Aquatic Vegetation of Lake Fourteen

June, 2012
Lake Fourteen, ID# 69-0793-00

St. Louis County, Minnesota

Minnesota
DEPARTMENT OF NATURAL RESOURCES

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Acknowledgements:

We would like to thank David Wright, MNDNR Ecological and Water Resources Supervisor (St. Paul) and Joe Mix MNDNR Assistant Regional Fisheries Supervisor (Grand Rapids) for their helpful review of this report.

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.

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Perleberg, D. and S. Simon. 2012. Aquatic vegetation of Lake Fourteen (69-0793-00), St. Louis County, Minnesota, 2012. Minnesota Department of Natural Resources, Division of Ecological and Water Resources, 1601 Minnesota Drive, Brainerd, MN 56401. 22 pp.

SUMMARY

Lake Fourteen is a 386 acre, mesotrophic, soft water lake in northeastern Minnesota. The lake is entirely shallow and water clarity is sufficient to allow plant growth at all depths. As early as 1947, Lake Fourteen residents expressed concern about the amount of submerged plant growth. This concern continues today, particularly in mid-summer when submerged plants naturally fragment and accumulate along shorelines.

A quantitative survey of the lake was conducted in June, 2012. The survey was conducted before most plants had reached full summer growth, but the resulting data can be used to characterize the general plant communities and identify potential sites for habitat protection and/or to discuss recreational access objectives.

A total of 27 native aquatic plant taxa were recorded in Lake Fourteen including 3 emergent, 3 floating-leaf and 21 submerged taxa. To date, non-native aquatic plants have not been documented in Lake Fourteen. Extensive emergent and floating-leaf plant beds have never been reported in this lake and in 2012 they were limited to narrow bands along shore and at the western outlet.

Submerged plants were found at all depths but at the time of the June 2012 survey, they did not form surface mats. A wide diversity of submerged plants were found and included taller growing, leafy plants that are common in fertile, hard-water lakes and short, rosette-forming plants that are more common in nutrient poor, soft-water lakes. Despite the high number of submerged taxa, two plants, Canada waterweed (*Elodea canadensis*) and narrow-leaf pondweed (*Potamogeton* sp.), dominated the plant community, with each present in more than 50% of the sites. These plants were most common in the 6-16 feet depth zone. Broad-leaf pondweeds (*Potamogeton* spp.), coontail (*Ceratophyllum demersum*) and stonewort (*Nitella* sp.) were also frequent, occurring in 10% or more of sites.

A suite of unique submerged plants that are adapted to soft water, nutrient poor lakes were identified in Lake Fourteen for first time in 2012. They were likely present in earlier years but overlooked due to their small stature. They appeared to be restricted to shallow, sandy sites close to shorelines; these sites were likely not favorable to the taller, leafier plants and provided a competition-free location for these tiny plants.

Because historical data are limited and Lake Fourteen has been developed for many decades, it is difficult to know how the plant community and/or water quality may have changed since the 1930's. In other lakes where human caused eutrophication has occurred, there have been documented shifts from small soft water plants to taller, leafy, hard water plants. Lake Fourteen currently contains both types of these habitats, with the soft water plants restricted to sandy, shallow areas near shore. These sites, along with isolated beds of waterlilies, narrow bands of emergent plants, and beds of broad-leaf pondweeds provide unique habitat areas in this lake. The deeper water submerged beds, though less diverse, also serve an important role in the lake's ecosystem by providing oxygen and fish habitat to the lake.

INTRODUCTION

Lake description

Lake Fourteen is located about 11 miles south of the town of Cook within St. Louis County of northeast Minnesota. The lake is named "Fourteen" because it occurs almost entirely within Section 14 of Township 60. Historical reports also list the lake name as "Crescent" which may refer to its crescent-shaped perimeter. The lake occurs within the Little Fork River Watershed (Figure 1). There are no permanent inlets to the lake and it outlets to the west. Flow continues northwest through the Dark River and Bear River before joining the Little Fork River which drains the watershed to the north[1].

Land use in this watershed is primarily forested land and wetlands. Lake Fourteen occurs within the boundaries of the Superior National Forest but riparian ownership is private with no designated public access. For decades, most of the shoreline has been developed with residential homes with the exception of the west bay that is bordered by a wetland.

With a surface area of 386 acres and 4 miles of shoreline, it is one of the smaller lakes in the county and the eleventh largest lake in the watershed. It is a shallow lake with a maximum recorded depth of 18 feet and a mean depth of 8 feet; about 90% of the lake is less than 15 feet deep (Figure 2).

Figure 1. Lake Fourteen within Little Fork River Watershed.

