Aquatic Vegetation Survey of
Pine Mountain Lake (DOW 11-0411-00)
Cass County, Minnesota

2007

Pine Mountain Lake, Cass County, MN. 2007

Report by: Donna Perleberg and Stephanie Loso
Minnesota Department of Natural Resources
Division of Ecological Resources
1601 Minnesota Dr.
Brainerd, MN 56401
Phone: 218.833.8727
Email: donna.perleberg@dnr.state.mn.us

Lakewide sampling (2007): Donna Perleberg, Stephanie Loso, Brent Vacinek, Rachel Bulman, MnDNR Division of Ecological Resources, Brainerd.

Bulrush mapping (2007): Paul Radomski, Kevin Woizeschke, Lucas Wandrie, Jesse Amo, MnDNR Division of Ecological Resources, Brainerd.

Funding: Collection of the 2007 data was made possible by support from the Heritage Enhancement Fund and Game and Fish Fund.

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:
Perleberg, D. and S. Loso. 2009. Aquatic vegetation of Pine Mountain Lake (DOW 11-0411-00), Cass County, Minnesota, 2007. Minnesota Department of Natural Resources, Ecological Resources Division, 1601 Minnesota Dr., Brainerd, MN 56401. 21 pp.

Summary

Aquatic vegetation surveys of Pine Mountain Lake (11-0411-00), Cass County, Minnesota, were conducted in August 2007. A lakewide assessment included a survey of vegetation and water depths at over 800 sample stations and a characterization of shoal water substrates. Major emergent and floating-leaf plant beds were delineated.

Plants occurred around the entire perimeter of Pine Mountain Lake and about 50 percent of the lake contained vegetation. A total of 40 native aquatic plant species were recorded including 12 emergent, five floating-leaved, two free-floating and 20 submerged plants. No non-native aquatic plants were found in Pine Mountain Lake.

Emergent and floating-leaf plant beds ringed the lake and covered about 303 acres, or about 20 percent of the lake. Approximately 153 acres of bulrush (*Scirpus* spp.), 105 acres of wild rice (*Zizania palustris*) and 45 acres of white and yellow waterlilies (*Nymphaea odorata* and *Nuphar variegata*) were mapped.

Submerged plants were found to a depth of 20 feet but were most common from shore to the 10 feet depth where 95 percent of the sample sites contained vegetation. Plant occurrence was sparse beyond the 15 feet depth. The two most common submerged plant species were muskgrass (*Chara* sp.) (39% occurrence within the shore to 20 feet depth zone) and coontail (*Ceratophyllum demersum*) (20% occurrence). Other submerged plants included flat-stem pondweed (*Potamogeton zosteriformis*), several broad-leaf pondweeds (*Potamogeton* spp.), and bushy pondweed (*Najas flexilis*).

Introduction

Pine Mountain Lake (MnDNR ID #11-0411-00) is located west of the city of Backus, in Cass County, north-central Minnesota (Figure 1). The lake occurs in the northwest section of the Pine River Watershed and forms the headwaters for the main branch of the Pine River. The majority of the land use in the watershed is forested (Lindon 2005).

A small stream enters the north side of Pine Mountain Lake and a second stream enters in the southwest corner. The main branch of Pine River exits the southeast side of the lake and flows through a series of small lakes before reaching Whitefish Lake (Figure 2) and eventually meeting the Mississippi River.

Figure 1. Pine Mountain Lake, Cass County, MN

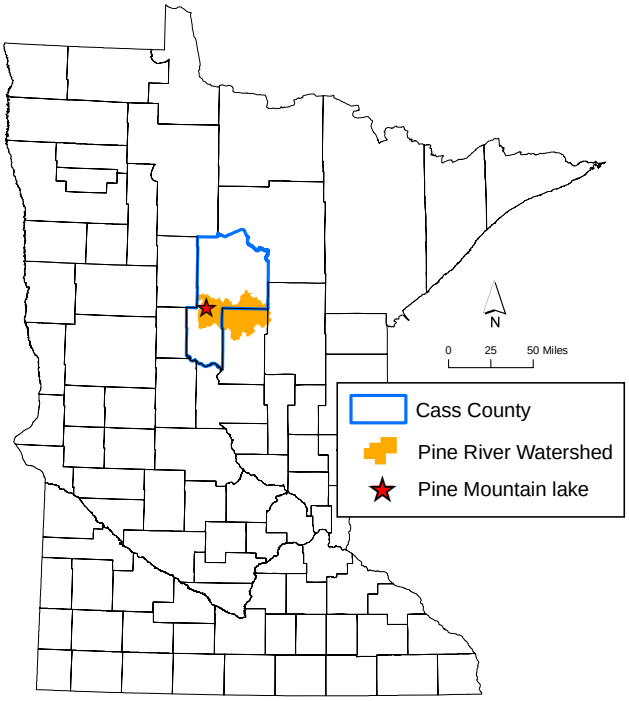
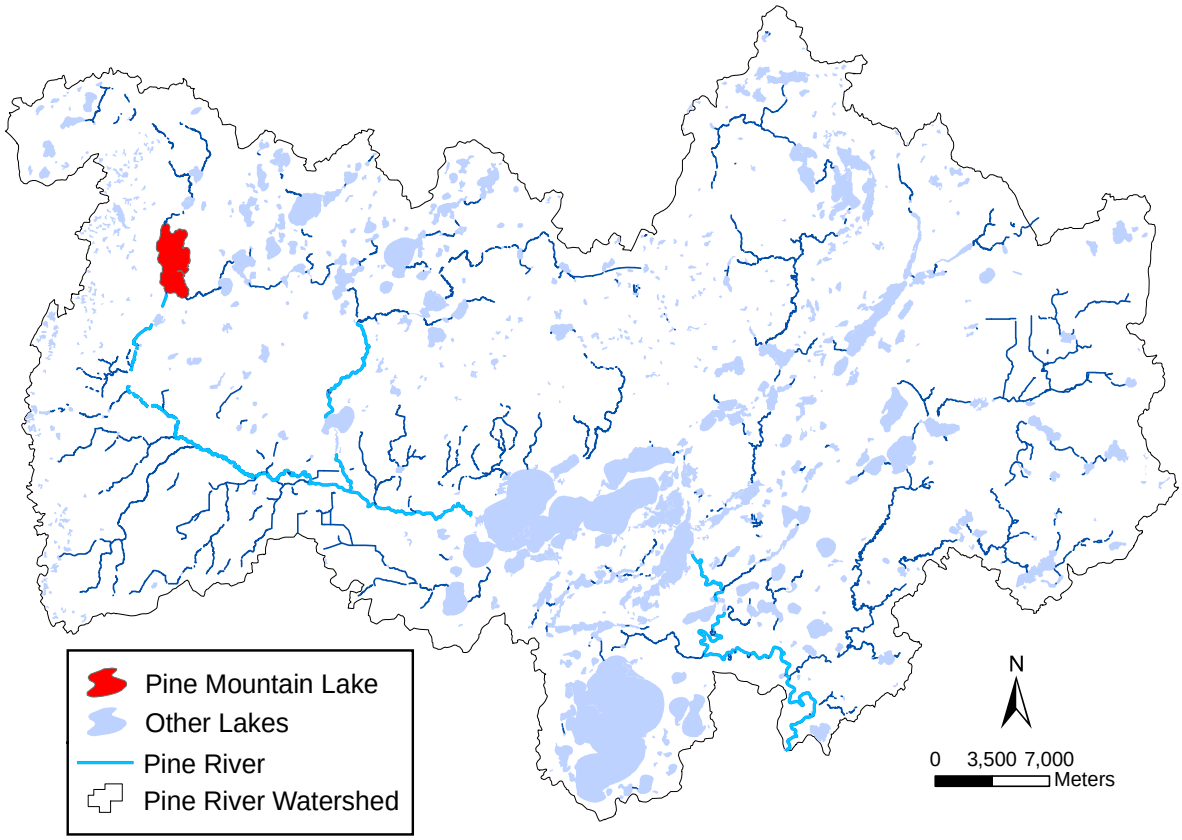
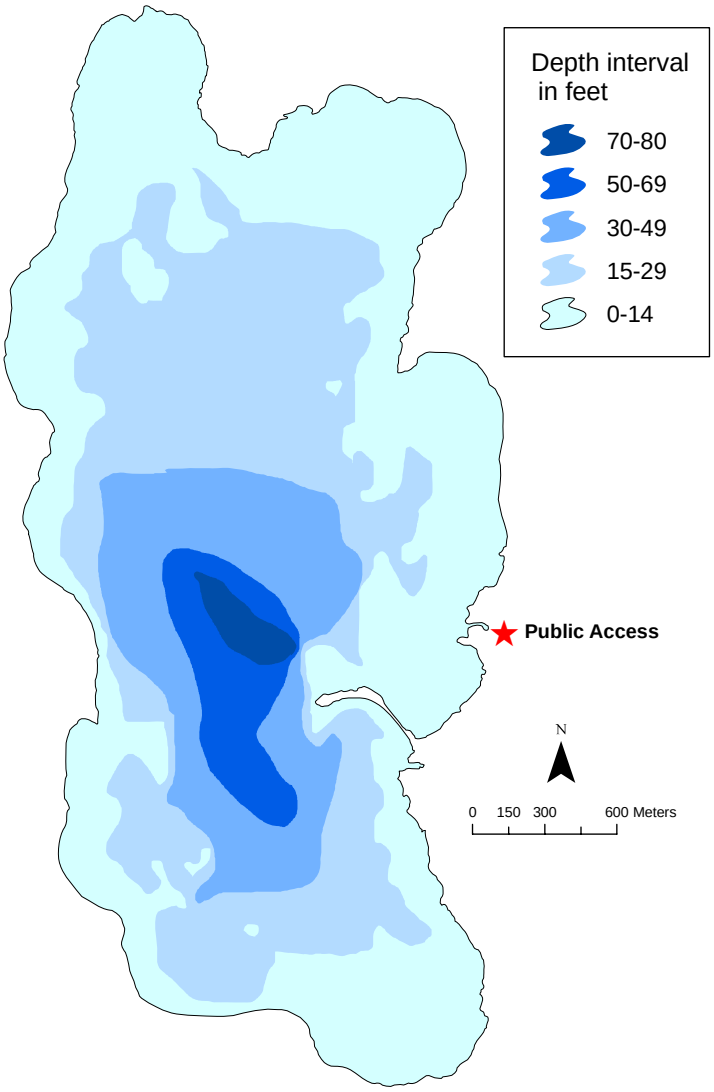


