Aquatic vegetation of Pig Lake

July, August, 2011

Pig Lake, ID# 18-0354-00

Crow Wing County, Minnesota

Emergent aquatic plants in the west bay, Pig Lake, July 2011.

Minnesota
DEPARTMENT OF NATURAL RESOURCES

Report by:
Stephanie Simon, Aquatic Biologist
Donna Perleberg, Aquatic Plant Ecologist

Minnesota Department of Natural Resources
Division of Ecological and Water Resources
Lakes and Rivers Program
1601 Minnesota Drive, Brainerd, MN 56401

Surveyors (Point-Intercept Survey):
Stephanie Simon
Donna Perleberg
Sam Eininger, Intern, MnDNR Ecological and Water Resources, Brainerd
Michelle Dickson, Intern, MnDNR Ecological and Water Resources, Brainerd

Emergent Plant Bed Mapping:
Stephanie Simon and Sam Eininger

A note to readers:
Text that appears in blue underline is a hypertext link to a web page where additional information is provided. If you are connected to the Internet, you can click on the blue underlined text to link to those web pages.

This report is also available online at:
http://www.dnr.state.mn.us/eco/pubs_aquatics/veg_reports.html

This report should be cited as:
S. Simon and D. Perleberg. 2012. Aquatic vegetation of Pig Lake (ID# 18-0354-00), Crow Wing County, Minnesota, 2011. Minnesota Department of Natural Resources, Division of Ecological and Water Resources, 1601 Minnesota Drive, Brainerd, MN 56401. 22 pp.

Survey Context

This lake vegetation survey of Pig 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

Pig 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 the lake. Surveys included searches for emergent and floating-leaf plant beds and sampling plant occurrence and diversity at 88 sites.

Plants were found to a depth of 21 feet in Pig Lake and in the 0-25 feet depth zone, 91% of the survey sites contained vegetation. Vegetation was most common in the 0-15 feet depth zone, where 98% of sites contained plants and in depths greater than 20 feet, only 25% of the sites were vegetated.

Pig Lake includes a diversity of native plants, with 29 aquatic plant species recorded. The plant community was primarily comprised of submerged plants and emergent and floating-leaf plant beds were restricted to the shallow northwest bay.

The most frequently occurring species were naiads (*Najas* spp.) (48% occurrence), coontail (*Ceratophyllum demersum*) (47%), muskgrass (*Chara* sp.) (38%), northern watermilfoil (*Myriophyllum sibiricum*) (25%), flat-stem pondweed (*Potamogeton zosteriformis*) (25%) and narrow-leaf pondweeds (*Potamogeton* spp.) (21%).

The only non-native plant detected in the lake was the submerged plant, curly-leaf pondweed (*Potamogeton crispus*) which occurred in 3% of the sites and was not an important part of the plant community.

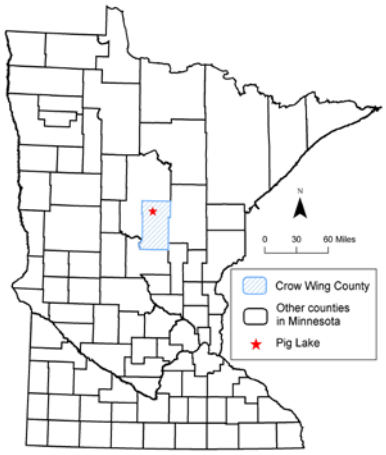
The greatest diversity of plants occurred in near-shore zone where water depths were 10 feet and less. Ninety-eight percent of the plant species were restricted to this narrow zone. This shallow water is also where much recreational activity occurs, some of which may threaten this critical habitat if 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.