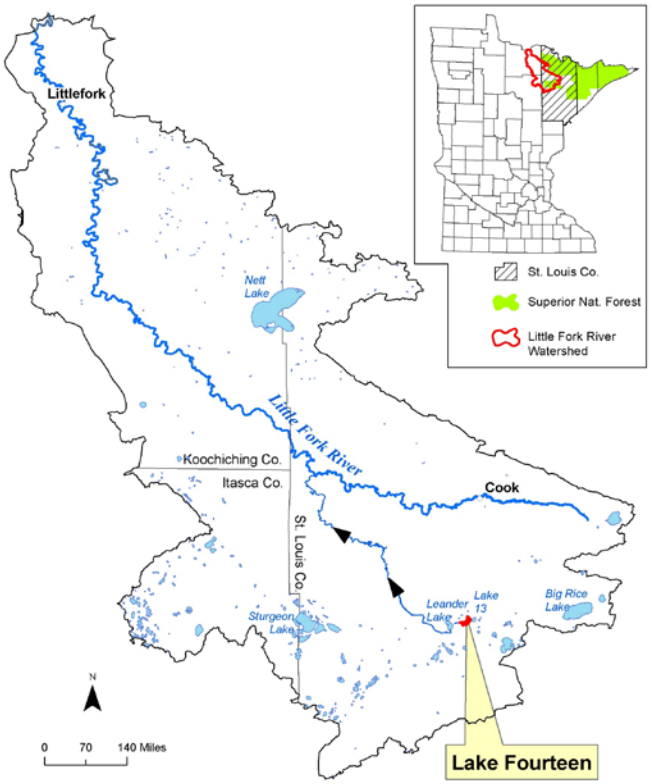
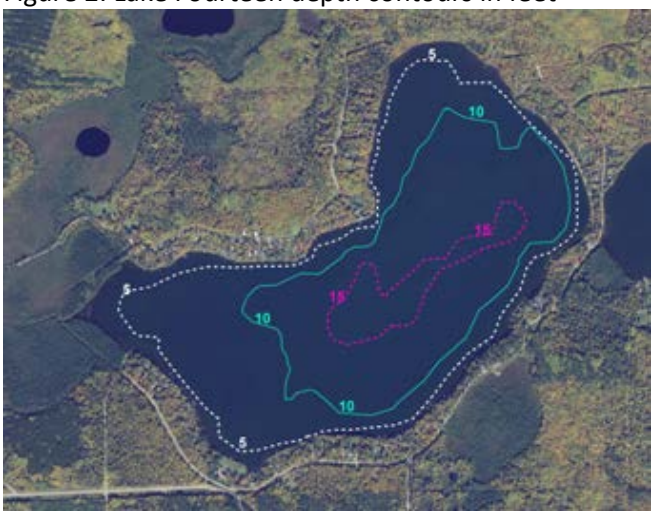


Figure 2. Lake Fourteen depth contours in feet



Depths based on 2012 survey data. 2010 FSA aerial photograph

[1] The Little Fork River flows north to Rainy River, then Lake of the Woods and eventually to Hudson Bay.

Water quality data are limited but Lake Fourteen has been described as a **soft water, mesotrophic** lake[2]. It is a bog-stained lake with sandy shorelines and summer clarity estimated at 5-13 feet[3].

Historical aquatic plant community

Historical information on the aquatic plant community of Lake Fourteen are available from periodic surveys conducted from 1936 through 1991 by MNDNR staff (MNDNR Lake Files). Caution must be used when comparing historical and present survey data because of differences in survey methods, including differences in the lake areas surveyed. Additionally, lake plant populations can fluctuate naturally and dramatically. For **species** with certain types of reproductive characteristics, abundant plant growths may suddenly appear or decline without obvious reasons.

Types of plants present

A total of 17 native aquatic plant **taxa** have been recorded in past surveys of Lake Fourteen including 3 **emergent**, 3 **floating-leaf** and 11 **submerged** taxa. The plants reported in these surveys are commonly found in moderate **alkalinity** (hard-water), fertile lakes of central and north-central Minnesota. They can be described as "leafy" plants that grow tall in the water column. They include taxa that are tolerant of turbidity as well as taxa that require clear water. Some of these plants take up nutrients through root systems and/or the water column, while others are only loosely attached to the lake bottom and absorb most nutrients through the water column. To date, non-native aquatic plants have not been documented in Lake Fourteen.

Depth and extent of plant growth

Factors that may influence the depth of plant growth include water clarity, substrate type, wind fetch and the types of plants present. Emergent and floating-leaf plants have only periodically been reported as "common" and there are no descriptions of large beds of these types of plants in Lake Fourteen. In 1955, yellow waterlily was described as "common", which may indicate that at least small beds of these plants occurred at several locations around the lake. In 1991, only 1% of the lake was estimated to contain emergent plants and waterlilies were reported as mainly growing in the west bay.

Photo 1: Submerged plants accumulated along Lake Fourteen shore, summer 2011

submitted by Sue Hendrickson, Lake Fourteen resident

Based on water clarity alone, submerged plants have the potential to grow at all depths within Lake Fourteen[4] and it has historically supported abundant submerged plant

[2] Based on limited field alkalinity measurements ranging from 22 ppm to 68 ppm and a single (1955) total phosphorus measurement of 0.02 ppm (total N was 0.76 ppm).

[3] Water clarity data as estimated from satellite imagery (U of MN Remote Sensing Lab U OF MN GIS-Lakes).

[4] As a general rule, sunlight can penetrate to a depth of 2 times the Secchi depth and aquatic plants can grow to a depth of 1.5 times the Secchi depth.

growth to at least the 10 foot depth. The types of submerged plants recorded as most common have varied between survey years. In 1955, Canada waterweed (*Elodea canadensis*) was reported as "common" at all depths and most abundant in depths less than 10 feet with large masses of the plant found drifting around the lake and stranded along the shoreline. In 1980, dense watermilfoil (*Myriophyllum* sp.) growth was reported over much of the lake. In 1991 and 2011[5], Canada waterweed was again reported as abundant. Also in 2011, coontail (*Ceratophyllum demersum*) was reported for the first time and was also described as "high density".

Aquatic plant control

As early as 1947, Lake Fourteen residents expressed concern about the amount of submerged plant growth. Past attempts to control plants have included herbicide applications and mechanical harvesting. In recent years, lake residents have again expressed concern about submerged plant growth, particularly when plants uproot and accumulate along shorelines (Photo 1).

Survey objectives

A quantitative plant survey of Lake Fourteen was conducted in June 2012 to describe the composition, distribution and abundance of the in-lake plant communities. In northern Minnesota lakes, vegetation surveys are typically conducted in late summer when aquatic plants are at peak growth. However, the Lake Fourteen 2012 survey was conducted in June to provide immediate information to lake residents who were considering plant management options. The results provide a snapshot of what the plant communities looked like in early summer but do not provide information on plants that begin growth later in the summer. Nevertheless, the June survey data may be useful to help identify potential sites for habitat protection and/or to discuss recreational access objectives. Survey objectives included:

1. Record the aquatic plant taxa observed in the lake.
2. Describe the distribution and abundance of the commonly occurring taxa.
3. Identify areas of unique plants that may warrant special protection.