Figure 2. Pine Mountain Lake at the headwaters of Pine River Watershed.



There are about 250 Cass County lakes that are at least 50 acres in size and Pine Mountain Lake ranks tenth in size with a surface area of 1,567 acres and about nine miles of shoreline. Pine Mountain Lake is an ice-block lake (Lindon 2005) formed by the retreat of glaciers about 12,000 years ago. The lake has an irregular outline with several shallow bays. It has a maximum depth of 80 feet and nearly half of the lake is less than 15 feet in depth (Figure 3).

Figure 3. Depth contours of Pine Mountain Lake



The shoreline of Pine Mountain Lake is primarily forested and moderately developed with residential homes. The southwest section of the lake is within the Foothills State Forest. The city of Backus is on the east side of the lake and there is a public boat launch in a city park on the east shore (Figure 3).

A 2004 water quality study concluded that Pine Mountain Lake was typical of minimally impacted lakes in northeast Minnesota (Lindon 2005). It is characterized as a mesotrophic, or moderately nutrient enriched, lake with relatively high water clarity.

The Secchi disc (Figure 4) 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. 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 half times the Secchi depth. Between 1998 and 2007, midsummer water clarity of Pine Mountain Lake, as measured by Secchi disc readings, ranged from six feet to 11 feet, with a mean of nine feet (MPCA 2007). Based on Secchi disc measurements alone, aquatic plants are expected to grow to a maximum depth of about 13 feet in Pine Mountain Lake.

Figure 4. Measuring Secchi Disc transparency

Other factors that may influence the depth of plant growth include substrate types, wind fetch, and the plant community composition.

Previous vegetation surveys of Pine Mountain Lake found at least 23 different native aquatic plant species and vegetation growth was reported to be about 20 feet. (MnDNR Fisheries Lake Files).

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

1) Describe the shoal substrates 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
A lakewide vegetation survey of Pine Mountain Lake was conducted August 13-16, 2007. A point-intercept survey method was used and followed the methods described by Madsen (1999) and (MnDNR 2008a). Survey waypoints were created using a Geographic Information System (GIS) computer program and downloaded into a handheld Global Positioning System (GPS) receiver. Survey points were spaced 65 meters (213 feet) apart, resulting in about one survey point per acre. Two field crews, each consisting of one boat and two surveyors, conducted the survey. In the field, surveyors did not find vegetation beyond a depth of 20 feet and therefore sampled all survey points between shore and 20 feet and only a selected number of points in deeper water. A total of 834 points were surveyed and 829 points occurred within shore to 20 feet depth zone. (Figure 5, Table 1). If sites occurred within shallow beds of emergent or floating-leaf vegetation, surveyors either used an electric motor to navigate to the site or did not survey the site.

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 measuring stick in water depths less than eight feet and an electronic depth finder in depths greater than eight feet. The surveyors recorded all plant species found within a one meter square 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 surface (Figure 6). Any additional plant species found outside the sample sites were recorded as present in the lake. At each sample site where water depths were seven feet and less, surveyors described the bottom substrate using standard substrate classes (Table 2). If a mixture of substrates occurred at a site, surveyors recorded the most abundant type.

Figure 5. 2007 Pine Mountain Lake vegetation survey sites.

