Aquatic Vegetation of Turtle Lake

July, August and September, 2013

Turtle Lake, ID# 31-0725-00

Itasca County, Minnesota

Floating-leaf and emergent plants in Turtle Lake, July, 2013.

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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.

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Contents

Survey Context

This vegetation survey of Turtle Lake was part of the larger Sensitive Lakeshore Identification project conducted by MNDNR. During 2013, MNDNR biologists conducted field surveys of aquatic vegetation, loons, frogs and near-shore fish in Turtle Lake. These field data and physical characteristics of the lake 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 receive sufficient protection.

More information on the MNDNR's Sensitive Lakeshore Identification, including Sensitive Lakeshore reports for individual lakes, can be found online at: Sensitive Shoreline Reports.

Summary

Aquatic vegetation surveys of Turtle Lake (31-0725-00), Itasca County, Minnesota, were conducted in July, August and September of 2013. 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 1,000 sample stations.

Forty-four native aquatic plant taxa were found including 11 emergent, six floating-leaved, and 27 submerged taxa.

Emergent and floating-leaved plants occurred in shallow water (0-10 feet deep) and occupied 311 acres within that depth zone (or 15% of the shallows). Approximately 229 acres of bulrush (*Schoenoplectus* sp.) beds were delineated. Floating-leaf plants covered about 81 acres and included white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegata*), watershield (*Brasenia schreberi*) and floating-leaf pondweed (*Potamogeton natans*).

Submerged plants were found to a maximum depth of 25 feet but were most frequent in depths from shore to 15 feet, where 94% of the sites contained at least one submerged species. The most common submerged plant species were muskgrass (*Chara* sp.) (69% occurrence within the shore to 25 feet zone), greater bladderwort (*Utricularia vulgaris*) (11%), narrow-leaved pondweed (*Potamogeton* spp.) (10%), flat-stem pondweed (*Potamogeton zosteriformis*) (9%), native watermilfoils (*Myriophyllum* sp.) (8%) and naiads (*Najas flexilis* and *N. guadalupensis*) (8%).

No state or federally listed rare plants were found in the lake but several unique aquatic plants included flat-leaved bladderwort (*Utricularia intermedia*), lesser bladderwort (*Utricularia minor*), mare's tail (*Hippuris vulgaris*), creeping spearwort (*Ranunculus flammula*), water bulrush (*Schoenoplectus subterminalis*) and quillwort (*Isoetes* sp.). These species are not widespread in Minnesota and are usually associated with undisturbed areas in clear water lakes of northern Minnesota.

The abundance and diversity of native plants, including the extensive beds of emergent and floating-leaf plants and mixture of many types of submerged plants, help maintain high water clarity and provide critical habitat for fish and wildlife in this lake.

Non-native plant species were not found growing in the lake but two non-native emergent plants were found at scattered locations along shorelines. Purple loosestrife (*Lythrum salicaria*) and reed canary grass (*Phalaris arundinaceae*) are not native to Minnesota and often invade wet areas along lakeshores.

Introduction

Lake location and characteristics

Turtle Lake is in the Laurentian Mixed Forest Province of northeast Minnesota, about one mile north of Marcell in Itasca County (Map 1). This region of the state is characterized by broad areas of conifer forest, mixed hardwood and conifer forests, and conifer bogs and swamps with numerous glacial lakes.

Turtle Lake lies within the Big Fork River watershed. It is a flow-through lake that receives inflow from two small streams that flow into the north bay. One stream flows south from Hatch Lake and the other flows west from Maple Lake. The lake outflows from the west bay to form the Turtle River (Map 1). The Turtle River flows south into the Big Fork River which flows north to form the Minnesota/Canada border.

Turtle Lake occurs entirely within the boundaries of the Chippewa National Forest but the surrounding shoreland ownership includes a mix of state, federal, county, and private land. With a surface area of 2,126 acres, Turtle Lake is the 13th largest lake in Itasca County and the 6th largest lake in the watershed. The lake has an irregular outline with several islands and a total of 26 miles of shoreline. About (70%) of the shoreline is developed with residential homes and several resorts. The State of Minnesota maintains a public access on the northeast side of the northwest basin (Map 2).

Turtle Lake has a maximum depth of 137 feet but about 25% of the lake is 15 feet or less in depth (Map 2). The lake is a **hard water** lake and is characterized as **mesotrophic**, based on phosphorus (11 ppb nutrients), chlorophyll a (2 ppb algae concentration) and Secchi depth (transparency). The 2003 to 2012 mean summer water clarity was 16 feet (MPCA 2013). Based on Secchi disc measurements alone, aquatic plants have the potential to reach depths of about 24 feet in the lake. 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 Turtle Lake were conducted in 1935, 1950, 1975, and 2001 (MNDNR Lake files). These surveys varied in methods; the earliest surveys were conducted by non-botanists and focused on the commonly occurring in-lake plants while the 2001 survey included a detailed listing of any plant taxa encountered by an experienced botanist.

In 1935, surveyors mapped the major stands of aquatic plants by hand drawing the plant bed boundaries onto a field map. Bulrush was the most common emergent plant mapped and covered about 200 acres and extended around nearly the entire shoreline. Waterlilies were documented in the shallow bays and covered about 35 acres. A small, less than 2 acres, stand of wild rice was mapped on the north shore of Moose Bay (Map 3). Extensive beds of muskgrass (*Chara* sp.) and pondweeds (*Potamogeton* sp.) were also mapped (Map 4).

Collectively, from all of the previous surveys, a total of 35 native aquatic plant **taxa** have been reported in Turtle Lake including: five emergent, three floating-leaf, and 27 submerged taxa (Appendix 1). These include plants that are commonly found in many clear-water northern Minnesota lakes: a variety of pondweeds, northern watermilfoil (*Myriophyllum sibiricum*), and greater bladderwort (*Utricularia* *vulgaris*). Rare plant species or non-native aquatic plants have not been documented in Turtle Lake. The non-native emergent wetland plant, purple loosestrife does occur on the shorelines and is managed by the lake group.

Objectives

The purpose of this vegetation survey was to provide a quantitative description of the 2013 plant population of Turtle 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 emergent and floating-leaf 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 15, and September 3, 4, 2013 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 9 through September 3, 2013 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. To ensure a sufficient number of sample points in the near-shore zone, survey points were stratified by water depth (Map 5). Sample points were spaced closer together in shallow water to increase the survey effort in the area of the lake most likely to contain high diversity (Table 1). In the field, surveyors sampled sites where water depth was less than 26 feet for a total of 1,066 sites which occurred within the 0-25 feet depth zone.

Table 1. Survey effort by depth interval.

Water depth (feet)	Point spacing in meters	Number of survey sites
0 to 5	50	535
6 to 10	50	220
11 to 15	50	110
16 to 20	65	100
21 to 25	100	101
Total		1066

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 seven feet and an electronic depth finder in deeper water.

Substrate sampling

At each sample site where water depths were seven 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 (Photo 1). 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 (2013).

Photo 1. Survey rake.

Frequency of occurrence was calculated for the entire vegetated zone (0-25 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.

Results and Discussion

Near-Shore Substrates

The near-shore substrates of Turtle Lake included a mix of hard substrates (boulder, rubble, sand and gravel) and soft substrates (silt, marl and muck) (Map 6). Shallow, protected bays had soft substrates and windswept shores had harder substrates.

Distribution of aquatic plants

Plants were found to a depth of 25 feet in Turtle Lake and in the 0-25 feet depth zone, 85% of the survey sites contained vegetation. Vegetation was most common in the 0-15 feet depth zone, where 94% of sites contained plants (Figure 1). Plant abundance declined with increasing water depth and in depths of

21-25 feet, 33% of the sites were vegetated. Plants were distributed around Turtle Lake with the broadest zones of vegetation occurring in the shallow protected areas (Map 7).

Plant richness and diversity

A total of 44 aquatic plant taxa (types) were recorded in Turtle Lake. The plants included 11 emergent, six floating-leaved, and 27 submerged plants (Appendix 1). Seventeen of these taxa were recorded for the first time during the 2013 survey.

Figure 1. Percent of vegetated sites vs. water depth.