METHODS

Water quality

On June 21, 2012, a surface water sample was collected from the center of the lake, packed in ice, and shipped to the Minnesota Department of Agriculture (MDA) laboratory in St. Paul for analysis. Analyses included pH, conductivity, alkalinity, total dissolved solids, total phosphorus, and chlorophyll a. Because alkalinity can be susceptible to change over time, it was also

[5] October 2011 survey by Lake Management, Inc. (LMI), Marine on St. Croix, MN.

measured immediately in the field. Moderate wind prevented surveyors from measuring water clarity with a Secchi disc.

Table 3. Water quality analysis, June 21, 2012.

Parameter	Lake Fourteen
pH	7.25
Total alkalinity (ppm = mg/L)	25[a] -30[b]
Specific conductivity (umhos/cm)	85.4
Total dissolved solids (ppm)	124
Total phosphorus (ppb)	20
Chlorophyll a concentration (ppb)	2.4[c]-4.9[d]

[a]lab measurement, [b]field measurement
[c]trichromatic method calculation
[d]pheophytin a correction method calculation

Lakewide vegetation survey

A lakewide vegetation survey was conducted on June 20 and 21, 2012 using a point-intercept survey method (Madsen 1999, MNDNR 2012). Survey waypoints were created using a geographic information system (GIS) computer program and downloaded into a handheld geographic positioning system (GPS unit). Sample methodology requires that a minimum of 100 points be sampled to estimate the frequency of occurrence of the most common taxa. Survey points were placed across the entire lake and spaced 80 meters (262 feet) apart; this resulted in a total of 241 survey sites (Figure 3, Table 1).

The survey was conducted by boat and a GPS unit was used to navigate to each sample point. One side of the boat was designated as the sampling area. At each site, water depth was recorded in one-foot increments using a measured stick in water depths less than seven feet and an electronic depth finder in deeper water.

Figure 3. 2012 vegetation survey sites on Lake Fourteen.

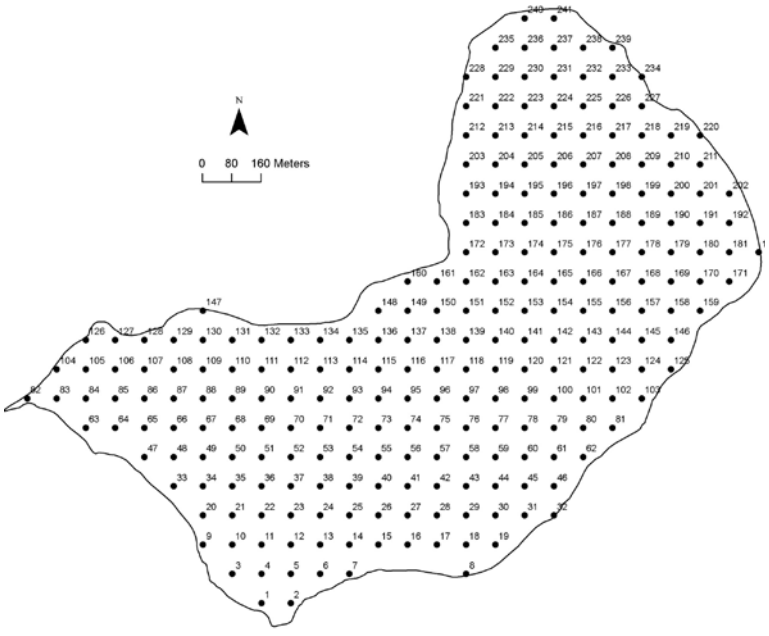


Table 1. Survey effort by depth

Water depth (feet)	Number of survey sites
0 to 5	41
6 to 10	106
11 to 16	94
Total	241

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 7 feet, surveyors collected depth and vegetation data and then motored into shallower water and recorded the substrate type adjacent to the actual survey point; this information was used for mapping purposes.

Table 2. Substrate classes

boulder	diameter > 10 inches
rubble	diameter 3 - 10 inches
gravel	diameter 1/8 - 3 inches
sand	diameter < 1/8 inch
silt	fine material with little grittiness
marl	calcareous material
muck	decomposed organic material
detritus	leaf litter

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 2). Plant identification followed Crow and Hellquist (2000) and Flora of North America (1993+) and nomenclature followed MNTaxa (2012).

Photo 2. Survey rake.

Frequency of occurrence was calculated for the entire lake 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.

Mapping emergent and/or floating-leaf vegetation beds

Because the sample points for the lakewide survey were 80 meters apart, small but important beds of emergent and floating-leaf plants can be undetected; therefore, surveyors used a different method to delineate any emergent or floating-leaf plant beds in the lake. Surveyors mapped any in-lake 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). Surveyors used an electric trolling motor to motor around the perimeter of each bed and recording a track with a handheld GPS unit. Field data were uploaded to a computer and a GIS software program was used to estimate acreage. Plant beds were classified by the dominant taxa.

RESULTS AND DISCUSSION

Water quality

Based on the single water sample collected in 2012, Lake Fourteen can be described as a mesotrophic, soft water lake (Table 3).