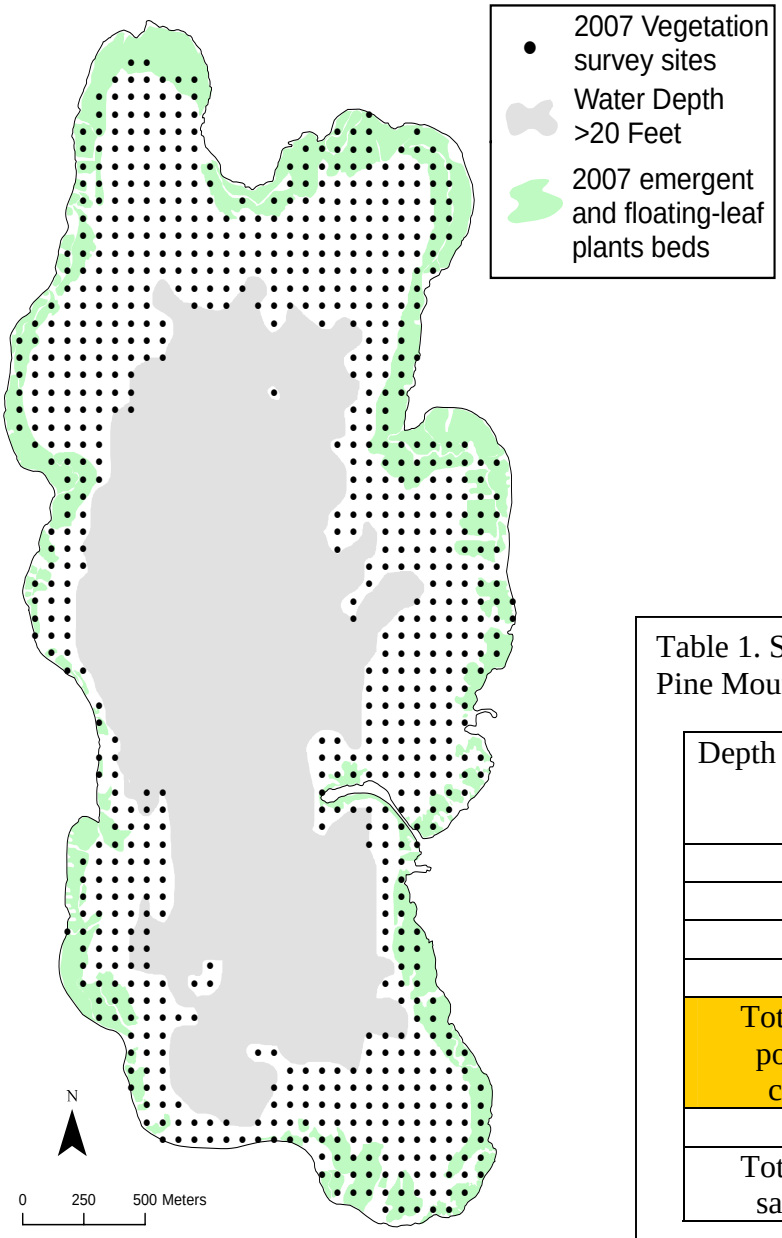


Figure 6. Vegetation survey rake

Table 1. Sampling effort by water depth, Pine Mountain Lake, 2007.

Depth interval in feet	Number of sample points
0 to 5	331
6 to 10	154
11 to 15	185
16 to 20	159
Total number of points used in calculations	829
21 to 25	5
Total number of sample points	834

Plant identification and nomenclature followed Crow and Hellquist (2000). Voucher specimens were collected for most plant species and are stored at the MnDNR in Brainerd. Data were entered into a Microsoft Access database and frequency of occurrence was calculated for each species as the number of sites in which a 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 four depth zones for analysis (Table 1).

Example:

In Pine Mountain Lake there were 829 samples sites in the zone from shore to the 20 feet depth.

Muskgrass (*Chara* sp.) occurred in 327 of those sites.

Frequency of muskgrass in the shore to 20 feet depth zone = 327/829 (*100) = 39 %

Table 2. Substrate classes

muck	decomposed organic material
marl	calcareous material
silt	fine material with little grittiness
sand	Diameter less than 1/8 inch
gravel	Diameter 1/8 to 3 inches
rubble	Diameter 3 to 10 inches
boulder	Diameter over 10 inches

Floating-leaf and emergent vegetation beds

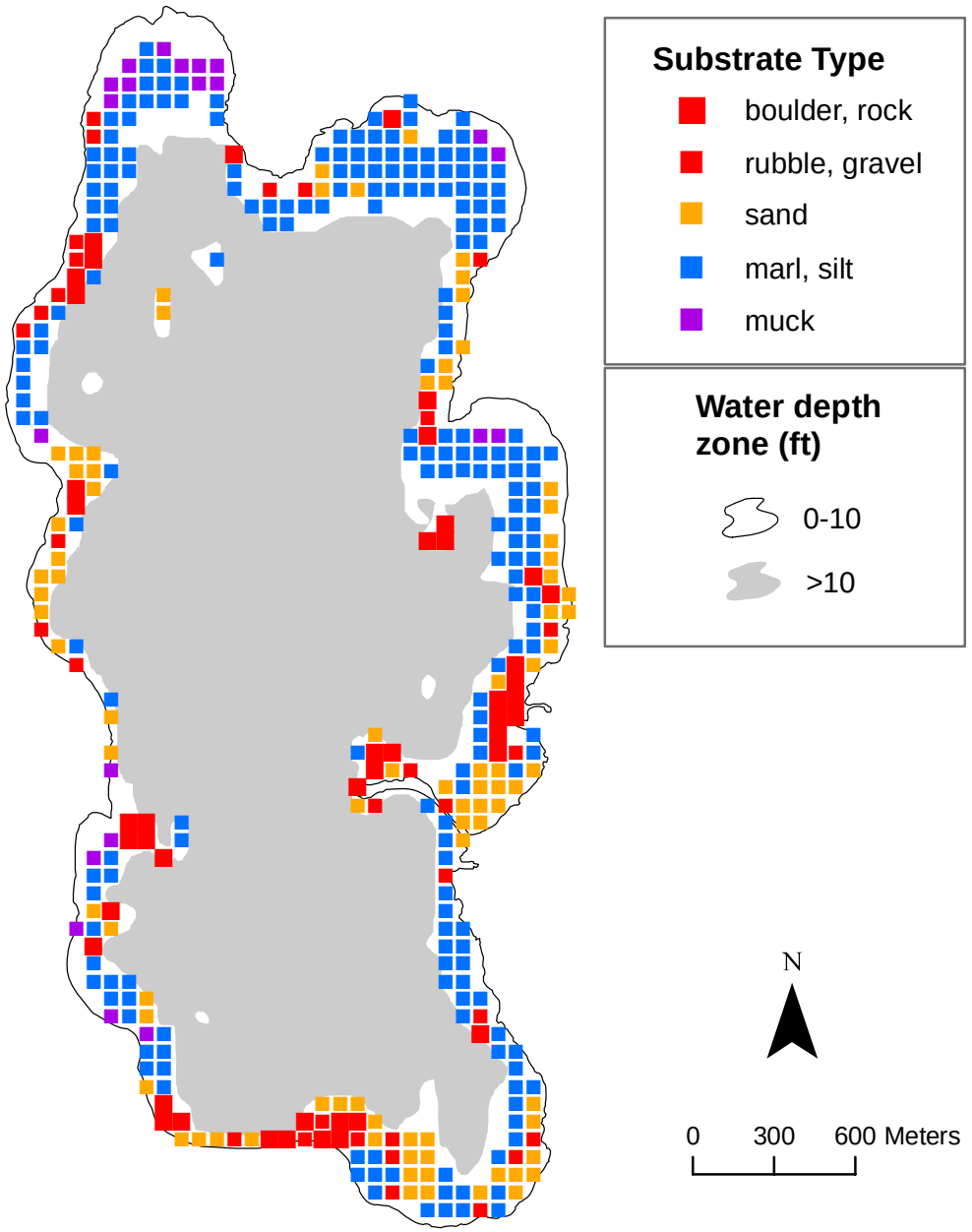
Farm Service Administration (FSA) true color aerial photographs, 2003-2004, were used to delineate beds of floating-leaf vegetation. Ground truthing was conducted in August 2007 to verify plant community composition within major beds. Bulrush (*Scirpus* spp.) beds are difficult to detect on aerial photographs and therefore, surveyors mapped bulrush beds in the field in August 2007. Surveyors motored around the lakeside perimeter of major bulrush beds and recorded locations with a handheld GPS receiver. To avoid damage to these plant beds, surveyors did not motor into these sites. Field data were uploaded to a computer and a GIS software program was used to estimate acreage.

