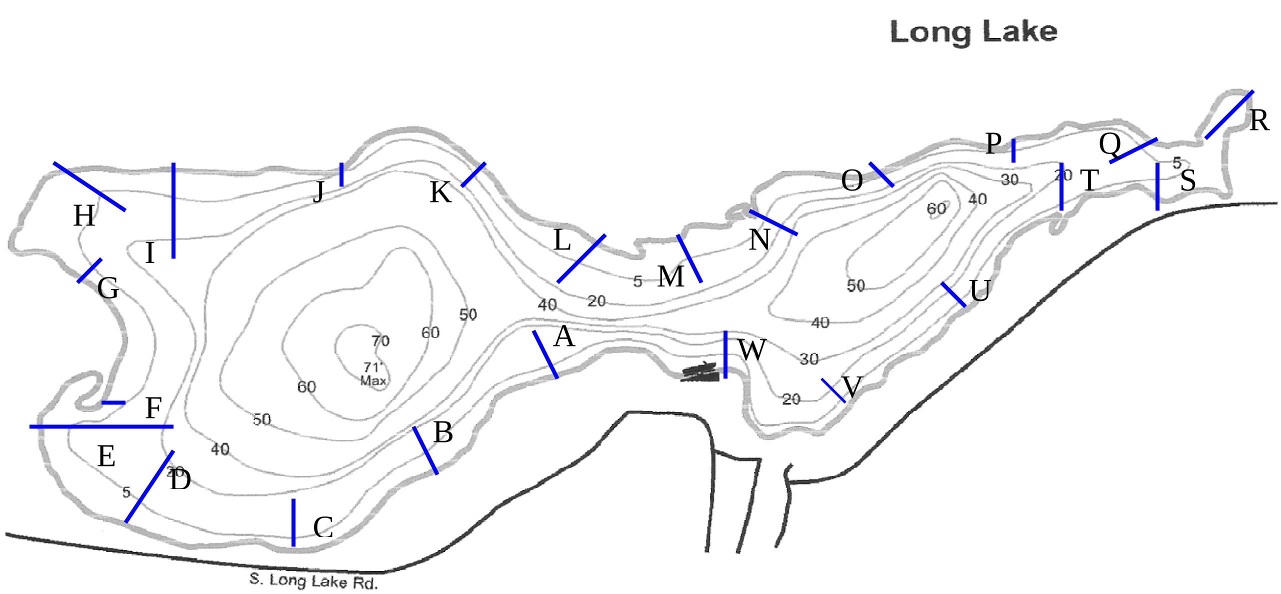
During the course of this project, a concerted effort was made to locate exotic aquatic plant species. Efforts focused primarily on identifying Eurasian watermilfoil (*Myriophyllum spicatum*), curly-leaf pondweed (*Potamogeton crispus*), and purple loosestrife (*Lythrum salicaria*). Survey methods included observation from a boat, use of an underwater camera and snorkeling. GPS technology was available for mapping and determining the areas of any exotic plant beds found.

As part of this effort, the maximum extent of rooted vegetation (the littoral zone) was also determined and mapped.

Fishery Habitat Assessment

The assessment of fishery habitat in Long Lake was a three-fold process. The first step involved identifying fish species utilizing the lake. The second step involved researching habitat requirements (i.e. spawning and nursery areas) for these species through literature review. The third step involved identifying these habitats in Long Lake through direct field observation and recording them on a map.

Figure 2. Long Lake aquatic plant survey transects.



Results and Discussion

Submergent Plant Community Characteristics

A total of 14 macrophytes were found during the submergent plant survey (Table 1). By far the most abundant plant encountered in Long Lake was chara or musk grass (*Chara spp.*). Chara was found in 87.7% of quadrants, and made up nearly 50% of plant community composition. The next most abundant plants were Illinois pondweed (*Potamogeton illinoiensis*), variable pondweed (*P. gramineus*) and northern watermilfoil (*Myriophyllum sibericum*). Together with chara, these species comprised 82.5% of plants found in the submergent survey. No plants were found in 32 (9.6%) of the quadrants.

Table 1. Long Lake 2004 submergent plant survey results.

Species ***Common Name***	***Scientific Name***	**Number of Observations**	**Percent Frequency**	**Percent Composition**
Chara	*Chara spp.*	291	87.7	49.9
Illinois Pondweed	*Potamogeton illinoiensis*	81	24.4	13.9
Variable Pondweed	*Potamogeton gramineus*	66	19.9	11.3
Northern Water Milfoil	*Myriophyllum sibericum*	43	13.0	7.4
no plants found		32	9.6	--
Water Celery	*Valisneria americana*	29	8.7	5.0
Sago Pondweed	*Potamogeton pectinatus*	19	5.7	3.3
Large-leaf Pondweed	*Potamogeton amplifolius*	16	4.8	2.7
Flatstem Pondweed	*Potamogeton zosteriformis*	13	3.9	2.2
Floating Leaf Pondweed	*Potamogeton natans*	10	3.0	1.7
Bushy Pondweed	*Najas flexilis*	9	2.7	1.5
White-stem Pondweed	*Potamogeton praelongus*	4	1.2	0.7
Coontail	*Ceratophyllum demersum*	1	0.3	0.2
White Water Lily	*Nymphaea odorata*	1	0.3	0.2
		583		100.0

Table 2 gives the submergent plant survey data by transect. Chara was the most widely distributed plant, and the only one found in all 23 transects. White-stem pondweed (*P. praelongus*) was the rarest submergent specie, having been found in only two transects. Transects E, H, O and Q were the most diverse, each having eight species. Transect A was the least diverse, with only two species.

Table 2. Submergent plant survey data by transect

Species	occurences by transect											
	A	B	C	D	E	F	G	H	I	J	K	L
Bushy Pondweed									1			
Chara	15	14	13	14	14	8	16	12	16	14	13	8
Coontail					1							
Flatstem Pondweed								4				2
Floating Leaf Pondweed										2	6	1
Illinois Pondweed				4	3		5	7	7	1	1	4
Large-leaf Pondweed		1						6				
Northern Water Milfoil				7	6		1	3	4	1		1
Sago Pondweed				1	1			1	1			
Variable Pondweed	1	6	1	2	4	6	5		6		2	
Water Celery				1	1			4	1			
White Water Lily												
White-stem Pondweed								3				
no plants found		2	3	2	2					2	3	8

Species	occurences by transect											
	M	N	O	P	Q	R	S	T	U	V	W	TOTAL
Bushy Pondweed			1			4	2				1	9
Chara	10	16	16	14	10	3	7	11	16	16	15	291
Coontail												1
Flatstem Pondweed			1	1		4		1				13
Floating Leaf Pondweed					1							10
Illinois Pondweed	5	2	5	7	6	4	7	6	2	4	1	81
Large-leaf Pondweed			2	2	3				2			16
Northern Water Milfoil	4	3	1	3	3			5	1			43
Sago Pondweed				4	4	1	2	4				19
Variable Pondweed	2	2	4	4	3		2		8	8		66
Water Celery	3	4	4		1	4	1		3		2	29
White Water Lily						1						1
White-stem Pondweed								1				4
no plants found	5							4			1	32
												615

Emergent Plant Community Characteristics

Emergent plants, those plant with stems or leaves growing at or above the water's surface, were assessed in a separate survey. This survey considered only those plants actually growing in the water. Some emergent species are also commonly found in moist soils at the water's edge. These plants were not counted. Table 3 gives the results of the emergent survey. A total of 23 species were encountered. The most abundant were three square bulrush (*Scirpus pungens*), white water lily (*Nymphaea tuberosa*) and creeping spikerush (*Eleocharis palustris*). While Long Lake's emergent plant community contained a high diversity of species, species density was low. 20 of the 23 species were found at less than 10% frequency. Twelve of the species encountered were observed only one or two times.