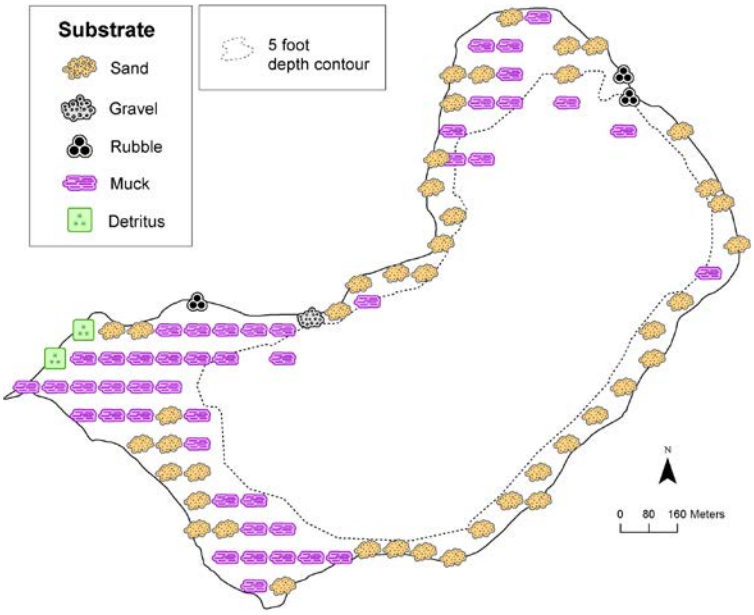
Substrates

Shallow water (0-7 feet) substrates of Lake Fourteen were mostly sand but muck occurred in areas of the west and north shore (Figure 4). In deeper water, surveyors frequently observed muck attached to vegetation samples and it is presumed that deep water substrates were primarily muck.

Types of plants recorded

A total of 27 native aquatic plant taxa were recorded in Lake Fourteen. The plants included 3 emergent, 3 floating-leaved and 21 submerged taxa. No non-native aquatic plants were detected.

Figure 4. Nearshore substrates of Lake Fourteen, 2012.



The plant community was composed of a mixture of hard water taxa and several taxa that are unique to soft water lakes. One-third of these taxa were recorded for the first time during the 2012 survey (Table 4). Most of these newly discovered taxa were small, soft water taxa that can be difficult to locate; they were not found in high numbers in 2012 and were likely present in previous years but undetected. Water milfoil (*Myriophyllum* sp.), which was reported as growing densely in 1980, was not detected in 2012 and this may reflect a real variation in the annual abundance of this plant. The emergent plant, bulrush (*Schoenoplectus* sp.), and the submerged plant, greater bladderwort (*Utricularia vulgaris*), were the only other taxa reported during historical surveys that were not found in 2012; neither of these taxa were reported as widespread or common in previous surveys and their absence from the 2012 survey may simply reflect their sparse occurrence in the lake. In addition to the taxa detected in June of 2012, there may have been additional taxa that emerged later in the growing season and therefore went undetected.

Table 4. Summary of plant species recorded in Lake Fourteen, 1936-2012.

Life Form		Scientific name	Common name		Survey Year					
					1936	1955	1963	1980	1991	2012
Soft-water taxa[1]	Submerged	*Isoetes* sp.	Quillwort							2
		Juncus pelocarpus	Brown-fruited rush							1
		Elatine minima	Waterwort							1
		Eleocharis sp.	Needlerush						P	<1
		Lobelia dortmana	Water lobelia							1
		Myriophyllum tenellum	Leafless water milfoil							1
		Potamogeton vaseyi	Vasey's pondweed							<1
	floating	*Sparganium fluctuans*	Floating-leaf burreed						O	<1
Hard water taxa	Submerged	*Elodea canadensis*	Canada waterweed			A			A	57
		Potamogeton sp.*	Straight-leaved pondweed						A	55
		Ceratophyllum demersum	Coontail							19
		Nitella sp.	Stonewort							18
		Potamogeton robbinsii	Broad-leaf pondweeds	Robbin's pondweed					C	14
		Potamogeton amplifolius		Large-leaf pondweed	P	C	P		O	9
		Potamogeton gramineus		Variable pondweed		C				8
		Potamogeton praelongus		White-stem pondweed						3
		Potamogeton richardsonii		Clasping-leaf		C			A	2
		Potamogeton alpinus		Alpine pondweed						<1
		Myriophyllum sp.	Water milfoil					A		
		Najas flexilis	Bushy pondweed		P					4
		Vallisneria americana	Water celery			C			R	2
		Utricularia vulgaris	Common bladderwort				P		R	
		Chara sp.	Muskgrass							1
		Not identified to genus	Watermoss							<1
	floating	*Nuphar variegata*	Common yellow waterlily		P	C			O	P
		Nymphaea odorata	Common white waterlily		P				O	P
Emergent		*Calla palustris*	Water arum							P
		Sagittaria sp.	Arrowhead						C	1
		Schoenoplectus sp.	Bulrush		P					
		Typha sp.	Cattail		P				P	P
Total number of taxa detected					6	6	2	1	13	27

[1]These species are typically found in low alkalinity (<100 mg/L), low conductivity (<200 umhos/cm) lakes.

A=abundant, C= common, R=rare, P=present
In 2012, the frequency (percent of sites where plant occurred) is listed, number of sample sites = 241.

*One species of narrow-leaf pondweed, Potamogeton strictifolius, was identified in 1991 but other species may be present. Mature plants were not present at the time of the 2012 survey so the plants could not be identified to the species level.

Distribution and richness of aquatic plants

Plants were found to a depth of 16 feet, the maximum depth sampled, and 93% of all sites contained vegetation (Figure 5). The highest number of plant taxa was found in the shallow water, in depths less than 6 feet. All but 2 of the 27 taxa found in the lake were present within

this shallow zone and 11 were only found in this area. Only 6 submerged taxa occurred in depths greater than 10 feet (Figure 6). The number of plant taxa found at each sample site ranged from 0 to 7 with a mean of 2.0 taxa per site.

Figure 5. Plant distribution in Lake Fourteen, 2012.