Results

Shoal substrates

Hard substrates of sand, rubble, gravel, rock and boulder occurred along the south, east and west shores. The northern bays were primarily soft substrates of marl, silt and muck (Figure 7).

Figure 7. Shoal substrates of Pine Mountain Lake, 2007.

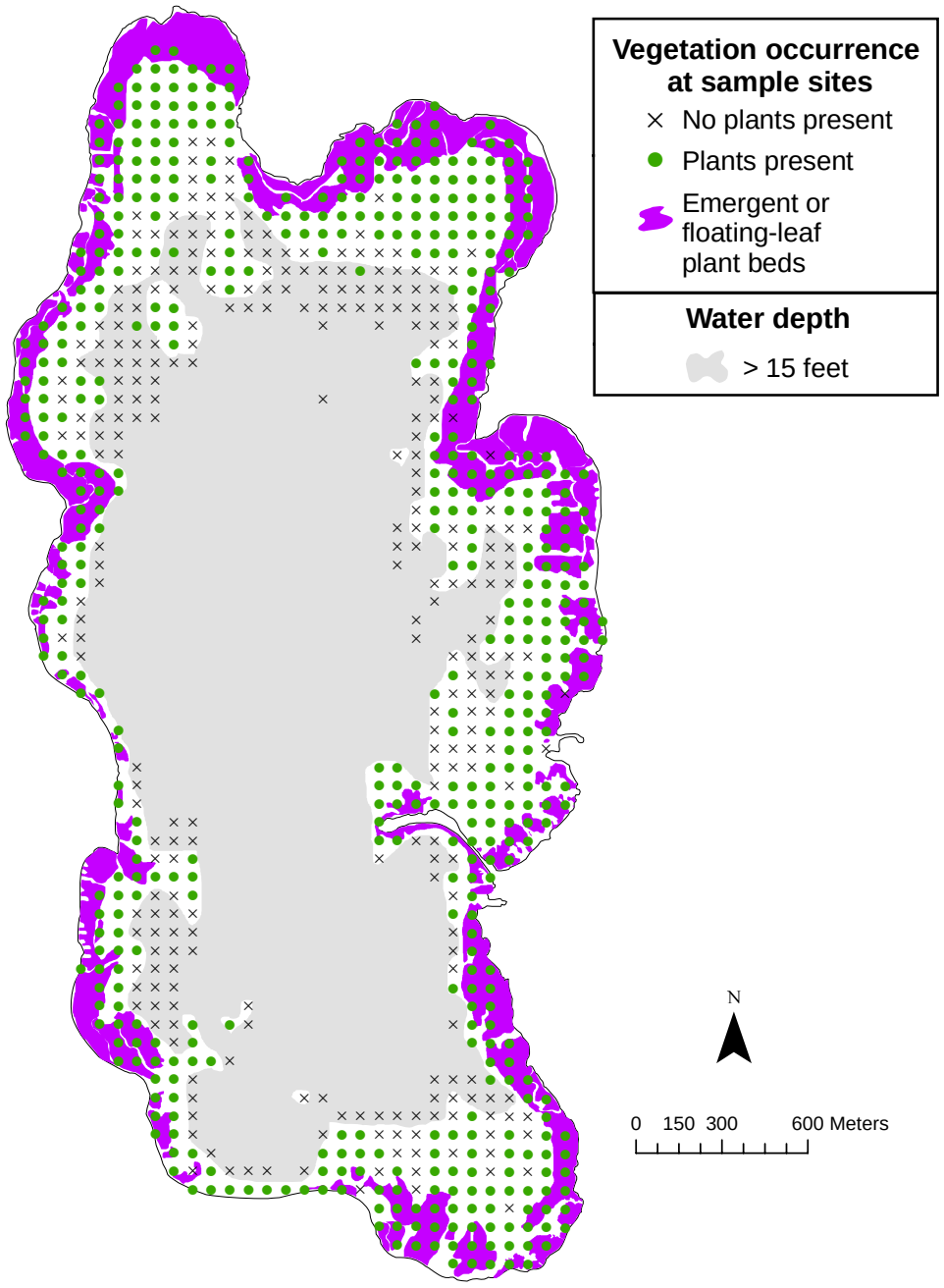


Distribution of plant types by water depth and lake area

Aquatic plants were found around the entire perimeter of Pine Mountain Lake. Within the depth zone from shore to 20 feet, 66 percent of the sample sites contained vegetation (Figure 8).

Emergent and floating-leaf plant beds ringed the lake and covered about 303 acres, or about 20 percent of the lake (Figure 8). Within the shore to five feet depth zone, 53 percent of the sample sites contained at least one emergent or floating-leaf plant.

Figure 8. Distribution of aquatic plants in Pine Mountain Lake, 2007.



Submerged plants were found to a maximum depth of 20 feet. Most plants occurred in the zone from shore to 15 feet (about 737 acres or 47 percent of the lake, Table 3). Vegetation was most common in the shore to 10 feet water depth zone where 95 percent of the survey sites contained plants (Figure 9). Vegetation occurrence decreased with increasing water depth and beyond the 15 feet depth, only four survey sites contained vegetation.

Figure 9. Plant occurrence at each water depth interval.

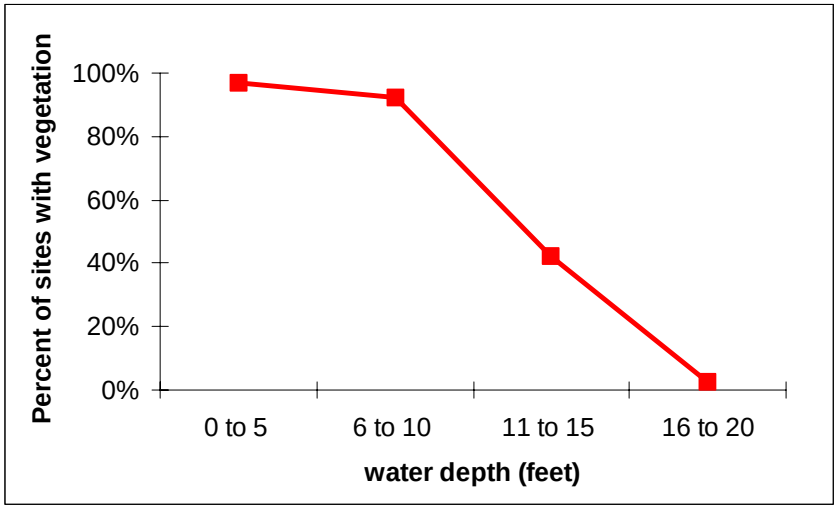


Table 3. Acres occupied by vegetation, Pine Mountain Lake, 2007.

