Aquatic vegetation of Clamshell Lake

July, 2011

Clamshell Lake, ID# 18-0356-00

Crow Wing County, Minnesota

North bay, Clamshell Lake, 2011.

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Survey Context

This lake vegetation survey of Clamshell 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

Clamshell Lake is one 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 these lakes. Surveys included mapping emergent and floating-leaf plant beds and sampling plant occurrence and diversity at 186 sites.

The aquatic plant community of Clamshell Lake is diverse with native plants. Since 1938 a total of 42 species have been found in the lake and in 2011, 37 species were recorded including 5 emergent, 4 floating-leaved, 2 free-floating, and 26 submerged plants. Fifteen of these species were recorded for the first time in the lake in 2011 and all of the species located during historical surveys are still relatively common in the lakes.

Plants were found to a depth of 24 feet but were sparsely distributed in depths greater than 20 feet. Within the 0-25 feet depth zone, 92% of the survey sites contained vegetation.

Approximately 29 acres of emergent and floating-leaf plant beds were mapped with major beds occurring in shallow water along undeveloped shorelines such as shorelines adjacent to islands or wetlands. Most of these plant beds were classified as "mixed waterlily" beds and with white waterlily (*Nymphaea odorata*) and yellow waterlily (*Nuphar variegata*), and scattered emergent plants such as giant burreed (*Sparganium eurycarpum*), bulrush (*Schoenoplectus* sp.) and spikerush (*Eleocharis* spp.).

The submerged plant community was composed of a diversity of native species. Naiads (*Najas flexilis* and *Najas guadalupensis*) were the most common species and occurred in 49% of the survey sites. Other submerged plants that occurred in at least 30% of the sites were broad-leaf pondweeds (*Potamogeton* spp.), flat-stem pondweed (*Potamogeton zosteriformis*), Canada waterweed (*Elodea canadensis*), wild celery (*Vallisneria americana*), and northern watermilfoil (*Myriophyllum sibiricum*). No non-native aquatic plants were found during the survey.

The greatest diversity of plants occurred in the near-shore zone where water depths were 10 feet and less. Ninety-seven 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

Clamshell 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]. Clamshell Lake lies on the south side of the chain and is not directly connected to the Pine River, which flows east through the larger lakes of the chain. Many of the smaller lakes, including Clamshell were not originally connected but were joined around 1886 when the Pine River Dam was completed 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 1. Clamshell Lake, Crow Wing County, Minnesota.

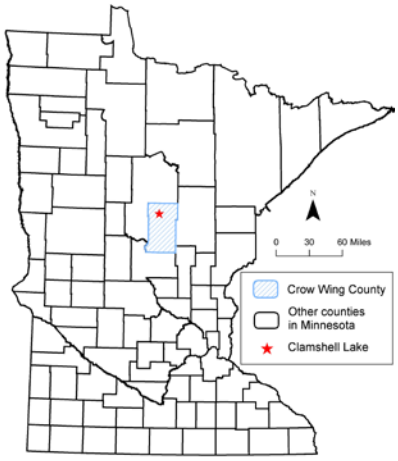
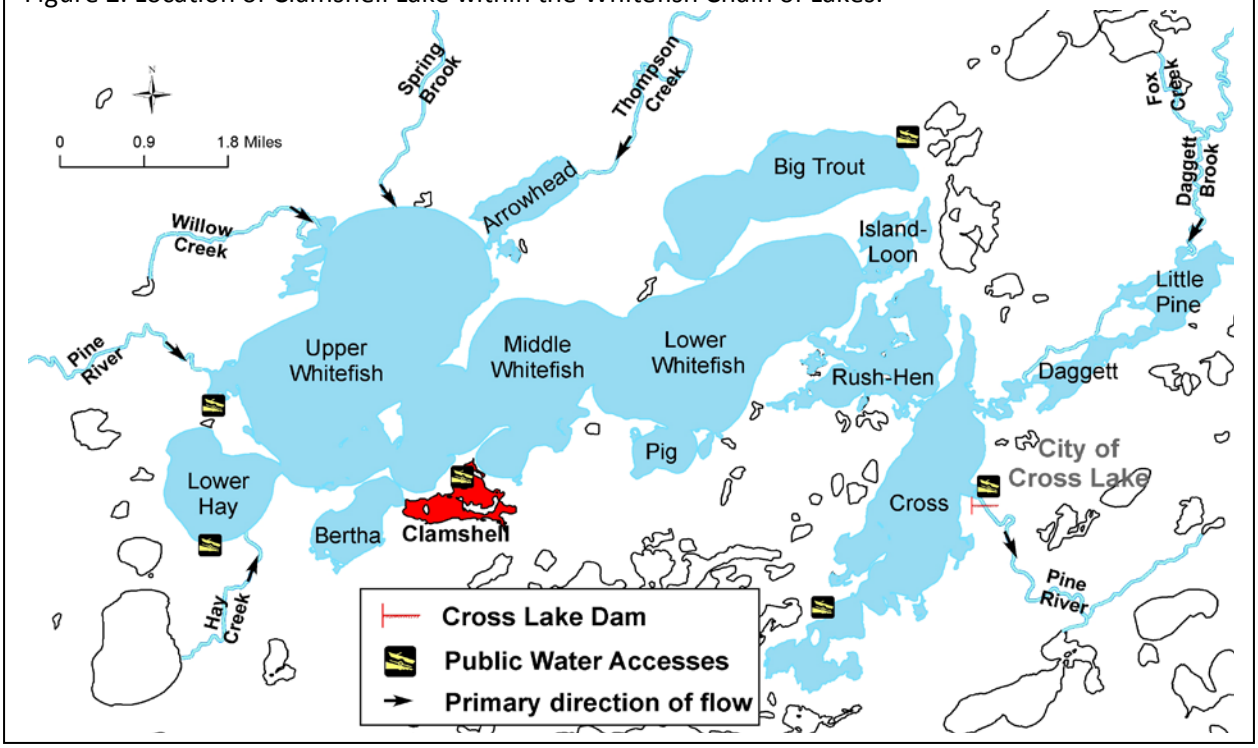


Figure 2. Location of Clamshell Lake within the Whitefish Chain of Lakes.

