Aquatic vegetation of Whitefish Lake

June, July, August, 2011

Whitefish Lake, ID# 18-0310-00

Crow Wing County, Minnesota

Emergent and floating-leaf aquatic plants in Willow Creek Bay, Whitefish Lake, August 2011.

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Survey Context

This lake vegetation survey of Whitefish Lake was part of the larger Sensitive Lakeshore Identification project conducted by MNDNR on the Whitefish Chain of Lakes. During 2010 and 2011, MNDNR biologists conducted field surveys of aquatic vegetation, near-shore fish and frogs, and shoreland birds in these lakes: Lower Hay, Bertha, Clamshell, Arrowhead, Whitefish (Upper, Middle and Lower), Pig, Big Trout, Island, Loon, Rush-Hen, Cross, Daggett and Little Pine. Field data will be used to identify areas along lakeshores that provide unique or critical ecological habitat. Once those areas are identified, local and state resource managers can use the information to help ensure that sensitive habitats are receiving sufficient protection.

More information on the MNDNR's Sensitive Lakeshore Identification, including Sensitive Lakeshore reports for individual lakes, can be found online at:
http://www.dnr.state.mn.us/eco/sli/index.html

Summary

Whitefish Lake is the largest of 13 connected waterbodies that comprise the Whitefish Chain of Lakes in Crow Wing County. In 2011, as part of the DNR's larger Sensitive Lakeshore Identification project, surveyors assessed the aquatic vegetation of the lake. Surveys included mapping emergent and floating-leaf plant beds and sampling plant occurrence and diversity at 1,522 sites.

Since 1938, a total of 45 aquatic plant species (types) have been recorded in Whitefish Lake, making it among the richest lakes in the state. In 2011, 37 plant species were found including 6 emergent, 4 floating-leaved, 3 free-floating and 24 submerged plants. Eight of these species were recorded for the first time during the 2011 survey and many of the species located during historical surveys are still relatively common in the lake.

Plants were found to a depth of 28 feet and in the 0-30 feet depth zone, 75% of the survey sites contained vegetation. In both basins, plant growth was greatest in the 0-15 feet depth zone, where 89% of sites contained plants. Plant growth in shallow water (0-5 feet) of Lower-Middle Whitefish was 73% compared to 92% in Upper Whitefish and this difference may be due to heavy wave action along windswept shallow shores of Lower-Middle Whitefish compared to Upper Whitefish where most shallow water sample sites were within protected bays. In both basins, plant abundance decreased sharply in depths greater than 15 feet and in depths greater than 20 feet, plant growth was sparse (<10%) in both basins.

Emergent and floating-leaf plants occupied 153 acres with the largest beds in Delta, Willow Creek and Killworry bays along the western shore. Wild rice (*Zizania palustris*) dominated these areas with scattered occurrences of cattails (*Typha* sp.), burreed (*Sparganium* sp.), bulrush (*Schoenoplectus* sp.) and pockets of waterlilies (*Nuphar variegata* and *Nymphaea odorata*).

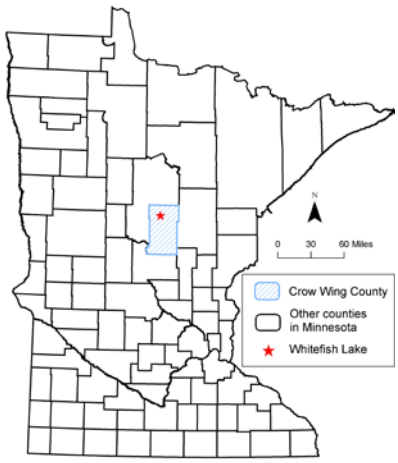
The most frequently occurring submerged species were native species: naiads (*Najas* spp.), coontail (*Ceratophyllum demersum*), muskgrass (*Chara* sp.), northern watermilfoil (*Myriophyllum sibiricum*), flat-stem pondweed (*Potamogeton zosteriformis*) and Canada waterweed (*Elodea canadensis*). Each of these species occurred with a frequency of at least 15%. The only non-native plant detected in the lake was the submerged plant, curly-leaf pondweed (*Potamogeton crispus*) which occurred in less than 1% of the sites and was not an important part of the plant community.

The greatest diversity of plants occurred in the near-shore zone where water depths were 10 feet and less. Ninety-one percent of the plant species were restricted to this shallow zone. This shallow water is also where much recreational activity occurs, some of which may threaten this critical habitat if aquatic plants are damaged or removed. Protecting existing native aquatic plant beds will help maintain critical fish and wildlife habitat and the general water quality of the lake.

Introduction

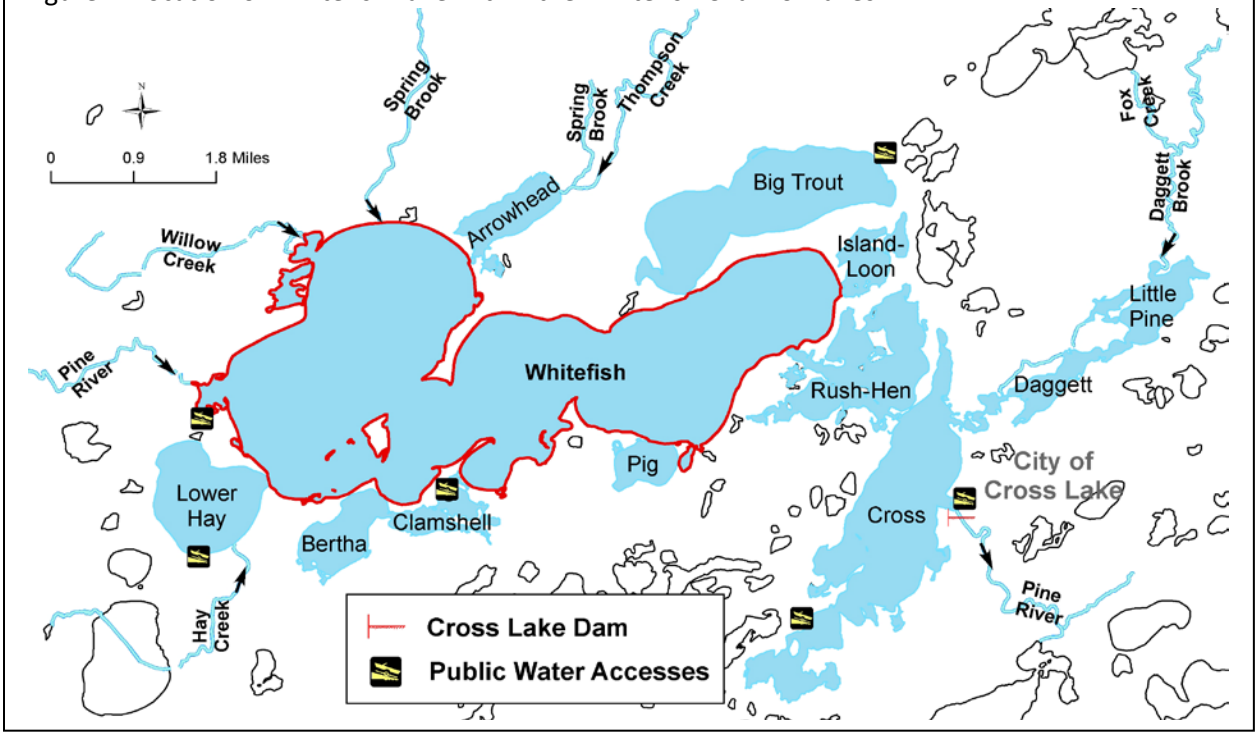
Whitefish Lake is located in the forested, lake-rich region of north central Minnesota (Figure 1). It is one of 13 waterbodies in the 14,000 acre Whitefish Chain of Lakes[1]. The lake is named after the cold water game fish, lake whitefish, and early maps listed the lake as "Kadikomeg Lake", in an attempt to record the Ojibwe name which translates to "the place of whitefish" (Upham 1920).

Figure 1. Whitefish Lake, Crow Wing County, Minnesota.



Whitefish Lake is a natural flow-through lake with an inlet from and outlet to the Pine River. Many of the connections to adjacent lakes were created in 1886 when the Pine River Dam was completed at Cross Lake and raised water levels making permanent channels between the lakes (Upham 1920). The U.S. Army Corps of Engineers attempts to maintain fairly stable water levels on the entire chain by regulating outflow at the Cross Lake Dam but heavy rain or drought conditions can also influence the water level. Although lakes in the Whitefish Chain are connected, differences such as lake size, depth, flow, and shoreland management create differences in nutrient levels and water clarity between the lakes. These physical differences influence the types and amounts of plants that occur in each lake.

Figure 2. Location of Whitefish Lake within the Whitefish Chain of Lakes.