Northwest Bay of Pig Lake, 2011

Introduction

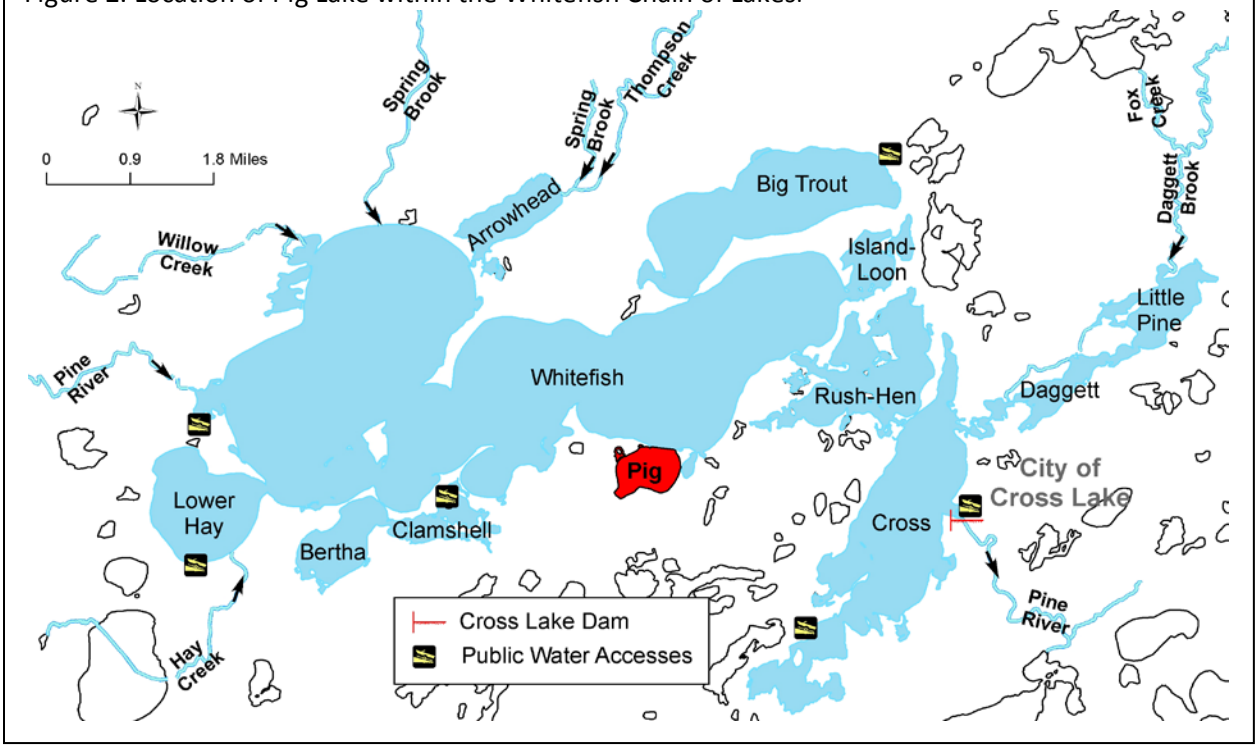
Pig Lake is located in the forested, lake-rich region of north central Minnesota (Figure 1). It is one of 13 waterbodies in the 14,000 acre Whitefish Chain of Lakes[1]. The Pine River flows east through the chain and outlets at the Pine River Dam at Cross Lake (Figure 2). The dam was completed in 1886 and raised water levels making channels between the lakes (Upham 1920). The waterways were used by early loggers to float timber downstream. A "pig" was the term used for a bundle of logs (Figure 3) and Pig Lake was used as a storage site for logs awaiting transport. Today, 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.

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



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 Pig 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

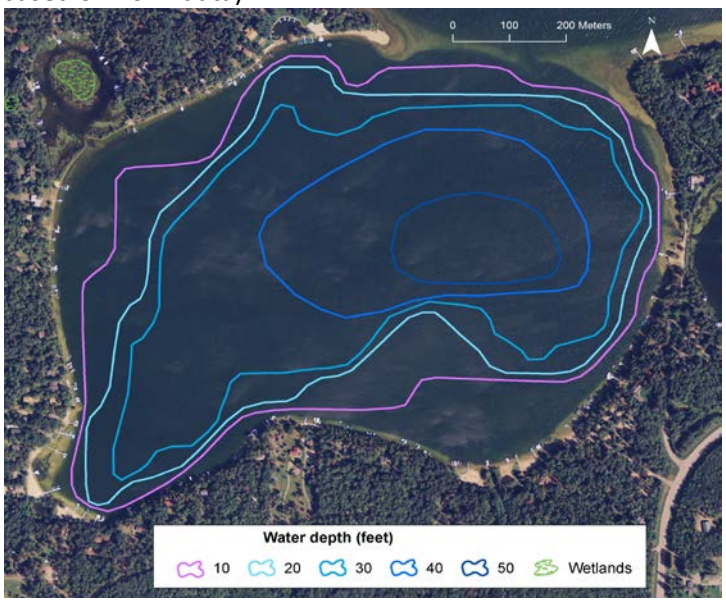
Pig Lake is the third smallest lake in the Whitefish Chain and is located on the southeast side of Lower Whitefish Lake. There are no inlets to the lake and a broad channel connects it to Lower Whitefish. Boat access is possible by navigating through the connecting lakes.

Figure 3. Log drivers moving timber, bundled in "pigs", downstream.

Copyright: MN Historical Society

The lake has a surface area of 191 acres and a total shoreline length of about 2 miles. It is oval shaped in outline with two small bays on the northwest shore (Figure 4). It has a maximum depth of 56 feet and 39% of the lake is shallow (15 feet or less in depth) (Figure 4). Shallow sandbars border the channel opening to Lower Whitefish and a narrow (5 meter wide) channel on the east shore connects Pig Lake to a small bay of Lower Whitefish.

Figure 4. Depth contours of Pig Lake (10, 20 and 30 feet based on 2011 data).



Most of the shoreline is privately owned and developed with residential homes and while trees remain on many lake lots, much of the understory vegetation has been removed at developed lots.