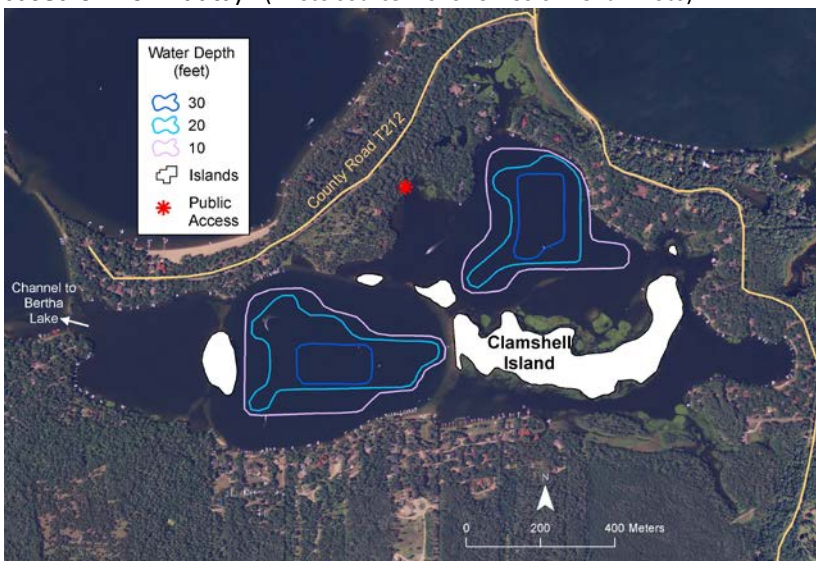


[1] The total number of waterbodies considered to be part of the Whitefish Chain of Lakes varies. We included the lakes that are directly connected within the main portion of the chain.

Lake Characteristics

Clamshell Lake is triangular shaped in outline with a surface area of 211 acres. Historically the lake was two separate basins (east and west) that were joined when water levels rose following the construction of the Pine River dam. Flooding resulted in the adjacent lowlands becoming part of the new unified lake and adjacent high ground became isolated as today's islands and sandbars. There are no permanent tributaries to Clamshell Lake but water flow occurs through a navigable channel that connects Clamshell to Bertha Lake which joins Whitefish Lake on the north (Figure 2). A narrow strip of land separates the north shore of Clamshell from Whitefish Lake.

Figure 3. Depth contours of Clamshell Lake (10ft, 20ft and 30ft based on 2011 data). (Photo source: 2010 FSA Color Aerial Photo)



The lake has a maximum depth 44 feet but most (68%) of the lake is shallow (15 feet or less in depth) (Figure 3). The two original lakes are now represented by two deep (>30 feet) basins separated by shallow water.

The shoreline of Clamshell Lake is about 6 miles in length. There are 4 islands and the largest, Clamshell Island, is 20 acres in surface area and covers most of the southeast third of the lake. Several large forested tracts occur on the south side of the lake but most of the shoreline has been developed with residential homes and two resorts. Public access is available at the Army Corps of Engineers boat launch on the northwest side of the lake.

Clamshell Lake is characterized as mesotrophic, based on phosphorus (nutrients), chlorophyll a (algae concentration) and Secchi[2] depth (transparency). Transparency in the lake stays relatively consistent throughout the summer and in 2010, mean summer[3] water clarity was 13 feet (MPCA 2011). Based on Secchi disk measurements alone, aquatic plants have the potential to reach depths of about 19 feet in Clamshell Lake[4].

[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] June through September

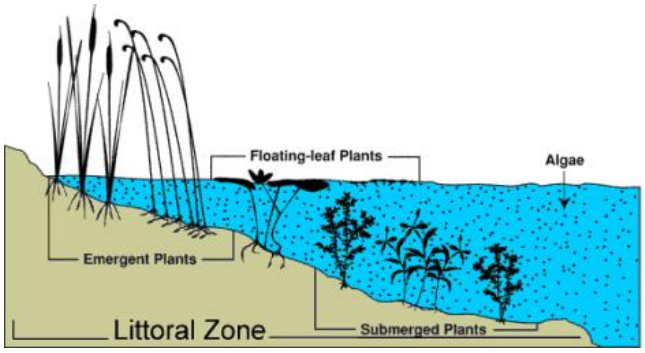
[4] As a general rule, sunlight can penetrate to a depth of two times the Secchi depth and aquatic plants can grow to a depth of one and a half times the Secchi depth.

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 4), 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 4. 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 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[5]. 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 Clamshell Lake were conducted in 1942, 1950, 1990, and 1995 (MnDNR Lake files). These surveys focused on the commonly occurring in-lake plants and recorded a total of 25 aquatic plant species: 4 emergent, 4 floating-leaf, 1 free-floating, and 16 submerged species (Appendix 1). The 1990 survey reported submerged plants to a depth of 20 feet and found emergent plants scattered along the shoreline. Plants that were reported in the previous surveys included native plants that are commonly found in many Crow Wing County lakes: a variety of pondweeds (*Potamogeton* spp., *Stuckenia pectinata*), northern watermilfoil (*Myriophyllum sibiricum*), coontail (*Ceratophyllum demersum*), Canada waterweed (*Elodea canadensis*), and wild celery (*Vallisneria americana*).