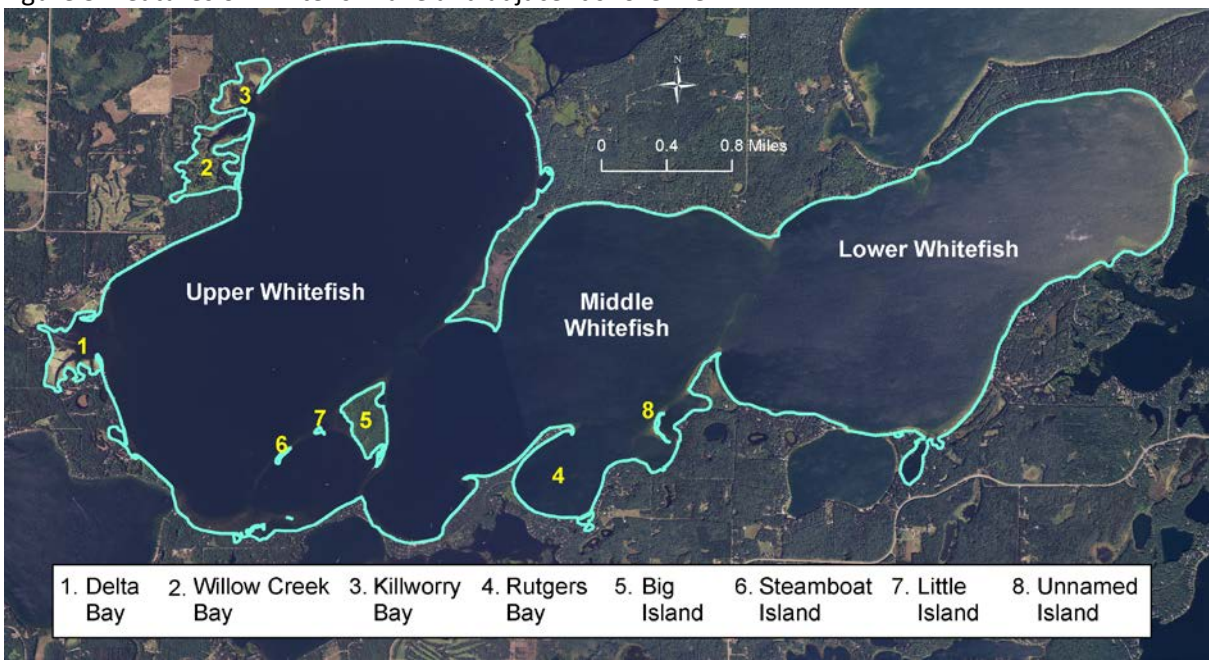
[1] The total number of waterbodies considered to be part of the Whitefish Chain of Lakes varies. We included the lakes that are directly connected within the main portion of the chain.

Lake Characteristics

The main flow into Whitefish Lake is from the Pine River as it enters Delta Bay at the west end of the lake. Inflow is also received from Willow Creek, Spring Brook and seven of the other lakes in the chain (Figure 2). Outflow from Whitefish Lake is to Rush-Hen Lake, then to Cross Lake where the entire chain outlets to the Pine River. A public boat ramp exists on the west shore of Whitefish and navigation into the lake is also possible through channels from connecting lakes.

With a surface area of 7,715 acres, Whitefish is the 4th largest lake in the county and in the upper 5% of lakes in the state in terms of size. It accounts for half the surface area of the entire chain of lakes. The lake includes three main basins: Upper, Middle and Lower with several smaller bays on the east and south shores (Figure 3). The basins are named based on the east-west direction of water flow.

Figure 3. Features of Whitefish Lake and adjacent shoreline.



Total shoreline length of the entire lake is about 32 miles with a distance of about 7 miles from east to west shores and a maximum north to south length of about 3 miles. Most of the shoreline is privately owned and developed with residential homes and several resorts. While trees remain on many lake lots, much of the understory vegetation has been removed at developed lots. Three undeveloped islands (Big, Steamboat and Little) occur on the south side of Upper Whitefish and total about 54 acres in area. These islands are publicly owned by the State of Minnesota, Crow Wing County and Ideal Township and have been designated as the Rollie Johnson Natural and Recreational Area. A one-acre, undeveloped island occurs on the south side of Middle Whitefish Lake.

Whitefish Lake has a maximum depth of 138 feet but about half of the lake is less than 30 feet in depth and more than 1/3rd is 15 feet or less in depth (Figure 4). Lower Whitefish is the deepest basin and Upper and Middle Whitefish have maximum depths of 90 feet. The boundaries of the three basins are loosely defined by shallow (8-10 feet in depth) bars that extend across the lake in a north-south direction (Figure 5). Willow Creek Bay and Killworry Bay are the largest areas where water depths are less than 6 feet in depth. There are several off-shore shallow bars with maximum depths of 8-10 feet.

Figure 4. Whitefish Lake depth contours (10 and 30 feet based on 2011 data).

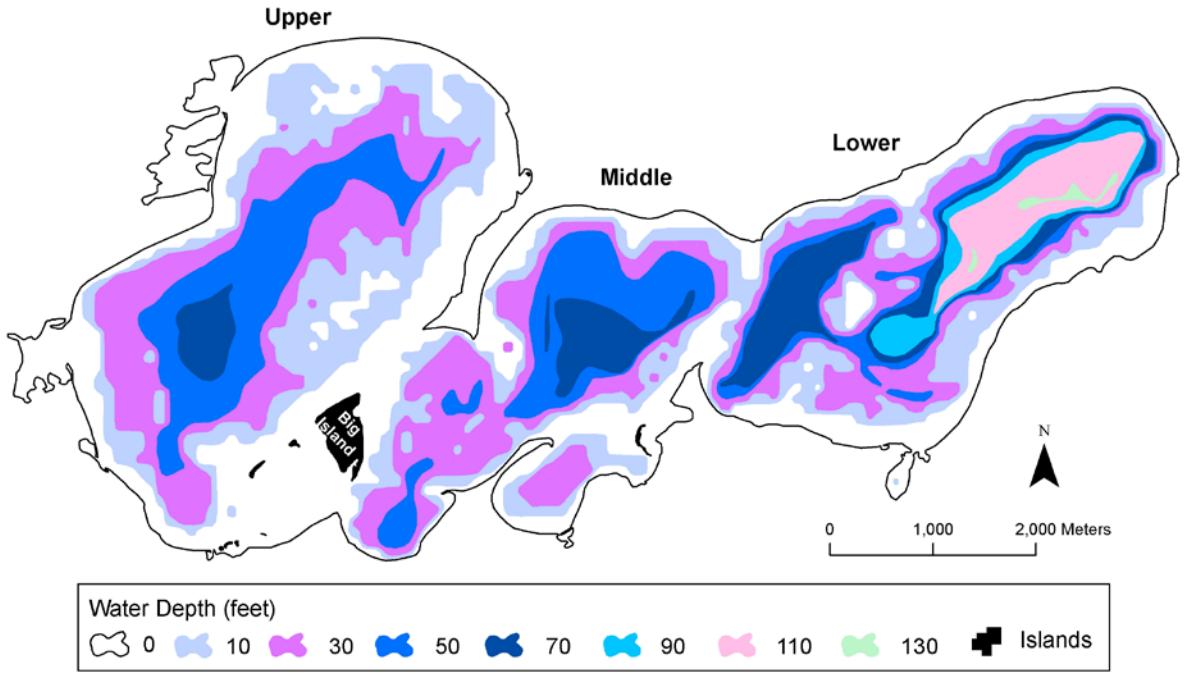


Figure 5. Juvenile bald eagles on sandbar, south side of Big Island.

Whitefish Lake is characterized as mesotrophic, based on phosphorus (nutrients), chlorophyll a (algae concentration) and Secchi[2] depth (transparency) (RMB 2008)[3]. Upper Whitefish tends to have higher phosphorus concentrations and lower clarity than Middle and Lower Whitefish and these differences could be due to the fact that the Pine River drains directly into Upper Whitefish Lake, carrying nutrients and sediments from upstream in the watershed (RMB 2008). Transparency in the lake stays relatively consistent throughout the summer and in 2010, mean

[2] The Secchi disc transparency measures the depth to which a person can see into the lake and provides a rough estimate of the light penetration into the water column. Water clarity is influenced by the amount of particles in the water column and can fluctuate seasonally and annually.

[3] This report provides details of the water quality of Whitefish Lake.

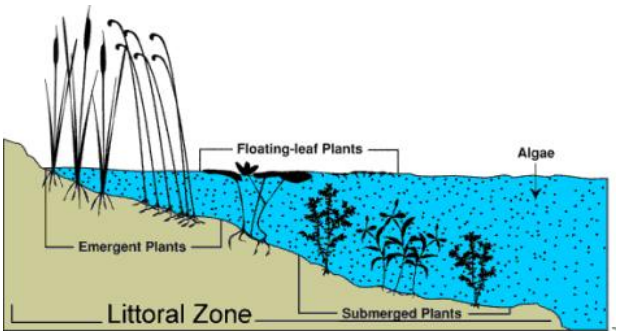
summer[4] water clarity was 11 feet in Upper Whitefish and 13 feet in Middle-Lower Whitefish (MPCA 2011). Based on Secchi disk measurements alone, aquatic plants have the potential to reach depths of about 16 to 20 feet in the lake[5].