Pig 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 Pig 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

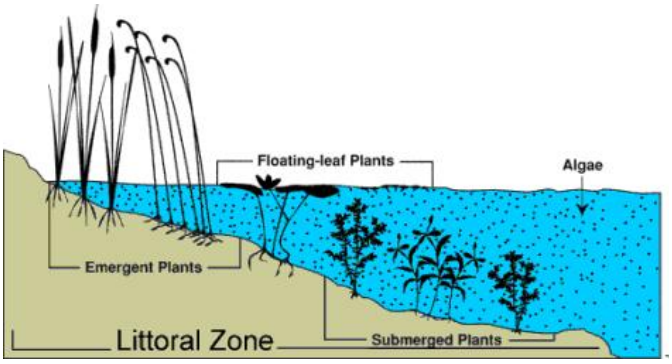
[4] As a general rule, sunlight can penetrate to a depth of two times the Secchi depth and aquatic plants can grow to a depth of one and a half times the Secchi depth.

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 5), 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 5. 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 Pig Lake were conducted in 1990 and 1995 (MnDNR Lake files). The surveys focused on the commonly occurring in-lake plants and recorded a total of 19 aquatic plant species including native plants that are commonly found in many Crow Wing County lakes: white waterlily (*Nymphaea odorata*), muskgrass (*Chara* sp.), a variety of pondweeds (*Potamogeton* spp., *Stuckenia pectinata*), northern watermilfoil (*Myriophyllum sibiricum*), coontail (*Ceratophyllum demersum*) and Canada waterweed (*Elodea canadensis*). The non-native submerged plant curly-leaf pondweed (*Potamogeton crispus*) was documented in Pig Lake in 1990 and has been present in the chain since at least 1961 (MnDNR Lake files).

Objectives

The purpose of this vegetation survey was to provide a quantitative description of the 2011 plant population of Pig 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 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 26, 27; August 18, 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 for a total of 88 sites (Figure 6, 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 6. 2011 vegetation survey sites on Pig Lake

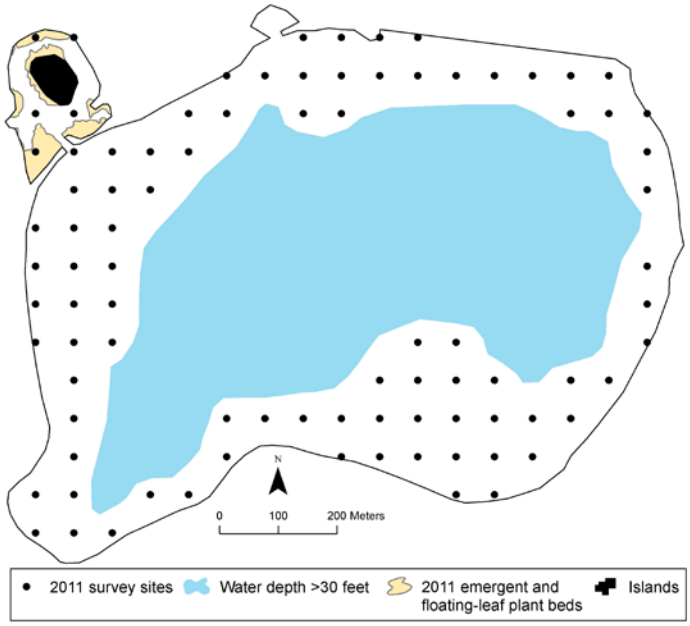


Table 1. Survey effort by depth interval.

Water depth (feet)	Number of sample sites
0 to 5	20
6 to 10	28
11 to 15	9
16 to 20	16
21 to 25	4
Total (0-25)	77
26 to 30	11
Total	88

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.

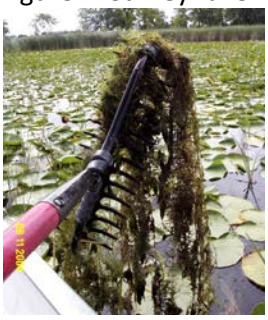
Table 2. Substrate classes

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

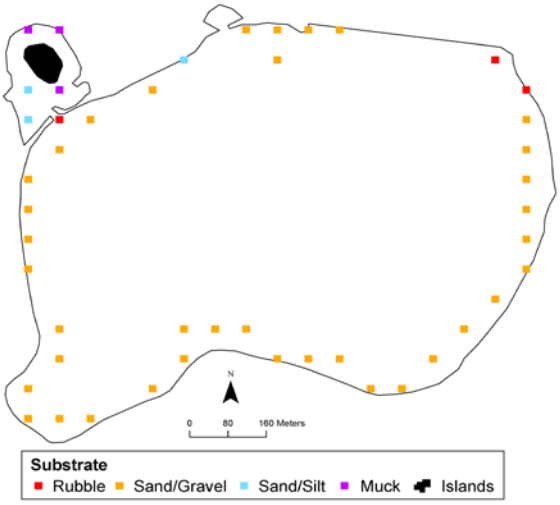
Surveyors recorded all plant species found at each sample site (approximately a one square meter sample site at the pre-designated side of the boat). A double-headed, weighted garden rake, attached to a rope was used to survey vegetation not visible from the water surface (Figure 7). Any additional plant 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 7. 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).

