Aquatic vegetation of Turtle and Partridge Lakes

July, 2010

ID# 18-0047-00; 18-0048-00

Crow Wing County, Minnesota

Channel between Turtle and Partridge lakes, 2010.

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

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

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Summary

Turtle and Partridge lakes are connected waterbodies in the headwaters of the Rum River watershed, in Crow Wing County, north-central Minnesota. In 2010, surveyors conducted lakewide assessments of the vegetation that included sampling aquatic plant distribution and diversity at over 400 sites.

The aquatic plant communities of these lakes include a diversity of native plants, with 39 species (types) recorded, including eight emergent, five floating-leaved, and 26 submerged species. Eleven of these species were recorded for the first time in the lake in 2010. No non-native plants were found during the surveys.

Plants were found to a depth of 29 feet in Turtle Lake and to 30 feet in Partridge Lake. Within the 0-30 feet depth zone, 89% of the Partridge Lake sites and 74% of the Turtle Lake sites contained plants. Plants were most frequent in depths of 10 feet and less.

Emergent and floating-leaf plants occupied 49 acres, and were most frequent within the 0-5 feet zone. Common species included white waterlily (*Nymphaea odorata),* yellow waterlily (*Nuphar variegata*), watershield (*Brasenia schreberi*), and burreeds (*Sparganium* spp).

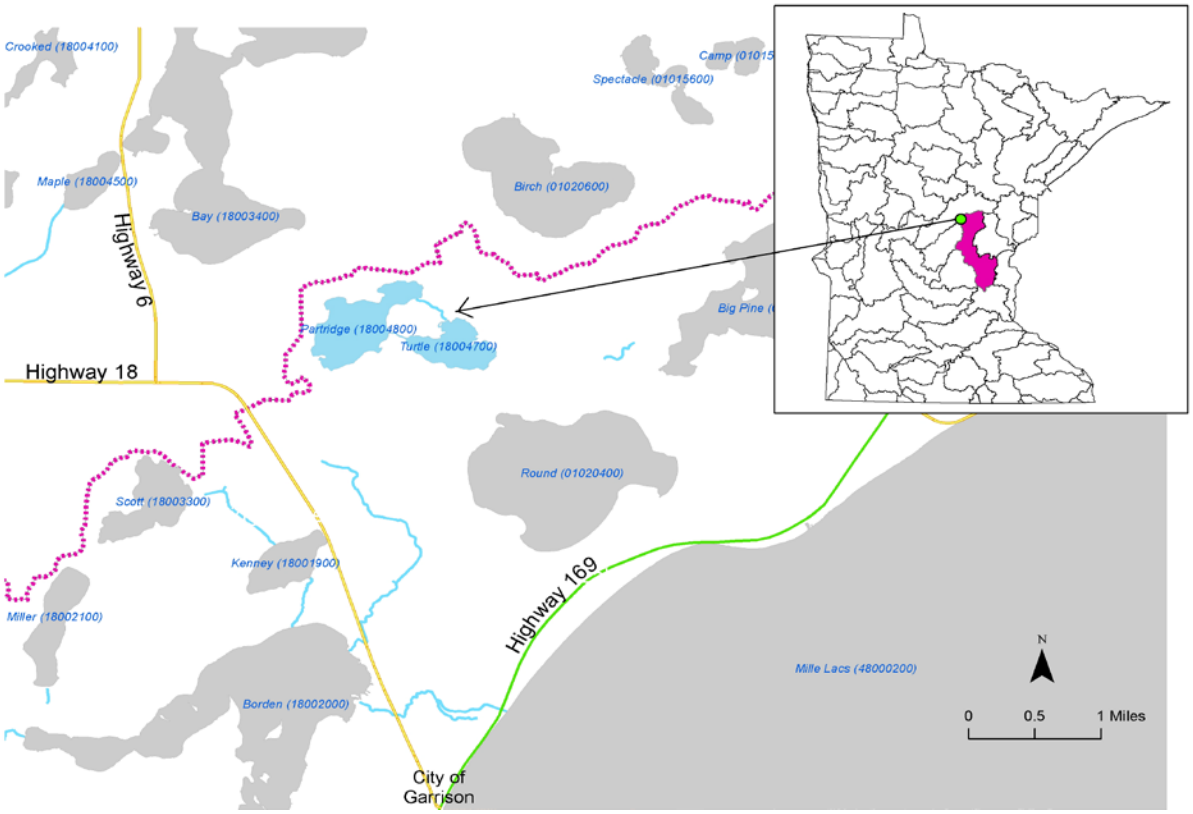
The submerged plant community was dominated by Robbin's pondweed (*Potamogeton robbinsii*) which was found in 69% of the Turtle Lake sites and in 47% of the Partridge Lake sites. This was the most common plant in water depths less than 16 feet. In deeper water, watermoss was the most common plant.