Table 4 gives emergent plant survey data by transect. No single plant species was found in every transect. Three square bulrush was the most widely distributed plant, having been found in 18 of the 23 transects. White water lily was the next most widely distributed plant, found in 14 transects. Transect GH, located in the bay on the northwest corner of the lake, contained the highest diversity of plants with 18 species. Transects EF, QR and RS, located in other protected bays, also contained higher species diversity, however most of the remaining transects had relatively few emergent plants. Six transects contained only one species, while two of the transects had no emergent plants.

Plant Distribution

Table 5 shows the occurrence of plant species found at different depths among the two surveys. In a typical lake environment, plant diversity inversely correlates with depth. As depth increases, species diversity decreases. Indeed, in Long Lake the greatest diversity was found along shore, however species diversity decline sharply in the 2.5 and 5 foot intervals. At the 10 foot range though, species diversity increased. This change in plant diversity was readily observed during the field studies. In many shallow areas of the lake, particularly around docks and swim areas, aquatic plants were scarce or non-existent. In shallow areas where aquatic plants were better established, numerous scars from boat prop wash were observed. The greatest diversity and abundance of was observed in the 7 to 15 foot depth range.

While human disturbance is clearly responsible for much shallow water plant loss, some areas of the lake may have historically lacked plants. Analysis of bottom substrates reveals high percentages of sand, gravel and cobble in the 2.5 and 5 foot depth ranges (Table 6). These substrates are not as suited to aquatic plant growth as the muck bottoms found in other areas of the lake.

The maximum depth where aquatic plant grew in Long Lake was typically found at 34 feet. This zone of aquatic plant growth is referred to as the littoral zone. A map of the littoral zone is given in Figure 3. The extent of the littoral zone is a function of light penetration. The great depths to which plants were found in Long Lake was due to the lake's exceptional clarity. At depths beyond 30 feet, the plant community consisted almost entirely of chara.

Table 3. Long Lake 2004 emergent (shoreline) plant survey results.

Species *Common Name*	*Scientific Name*	Number of Observations	Percent Frequency	Percent Composition
Three-square Bulrush	*Scirpus pungens*	35	38.0	26.3
White Water Lily	*Nymphaea tuberosa*	23	25.0	17.3
Creeping Spikerush	*Eleocharis palustris*	12	13.0	9.0
Floating Leaf Pondweed	*Potamogeton natans*	9	9.8	6.8
Porcupine Sedge	*Carex hystericina*	9	9.8	6.8
Large-leaf Pondweed	*Potamogeton amplifolius*	7	7.6	5.3
Hardstem Bulrush	*Scirpus acutus*	5	5.4	3.9
Water Smartweed	*Polygonum amphibium*	5	5.4	3.9
Blue Vervain	*Verbina hastata*	4	4.3	3.0
Softstem Bulrush	*Scirpus validus*	4	4.3	3.0
Broad-leaved Cattail	*Typha latifolia*	3	3.3	2.3
Blue Flag Iris	*Iris versicolor*	2	2.2	1.5
Boneset	*Eupetorium perfoliatum*	2	2.2	1.5
Broad-leaved Arrowhead	*Sagittaria latifolia*	2	2.2	1.5
Marsh Milkweed	*Asclepias incarnata*	2	2.2	1.5
Willow spp.	*Salix spp.*	2	2.2	1.5
Canada Rush	*Juncus effusius*	1	1.1	0.7
Common Bugleweed	*Lycopus americanus*	1	1.1	0.7
Green Bulrush	*Scirpus atrovirens*	1	1.1	0.7
Narrow-leaved Cattail	*Typha angustifolia*	1	1.1	0.7
Red Top	*Agrostis gigantea*	1	1.1	0.7
Reed Canary Grass	*Phalaris arundinacea*	1	1.1	0.7
Spadderdock	*Nuphar variegata*	1	1.1	0.7
		133		100.0

Table 4. Emergent plant survey data by transect

Species	occurences by transect											
	A-B	B-C	C-D	D-E	E-F	F-G	G-H	H-I	I-J	J-K	K-L	L-M
Blue Flag Iris												
Blue Vervain							1					1
Boneset					1		1					
Broad-leaved Arrowhead							1	1				
Broad-leaved Cattail					1		1					
Canada Rush												
Common Bugleweed												
Creeping Spikerush					2		3					
Floating Leaf Pondweed					2		2	1				2
Green Bulrush												
Hardstem Bulrush				1	1	1	2					
Large-leaf Pondweed				1	1		1					1
Marsh Milkweed							1					
Narrow-leaved Cattail					1							
Porcupine Sedge					2		2					
Red Top							1					
Reed Canary Grass							1					
Softstem Bulrush							2					1
Spadderdock							1					
Three-square Bulrsuh				1	3	1	4	2	1		1	3
Water Smartweed	2	1		1			1					
White Water Lily				1	2		4	1				1
Willow spp.							1					1

Species	occurences by transect											
	M-N	N-O	O-P	P-Q	Q-R	R-S	S-T	T-U	U-V	V-W	W-A	TOTAL
Blue Flag Iris					1	1						2
Blue Vervain					1	1						4
Boneset												2
Broad-leaved Arrowhead												2
Broad-leaved Cattail					1							3
Canada Rush						1						1
Common Bugleweed						1						1
Creeping Spikerush					3	4						12
Floating Leaf Pondweed	1									1		9
Green Bulrush						1						1
Hardstem Bulrush												5
Large-leaf Pondweed							1		1	1		7
Marsh Milkweed					1							2
Narrow-leaved Cattail												1
Porcupine Sedge				1	2	2						9
Red Top												1
Reed Canary Grass												1
Softstem Bulrush						1						4
Spadderdock												1
Three-square Bulrush	2	1	1	3	4	2	3	1		1	1	35
Water Smartweed												5
White Water Lily	1	1	1	1	4	3	1		1	1		23
Willow spp.												2
												133

Table 5. Plant species occurrence by depth interval.

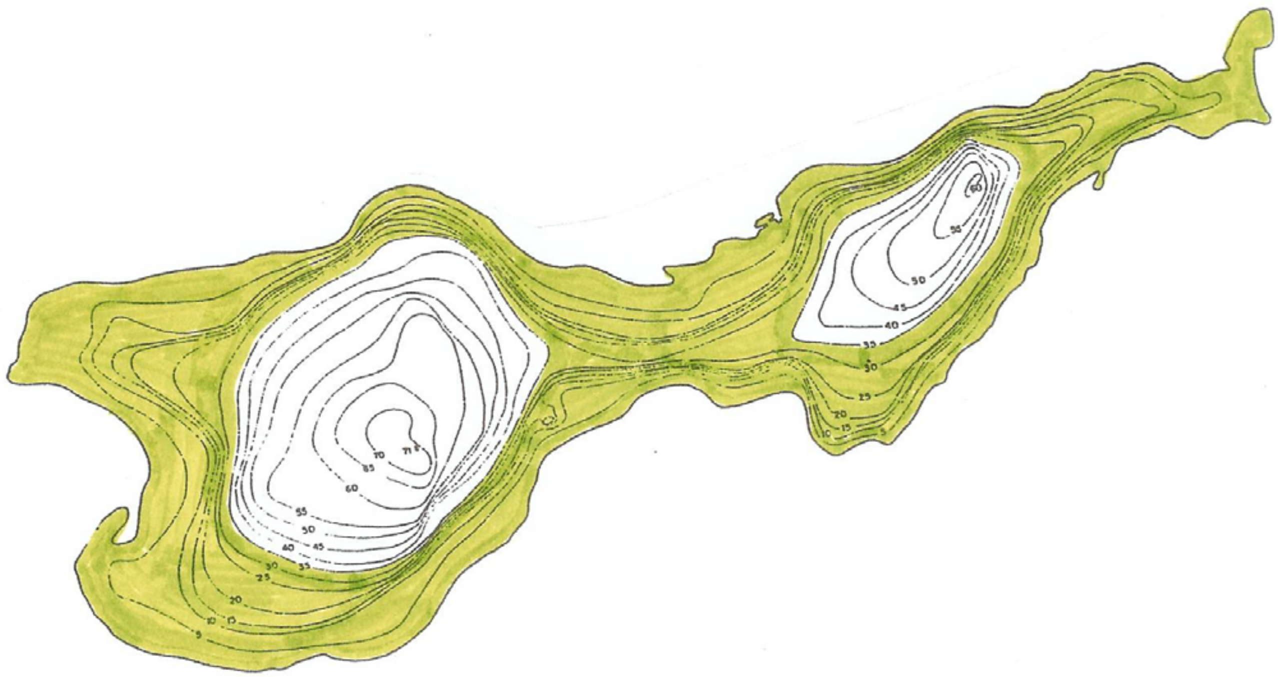
Depth Interval				
< 1 ft.	2.5 ft.	5.0 ft.	10.0 ft.	20.0 ft
Blue Flag Iris	Chara	Chara	Chara	Chara
Blue Vervain	Illinois Pondweed	Illinois Pondweed	Illinois Pondweed	Illinois Pondweed
Boneset	Variable Pondweed	Variable Pondweed	Variable Pondweed	Variable Pondweed
Broad-leaved Arrowhead	Bushy Pondweed	Northern Water Milfoil	Northern Water Milfoil	Northern Water Milfoil
Broad-leaved Cattail	Water Celery	Water Celery	Water Celery	
Canada Rush	Sago Pondweed	Sago Pondweed	Large-leaf Pondweed	
Common Bugleweed	Large-leaf Pondweed	Large-leaf Pondweed	Flatstem Pondweed	
Creeping Spikerush	Flatstem Pondweed	White-stem Pondweed	Floating Leaf Pondweed	
Floating Leaf Pondweed	White Water Lily	Floating Leaf Pondweed	Bushy Pondweed	
Green Bulrush			White-stem Pondweed	
Hardstem Bulrush			Coontail	
Large-leaf Pondweed				
Marsh Milkweed				
Narrow-leaved Cattail				
Porcupine Sedge				
Red Top				
Reed Canary Grass				
Softstem Bulrush				
Spadderdock				
Three-square Bulrush				
Water Smartweed				
White Water Lily				
Willow spp.				