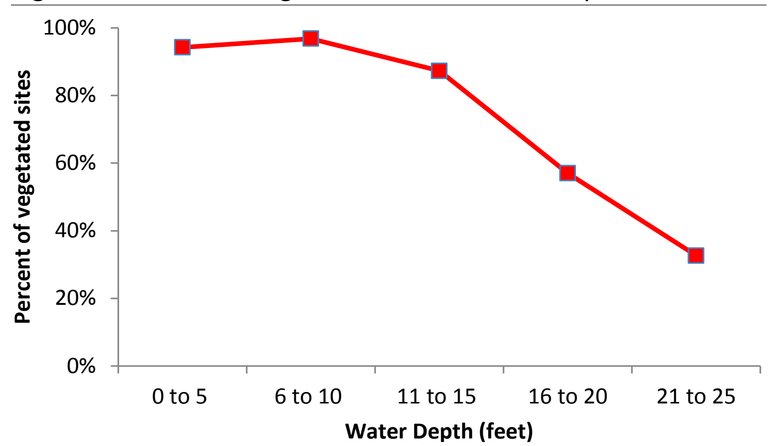
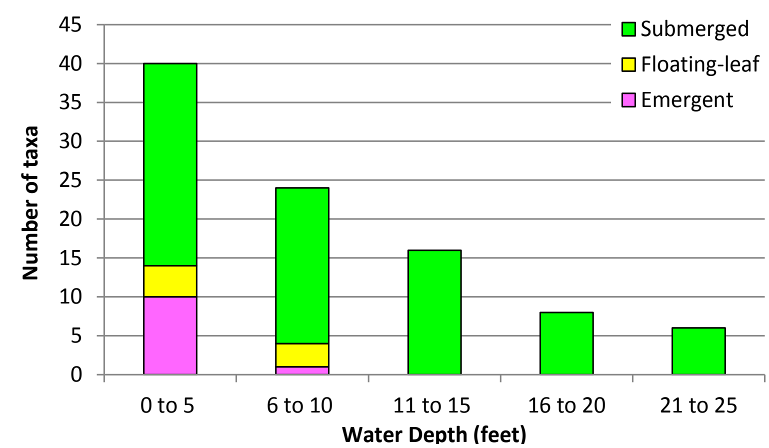


Figure 2. Number of taxa in each life form by water depth.



The highest number of plant taxa was found in shallow water, in depths less than 11 feet. All of the 44 taxa found in the lake were present within this shallow zone and 18 were only found in this area. Only six taxa occurred in depths greater than 20 feet (coontail, muskgrass, stonewort, narrow-leaf pondweeds, watermoss, and flat-stem pondweed) (Figure 2).

The number of plant taxa found at each sample site ranged from 0 to 13 with a mean of 2 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 (Map 8).

No non-native submerged aquatic plants were detected in Turtle Lake. The non-native wetland emergent species, purple loosestrife (*Lythrum salicaria*), was present along the lakeshore of Turtle Lake. The lake group has a management plan for this species.

Emergent and Floating-leaf Plant Beds

Emergent and floating-leaf plants were restricted to shallow water and within the 0-10 feet depth zone, 15% of the lake, 311 acres were occupied by emergent or floating-leaf plant beds. Approximately 230 acres of emergent plant beds and 81 acres of floating-leaf plant beds were mapped (Map 9). 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 east shore of Turtle Lake where even low winds can create substantial wave action.

Photo 2. Bulrush bed in Turtle Lake, 2013.

Bulrush (*Schoenoplectus* spp.) occupied about 229 acres and was found on sandy sites in water depths from shore to seven feet. The largest bulrush beds occurred along shorelines in the southern 2/3rds of the lake including shorelines around islands. Bulrush (Photo 2) 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.

Photo 3. Waterlilies in Turtle Lake, 2013.

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*), watershield (*Brasenia schreberi*) 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 (Photo 3). 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).

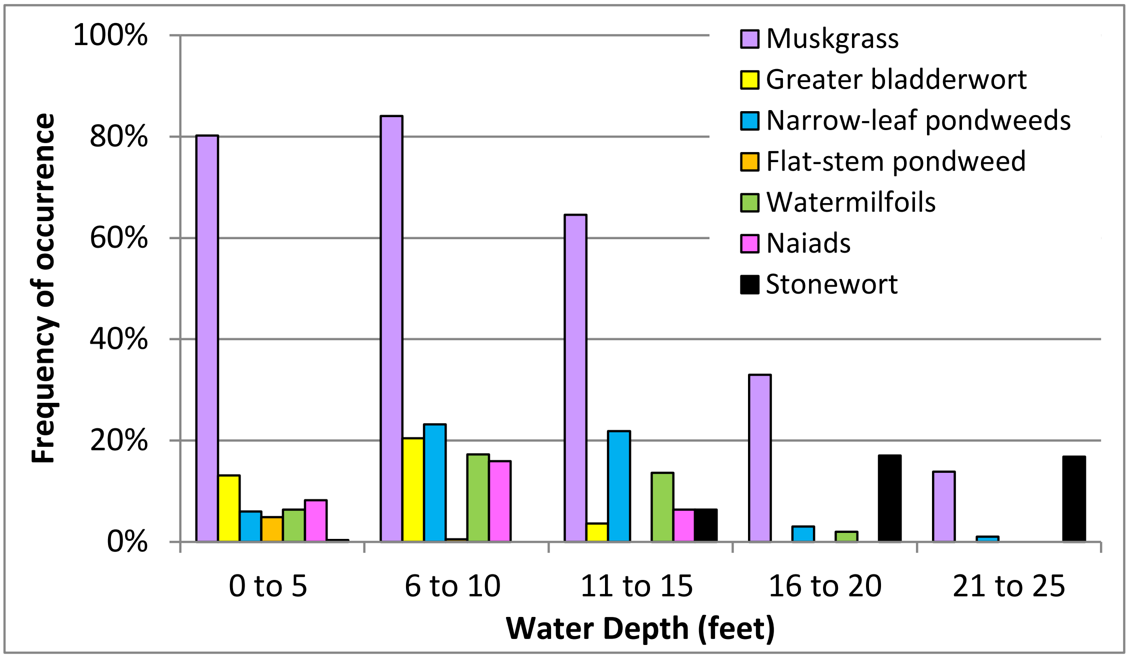
Other emergent plants included spikerush (*Eleocharis acicularis*), burreed (*Sparganium* sp.), broad-leaf arrowhead (*Sagittaria latifolia*), cattails (*Typha* sp.), giant cane (*Phragmites australis*) and river bulrush (*Bolboschoenus fluviatilis*).

A small area (1 acre) of wild rice (*Zizania palustris*) was reported along the north shore of Moose Bay in 1935 but this plant was not detected during the 2013 survey.

Submerged aquatic plants

The submerged plant community included a mix of macroalgae and rooted plants with both types occurring in 85% of the sites, only macroalgae found in 24% and only rooted plants found in 13% (Map 10). Submerged plants were found to a depth of 25 feet but were most frequent in depths of 15 feet and less. Macroalgae (muskgrass and/or stonewort) occurred at all depths while most rooted plants were restricted to depths of 15 feet and less (Figure 3).

Figure 3. Common submerged aquatic plants in Turtle Lake.



Macroalgae

Algae are primitive forms of submerged plants that do not form true roots, flowers or vascular tissue. They range in size from single cell plants to larger plants that resemble rooted plants. Macroalgae can provide similar habitat and water quality benefits as rooted plants and were therefore included in this survey.

Photo 4. Muskgrass

Muskgrass (*Chara* sp.) is a freshwater macroalgae and is common in many **hard water** Minnesota lakes. It has a brittle texture and a characteristic "musky" odor. Because muskgrass does not form true stems, it is a low-growing plant, often found entirely beneath the water surface where it may form low "carpets" on the lake bottom (Photo 4). Muskgrass is adapted to variety of substrates, can withstand heavier wave action than can rooted plants, 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 fish spawning and nesting habitat.

Muskgrass dominated the submerged plant community in Turtle Lake, occurring in 69% of the survey sites (Appendix 1). It was the most frequent plant in all depth zones (Figure 3) and was distributed around the shorelines of the entire lake (Map 10).

Photo 5. Stonewort

Stonewort (*Nitella* sp.) is also a large algae but lacks the brittle texture and musky odor of muskgrass. It is often bright green in color and resembles strands of hair (Photo 5). Stonewort is often found in deeper water than muskgrass. Stonewort was common in depths greater than 15 feet (Figure 3).

Rooted Plants

Other submerged plants in Turtle Lake are flowering plants that form some sort of root structure (Map 10). They may be firmly anchored to the lake bottom or may drift freely with the water current. A wide diversity of submerged plants were found including broad "cabbage" leaf plants, finely-divided leaf plants, grass-like plants, and needle-leaf plants. Several of these plants also have the ability to form floating-leaves, particularly in shallow, protected waters.

The most frequently occurring rooted plant groups included bladderworts (*Utricularia* spp.), pondweeds (*Potamogeton* spp.), native watermilfoils (*Myriophyllum* spp.), and naiads (*Najas* spp.) (Appendix 1).

Photo 6. Bladderwort flowers

Bladderworts (*Utricularia* spp.) are submerged plants with finely divided leaves. They produce roots but do not firmly anchor to the lake bottom. 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 (Photo 6) 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. Greater bladderwort (*U. vulgaris*) is found in lakes and ponds throughout Minnesota and occurred in 11% of the survey sites (Appendix 1).

