Aquatic vegetation of Mule Lake

August, 2010

ID# 11-0200-00

Cass County, Minnesota

Northeast bay of Mule Lake, 2010.

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Summary

Mule Lake, in north-central Minnesota, is a 525 acre lake with extensive shallow zones. It is characterized as an oligotrophic, hardwater lake with relatively clear water. In 2010, surveyors conducted a lakewide assessment of Mule Lake's vegetation that included water depth and sampling at 453 sites.

The aquatic plant communities of Mule Lake includes a diversity of native plants, with 32 species (types) recorded, including 7 emergent, 4 floating-leaved and 23 submerged and/or free-floating species. Sixteen of these species were recorded for the first time in the lake in 2010.

Within the 0-20 feet depth zone of Mule Lake, 83% of sites contained plants. Plants were most frequent in depths of 10 feet or less and the broadest zones of plants were found in the shallow northeast basin.

Emergent and floating-leaf plants were restricted to water depths less than 7 feet. They were most frequent within the 0-5 feet zone, where they occurred in 30% of the sample sites. White waterlily (*Nymphaea odorata*) was the most common floating-leaf plant and occurred in 20% of the shallow water sites (0-5 feet). Other floating-leaf included yellow waterlily (*Nuphar variegata*) and watershield (*Brasenia schreberi*).

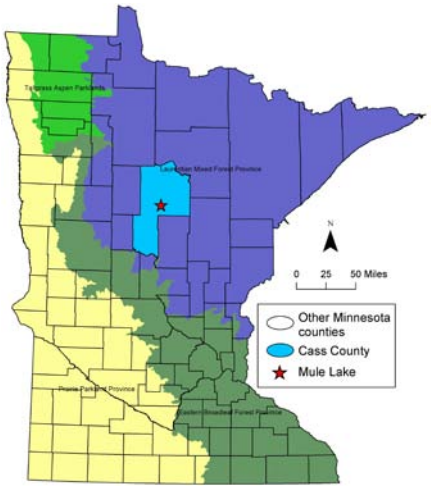
Submerged plants were found to a maximum depth of 19 feet. The submerged plant community was composed of a diversity of native species. Canada waterweed (*Elodea canadensis*) was the most common species and occurred in 55% of the survey sites. It dominated the 6 to 20 feet depth zones where it was found in 61% of the sites. Other submerged plants that occurred in at least 9% of the sites were flat-stem pondweed (*Potamogeton zosteriformis*), large-leaf pondweed (*Potamogeton amplifolius*), Robbin's pondweed (*Potamogeton robbinsii*), coontail (*Ceratophyllum demersum*), muskgrass (*Chara* sp.) and narrow-leaf pondweed (*Potamogeton* sp.).

The shallow northeastern bay contained the highest diversity of aquatic plants with beds of emergent and floating-leaf plants and a rich mix of submerged plants.

Introduction

Mule Lake is located about 5 miles south of the City of Longville in Cass County, north central Minnesota (Figure 1). It occurs within the Laurentian Mixed Forest Region of the state.

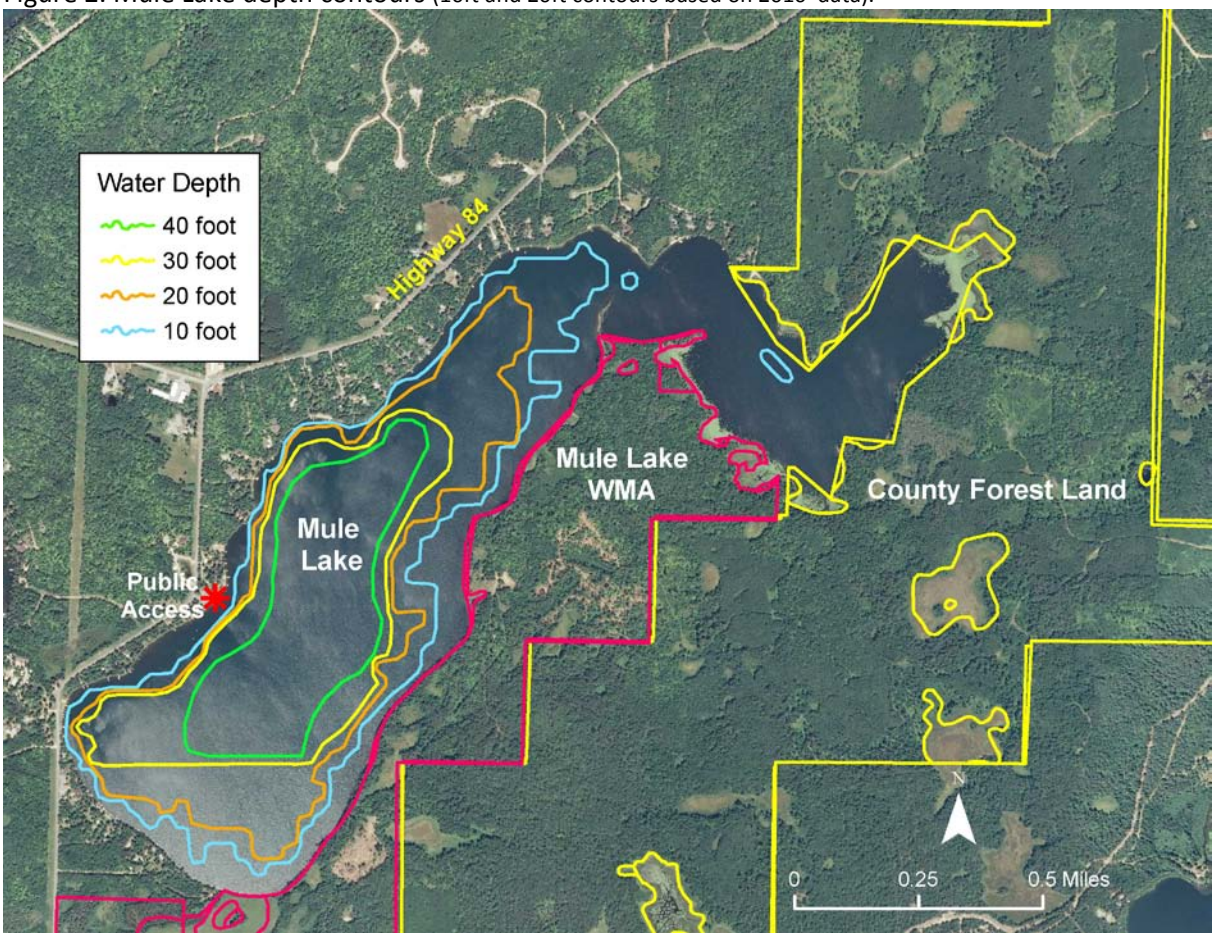
Figure 1. Mule Lake, Cass County, Minnesota.



