Aquatic Vegetation of Bass Lake

July, August and September, 2012

Bass Lake, ID# 31-0576-00

Itasca County, Minnesota

Bulrush, wild rice and waterlilies in channel between the North and South basins of Bass Lake, 2012.

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A note to readers:
Text that appears in **green underline** is a hypertext link to the glossary provided at the end of this report.

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

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Survey Context

This lake vegetation survey of Bass Lake was part of the larger Sensitive Lakeshore Identification project conducted by MNDNR. During 2012, MNDNR biologists conducted field surveys of aquatic vegetation, and near-shore fish and frogs in Bass Lake. 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

Aquatic vegetation surveys of Bass Lake (31-0576-00), Itasca County, Minnesota, were conducted in July, August and September of 2012. Surveys included characterization of near-shore substrate types, mapping of emergent and floating-leaf plant beds and lakewide assessments of vegetation and water depths at over 1,300 sample stations.

Forty-four native aquatic plant species were found including 10 emergent, six floating-leaved, three free-floating and 25 submerged species. This makes Bass Lake one of the richest lakes in the Upper Mississippi Headwaters watershed in terms of plant diversity; only 11 other lakes in the watershed have had 40 or more species recorded in recent surveys. Non-native plant species were not found growing in the lake.

Emergent and floating-leaved plants were restricted to shallow water and within the 0-10 feet depth zone, 37 percent of the lake, 1,005 acres were occupied by emergent or floating-leaved plant beds. About 419 acres of wild rice (*Zizania palustris*) or mixed beds of wild rice and other plants were mapped. Approximately 383 acres of bulrush (*Schoenoplectus* sp.) beds were delineated. Floating-leaf plants covered about 196 acres and included white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegata*) and floating-leaf pondweed (*Potamogeton natans*).

Submerged plants occurred to a maximum depth of 20 feet but were most common in depths from shore to 15 feet, where 84 percent of the sites contained at least one submerged species. The most common submerged plant species were muskgrass (*Chara* sp.) (37% occurrence within the shore to 20 feet zone), coontail (*Ceratophyllum demersum*) (16%), flat-stem pondweed (*Potamogeton zosteriformis*) (16%), Canada waterweed (*Elodea canadensis*) (14%) and northern watermilfoil (*Myriophyllum sibiricum*) (14%).

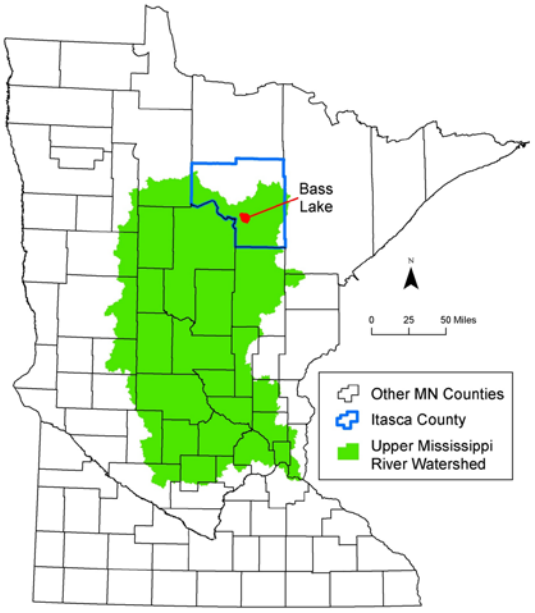
Unique aquatic plants that were found in Bass Lake were hornwort (*Ceratophyllum echinatum*), flat-leaved bladderwort (*Utricularia intermedia*) and lesser bladderwort (*Utricularia minor*). These species are not widespread in Minnesota and are usually associated with undisturbed areas in clear water lakes of northern Minnesota.

The diversity of native plants, including the extensive beds of emergent and floating-leaf plants and mixture of many types of submerged plants, provides critical habitat for fish and wildlife in this lake.

Introduction

Bass Lake is located near the city of Cohasset in Itasca County, Minnesota. It lies just outside the boundaries of the Chippewa National Forest and occurs within the Upper Mississippi River Headwaters watershed (Figure 1). Bass Lake is named after the Ojibwa word "ushigunikan" which means "the place of bass" (Heiskary et. al 2004).

Figure 1. Location of Bass Lake.

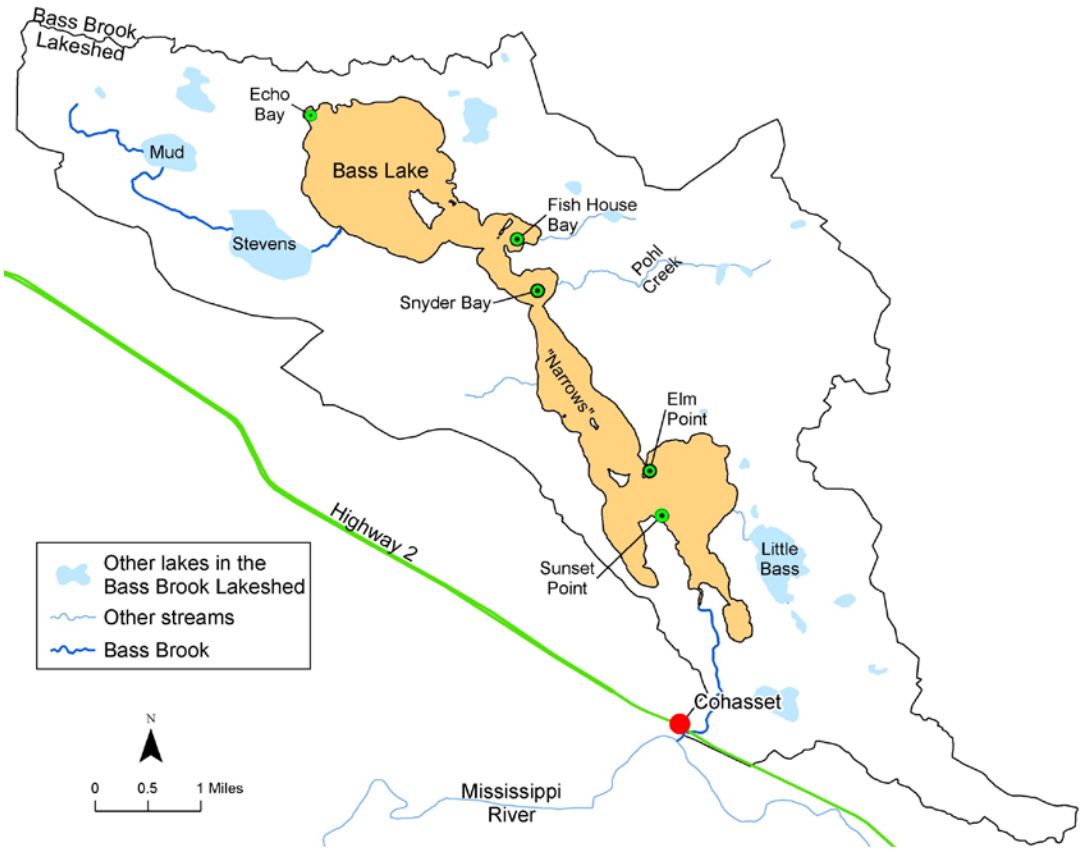


Lake Characteristics

With a surface area of 2,714 acres, Bass Lake is the 10th largest lake in Itasca County. The lake is seven miles long and has a total shoreline length of 24 miles. A north and a south basin are connected by a broad, 0.5 mile wide and 1.8 mile long channel.