Photo 7. Flat-leaved bladderwort

In addition to common bladderwort (*Utricularia vulgaris*) there are several other species that are much less common in Minnesota lakes. Unique bladderwort species include flat-leaved bladderwort (*U. intermedia*) (Photo 7) and lesser bladderwort (*U. minor*). They are found in protected, shallow lake areas and have been documented at scattered locations throughout northern Minnesota (Ownbey and Morley 1991).

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).

Narrow-leaf pondweeds occurred in 10% of the survey sites (Appendix 1). They were found to a depth of 23 feet and within the 6-15 feet depth zone they occurred in about 22% of the sites (Figure 6). These include taxa that can be difficult to identify if not found in flower or fruit. Fries' pondweed

(*Potamogeton friesii*), small pondweed (*P. pusillus*), and sago pondweed (*Stuckenia pectinata*; Photo 8) were positively identified in the lake, but additional narrow-leaf species may have also been present.

Photo 8. Sago Pondweed

Flat-stem pondweed (*Potamogeton zosteriformis*) is named for its flattened, grass-like leaves (Photo 9). It was the most common **pondweed** in Turtle Lake (Figure 6), occurring with a frequency of 9% (Appendix 1). It was most frequent in the 6-10 feet depth zone, where it was found in 23% of the sites. 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.

Photo 9. Flat-stem pondweed.

Watermilfoils are mostly submerged rooted perennial plants with finely dissected, “feather-shaped” leaves. There are several native species of watermilfoils in Minnesota and these plants are not tolerant of turbidity (Nichols 1999) and grow best in clear water lakes. Particularly in depths less than 10 feet, watermilfoils may reach the water surface and their flower stalk will extend above the water surface (Photo 10). They spread primarily by stem fragments and over-winters by hardy rootstalks and winter buds. Two species of watermilfoils were found in Turtle Lake: Northern watermilfoil (*Myriophyllum sibiricum*) and whorled watermilfoil (*M. verticillatum*). They were found in 8% of all sites (Appendix 1), occurred to a depth of 16 feet and were most common in the 6-10 feet depth zone (Figure 6).

Photo 10. Northern watermilfoil

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

Naiads [Bushy pondweed (*Najas flexilis*; Photo 11) and southern naiad (*Najas guadalupensis*)] are native submerged plants that often grow low in the water column and form inconspicuous flowers. The two species look very similar, but bushy pondweed is unusual because it is one of the few annual submerged species in Minnesota and must re-establish every year from seed. It prefers hard substrates and is not tolerant of turbidity (Nichols 1999b). Southern naiad may overwinter as a perennial plant or sprout from seed. The seeds and foliage of both plants are an important duck food and the foliage provides good fish cover. Naiads were found in 8% of the surveyed sites (Appendix 1) and were common in the 6-10 feet depth zone where they occurred in 16% (Figure 6).

Photo 11. Bushy pondweed

Photo by Gary Fewless (UW Green bay)

Unique plants

In addition to the commonly occurring groups of native submerged plants in Turtle Lake, there were several unique plants located during the survey including mare’s tail (*Hippuris vulgaris*), creeping spearwort (*Ranunculus flammula*), water bulrush (*Schoenoplectus subterminalis*) and quillwort (*Isoetes* sp.). 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 Turtle Lake but their presence may indicate unique microhabitat conditions in some areas of the lake.

Mare's tail (*Hippuris vulgaris*) is a submerged plant with whorls of leaves that resemble a horse's tail (Photo 12). This plant occurs primarily in northern Minnesota lakes but is relatively uncommon. It is often associated with cold-water streams or springs (Voss 1985) and its presence in a waterbody may be indicative of relatively good water quality. This submerged plant may form emergent leaves and stems in shallow water.

Photo 12. Mare's tail

Creeping spearwort (*Ranunculus flammula*) is mostly found in the northern half of Minnesota (Flora of North America 1993+). It grows on hard substrates like sand and gravel (Borman et al. 2001). Creeping spearwort often grows as a submerged plant but may grow as a short emergent on mudflats. It has linear leaves that emerge in small clusters from the arched runners or stolons. This plant is in the buttercup family and if stranded on mudflats, it may form characteristic yellow buttercup flowers (Photo 13).

Photo 13. Creeping spearwort

Photo by: Emmit Judziewicz, U of WI-Stevens Point Herbarium

Water bulrush (*Schoenoplectus subterminalis*) is closely related to the emergent bulrush plants but grows primarily as a submerged plant. It is a rooted perennial with fine, grass-like leaves and may form mats near the water surface. In mid to late summer its leaf tips and flower stalk may emerge above the water surface (Photo 14). This species once had a patchy distribution throughout North America but may now be extirpated from Illinois (Flora of North America 1993+) and its conservation status is listed as critically impaired in several other states (NatureServe 2008). It is infrequently found in Wisconsin (Nichols 1999) and Minnesota (Ownbey and Morley 1991) lakes.

Photo 14. Water bulrush
Copyright 1996 D.W. Taylor

Quillwort (*Isoetes* sp.) (Photo 15) is a submerged plant that is primarily found in softwater lakes (Nichols 1999) of northeastern Minnesota (Ownbey and Morley 1991). It is specially adapted to live in very low carbon environments (Bolton and Adams 1986). This is not a flowering plant but reproduces and spreads by megaspores that are produced late in the summer. These plants are not flowering plants and are named for their leaf-like structures that resemble "quills." Quillworts are among a specialized group of aquatic plants that are compact, slow-growing and ever-green and

Photo 15. Quillwort (*Isoetes* sp.)
Photo: C. Taylor USDA-NRCS PLANTS Database

capable of surviving in low nutrient habitats (Madsen 1991).

Aquatic plant community dynamics

Turtle 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 2013 survey provides a snapshot of the Turtle 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 2013 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 Turtle Lake increases, submerged vegetation may be more common at depths greater than 20 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 Turtle 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 Turtle Lake, 1935 to 2013

Submerged plants

	Common Name	Scientific Name	1935	1950	1975	2001	2013
Lg Algae +Moss	Muskgrass	*Chara* sp.			X		69
	Stonewort	*Nitella* sp.		X			4
	Watermoss	Not identified to genus					3
Monocots	Needlerush	*Eleocharis acicularis*					P
	Canada waterweed	*Elodea canadensis*				X	4
	Water star-grass	*Heteranthera dubia*					<1
	Quillwort	*Isoetes* sp.					P
	Naiads	*Najas flexilis*				X	[B]8
		Najas guadalupensis					
	Slender naiad	*Najas gracillima*[A]		?			--
	Large-leaf pondweed	*Potamogeton amplifolius*			X		2
	Narrow-leaf pondweed group	*Potamogeton friesii*				X	[B]10
		Potamogeton pusillus				X	
		Potamogeton obtusifolius		X			
		Potamogeton strictifolius				X	
	Variable pondweed	*Potamogeton gramineus*				X	3
	Illinois pondweed	*Potamogeton illinoensis*				X	7
	White-stem pondweed	*Potamogeton praelongus*				X	2
	Clasping-leaf pondweed	*Potamogeton richardsonii*		X	X	X	4
	Robbin's pondweed	*Potamogeton robbinsii*				X	1
	Flat-stem pondweed	*Potamogeton zosteriformis*		X	X	X	9
	Widgeon grass	*Ruppia occidentalis*[A]			?		--
	Water bulrush	*Schoenoplectus subterminalis*					1
	Sago pondweed	*Stuckenia pectinata*			X	X	2
	Wild celery	*Vallisneria americana*	X			X	4
Dicots	Water marigold	*Bidens beckii*				X	<1
	Coontail	*Ceratophyllum demersum*		X		X	4
	Northern watermilfoil	*Myriophyllum sibiricum*		X		[B]X	[B]8
	Whorled watermilfoil	*Myriophyllum verticillatum*					
	Marestail	*Hippuris vulgaris*				X	P
	White water buttercup	*Ranunculus aquatilis*				X	--
	Creeping spearwort	*Ranunculus flammula*				X	P
	Greater bladderwort	*Utricularia vulgaris*		X		X	11
	Flat-leaved bladderwort	*Utricularia intermedia*					2
	Lesser bladderwort	*Utricularia minor*					2
		Total	1	8	6	20	27

Floating-leaved plants

Common Name	Scientific Name	1935	1950	1975	2001	2013
Watershield	*Brasenia schreberi*					2
Yellow waterlily	*Nuphar variegata*	X	X		X	6
White waterlily	*Nymphaea odorata*	X	X		X	9

Common Name	Scientific Name	1935	1950	1975	2001	2013
Floating-leaf smartweed	*Persicaria amphibia*					P
Floating-leaf pondweed	*Potamogeton natans*		X		X	8
Floating-leaf burreed	*Sparganium fluctuans*					<1
	Total	2	3	0	3	6