Depth interval in feet	Acres	Percent of lake area	Frequency of vegetation
0 to 10	515	33%	95%
11 to 15	222	14%	42%
16 to 20	150	10%	3%
>20	680	43%	0

Number and types of plants recorded

A total of 40 native aquatic plant species were recorded in Pine Mountain Lake including 12 emergent, five floating-leaved, two free-floating and 20 submerged plants (Table 4).

Table 4. Frequency of aquatic plants in Pine Mountain Lake Point-intercept survey, August 2007.

(Frequency is the percent of sample sites in which a plant taxon occurred within the shore to 20 ft water depth.)

829 sample sites

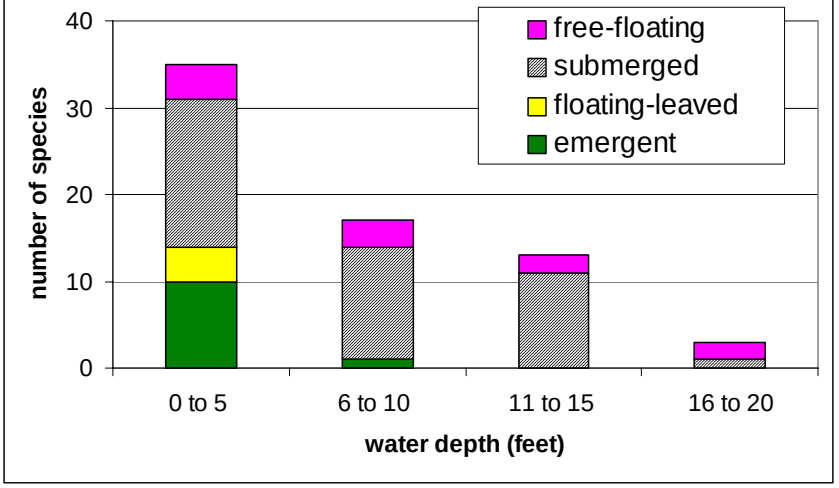
Life Forms		Common Name		Frequency
SUBMERGED These plants grow primarily under the water surface. Upper leaves may float near the surface and flowers may extend above the surface. Plants may or may not be anchored to the lake bottom.	Large Algae and mosses	Muskgrass	*Chara sp.*	39
		Watermoss	*Not identified to genus*	2
		Stonewort	*Nitella* sp.	<1
	Dissected leaved plants	Coontail	*Ceratophyllum demersum*	20
		Greater bladderwort	*Utricularia vulgaris*	7
		Northern water milfoil	*Myriophyllum sibiricum*	3
		White water buttercup	*Ranunculus aquatilis*	<1
	Grass-leaved plants	Flat-stem pondweed	*P. zosteriformis*	18
		Wild celery	*Vallisneria americana*	1
		Water stargrass	*Zosterella dubia*	<1
	Broad-leaved plants	Illinois pondweed	*P. illinoensis*	11
		Variable pondweed	*P. gramineus*	5
		White-stem pondweed	*Potamogeton praelongus*	2
		Clasping-leaf pondweed	*Potamogeton richardsonii*	1
		Large-leaf pondweed	*Potamogeton amplifolius*	<1
	Small-leaved plants	Bushy pondweed	*Najas flexilis*	10
		Canada waterweed	*Elodea canadensis*	8
		Narrow-leaf pondweed	*Potamogeton* sp.*	4
		Fries' pondweed	*Potamogeton friesii*	2
		Small pondweed	*Potamogeton pusillus*	present
		Sago pondweed	*Stuckenia pectinata*	2
FREE-FLOATING These plants drift freely with current.		Star duckweed	*Lemna trisulca*	4
		Greater duckweed	*Spirodela polyrhiza*	<1
FLOATING These plants are rooted in the lake bottom and have leaves that float on the water surface.		Yellow waterlily	*Nuphar variegata*	3
		White waterlily	*Nymphaea odorata*	2
		Floating leaf pondweed	*Potamogeton natans*	1
		Floating-leaf smartweed	*Polygonum amphibium*	present
		Floating-leaf burreed	*Sparganium emersum*	present
EMERGENT These plants extend well above the water surface and are usually found in shallow water, near shore.		Bulrush	*Scirpus acutus*	16
		Wild Rice	*Zizania palustris*	6
		Arrowhead	*Sagittaria latifolia*	1
		Three-square	*Scirpus pungens*	<1
		Spikerush	*Eleocharis* sp.	<1
		Needlegrass	*Eleocharis* sp.	<1
		Giant Cane	*Phragmites australis*	<1
		Horsetail	*Equisetum* sp.	<1
		Broad-leaf cattail	*Typha latifolia*	<1
		Narrow-leaf cattail	*Typha angustifolia*	<1
		Arum-leaved arrowhead	*Sagittaria cuneata*	present
		Giant burreed	*Sparganium eurycarpum*	present

"Present" indicates plant was observed in the lake but did not occur within any of the sample sites.

* *Potamogeton friesii* and *Potamogeton pusillus* were positively identified in this lake but there may have been other narrow-leaved pondweed (*Potamogeton*) species present as well. These other unidentified "narrow-leaf pondweeds" were recorded as "*Potamogeton* sp." and were not included in the total species tally.