Figure 8. 2011 substrate on Pig Lake.



Results and Discussion

Shoal Substrates

The shoal substrates of Pig Lake were primarily hard substrates of sand, and gravel (Figure 8). Softer substrates of muck were found in the protected northwest bay.

Types of plants recorded

A total of 29 aquatic plant species (types) were recorded in Pig Lake. The plants found included 6 emergent, 3 floating-leaved and 20 submerged plants (Table 3). Eleven of these species were recorded for the first time during the 2011 survey (Appendix 1).

Nearly all of the plants found are native to Minnesota. The non-native submerged plant, curly-leaf pondweed (*Potamogeton crispus*) was located in the survey but was not a large component of the plant community. One non-native emergent plant, reed canary grass (*Phalaris arundinaceae*) was located along shore.

Distribution of aquatic plants

Plants were distributed around Pig Lake with the broadest zones of vegetation occurring along the northwest and southeast shores where shallow water extends up to 200 meters from shore (Figure 9). On the southwest and the east shores of Pig vegetation was confined to the narrow zone of shallow water.

Plants were found to a depth of 21 feet in Pig Lake and in the 0-25 feet depth zone, 91% of the survey sites contained vegetation. Vegetation was most common in the 0-15 feet depth zone, where 98% of sites contained plants (Figure 10). Plant abundance declined with increasing water depth and in depths of 21-25 feet, 25% of the sites were vegetated.

Plant communities richness

The highest number of plant species was found in shallow water, from 6-10 feet. Most submerged species were found in depths of 15 feet and less and only 2 species (coontail and Canada waterweed) occurred in depths greater than 20 feet (Figure 11).

The number of plant species found at each sample site ranged from 0 to 9 with a mean of 3 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 (Figure 9).

Table 3. Frequency of submerged aquatic plants in Pig Lake, July, August, 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) 77 sites
EMERGENT[1]		Spikerush	*Eleocharis palustris*	P
		Arrowhead	*Sagittaria* sp.	P
		Bulrush	*Schoenoplectus* sp.	P
		Giant burreed	*Sparganium eurycarpum*	P
		Broad-leaved cattail	*Typha latifolia*	P
		Narrow-leaved cattail	*Typha* sp.[a]	
FLOATING-LEAVED		White waterlily	*Nymphaea odorata*	4
		Yellow waterlily	*Nuphar variegata*	P
		Floating-leaf pondweed	*Potamogeton natans*	P
SUBMERGED	Macroalgae	Muskgrass	*Chara* sp.	38
	Dissected-leaf rooted plants	Coontail	*Ceratophyllum demersum*	47
		Northern watermilfoil	*Myriophyllum sibiricum*	25
		Water marigold	*Bidens beckii*	6
		White-water buttercup	*Ranunculus aquatilis*	1
	Small-leaf rooted plants	Bushy pondweed	*Najas flexilis*[b]	48
		Southern naiad	*Najas guadalupensis*[b]	
		Canada waterweed	*Elodea canadensis*	13
	Narrow-leaf pondweeds	Narrow-leaf pondweed group[c]	*Potamogeton friesii*	21
		Sago pondweed	*Stuckenia pectinata*	6
	Broad-leaf pondweeds	White-stem pondweed	*Potamogeton praelongus*	13
		Variable pondweed	*Potamogeton gramineus*	6
		Clasping-leaf pondweed	*Potamogeton richardsonii*	5
		Illinois pondweed	*Potamogeton illinoensis*	5
		Curly-leaf pondweed(I)	*Potamogeton crispus*	3
		Large-leaf pondweed	*Potamogeton amplifolius*	1
	Grass-leaf rooted plants	Flat-stem pondweed	*Potamogeton zosteriformis*	25
		Wild celery	*Vallisneria americana*	10
		Robbin's pondweed	*Potamogeton robbinsii*	9
		Water star-grass	*Heteranthera dubia*	8

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

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

[a]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*).

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

[c]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.

Figure 9. Number of species per site, Pig Lake 2011.