Table 6. Bottom substrates found during the submergent plant survey.

Substrate	Percentage / Depth Interval				
	2.5 ft.	5.0 ft.	10.0 ft.	20.0 ft	Average
Muck	17%	59%	95%	100%	66%
Sand	61%	27%			24%
Gravel	9%	14%	5%		7%
Cobble	13%				3%

Definitions:
Muck = finely divided, well decomposed organic soil material.
Sand = rock or mineral fragments 0.5 to 2.0 mm in diameter.
Gravel = rock or mineral fragments 2 to 75 mm in diameter.
Cobble = rounded fragments of rock 7.5 to 25 cm in diameter

Figure 2. Long Lake littoral zone (zone of rooted vegetation).



The Importance of Aquatic Plants

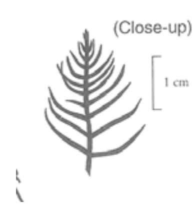
Aquatic plants serve an important purpose in the aquatic environment. They play an instrumental role in maintaining ecological balance in ponds, lakes, wetlands, rivers, and streams. Native aquatic plants have many values. They serve as important buffers against nutrient loading and toxic chemicals, they act as filters that capture runoff borne sediments, they stabilize lake bed sediments, they protect shorelines from erosion, and they provide critical fish and wildlife habitat. Therefore, it is essential that the native aquatic plant community in Long Lake be protected. The following is a list of common native aquatic plants that were found in Long Lake. Ecological values and a description are given for each plant. Plant information was gathered from Borman et.al. (1997), Eggers (1997), Fink (2000), and Whitley et.al.(1999).

Submersed Plants (Plants that tend to grow with their leaves under water.)

Musk grass (*Chara spp*.) is a complex alga that resembles a higher plant. It's identified by its pungent, skunk-like odor and whorls of toothed branched leaves. Ecologically, musk grass provides shelter for juvenile fish and is associated to black crappie spawning sites. Waterfowl love to feast on *Chara* when the plant bears its seed-like oogonia. Musk grass serves an important role in stabilizing bottom sediments, tying up nutrients in the water column, and maintaining water clarity.

Coontail *(Ceratophyllum demersum)* produces whorls of narrow, toothed leaves on a long trailing stem that often resembles the tail of a raccoon. The leaves tend to be more crowded toward the tip. Coontail blankets the bottom, which helps to stabilize bottom sediments. Tolerant to nutrient rich environments, coontail filters a high amount of phosphorus out of the water column. Coontail provides a home for invertebrates and juvenile fish. Seeds are consumed by waterfowl, but are not of high preference.

Northern Watermilfoil (*Myriophyllum spicatum*) produces whorls of feather-like leaflets from a fairly stout stem. Northern watermilfoil is identified by its 5 to 12 pairs of leaflets that become progressively longer near the base of the leaf – giving the leaf a candelabra-like appearance. The leaves and fruit of this plant are eaten by a variety of waterfowl. Its finely divided leaves are habitat for numerous invertebrates that fish feed upon. Northern watermilfoil is an indicator of good water quality, as the plant seldom survives in more eutrophic environments.



Bushy Pondweed (*Najas flexilis*) has a finely branched stem that grows from a rootstock. Leaves are short (1-4 cm), pointed and grow in pairs. Bushy pondweed is an annual and must grow from seed each year. It tends to establish well in disturbed areas. Bushy pondweed is a one of waterfowl's favorite foods and considered very important. Seeds, leaves and stems are relished by waterfowl, marsh birds, and muskrats. Bushy pondweed stabilizes bottom sediment and offers cover for fish.

Sago Pondweed (*Potamogeton pectinatus*) is a perennial herb that emerges from a slender rhizome that contains many starchy tubers. Leaves are sharp, thin, and resemble a pine needle. Reddish nutlets (seeds) that resemble beads on a string rise to the water surface in mid-summer. Sago pondweed produces a large crop of seeds and tubers that are valued by waterfowl. Juvenile fish and invertebrates utilize sago pondweed for cover.

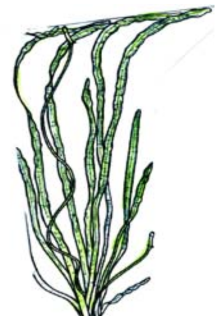
Large-Leaf Pondweed (*Potamogeton amplifolius*) also referred to by fisherman as cabbage weed, is a perennial herb that emerges from a ridged black rhizome. This pondweed is the largest of all pondweeds. The sturdy stem supports large broad leaves that are numerously veined (25-37). Growing upright throughout most of the water column, Large-leaf pondweed provides excellent shade, shelter, and foraging habitat for fish. Producing a large number of nutlets, cabbage weed is also valued by waterfowl.

Floating Leaf Pondweed (*Potamogeton natans*) is a perennial that emerges from a red-spotted rhizome. Leaves that rest at the waters surface are heart shaped. Submerged leaves tend to be longer and skinnier than floating leaves. Fish find this pondweed to be useful for foraging opportunities and shelter. Growing upright in the water column, floating leaf pondweed attracts many aquatic invertebrates. Muskrats, ducks, and geese all graze on the plant.

Illinois Pondweed (*Potamogeton illinoiensis*) and **Variable Pondweed** (*P. gramineus*) are very similar-looking perennial herbs that emerge from a rhizome. Their stout stems support lance-shaped leaves that come to a sharp point. Both of these pondweeds provide excellent cover for fish and invertebrates. Ducks, geese, muskrats, and beaver find most parts of these plants to be a tasty meal.

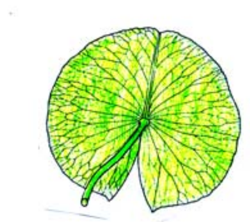
Flat-stem Pondweed (*Potamogeton zosteriformis*) emerges from a rhizome, which has strongly flattened stems. The leaves are narrow and grow 4-8 inches long. Leaves contain a prominent mid-vein and many fine parallel veins. Ecologically, flat-stem pondweed provides a home for fish and invertebrates, and is grazed by waterfowl and muskrats.