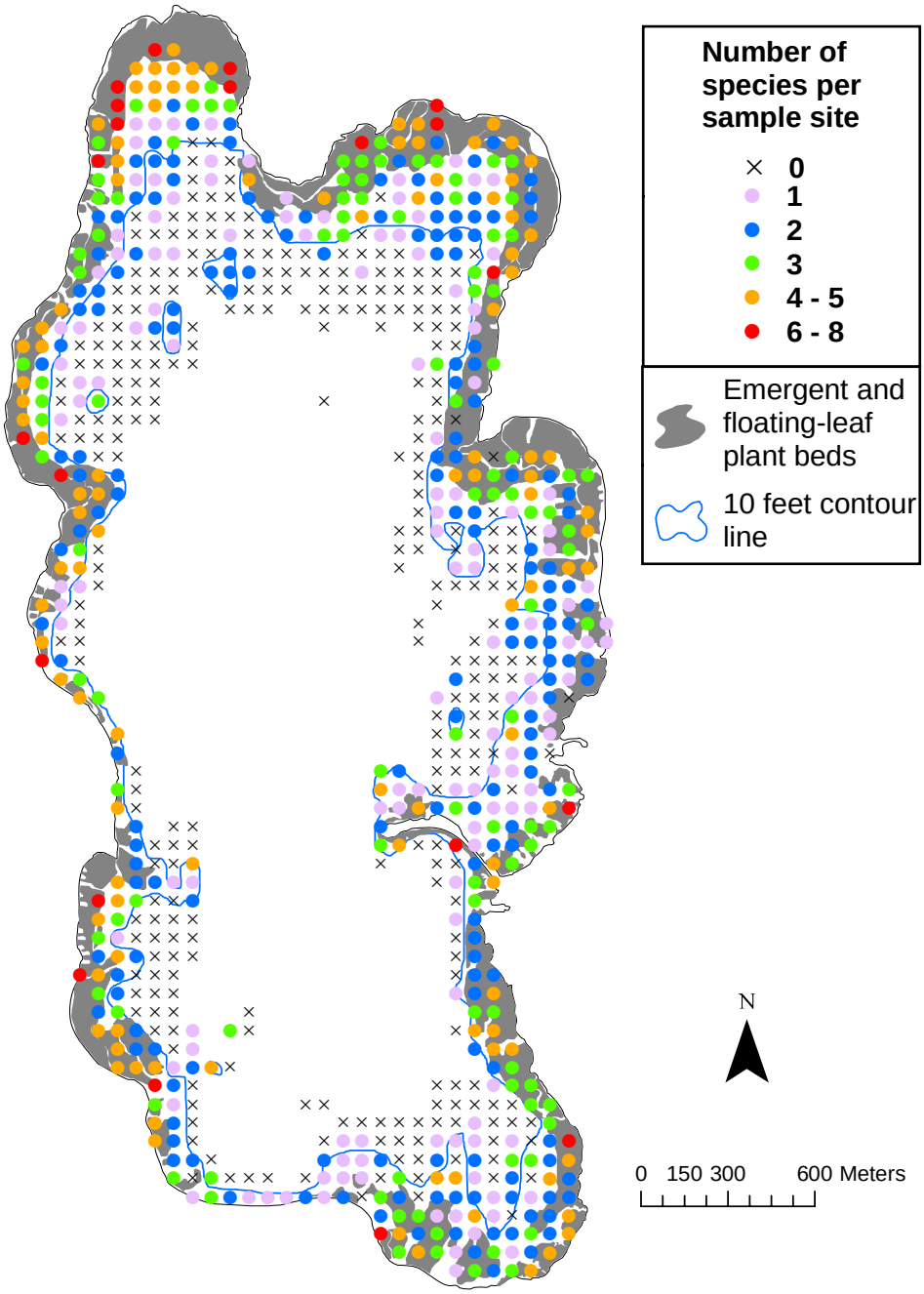
The highest number of plant species was found in shallow water, from shore to a depth of five feet (Figure 10). All four plant types: emergent, floating-leaved, submerged and free-floating, occurred in this depth zone. The total number of species present declined as water depth increased. Floating-leaved species were restricted to water depths less than six feet and emergents occurred to a maximum depth of six feet. Most submerged and free-floating plants were found from shore to 15 feet depth zone but only three species occurred beyond that depth.

Figure 10. Number of species found at each water depth interval



The number of plant species found at each square meter site ranged from zero to eight. Sites with the highest number of plant species occurred in water depths less than six feet and in mixed beds of emergent, floating and submerged vegetation (Figure 11). In water depths greater than ten feet, most sites were either un-vegetated or contained only one species.

Figure 11. Number of plant species per sample site, Pine Mountain Lake, 2007



Emergent and floating-leaf plants

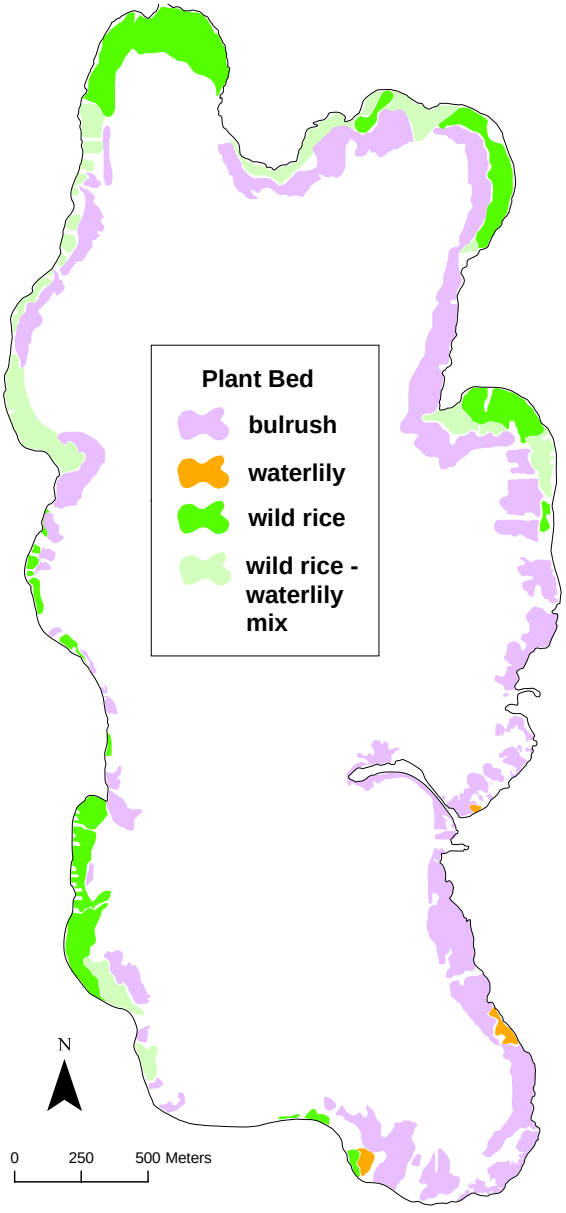
The most common plant bed types identified were bulrush, wild rice, waterlilies, and mixed stands of wild rice and waterlilies (Figure 12).

Hard-stem bulrush (*Scirpus acutus*) (Figure 13) occurred in 41 percent of the sites in the shore to five feet depth zone and was the most common emergent plant found. A total of 153 acres of bulrush beds were delineated and they occurred around the entire perimeter of the lake (Figure 12). Bulrush stands occurred adjacent to shore and on the lakeward edge of waterlily beds.

Bulrush plants are rooted in the lake bottom and the narrow stems may extend several feet above the water. Bulrush is a perennial plant that can spread by rhizomes in shallow water. Restoration of bulrush beds can be very difficult, making established beds particularly unique and valuable.

Figure 13. Emergent bulrush (*Scirpus*) beds in Pine Mountain Lake

Figure 12. Emergent and floating-leaf plant bed types. Pine Mountain Lake, 2007.



Wild rice (*Zizania palustris*) (Figure 14) occurred in 14 percent of the shallow water (shore to five feet) sites and about 105 acres were mapped including wild rice mixed with waterlilies and bulrush. It was most common along the northern shores and the southwestern bay (Figure 12) and was often associated with soft substrates.

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

About 45 acres of water lily beds were mapped, which includes areas of mixed waterlilies and wild rice (Figure 12). Because surveyors avoided motoring into floating-leaf plant beds, the frequency values obtained for these species were lower than the actual occurrence. Frequency values for floating-leaf species represent the occurrence of these species only within the sites that were surveyed. Common species included yellow waterlily (*Nuphar variegata*) (Figure 15) and white waterlily (*Nymphaea odorata*) (Figure 16). Waterlily beds were usually associated with muck substrate.

Figure 14. Wild rice (*Zizania palustris*).

Floating-leaf and emergent plant beds protect shorelines against erosion by buffering the wave action and by holding soil in place. They offer shelter and shade for insects and young fish as well as food, cover and nesting material for waterfowl, marsh birds and muskrats.

Figure 15. Yellow waterlily (*Nuphar variegata*)

Submerged plants

Submerged plants occurred in 65 percent of the Pine Mountain Lake sample sites between shore and the 20 feet depth. A mixture of plant types was found including one annual plant, strongly rooted perennials, and weakly rooted or free-floating plants.