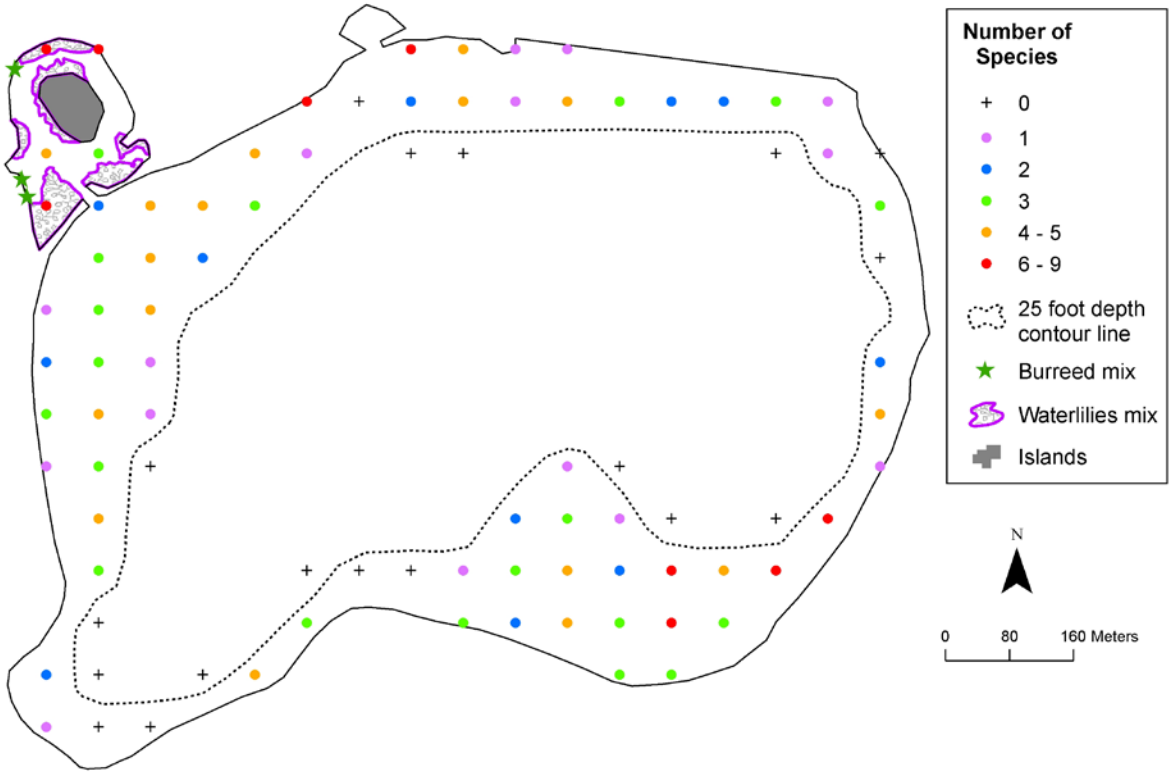


Figure 10. Aquatic plant frequency vs. water depth.

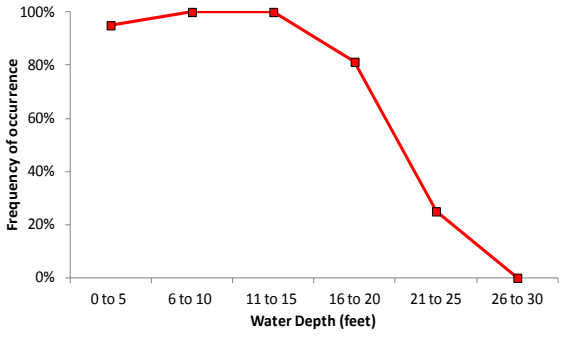
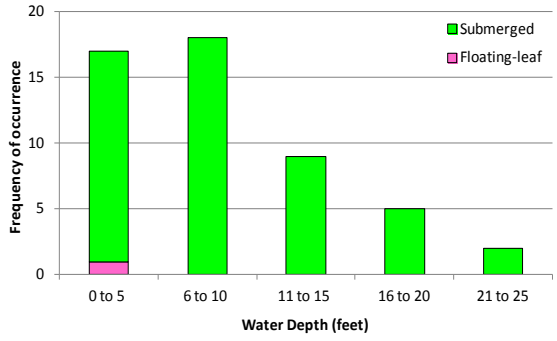


Figure 11. Number of plant species vs. water depth.



Emergent and Floating-leaf Plant Beds

Approximately 2 acres of emergent and floating-leaf plant beds were mapped and these occurred in the northwest bay (Figure 9). Most of these plant beds were classified as "mixed waterlily" beds and were dominated by floating-leaf plants such as white waterlily (*Nymphaea odorata*; Figure 12). Waterlily beds often contained scattered emergent plants such as burreed and submerged plants. 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 rhizomes are a food source for muskrats and deer (Borman et al. 2001).

Figure 12. White waterlily

Emergent plants included species with broad grass-like leaves such as cattails (*Typha* sp.) and burreed (*Sparganium* sp.) and narrow-leaf bulrush (*Schoenoplectus* sp.) plants. All emergent plants were found in the west bay of Pig Lake (Figure 9). The largest bed occurred on the southwest side of the bay and was dominated by burreed (Figure 13).

Figure 13. Burreed and waterlilies in the west bay of Pig Lake.

Burreeds are perennial, emergent plants with leaves that resemble cattails but they are shorter in height with triangular shaped leaves. Burreed grows in shallow water (typically less than 4 feet) along shorelines and in wetlands throughout Minnesota. Some burreed species form only floating-leaves, some are only emergent and some can form both types of leaves. The plants produce fruits with nut-like achenes that are eaten by ducks, common snipe and rails; the stems and leaves are a preferred food of muskrats and deer (Newmaster et al. 1997).