Amounts and types of aquatic plants in Minnesota lakes

Within a lake, types and amounts of aquatic plants are influenced by a variety of factors including water clarity, water chemistry, water depth, substrate and wave activity. Deep or wind-swept areas may lack aquatic plant growth, whereas sheltered shallow areas may support an abundant and diverse native aquatic plant community. The annual abundance, distribution and composition of aquatic plant communities may change due to environmental factors, predation, the specific phenology of each plant species, introductions of non-native plant or animal species and human activities in and around the lake.

Aquatic plants can be divided into four groups or "life forms" based on whether the main portion of the plant occurs above, on, or below the water surface. These life forms: emergent, floating-leaved, free-floating and submerged plants (Figure 6), often favor certain water depth zones around the lake but overlap occurs with one life form grading into another. Each life form group has unique functions and values.

Figure 6. Forms of aquatic plants found in Minnesota lakes.



Emergent plants, like cattails and bulrush, are rooted in the lake bottom with most of their leaves and stems extending above the water surface. Floating-leaf plants, such as waterlilies, are also anchored in the lake bottom with leaves and flowers that float on the water surface. Root systems of these plants form extensive networks that take up nutrients and help consolidate and stabilize bottom substrate. Beds of floating-leaf and emergent plants also help buffer the shoreline from wave action, offer shelter for insects and young fish, and provide shade for fish and frogs. These beds also provide food, cover and nesting material for waterfowl, marsh birds and muskrat. Floating-leaf and emergent plants are most often found in shallow water to depths of about 6 feet and may extend lake-ward onto mudflats and into adjacent wetlands.

Submerged plants have stems and leaves that primarily grow underwater but they may also form flowers, fruits and some leaves that emerge above or float on the water surface. Submerged plants are typically anchored to the lake bottom but some species do drift freely with the currents. This group includes non-flowering plants such as large algae, mosses, and

[4] June through September

[5] As a general rule, sunlight can penetrate to a depth of two times the Secchi depth and aquatic plants can grow to a depth of one and a half times the Secchi depth.

fern-like plants, and flowering plants that may produce flowers above or below the water surface. Submerged plants may form low-growing mats or may grow several feet in the water column with leaf shapes that include broad ovals, long and grass-like, or finely dissected. Submerged plants release oxygen into the water column, compete for nutrients with microscopic algae, and provide food and shelter for a variety of invertebrates, fish, amphibians and other wildlife.

Free-floating plants are the smallest of Minnesota's lake plants and include small flowering plants that are commonly known as "duckweeds" as well as microscopic algae. Different survey methods are required to assess microscopic algae and they are not included in this report. Duckweeds are present in many Minnesota lakes and if present in sufficient amounts, they can accumulate into mats and create a shade barrier along protected shorelines. As their name implies, they are also an important food source for waterfowl.

Plant species richness is a term used to describe the total number of plant species present in a lake and it can be used to help describe the general health of the waterbody. In Minnesota, plant species richness can range from zero (un-vegetated lakes) to more than 40 species in a lake[6]. Species richness is generally higher in high clarity lakes than in turbid lakes and more species are usually found in moderately fertile lakes than in nutrient poor lakes. Therefore, lakes of north central Minnesota are often among the "richest" in terms of numbers of plant species. Water quality changes that result in lower clarity may also result in the loss of some plant species, or a lower species richness. However, caution must be used when comparing historical and present survey data because of differences in how the surveys were conducted. For example, if a current MNDNR plant survey locates more species than found during an historical "one-day" survey, it may be due to the more extensive sampling that occurs during current surveys. If fewer species are located during current surveys, it may indicate a true decline in the plant species richness of the lake.

Historic aquatic plant community

Previous lakewide, aquatic plant surveys of Whitefish Lake were conducted in 1938, 1950, 1954, 1960, 1991, and 1995 (MnDNR Lake files). These surveys focused on the commonly occurring in-lake plants and recorded a total of 37 aquatic plant species: 8 emergent, 4 floating-leaf, 5 free-floating, and 20 submerged species (Appendix 1). Plants that were reported in all of the previous surveys included native plants that are commonly found in many Crow Wing County lakes: white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegata*), muskgrass (*Chara* sp.), a variety of pondweeds (*Potamogeton* spp., *Stuckenia pectinata*), northern watermilfoil (*Myriophyllum sibiricum*), coontail (*Ceratophyllum demersum*) and Canada waterweed (*Elodea canadensis*). Three non-native plants were recorded during the 1991 survey and included curly-leaf pondweed (*Potamogeton crispus*), purple loosestrife (*Lythrum salicaria*) and reed canary grass (*Phalaris arundinaceae*).

[6] These values are from a review of MNDNR lake vegetation surveys.

Objectives

The purpose of this vegetation survey was to provide a quantitative description of the 2011 plant population of Whitefish Lake. Specific objectives included:

1. Describe the general distribution of plants in the lake including the depths at which plants occur.
2. Record the aquatic plant species that occur in the lake
3. Estimate the abundance of each species
4. Develop distribution maps for the commonly occurring species

Methods

Mapping floating-leaf and emergent vegetation beds

Mapping focused on plant beds that were at least 0.01 acres, or about 400 square feet, in size (generally larger than the surface area covered by a pontoon boat). Draft maps of floating-leaf and emergent plant beds were created prior to field surveys using 2010 Farm Service Administrative (FSA) true color aerial photographs. Field surveys were conducted July 21; August 22, 30, 31, 2011 to map plants like bulrush (*Schoenoplectus* spp.), which are difficult to identify from aerial photos, and to verify photo-interpretation of other plant beds. Surveyors mapped emergent and floating-leaf plant beds in the field by motoring or wading around the perimeter of each bed and recording a track with a handheld Global Positioning System (GPS) unit. Field data were uploaded to a computer and a Geographic Information System (GIS) software program was used to estimate acreage. Plant beds were classified by the dominant species or species-group.

Lakewide vegetation survey

A lakewide vegetation survey was conducted on June 8; July 25, 26, 28; August 3, 4, 10, 11, 15, 18, 22, 2011 using a point-intercept survey method (Madsen 1999, MnDNR 2009). Survey waypoints were created using a GIS computer program and downloaded into a handheld GPS unit. Survey points were placed across the entire lake and spaced 65 meters (213 feet) apart in the bays and 100 meters (328 feet) apart in the main basin. In the field, surveyors sampled sites where water depth was less than 31 feet. To minimize damage to vegetation, surveyors did not survey a few sites because they occurred in dense beds of emergent or floating-leaf plants. A total of 1,522 sites were surveyed in Whitefish Lake with about half of the sites in Upper Whitefish and half in Lower-Middle Whitefish (Table 1, Figure 7).

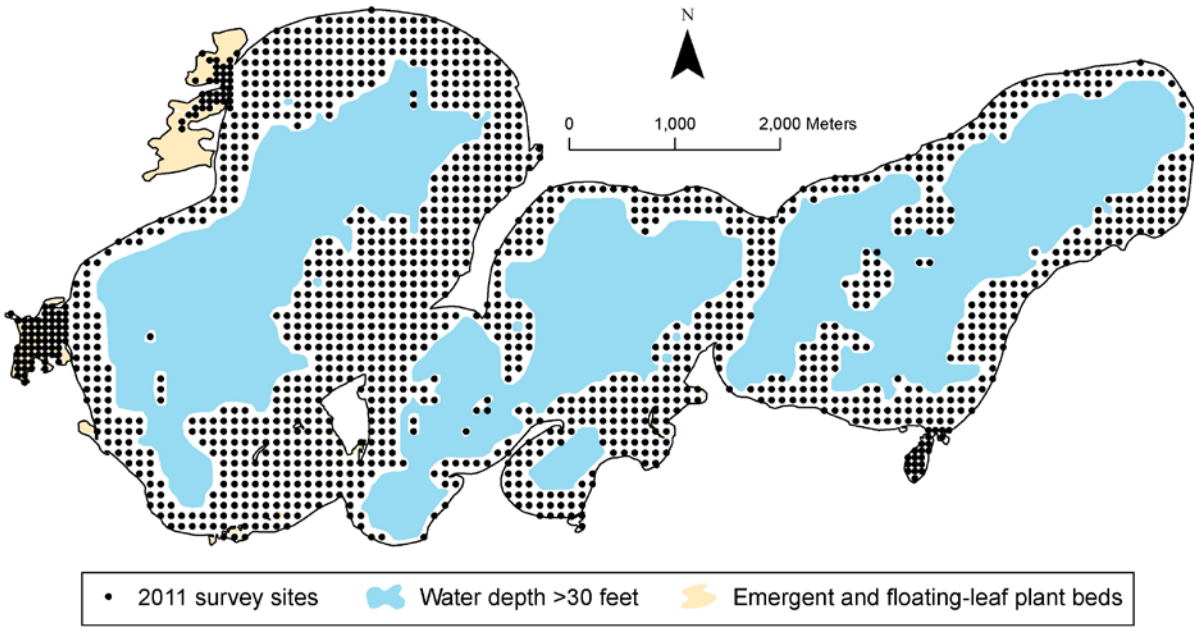
Table 1. Survey effort by depth interval.