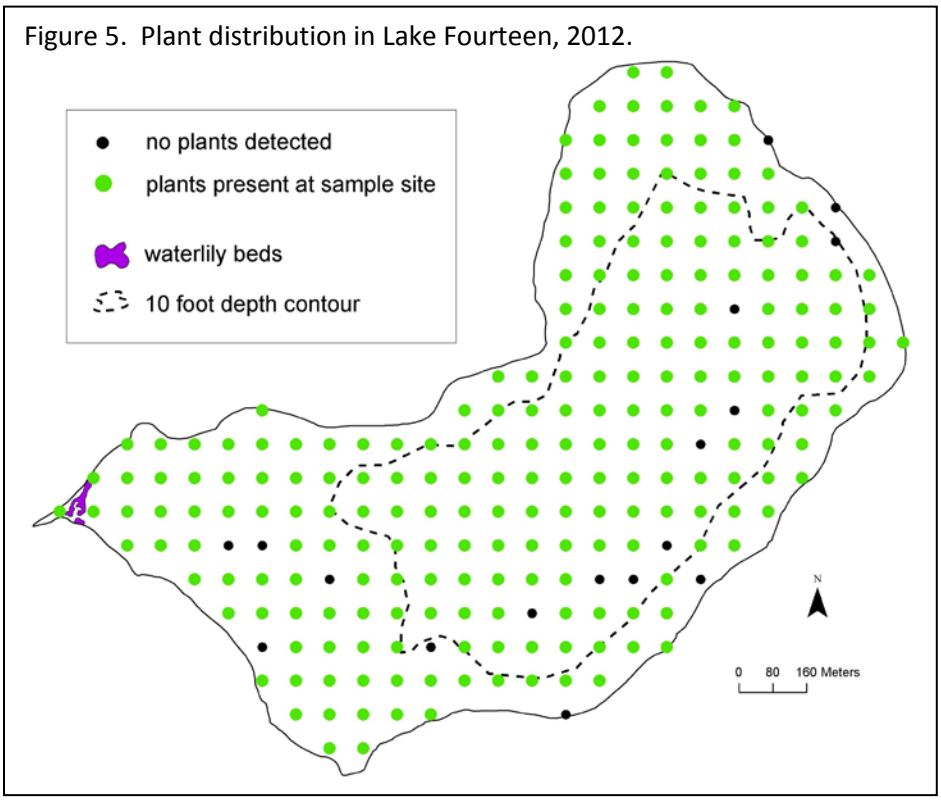
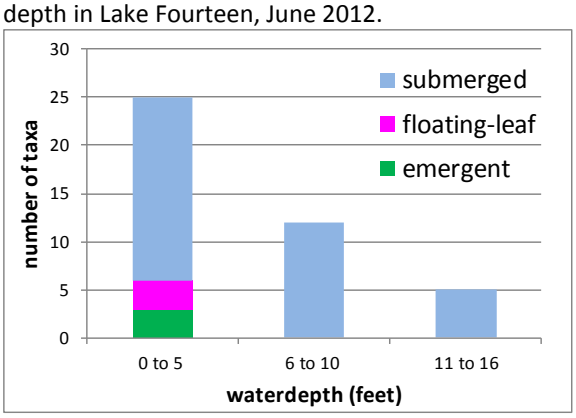


Figure 6. Number and types of plants by water depth in Lake Fourteen, June 2012.



Emergent and floating-leaf plant beds

In 2012, emergents were present in narrow bands along undeveloped shorelines and included cattails (Typha sp.) (Photo 3), arrowhead (Sagittaria sp.) and water arum (Calla palustris) (Photo 4). Numerous native emergent taxa occurred in adjacent wetlands were not inventoried during this survey. A floating-leaf plant bed, about 0.5 acres in area, occurred at the outlet on the

west side of the lake(Figure 5) and included white waterlily (Nymphaea odorata), yellow waterlily (Nuphar variegata), and floating-leaf burreed (Sparganium fluctuans).

Photo 3. Loon nesting in emergent cattails and water arum on Lake Fourteen shoreline.

Photo 4. Yellow waterlilies (floating) and water arum (emergent) along Lake Fourteen shoreline.

Submerged plants

In Lake Fourteen, submerged plants were found at all depths but at the time of the June 2012 survey, they did not form surface mats. A wide diversity of submerged plants were found and included taller growing, leafy plants that are common in fertile, hard-water lakes and short, rosette-forming plants that are more common in nutrient poor, soft-water lakes. Distribution maps of the commonly occurring submerged plants are provided in the Appendix.

Hard water submerged plants

Despite the high number of submerged taxa, two plants, Canada waterweed (*Elodea canadensis*) and narrow-leaf pondweed (*Potamogeton* sp.), dominated the plant community, with each present in more than 50% of the sites (Table 4). Broad-leaf pondweeds (*Potamogeton* spp.), coontail (*Ceratophyllum demersum*) and stonewort (*Nitella* sp.) were also frequent, occurring in 10% or more of sites.

Photo 5. Canada waterweed.

Canada waterweed (*Elodea canadensis*; Photo 5) is a perennial submerged plant that is widespread throughout Minnesota. It is adapted to a variety of conditions and is tolerant of low light and prefers soft substrates (Nichols 1999). It is a weakly rooted plant and obtains most of it nutrients directly from the water column. Because it lacks a true winter dormant phase, it relies on receiving adequate winter sunlight to overwinter as a green plant under the ice. This plant can form flowers and produce seeds, but it mostly spreads by vegetative fragments that break from the plant and drift with water currents to new sites.

Canada waterweed was found in 57% of the Lake Fourteen survey sites (Figure 7) and at any depth zone it occurred in at least 40% of sites (Figure 8). In most (94%) of the sites where it occurred, it was found with at least one other taxon and was commonly found with narrow-leaf pondweed (*Potamogeton* sp.).

Figure 7. Distribution of Canada waterweed, narrow-leaf pondweed and other taxa in Lake Fourteen, June, 2012.