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

Submerged plants occurred in 91% of the Pig Lake sample sites and were found around the entire shoreline. The most frequently occurring species were naiads (*Najas* spp.), coontail (*Ceratophyllum demersum*), muskgrass (*Chara* sp.), northern watermilfoil (*Myriophyllum sibiricum*), flat-stem pondweed (*Potamogeton zosteriformis*) and narrow-leaf pondweeds (*Potamogeton* spp.). Within the 0-25 feet depth zones, these species occurred with a frequency of at least 20% (Table 3). The species with the highest lakewide occurrence (naiads coontail and muskgrass), were frequent in both shallow and deep water, while the other species were generally less frequent or not detected in depths greater than 15 feet (Figure 14, 15).

Figure 14. Distribution of commonly occurring submerged plants in Pig Lake, 2011.

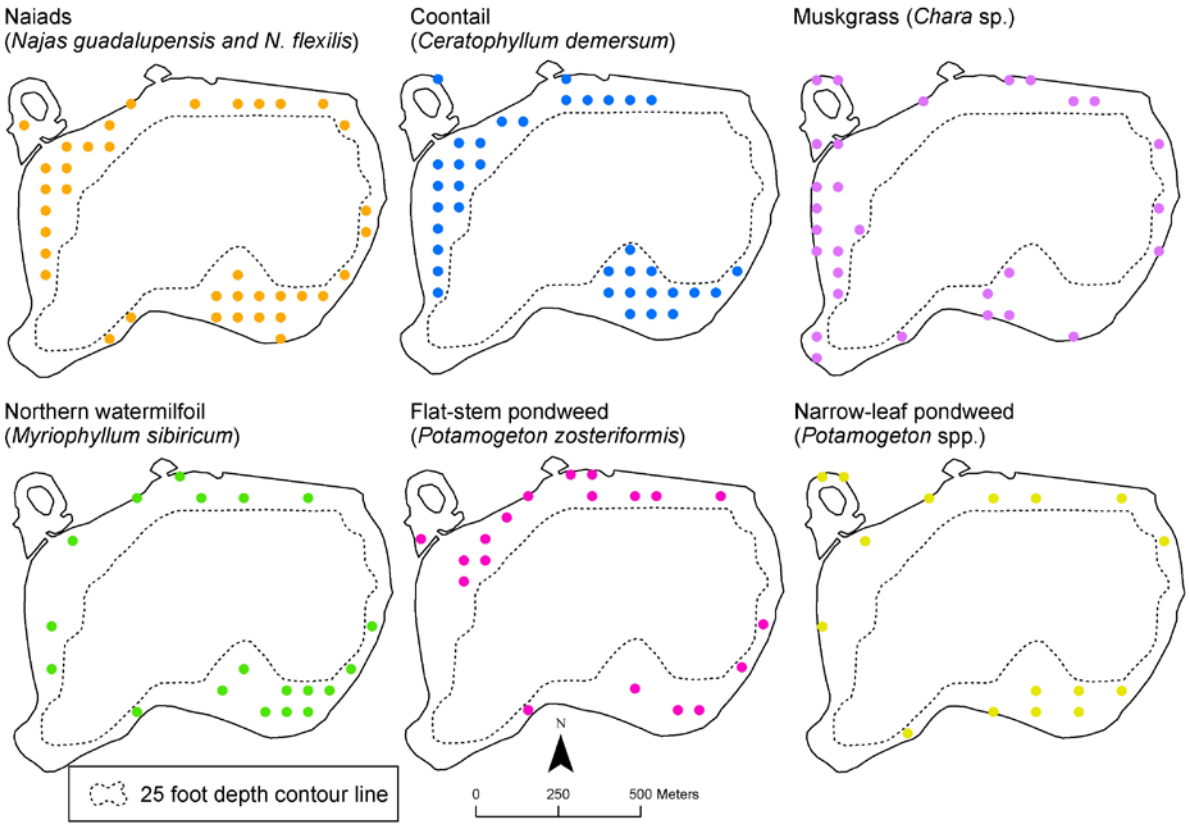


Figure 15. Common submerged plants at each water depth interval, Pig Lake, 2011.