Emergent plants

Common Name	Scientific Name	1935	1950	1975	2001	2013
Sweet flag	*Acorus americanus*					P
River bulrush	*Bolboschoenus fluviatile*					<1
Sedge	*Carex* sp.					<1
Spikerush	*Eleocharis palustris*				X	1
Horsetail	*Equisetum fluviatilis*				X	<1
Baltic rush	*Juncus articus var. balticus*					P
Giant cane	*Phragmites australis*					P
Broad-leaf arrowhead	*Sagittaria latifolia*	[B]X			X	[B]<1
Bulrush	*Schoenoplectus* sp.[C]		X		X	24
Giant burreed	*Sparganium eurycarpum*					[B]<1
Narrow-leaf cattail	*Typha angustifolia*					[B]<1
Broad-leaf cattail	*Typha latifolia*					
	Total	1	1	0	4	11

Non-native shoreline emergent plants

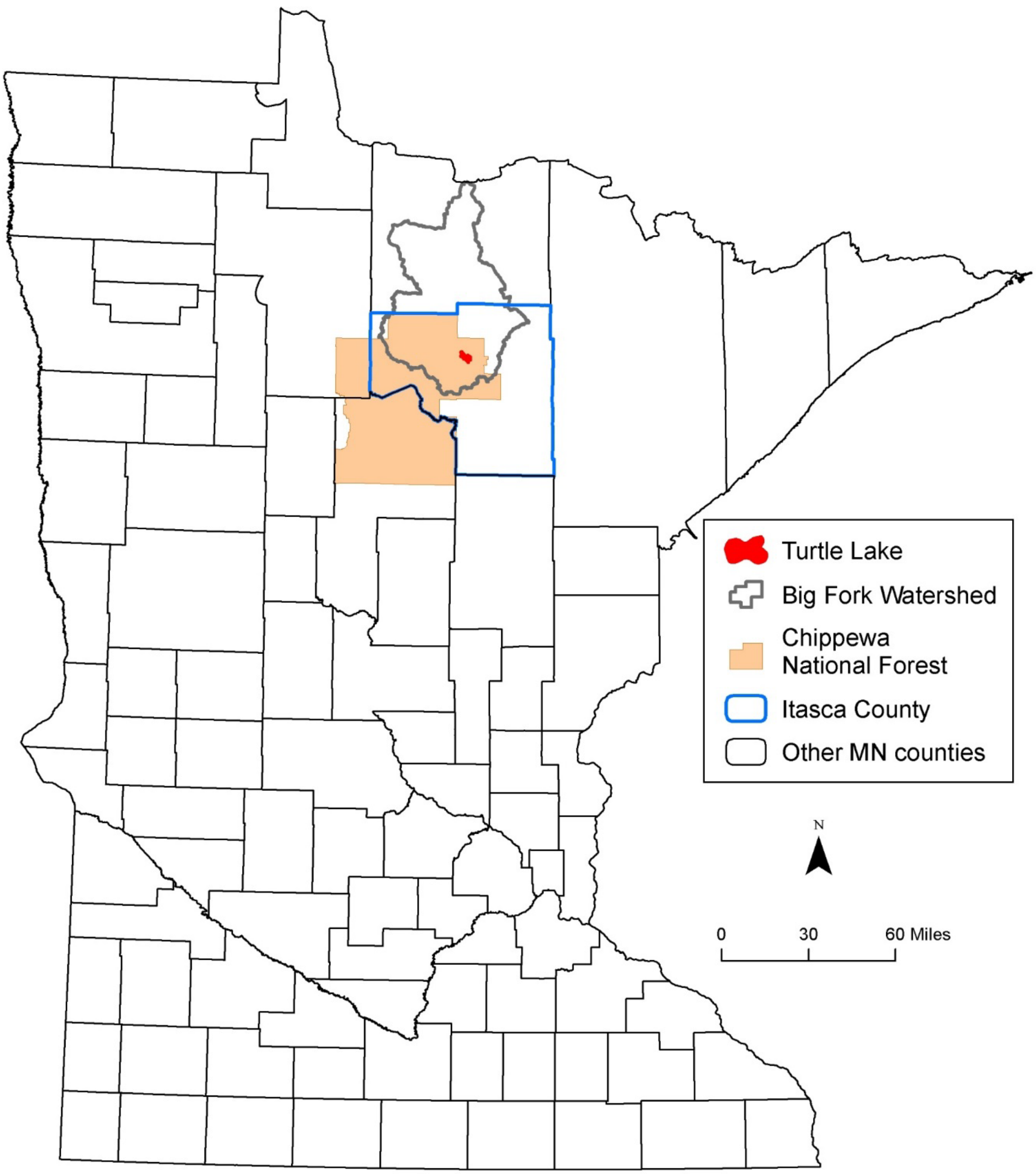
Common Name	Scientific Name	1935	1950	1975	2001	2013
Purple loosestrife (I)	*Lythrum salicaria*				X	P
Reed Canary Grass (I)	*Phalaris arundinacea*				X	P
	Total	0	0	0	2	2

(I)= Introduced to Minnesota

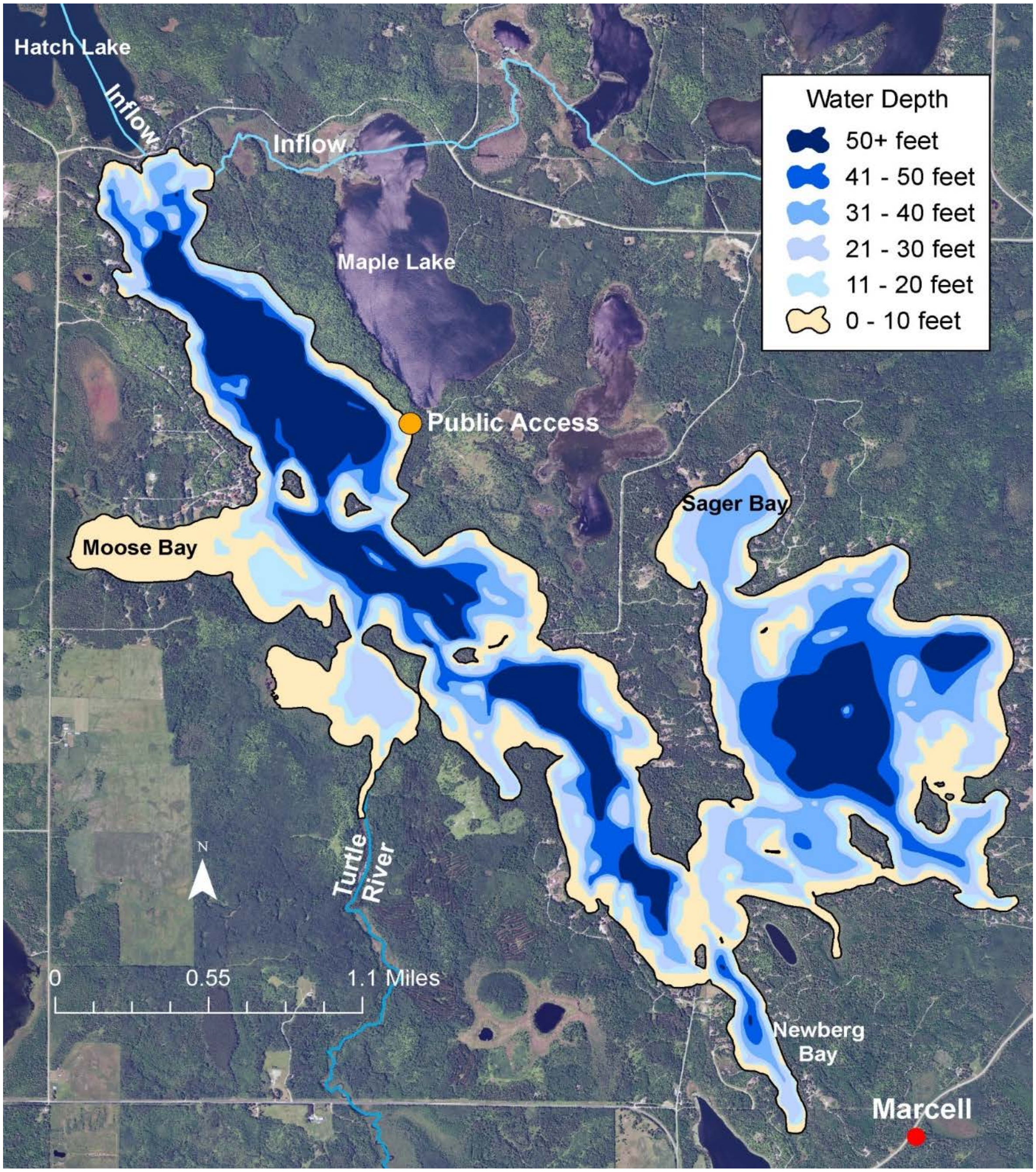
[A] *Najas gracillima* and *Ruppia occidentalis* are rare species that were reported, but not officially confirmed, in Turtle Lake in 1950 and 1975. These plants closely resemble several other submerged plants and without a voucher specimen it is not possible to confirm these plants in the lake.
[B]some plants were only identified to the genus level in this lake. It is possible that additional species of this genus were present in the lake, but only one species was positively identified.
[C]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.