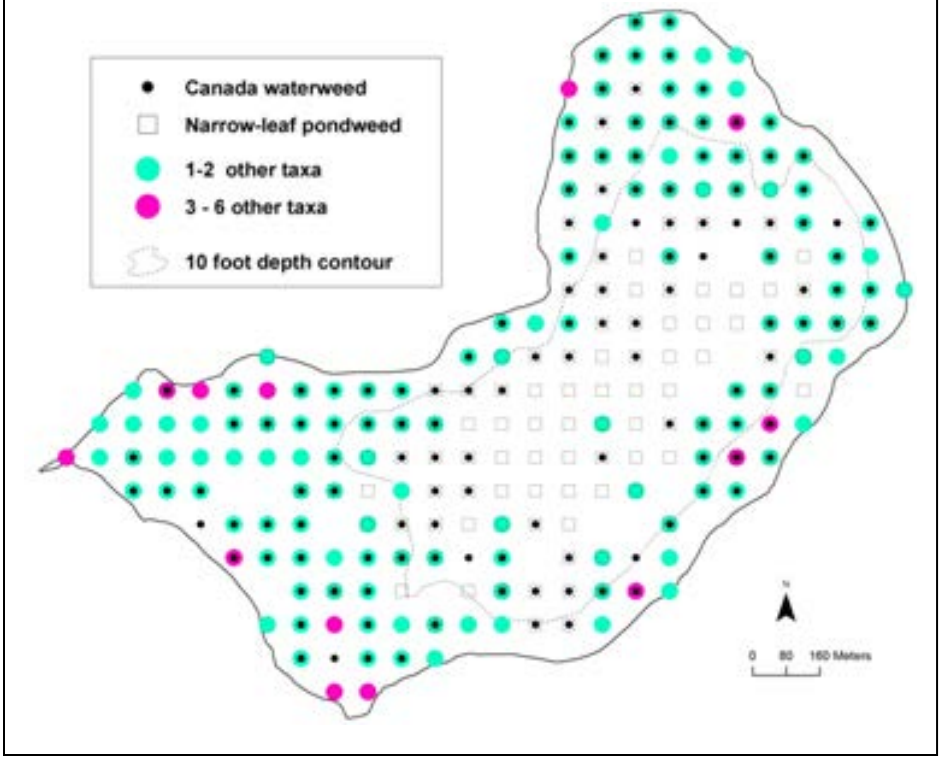
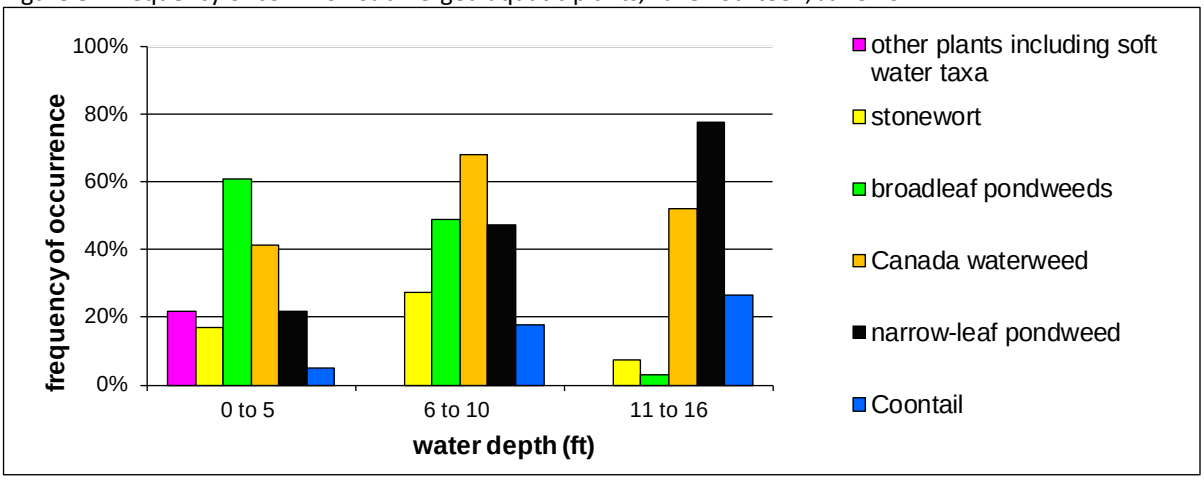


Figure 8. Frequency of common submerged aquatic plants, Lake Fourteen, June 2012



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.

About half of Minnesota's pondweeds can be described as Narrow-leaf pondweeds (Photo 6) because their leaves are only a few centimeters in width while many others are grouped as Broad-leaf pondweeds (Photo 7) with leaves that may be up to 10 centimeters wide.

Photo 6. Narrow-leaf pondweed.

Photo 7. Broad-leaf pondweed.

In Lake Fourteen, narrow-leaf pondweed occurred in 55% of all sample sites (Figure 11), was present at all depths and was most common in the 11 to 16 feet depth zone where it occurred in 78% of sites (Figure 8). In one-third of these deep water sites, narrow-leaf pondweed was the only plant detected. When it did co-occur with other plants, it was most often found with Canada waterweed and/or coontail (*Ceratophyllum demersum*).

Broad-leaf pondweeds, also referred to as "cabbage" are particularly important fish habitat. Most broad-leaf pondweeds are intolerant of turbidity and are among the first plants to disappear or decline in a lake if water clarity declines. Six different species of broad-leaf pondweeds were found in Lake Fourteen and 32% of all sites contained at least one of these taxa. Broad-leaf pondweeds were primarily found in depths of 10 feet and less and were often found co-occurring with at least one other taxon.

Coontail (*Ceratophyllum demersum*) (Photo 8) is the most common submerged plant in Minnesota. This plant grows entirely submerged and its roots are only loosely anchored to the lake bottom. Like Canada waterweed, it obtains nutrients primarily from the water column. 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

Photo 8. Coontail

spring, spreading primarily by stem fragmentation. The finely divided leaves of this plant provide a home for insects valuable as fish food. Coontail occurred in 19% of the Lake Fourteen sites. It was one of the few taxa present in the 11 to 16 feet depth zone, where it reached its maximum frequency of 27%.