Bass Lake is a flow-through lake. Bass Brook

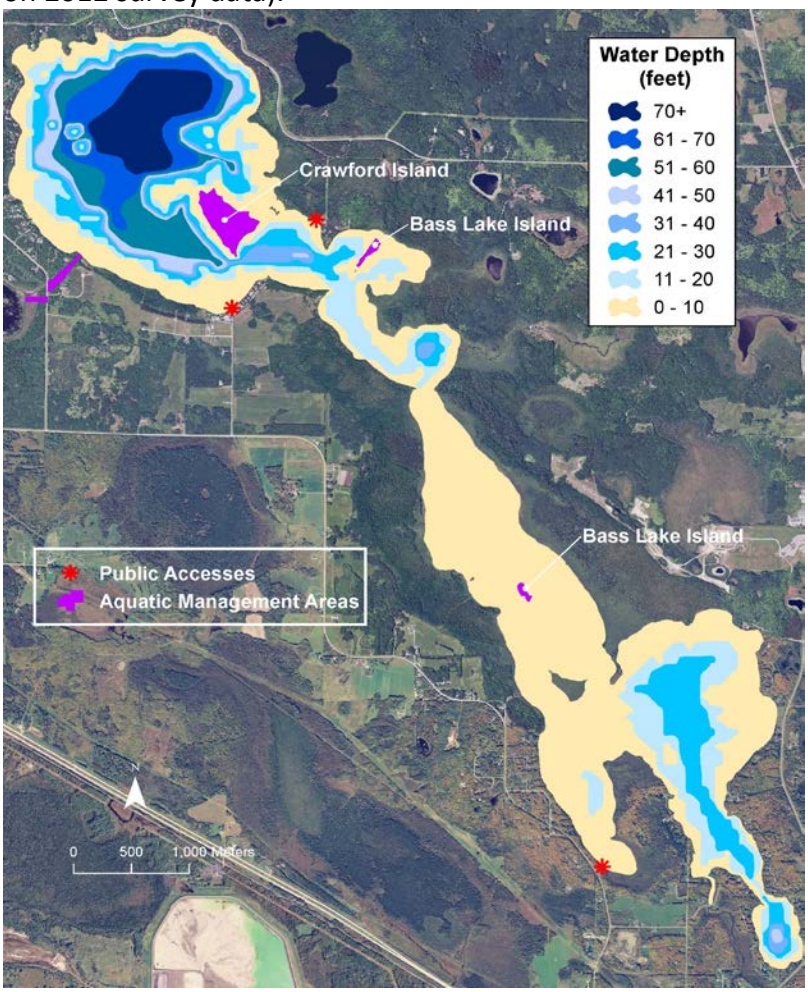
Figure 2. Bass Lake within Bass Brook Lakeshed.



flows into the north basin from Stevens Lake, outflows from the southern basin and continues south to the city of Cohasset where it empties into the Mississippi River (Figure 2). Other inlets to Bass Lake include an unnamed tributary that enters Fish House Bay, Pohl Creek which flows west into Snyder Bay, and a stream from Little Bass Lake.

The land surrounding Bass Lake is primarily forested and includes a mix of state, county, and private land. Residential homes and several resorts occur on the north and south basins while the channel's shoreline remains relatively undeveloped. Three undeveloped islands are protected as state-owned Aquatic Management Areas (AMA's): Crawford Island AMA in the north basin is 35 acres and the Bass Lake Islands AMA's in the central channel cover six acres. The lake has three public accesses, two on the north basin and one on the south basin (Figure 3).

Figure 3. Depth contours of Bass Lake (10, 20 foot are based on 2012 survey data).



Bass Lake has a maximum depth of 76 feet but about half of the lake is 15 feet or less in depth. The deepest area occurs in the north basin and depths in the central channel do not exceed 10 feet (Figure 3). The lake is a **hard water** lake[1] and is characterized as **Mesotrophic**, based on phosphorus (nutrients), chlorophyll a (algae concentration) and Secchi[2] depth (transparency). In 2011 mean summer[3] water clarity was 13 feet (MPCA

[1] alkalinity was measured as 180 ppm (N Basin), 140 ppm (Channel), and 120 ppm (S Basin) in field during 2012 survey

[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 as well as by the water's color and can fluctuate seasonally and annually.

[3] June through September

2012). Based on Secchi disc measurements alone, aquatic plants have the potential to reach depths of about 20 feet in the lake[4]. Other factors that may influence the depth of plant growth include substrate, wind fetch and the types of plants present.

Historic aquatic plant community

Previous lakewide, aquatic plant surveys of Bass Lake were conducted in 1946, 1998 and 2000 (MNDNR Lake files). These surveys focused on the commonly occurring in-lake plants and recorded a total of 38 aquatic plant **taxa**: nine emergent, four floating-leaf, three free-floating, and 22 submerged taxa (Appendix 2). The 1946 survey reported submerged plants to a depth of 10 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 Minnesota lakes: a variety of pondweeds (*Potamogeton* spp., *Stuckenia pectinata*), northern watermilfoil (*Myriophyllum sibiricum*), coontail (*Ceratophyllum demersum*), Canada waterweed (*Elodea canadensis*) and wild rice (*Zizania palustris*). Non-native aquatic plants have not been documented in Bass Lake.

Objectives

The purpose of this vegetation survey was to provide a quantitative description of the 2012 plant population of Bass 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 taxa that occur in the lake.
3. Estimate the abundance of plants by estimating the frequency of occurrence of each taxon within the vegetated zone.
4. Develop distribution maps for the commonly occurring taxa.

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). Field surveys were conducted August 28, September 4, 13, 2012 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.

[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.

Lakewide vegetation survey

A lakewide vegetation survey was conducted on July 30, 31 and August 1, 6, 7, 8, 2012 using a point-intercept survey method (Madsen 1999, MNDNR 2012). 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 21 feet. Surveyors conducted preliminary sampling within the 21-25 feet depth zone and detected no vegetation; a decision was made to focus sampling within the shore to 20 feet depth zone. A total of 1,389 sites were surveyed in Bass Lake and 1,349 sites occurred within the 0-20 feet depth zone (Table 1; Figure 4).

Figure 4. 2012 Vegetation survey sites on Bass Lake.

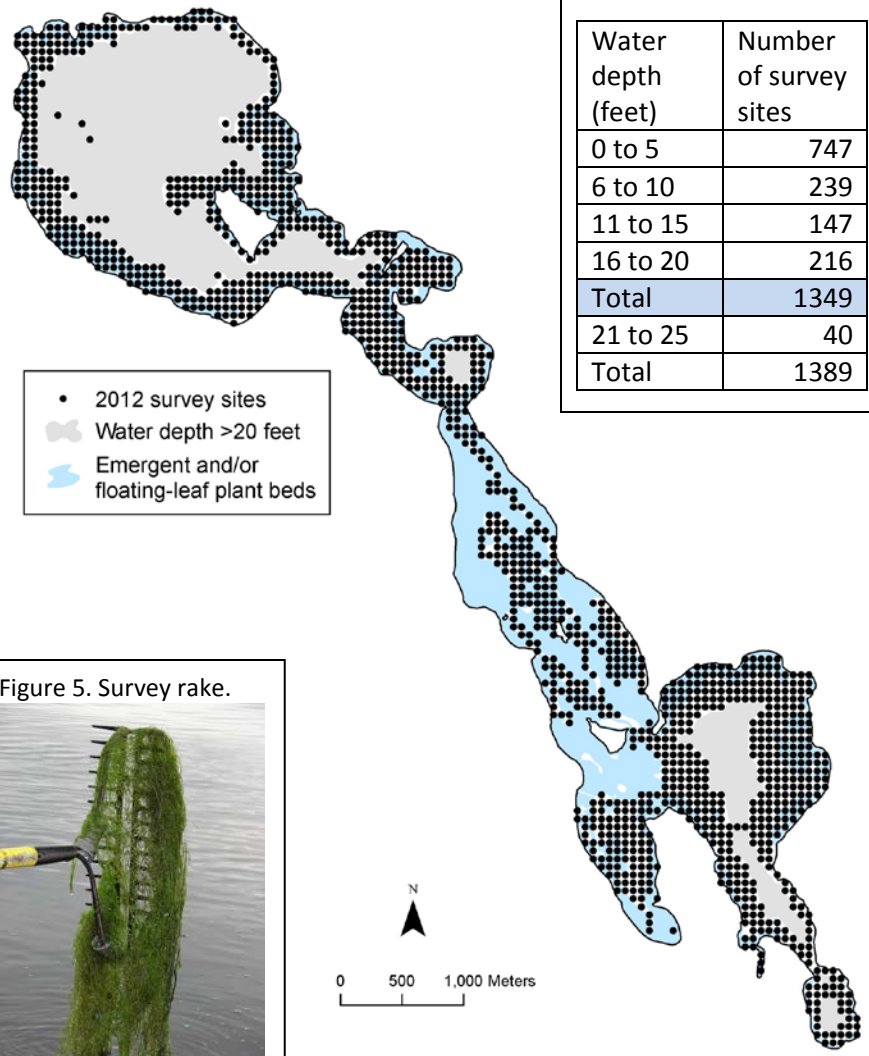


Table 1. Survey effort by depth interval.