Objectives

The purpose of this vegetation survey was to provide a quantitative description of the 2011 plant population of Clamshell 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

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

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 August 22, 30, 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 July 27, 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 field, surveyors sampled sites where water depth was less than 31 feet. A total of 186 sites were surveyed in Clamshell Lake (Figure 5, Table 1).

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 5. 2011 survey sites on Clamshell Lake.

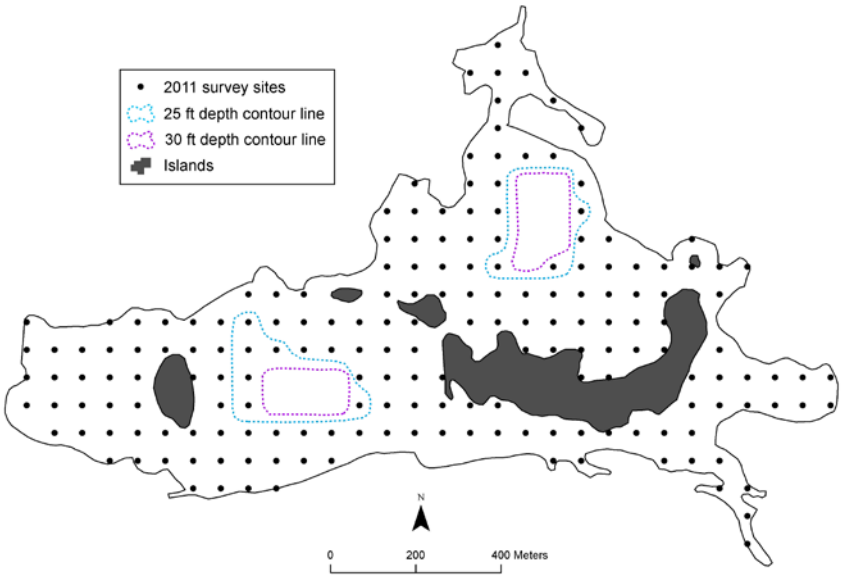


Table 1. Survey effort by depth interval.

Water depth (feet)	Number of sample sites
0 to 5	77
6 to 10	70
11 to 15	4
16 to 20	13
21 to 25	13
Total (0-25)	177
26 to 30	9
Total	186

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.

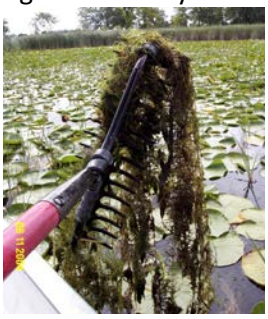
Table 2. Substrate classes

muck	decomposed organic material
marl	calcareous material
silt	fine material with little grittiness
sand	diameter l< 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 6). 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 (2011).

Figure 6. Survey rake.



Frequency was calculated for the area from shore to 25 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).

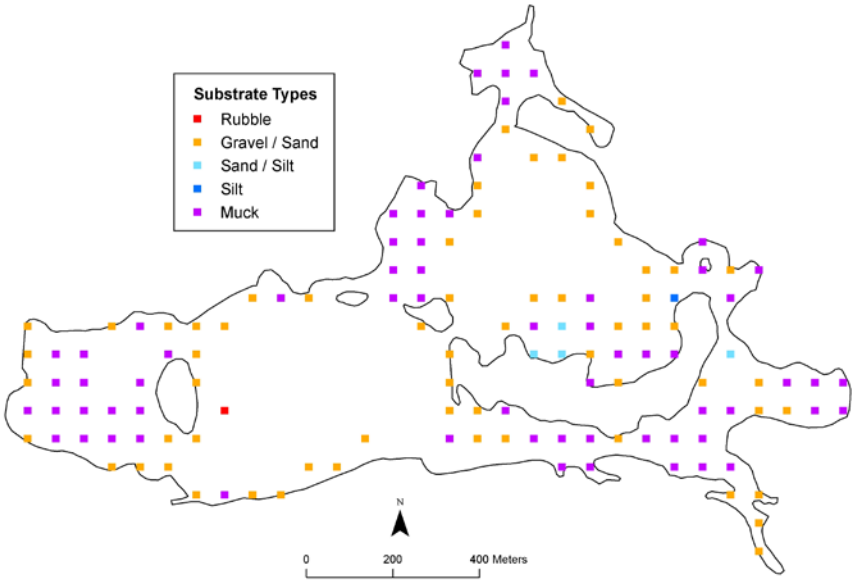
Surveyors on Clamshell Lake.

Results and Discussion

Shoal Substrates

The shoal substrates of Clamshell Lake included a mix of soft substrates of muck and silt as well as hard substrates of sand and gravel (Figure 7).

Figure 7. 2011 substrate on Clamshell Lake.



Types of plants recorded

A total of 37 aquatic plant species (types) were recorded in Clamshell Lake. The plants included 5 emergent, 4 floating-leaved, 2 free-floating, and 26 submerged plants (Table 3). Fifteen of these species were recorded for the first time during the 2011 survey (Appendix 1). No non-native aquatic plants were detected in the lake.

Table 3. Frequency of submerged aquatic plants in Clamshell Lake, July, 2011.

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

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

[b]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*).