Stonewort (*Nitella* sp.) (Photo 9) is a large algae that resembles a submerged flowering plant but does not form true stems, leaves, roots or flowers. Like coontail and Canada waterweed, it may be loosely attached to the substrate or may float freely and it obtains nutrients directly from the water column. It grows entirely submerged is often found in deeper water than rooted plants. In some lakes it may represent the only submerged habitat in the deep water zone. In Lake Fourteen, stonewort occurred in 18% of the sample sites and was most frequent in the intermediate depth zone of 6 to 10 feet.

Photo 9. Stonewort

Softwater submerged plants

In addition to the commonly occurring hard water submerged plants in Lake Fourteen, there were a suite of unique plants that are adapted to soft water, nutrient poor lakes. These species were identified in Lake Fourteen for the first time in 2012 but were likely present in early years and overlooked in previous surveys due to their small stature. Some examples of these species include quillwort (*Isoetes* sp.) (Photo 10), waterwort (*Elatine minima*) (Photo 11), leafless watermilfoil (*Myriophyllum tenellum*) (Photo 12) and water lobelia (*Lobelia dortmanna*) (Photo 13).

These small plants are very efficient at nutrient uptake with high root-to-shoot ratios and low leaf turnover. In contrast, more fertile lakes are often dominated by taller leafy plants (such as Canada waterweed and pondweeds). In Lake Fourteen, the small, softwater species were not frequently found. They appeared to be restricted to shallow, sandy sites close to shorelines; these sites were likely not favorable to the taller, leafier plants and provided a competition-free location for these tiny plants (Murphy et al. 1990).

Photo 10. Quillwort

photo: gobotany.newenglandwild.org

Photo 11. Waterwort

Photo: R. Freckman, U of WI Stevens Point Herbarium

Photo 12. Leafless milfoil

Photo: Gary Fewless, U of WI Stevens Point Herbarium

Photo 13. Water lobelia

Photo: Gary Fewless, U of WI Stevens Point Herbarium

Aquatic plant community dynamics

Within a lake, types and amounts of aquatic plants are influenced by a variety of factors. In shallow lakes like Lake Fourteen, the entire basin has the potential to support abundant plant growth but within the lake differences in water clarity, substrate, wave activity and human activity can result in different types and amounts of vegetation. Currently in Lake Fourteen, two submerged species dominate the plant community and because they grow tall in the water column and have a tendency to easily fragment, they may create recreational nuisances. From the limited information available from past survey years, this does not appear to be a recent occurrence in the lake. The shallow, sandy sites near shore contain a unique set of soft water plants. These plants are likely restricted to this zone because they cannot compete with the taller plants that grow in deeper water and they do not grow well in the muck substrates found in deeper water.

With the limited historical data, it is impossible to describe the aquatic plant communities that occurred in Lake Fourteen prior to development. But, in 1949, Dr. John Moyle6 noted that Canada waterweed was not recorded during a 1930's assessment of Lake Fourteen and its abundance in the late 1940's may have been a recent development. Because Canada waterweed mostly obtains nutrients from the water column, Moyle hypothesized that its heavy growth in Lake Fourteen may reflect increased fertility in the lake, possibly from changes of adjacent land drainage and/or overflow of shoreline septic systems. In a study of northern Wisconsin lakes, Borman (2007) also found that leafy plants, such as Canada waterweed, that were not historically found in softwater lakes of Wisconsin, may have entered these lakes since the 1930's as residential development increased and there was a corresponding shift from sand substrates to silt/muck sediments. Borman, et al (2009) suggested that certain changes in lake environments that favor leafier plants, including decreased water clarity, changes in sediment composition, and human disruption to existing plant beds, could be detrimental to the small, softwater plants.

While abundant aquatic plant growth may be a frequent occurrence in Lake Fourteen, there may be year to year differences in the plant communities. It is interesting to note that in 1980 surveyors recorded water milfoil, not Canada waterweed, as the dominant plant; narrow-leaf pondweed was not described as abundant until 1991, and coontail was not even detected in the lake until 2012 when it was described as dense. 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. As an example, because Canada waterweed lacks a winter dormant phase, 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. Changes in the abundance of one species may trigger a change in other species as they compete with each other for available space.

[6] 12/08/1949 letter from Dr. John B. Moyle, Minnesota Dept. of Conservation to Mr. P.S. Engman of Virginia, MN.

Finally, it is important to note that, whether or not Canada waterweed, narrow-leaf pondweed or other plants were abundant in Lake Fourteen prior to the 1940's, they currently compete with filamentous algae for nutrients. Large-scale removal of these plants would remove this competition and could result in increased algal blooms in the lake. These submerged plants also provide other critical functions to the lake including oxygen production, and shelter, shade and food for fish and aquatic wildlife.

Unique habitat sites in Lake Fourteen

The aquatic plant communities of Lake Fourteen can be divided into at least five general types:

a. Shoreline emergent plants (example, Photo 14)
b. Floating-leaf bed at western outlet
c. Soft water rosette plants and unique pondweeds (Photo 15) in shallow sandy sites near shore
d. Broad-leaf pondweed beds at various locations between shore and 10 feet depth
e. Less diverse beds of Canada waterweed and narrow-leaf pondweed in 6 to 16 feet depth

The first four plant groups are particularly sensitive to disturbance and warrant extra protection, particularly since they are not commonly found in the lake. As is typical in a lake environment, these communities do not have well defined boundaries and often intergrade. It is also important to remember that the 2012 survey was conducted in June, before some native species had reached maturity and that the survey did not include an exhaustive search of all sites. There are likely additional sites, particularly in shallow water, where unique plants occur and there may be additional plant species present in the lake that were not detected during the late Spring 2012 survey.

Photo 14: Water arum along Lake Fourteen shoreline

Photo 15: Alpine pondweed and Vasey's pondweed in shallow waters of Lake Fourteen

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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.