Water depth (feet)	Number of survey sites
0 to 5	747
6 to 10	239
11 to 15	147
16 to 20	216
Total	1349
21 to 25	40
Total	1389

Figure 5. Survey rake.

The surveys were 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. To minimize damage to vegetation surveyors did not navigate into shallow water sites with dense emergent or floating-leaf vegetation (such as shallow portions of the central channel). These sites were not surveyed and vegetation type was interpreted from aerial photographs.

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). Surveyors evaluated substrate by tapping a pole into the lake bottom; soft substrate could usually be brought to the surface on the pole or sampling rake for evaluation. If this method was not feasible, substrate was evaluated by visual observation of the lake bottom. If more than one substrate type was found, surveyors recorded the most common type. Surveyors attempted to record a substrate description around the entire perimeter of the lake. If a sample site occurred near shore but in water depths greater than seven 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 taxa 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 5). Any additional plant taxa found outside of sample sites were recorded as "present" in the lake but these data were not used in frequency of occurrence calculations. Plant identification followed Crow and Hellquist (2000) and Flora of North America (1993+) and nomenclature followed MNTaxa (2012).

Frequency of occurrence was calculated for the entire vegetated zone (0-20 feet) and data were also separated into five feet increment depth zones for analysis (Table 1). Frequency estimates were also calculated for individual taxa and selected groups of plants.

This method is designed to estimate the frequency of occurrence of commonly occurring taxa. To detect infrequently occurring taxa, thousands of samples would be required. Surveyors did conduct some special searches for infrequent taxa; any additional plant taxa found outside of sample sites were recorded as "present" in the lake but these data were not used in frequency of occurrence calculations.

Results and Discussion

Near-Shore Substrates

The near-shore substrates of Bass Lake included a mix of hard substrates (boulder, rubble, sand and gravel) and soft substrates (silt and muck) (Figure 6). The north and south basins were primarily hard substrates of sand, gravel and rubble (Figure 7). Surveyed areas within the channel were primarily softer substrates of silt and muck.

Types of plants recorded

"Richness" is a term used to describe the total number of plant taxa present in a lake and can help describe the general health of the waterbody. In Minnesota, plant taxa richness can range from zero (un-vegetated lakes) to more than 40 taxa in a lake (Radomski and Perleberg 2012). Plant taxa richness is generally higher in high clarity lakes than in turbid lakes and more plant taxa 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 taxa. Water quality changes that result in lower clarity may also result in the loss of some plant taxa, or a lower taxa 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 a historical "one-day" survey, it may be due to the more extensive sampling that occurs during current surveys. If fewer taxa are located during current surveys, it may indicate a true decline in the plant taxa richness of the lake.

A total of 44 aquatic plant taxa (types) were recorded in Bass Lake. This makes Bass Lake one of the richest lakes in the Upper Mississippi Headwaters watershed in terms of plant diversity; only 11 other lakes in the watershed have had 40 or more species recorded in recent surveys. The plants included 10 emergent, six floating-leaved, three free-floating and 25 submerged plants (Appendix 1). Eleven of these taxa were recorded for the first time during the 2012 survey (Appendix 1). No non-native submerged aquatic plants were detected in Bass Lake.

Distribution and richness of aquatic plants

Plants were found to a depth of 20 feet in Bass Lake and in the 0-20 feet depth zone, 77 percent of the survey sites contained vegetation. Vegetation was most common in the 0-10 feet depth zone, where 87 percent of sites contained plants (Figure 8). Plant abundance declined with increasing water depth and in depths of 16-20 feet, six percent of the sites were vegetated.

Figure 6. Near-shore substrates of Bass Lake, 2012.

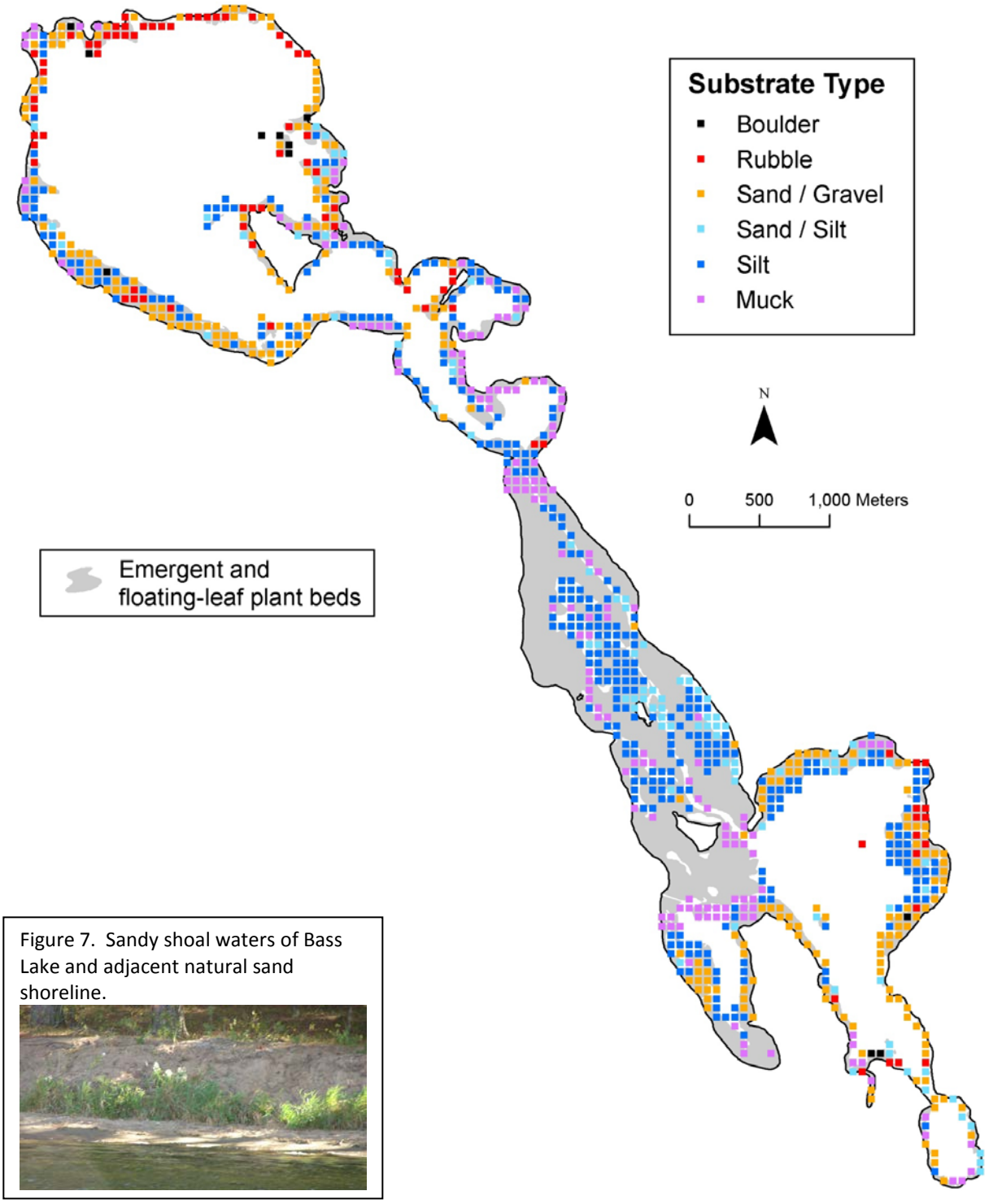
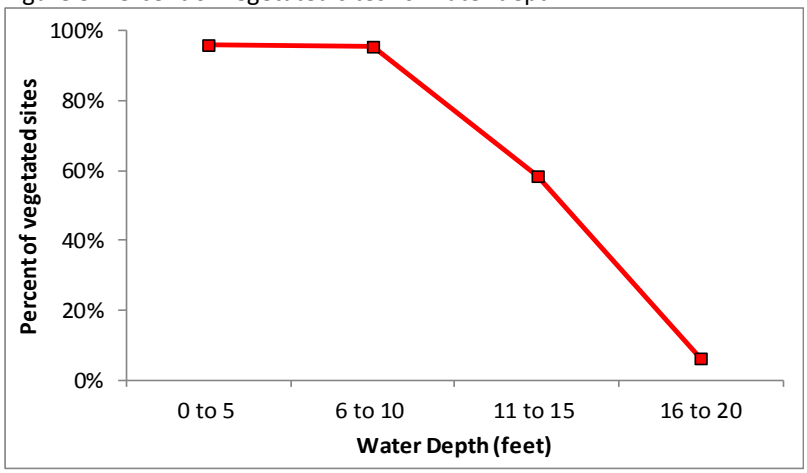