[c]Bushy pondweed (*Najas flexilis*) and Southern naiad (*Najas guadalupensis*) were grouped together for analysis because field identification to the species level was difficult.

[d]Species in this genus were grouped together for analysis because field identification to the species level was difficult. At least one species of narrow-leaf pondweeds were identified in the lake: Fries' pondweed (*Potamogeton friesii*). Additional narrow-leaf pondweed species (*Potamogeton* spp.) may have also been present.

Table 3. (continued) Frequency of submerged aquatic plants in Clamshell Lake, July, 2011.
[Frequency is the percent of sample sites in which a plant species occurred within the 0 to 25 ft water depth].

Life Form		Common Name	Scientific Name	Frequency (% occurrence) 177 sites
EMERGENT		Arrowhead	*Sagittaria* sp.	3
		Spikerush	*Eleocharis* sp.	1
		Needlegrass	*Eleocharis acicularis*	P
		Bulrush	*Schoenoplectus* sp.[a]	P
		Giant burreed	*Sparganium eurycarpum*	P
		Narrow-leaved cattail[b]	*Typha* sp.	P
FLOATING-LEAVED		White waterlily	*Nymphaea odorata*	10
		Yellow waterlily	*Nuphar variegata*	5
		Floating-leaf pondweed	*Potamogeton natans*	5
		Floating-leaf smartweed	*Persicaria amphibia*	P
SUBMERGED	Macroalgae	Muskgrass	*Chara* sp.	25
	Moss	Watermoss	*Not identified to genus*	2
	Dissected-leaf rooted plants	Northern watermilfoil	*Myriophyllum sibiricum*	32
		Coontail	*Ceratophyllum demersum*	24
		Water marigold	*Bidens beckii*	3
		Greater bladderwort	*Utricularia vulgaris*	3
		White-water buttercup	*Ranunculus aquatilis*	2
		Flat-leaved bladderwort	*Utricularia intermedia*	1
		Minor bladderwort	*Utricularia minor*	1
		Humped bladderwort	*Utricularia gibba*	1
		Creeping spearwort	*Ranunculus flammula*	1
	Small-leaf rooted plants	Bushy pondweed	*Najas flexilis*[c]	49
		Southern naiad	*Najas guadalupensis*[c]	
		Canada waterweed	*Elodea canadensis*	34
	Narrow-leaf pondweeds	Narrow-leaf pondweed group[d]	*Potamogeton friesii*	25
		Sago pondweed	*Stuckenia pectinata*	6
	Broad-leaf pondweeds	Clasping-leaf pondweed	*Potamogeton richardsonii*	25
		Illinois pondweed	*Potamogeton illinoensis*	12
		Large-leaf pondweed	*Potamogeton amplifolius*	11
		White-stem pondweed	*Potamogeton praelongus*	7
		Variable pondweed	*Potamogeton gramineus*	5
	Grass-leaf rooted plants	Flat-stem pondweed	*Potamogeton zosteriformis*	38
		Wild celery	*Vallisneria americana*	32
		Robbin's pondweed	*Potamogeton robbinsii*	13
		Water star-grass	*Heteranthera dubia*	10
FREE-FLOATING		Star duckweed	*Lemna trisulca*	11
		Greater duckweed	*Spirodela polyhriza*	1

Distribution and richness of aquatic plants

Plants were found to a depth of 24 feet in Clamshell Lake and in the 0-25 feet depth zone, 92% of the survey sites contained vegetation. Vegetation was most common in the 0-20 feet depth zone, where 97% of sites contained plants (Figure 8). Plant abundance declined with increasing water depth and in depths of 21-25 feet, 23% of the sites were vegetated. No plants were found in the 26-30 feet depth zone.

The highest number of plant species was found in the shallow water, in depths less than 11 feet. All of the 36 species found in the lake were present within this shallow zone and 26 were only found in this area. Only 6 species occurred in depths greater than 15 feet and only 3 species (coontail, naiads, and Fries' pondweed) occurred in depths greater than 20 feet (Figure 9).

Figure 8. Plant frequency vs. water depth.

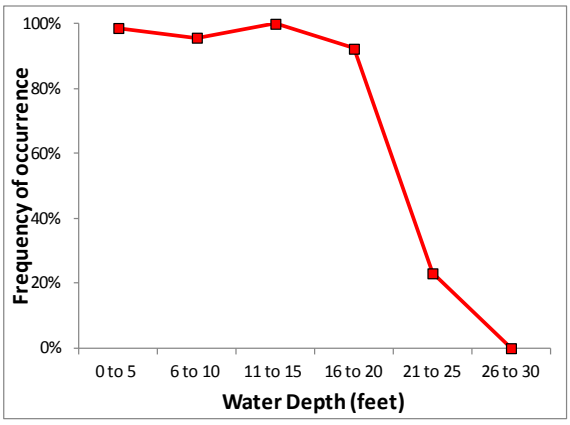
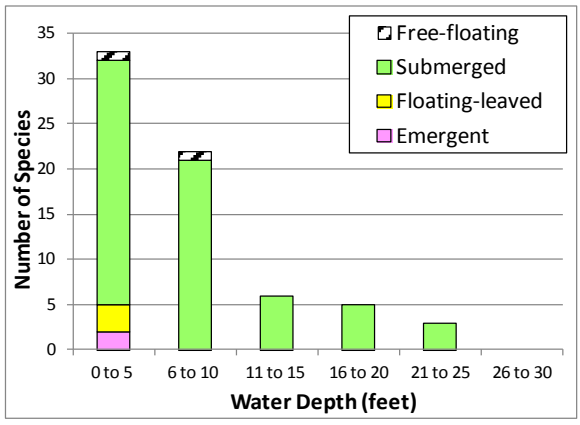


Figure 9. Number of plant species by depth.