Mule Lake has a surface area of about 525 acres. It has two basins – the main bay is oval in outline and connects to a smaller "V-shaped" northeastern bay. The lake is about 2 miles long, from north to south, with an average width of about one-third of a mile and 7 miles of total shoreline. Mule Lake has a maximum depth of 47 feet and 35% of the lake is shallow (15 feet or less in depth); the northeast bay is entirely shallow with a maximum depth of 10 feet (Figure 2).

The lakeshed of Mule Lake, the land area that drains directly to the lake, covers about 1,600 acres and is dominated by forested land. Mule Lake

Figure 2. Mule Lake depth contours (10ft and 20ft contours based on 2010 data).



Wildlife Management Area (WMA) runs along the eastern shore of Mule Lake, the northeast bay is County land. A public boat ramp is located on the southwest shore of the lake off State Highway 84 (Figure 2). The remaining shoreline of Mule Lake is privately owned; the western shore is developed with residential homes and the northeast bay remains undeveloped.

Mule Lake is primarily landlocked with only intermittent flow. The lake can be described as a seepage lake because it receives most of its flow from precipitation and groundwater flow. Water levels on seepage lakes can fluctuate seasonally and annually because their water level is a reflection of the elevation of the water table, which in turn reflects the amount of rain water and snow melt. Because Mule Lake is not a flow-through lake, it is particularly susceptible to increased nutrient and particle input that may result from poor shoreland management practices.

Mule Lake is characterized as an oligotrophic (low nutrients), hard water lake, with relatively clear water (RMB Environmental Lab report). 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 can fluctuate annually and depends on the amount of particles in the water. In 2009, mean summer (June through September) water clarity, as measured by Secchi disc readings, was 19 feet in Mule Lake (MPCA 2010). 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. Based on Secchi disk measurements alone, aquatic plants have the potential to reach depths of 28 feet in this lake. Other factors that influence the depth of plant growth include substrate type, wind fetch and the types of plants present in the lake.

Historic aquatic plant community

Previous lakewide, aquatic plant surveys of Mule Lake were conducted in 1951, 1969, 1986 and 2001 (MnDNR Lake files). These surveys recorded a total of 20 aquatic plant species: 3 emergent, 5 floating-leaf and 12 submerged species (Appendix 1).

Emergent and floating-leaf aquatic plants offer food, cover and nesting material for waterfowl, marsh birds and muskrats, and provide shelter and shade for insects, young fish and amphibians. The root systems of emergent and floating-leaf plants protect shorelines against erosion by buffering the wave action and by holding soil in place. Species that were previously found in Mule Lake included bulrush (*Schoenoplectus* spp.; Figure 3), cattail (*Typha* spp.; Figure 4), white waterlily (*Nymphaea odorata*; Figure 5) and yellow waterlily (*Nuphar variegata*; Figure 6).

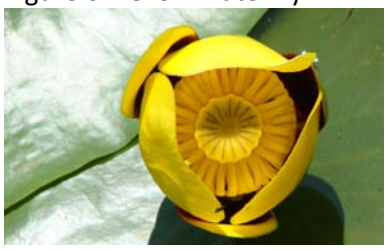
Figure 3. Bulrush

Figure 4. Cattails

The lake has historically supported an abundant and healthy submerged plant community with plants commonly found to a depth of 15 feet. Submerged species included Canada waterweed (*Elodea canadensis*), coontail (*Ceratophyllum demersum*), native pondweeds (*Potamogeton* spp.), northern watermilfoil (*Myriophyllum sibiricum*), and muskgrass (*Chara* sp.).

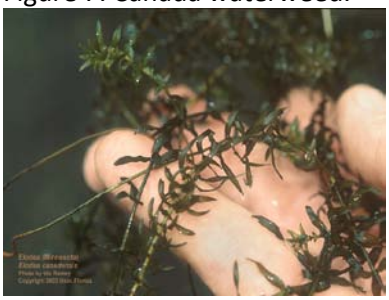
Figure 5. White waterlily

Figure 6. Yellow waterlily



Canada waterweed (Figure 7) 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. Canada waterweed can overwinter as an evergreen plant and spreads primarily by fragments.

Figure 7. Canada waterweed.



Coontail (Figure 8) 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. 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 provide a home for insects valuable as fish food.

Figure 8. Coontail

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 (*Potamogeton zosteriformis*; Figure 9) is named for its flattened, grass-like leaves. Broad-leaf pondweeds include large-leaf pondweed (*Potamogeton amplifolius;* Figure 10), variable pondweed (*P. gramineus*), and Illinois pondweed (*P. illinoensis)*. These rooted, perennial plants

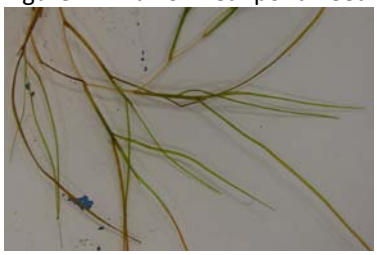
Figure 9. Flat-stem pondweed.