Other submerged plants that were common in these lakes included water bulrush (*Schoenoplectus subterminalis*), bladderworts (Utricularia spp.), and a variety of pondweeds (*Potamogeton* spp. and *Najas* spp). These species were primarily found in depths less than six feet. Also present in these lakes were unique "rosette-forming" submerged plants that are adapted to soft water lakes. These species are often overlooked because of their small size but they are important indicators of the lake conditions.

Introduction

Turtle and Partridge lakes are located about five miles northwest of the town of Garrison, in Crow Wing County, Minnesota. These lakes lie two miles northwest of Mille Lacs Lake in the headwaters of the Rum River Watershed (Figure 1).

Figure 1. Location of Turtle and Partridge lakes in Rum River Watershed.



Lake Characteristics

Photo 1: channel between Partridge and Turtle lakes

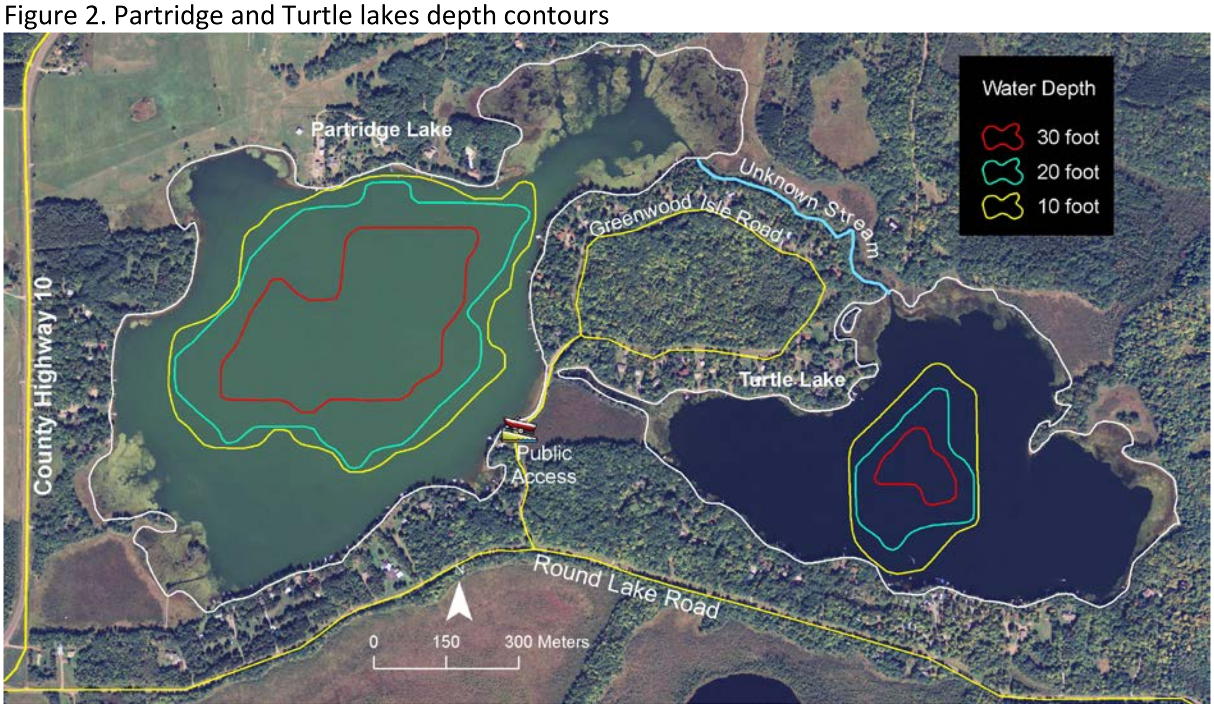
These lakes can be described as seepage lakes because they receive most of their flow from precipitation and groundwater flow. Each lake is primarily landlocked and they are connected to each other by a navigable channel on the south (Photo 1) and a narrow stream on the north. Water levels on seepage lakes can fluctuate seasonally and annually because their water level is a reflection of the elevation of the water table, which in turn reflects the amount of rain water and snow melt. Because Partridge and Turtle are not flow-through lakes, they are particularly susceptible to increased nutrient and particle input that may result from poor shoreland management practices.

The lakeshed of each lake, or the land that drains directly to the lake, is primarily forested with small wetland inclusions. The shorelines of both lakes are moderately developed with residential homes. There is a public access on the southeast side of Partridge Lake and a private reosrt access on the south shore of Turtle Lake.