Water depth (feet)	Number of sample sites		
	Upper Whitefish	Lower and Middle Whitefish	Lakewide
0 to 5	183	96	279
6 to 10	362	346	708
11 to 15	141	124	265
16 to 20	49	47	96
21 to 25	33	39	72
26 to 30	54	48	102
Total	822	700	1522

The survey was conducted by boat and a GPS unit was used to navigate to each sample point.

One side of the boat was designated as the sampling area. At each site, water depth was recorded in one-foot increments using a measured stick in water depths less than 7 feet and an electronic depth finder in deeper water.

Figure 7. 2011 vegetation survey sites on Whitefish Lake.



Substrate sampling

At each sample site where water depths were 7 feet and less, surveyors described the bottom substrate using standard substrate classes (Table 2). If more than one substrate type was found, surveyors recorded the most common type. Surveyors attempted to record a substrate description at the shore side of each row of points. If a sample site occurred near shore but in water depths greater than 7 feet, surveyors collected depth and vegetation data and then motored into shallower water and recorded the substrate type adjacent to the actual survey point; this information was used for mapping purposes.

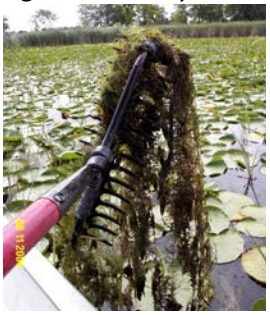
Table 2. Substrate classes

muck	decomposed organic material
marl	calcareous material
silt	fine material with little grittiness
sand	diameter < 1/8 inch
gravel	diameter 1/8 - 3 inches
rubble	diameter 3 - 10 inches
boulder	diameter >10 inches

Plant sampling

Surveyors recorded all plant species found at each sample site (approximately a one square meter sample site at the pre-designated side of the boat). A double-headed, weighted garden rake, attached to a rope was used to survey vegetation not visible from the water surface (Figure 8). Any additional plant species found outside of sample sites were recorded as "present" in the lake but these data

Figure 8. Survey rake.



were not used in frequency calculations. Plant identification followed Crow and Hellquist (2000) and Flora of North America (1993+) and nomenclature followed MnTaxa (2011).

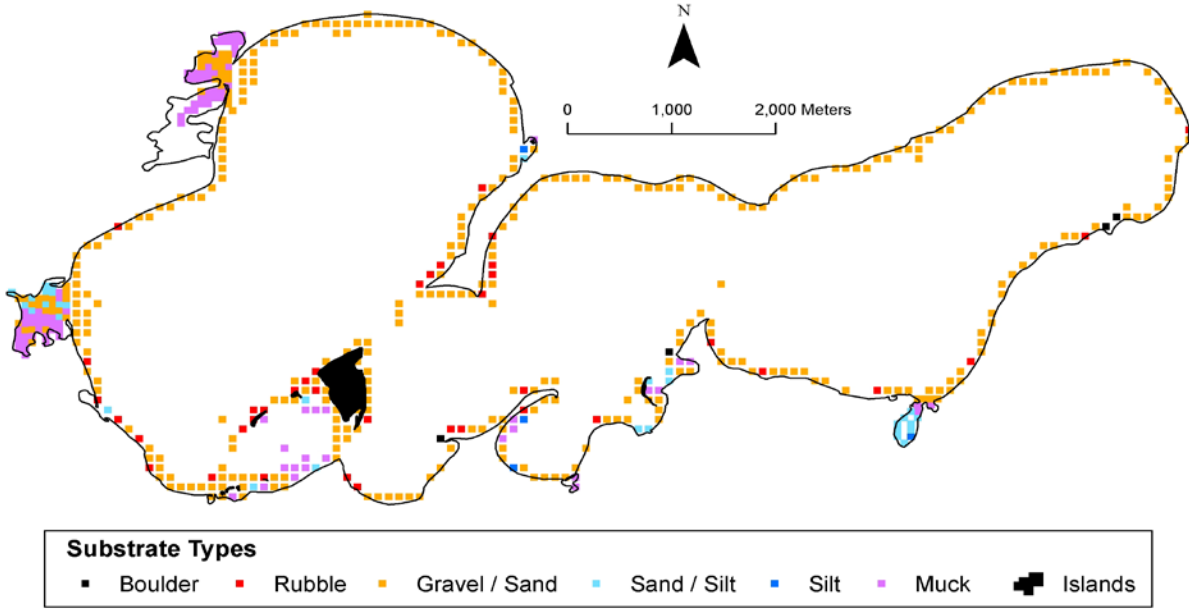
Frequency was calculated for the area from shore to 30 feet (the depth zone where plants were detected) and data were also separated into 5 feet increment depth zones for analysis (Table 1). Frequency estimates were also calculated for individual species and selected groups of species (example calculations shown in Appendix 2). Because of water clarity differences between Upper Whitefish and Middle-Lower Whitefish, plant data were also analyzed by sub-basins.

Results and Discussion

Shoal Substrates

The shoal substrates of Whitefish Lake included hard substrates of boulders, sand, gravel and rubble throughout the main basins of the lake, the perimeters of the islands and other exposed shores (Figure 9). Softer substrates of silt and muck were found in protected areas including small bays.

Figure 9. Shoal substrate of Whitefish Lake, 2011. (note that portions of Killworry Bay were not surveyed but are presumed to be dominated by muck substrates).



Types of plants recorded

A total of 37 aquatic plant species (types) were recorded in Whitefish Lake in 2011, making it among the richest lakes in the state in terms of number of plant species. The plants found included 6 emergent, 4 floating-leaved, 3 free-floating and 24 submerged plants (Table 3). Eight of these species were recorded for the first time during the 2011 survey (Appendix 1).

Table 3. Frequency of submerged aquatic plants in Whitefish Lake, June, July, August, 2011.

Life Form		Common Name	Scientific Name	Frequency (% occurrence) 1522 sites
EMERGENT[1]		Arrowhead	*Sagittaria cuneata*[a]	<1
		Bulrush	*Schoenoplectus* sp.[b]	<1
		Giant burreed	*Sparganium eurycarpum*	<1
		Broad-leaved cattail	*Typha latifolia*	P
		Narrow-leaved cattail	*Typha* sp.[c]	<1
		Wild rice	*Zizania palustris*	3
FLOATING-LEAVED		White waterlily	*Nymphaea odorata*	1
		Yellow waterlily	*Nuphar variegata*	<1
		Floating-leaf pondweed	*Potamogeton natans*	<1
		Floating-leaf smartweed	*Persicaria amphibia*	P
SUBMERGED	Macroalgae	Muskgrass	*Chara* sp.	27
	Moss	Watermoss	*Not identified to genus*	<1
	Dissected-leaf rooted plants	Coontail	*Ceratophyllum demersum*	35
		Northern watermilfoil	*Myriophyllum sibiricum*	20
		Water marigold	*Bidens beckii*	1
		White-water buttercup	*Ranunculus aquatilis*	1
		Greater bladderwort	*Utricularia vulgaris*	1
	Small-leaf rooted plants	Bushy pondweed	*Najas flexilis*[d]	51
		Southern naiad	*Najas guadalupensis*[d]	
		Canada waterweed	*Elodea canadensis*	16
	Narrow-leaf pondweeds	Narrow-leaf pondweed group[e]	*Potamogeton friesii*	10
			Potamogeton pusillus	P
		Sago pondweed	*Stuckenia pectinata*	2
	Broad-leaf pondweeds	White-stem pondweed	*Potamogeton praelongus*	6
		Variable pondweed	*Potamogeton gramineus*	5
		Clasping-leaf pondweed	*Potamogeton richardsonii*	5
		Illinois pondweed	*Potamogeton illinoensis*	3
		Large-leaf pondweed	*Potamogeton amplifolius*	1
		Curly-leaf pondweed (I)	*Potamogeton crispus*	<1
	Grass-leaf rooted plants	Flat-stem pondweed	*Potamogeton zosteriformis*	19
		Wild celery	*Vallisneria americana*	6
		Water star-grass	*Heteranthera dubia*	3
		Robbin's pondweed	*Potamogeton robbinsii*	1
		Needlegrass	*Eleocharis acicularis*	<1
FREE-FLOATING		Star duckweed	*Lemna trisulca*	7
		Greater duckweed	*Spirodela polyhriza*	1
		Watermeal	*Wolffia* sp.	<1

Frequency is the percent of sample sites in which a plant species occurred within the 0 to 30 ft water depth.

Table 3 (cont.) Frequency of aquatic plants in Whitefish Lake, June, July and August, 2011.