Figure 10. Large-leaf pondweed

with wide leaves are often called "cabbage" plants by anglers. Broad-leaf pondweeds are primarily submerged but many will form floating leaves in shallower water. Robbin's pondweed (Figure 11) is a submerged perennial plant with serrated leaf margins. The leaves have a fern-like appearance, are linear shaped and have a finely serrated margin. Robbin's pondweed produces whorls of flowers that develop in the upper leaf axils. Narrow-leaf pondweeds (Figure 12) have small, thin leaves. There are several species of narrow-leaf pondweeds and they can be difficult to identify to the species level if not found in flower or fruit.

Figure 11. Robbin's pondweed

Figure 12. Narrow-leaf pondweed



Northern watermilfoil (Figure 13) is a native, 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 and grows best in clear water lakes. For information on how to distinguish the native northern watermilfoil from the non-native, Eurasian watermilfoil, click here: identification.

Figure 13. Northern watermilfoil

Muskgrass (Figure 14) is a freshwater macroalgae 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 a 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.

Figure 14. Muskgrass

Objectives

The purpose of this vegetation survey was to provide a quantitative description of the 2010 plant population of Mule Lake. Specific objectives included:

1. Describe the shoal sediments of the lake
2. Estimate the maximum depth of rooted vegetation
3. Estimate the percent of the lake occupied by rooted vegetation
4. Record the aquatic plant species that occur in the lake
5. Estimate the abundance of common species
6. Develop distribution maps for the common species

Methods

Lakewide vegetation survey

Mule Lake was surveyed in 2010 on August 4, 11, 16 using a point-intercept survey method (Madsen 1999, MnDNR 2009). Survey waypoints were created using a Geographic Information System (GIS) computer program and downloaded into a handheld Global Positioning System (GPS) unit. Survey points were placed across the entire lake and spaced 50 meters (164 feet) apart.

In the field, surveyors sampled all sites where water depth was less than 21 feet. An additional 35 sites were surveyed from 21 to 30 feet but surveyors found no vegetation beyond 20 feet. To minimize damage to vegetation, surveyors did not survey sites if they occurred in shallow, dense beds of emergent or floating-leaf plants (for example, the shoreline of the northeastern bay). A total of 488 sites were surveyed in Mule Lake and 453 sites occurred within the vegetated zone (0 to 20 feet) (Figure 15, Table 1). The survey was conducted by boat and a GPS unit was used to navigate the boat 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 15. 2010 vegetation survey sites on Mule Lake.

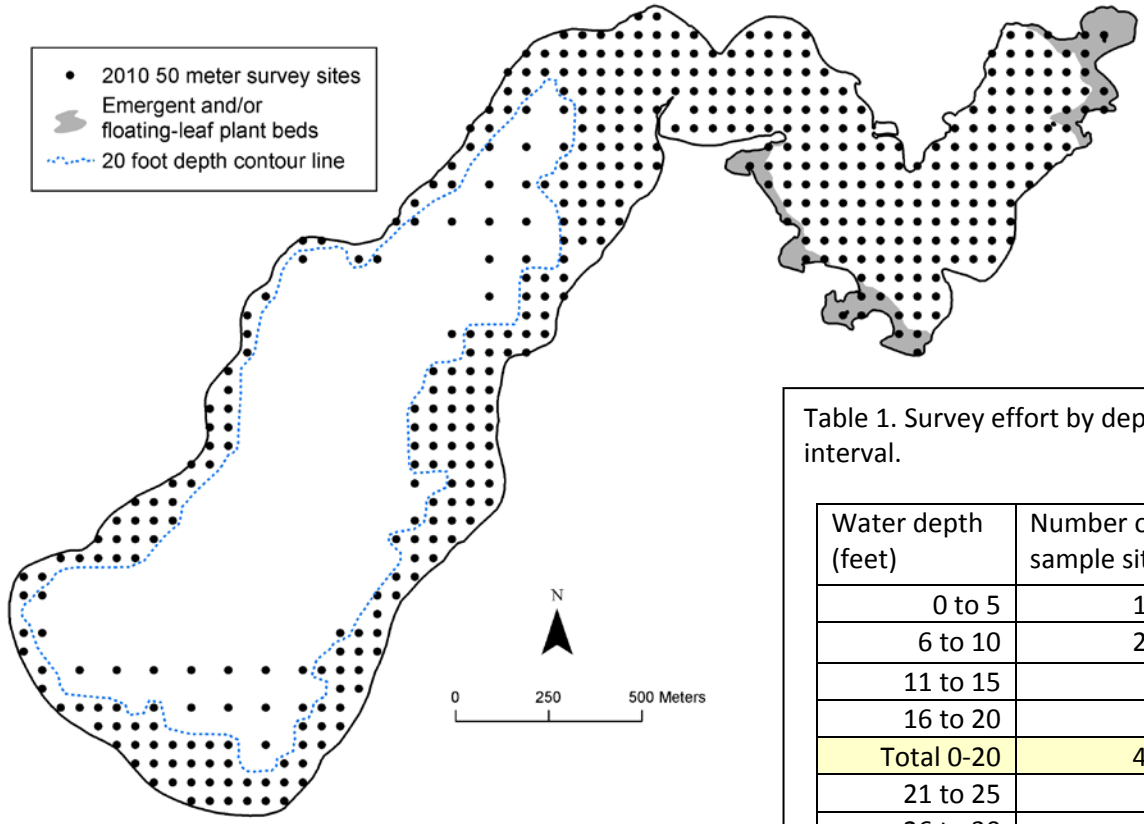


Table 1. Survey effort by depth interval.