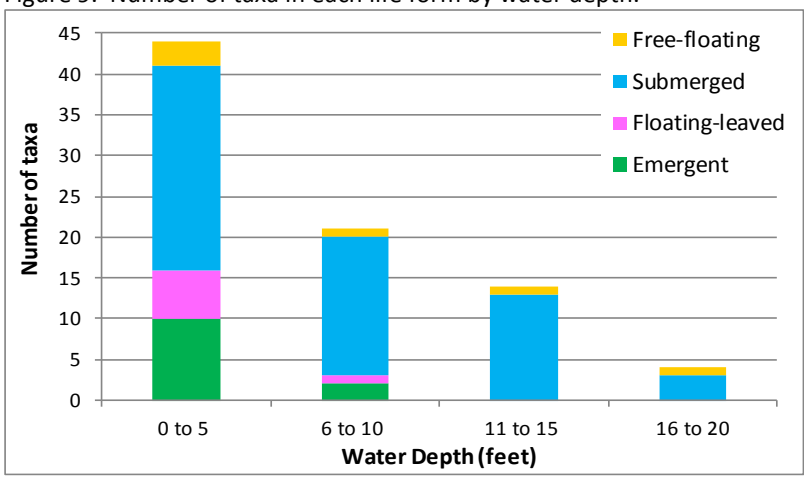
Figure 7. Sandy shoal waters of Bass Lake and adjacent natural sand shoreline.

Figure 8. Percent of vegetated sites vs. water depth.



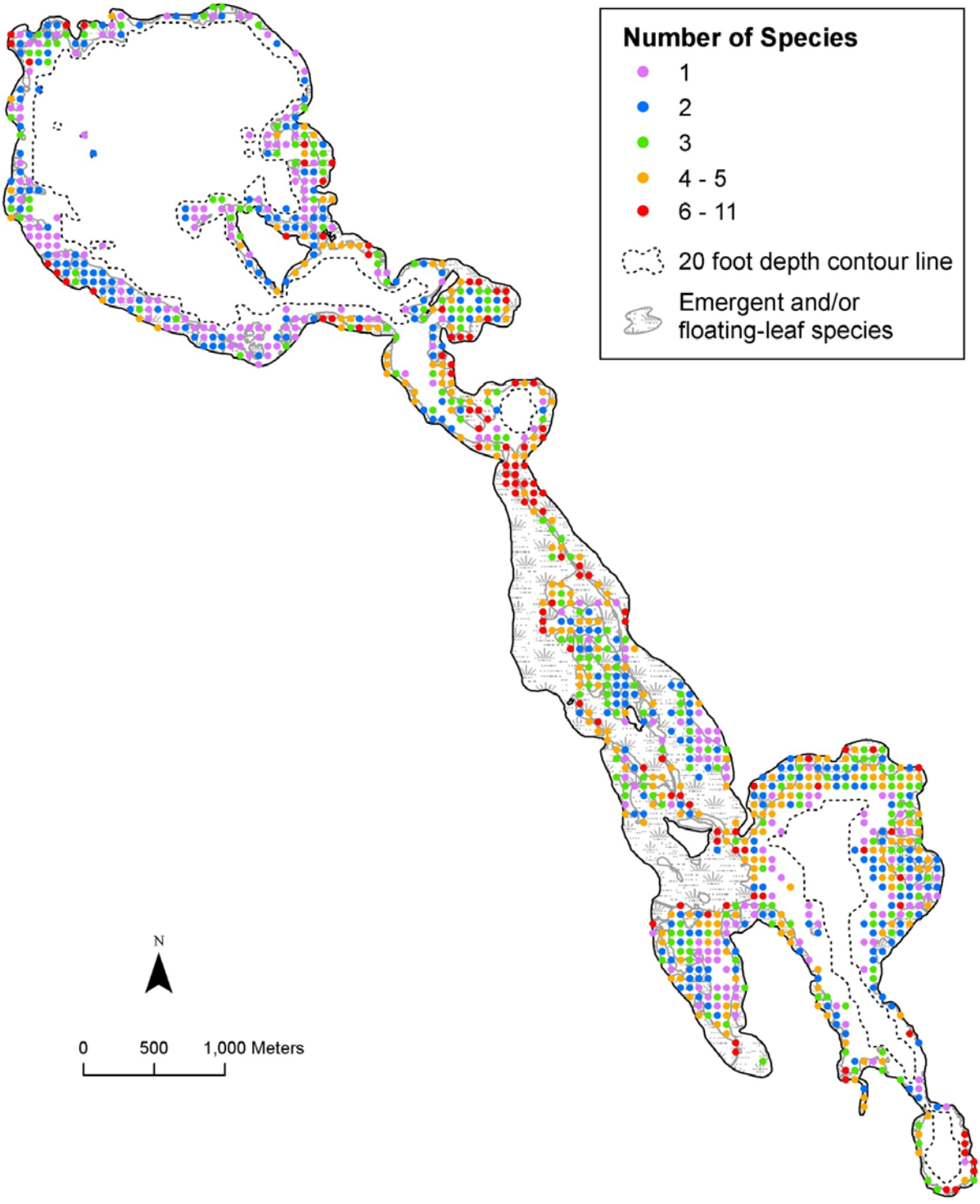
The highest number of plant taxa was found in the shallow water, in depths less than 11 feet. All of the 44 taxa found in the lake were present within this shallow zone and 38 were only found in this area. Only four taxa occurred in depths greater than 15 feet (coontail, Canada waterweed, nitella, star duckweed) (Figure 9).

Figure 9. Number of taxa in each life form by water depth.



Plants were distributed around Bass Lake with the broadest zones of vegetation occurring in the shallow protected areas (Figure 10). The number of plant taxa found at each sample site ranged from 0 to 11 with a mean of 2.4 species per site. Sites of high species richness (6 or more taxa per site) often occurred in depths less than 10 feet and included sites of where emergent, floating-leaf and submerged plants co-occurred.

Figure 10. Number of taxa per sample site, Bass Lake, 2012.



Emergent and Floating-leaf Plant Beds

Emergent and floating-leaf plants were restricted to shallow water and within the 0-10 feet depth zone, 37 percent of the lake, 1,005 acres were occupied by emergent or floating-leaf plant beds. Approximately 809 acres of emergent plant beds and 196 acres of floating-leaf plant beds were mapped (Figure 11).

Most of these beds (419 acres) were dominated by wild rice (*Zizania palustris*) and classified as wild rice or "mixed wild rice" if intermixed with other taxa. Wild rice beds were primarily found in the channel that connects the north and south basin of Bass Lake. It frequently co-occurred with waterlilies and/or other emergent vegetation. Wild rice is an annual plant that germinates each year from seed that fell to the lake bottom in the previous fall. The plant begins growth underwater and then forms a floating-leaf stage before becoming fully emergent (Figure 12). The plant prefers soft substrates (Lee 1986, Nichols 1999) and generally requires moving water for abundant growth (MNDNR 2008). Wild rice is susceptible to disturbance because it is weakly rooted to the lake bottom. In addition to its ecological value as habitat and food for wildlife, wild rice has important cultural and economic values in Minnesota (MNDNR 2008). This valuable plant is increasingly threatened by factors such as lakeshore development and increased water recreational use (MNDNR 2008).

Bulrush (*Schoenoplectus* spp.) occupied about 383 acres and was found on sandy sites in water depths from shore to seven feet. The largest bulrush beds occurred in the north basin and around Crawford Island which were ringed with bulrush or mixed bulrush stands. Bulrush (Figure 13) is an emergent, perennial plant that is rooted in the lake bottom with narrow stems that may extend several feet above the water. In addition to providing valuable fish and wildlife habitat, the extensive root network of these plants help to stabilize sandy shorelines. In shallow water, they may spread by underground rhizomes but these plants are particularly susceptible to destruction by direct cutting by human, motorboat activity and excess herbivory. Restoration of bulrush beds can be very difficult, making established beds particularly unique and valuable.