[1](includes only in-lake emergents and not wetland plants) P=Present in lake but did not occur in any sample sites

(I) = introduced to Minnesota

The following taxonomic groupings were made because field identification to the species level was difficult or not possible:

[a]Arum-leaved arrowhead (*Sagittaria cuneata*) was positively identified but it is not known whether all arrowhead plants found in that survey were *S. cuneata.* Plants identified as *S. cuneata* or *Sagittaria* sp. were grouped together for analysis.
[b]species of bulrush (*Schoenoplectus* sp.) was used to record bulrush plants that was hard-stem bulrush (*Schoenoplectus acutus*), soft-stem bulrush (*S. tabernaemontani*) or the hybrid.
[c]Narrow-leaf cattail was identified in survey but it is not known whether this included narrow-leaf cattail (*Typha angustifolia*) and/or the hybrid of narrow-leaf and broad-leaf cattail (*Typha x glauca*).
[d]Bushy pondweed (*Najas flexilis*) and Southern naiad (*Najas guadalupensis*) were grouped together for analysis because field identification to the species level was difficult.
[e]At least two species of narrow-leaf pondweeds were identified in the lake: Fries' pondweed (*Potamogeton friesii*) and small pondweed (*Potamogeton pusillus*). Additional narrow-leaf pondweed species (*Potamogeton* spp.) may have also been present.

Of the 37 species identified in historical surveys, 29 were also found in 2011. Species that were not relocated include small duckweeds and narrow-leaf pondweeds that were not historically common and may still be present in the lake but not detected during the current survey.

All but one of the lake plants found are native to Minnesota. The only non-native plant detected in the lake was the submerged plant, curly-leaf pondweed (*Potamogeton crispus*). The 2011 survey did not include a complete inventory of shoreland plants but non-native shoreland plants such as reed canary grass (*Phalaris arundinaceae*) and Kentucky bluegrass (turf grass) were present (Appendix 1).

Distribution of aquatic plants

Aquatic plants were distributed around the entire shoreline in Whitefish Lake with the broadest zones of vegetation occurring along the east and north shores of Upper Whitefish and in the protected bays (Figure 10). Narrower plant beds occurred along shores with steep depth changes, such as the west shore of Upper Whitefish and the northeast shores of Lower Whitefish. On some off-shore reefs (such as the one in Lower Whitefish) plant growth was common, while others had sparse or no vegetation.

Plants were found to a depth of 28 feet in Whitefish Lake and in the 0-30 feet depth zone, 75% of the survey sites contained vegetation. Lakewide, vegetation was most common in the 0 to 15 feet depth zone, where 89% of sites contained plants (Figure 11). Lakewide plant frequency in Upper Whitefish was similar (77%) to that found in Lower-Middle Whitefish (72%). Plant growth in shallow water (0-5 feet) of Lower-Middle Whitefish was only 73% compared to 92% in Upper Whitefish and this difference may be due to heavy wave action along shallow shores of Lower-Middle-Whitefish compared to Upper Whitefish where most shallow water sample

sites were within protected bays. In both basins, plant abundance decreased sharply in depths greater than 15 feet. In the 16-20 feet zone, plant frequency was 9% in Upper Whitefish compared to 20% in Middle-Lower Whitefish. This difference is reflective of the available light in each basin lake with Upper Whitefish having slightly lower water clarity. In depths greater than 20 feet, plant growth was sparse (<10%) in both basins.

Plant communities richness

The highest number of plant species was found in shallow water, (0-5 feet) (Figure 12). Emergent plants and most floating-leaf plants were restricted to this shallow depth zone. Most submerged species were found in depths less than 16 feet and only 5 species (naiads, coontail, Canada waterweed, narrow-leaf pondweed and star duckweed) occurred in depths greater than 20 feet.

Figure 10. Distribution of plants and number of species per site, Whitefish Lake 2011.

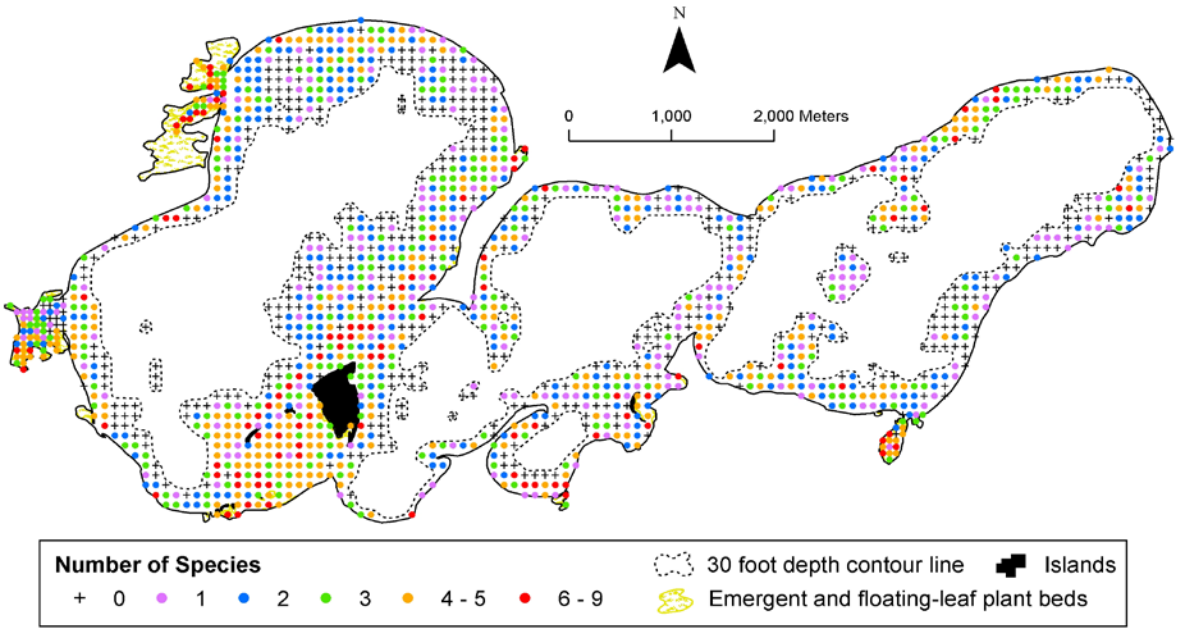


Figure 11. Aquatic plant frequency vs. water depth.

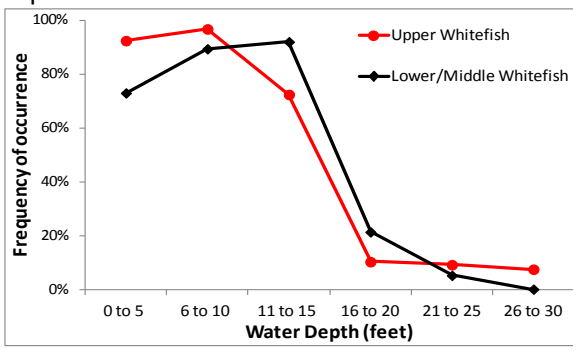
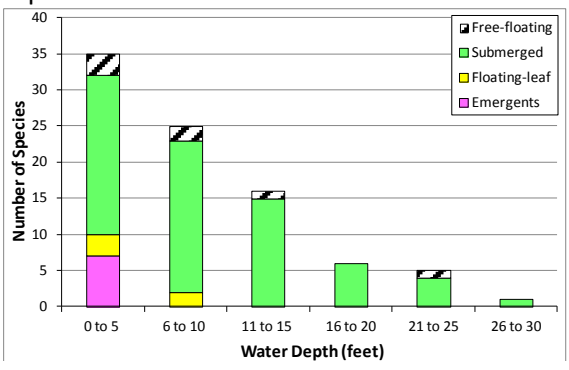


Figure 12. Number of plant species vs. water depth.

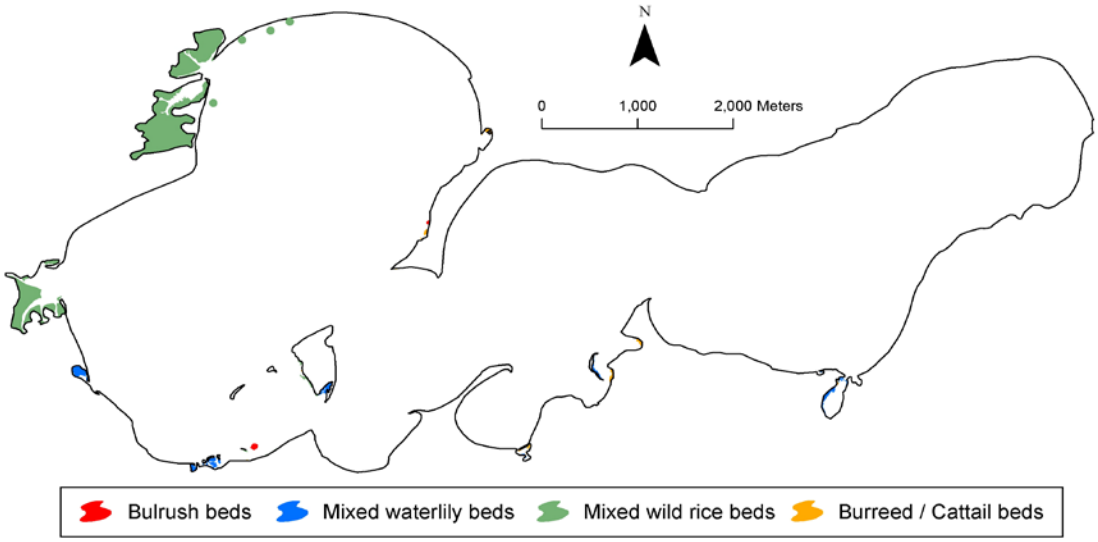


The number of plant species found at each sample site ranged from 0 to 9 with a mean of 2 species per site. Sites of high species richness (6 or more species per site) often occurred in depths less than 10 feet and included sites like shallow bays where emergent, floating-leaf, and submerged plants co-occurred (Figure 10).