Water depth (feet)	Number of sample sites
0 to 5	139
6 to 10	212
11 to 15	68
16 to 20	34
Total 0-20	453
21 to 25	25
26 to 30	10
Total	488

Plant sampling

Surveyors recorded all plant species found within 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 16). Any additional plant species found outside of sample sites were recorded as "present" in the lake but these data were not used in frequency calculations. Plant identification followed Crow and Hellquist (2000) and Flora of North America (1993+) and nomenclature followed MnTaxa (2010).

Figure 16. Survey rake.

Data were entered into a Microsoft Access database and frequency of occurrence was calculated for each species as the number of sites in which the species occurred divided by the total number of sample sites. Frequency was calculated for the entire area from shore to 20 feet and sampling points were also grouped by water depth and separated into 4 depth zones for analysis (Table 1).

Example:
There were 453 samples sites in the 0-20 feet depth zone.
Muskgrass occurred in 54 sites.
Frequency of Muskgrass in 0 to 20 feet zone =
(54/ 453)*100 = 12%

Emergent and floating-leaf plant bed mapping

The boundaries of major plant beds were estimated using the results of the point-intercept survey and from review of 2008 aerial photographs with in-field verification. This provides a general estimation of plant bed location and size but detailed mapping of plant beds using GPS was not conducted.

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 depth 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.

Table 2. Substrate classes

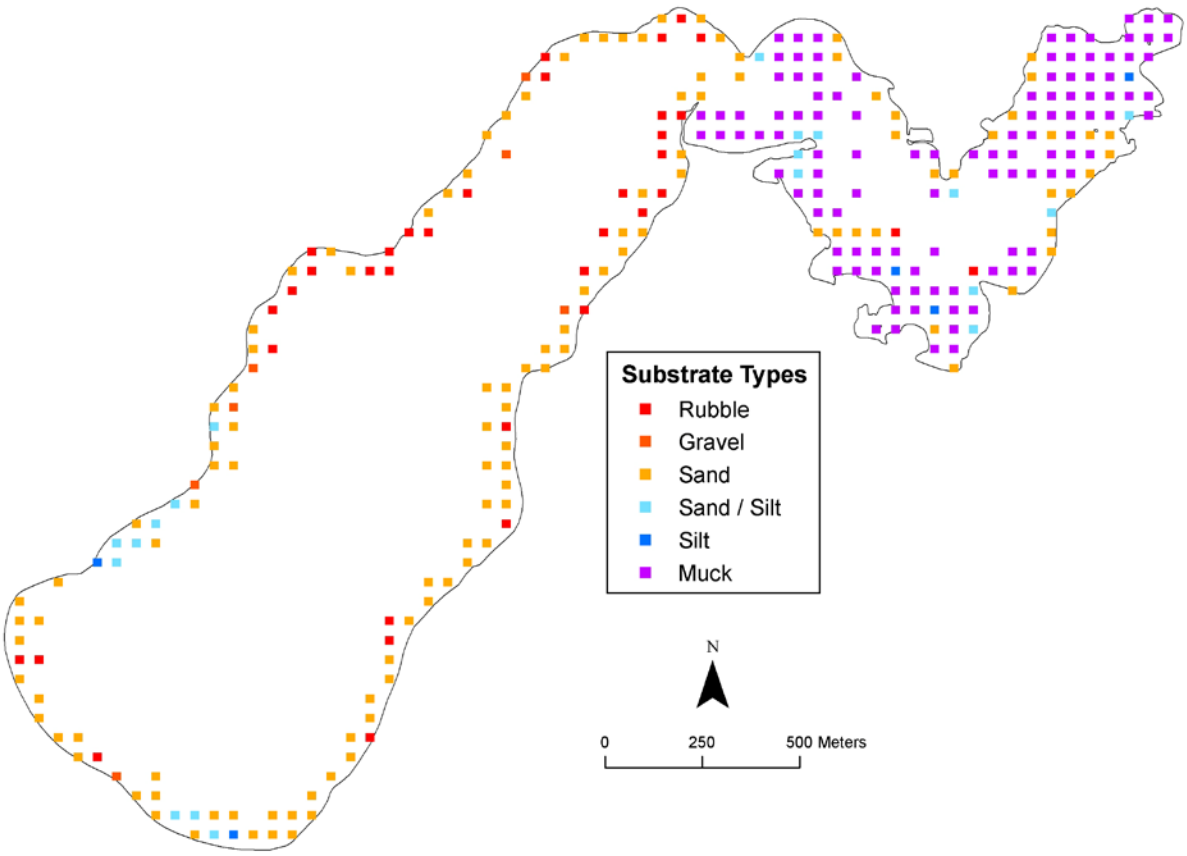
muck	decomposed organic material
marl	calcareous material
silt	fine material with little grittiness
sand	diameter < 1/8 inch
gravel	diameter 1/8 to 3 inches
rubble	diameter 3 to 10 inches
boulder	diameter > 10 inches

Results and Discussion

Shoal Substrates

The shoal substrates of Mule Lake included hard substrates of sand, gravel and rubble in the main part of the lake (Figure 17). Softer substrates of silt and muck were found in the shallow, protected northeast basin (Figure 17).

Figure 17. Shoal substrates of Mule Lake, 2010.



Distribution of aquatic plants

Plants were distributed around the entire shoreline and 83% of the sample sites (0-20 feet zone) contained plants. The broadest zone of vegetation occurred in the shallow northeast basin (Figure 18). Along the west shore where the depth contours are close together, vegetation beds were narrow and extended less than 100 meters lakeward. The largest beds of emergent and floating-leaf plants occurred in the northeast bay where about 17 acres were covered by waterlilies or mixed beds of waterlilies and emergents.

Plants were found to a depth of 19 feet and vegetation was most frequent in the 0 to 10 feet depth zone, where 95% of sites contained plants (Figure 19). Plant abundance declined with increasing water depth and in depths of 16 to 20 feet only 9% of sites contained plants.