The most commonly occurring submerged species were muskgrass (*Chara* sp.), coontail (*Ceratophyllum demersum*), flat-stem pondweed (*Potamogeton zosteriformis*), Illinois pondweed (*Potamogeton illinoensis*) and bushy pondweed (*Najas flexilis*). These species each occurred in at least ten percent of the samples sites (Table 4) and had lakewide distributions (Figure 17).

Figure 16. White waterlily (*Nymphaea odorata*)

Figure 17. Distribution of muskgrass (*Chara* sp.), coontail (*Ceratophyllum demersum*), flat-stem pondweed (*Potamogeton zosteriformis*), Illinois Pondweed (*Potamogeton illinoensis*), and bushy pondweed (*Najas flexilis*) in Pine Mountain Lake, 2007.

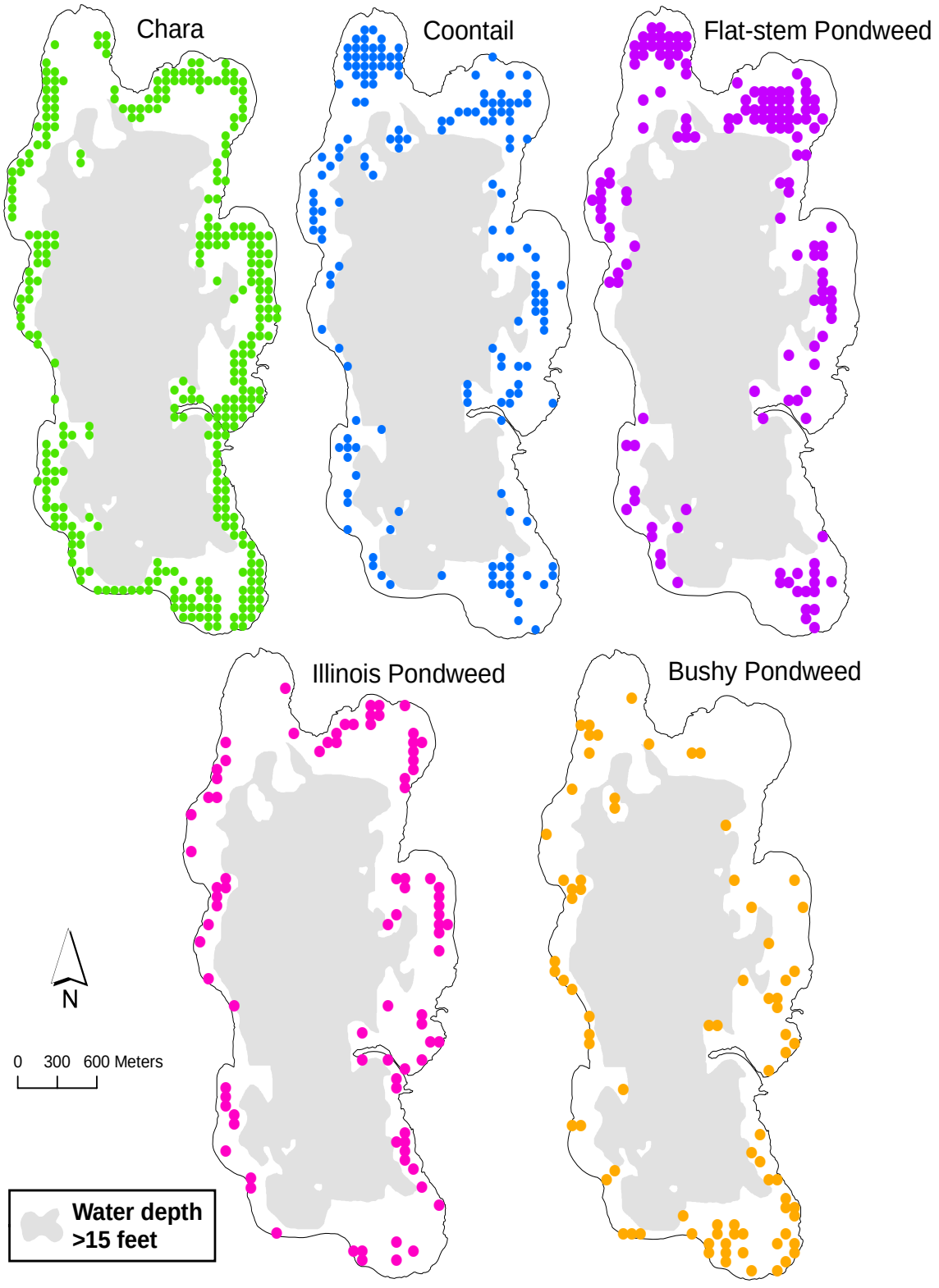
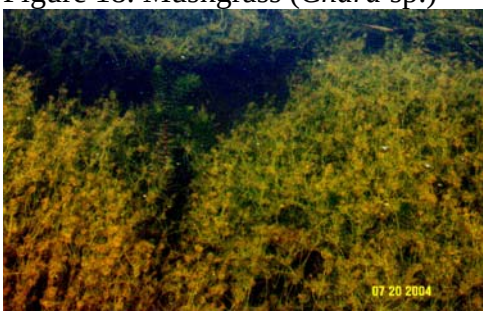


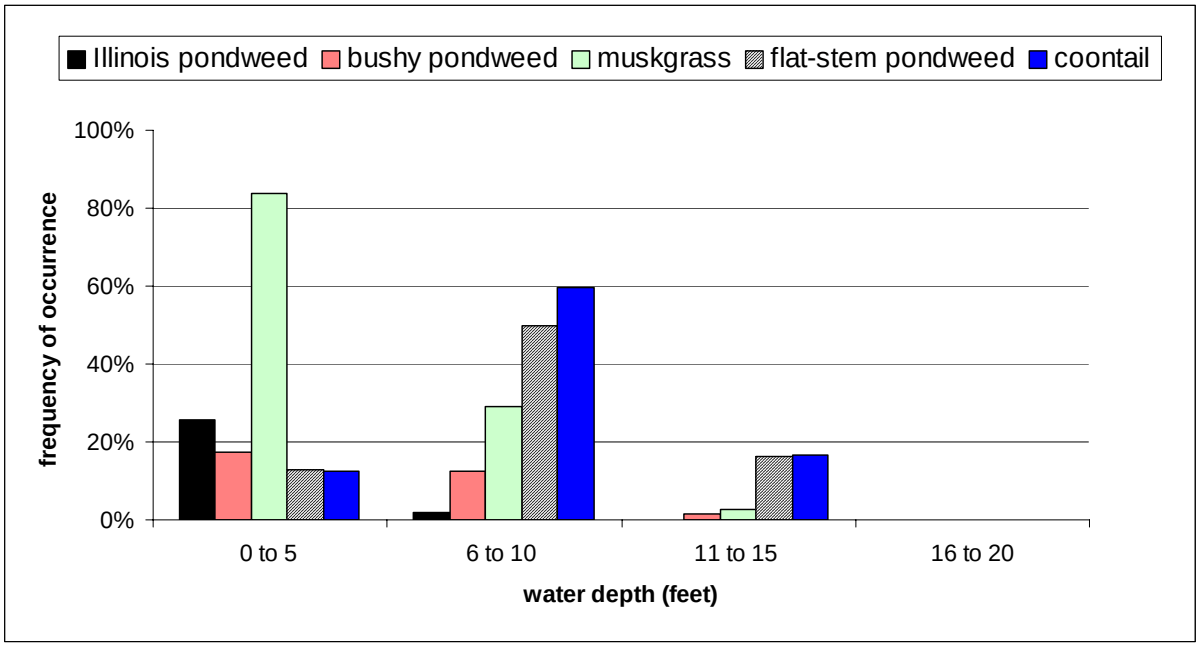
Figure 18. Muskgrass (*Chara* sp.)