2013 (July 9, 10, 11, 22, 23, 24, 25, 30, 31, August 14-15, September 3)
Perleberg, Simon, Froelich, Hauck, Schubert, MNDNR EWR Lakes and Rivers Unit
2001 (July 24) Karen Myhre, MNDNR County Biological survey
1975 survey (July 21-25) Marc Olson, MNDNR Division of Game and Fish: Major bulrush stands grew on North shore of main basin and heavy stands of bulrush in southwest bay of lake. Submerged vegetation found to a depth of 17 feet.
1950 (August 16-23) Robert Erickson, Robert Farmes, MN Department of Conservation Division of game and fish.
1935 (September 4) Chippewa National Forest survey.

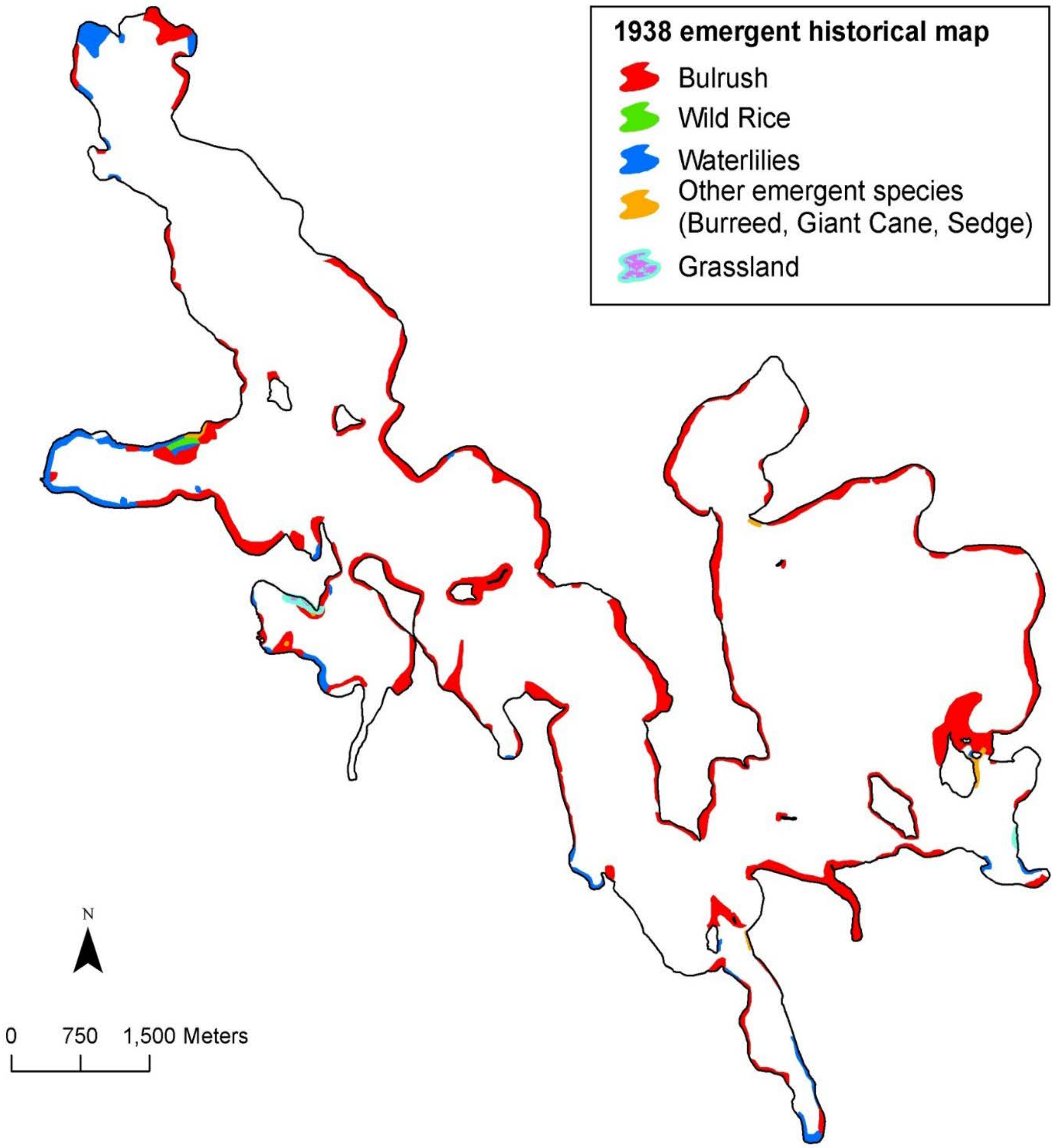
Map 1. Turtle Lake within Big Fork River Watershed.



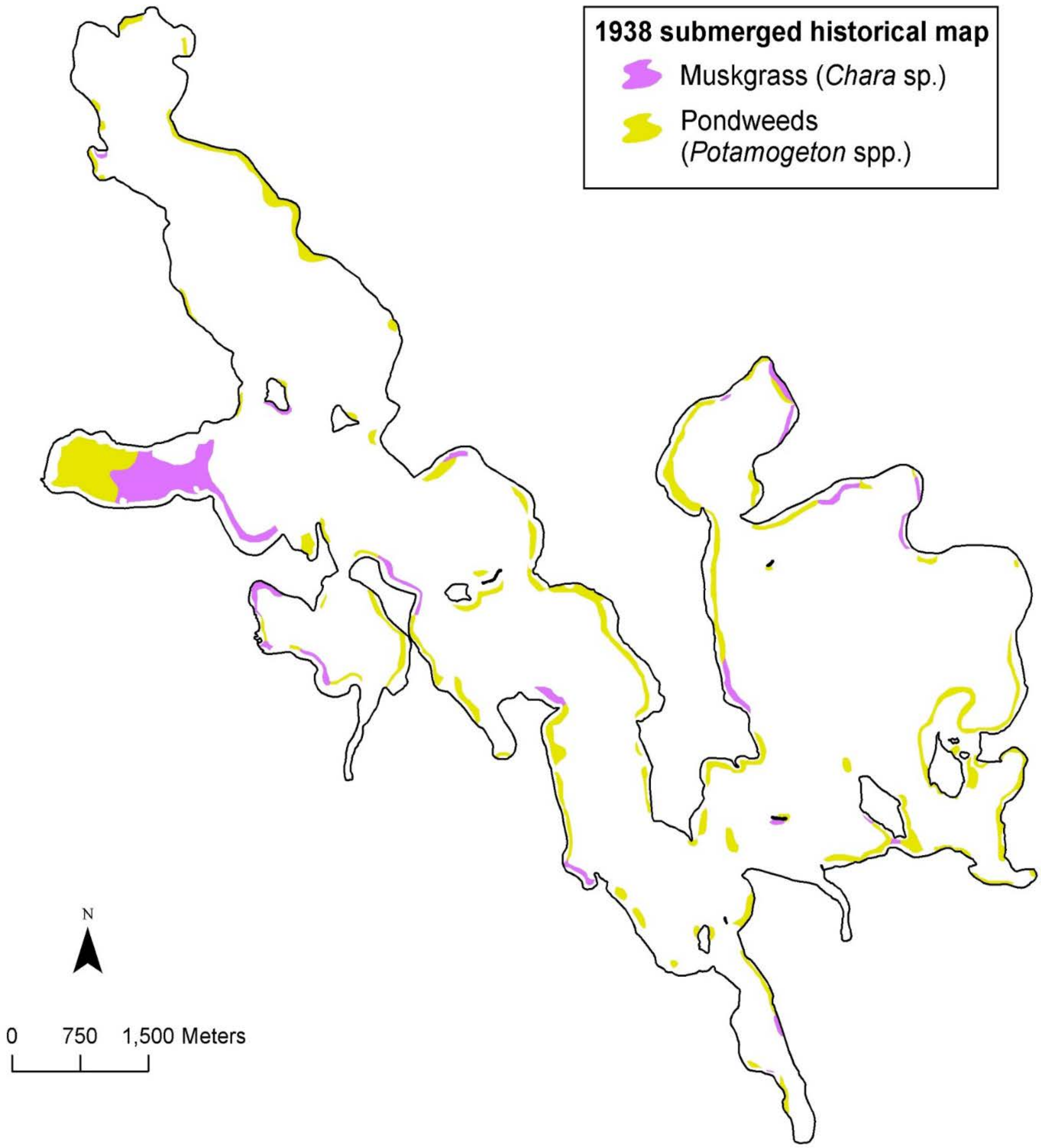
Map 2. Depth contours and features of Turtle Lake (10, 20 foot are based on 2013 vegetation survey data).