Figure 18. Distribution of aquatic plants, Mule Lake 2010

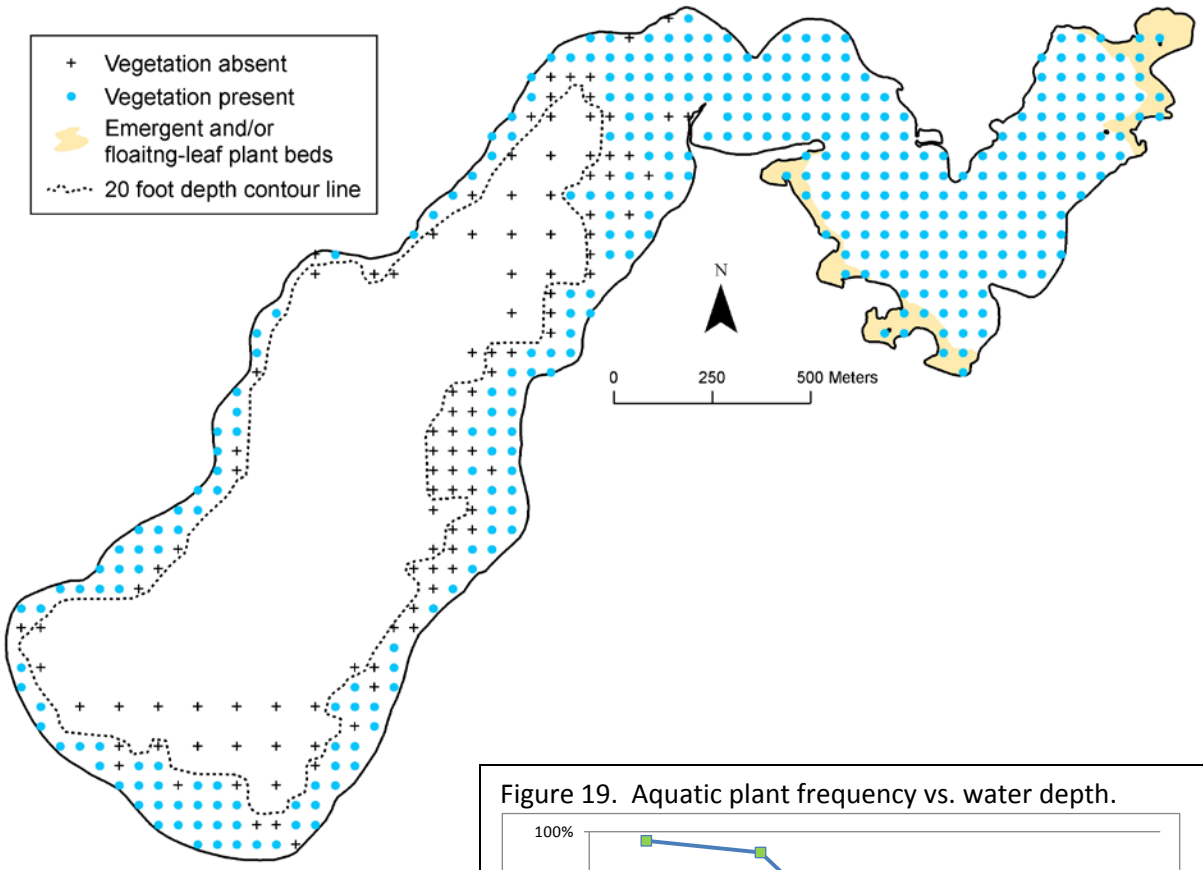
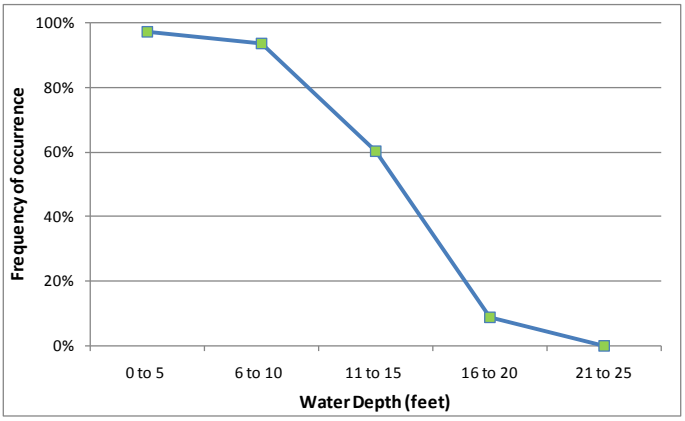


Figure 19. Aquatic plant frequency vs. water depth.



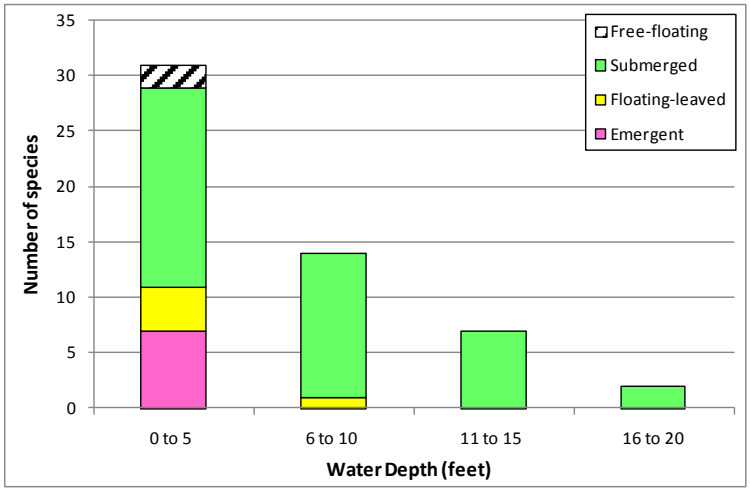
Types of plants recorded

A total of 32 native aquatic plant species (types) were recorded in Mule Lake including 7 emergent, 4 floating-leaved and 23 submerged and/or free-floating plants (Appendix 1). Sixteen of the 32 aquatic plants were recorded for the first time during the 2010 survey of Mule Lake. Submerged plants included macroalgae and a diversity of rooted, flowering plants that can be grouped by leaf shape and size: dissected, small, narrow, broad and grass-leaved plants. The 2010 survey did not include an inventory of all shoreland plants but surveyors did record the presence of several emergent wetland plants (Appendix 1).