Most of the other plant beds were classified as "waterlily" beds and were dominated by floating-leaf plants such as white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegata*) and floating-leaf pondweed (*Potamogeton natans*). Waterlily beds often contained scattered emergent plants such as wild rice, burreed, bulrush and submerged plants. The floating leaves of waterlilies provide shade and shelter for fish, frogs and invertebrates (Figure 14). 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 addition to providing critical habitat for fish and wildlife, the extensive root network of emergent and floating-leaf plants help to stabilize shorelines and provide a buffer from waves. This is particularly important on large areas of lakes such as the north and south basin of Bass Lake where even low winds can create substantial wave action.

Figure 11. Emergent and floating-leaf plant beds, Bass Lake, 2012.

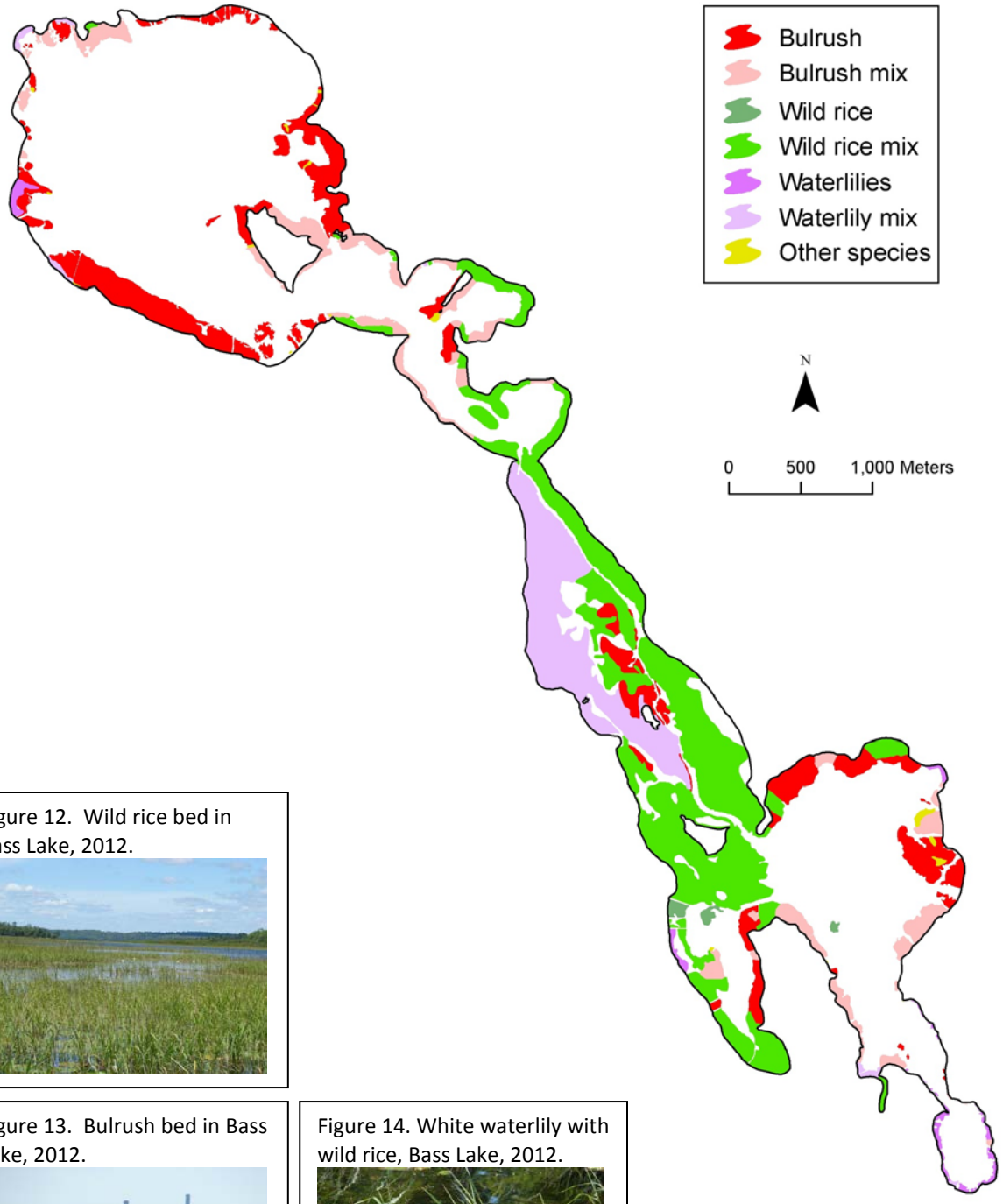


Figure 12. Wild rice bed in Bass Lake, 2012.

Figure 13. Bulrush bed in Bass Lake, 2012.

Figure 14. White waterlily with wild rice, Bass Lake, 2012.

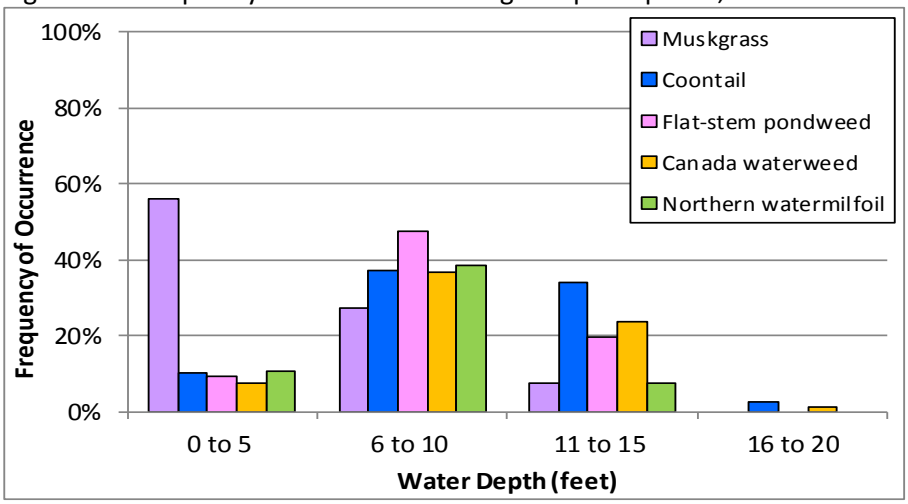
Submerged and free-floating aquatic plants

Submerged and free-floating plants were found to a depth of 20 feet in Bass Lake but were most frequent in depths of 15 feet and less. They included a mix of rooted plants and macroalgae.

Figure 15. Muskgrass

Muskgrass (*Chara* sp.) was the most frequently occurring submerged plant in Bass Lake, occurring in 37 percent of the survey sites (Appendix 1). This is a freshwater macroalgae[5] 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 (Figure 15). 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. It was the most frequent plant in the 0-5 feet depth zone where it occurred in 56 percent of the sites (Figure 16). It was widespread around the shorelines of the north and south basins and was also scattered through the center of the channel (Figure 17).

Figure 16. Frequency of common submerged aquatic plants, Bass Lake2012.



Five rooted plant taxa occurred with a frequency of at least 10 percent (Appendix 1). The most frequently occurring rooted plants were coontail (*Ceratophyllum demersum*), flat-stem pondweed (*Potamogeton zosteriformis*), Canada waterweed (*Elodea canadensis*) and northern watermilfoil (*Myriophyllum sibiricum*).

[5] 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.

Figure 17. Macroalgae vs. rooted plants, Bass Lake, 2012.