Water Celery (*Valisneria americana*) also known as eelgrass has long ribbon-like leaves that emerge in clusters. Leaves have a prominent central stripe and leave tips tend to float gracefully at the water's surface. In the fall, a vegetative portion of the rhizome will break free and float to other locations. Water Celery is considered one of the best all natural waterfall foods. The entire plant is relished by waterfowl, especially canvasbacks. Eelgrass beds serve as an important food source for sea ducks, marsh birds, and shore birds. Fish also find water celery as a popular hiding spot.



Floating Leaf Plants (Plants that are rooted into the bottom and have leaves that float at the water's surface.)

White Water Lily (*Nymphaea odorata*) emerges from a buried rhizome. Durable round stalks grow up from the rhizome. This perennial herb supports large round leaves (4-10 inches) wide that float at the water's surface. Leaves appear waxy green on top and reddish-purple on their undersides. At mid-summer showy white flowers float at the waters surface. Lilies serve as important fish cover, especially for largemouth bass. White water lily seeds are eaten by waterfowl. Rhizomes, flowers, and leaves are consumed by muskrats, beaver, deer, and moose. With large broad leaves, lilies also help prevent shoreline erosion by slowing wave action.



Spatterdock (*Nuphar variegata*) is a perennial herb that produces yellow, rounded flowers. Large (4-10 inches) long, heart-shaped leaves float at the waters surface. Leaf stalks have flattened wings and emerge from a buried spongy rhizome. With large buried rhizomes, spatterdock helps stabilize bottom sediment. The large leaves also help buffer the impact of wave action on the shoreline. Like lilies, spatterdock offers excellent fish habitat. Seeds are eaten by waterfowl; leaves, rhizomes, and flowers are relished by muskrats, beaver, moose, and deer.

Emergent Plants (Plants that are rooted into the bottom and have leaves that emerge above the water's surface.)

Bulrushes (*Scirpus spp.*) found in Long Lake include hardstem bulrush, softstem bulrush, green bulrush and three-square bulrush. Bulrushes are perennial herbs that prefer growing on hard bottom substrates. Olive-green stems emerge above the water's surface. Stems grow 3-9 ft., and can grow in water up to 6 ft. deep. Bulrushes provide important spawning, nursery, and foraging habitat for fish, especially northern pike. Seeds are feasted on by a variety of waterfowl. They also provide food and shelter for muskrats. Bulrushes offer important cover and nesting opportunities for marsh birds. Bulrushes are second only to pondweeds in the number of animal users. Bulrushes also play an important role in improving water quality. They are known for their ability at up-taking excessive nutrients and stabilizing both shoreline and bottom sediment.

Common Arrowhead (*Sagittaria latifolia*) also known as duck potato, is a perennial herb that is a very common shoreline plant. As its' name implies, leaves are shaped like an arrowhead. The size and shape of leaves has great variability. Common arrowhead produces small white flowers made up of three rounded petals. Ecologically, duck potato is considered one of the highest valued aquatic plants for wildlife. The large high-energy tubers are relished by migrating waterfowl, muskrats, and beavers. Marsh birds, ducks, and songbirds all eat arrowhead seeds. Arrowhead stands provide rearing habitat for fish and help aid in shoreline stabilization.

Sedges (*Carex spp*.) are perennial herbs that appear grass-like and have triangular solid stems. Sedges contain a perigynium, a sac-like structure that covers the ovary and nutlet. The perigynium distinguishes sedges from all other plants. Sedges provide important nesting cover and food for a wide variety of songbirds, upland game birds, shore birds, and waterfowl. Amphibians, including frogs and salamanders utilize *Carex* for feeding, shade, and protection. Sedges also serve as important buffer species against nutrient loading and shoreline erosion.

Creeping spikerush (*Eleocharis palustris*) grows as small clusters of stems that are 0.1 to 1 meter tall. Each stem is topped with a single pointed spikelet. Creeping spikerush prefers firm substrates, such as those found along lakeshores. The extensive beds formed by this plant stabilize shorelines and filter sediments. Its nutlets are grazed by ducks, geese and muskrats. Plant beds also provide nursery areas for juvenile fish.

Broad-Leaved Cattail (*Typha latifolia*) emerges from a robust spreading rhizome. This perennial herb has pale green, sword-like leaves that grow up to 9 ft. tall. The male and female flowers grow on the same spike and there's no gap between them. Cattails provide cover and or food for a variety of wildlife including muskrats, black birds, marsh wrens, and waterfowl. Deer and pheasants also seek cattail stands for winter cover. Cattails serve as a home to many invertebrates and are an important spawning habitat for fish. With a network of large rhizomes, cattails also are sturdy shoreline stabilizers.

Narrow-Leaved Cattail (*Typha angustifolia*) is a perennial herb that emerges from a large spreading rhizome. Leaves are dark green, sword-like, and grow up to 9 ft. tall. The male and female flowers grow on the same spike and have a gap of up to 1 inch between them. Narrow leaved cattail is very similar in ecological values as broad-leaved cattail.

Exotic Species

During the extensive surveys done on Long Lake no exotic aquatic plant species were encountered. The invasive exotic plants commonly occur in Waushara County lakes: Eurasian watermilfoil, curly-leaf pondweed and purple loosestrife. The following descriptions are given to promote awareness of these plants.

Eurasian Watermilfoil (*Myriophyllum spicatum*) produces long spaghetti-like stems that often grow up to the water's surface. Leaves are feather-like and resemble bones on a fish. 3-5 leaves are arranged in whorls around the stem, and each leaf contains 12-21 pairs of leaflets. At mid-summer small reddish flower spikes may emerge above the water's surface. Perhaps the most distinguishing characteristic though, is the plant's ability to form dense, impenetrable beds that, inhibiting boating, swimming, fishing, and hunting.

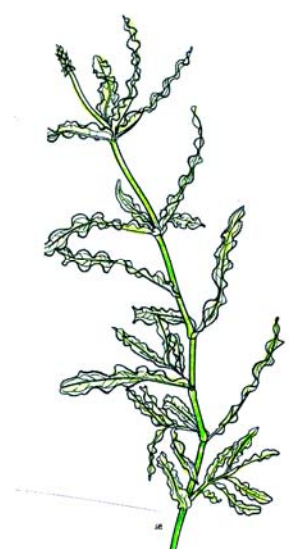
Eurasian watermilfoil is native to Europe, Asia and Northern Africa. Of the eight milfoil (*Myriophyllum*) species found in Wisconsin, Eurasian watermilfoil is the only exotic. The plant was first introduced into U.S. waters in 1940. By 1960, it had reached Wisconsin's lakes. Since then, its expansion has been exponential (Brakken, 2000).

Eurasian watermilfoil begins growing earlier than native plants, giving it a competitive advantage. The dense surface mats formed by the plant block sunlight and have been found to displace nearly all native submergent plants. Over 200 studies link declines in native plants with increases in Eurasian watermilfoil (Madsen, 2001).   The resultant loss of plant diversity degrades fishery habitat (Pullman, 1993), and reduces foraging opportunities for waterfowl and aquatic mammals. Eurasian watermilfoil has been found to reduce predatory success of fish such as largemouth bass (Engle, 1987), and spawning success for trout (*Salmonidae spp.*) (Newroth, 1985).

The continued spread of Eurasian watermilfoil can produce significant economic consequences. In the Truckee River Watershed below Lake Tahoe, located in western Nevada and northeastern California, economic damages caused by Eurasian watermilfoil to the recreation industry have been projected at $30 to $45 million annually (Eiswerth, et.al., 2003). In Tennessee Valley Authority Reservoirs, Eurasian watermilfoil was found to depress real estate values, stop recreational activities, clog municipal and industrial water intakes and increase mosquito breeding (Smith, 1971).