Plant communities richness

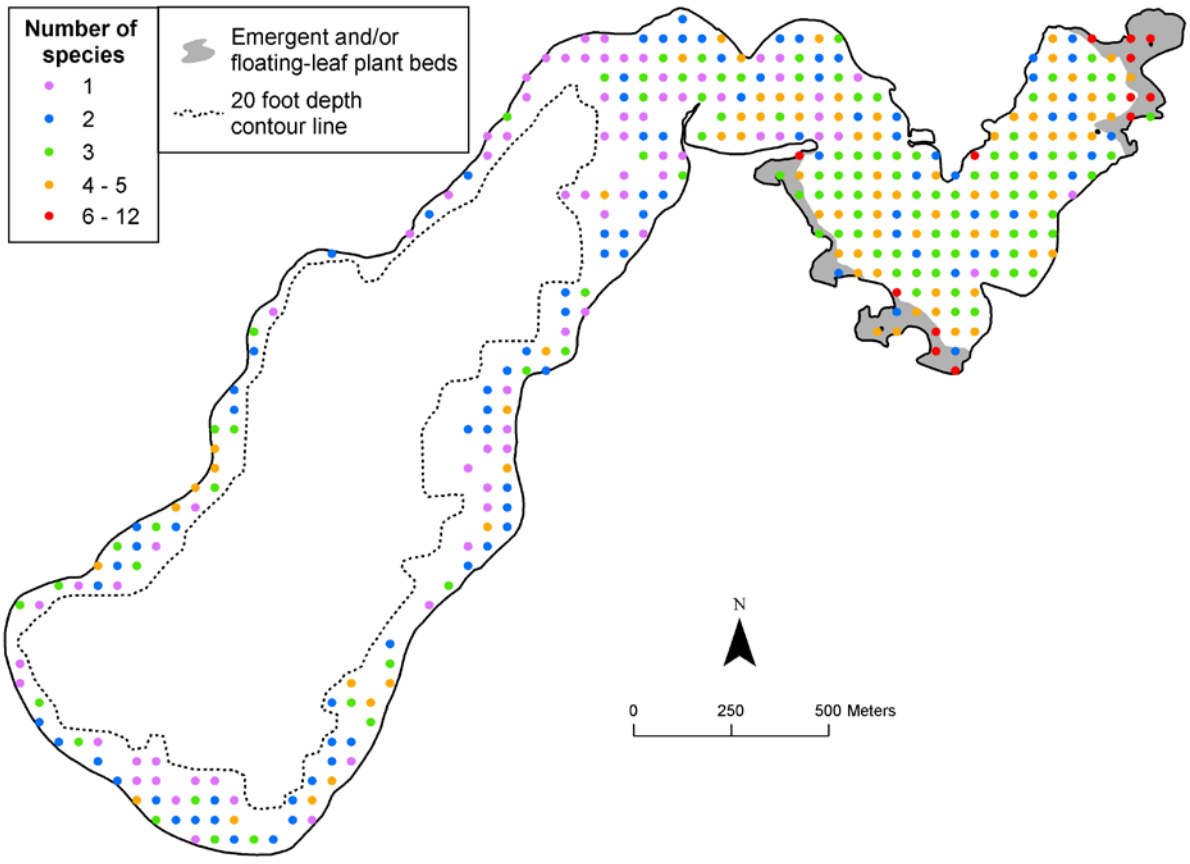
The highest number of plant species was found in shallow water, from shore to a depth of 5 feet (Figure 20). Most emergent and floating-leaf plants were restricted to shallow water (less than 6 feet). Most submerged species were found in depths of 15 feet and less and only 2 species [stonewort (*Nitella* sp.) and Canada waterweed] occurred in depths greater than 15 feet.

Figure 20. Number of species vs. water depth, Mule Lake, 2010.



The number of plant species found at each one square meter sample site ranged from 0 to 12 with an average of 2 species per site. Sites of high species richness (4 or more species per site) occurred in the shallow northeast basin (Figure 21).

Figure 21. Number of species per site, Mule Lake 2010.



Submerged aquatic plant species that were common in 2010

In 2010, plant species that were common (occurring in at least 9% of the sample sites in the 0-20 feet depth zone) were Canada waterweed (55%), flat-stem pondweed (42%), large-leaf pondweed (36%), Robbin's pondweed (16%), coontail (14%), muskgrass (12%), narrow-leaf pondweeds (11%) and northern watermilfoil (9%) (Appendix 1). All other species were found in less than 8% of the sites.

Canada waterweed was the dominant species in depths greater than 5 feet and was a co-dominant species in shallower water (Figure 22). It was found along all shorelines of the lake (Figure 23). Pondweed species (flat-stem, large-leaf, Robbin's and narrow-leaf) also had a widespread distribution around the lake (Figure 23) but were more frequent in depths of 10 feet and less (Figure 22). Coontail was most frequent in depths of 6 to 15 feet (Figure 22) and was concentrated in the northeast basin (Figure 23). Muskgrass was most common in the 0 to 5 feet depth zone (Figure 22) and occurred at scattered locations in Mule Lake (Figure 23).

Figure 22. Common submerged plants at each water depth interval, Mule Lake 2010.