Plants were distributed around Clamshell Lake with the broadest zones of vegetation occurring in the protected bays, and along the shallow southern shoreline (Figure 10). The number of plant species found at each sample site ranged from 0 to 13 with a mean of 4 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 of where emergent, floating-leaf, and submerged plants co-occurred (Figures 10, 11).

Emergent and Floating-leaf Plant Beds

Approximately 29 acres of emergent and floating-leaf plant beds were mapped in Clamshell Lake (Figure 11). Most of these 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*), floating-leaf smartweed (*Persicaria amphibia*), and floating-leaf pondweed (*Potamogeton natans*) intermixed with emergent plants such as burreed (*Sparganium eurycarpum*), arrowhead (*Sagittaria* sp.) and spikerush (*Eleocharis* spp) (Figure 12). A bed of bulrush (*Schoenoplectus* spp.) occurred along the southeast shoreline (Figure 11).

Figure 10. 2011 distribution and number of species on Clamshell Lake.

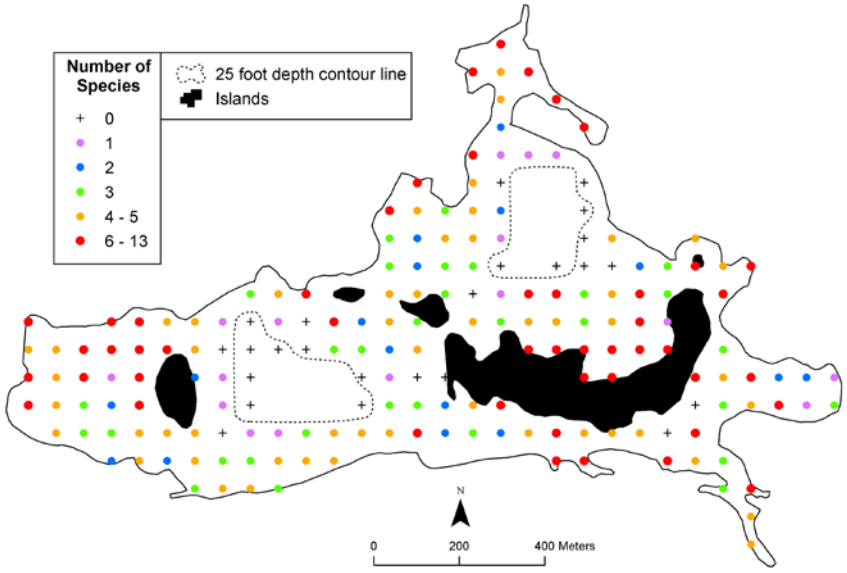
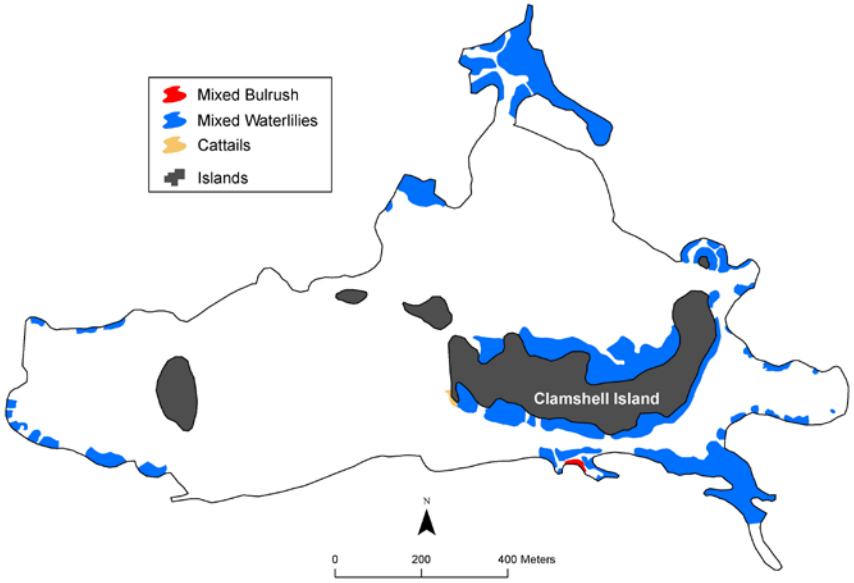


Figure 11. 2011 emergent and floating-leaf plant beds on Clamshell Lake.



The extensive root network of these emergent and floating-leaf plants help to stabilize shorelines and provide critical habitat to a variety of wildlife (Figures 13, 14, 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). 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.

Figure 12. Mixed bed of waterlilies, burreed and arrowhead on Clamshell Lake, 2011

Figure 13. Painted turtles in yellow waterlilies on Clamshell Lake, 2011

Figure 14. Damselfly on aquatic plants Clamshell Lake, 2011

Figure 15. Dragonfly on aquatic plants Clamshell Lake, 2011

Submerged aquatic plants

Submerged plants were found to a depth of 24 feet in Clamshell Lake but were common in depths of 10 feet and less (Figure 10). Six species occurred with a frequency of at least 30%[6] (Table 3). The most frequently occurring species were naiads (*Najas* spp.), broad-leaf pondweeds (*Potamogeton* spp.), flat-stem pondweed (*Potamogeton zosteriformis*), Canada waterweed (*Elodea canadensis*), wild celery (*Vallisneria americana*), and northern watermilfoil (*Myriophyllum sibiricum*) (Figure 16).