Emergent and Floating-leaf Plant Beds

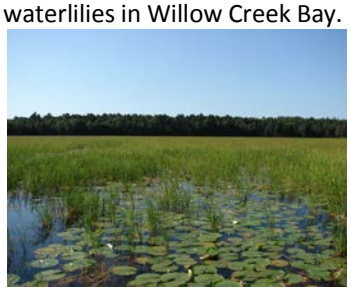
The 0-5 feet depth, where most emergent and floating-leaf plants occurred, covers 723 acres in Whitefish Lake. Approximately 153 acres, or 21% of this depth zone, contained emergent and floating-leaf plant beds and 25% of the survey sites in this depth zone contained at least one emergent or floating-leaf plant. The major sites of emergent and floating-leaf plant beds were in Delta, Willow Creek and Killworry bays (Figure 13). Navigational channels have been created through most of these plant beds.

Figure 13. Emergent and floating-leaf plant beds, Whitefish Lake 2011.



Emergent plants included species with broad grass-like leaves such as wild rice (*Zizania palustris*), cattails (*Typha* sp.), burreed (*Sparganium* sp.) and narrow-leaf bulrush (*Schoenoplectus* sp.) plants.

Figure 14. Wild Rice and white waterlilies in Willow Creek Bay.



Wild rice (*Zizania palustris*) was the most frequent emergent in Whitefish and covered 135 acres and most beds occurred in Willow Creek Bay and Delta Bay (Figure 13, 14). Wild rice frequently co-occurred with waterlilies or other emergent vegetation. Wild rice is an annual plant that germinates each

year from seed that fell to the lake bottom in the previous fall. The plant begins growth underwater and then forms a floating-leaf stage before becoming fully emergent. The plant prefers soft substrates (Lee 1986, Nichols 1999) and generally requires moving water for growth (MnDNR 2008). Wild rice is susceptible to disturbance because it is weakly rooted to the lake bottom. In addition to its ecological value as habitat and food for wildlife, wild rice has important cultural and economic values in Minnesota (MnDNR 2008). This valuable plant is increasingly threatened by factors such as lakeshore development and increased water recreational use (MnDNR 2008).

Most of the other plant beds were classified as "mixed waterlily" beds and were dominated by floating-leaf plants such as white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegata*) and floating-leaf pondweed (*Potamogeton natans*). Waterlily beds often contained scattered emergent plants such as wild rice, burreed, bulrush and submerged plants (Figure 15). The floating leaves of waterlilies provide shade and shelter for fish, frogs and invertebrates. The showy flowers produce seeds that are eaten by waterfowl and the rhizome are a food source for muskrats and deer (Borman et al. 2001).

Figure 15. Burreed and waterlilies around Big Island

Figure 16. Green heron in waterlily bed, Delta Bay.

In addition to providing valuable fish and wildlife habitat, the extensive root network of these emergent and floating-leaf plants help to stabilize sandy shoreline. In shallow water, they may spread by underground rhizomes but these plants are particularly susceptible to destruction by direct cutting by humans, motorboat activity and excess herbivory. Restoration of emergent and floating-leaf plant beds can be very difficult, making established beds particularly unique and valuable.

Submerged aquatic plants

Within the 0-30 feet depth zone[7], submerged plants occurred in 78% of the sample sites. The most frequently occurring species were Naiads (*Najas guadalupensis* and *N. flexilis*), coontail (*Ceratophyllum demersum*), muskgrass (*Chara* sp.), northern watermilfoil (*Myriophyllum sibiricum*), flat-stem pondweed (*Potamogeton zosteriformis*) and Canada waterweed (*Elodea canadensis*). Each of these species occurred with a frequency of at least 15% (Table 3) and could be found in each of the three basins (Figure 17). Muskgrass and flat-stem pondweed were restricted to depths of 15 feet and less and the other 3 species were found in shallow and deep water (Figure 18).

[7] Unless otherwise noted, all frequency values for submerged species are for the 0-30 feet depth zone.

Figure 17. Distribution of commonly occurring submerged plants in Whitefish Lake, 2011.

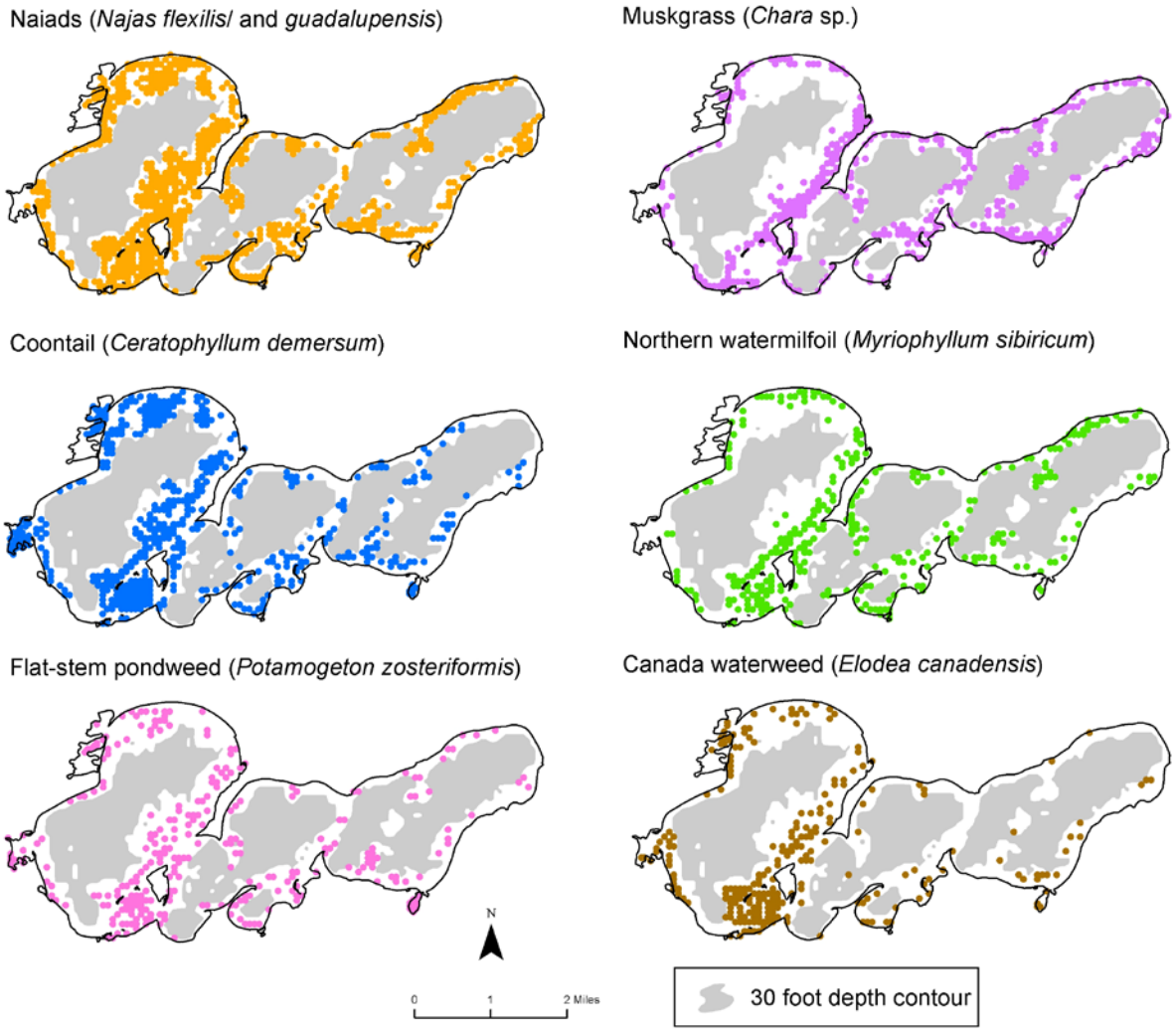


Figure 18. Common submerged plants at each water depth interval, Whitefish Lake, 2011.