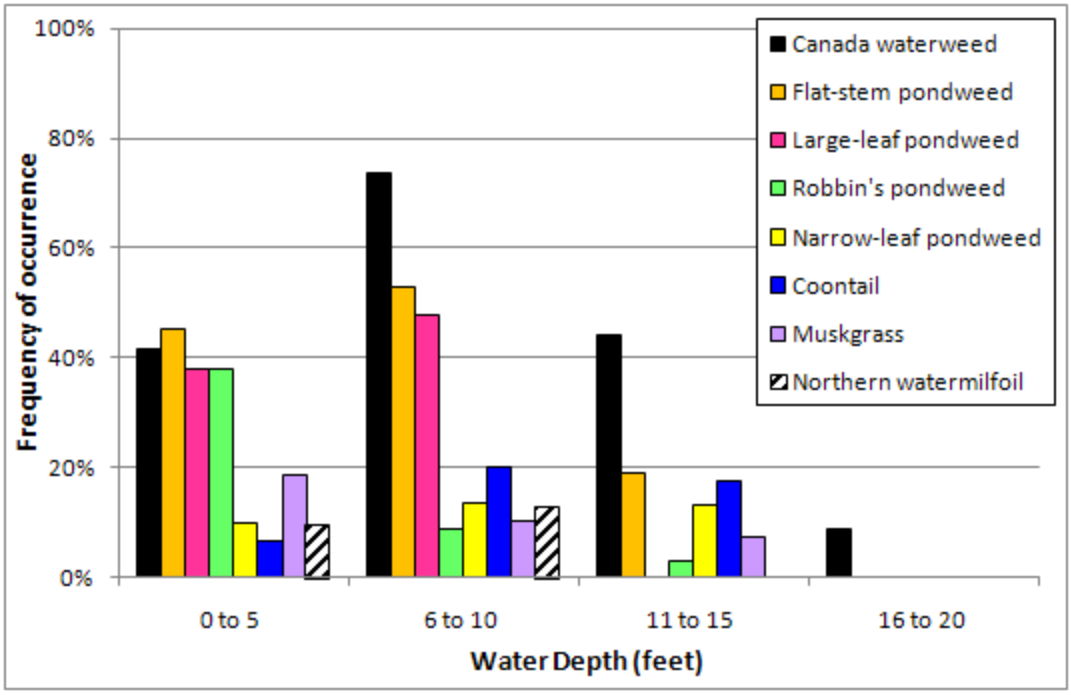
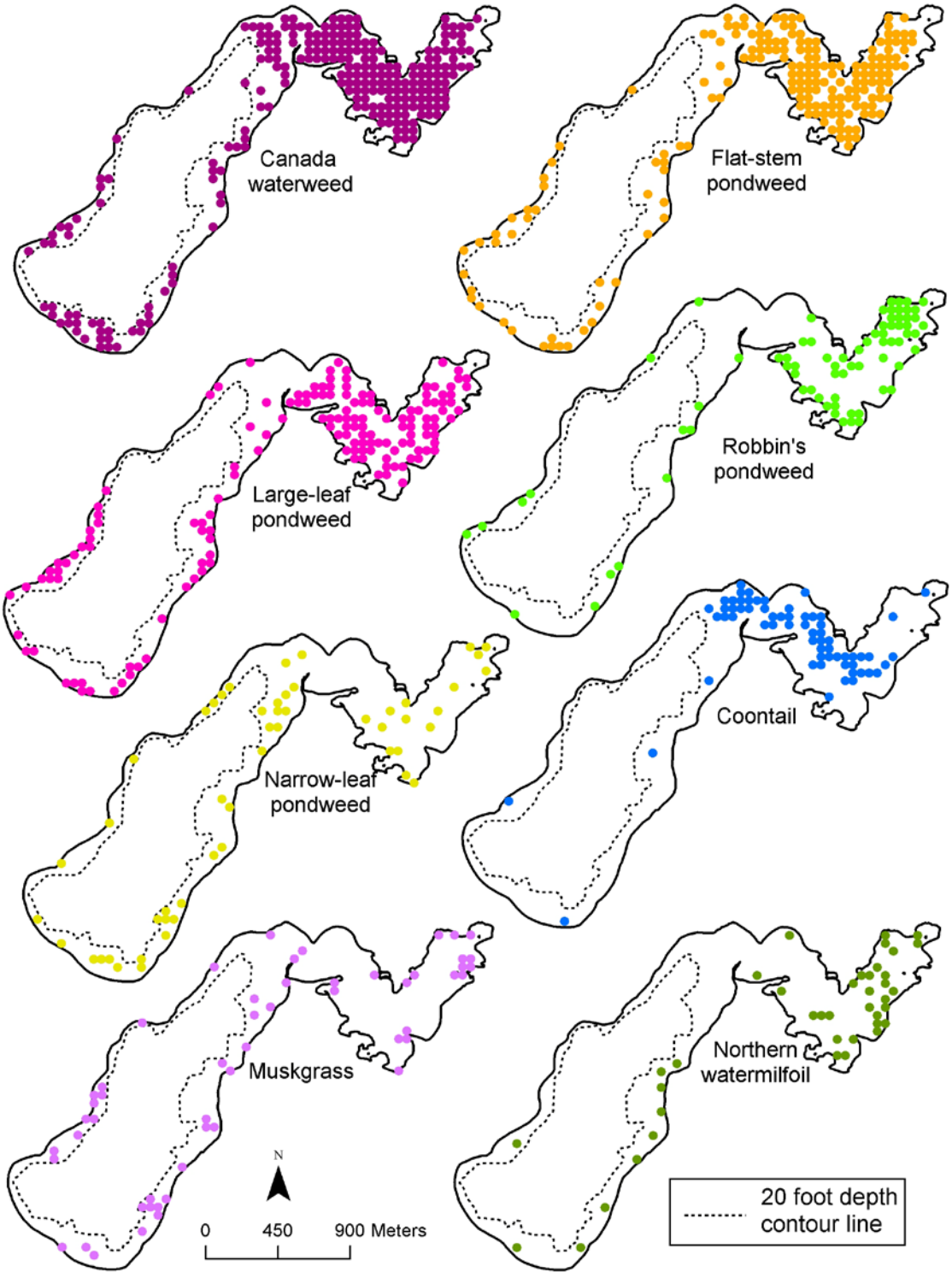


Figure 23. Distribution of commonly occurring submerged plants in Mule Lake, 2010.