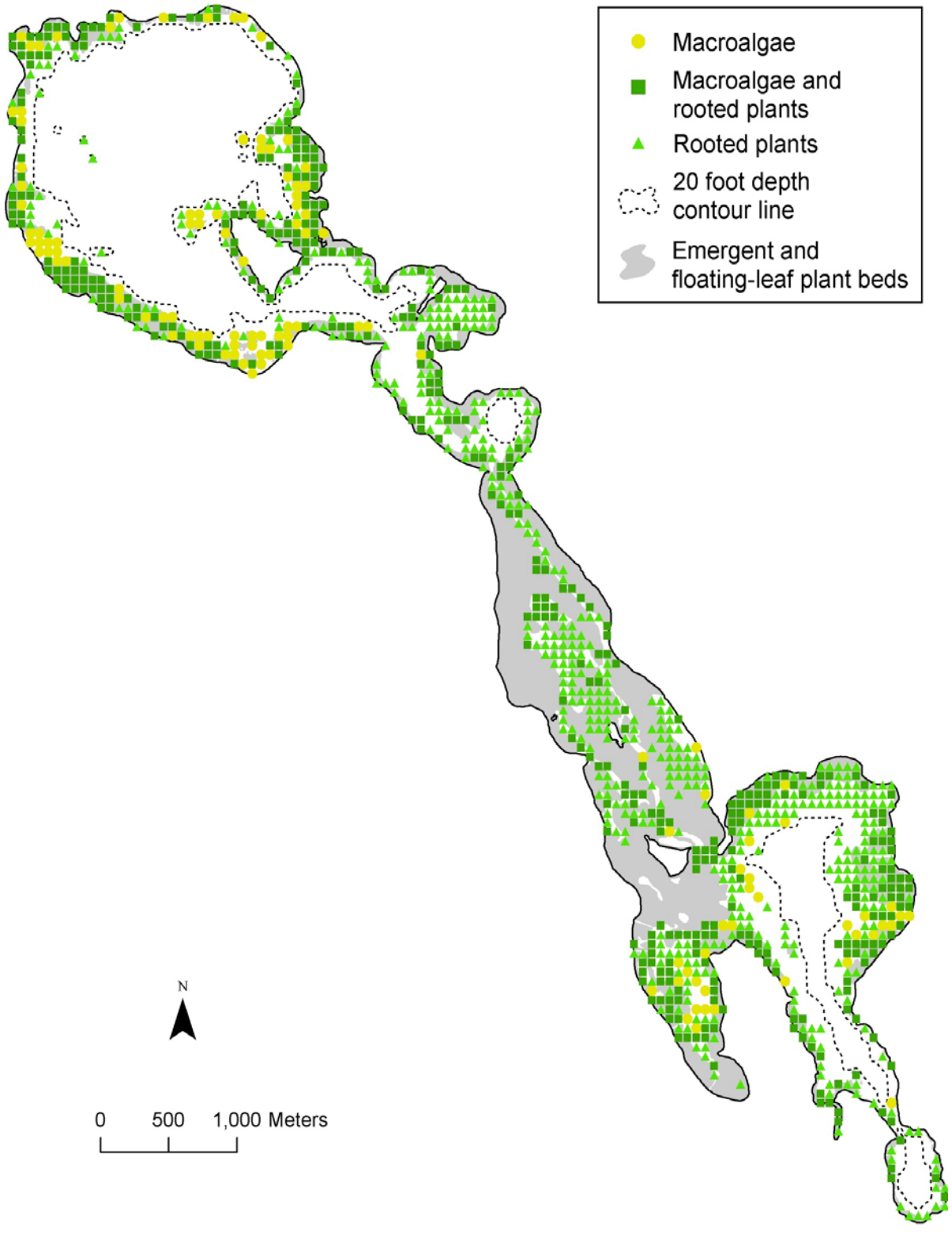


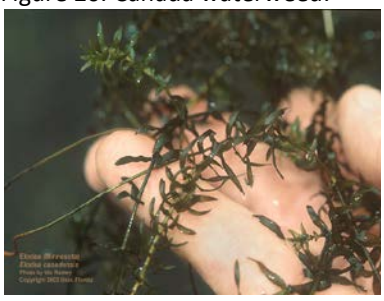
Figure 18. Coontail

Coontail (*Ceratophyllum demersum*) is the most common submerged plant in Minnesota and was also common in Bass Lake where it occurred with a frequency of 16 percent (Appendix 1). It was found to a depth of 20 feet (Figure 17) but was most frequent in the 6-15 feet zone where it occurred in 36 percent of the sites (Figure 16). This plant grows entirely submerged and its roots are only loosely anchored to the lake bottom. It is adapted to a broad range of lake conditions and is tolerant of higher turbidity and can grow in muck substrates (Nichols 1999). Coontail is perennial and can over winter as a green plant under the ice and then begins new growth early in the spring, spreading primarily by stem fragmentation. The finely divided leaves of this plant (Figure 18) provide a home for insects valuable as fish food.

Figure 19. Flat-stem pondweed.

Flat-stem pondweed (*Potamogeton zosteriformis*) is named for its flattened, grass-like leaves (Figure 19). It was the most common **pondweed** in Bass Lake (Figure 17), occurring with a frequency of 16 percent (Appendix 1). It was most frequent in the 6-10 feet depth zone, where it was found in 48 percent of the sites (Figure 16). Flat-stem pondweed is a perennial submerged plant that occurs in many Minnesota lakes but it is not tolerant of turbid lakes (Nichols 1999). It prefers soft substrates and reproduces mainly by cloning but can also produce seeds.

Figure 20. Canada waterweed.



Canada waterweed (*Elodea canadensis*; Figure 20) was found in 14 percent of the Bass Lake survey sites (Appendix 1) and was common in 6-10 feet depth zone where it occurred in 37 percent (Figure 16). It was found to a depth of 17 feet (Figure 17). This perennial submerged taxa 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.

Northern watermilfoil (*Myriophyllum sibiricum*;) was found in 14 percent of all sites (Appendix 1). It occurred to a depth of 14 feet and was most common in the 6-10 feet depth zone (Figures 16, 17). This native[6], submerged plant 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 (Figure 21). It

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

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.

Figure 21. Northern watermilfoil

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

Unique plants

In addition to the commonly occurring native submerged plants in Bass Lake, there were several unique plants located during the survey including hornwort (*Ceratophyllum echinatum*), flat-leaved bladderwort (*Utricularia intermedia*), and lesser bladderwort (*Utricularia minor*). These species are not widespread in Minnesota and are usually associated with undisturbed areas in clear water lakes of northern Minnesota. None of these species were common in Bass Lake but their presence may indicate unique microhabitat conditions in some areas of the lake.

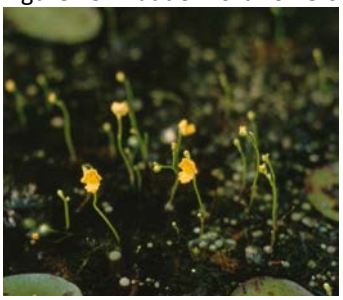
Hornwort (*Ceratophyllum echinatum*) is a submerged plant that resembles the more commonly occurring coontail. Hornwort leaves are forked three times whereas coontail is forked only twice (Nichols 1999). It forms distinctive spiny seeds (Figure 22). Hornwort occurs in soft-water (low alkalinity) lakes of northern Minnesota. It is found on softer substrates and can grow in water depths up to three meters.

Figure 22. Hornwort

Photo by: Paul Skawinski (U of WI-Stevens point Herbarium)

Bladderworts (*Utricularia* spp.) are a group of submerged plants with finely divided leaves. They produce roots but do not firmly anchor to the lake bottom. Greater bladderwort (*U. vulgaris)* is found in lakes and ponds throughout Minnesota but several other species are much less common. Unique bladderwort species include flat-leaved bladderwort (*U. intermedia*) and lesser bladderwort (*U. minor*). Bladderworts have specialized air bladders that regulate their position in the water column. They also act as "underwater Venus fly-traps" by catching and digesting small insects in the bladders. Bladderworts produce small but showy flowers (Figure 23) that emerge above the water surface. They prefer soft substrates (Nichols 1999) but also float freely in the water column and may be found in protected areas such as waterlily beds. They are found in protected, shallow lake areas and have been documented at scattered locations throughout northern Minnesota (Ownbey and Morley 1991).

Figure 23. Bladderwort flowers



Aquatic plant community dynamics

Bass Lake supports an excellent diversity of native plant communities that provide critical fish and wildlife habitat and other lake benefits. (Click here for more information on: value of

aquatic plants). The types and amounts of aquatic plants are influenced by a variety of factors including water clarity, water chemistry, depth, substrate type and wave activity. Within lake differences in these physical features as well as different levels of human activity can result in different types and amounts of vegetation.