Eurasian watermilfoil has been found to reduce water quality in lake by several means. Dense mats of Eurasian watermilfoil have been found to alter temperature and oxygen profiles – producing anoxic conditions in bottom water layers (Unmuth, et.al., 2000). These anoxic conditions can cause localized die-offs of mollusks and other invertebrates. Eurasian watermilfoil has also been found to increase phosphorus concentration in lakes through accelerated internal nutrient cycling (Smith and Adams, 1986). Increased phosphorus concentrations caused by Eurasian watermilfoil have been linked to algae blooms and reduced water clarity.

Curly Leaf Pondweed (*Potamogeton crispus*) has oblong leaves that are 2-4 inches long and attach to a slightly flattened stem in an alternate pattern. The most distinguishing characteristics are the curled appearance of the leaves, and the serrated leaf edges. Curly-leaf pondweed produces a seed-like turion, which resembles a miniature pinecone. This exotic pondweed is a cold-water specialist.   Curly-leaf pondweed can begin growing under the ice, giving it a competitive advantage over native plants, which are still lying dormant. By mid-summer when water temperatures reach the upper 70° F, it begins to die off.



Curly-leaf pondweed has been found in the U.S. since at least 1910. A native of Europe, Asia, Africa and Australia, this plant is now found throughout much of U.S. (Baumann, et.al., 2000

As with Eurasian watermilfoil, curly-leaf pondweeds aggressive early season growth allows it to out compete native species and grow to nuisance levels. Because the plant dies back during the peak of the growing season for other plants though, it is better able to coexist with native species than Eurasian watermilfoil. Perhaps the most significant problem associated with curly-leaf pondweed involves internal nutrient cycling. The die-off and decomposition of the plant during the warmest time of year leads to a sudden nutrient release in the water. This often leads to nuisance algae blooms and poor water quality.

Purple Loosestrife (*Lythrum salicaria*) forms bright purple flowers in a spike atop stems that reach 2 to 7 feet in height. Lance-shaped leaves are arranged oppositely along the stem. Purple loosestrife can be found in a wide variety of habitats from shallow water to moist soils. Like Eurasian watermilfoil it is a very aggressive plant that can displace many native wetland plants including cattails (*Typha spp.*). Purple loosestrife plants produce hundreds of thousands of tiny seeds. When purple loosestrife is cut, seeds stick to mowing equipment and are spread to new locations. This invasive plant causes significant economic damage by clogging waterways and irrigation canals. Unlike cattails, purple loosestrife has little food or cover value for wildlife (Borman, et. al. 1997). When food and cover disappear, so do the species that depend on it.

Fish Habitat

Fish community characteristics

A fish survey conducted on Long Lake by the WNDR in 2000 (Niebur,2000) found a fishery comprised of largemouth bass (*Micropterus salmoides*), northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), smallmouth bass (*Micropterus dolomieui*), muskellunge (*Esox masquinongy*), white sucker (*Catostomas commersoni*), Yellow bullhead (*Ictalurus natalis*), rock bass (*Ambloplites rupestris*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), black crappie (*Pomoxsis nigromaculatus*), and yellow perch (*Perca flavescens*). ABI staff also observed golden shiners (*Notemigonus crysoleucas*) in the lake. Cisco (*Coregonis artedii*), a fish historically found in Long Lake, was not reported.

Walleye and rock bass appeared to have healthy populations, but largemouth bass and bluegill had high densities and poor size structure (few quality-sized fish). Smallmouth bass, northern pike, black crappie, yellow perch, yellow bullhead and white sucker were present, but in low numbers.

The primary recommendation of this report was to protect important habitats in the east and west bays through Sensitive Area Designation, and through limiting boating disturbances. The second recommendation was to increase woody debris in the lake by installing fish cribs, half-logs, and Christmas tree bundles, and by conducting tree-drops. Other recommendations were to bolster populations of white suckers, cisco, and yellow perch, to continue with walleye stocking, and to explore options for maintaining spotted musky at low numbers.

A fish survey conducted by WNDR in 2002 (Bartz, 2003) found a similar fishery, but noted a decline in both yellow perch and white sucker from the previous survey. The report also commented on the absence of cisco.

The primary recommendation of this report was also to preserve and enhance habitat. Restoring and enhancing lost near shore habitat was specifically recommended. Other recommendations were to continue with the successful walleye stocking program, and to explore options for phasing out the controversial spotted musky program.

Habitat requirements of fish found in Long Lake

Table 7 presents the results of a literature review of fish habitat requirements and improvements. Information in this table was taken from Becker (1983) and Hubbs and Lagler (1964). The results of the literature review correlate with the 2000 and 2002 WDNR fish survey findings. Largemouth bass, bluegill and walleye, all fish found in high numbers, have adequate habitat for all life stages in Long Lake. Species that depend on emergent vegetation, a very limited habitat in Long Lake, such as northern pike, yellow perch and golden shiner were found in low numbers. Likewise with species that depend on woody cover, such as yellow perch, yellow bullhead and black crappie. The lack of this type of habitat in Long Lake correlates with the low numbers found for these species.

While ciscos appear to have adequate habitat, the decline of this species may be tied to the dissolved oxygen and temperature profiles presented in the R.A. Smith report (1996) (pages 8-9). Ciscos require temperatures below 18°C (64°F) and dissolved oxygen concentrations above 4 ppm (Becker, 1983). During August 1993 in Long Lake temperatures below 18°C were found below a depth of 25 feet. This is also the depth at which an oxycline began. Below 35 feet oxygen was insufficient for ciscos. These conditions would crowd ciscos into a narrow part of the water column in Long Lake. This may have increased stress of the fish, and may have made them more susceptible to predation by walleye, musky and northern pike. A lack of oxygen in the depths in Long Lake is likely the result of increased nutrient loading (the R.A. Smith report listed riparian septic systems as the main source of nutrient loading in the lake (page 27)). This trend may well have worsened in recent years.

Conclusions and Recommendations

Exotic Species Contingency Plans

Long Lake is very fortunate not to have invasive exotic plants. This finding is rather remarkable considering the prevalence of exotic plant in other nearby lakes, and considering the high public use the lake receives. The Long Lake Association would be wise to take the threat of invasive plants seriously. The best course of action will be to have a plan for dealing with exotic plant infestation should it occur, while at the same time implementing education and prevention measures to reduce the likelihood of invasion.

Eurasian watermilfoil management options

Hand pulling

This method, while labor intensive, may be the most appropriate for Long Lake if Eurasian watermilfoil is discovered to be present in a small number of plants. For this method to be successful though, care must be taken to remove the entire root mass along with the plant or else it will quickly regenerate.

Mechanical harvesting

Mechanical control methods involve hand cutters and boat-mounted mechanical weed harvesters. While these methods provide temporary nuisance relief, they are not recommended control methods for Eurasian watermilfoil. Eurasian watermilfoil can reproduce by fragmentation (Borman, et. al. 1997), and the free-floating plant matter left from cutting operations can accelerate dispersal of the plant. Attempting to control a pioneering stand of Eurasian watermilfoil in Long Lake through mechanical harvesting would likely lead to it being spread throughout the lake. Given this fact, mechanical harvesting would be a poor choice.

Milfoil weevils

There has been considerable research on biological vectors, such as insects, and their ability to affect a decline in Eurasian watermilfoil populations. Of these, the milfoil weevil has received the most attention. Native milfoil weevil populations have been associated with declines in Eurasian watermilfoil in natural lakes in Vermont (Creed and Sheldon, 1995), New York (Johnson, et. al., 2000) and Wisconsin (Lilie, 2000). However there is scant evidence that *stocked* weevils can produce a decline in Eurasian watermilfoil density. A twelve lake study called “The Wisconsin Milfoil Weevil Project” (Jester, et. al. 1999) conducted by the University of Wisconsin, Stevens Point in conjunction with the Wisconsin Department of Natural Resources researched the efficacy of weevil stocking. This report concluded that milfoil weevil densities were not elevated, and that Eurasian watermilfoil was unaffected by weevil stocking in any of the study lakes.