The species with the highest lakewide occurrence (naiads) were frequent in both shallow and deep water, while the other species were common in depths of 15 feet and less (Figure 17).

[6] Unless otherwise noted, frequency values are calculated for the 0-25 feet depth zone.

Figure 16. Distribution of commonly occurring submerged plants in Clamshell Lake, 2011.

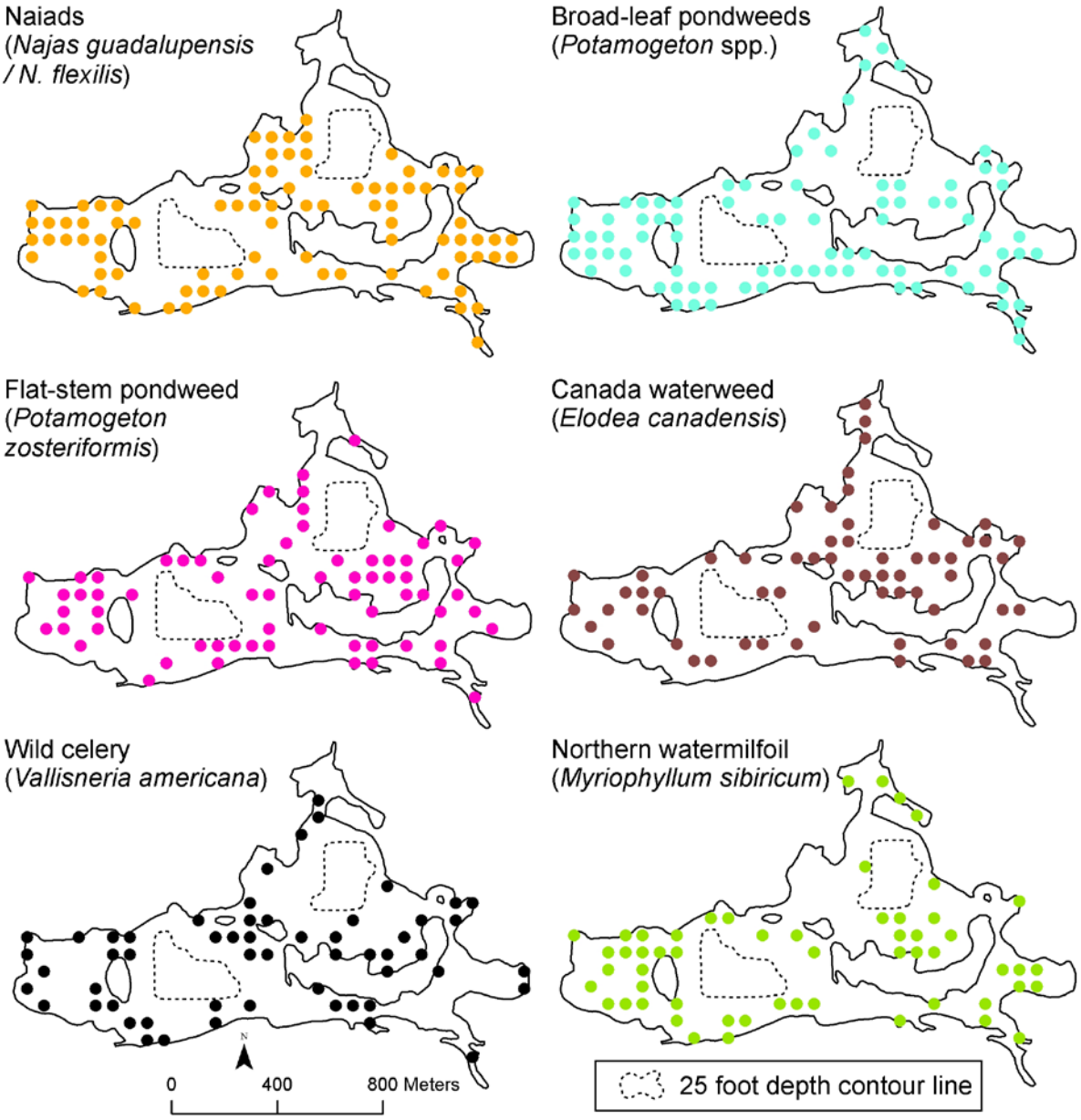
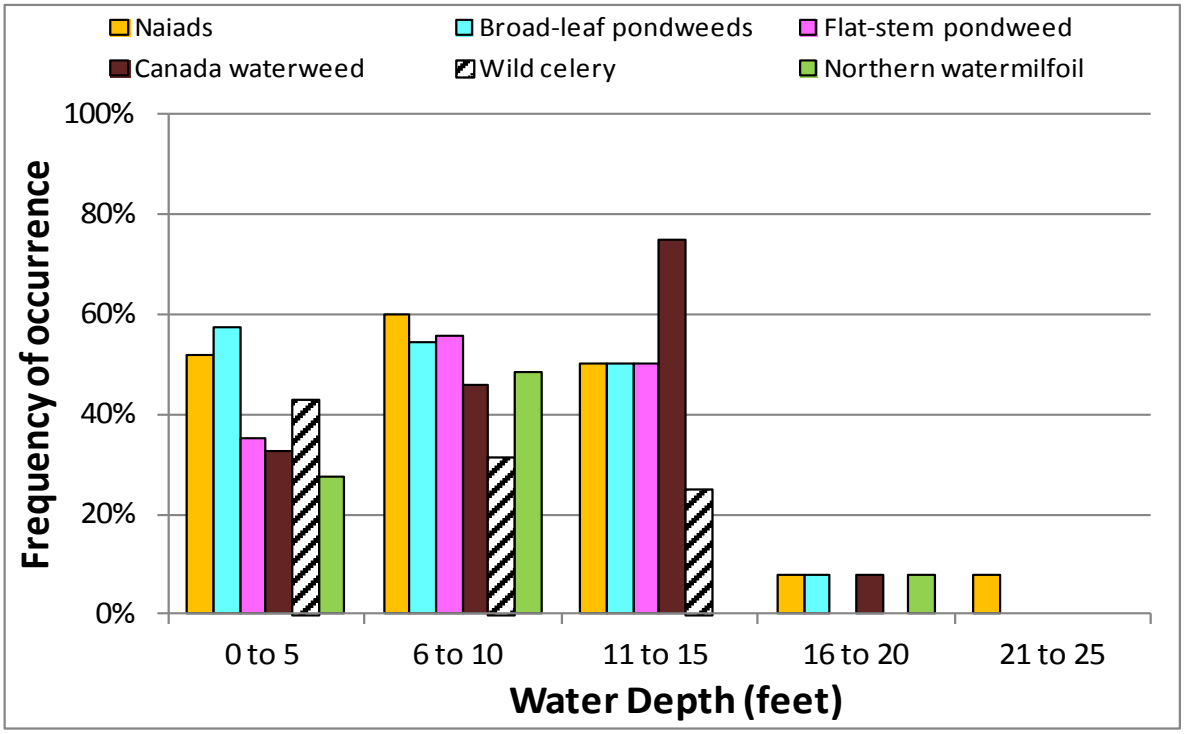