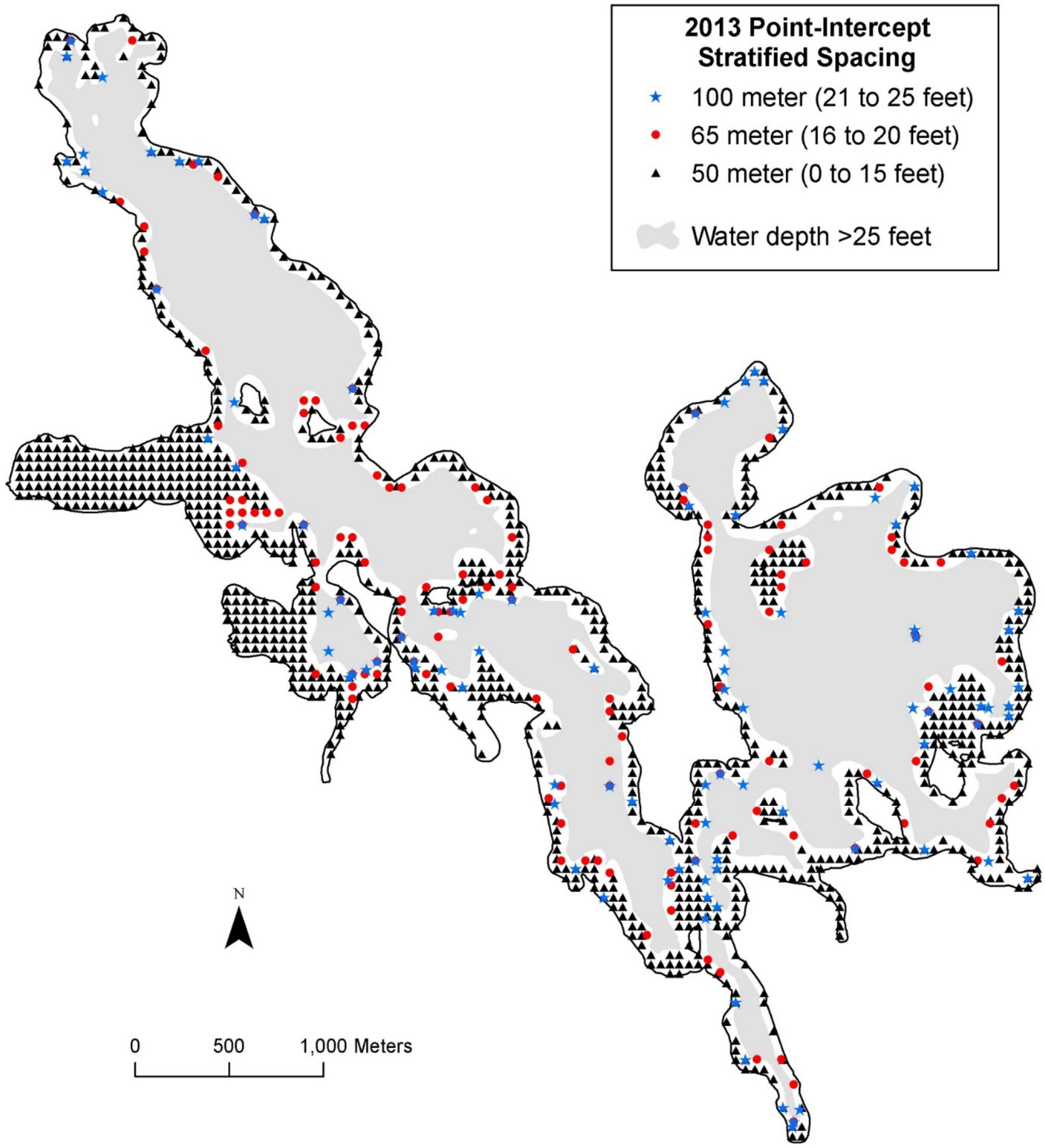
Map 3. 1938 historical emergent vegetation.



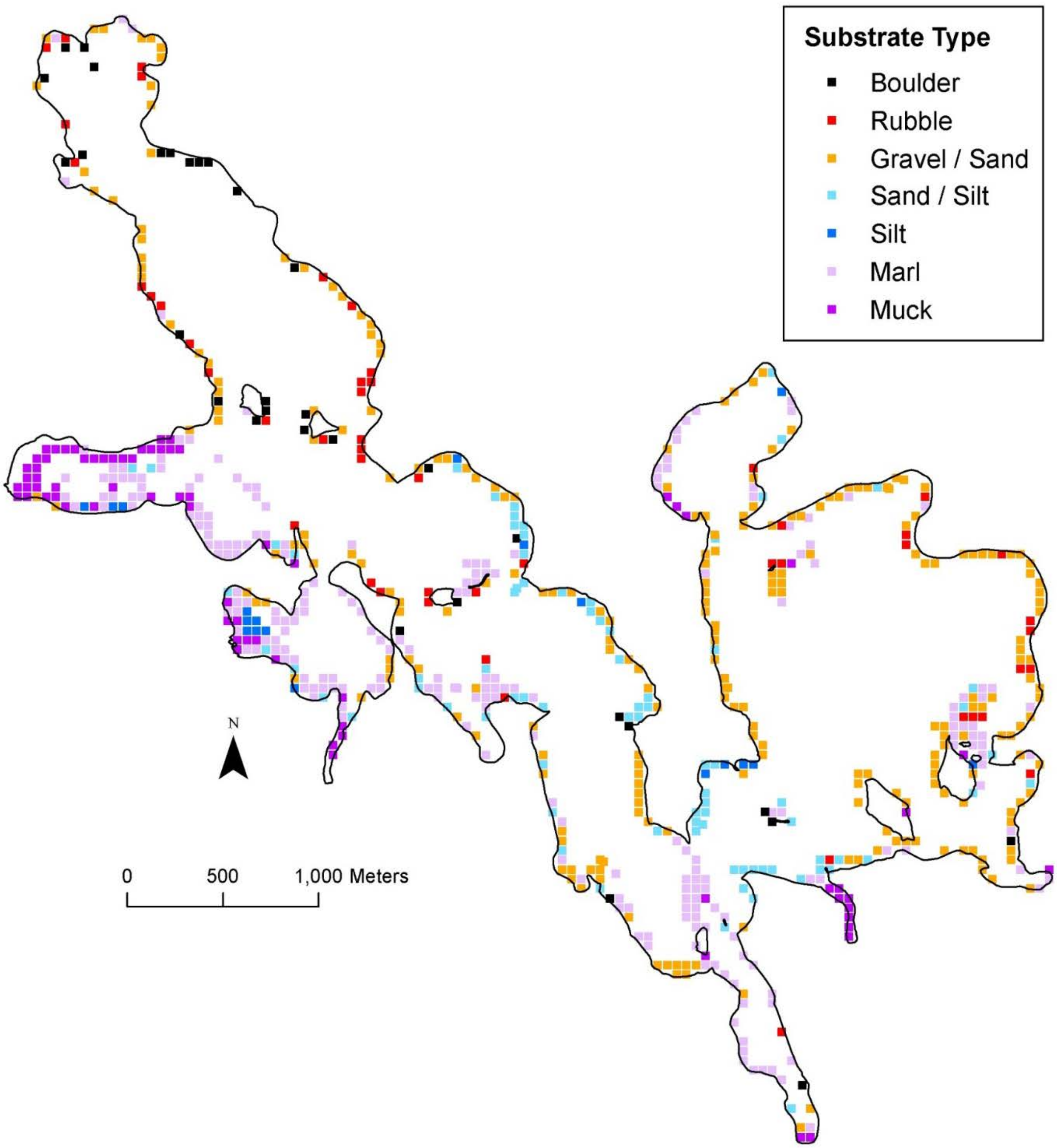
Map 4. 1938 historical submerged vegetation.