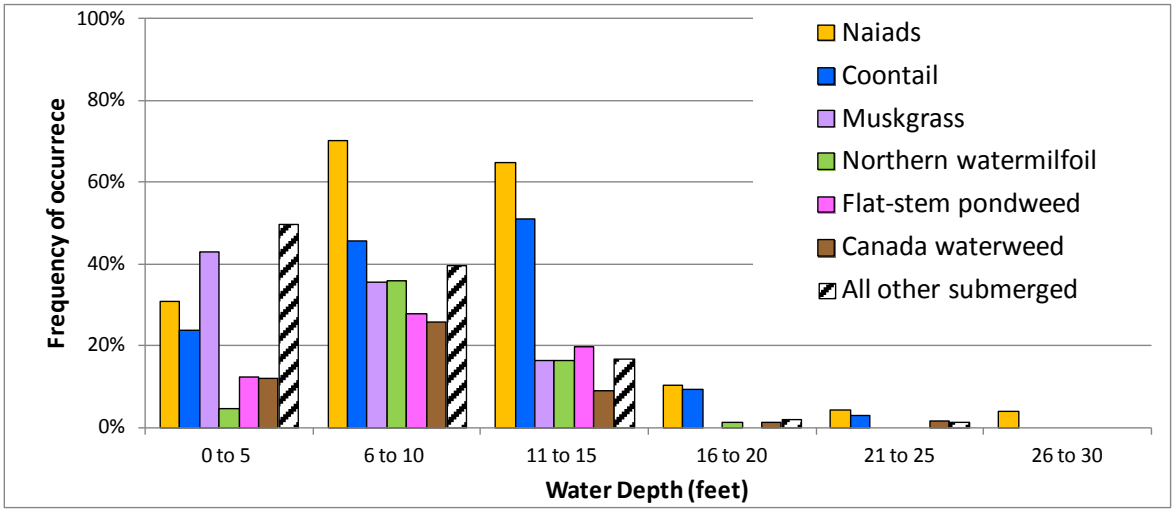


Figure 19. Southern naiad.
Photo: Kerry Dressler ©1996 Univ. of Florida Center for Aquatic Plants

Naiads (*Najas guadalupensis/ and N. flexilis*) were the most commonly found submerged plant group in Whitefish Lake and occurred in 51% of the sample sites (Table 3). Two species of naiads were found in Whitefish Lake and since they can be difficult to distinguish, they were grouped together for analyses. Southern naiad (*Najas guadalupensis*; Figure 19) can sprout from seed or overwinter as a perennial plant. Bushy pondweed (*Najas flexilis*) is an annual plant that grows each year from seed. Both species grow entirely submerged and produce seeds and foliage that provide important duck food and good fish cover. Within the 6-15 feet zone, Naiads dominated (Figure 17) and occurred in 69% of the sites (Figure 18). They were one of only 6 species that occurred in depths greater than 20 feet.

Figure 20. Coontail

Coontail (*Ceratophyllum demersum*) is the most common submerged plant in Minnesota and was also common in Whitefish Lake where it occurred with a frequency of 35% (Table 3). This plant grows entirely submerged and its roots are only loosely anchored to the lake bottom. It is adapted to a broad range of lake conditions and is tolerant of higher turbidity and can grow in muck substrates (Nichols 1999). In Whitefish Lake it was found to 24 feet but was most frequent in the 0-15 feet zone where it occurred in 42% of the sites (Figure 18). Coontail is perennial and can over winter as a green plant under the ice and then begins new growth early in the spring, spreading primarily by stem fragmentation. The finely divided leaves of this plant (Figure 20) provide a home for insects valuable as fish food.

Figure 21. Muskgrass

Muskgrass (*Chara* sp.; Figure 21) is a freshwater macroalgae[8] and is common in many hard water Minnesota lakes. It has a brittle texture and a characteristic "musky" odor. Because muskgrass does not form true stems, it is a low-growing plant, often found entirely beneath the water surface where it may form low "carpets" on the lake bottom. Muskgrass is adapted to variety of substrates and is often the first species to colonize open areas of lake bottom where it can act as a sediment stabilizer. Beds of muskgrass can provide important fish spawning and nesting habitat. Muskgrass occurred in 27% of the Whitefish Lake survey sites (Table 3). It was found along the sandy shorelines of

[8] Algae are primitive forms of plants that do not form true roots, flowers or vascular tissue. They range in size from single cell to giant seaweed. Freshwater algae that live in Minnesota lakes include tiny, free-floating planktonic algae, filamentous algae and macroalgae. Macroalgae often resemble rooted plants and provide similar habitat and water quality benefits and were therefore included in this survey.

Whitefish (Figure 17) and was the most frequent plant in the 0 to 5 feet depth zone where it occurred in 43% of the sites (Figure 18).

Northern watermilfoil (*Myriophyllum sibiricum*; Figure 22) is a native[9], submerged plant. It is a rooted perennial with finely dissected leaves. Particularly in depths less than 10 feet, this plant may reach the water surface and its flower stalk will extend above the water surface. It spreads primarily by stem fragments and over-winters by hardy rootstalks and winter buds. Northern watermilfoil is not tolerant of turbidity (Nichols 1999) and grows best in clear water lakes. Northern watermilfoil was found in 20% of all sites (Table 3). It occurred to a depth of 17 feet (Figure 17) and was most common in the 0 to 15 feet depth zones (Figure 18).

Figure 22. Northern watermilfoil

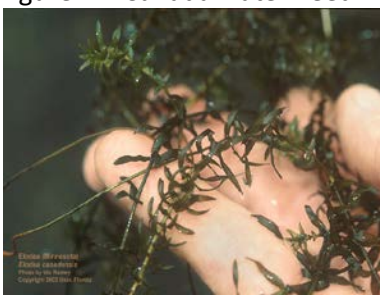
Photo by: Andrew Hipp (UW Madison-Wisc State Herbarium)

Flat-stem pondweed (*Potamogeton zosteriformis*; Figure 23) is one of 9 native pondweeds found in Whitefish Lake. Pondweeds (*Potamogeton* spp. *and Stuckenia* spp.) are primarily submerged, perennial plants that are anchored to the lake bottom by underground rhizomes. Depending on water clarity and depth, these plants may reach the water surface and may produce flowers that extend above the water. Pondweed seeds and tubers are an important source of waterfowl food (Fassett 1957) and the foliage of pondweeds is food for a variety of marsh birds, shore birds and wildlife and provides shelter, shade and spawning sites for a range of fish species (Borman et al. 2001). Flat-stem pondweed is named for its flattened, grass-like leaves. It was the most common pondweed in Whitefish Lake, occurring with a frequency of 19% (Table 3) and was most frequent in the 6-10 feet depth zone, where it was found in 28% of the sites (Figure 18). Unlike some of the other commonly occurring species, it was not found beyond the 15 feet depth. Other native pondweeds in Whitefish Lake included plants with broad leaves (often called "cabbage" by anglers) and narrow-leaved plants (Table 3).

Figure 23. Flat-stem pondweed.

Canada waterweed (*Elodea canadensis*; Figure 24) is a perennial submerged species that is widespread throughout Minnesota. It is adapted to a variety of conditions and is tolerant of low light and prefers soft substrates (Nichols 1999). Canada waterweed can overwinter as an evergreen plant and spreads primarily by fragments. Canada waterweed was found in 16% of the Whitefish Lake survey sites (Table 3) and was more common in Upper Whitefish (22%) than in Middle-Lower (8%) (Figure 17). It was found to

Figure 24. Canada waterweed.



[9] For information on how to distinguish the native northern watermilfoil from the non-native, Eurasian watermilfoil, click here: identification.

a depth of 24 feet but was most frequent in depths of 10 feet and less (Figure 18).

Other submerged species occurred in 10% or less of the survey sites and most were restricted to the 0-15 feet depth zone. The submerged plant community included a diversity of growth forms including broad-leaf "cabbage" plants, grass-leaved plants and finely divided leaf plants.

Curly-leaf pondweed (*Potamogeton crispus*) (Figure 25) was found in less than 1% of the survey sites in 2011 (Table 3) and was not an important part of the plant community. This non-native, submerged plant that has been present in Minnesota since at least 1910 (Moyle and Hotchkiss 1945) and is now found in more than 700 Minnesota lakes (Invasive Species Program 2010). It was first documented in the Whitefish Chain in 1961 and has been present in Whitefish Lake since at least 1991 (Appendix 1).

Figure 25. Curly-leaf pondweed.

Like many native submerged plants, it is perennial but has a unique life cycle that may provide a competitive advantage over native species. Curly-leaf pondweed is actually dormant during late summer and begins new growth in early fall. Winter foliage is produced and continues to grow under ice (Wehrmeister and Stuckey 1978). Curly-leaf reaches its maximum growth in May and June, when water temperatures are still too low for most native plant growth. In late spring and early summer, curly-leaf plants form structures called "turions" which are hardened stem tips that break off and fall to the substrate. Turions remain dormant through the summer and germinate into new plants in early fall (Catling and Dobson 1985). The foliage of curly-leaf pondweed does provide some fish and wildlife habitat, but it may also create problems in some lakes, or in areas of some lakes. During its peak growth in spring, curly-leaf may reach the water surface at certain depths and create dense mats. These dense growths may compete with native vegetation and can also cause problems for recreational lake users. Protecting existing native plant beds may help reduce possible negative impacts of non-native species like curly-leaf pondweed.