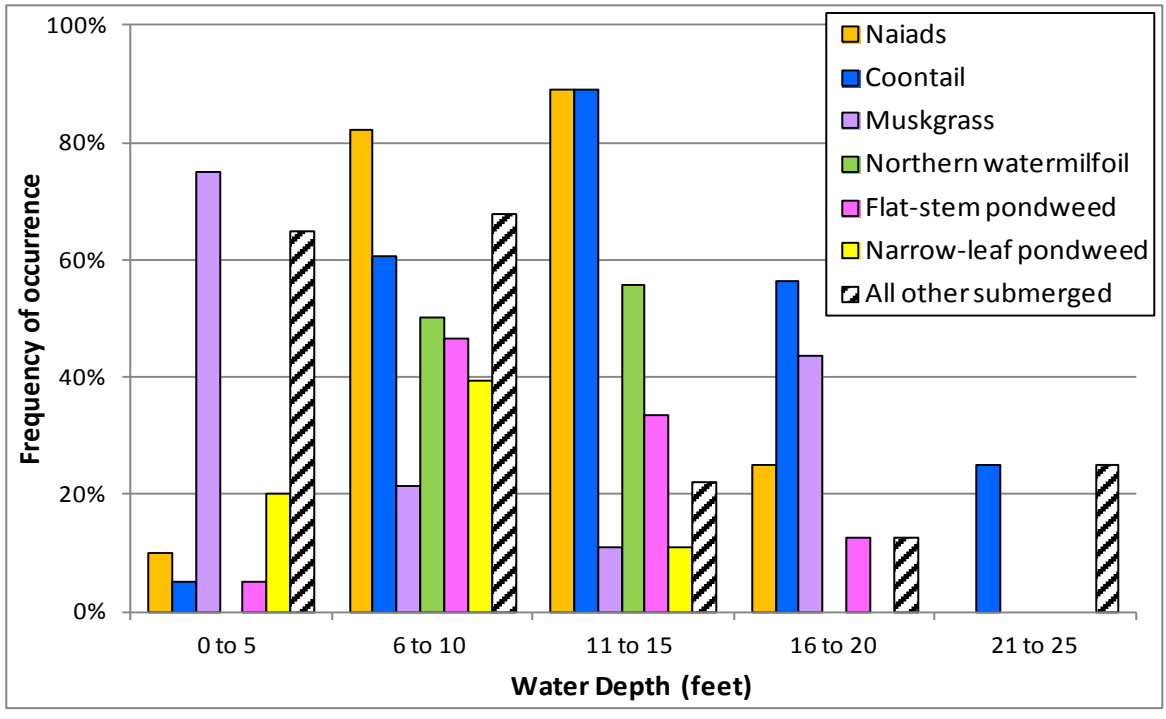


Figure 16. Southern naiad.
Photo: Kerry Dressler ©1996 Univ. of Florida Center for Aquatic Plants

Naiads (*Najas guadalupensis* and *N. flexilis*) were the most commonly found submerged plant group in Pig Lake and occurred in 48% of the sample sites (Table 3). Two species of naiads were found in Pig Lake and since they can be difficult to distinguish, they were grouped together for analyses. Southern naiad (*Najas guadalupensis*; Figure 16) 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 6-15 feet zones, naiads dominated (Figure 14) and occurred in 84% of the sites (Figure 15).

Figure 17. Coontail

Coontail (*Ceratophyllum demersum*; Figure 17) 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). 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. Coontail was found in 47% of the sample sites in Pig Lake (Table 3) and was most frequent in the 11-15 feet zone where it occurred in 89% of the sites (Figure 15).

Figure 18. Muskgrass

Muskgrass (*Chara* sp.; Figure 18) is a freshwater macroalgae[6] 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 38% of the Pig Lake survey sites (Table 3). It was found along the sandy shorelines of Pig (Figure 14) and was the most frequent plant in the 0-5 feet depth zone where it occurred in 75% of the sites (Figure 15).

[6] 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.

Northern watermilfoil (*Myriophyllum sibiricum*; Figure 19) 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 25% of all sites (Table 3). It occurred to a depth of 14 feet and was most common in the 6 to 15 feet depth zones (Figure 15).

Figure 19. Northern watermilfoil

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

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 20) is one of 8 native pondweeds found in Pig Lake. Flat-stem pondweed is named for its flattened, grass-like leaves. It was the most common pondweed in Pig Lake, occurring with a frequency of 25% (Table 3). It was most frequent in the 6-10 feet depth zone, where it was found in 46% of the sites (Figure 15).

Figure 20. Flat-stem pondweed.

Narrow-leaf pondweeds are rooted, perennial submerged plants with small, thin leaves. Leaves grow entirely below the water surface but flowers extend above the water. There are several species of narrow-leaf pondweeds and they can be difficult to identify if not found in flower or fruit. Fries' pondweed (*Potamogeton friesii*; Figure 21) was positively identified in the lake, but additional narrow-leaf species may have also been present. For analysis, all narrow-leaf pondweeds were grouped together. In Pig Lake, narrow-leaf pondweeds were found in 21% of the sites and were frequently found in depths of 10 feet and less (Table 3, Figure 15).

Figure21. Fries' pondweed

(Photo by O Angerer)

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

Other submerged species occurred in 48% 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 22) was found in 3% 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 22. 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 Pig 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 Pig Lake provide critical fish and wildlife habitat and other lake benefits. (Click here for more information on: value of aquatic plants).

Literature Cited

Borman, S., R. Korth and J. Temte. 2001. Through the looking glass: A field guide to aquatic plants. The Wisconsin Lakes Partnership. Stevens Point, Wisconsin. 248 pp.

Crow, G.E. and C.B. Hellquist. 2000. Aquatic and wetland plants of Northeastern North America. 2 volumes. The University of Wisconsin Press.