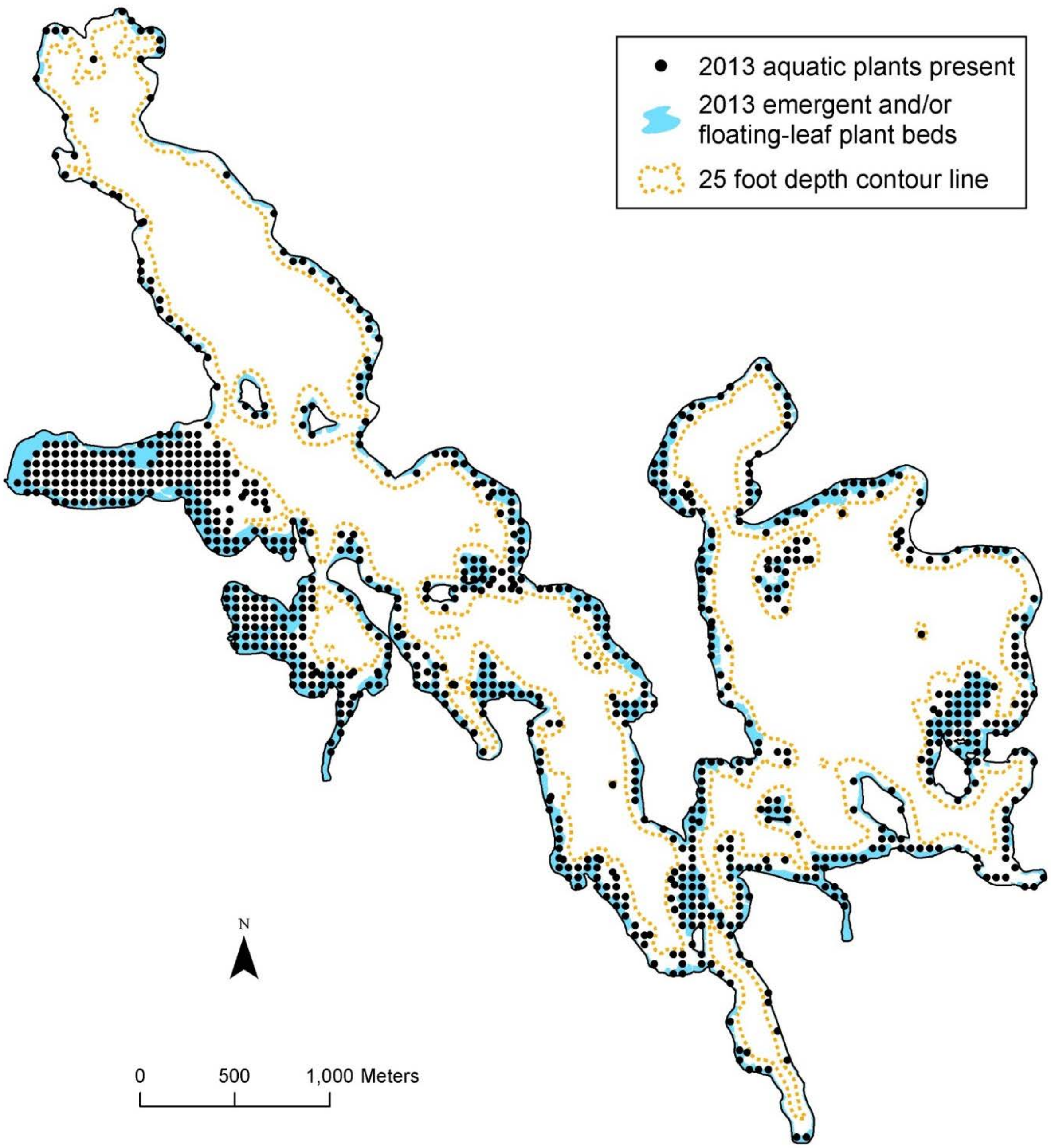
Map 5. 2013 Point-Intercept stratified survey sites on Turtle Lake.



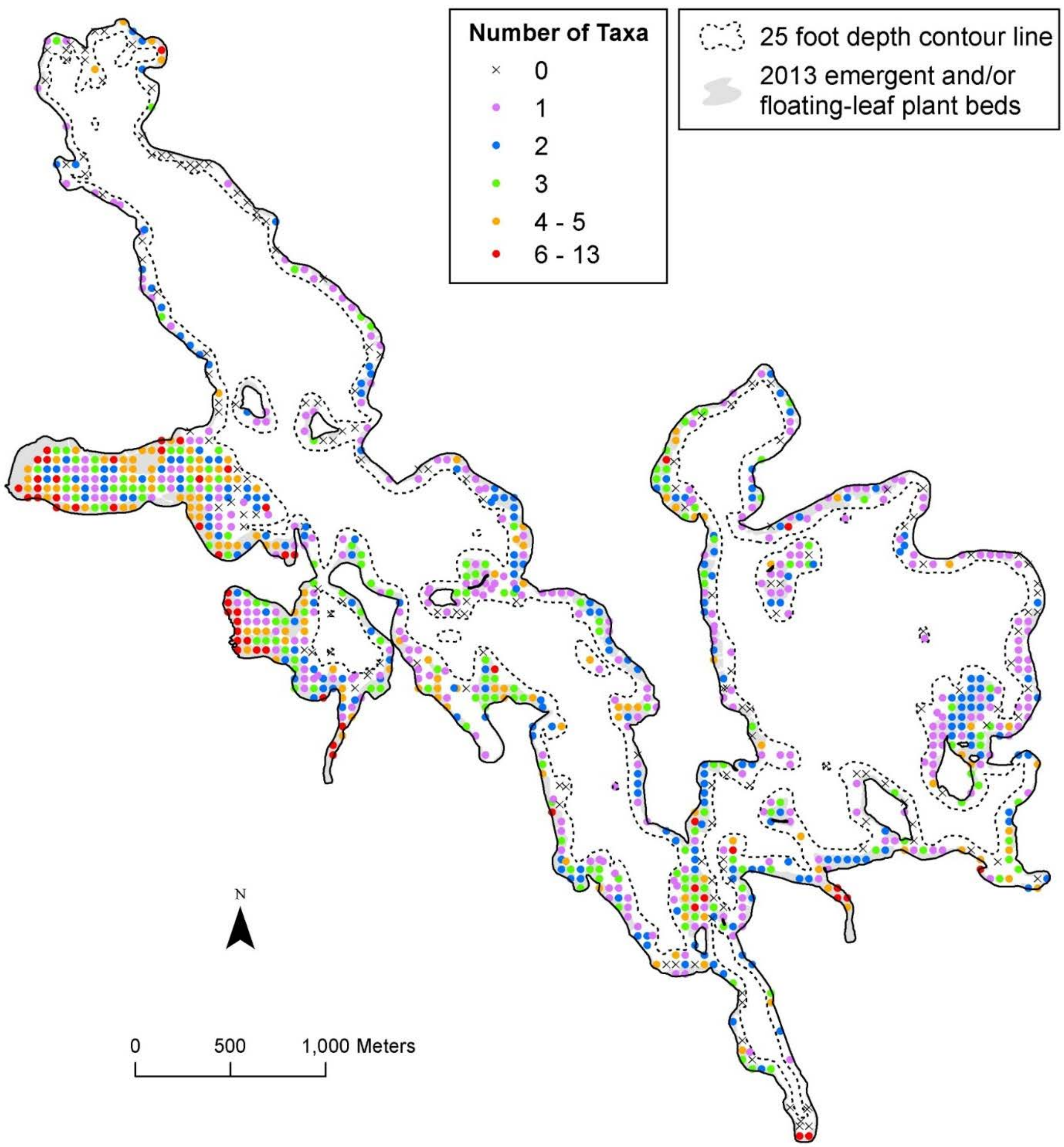
Map 6. Near-shore substrates of Turtle Lake, 2013.



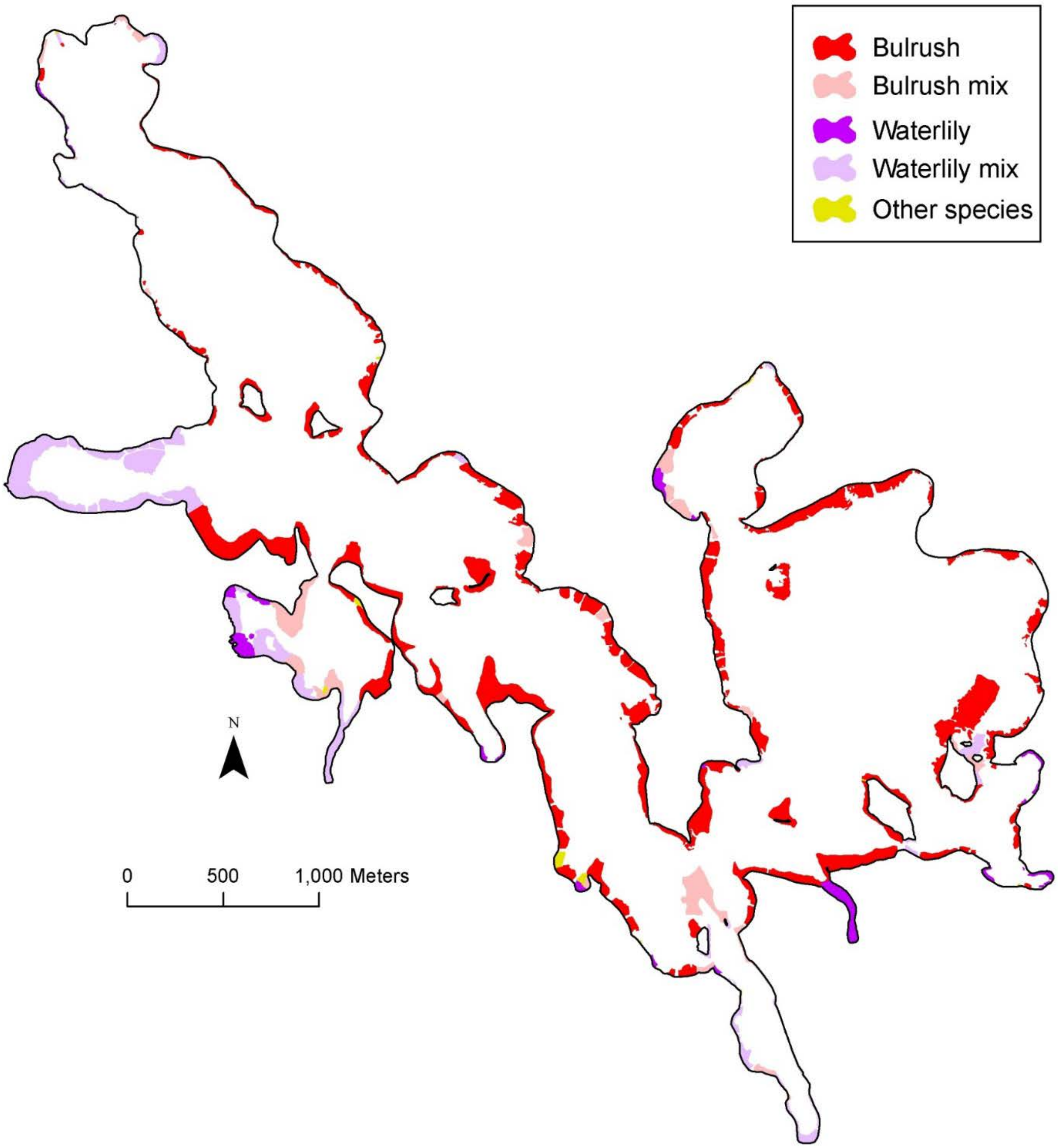
Map 7. 2013 aquatic vegetation distribution, Turtle Lake, 2013.