Factors influencing aquatic plant communities

The types and amounts of aquatic vegetation that occur within a lake are influenced by a variety of factors including water clarity, water chemistry, depth, substrate type and wave activity. Monitoring change in the aquatic plant community can be helpful in determining whether changes in the lake water quality are occurring and for estimating the quality of vegetation habitat available for fish and wildlife communities. Data collected in 2011 can be used to monitor finer-scale changes that may occur, such as an increase in a particular species, loss of species, or changes in the depths at which individual species occur. In general, factors that may lead to change in aquatic plant communities include:

- Change in water clarity

If water clarity in Whitefish Lake increases, submerged vegetation may be more common at depths greater than 15 feet. Declines in water clarity may lead to fewer plants and fewer types of plants in the deep end of the current vegetated zone.

- Snow and ice cover

  Many native submerged plants also have the ability to grow under the ice, especially if there is little snow cover and sunlight reaches the lake bottom. In years following low snow cover, and/or a reduced ice-over period, submerged plants may increase in abundance or there may be a shift in species dominance.

- Water temperatures / length of growing season

  In years with cool spring temperatures, submerged plants may be less abundant than in years with early springs and prolonged warm summer days.

- Aquatic plant management activities

  Humans can impact aquatic plant communities directly by destroying vegetation with herbicide or by mechanical means. The results of these control activities can be difficult to predict and should be conducted with caution to reduce potential negative impacts to non-target species. Motorboat activity in vegetated areas can be particularly harmful for species such as wild rice. Shoreline and watershed development can also indirectly influence aquatic plant growth if it results in changes to the overall water quality and clarity. For information on the laws pertaining to aquatic plant management: MnDNR APM Program.

The abundant and diverse aquatic plant communities found in Whitefish Lake provide a habitat complexity that can be utilized by a diversity of fish and wildlife and also provides a variety of other lake benefits. Protecting existing native aquatic plant beds will help maintain critical fish and wildlife habitat and the general water quality of the lakes. (Click here for more information on: value of aquatic plants).

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Appendix 1. Historical aquatic and wetland plants of Whitefish Lake

Blue highlight indicates taxa that were common (occurring in at least 15% of sites) in 2011.

Submerged plants

Common Name	Scientific Name	1938	1950	1954	1960	1991	1995	2011
Water marigold	*Bidens beckii*							X
Coontail	*Ceratophyllum demersum*	X	X	X	X	X	[a,b]X	X
Muskgrass	*Chara* sp.	X	X	X	X	X	[a]X	X
Needlerush	*Eleocharis acicularis*							X
Canada waterweed	*Elodea canadensis*	X	X		X	X	[a,b]X	X
Water star-grass	*Heteranthera dubia*							X
Northern watermilfoil	*Myriophyllum sibiricum*	X	X	X	X	X	[a]X	X
Bushy pondweed	*Najas flexilis*	X				X	[a,b]X	X
Southern naiad	*Najas guadalupensis*							X
Large-leaf pondweed	*Potamogeton amplifolius*					X	[a,b]X	X
Curly-leaf pondweed (I)	*Potamogeton crispus*					X		X
Narrow-leaf pondweed[1]	*Potamogeton friesii*							X
	Potamogeton pusillus						[b]X	X
	Potamogeton strictifolius						[b]X	
	Potamogeton sp.	X				X	[a]X	
Variable pondweed	*Potamogeton gramineus*					X	[a,b]X	X
Illinois pondweed	*Potamogeton illinoensis*							X
White-stem pondweed	*Potamogeton praelongus*	X			X	X	[a,b]X	X
Clasping-leaf pondweed	*Potamogeton richardsonii*					X	[a,b]X	X
Robbin's pondweed	*Potamogeton robbinsii*					X	[a]X	X
Flat-stem pondweed	*Potamogeton zosteriformis*	X			X	X	[a,b]X	X
White water buttercup	*Ranunculus aquatilis*						[a]X	X
Thread-leaved pondweed	*Stuckenia filiformis*						[b]X	
Sago pondweed	*Stuckenia pectinata*	X			X	X	[a,b]X	X
Greater bladderwort	*Utricularia vulgaris*						[a,b]X	X
Flat-leaved bladderwort	*Utricularia intermedia*						[a]X	
Wild celery	*Vallisneria americana*	X			X	X	[a,b]X	X
Watermoss	*Not identified to genus*							X
	Total	10	4	3	8	15	20	24

Floating-leaved plants

Common Name	Scientific Name	1938	1950	1954	1960	1991	1995	2011
Floating-leaf pondweed	*Potamogeton natans*	X				X	[a,b]X	X
White waterlily	*Nymphaea odorata*					X	[a,b]X	X
Yellow waterlily	*Nuphar variegata*					X	[a,b]X	X
Floating-leaf smartweed	*Persicaria amphibia*					X		X
	Total	1	0	0	0	4	3	4

Free-floating plants

Common Name	Scientific Name	1938	1950	1954	1960	1991	1995	2011
Star duckweed	*Lemna trisulca*						[a,b]X	X
Duckweed	*Lemna* sp.						[a,b]X	
Greater duckweed	*Spirodela polyhriza*						[b]X	X
Spotted Watermeal	*Wolffia borealis*						[b]X	*X
Columbian Watermeal	*Wolffia columbiana*						[b]X	
	Total	0	0	0	0	0	5	3

Emergent plants

Common Name	Scientific Name	1938	1950	1954	1960	1991	1995	2011
Bald spikerush	*Eleocharis erythropoda*						[b]X	
Marsh spikerush	*Eleocharis palustris*						[b]X	
Arrowhead	*Sagittaria cuneata*					*X	[a]X	[2]X
Broad-leaf arrowhead	*Sagittaria latifolia*						[b]X	
Bulrush[3]	*Schoenoplectus acutus*			*X	*X		[a,b]X	[a]X
	Schoenoplectus tabernaemontani							
Giant burreed	*Sparganium eurycarpum*						[a,b]X	X
Narrow-leaved cattail	*Typha angustifolia*[4]		*X	*X				X
Broad-leaved cattail	*Typha latifolia*				X	X		X
Wild rice	*Zizania palustris*						[a,b]X	X
	Total	0	1	2	2	2	7	6

Wetland emergent plants

Common Name	Scientific Name	1938	1950	1954	1960	1991	1995	2011
Sweet flag	*Acorus americanus*				X			
Alder	*Alnus* sp.							X
Swamp milkweed	*Asclepias incarnata*					X		X
Sedges	*Carex* spp.							X
Red-osier dogwood	*Cornus sericea*							X
Purple loosestrife (I)	*Lythrum salicaria*					X		
Reed canary grass (I)	*Phalaris arundinaceae*					X		X
Willow	*Salix* sp.							X
Goldenrod	*Solidago* sp.							X
	Total	0	0	0	1	3	0	7

I = introduced
*X = Plant was identified only to genus level.

[1] narrow-leaf pondweed (*Potamogeton* sp.). This may have been one of several different *Potamogeton* species that have narrow, submerged leaves. In 2011, two narrow-leaved pondweeds, *Potamogeton friesii* and *Potamogeton pusillus*, were positively identified but it is not known whether all narrow-leaved pondweeds found in that survey were *P. friesii* or *P. pusillus*. Plants identified as *P. friesii, P. pusillus* or *Potamogeton* sp. were grouped together for analysis.

[2] Arrowhead (*Sagittaria* sp.). There are several species of arrowhead. In 2011, arum-leaved arrowhead, *Sagittaria cuneata*, was positively identified but it is not known whether all arrowhead plants found in that survey were *S. cuneata.* Plants identified as *S. cuneata* or *Sagittaria* sp. were grouped together for analysis.

[3]a species of bulrush (*Schoenoplectus* sp.) was used to record bulrush plant that was hard-stem bulrush (*Schoenoplectus acutus*), soft-stem bulrush (*S. tabernaemontani*) or the hybrid.

[4]Narrow-leaf cattail was identified in survey but it is not known whether this included narrow-leaf cattail (*Typha angustifolia*) and/or the hybrid of narrow-leaf and broad-leaf cattail (*Typha x glauca*).

Sources:
1938 (June 1): Robert Sharp, Division of Game and Fish
1950 (May 22-24): Division of Game and Fish
1954 (August 17-31, September 1-3): Allen Rasmussen, Jerry Malquist, Division of Game and Fish
1960 (April – September): Thomas Bonde (Crew Leader), Howard Knight, Howard Trick; DNR Fisheries Survey
1991 (August 13-31): Wayne Mueller (Crew Leader); DNR Fisheries Survey
1995[a] (August 7): MnDNR Fisheries Survey
1995[b] (July 1): Karen Myhre, MnDNR Division of Ecological and Water Resources, MN County Biological Survey Program, survey of site along southern shore near public access.
2011 (June, July, August): Perleberg, Simon, Eininger, Dickson, Point-Intercept survey, MnDNR Division of Ecological and Water Resources

Appendix 2:

Frequency of occurrence was calculated as the percent of sites, within a specific depth zone, where a plant species was detected. Unless otherwise noted, frequency values were calculated for the 0-30 feet depth zone.

Example:

In Whitefish Lake there were 1,522 sample sites in the 0-30 feet depth zone.
Coontail occurred in 533 sites.
Frequency of Coontail in 0-30 feet zone = (533/1,522)*100 = 35%