Figure 17. Common submerged plants at each water depth interval, Clamshell Lake, 2011.



Naiads (*Najas guadalupensis* and *N. flexilis*) were the most commonly found submerged plant group in Clamshell Lake and occurred in 49% of the sample sites (Table 3). Two species of naiads were found in Clamshell Lake and since they can be difficult to distinguish, they were grouped together for analyses. Southern naiad (*Najas guadalupensis*; Figure 18) can sprout from seed or overwinter as a perennial plant. Bushy pondweed 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 6-10 feet zone, naiads dominated and occurred in 60% of the sites (Figure 17).

Figure 18. Southern naiad.
Photo: Kerry Dressler ©1996 Univ. of Florida Center for Aquatic Plants

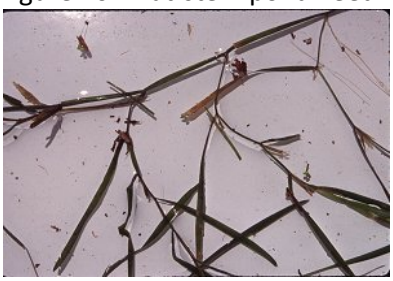
Pondweeds (*Potamogeton* spp. and *Stuckenia* spp.) are primarily submerged, perennial plants that are anchored to the lake bottom by underground rhizomes. Depending on water clarity and depth, these plants may reach the water surface and may produce flowers that extend above the water. Pondweed seeds 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).

Broad-leaf pondweeds include large-leaf pondweed (*Potamogeton amplifolius*), variable pondweed (*P. gramineus*), Illinois pondweed (*P. illinoensis*), white-stem pondweed (*P. praelongus*), and clasping-leaf pondweed (*P. richardsonii*; Figure 19). These plants are often called "cabbage" plants by anglers. Some broad-leaf pondweeds may form floating-leaves in sheltered areas while other species have only submerged leaves. Species like white-stem and large-leaf pondweed are common in many clear water Minnesota lakes but are often among the first species to decline in degraded water. White-stem and large-leaf pondweeds are not tolerant of turbidity (Nichols 1999) and may be negatively impacted by increased lake development. Broad-leaf pondweeds were found in 48% of the sites (Table 3) and were frequent in depths of 10 feet and less (Figure 17).

Figure 19. Clasping-leaf pondweed

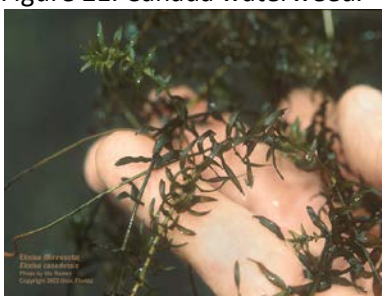
Flat-stem pondweed (*Potamogeton zosteriformis*; Figure 20) is named for its flattened, grass-like leaves. It was the second-most common pondweed in Clamshell Lake, occurring with a frequency of 38% (Table 3). It was most frequent in the 6-10 feet depth zone, where it was found in 56% of the sites (Figure 17).

Figure 20. Flat-stem pondweed.



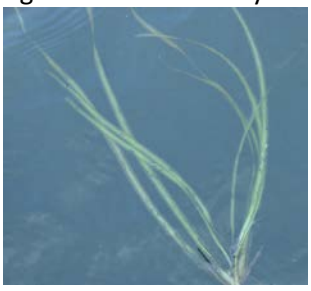
Canada waterweed (*Elodea canadensis*; Figure 21) is a perennial submerged species that is widespread throughout Minnesota. It is adapted to a variety of conditions and is tolerant of low light and prefers soft substrates (Nichols 1999). Canada waterweed can overwinter as an evergreen plant and spreads primarily by fragments. Canada waterweed was found in 34% of the survey sites (Table 3). It was found to a depth of 16 feet but was most frequent in depths of 10-15 feet (Figure 17).

Figure 21. Canada waterweed.