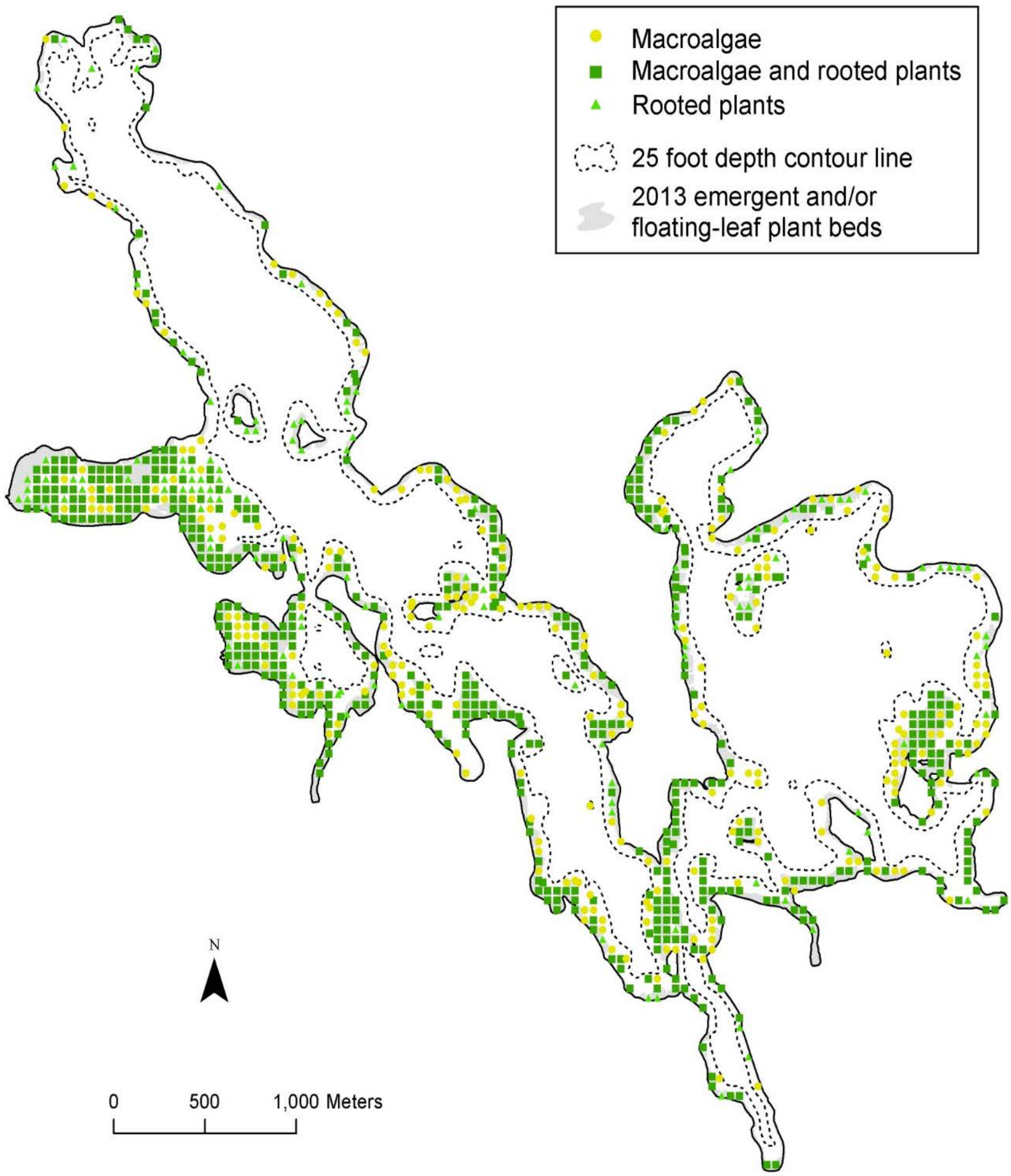
Map 8. Number of taxa per sample site, Turtle Lake, 2013.



Map 9. Emergent and floating-leaf plant beds, Turtle Lake, 2013.



Map 10. Macroalgae vs. rooted plants, Turtle Lake, 2013.



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.

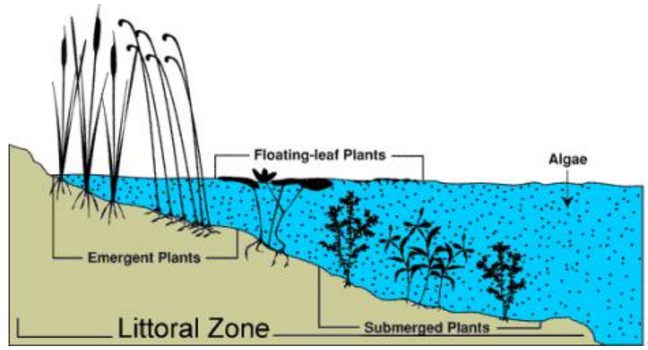
Taxa (singular taxon) is a term that refers to any group of plants, such as species or genus. In this report it is used to identify the number of different types of plants that were identified during a lake survey. In several cases, plants could not be identified to the species level but could be distinguished 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.

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.

Figure A. Forms of aquatic plants found in Minnesota lakes.



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

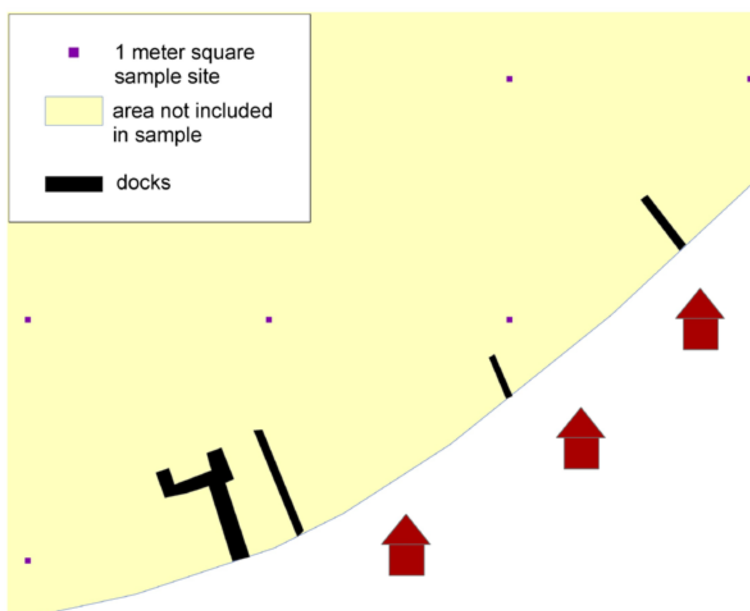
“Abundance” is a general term that does not have any quantitative meaning. For vegetation sampling, there are several ways to quantify abundance.

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 Turtle Lake there were 1066 sample sites in the 0-25 feet depth zone.
Muskgrass occurred in 735 sites.
Frequency of Muskgrass in 0-25 feet zone = (735/1066)*100 = 69%

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. This method is designed to estimate the frequency of occurrence of commonly occurring taxa. To detect infrequently occurring

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



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.

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.

Richness = is 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.