There have been numerous reasons given for the lack of success of weevil stocking as a management option, including calcium carbonate deposits on plants (Jester, et. al. 1999), poor over-wintering habitat (Newman, et, al. 2001), high pH (C. Kendziorski, 2001) and sunfish predation (Newman, pers. comm.). Perhaps the most compelling reason why weevil stocking has been unsuccessful may be that weevil populations are already at carrying capacity in many lakes. Recent studies in Wisconsin indicate that milfoil weevils are widely distributed throughout Wisconsin's lakes (Jester, et. al. 1997). Further, recent studies conducted by Aquatic Biologists, Inc. staff (Cason, 2003) concluded that a relationship may exist between wind energy and the ability of milfoil weevils to affect a decline in Eurasian watermilfoil. It appears that lakes must be large enough (300 acres +) to generate sufficient wave action before milfoil stems burrowed by weevils will collapse. Given the findings of this literature review it would seem that weevil stocking would be a poor milfoil control option.

Herbicides

Herbicides have been the most widely used and most successful tools for controlling Eurasian watermilfoil. The two herbicide groups most commonly employed are fluridone (Avast®, Sonar®) and 2,4D (Aquacide®, Aquakleen®, Navigate®, and Weedar 64®). Whole-lake Sonar® treatments have been done on several Wisconsin Lakes. While initial results were encouraging (species selectivity, 95-100% initial control), continued monitoring found that desired long-term control was not achieved (Cason, 2002). 2,4D herbicides, on the other hand, have been used on hundreds of Wisconsin Lakes with good success. Before any treatment plan is adopted for a lake though, the following concerns should be addressed:

Is it safe for humans? The E.P.A. lists 2,4D as a Class D herbicide; which means that there is no data to support that it is harmful to humans. The E.P.A. product label lists no water use restrictions for swimming or fish consumption following treatment with 2,4D. The University Of Michigan School Of Public Health recently concluded a review of more than 160 toxicological and epidemiological studies on 2,4D and concluded that there was no adequate evidence to link 2,4D exposure to any forms of cancer. Nor does 2,4D from treated lakes appear to be able to contaminate well water. The Michigan Department of Environmental Quality recently released results of a 4-year study of drinking water wells surrounding twelve lakes heavily treated with 2,4D. To date, no traces of 2,4D have been found in any of the test wells (Bondra, 2002). While no one will guarantee that any herbicide is 100% safe, the overwhelming body of evidence suggests that 2,4D poses minimal risks to humans.

Is it safe for the environment? 2,4D is a biodegradable organic herbicide that does not persist in the environment in any form. 2,4D does not bioaccumulate. Even if fish consume 2,4D pellets, the chemical passes through the gut without entering muscle tissues. Hence, the reasons there are no label restrictions on fish consumption.

Will it affect desirable plants? Applied correctly at prescribed rates, 2,4D is highly selective to Eurasian watermilfoil. According the product label, the following plants found in Long Lake are susceptible to 2,4D at higher rates: northern watermilfoil, white water lily, spadderdock, and coontail. At lower rates (100 lbs / acre) these and other native plants typically respond positively to treatments.

Is it effective? 2,4D has been used on thousands of lakes throughout North America. To date 2,4D treatments have been the single most effective Eurasian watermilfoil control program. In fact, the number of lakes in Michigan having Eurasian watermilfoil problems has actually declined as a result of 2,4D use (Pullman, 1993).

Is it economical? While no control method could be considered cheap, 2,4D treatments are among the least costly of methods. Perhaps the greatest consideration is that 2,4D typically produces long-term milfoil control. This means that lake management units seldom need to spend as much in the long term as they do for the initial treatment. Once Eurasian watermilfoil is brought under control, the costs of annual maintenance treatments, if needed, are minimal.

What are the disadvantages? The greatest disadvantage of 2,4D treatments is that they rarely produce 100% control. As a granular formulation, the product tends to work only where applied. Unnoticed and untreated plants may eventually grow to dense beds if left unchecked. Factors such as pH and plant maturity may also reduce treatment efficacy. Several follow-up treatments, in-season or on subsequent years, may be needed to reduce Eurasian watermilfoil to target levels.

Given these considerations, the Long Lake Association should plan to implement a 2,4D treatment program to control Eurasian watermilfoil if it becomes established in the Lake to an extent that it cannot be controlled by hand pulling.

Purple loosestrife management options

Digging and cutting

There are several methods that are commonly used for purple loosestrife control: digging or hand pulling, cutting, herbicide treatments and biological controls. Digging and hand pulling are most effective for small infestations. Individual property owners are encouraged to use this method if they are able. Cutting involves removal and destruction of flowers and seed heads to inhibit plant propagation. Since cut plants tend to re-grow and since seeds present in the soils can sprout new plants, this method will need to be done for a number of years before desired control is achieved.

Herbicides

Herbicide treatments are the easiest and most economical of methods. The preferred herbicide is glyphosate (Eagre®, Rodeo®). This product rapidly biodegrades upon contact with soil or water. There are no water use restrictions following treatment. Because it is non-selective, each individual plant must be sprayed, as opposed to broadcast applications. Glyphosate is extremely effective in controlling purple loosestrife. It is also a very low cost treatment. The biggest disadvantage is that seeds in the soil will sprout new plants, requiring annual treatments for a number of years before desired control is achieved. A DNR permit is required for treatment; however the fee is waived.

Loosestrife beetles
Biological controls using several species of beetles and a weevil from Europe, by far show the most promise for long-term control of purple loosestrife (WDNR PUB-WT-276 2001). However this method is generally not recommended for small infestations such as found on Forest Lake because of the labor, time and expense involved. If purple loosestrife did become well established in Long Lake, and if volunteers are willing to donate the time and labor require for rearing beetles to control purple loosestrife, this would be the best management option for the lake. Started kits are available from the DNR. Contact:

Brock Woods
DNR Research Center
1350 Femrite Dr.
Monona, WI 53716
(608) 221-6349

If any of these methods are to be employed along the shores of Long Lake, full cooperation will be required from all lakeshore property owners, as purple loosestrife control would occur on private property.

Curly-leaf Pondweed Management Options

Hand pulling

As with Eurasian watermilfoil, this method may be the most appropriate for Long Lake if curly-leaf pondweed is discovered to be present in a small number of plants. Hand pulling will be most effective if the plant is discovered in its pioneering stage. If curly-leaf pondweed has existed long enough to produce turions, a vegetative reproductive structure, hand pulling may become a long-term, labor intensive process.

Mechanical harvesting and cutting
Both mechanical harvesting and hand cutting are commonly used to control curly-leaf pondweed. While cutting the plant provides temporary control, and may not encourage dispersal of the plant as it does with Eurasian watermilfoil, it is unlikely to provide any long-term control. Therefore this method is not a good choice for Long Lake.

Herbicides
The herbicide most often used is Aquathol®. Aquathol® is an endothol salt- based herbicide. Endothol herbicides are also rapidly biodegradable herbicides that do not persist in the environment. While endothol herbicides are effective on a broad range of aquatic monocots, early season applications made at low rates are highly species-selective. Both mechanical harvesting and herbicide treatments are very effective in providing short-term control. However neither method, as they are commonly applied,

tends to provide any long-term control of the plant. Curly-leaf pondweed produces in early summer that is called a turion. While herbicides effectively kill the parent plant, the turions are resistant to herbicides. This allows curly-leaf pondweed to regenerate annually.

Studies conducted by the Army Corps of Engineers however, have found that conducting treatments of curly-leaf pondweed using Aquathol when water temperatures are in the 50° F range will kill plants before turions form, thus providing long-term control. These treatments conducted over time were able to significantly reduce curly-leaf pondweed populations (Skogerboe and Poovey, 2002). These findings may make Aquathol® the tool of choice for controlling larger stands of curly-leaf pondweed in Long Lake.