Change in 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.

From a general review of historical data, the current aquatic plant communities of Mule Lake appear similar to those described in earlier years. Data collected in 2010 can be used to monitor finer-scale changes that may occur, such as an increase in a particular species or a change in the depths at which individual species occur. In general, factors that may lead to change in native and non-native aquatic plant communities include:

- Change in water clarity
  If water clarity in Mule Lake increases, submerged vegetation may be more common at depths greater than 15 feet.

- Snow and ice cover
  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, some submerged plants may increase in abundance.

- 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 (APM) 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 APM activities 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 waterlilies and bulrush. 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 Mule Lake provide critical fish and wildlife habitat and other lake benefits. (Click here for more information on: value of aquatic plants).

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Appendix 1. Historical and current aquatic and wetland plants of Mule Lake

Submerged	Common Name	Scientific Name	1951	1969	1986	2001	2010
Macro algae	Muskgrass	*Chara* sp.		O	C	O	12
	Stonewort	*Nitella* sp.					<1
Monocots	Canada waterweed	*Elodea canadensis*	C		P	C	55
	Water star-grass	*Heteranthera dubia*					1
	Bushy pondweed	*Najas flexilis*				C	7
	Large-leaf pondweed	*Potamogeton amplifolius*	C	O	O	A	34
	Variable pondweed	*Potamogeton gramineus*					1
	Illinois pondweed	*Potamogeton illinoensis*					<1
	White-stem pondweed	*Potamogeton praelongus*		P			
	Robbin's pondweed	*Potamogeton robbinsii*		P		A	16
	Narrow-leaf pondweed	*Potamogeton* spp.			O	C	11
	Flat-stem pondweed	*Potamogeton zosteriformis*	C	O	C	A	42
	Sago pondweed	*Stuckenia pectinata*			P		2
	Arrowhead (submerged form)	*Sagittaria* sp.					1
	Wild celery	*Vallisneria americana*		P			2
Dicots	Water marigold	*Bidens beckii*					1
	Coontail	*Ceratophyllum demersum*	C	O		C	14
	Northern watermilfoil	*Myriophyllum sibiricum*	C	O	O	A	9
	Greater bladderwort	*Utricularia vulgaris*					1
	Lesser bladderwort	*Utricularia minor*					1
	Flat-leaved bladderwort	*Utricularia intermedia*					1
		Total	5	8	7	9	20
		Max Depth (feet)	n/a	n/a	15	14	19

Free-floating	Common Name	Scientific Name	1951	1969	1986	2001	2010
	Star duckweed	*Lemna trisulca*					<1
	Greater duckweed	*Spirodela polyhriza*					<1
		Total	0	0	0	0	2

Floating-leaved	Common Name	Scientific Name	1951	1969	1986	2001	2010
	Floating-leaf pondweed	*Potamogeton natans*			P	O	<1
	White waterlily	*Nymphaea odorata*	P	O	O	C	6
	Yellow waterlily	*Nuphar variegata*		O	O		1
	Floating-leaf smartweed	*Persicaria amphibia*		P	P		
	Watersheild	*Brasenia schreberi*		P		C	4
		Total	1	4	4	3	4

	Common Name	Scientific Name	1951	1969	1986	2001	2010
Emergent	Three-way sedge	*Dulichium arundinaceum*					P
	Needlerush	*Eleocharis acicularis*					1
	Spikerush	*Eleocharis* sp.					P
	Broad-leaved arrowhead	*Sagittaria latifolia*					<1
	Bulrush	*Schoenoplectus acutus*			O	C	<1[a]
		Schoenoplectus validus		O			
	Burreed	*Sparganium* sp.					<1
	Broad-leaf cattail	*Typha latifolia*		P		C	<1
	Narrow-leaved cattail	*Typha* sp.					1
		Total	0	2	1	2	8

	Common Name	Scientific Name	1951	1969	1986	2001	2010
Wetland emergent	Sedge	*Carex* spp.				O	
	grass	*Not identified to genus*				A	
	Pale smartweed	*Polygonum lapathifolium*				C	
	Spotted Joe-Pye Weed	*Eutrochium maculatum*					P
	Reed meadow grass	*Glyceria grandis*			O		
	Jewelweed	*Impatiens* sp.					P
	Purple loosestrife (I)	*Lythrum salicaria*					P
	Reed canary grass (I)	*Phalaris arundinaceae*			O		
	Giant cane	*Phragmites australis*					P
	Blue vervain	*Verbena* sp.					P
	Common thistle	*Not identified to genus*					P
		Total	0	0	2	1	6

I = introduced
X[a] = Species identified only to genus level
Present = found in lake but not in any sample sites
1951, 1969 and 1986: P = Present, O = Occasional, C = Common
2001: A = abundant (for 2001 transect survey – "Abundant" is used to describe any species that was found on 14-20 of the transects
C = for 2001 transect survey "Common" was used to describe any species that was found on 2-5 of the transects
O = only found on 1 transect

Sources:
1951 (July 30): John Maloney, Department of Game and Fish Survey
1969 (August 27): Tim Schoenfelder, DNR Fisheries Survey
1986 (July 15): Steve Campbell, DNR Fisheries Survey – Plants grew to 15 feet and were scattered around the shoreline and primarily were found in the northeast bay
2001 (July 11): DNR Fisheries Survey – 20 transects
2010 (August 4, 11, 16): Simon, Perleberg, Van Dyne, Whichello, Point Intercept survey, MnDNR Division of Ecological and Water Resources
2010 - Frequency is the percent of sample sites in which a plant species occurred within the 0 to 20 ft water depth (N=453)