Wild celery (*Vallisneria americana*; Figure 22) is a rooted, perennial submerged plant that resembles ribbon-leaved pondweeds. Unlike the pondweeds that have branches of leaves, wild celery leaves all arise from the base of the plant. Beds of wild celery provide food and shelter for fish and all parts of the plant are consumed by waterfowl, shorebirds and muskrats (Borman et al. 2001). Wild celery is a particularly important food source for canvasback ducks (Varro 2003). Wild celery occurred in 32% of the sample sites (Table 3). It was found to a depth of 11 feet but was common in depths of 10 feet and less (Figure 17).

Figure 22. Wild celery



Northern watermilfoil (*Myriophyllum sibiricum*; Figure 23) is a native[7], 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 32% of all sites (Table 3). It occurred to a depth of 19 feet and was most common in the 6-10 feet depth zone (Figure 17).

Figure 23. Northern watermilfoil

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

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 Clamshell 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-

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

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 Clamshell 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 aquatic and wetland plants of Clamshell Lake

Blue highlight indicates species that were common (occurring in at least 30% of sites) in 2011.

Submerged plants

Common Name	Scientific Name	1942	1950	1990	1995	2011
Water marigold	*Bidens beckii*					X
Coontail	*Ceratophyllum demersum*	X	X	X	X	X
Muskgrass	*Chara* sp.			X	X	X
Needlerush	*Eleocharis acicularis*					X
Canada waterweed	*Elodea canadensis*		X	X	X	X
Water star-grass	*Heteranthera dubia*					X
Northern watermilfoil	*Myriophyllum sibiricum*	X	X	X		X
Leaf-less watermilfoil	*Myriophyllum tenellum*				X	
Bushy pondweed	*Najas flexilis*				X	X
Southern naiad	*Najas guadalupensis*					X
Large-leaf pondweed	*Potamogeton amplifolius*		X	X	X	X
Narrow-leaved pondweed group[1]	*Potamogeton friesii*					X
	Potamogeton spp.				X	
	Potamogeton strictifolius			X		
Variable pondweed	*Potamogeton gramineus*		X		X	X
Illinois pondweed	*Potamogeton illinoensis*					X
White-stem pondweed	*Potamogeton praelongus*					X
Clasping-leaf pondweed	*Potamogeton richardsonii*		X	X	X	X
Robbin's pondweed	*Potamogeton robbinsii*		X	X	X	X
Flat-stem pondweed	*Potamogeton zosteriformis*		X	X	X	X
White water buttercup	*Ranunculus aquatilis*				X	X
Creeping spearwort	*Ranunculus flammula*					X
Sago pondweed	*Stuckenia pectinata*				X	X
Greater bladderwort	*Utricularia vulgaris*				X	X
Lesser bladderwort	*Utricularia minor*					X
Flat-leaved bladderwort	*Utricularia intermedia*					X
Humped bladderwort	*Utricularia gibba*					X
Wild celery	*Vallisneria americana*			X	X	X
Watermoss	*Not identified to genus*					X
	Total	2	8	10	15	26

Floating-leaved plants

Common Name	Scientific Name	1942	1950	1990	1995	2011
Floating-leaf pondweed	*Potamogeton natans*		X		X	X
White waterlily	*Nymphaea odorata*		X	X	X	X
Yellow waterlily	*Nuphar variegata*		X	X	X	X
Floating-leaf smartweed	*Persicaria amphibia*				X	X
	Total	0	3	2	4	4

Free-floating plants

Common Name	Scientific Name	1942	1950	1990	1995	2011
Star duckweed	*Lemna trisulca*				X	X
Greater duckweed	*Spirodela polyhriza*					X
	Total	0	0	0	1	2

Emergent plants

Common Name	Scientific Name	1942	1950	1990	1995	2011
Spikerush	*Eleocharis* sp.					X
Horsetail	*Equisetum fluviatile*				X	
Arrowhead	*Sagittaria* sp.				X	X
Hard-stem bulrush	*Schoenoplectus acutus*			[a]X		[a]X
Soft stem bulrush	*Schoenoplectus tabernaemontani*					
Giant burreed	*Sparganium eurycarpum*					X
Narrow-leaf cattail	*Typha* sp.					[a]X
Broad-leaved cattail	*Typha latifolia*			X		
	Total	0	0	2	2	5

Wetland emergent plants

Common Name	Scientific Name	1942	1950	1990	1995	2011
Jewelweed	*Impatiens* sp.					X
Blue flag iris	*Iris versicolor*			X		[a]X
Reed canary grass	*Phalaris arundinaceae*					X
	Total	0	0	1	0	3

[a]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, one narrow-leaved pondweed, *Potamogeton friesii*, was positively identified but it is not known whether all narrow-leaved pondweeds found in that survey were *P. friesii*. Plants identified as *P. friesii* or *Potamogeton* sp. were grouped together for analysis.

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

Sources:
1942 (September 11): Robert Sharp, Division of Game and Fish
1950 (July 18): Maloney, Division of Game and Fish
1990 (June 25-27): Michael Caughey (Crew Leader); MnDNR Fisheries Survey
1995 (June 26) MnDNR Fisheries Survey
2011 (July, August): Perleberg, Simon, Eininger, Dickson, MnDNR Division of Ecological and Water Resources

Appendix 2: Calculation of plant abundance

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 0-25 feet depth zone.

Example:

In Clamshell Lake there were 177 sample sites in the 0-25 feet depth zone.
Coontail occurred in 42 sites.
Frequency of Coontail in 0-25 feet zone = (42/177)*100 = 24%