Both lakes are relatively small, mostly shallow, irregular shaped basins. With a surface area of 184 acres and six miles of shoreline, Partridge Lake is twice as large as Turtle Lake, which is 95 acres in area and has three miles of shoreline. Partridge has a maximum depth of 42 feet and about 63% is less than 15 feet in depth. Turtle Lake has a maximum depth of 33 feet and about 82% is less than 15 feet in depth (Figure 2).

The trophic, or growth, status of these lakes is characterized as **mesotrophic**, based on phosphorus (nutrients), chlorophyll a (algae concentration) and Secchi[1] depth (transparency). Water clarity in both lakes is described as "excellent[2]"; the average summer Secchi reading in 2010 was 14 feet in Partridge and 12 feet in Turtle. The depth to which rooted aquatic plants grow is largely dependent on water clarity and based on water clarity readings alone, aquatic plants have the potential to reach depths of about 18 to 21 feet in these lakes[3].

Figure 2. Partridge and Turtle lakes depth contours



(depths based on 2010 data; Photo source: 2010 FSA Aerial Photos)

[1] The Secchi disc transparency measures the depth to which a person can see into the lake and provides a rough estimate of the light penetration into the water column. Water clarity is influenced by the amount of particles in the water column as well as by the water's color and can fluctuate seasonally and annually.

[2] Excellent = $\geq$12 feet, Very Good = 6-11 feet, Good, 3-5 feet, Fair 1.5 – 2 feet, Poor - <1.5 feet

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

Partridge and Turtle Lakes are described as **soft-water** lakes because they are naturally low in concentrations of calcium and magnesium ions and have a low buffering capacity (**alkalinity**). This water chemistry influences the types of aquatic plants that may occur in these lakes.

Historic aquatic plant community

Previous plant surveys of these Partridge Lake were conducted in 1973, 1996 and 2000; Turtle Lake was surveyed in 1995. These surveys varied in methodology and surveyors recorded a total of 41 native aquatic plant **taxa**: 11 **emergent**, six **floating-leaf**, and 24 **submerged** taxa (Appendices 1, 2). The commonly occurring species found during these surveys were coontail (*Ceratophyllum demersum*), Canada waterweed (*Elodea canadensis*), native pondweeds (*Potamogeton* spp.), watershield (*Brasenia schreberi*), white waterlily (*Nymphaea odorata*), yellow waterlily (*Nuphar variegata*), and bulrush (*Schoenoplectus* sp.).

Objectives

This survey provides a quantitative description of the 2010 aquatic vegetation population in Turtle and Partridge lakes. Objectives included:

1. Estimate the maximum depth of rooted vegetation
2. Estimate the percent of the lake occupied by rooted vegetation
3. Record the aquatic plant species that occur in the lake
4. Estimate the abundance and distribution of common aquatic plant species

Methods

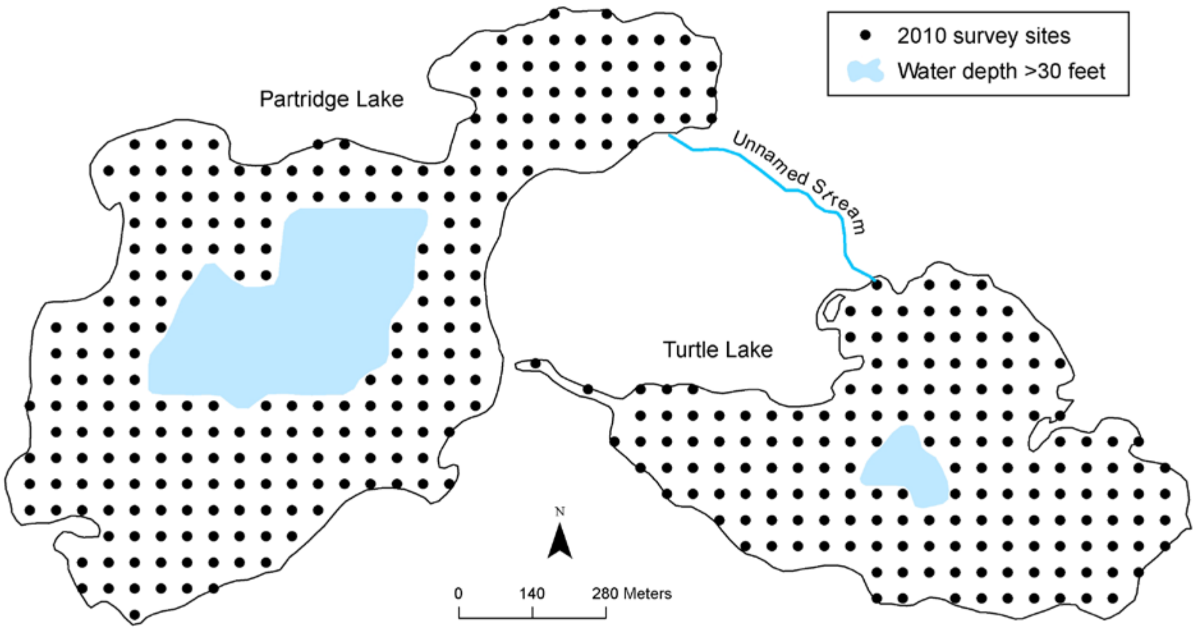
Partridge Lake was surveyed on July 15, 2010 and Turtle Lake was surveyed on July 19, 2010. A point-intercept survey method was used and followed the methods described by Madsen (1999) and MnDNR (2009). Survey waypoints were created using a Geographic Information System (GIS) computer program and uploaded into a handheld Global 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 in a grid pattern across the lake and spaced 50 meters (164 feet) apart (Figure 3). Surveyors sampled all sites where water depth was 30 feet or less. A total of 243 sites in Partridge Lake and 169 sites in Turtle Lake were surveyed (Table 1).