Water quality terms	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+

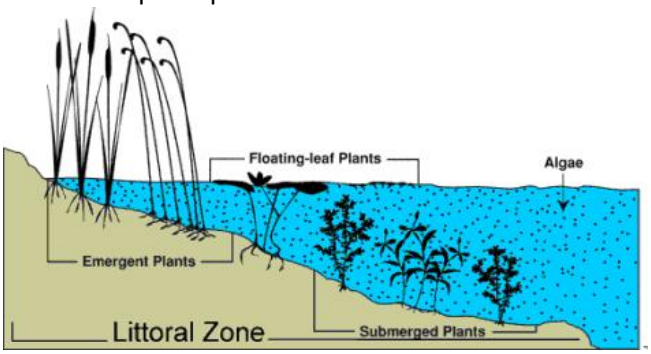
Sources: RMB Environmental Laboratories Inc. and Minnesota Pollution Control Agency

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.

Forms of aquatic plants found in Minnesota lakes.



Plant growth form terms

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.

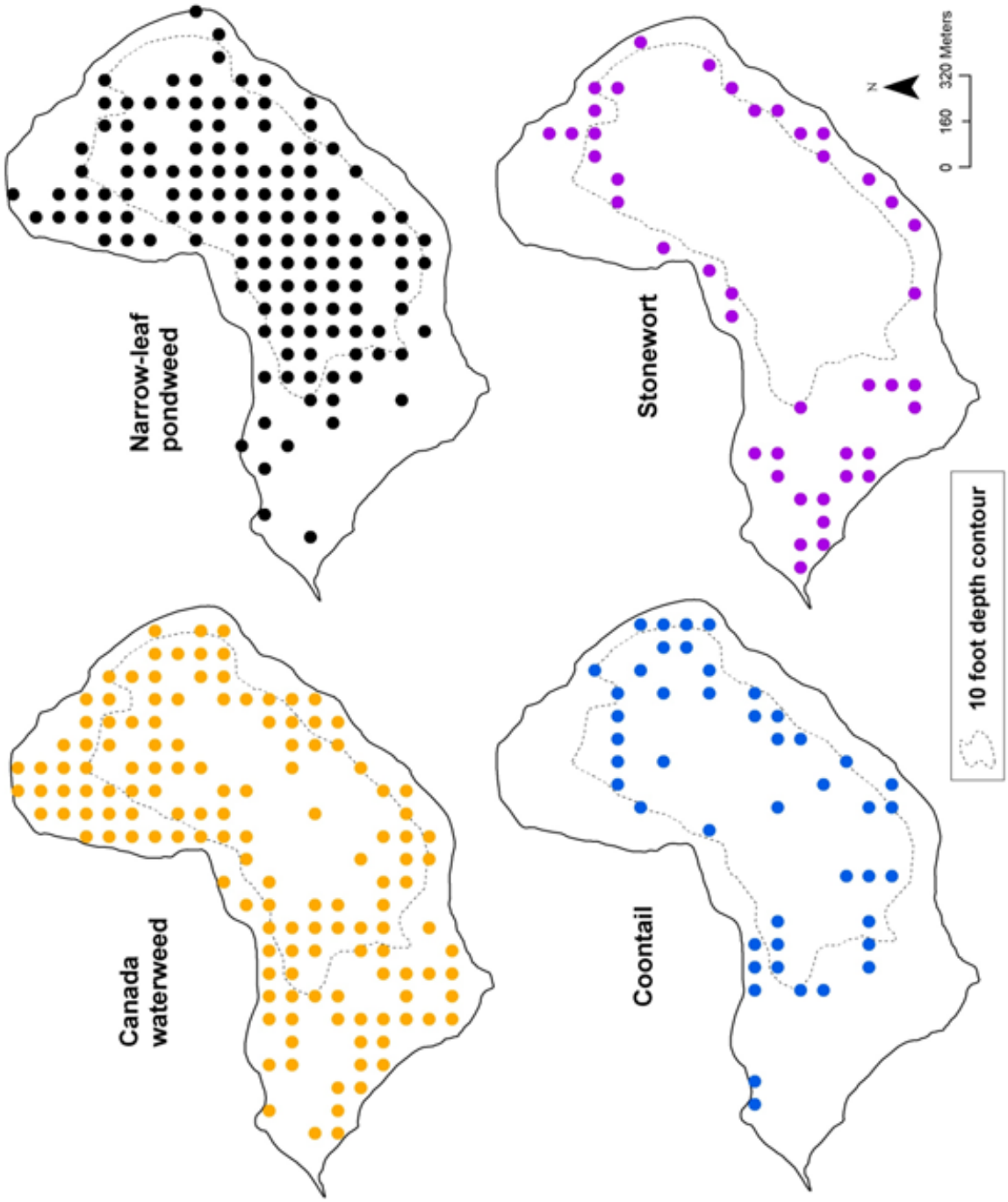
Submerged plants have stems and leaves that primarily grow underwater and many may also form flowers, fruits and/or some leaves that emerge above or float on the water surface. Submerged plants are typically anchored to the lake bottom but some types drift freely with the currents. Growth forms of these 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.

Free-floating plants are the smallest of Minnesota's lake plants and include small flowering plants that are commonly known as "duckweeds" as well as microscopic algae. Different survey methods are required to assess microscopic algae and they are not included in this report. Duckweeds are present in many Minnesota lakes and if present in sufficient amounts, they can accumulate into mats and create a shade barrier along protected shorelines. As their name implies, they are also an important food source for waterfowl.

Plant abundance terms

Frequency of occurrence = the percentage of sites where the plant taxon or taxa of interest occurred
Examples:
Lakewide, coontail occurred in 46 of the 241 sites = 19% occurrence lakewide
Within the 0-5 feet depth zone, coontail occurred in 2 of the 41 sites = 1% occurrence in this shallow zone.

APPENDIX. DISTRIBUTION MAPS OF COMMONLY OCCURRING SUBMERGED PLANTS, LAKE FOURTEEN, 2012



APPENDIX. DISTRIBUTION MAPS OF COMMONLY OCCURRING SUBMERGED PLANTS, LAKE FOURTEEN, 2012 (CONT'D)