The 2012 survey provides a snapshot of the Bass Lake plant communities and there may be a year to year difference in amounts and types of plants present in the lake. The annual abundance, distribution and composition of aquatic plant communities may change annually due to environmental factors and the specific phenology of each plant species. 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 2012 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.

Some taxa, such as muskgrass, perennial pondweeds, and firmly-rooted bulrush plants, regrow within the same lake area each year and are not likely to vary naturally on an annual basis. However, other plants have different reproductive and dispersal characteristics that result in changing patterns between years. As an example, Canada waterweed lacks a winter dormant phase, and in summers following heavy snow and/or ice cover on lakes, this particular plant may occur at lower abundance. However, during mild winters, Canada waterweed remains evergreen under the ice and has a competitive advantage in the following spring. Wild rice is an annual plant and relies on seeds produced in the previous year to germinate and grow to adults in order to have a successful growth year. Low seed production or storm activities that uproot young plants can result in low annual production for this particular plant. Changes in the abundance of one species may trigger a change in other species as they compete with each other for available space.

The rate of aquatic plant growth varies with temperature in years with cool spring temperatures, submerged plants may be less abundant than in years with early springs and prolonged warm summer days. If water clarity in Bass 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. 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.

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 taxa 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 Bass Lake provide critical fish and wildlife habitat and other lake benefits. (Click here for more information on: value of aquatic plants).

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Appendix 1: Historical and current aquatic plants in Bass Lake, 1946 to 2012

Submerged plants

	Common Name		Scientific Name	1946	1998	2000	2012[A]
Lg Algae +Moss	Muskgrass		*Chara* sp.		X		37
	Stonewort		*Nitella* sp.				3
	Watermoss		*Not identified to genus*				1
Monocots	Canada waterweed		*Elodea canadensis*	X	X	X	14
	Water stargrass		*Heteranthera dubia*			X	2
	Bushy pondweed		*Najas flexilis*	X	X	X	[B]9
	Southern naiad		*Najas guadalupensis*				
	Large-leaf pondweed		*Potamogeton amplifolius*		X	X	4
	Variable pondweed		*Potamogeton gramineus*	X	X	X	2
	Illinois pondweed		*Potamogeton illinoensis*		X	X	5
	Narrow-leaf pondweed	Fries pondweed	*Potamogeton friesii*		X	X	[C]3
		Leafy pondweed	*Potamogeton foliosus*			X	
		Straight-leaved pondweed	*Potamogeton strictifolius*			X	
		Not identified to species	*Potamogeton* sp.		X		
	River pondweed		*Potamogeton nodosus*		X		--
	White-stem pondweed		*Potamogeton praelongus*	X	X	X	1
	Clasping leaf pondweed		*Potamogeton richardsonii*	X	X	X	3
	Flat-stem pondweed		*Potamogeton zosteriformis*	X	X	X	16
	White water buttercup		*Ranunculus aquatilis*			X	3
	Yellow water crowfoot		*Ranunculus flabellaris*		X		--
	Sago pondweed		*Stuckenia pectinata*	X	X	X	1
	Wild celery		*Vallisneria americana*		X	X	8
Dicots	Water marigold		*Bidens beckii*		X	X	2
	Coontail		*Ceratophyllum demersum*	X	X	X	16
	Hornwort		*Ceratophyllum echinatum*				<1
	Northern watermilfoil		*Myriophyllum sibiricum*	X	X	X	14
	Whorled watermilfoil		*Myriophyllum verticillatum*				<1
	Flat-leaved bladderwort		*Utricularia intermedia*				2
	Lesser bladderwort		*Utricularia minor*				<1
	Greater bladderwort		*Utricularia vulgaris*	X	X	X	9
			Total	10	18	19	25

[A] In 2012, the numbers represent % frequency from 0-20 feet.
[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] At least one species of narrow-leaf pondweed was identified in the lake: Fries' pondweed (*Potamogeton friesii*). Additional narrow-leaf pondweed species (*Potamogeton* spp.) may have also been present.

Appendix 1 (cont.): Historical and current aquatic plants in Bass Lake, 1946 to 2012

Free-floating plants

Common Name	Scientific Name	1946	1998	2000	2012
Star duckweed	*Lemna trisulca*		X		9
Lesser duckweed	*Lemna* spp.		X		1
Greater duckweed	*Spirodela polyrhiza*		X	X	2
	Total	0	3	1	3

Floating-leaved plants

Common Name	Scientific Name	1946	1998	2000	2012
Watershield	*Brasenia schreberi*				<1
White waterlily	*Nymphaea odorata*	X	X	X	11
Yellow waterlily	*Nuphar variegata*	X	X	X	9
Floating-leaf smartweed	*Persicaria amphibia*		X	X	P
Floating leaf pondweed	*Potamogeton natans*	X	X	X	7
Floating-leaf burreed	*Sparganium natans*				<1
	Total	3	4	4	6

Emergent plants

Common Name	Scientific Name	1946	1998	2000	2012
River bulrush	*Bolboschoenus fluviatile*				P
Spikerush	*Eleocharis palustris*		[G]X	X	3
Horsetail	*Equisetum fluviatilis*		X		1
Brown-fruited rush	*Juncus pelocarpus*			X	--
Giant cane	*Phragmites australis*	X	X	X	1
Broad-leaf arrowhead	*Sagittaria latifolia*	[G]X	[G]X	X	[G]1
Bulrush	*Schoenoplectus* sp.	[H]X	[H]X	[H]X	[H]23
Narrow-leaf burreed	*Sparganium emersum*				P
Giant burreed	*Sparganium eurycarpum*		[G]X		<1
Narrow-leaved cattail	*Typha* sp.				[G]<1
Broad-leaved cattail	*Typha latifolia*	X			--
Wild rice	*Zizania palustris*	X	X	X	13
	Total	5	7	6	10

Wetland emergent plants

Common Name	Scientific Name	1946	1998	2000	2012
Sedge	*Carex* sp.				<1
Wild calla	*Calla palustris*				P
Purple loosestrife (I)	*Lythrum salicaria*				<1
	Total	0	0	0	3

[G]Some plants were only identified to the genus level in this lake. It is possible that additional species of the genus were present in the lake, but only one species was positively identified.
[H]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.
P=Present in lake but did not occur in any sample sites
(I)=non-native to Minnesota

1946 (August 14-29) Bureau of Fisheries Research, Minnesota Department of Conservation
1998 (July 13) Division of Fisheries survey
2000 (July 27) Karen Myhre, Minnesota Biological survey, MNDNR Division of Ecological and Water Resources
2012 (July and August) Simon, Perleberg, Johnson, Walker-O'Beirne, MNDNR Point-Intercept survey, Division of Ecological and Water Resources

Glossary

Within this glossary, 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.

Water quality terms

Alkalinity is a measure of the amount of carbonates, bicarbonates, and hydroxide present in the water. Carbonate and bicarbonate are two alkaline compounds that provide acid buffering to the lake. These compounds are usually found with two hardness ions: calcium and magnesium. Lakes with high quantities of calcium and magnesium in the water are described as "**hard water**" and lakes with low quantities are described as "**soft water**". A lake's hardness and alkalinity are affected by the type of minerals in the soil and watershed bedrock. In Minnesota, there is a general trend of increasing alkalinity from northeast to southwest, with soft-water lakes primarily found in the northeast, hard water lakes in central Minnesota, and very hard-water lakes in the southwest. Regardless of their location in the state, if a lake receives most of its water input from precipitation, hardness and alkalinity may be low.

Level of hardness	total hardness as mg/l of calcium carbonate
Soft	0 - 60
Moderately hard	61 - 120
Hard	121 - 180
Very hard	>180

Hard-water lakes are usually in watersheds with fertile soils that add phosphorus to the lake; they tend to produce more fish and aquatic plants than soft water lakes. Increasing alkalinity is often related to increased algae productivity.

Conductivity measures the water's ability to conduct an electric current and is related to the amount of dissolved minerals in the water. It is related to hardness; soft water lakes typically have lower conductivity than hard water lakes.

Lake trophic status refers to the fertility of the lake and is based on the amount of nutrients (phosphorus and nitrogen) available for organisms. Lakes can be classified based on their fertility:

Oligotrophic lakes have very low nutrients. These lakes are usually found in northern Minnesota, have deep clear water, rock and sandy bottoms and very little algae. Cold water fish like lake trout and whitefish may be found in these lakes. Aquatic plants growth is limited and may be dominated by short, rosette-forming plants.