Fassett, N.C. 1957. A manual of aquatic plants. The University of Wisconsin Press. 405 pp.

Flora of North America Editorial Committee, eds. 1993+. Flora of North America north of Mexico. 12+ vols. New York and Oxford. www.efloras.org

Madsen, J. D. 1999. Point intercept and line intercept methods for aquatic plant management. *APCRP Technical Notes Collection* (TN APCRP-M1-02). U.S. Army Engineer Research and Development Center, Vicksburg, MS. http://el.erdc.usace.army.mil/elpubs/pdf/apcmi-02.pdf

MnDNR Fisheries Lake Files. Minnesota Department of Natural Resources. Division of Fish and Wildlife, Section of Fisheries, Lake Survey Program. 500 Lafayette Rd., St. Paul, MN 55155.

MnDNR. 2009. Minnesota's Sensitive Lakeshore Identification Manual: a conservation strategy for Minnesota lakeshores (version 2). Division of Ecological and Water Resources, Minnesota Department of Natural Resources.

MnTaxa. 2011. Minnesota State checklist of vascular plants. Minnesota Department of Natural Resources, Division of Ecological and Water Resources, St. Paul.

MPCA. 2011. Minnesota Pollution Control Agency. St. Paul, MN. Lake Water Quality Assessment Program. Lake Water Quality Data Search website: http://www.pca.state.mn.us/water/lkwqSearch.cfm (accessed November 29)

Nichols, S.A. 1999. Distribution and habitat descriptions of Wisconsin lake plants. Wisconsin Geological and Natural History Survey. Bulletin 96. Madison. 266 pp.

Upham, W. 1920. Minnesota Geographic Names: their origin and historic significance. Collections of the Minnesota Historical Society Vol. 17. Minnesota Historical Society, St. Paul, MN. 440 pp.

Appendix 1. Historical aquatic and wetland plants of Pig Lake

Blue highlight indicates taxa that were common (occurring in at least 20% of sites) in 2011.

Submerged plants

Common Name	Scientific Name	1990	1995	2011
Water marigold	*Bidens beckii*			X
Coontail	*Ceratophyllum demersum*	X	X	X
Muskgrass	*Chara* sp.	X	X	X
Canada waterweed	*Elodea canadensis*	X		X
Water star-grass	*Heteranthera dubia*			X
Northern watermilfoil	*Myriophyllum sibiricum*	X	X	X
Bushy pondweed	*Najas flexilis*		X	X
Southern naiad	*Najas guadalupensis*			X
Large-leaf pondweed	*Potamogeton amplifolius*	X	X	X
Curly-leaf pondweed (I)	*Potamogeton crispus*	X		X
Narrow-leaf pondweed[1]	*Potamogeton friesii*			[a]X
	Potamogeton sp.	X	X	
Variable pondweed	*Potamogeton gramineus*			X
Illinois pondweed	*Potamogeton illinoensis*			X
White-stem pondweed	*Potamogeton praelongus*	X		X
Clasping leaf pondweed	*Potamogeton richardsonii*	X	X	X
Robbin's pondweed	*Potamogeton robbinsii*	X		X
Flat-stem pondweed	*Potamogeton zosteriformis*	X	X	X
White water buttercup	*Ranunculus aquatilis*			X
Sago pondweed	*Stuckenia pectinata*	X		X
Wild celery	*Vallisneria americana*	X	X	X
	Total	13	9	20

Floating-leaved plants

Common Name	Scientific Name	1990	1995	2011
Floating leaf pondweed	*Potamogeton natans*			X
White waterlily	*Nymphaea odorata*	X		X
Yellow waterlily	*Nuphar variegata*			X
	Total	1	0	3

Emergent plants

Common Name	Scientific Name	1990	1995	2011
Spikerush	*Eleocharis palustris*			X
Arrowhead	*Sagittaria* sp.			X
Bulrush[2]	*Schoenoplectus* sp.	[a]X		[a]X
Giant burreed	*Sparganium eurycarpum*	X		X
Broad-leaved cattail	*Typha latifolia*	X		[a]X
Narrow-leaved cattail	*Typha* sp.	X		
	Total	4	0	5

Wetland emergent plants

Common Name	Scientific Name	1990	1995	2011
Blue-flag iris	*Iris versicolor*	X		
Reed canary grass (I)	*Phalaris arundinaceae*	X		X
	Total	2	0	1

I = introduced
[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 plant that was hard-stem bulrush (*Schoenoplectus acutus*), soft-stem bulrush (*S. tabernaemontani*) or the hybrid.

Sources:
1990 (June 27-29): Wayne Mueller (Crew Leader); DNR Fisheries Survey
1995 (June 27): MnDNR Fisheries Survey
2011 (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 0-25 feet depth zone.

Example:

In Pig Lake there were 77 sample sites in the 0-25 feet depth zone.
Coontail occurred in 36 sites.
Frequency of Coontail in 0-25 feet zone = (36/77)*100 = 47%