Protecting Lake Water Quality

Nutrient inputs from human activities around the lake will adversely affect water quality. This may directly affect the fishery, by reducing or eliminating conditions needed for survival of fish such as the cisco. Further, many of the important plant species found in Long Lake occurred in depths of 10 feet or more. At these depths plant are susceptible to declines in water clarity. A large scale loss of aquatic plants would negatively affect the lake's fishery. Therefore protecting lake water quality is essential to maintaining and enhancing the fishery of Long Lake. The following list describes water quality enhancement activities for lakefront property owners.

Vegetative Buffer Zones

There are beneficial alternatives to the tradition-mowed lawn. The best alternative is to protect the natural shoreline and leave it undisturbed. If clearing is necessary to access and view the lake, consider very selective removal of vegetation. Restoring a vegetative buffer zone is also an important alternative.

A recommended buffer zone consists of native vegetation that may extent from 25 – 100 feet or more feet from the water's edge onto land, and 25 – 50 feet into the water. The buffer should cover at least 50%, and preferably 75% of the shoreline frontage (Henderson, et al). In most cases this still allows plenty of room for a dock, swimming area, and lawn. Buffer zones are made up of a mixture of native trees, shrubs, upland plants, and aquatic plants.

Shoreline vegetation serves as an important filter against nutrient loading and trapping loose sediment. The buffer provides excellent fish and wildlife habitat, including nesting sites for birds, and spawning habitat for fish. Properly vegetated shorelines also play a key role in bank stabilization.

Lawn Care Practices

Mowed grass up to the water's edge is a poor choice for the well being of the lake. Studies show that a mowed lawn can cause 7 times the amount of phosphorus, and 18 times the amount of sediment to enter the water body (Korth and Dudiak, 2003). Lawn grasses also tend to have shallow root systems that cannot protect the shoreline as well as deeper-rooted native vegetation (Henderson, et al).

Landowners living in close proximity to the water are not encouraged to use lawn fertilizers. Fertilizers contain nutrients, especially phosphorus that can wash directly into the lake and cause unsightly algae blooms. Landowners are encouraged to perform a soil test before fertilizing. A soil test will help determine if you need to fertilize, and give you direction on fertilizing. For assistance in having your soil tested, contact your county UW- extension office. If there is a need to fertilize your lawn, use a fertilizer that does not include phosphorus. Most lawns in Wisconsin don't need additional phosphorus. Phosphorus free fertilizers will read 0 in the middle of the label (25-0-5).

To further reduce nutrient loading, avoid raking twigs, leaves, and grass clippings into the lake. They contain nitrogen and phosphorus. The best disposal for organic matter, like leaves and grass clippings is to compost them. Composted material can then be used for gardening.

Septic System Maintenance

It is the responsibility of the landowner to ensure that septic systems are properly functioning. A failing septic system can contaminant both surface and ground water. Failing septic systems are a major cause of nutrient loading in lakes. Lakes like Long Lake, were groundwater recharge inlets are in close proximity to septic system drain fields, are at a greater risk. Systems should be professionally inspected every 3 years, and pumped every 2-5 years depending on operating circumstances (EPA, 2002). Avoid flushing toxic chemicals into the system. This can harm important bacteria that live in your tank and naturally break down wastes. Avoid planting trees in the drain field, compacting soil within the drain field, and directing additional surface runoff on top of the drain field.

Building Plan

If you choose to establish on a lake, you should develop a building plan that considers the well being of the lake first. Your decisions affect all lake users**.** Locate buildings and driveways as far from the lake as possible. This helps protect water quality by allowing more land surface to filter runoff. During construction use silt fencing and or erosion control blankets to help hold loose sediment intact. Be very selective on the clearing of vegetation, it serves an important purpose. Inform the contractor about your concerns, and fence off areas that don't need to be disturbed. If possible direct any runoff from buildings and driveways away from the lake.

Erosion Control

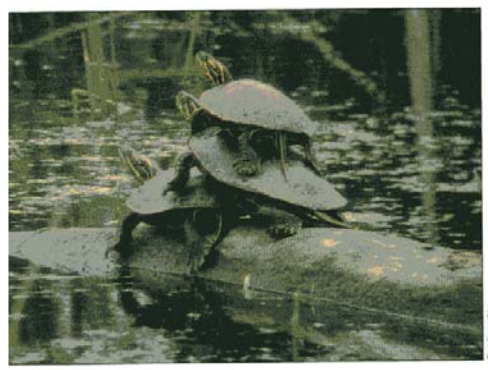
Erosion is a natural process, but it's for the benefit of the landowner and health of the lake that erosion control practices be carried out to slow the process as much as possible. Sedimentation into the lake causes nutrient pollution, turbid water conditions, eliminates fish spawning habitat, and increases eutrophication. Shoreline owners are encouraged to leave existing vegetation, which is a great shore stabilizer. The placement of logs, brush mats, and rock riprap are also options against erosion. When riprap is used it is recommended that desirable shrubs and aquatic plants be planted within the riprap.   The plantings serve as nutrient filters and habitat.

Rainfall is one of the most powerful things on earth (Holdren et al, 2001). When a rain event occurs loose sediment can be washed directly into the lake or into inlets that drain into the lake. Disturbed areas with loose soil, including plowed farm fields, pastures, and construction sites, should all be areas of concern.   Precautions in disturbed areas need to be addressed.   The use of silt fencing is a popular tool designed to help control erosion on construction sites.

Habitat Improvement

. " *Our lakes are a place to live or vacation--for us they are a chosen landscape. For the wildlife that live there, however, our lakes are their only home"*
- Robert Korth

Woody Debris



Fish and wildlife are an important part of the aquatic community.   In order for fish and wildlife to naturally function and exist, they must have a home. Providing fish and wildlife habitat can be as simple as leaving fallen trees and natural vegetation in place. Many shore owners consider woody debris as worthless, and quickly remove it from the water. Consider leaving trees in the water. Woody debris provides excellent habitat for a variety of fish and wildlife. Floating trees are like docks for turtles, frogs, marsh birds, muskrats, and beaver. Trees offer excellent cover and spawning habitat for a variety of fish. Woody debris also attracts many invertebrates that fish feed upon.

Wooden structures

Two types of constructed fish habitat improvement devices that would benefit Long Lake are half logs and fish cribs. Half logs are relatively simple structures that are easy and economical to build. They consist of a 6 to 8 foot section of log cut in half or a piece of slab wood that is supported by wooded blocks and anchored to the lakebed with and iron re-rod. Half logs would improve spawning success for smallmouth bass and may also benefit rock bass and yellow bullhead. Half logs should be placed in relatively shallow water, 2 -7 feet deep, and in areas having firm bottoms and little vegetation.

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Fish cribs are commonly installed in Wisconsin Lakes to improve fish habitat. Fish cribs are used by a variety of species at different life stages. Cribs may directly benefit populations of black crappie, yellow perch and rock bass. Fish cribs come in many forms, but are typically made of 8'x 8' (or 4'x 12') stacked logs. The logs are anchored together with iron re-rods. A base of wooden poles or slab logs supports field stones used to sink the crib. Cut brush or limbs are placed inside the crib. Cribs are usually installed in winter atop the ice. The best locations for cribs in Long Lake would be along the north and south shores in the main basins (where habitat is most lacking) and at depths of 15 to 25 feet. Better results are seen when several cribs are clustered together at a single location.

Emergent plant restoration

Shoreline vegetation can benefit lake ecology tremendously. A properly vegetated shoreline provides habitat for a variety of birds, furbearers, amphibians, and reptiles. Much of the shoreline and emergent vegetation in Long Lake appears to have been destroyed by lakefront development. Benefits to lake water quality, fishery and wildlife could be achieved by restoring this component of lake habitat. Lakefront habitat improvement is often done on a property by property basis. In recent years many new techniques have been developed for restoring lakefronts. This type of work often incorporates many attractive flowering plants and adds a great deal of aesthetic appeal to lakefronts as well.

Informational resources for shoreline restoration

Lakescaping for Wildlife and Water Quality. This 180 page booklet contains numerous color photos and diagrams. It is considered the bible of shoreline restoration by many. It is available from the Minnesota Bookstore (651-297-3000) for $19.95.