Mesotrophic lakes have a medium amount of nutrients and are usually found in central Minnesota. These lakes have clear water and algal blooms may occur in late summer. These lakes often support sportfish populations of walleye, perch, smallmouth bass, muskellunge and/or northern pike. Submerged plant growth may be abundant, particularly in shallow areas.

Eutrophic lakes are very fertile with high levels of nutrients. Algal and fish populations may be high. If sufficient light is available, submerged plant growth may be moderate but is often limited due to competition with algae.

Hypereutrophic lakes have excessive nutrients and are dominated by algal blooms. Rough fish typically dominate the community and few aquatic plants are present due to limited light availability.

	Oligotrophic	Oligotrophic-Mesotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Total Phosphorus (ppb)	<6	6-12	12-24	24-48	48-200+
Secchi depth (feet)	>26	13-26	6.5-13	1.5-6.5	<1.5
Chlorophyll a (ppb)	<0.95	.95-2.6	2.6-7.3	7.3-56	56-155+

Sources: RMB Environmental Laboratories Inc. and Minnesota Pollution Control Agency

Plant identification terms

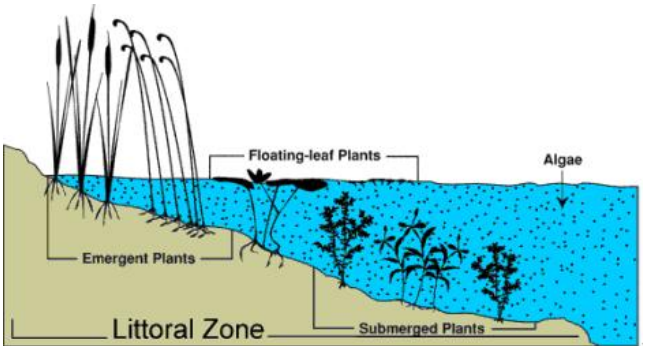
Species is a term to define a group of plants that are capable of interbreeding and producing fertile offspring in nature. Botanists assign a scientific name to each species that is a combination of the genus and species. As an example, red oak and bur oak are both species within the "Oak" genus. Red oak is assigned the scientific name of *Quercus rubra* and bur oak is named *Quercus macrocarpon*. If a surveyor cannot distinguish between a red oak and a bur oak tree, they give it the generic name of *Quercus* sp.

Taxa (singular taxon) is a term that refers to any group of plants, such as species or genus. In this report it is used to identify the number of different types of plants that were identified during a lake survey. In several cases, plants could not be identified to the species level but could be distinguished as unique types of plants. As an example, a surveyor may locate a maple tree and an oak tree during a survey but may not be able to distinguish the exact species of each tree (ex. red maple vs. sugar maple or red oak vs. bur oak). In this case, since the trees were not identified to the species level, it is more accurate to state that two taxa of trees were identified as opposed to two species.

Plant growth form terms

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 A), 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 A. Forms of aquatic plants found in Minnesota lakes.



Emergent plants are rooted in the lake bottom with most of their leaves and stems extending above the water surface. Root systems of these plants form extensive networks that take up nutrients and help consolidate and stabilize bottom substrate. Beds emergent plants help buffer the shoreline from wave action, offer shade and shelter for insects, young fish, and frogs and provide food, cover and nesting material for waterfowl, marsh birds and muskrat.

Floating-leaf plants such as waterlilies, are 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 plants help buffer the shoreline from wave action, offer shade and shelter for insects, young fish, and frogs and provide food, cover and nesting material for waterfowl, marsh birds and muskrat.

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.

Submerged plants have stems and leaves that primarily grow underwater and many may also form flowers, fruits and/or some leaves that emerge above or float on the water surface. Submerged plants are typically anchored to the lake bottom but some types drift freely with the currents. Growth forms of these plants range from low-growing mats to plants that grow several feet in the water column. Some plants obtain nutrients from the lake substrate and the water column, while others rely exclusively on the water column for nutrients. These plants play a key role in the ecosystem of a lake: they 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.

Pondweeds (*Potamogeton* spp. and *Stuckenia* spp.) are the largest group of submerged aquatic plants in Minnesota lakes with about 25 different species considered native to the state. These perennial plants are anchored to the lake bottom by underground rhizomes. Some species of pondweeds may form specialized floating leaves, while others grow entirely submerged below the water surface. Depending on water clarity and depth, any pondweed 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). Pondweeds are often named and described based on their leaf shape and size. Some pondweed species have very specific habitat requirements while others can grow in a wide range of lake conditions. Certain species have the ability to form submerged and floating leaves while others form only submerged leaves. The vegetative portions of pondweeds can be highly variable depending on water levels, water flow and other habitat conditions. If flowers or fruits are not present, pondweeds can be difficult to identify to the species level.

Plant abundance terms

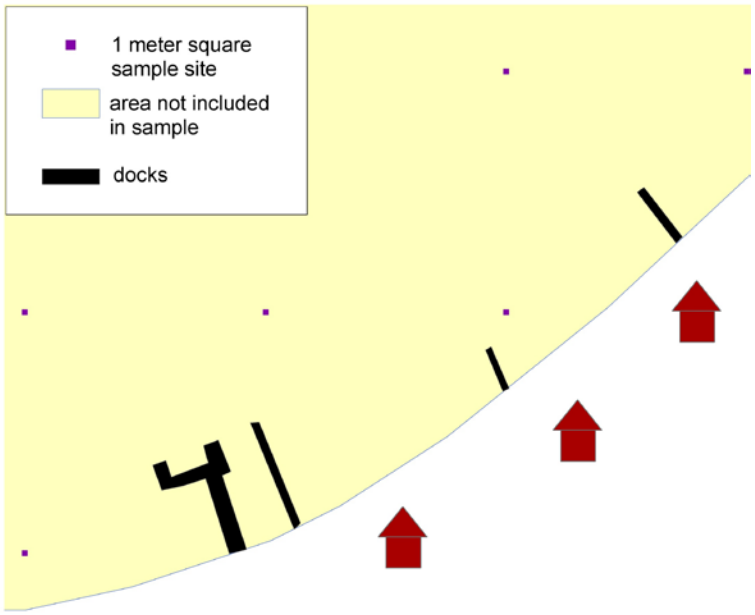
"Abundance" is a general term that does not have any quantitative meaning. For vegetation sampling, there are several ways to quantify abundance.

Frequency of occurrence = the percentage of sites where the plant taxon or taxa of interest occurred. This is the simplest way to measure plant abundance in lakes because it does not require underwater sampling with SCUBA gear nor does it require collecting and weighing plant biomass samples. Frequency of occurrence is less likely to change over the growth season than are other measurements such as stem density or biomass.

Example:
In Bass Lake there were 1349 sample sites in the 0-20 feet depth zone.
Coontail occurred in 216 sites.
Frequency of Coontail in 0-20 feet zone = (216/1349)*100 = 16%

Point intercept sample site: For point-intercept surveys, a very small area is actually sampled (see Figure B). Many small sites (represented by purple boxes) are surveyed and used to estimate plant abundance in much larger area of lake (yellow area). This information is useful on a lakewide basis but is not appropriate to describe "site-specific" conditions, such as abundance of plants immediately adjacent to an individual's shoreline home. For that type of information, a specific site visit is required.

Figure B. Actual area of sample site used in point-intercept survey compared to non-sampled areas of lake.



Other measures of "abundance" include:

Cover = the amount of surface area occupied by a plant. For submerged lake plants, this is very difficult to measure from the boat surface. Additionally, it is difficult to consistently measure cover because it is a visual estimate. For emergent and floating-leaf plants, cover is a useful measurement that can be reliably estimated from aerial photographs and/or by delineating plant beds with GPS.

Density = the number of stems within a sample area. For aquatic plants, this requires SCUBA gear and intensive underwater measurements. It is also complicated because many aquatic plants are highly branching and it is difficult to determine where one stem begins and another one ends.

Biomass = the mass or weight of plants within a sample area. For aquatic plants, this requires SCUBA gear or other specialized equipment and plant samples must be separated, cleaned and dried before measuring. Biomass typically increases throughout the growing season.