Muskgrass (*Chara sp.*) (Figure 18) is a macroscopic, or large, algae and is common in many hard water Minnesota lakes. It has a brittle texture and a characteristic "musky" odor. Algae do not form true stems and therefore, muskgrass 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 plant to colonize open areas of lake bottom where it can act as a sediment stabilizer. Beds of muskgrass can provide important habitat for fish spawning and nesting.

In Pine Mountain Lake, muskgrass occurred in 39 percent of the sample sites (Table 4) and was mostly found in depths of ten feet and less (Figure 19). It was found around the lake except for the northwest bay (Figure 17).

Figure 19. Frequency of common submerged plants by water depth interval. Pine Mountain Lake, August 2007.



Coontail (*Ceratophyllum demersum*) (Figure 20) is a submerged plant that grows entirely submerged. It is adapted to a broad range of lake conditions, including turbid water. Coontail is perennial and can over winter as a green plant under the ice and then begins new growth early in the spring. It is loosely rooted to the lake bottom and spreads primarily by stem fragmentation. The finely divided leaves of this plant provide a home for insects valuable as fish food.

Coontail was found in 20 percent of the Pine Mountain Lake sites (Table 4) and was most common in depths of six to ten feet, where it was the most common species (Figure 19). It occurred around the lake but not close to shore (Figure 17). Coontail often co-occurred with flat-stem pondweed.

Figure 20. Coontail (*Ceratophyllum demersum*)

Flat-stem pondweed (*Potamogeton zosteriformis*) (Figure 21) is named for its flattened, grass-like leaves. This perennial plant is 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. It may reproduce by seed and vegetative winter buds. Flat-stem pondweed was found in 18 percent of the sites (Table 3). Like coontail, it occurred around the entire lake and was most common in depths of six to ten feet (Figure 17, 19).

Figure 21. Flat-stem Pondweed (*Potamogeton zosteriformis*)

Illinois pondweed (*Potamogeton illinoensis)* (Figure 22) is a rooted, perennial plant with wide leaves. These plants are primarily submerged but many will form floating leaves in shallower water. This plant is sometimes called "cabbage" by anglers because of its wide leaves. The foliage of this plant provides cover for fish and its fruits are valuable waterfowl food.

Illinois pondweed was found in 11 percent of all sample sites (Table 4). It was most frequent in depths of five feet and less (Figure 23) and occurred along the west and east shores (Figure 24).

Figure 22. Illinois pondweed (*Potamogeton illinoensis*)
photo: ©1996 Allison Fox, Univ of Florida Center for Aquatic Plants

Bushy pondweed (*Najas flexilis*) (Figure 23) is unique because it is one of the few annual submerged species in Minnesota and must re-establish every year from seed. The seeds and foliage of this plant are an important duck food and beds of this plant provide good fish cover. Bushy pondweed is a low growing plant.

In Pine Mountain Lake, bushy pondweed was found in 10 percent of the sample sites (Table 4) and was most common in depths from shore to ten feet (Figure 19). It was scattered around the lake and was not common in the northern bays (Figure 17).

Figure 23. Bushy pondweed (*Najas flexilis*)

Discussion

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. The water clarity of Pine Mountain Lake is sufficiently high to allow aquatic plant growth to at least the 20 feet depth but the sandy shores of the main waterbody do not support lush aquatic plant growth. The sheltered bays do support abundant and diverse native aquatic plant communities that in turn, provide critical fish and wildlife habitat and other lake benefits. (Click here for more information on: value of aquatic plants).

The high number of plant species found in Pine Mountain Lake is a reflection of the excellent water clarity. Many of the plants found require clear water and are not found in lakes with higher turbidity. Another reason for the high diversity of plant types is that Pine Mountain Lake has a variety of substrate types and a mix of protected bays and open water sites. Plant species with different habitat requirements can exist within this system.

A review of past vegetation surveys indicates that, over the past 50 years, the general aquatic plant community has not likely changed greatly in Pine Mountain Lake. In all survey years, a relatively high number of native plants have been recorded and rooted plants remain well distributed throughout the bays. Data collected in 2007 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. 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.

In general, factors that may lead to change in the aquatic plant communities include:

- Change in water clarity
  If water clarity in Pine Mountain Lake decreases, submerged vegetation may be restricted to shallower water.
- Change in water level
  Many aquatic plants are adaptable to water level fluctuations and in low water years, aquatic plants may expand in distribution. The extent and duration of these distribution changes can be difficult to predict.
- Snow and ice cover
  Many submerged plants 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.
- Invasive species
  Non-native submerged species have not been documented in Pine Mountain Lake but if they invade the lake, they may directly or indirectly impact the native plant community. Non-native plant species, such as Eurasian watermilfoil (*Myriophyllum spicatum*) or curly-leaf pondweed (*Potamogeton crispus*) may form dense surface mats that may shade out native plants. The impact of these invasive species varies among lakes but the presence of a healthy native plant community may help mitigate the harmful effects of these exotics.

- Natural fluctuation in plant species abundance
  Many submerged plants are perennial and regrow in similar locations each year. However, a few species such as bushy pondweed (*Najas flexilis*) and wild rice (*Zizania palustris*) are annuals and are dependant on the previous years seed set for regeneration.
- Aquatic plant management activities
  Humans can impact aquatic plant communities directly by destroying vegetation with herbicide or by mechanical means. For information on the laws pertaining to aquatic plant management, click here: MnDNR APM Program or contact your local DNR office. Motorboat activity in vegetated areas can be particularly harmful for species such as bulrush and 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. Herbicide and mechanical control of aquatic plants can directly impact the aquatic plant community. Limiting these types of activities can help protect native aquatic plant species.

Literature Cited

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

Lindon, M., S. Heiskary, and Pine Mountain Lake Association. 2005. Pine Mountain Lake MnDNR ID #11-0411, Cass County. Minnesota Pollution Control Agency, Environmental Analysis and Outcomes Division. St. Paul, MN. http://www.pca.state.mn.us/publications/reports/wq-lar3-04.pdf

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. www.wes.army.mil/el/aqua

MnDNR. 2008a. Minnesota's Sensitive Lakeshore Identification Manual: a conservation strategy for Minnesota lakeshores (version 1). Division of Ecological Resources, Minnesota Department of Natural Resources.

MnDNR. 2008b. Natural wild rice in Minnesota. A wild rice study document submitted to the Minnesota Legislature by the Minnesota Department of Natural Resources, February 15, 2008. 117 pp. http://files.dnr.state.mn.us/fish_wildlife/legislativereports/20080215_wildricestudy.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.

MPCA. 2007. Clean Lake Monitoring Program. Minnesota Pollution Control Agency. St. Paul, MN. Available online at: http://www.pca.state.mn.us/water/clmp.html