The Living Shore. This video describes buffer zone construction and gives information on selecting and establishing plants. May be available at local library, or order from the Wisconsin Association of Lakes (800-542-LAKE) for $17.00.

A Fresh Look at Shoreland Restoration. A four page pamphlet that describes shoreland restorations options. Available from UW Extension (#GWQ027) or WDNR (#DNR-FH-055).

What is a Shoreland Buffer? A pamphlet that discusses both ecological and legal issues pertaining to riparian buffer zones. Available from UW Extension (#GWQ028) or WDNR (#DNR-FH-223).

Life on the Edge…Owning Waterfront Property. A guide to maintaining shorelands for lakefront property owners. Available from UW Extension-Lakes Program, College of Natural Resources, University of Wisconsin, Stevens Point, WI 54481, for $4.50.

The Water's Edge. A guide to improving fish and wildlife habitat on your waterfront property. Available from WDNR (#PUB-FH-428-00).

References

Bartz, David. 2003. *Long Lake Survey 2002.* Wisconsin Department of Natural Resources. Montello, WI.

Becker, G.C. 1983. *Fishes of Wisconsin.* University of Wisconsin Press. Madison.

Borman, Susan, Robert Korth, and Jo Temte. 1997. *Through the Looking Glass – A Field Guide to Aquatic Plants.* Wisconsin Lakes Partnership, University of Wisconsin, Stevens Point.

Brakken, J., 2000. *What are the odds of invasion?* Wisconsin Association of Lakes.

Cason, C.E. 2002. *Bughs Lake Update 2002*. Aquatic Biologists, Inc. Fond du Lac, WI.

Cason, C.E. 2003. *Loon Lake Comprehensive Survey Results and Management Plan.* Aquatic Biologists, Inc. Fond du Lac, WI.

Creed, R.P. Jr., and S.P. Sheldon. 1995. *Weevils and Watermilfoil: Did a North American herbivore cause the decline of and exotic weed?* Ecological Applications 5(4): 1113-1121.

Eggers, Steve, and Donald Reed. 1997. *Wetland Plants and Plant Communities of Minnesota and Wisconsin.* U.S. Army Corps of Engineers, St. Paul District.

Eiswerth, M.E., S.G. Donaldson and W.S. Johnson, 2003. *Potential environmental impacts and economic damages of Eurasian watermilfoil (Myriophyllum spicatum) in Western Nevada and Northeastern California.* Weed Technology: Vol. 14, No.3.

Engle, Sandy. 1985. *Aquatic community interactions of submerged macrophytes*. Technical Bulletin No. 156. Department of Natural Resources. Madison, Wisconsin.

Environmental Protection Agency. 2002. *A Homeowner's Guide to Septic Systems.* U.S. EPA Publications Clearinghouse. Cincinnati, OH.

Fasset, Norman C. 1940. *A Manual of Aquatic Plants.* University of Wisconsin Press, Madison.

Henderson, C.L. 1992. *Woodworking for Wildlife: Homes for Birds and Mammals*. State of Minnesota, Department of Natural Resources.

Henderson, C.L., C.J. Dindorf, and F. J. Rozumalski. *Lakescaping for Wildlife and Water Quality.* State of Minnesota, Department of Natural Resources.

Holdren, C.,W. Jones and J. Taggart, 2001. *Managing Lakes and Reservoirs*. North American Lake Management Society and Terrene Institute, in cooperation with Office of Water Assessment. Watershed Protection Division. U.S. Environmental Protection Agency, Madison, Wisconsin.

Hubbs, C.L. and K.F. Lagler. 1964. *Fishes of the Great Lakes Region.* University of Michigan Press. Ann Arbor.

Jester, L.L., M.A. Bozek, S.P. Sheldon, and D.R. Helsel. 1997. *New records for Euhrychiopsis lecontei (Coleoptera: Curculionidae) and their densities in Wisconsin Lakes.* Wisconsin Department of Natural Resources.

Jester, Laura L., Daniel R. Helsel and Michael A. Bozek. 1999. *Wisconsin Milfoil Weevil Project – Gilbert Lake Final Report.* University of Wisconsin – Stevens Point.

Johnson, R.L., P.J. Van Dusen, J.A. Tonerand N.G. Hairston. 2000. *Eurasian watermilfoil biomass associated with insect herbivores in New York.* Cornell University.

Kendziorski, C. 2001. *Effects of Sudden Exposure to Elevated pH on Milfoil Weevil Euhrychiopsis lecontei in Forest Lake, Fond du Lac County, Wisconsin.* Forest Lake Improvement Association, Inc.

Korth, Robert and Tamara Dudiak. 2003. *The Shoreland Stewardship Series #1.* University of Wisconsin-Extension, Wisconsin Department of Natural Resources, The Wisconsin Lakes Partnership, Wisconsin Association of Lakes, River Alliance of Wisconsin.

Lilie, R.A. 2000. *Temporal and spatial changes in milfoil distribution and biomass associated with weevils in Fish Lake, WI.* Wisconsin Department of Natural Resources.

Madsen, John. 2001. *Symposium: The potential to use fluridone to selectively control Eurasian watermilfoil in Minnesota.* University of Minnesota. St. Paul.

MDNR. 2002. *The Water's Edge.* State of Minnesota, Department of Natural Resources, Division of Fisheries.

Moore, P.D., and S.B. Chapman, 1976,1986. *Methods in Plant Ecology*. Blackwell Scientific Publications. Oxford, England.

Newman, R.M., D.W. Ragsdale, A. Miles, and C. Oien, 2001. *Overwinter habitat and the relationship of overwinter habitat to in-lake densities of the milfoil weevil, Euhrychiopsis lecontei , a Eurasian watermilfoil biological control agent.* University of Minnesota.

Nichols, Stanley A. 1974. *Mechanical and habitat manipulation for aquatic plant management.* Technical Bulletin No. 77. Department of Natural Resources. Madison, Wisconsin.

Nichols, Stanley A., and James G. Vennie. 1991. *Attributes of Wisconsin Lake Plants.* Wisconsin Geological and Natural History Survey.

Niebur, Alan. 2000. *Long Lake Fisheries Survey Summary Report-2000.* Wisconsin Department of Natural Resources. Wautoma, WI.

Pullman, Douglas G. 1993. *The Management of Eurasian Watermilfoil in Michigan.* The Midwest Aquatic Plant Management Society. Vol. 2, Ver. 1.0.

Skogerboe, J. and A. Poovey. 2002. *Long-term control of curlyleaf pondweed on Minnesota Lakes using Aquathol-K: Return of the natives.* Midwest Aquatic Plant Management Society annual conference. Brookfield, Wisconsin.

Smith, Gordon E., 1971. *Resume of studies and control of Eurasian watermilfoil (Myriophyllum spicatum) in the Tennessee Valley from 1960 through 1969.* Hyacinth Control Journal, vol. 9, no. 1.

Smith, C.S., and M.S. Adams, 1986. *phosphorus transfer from sediments by Myriophyllum spicatum.* Limnology and Oceanography. Vol. 31, no. 6.

Smith, R.A., & Associates. 1996. *Long Lake – Waushara County Protection Plan.* Brookfield, WI.

Unmuth, J.M.L., R.A. Lilie, D.S. Dreikosen, and D.W. Marshall, 2000. *Influence of dense growths of*

Eurasian watermilfoil on lake water temperature and dissolved oxygen. Journal of Freshwater Ecology. Vol. 15, no. 4.

USDA, 1985. *Soil Survey of Waushara County, Wisconsin.* United States Department of Agriculture Soil Conservation Service in cooperation with the University of Wisconsin.

WDNR. 1990. *Ecosystem responses to growth control of submerged macrophytes: a literature review.* Technical Bulletin No. 170. Department of Natural Resources. Madison, Wisconsin.

Whitley, J. R., Barbara Bassett, J. G. Dillard, and R. A. Haefner. 1999. *Water Plants for Missouri Ponds.* Conservation Commission of the State of Missouri.