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

Plant sampling

Surveyors recorded all plant taxa found within a one square meter sample site at the pre-designated side of the boat. A double- headed, weighted garden rake, attached to a rope is used to survey vegetation not visible from the water surface (Photo 2). Plant identification followed Crow and Hellquist (2000) and nomenclature followed MnTaxa (2011).

Figure 3. 2010 vegetation survey sites on Turtle and Partridge Lakes.



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.

Table 1. Sampling effort by water depth.

Water depth interval (feet)	Number of sample sites	
	Partridge	Turtle
0 - 5	96	48
6 - 10	73	92
11 - 15	12	6
16 - 20	9	6
21 - 25	23	7
26 - 30	30	10
Total	243	169

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

Photo 2. Sampling rake.

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

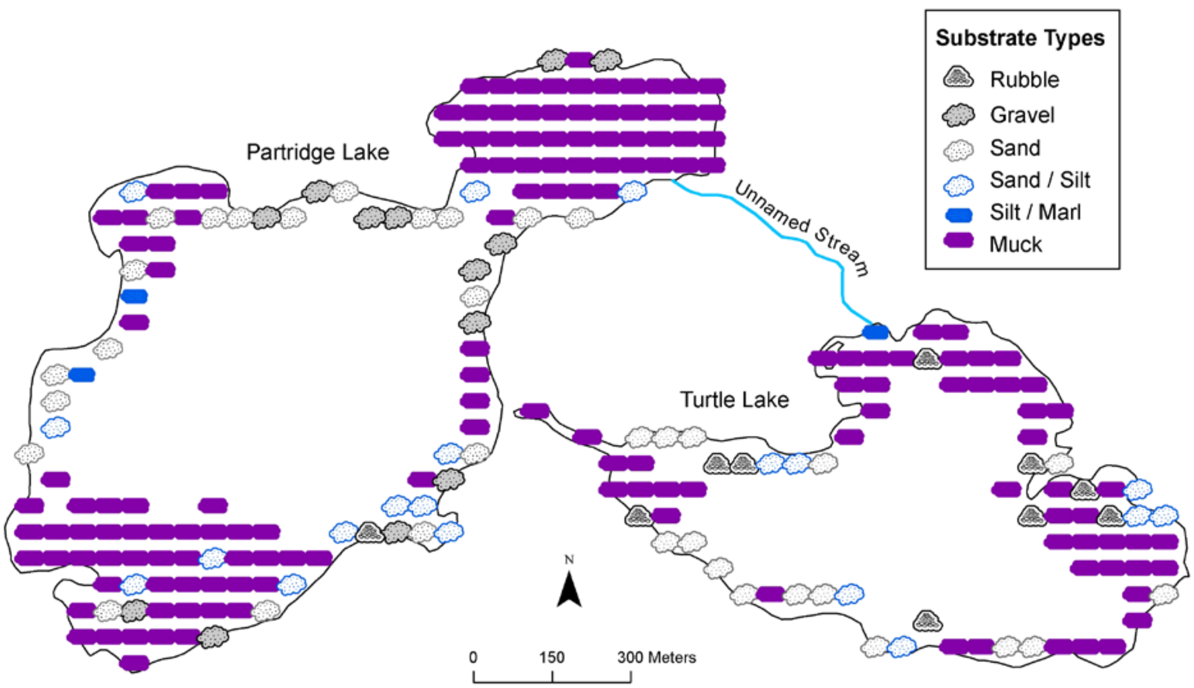
muck	decomposed organic material
marl	calcareous material
silt	fine material with little grittiness
sand	diameter <1/8 inch
gravel	diameter 1/8-3 inches
rubble	diameter 3- 10 inches
boulder	diameter > 10 inches

Results and Discussion

Shoal Substrates

The shoal substrates of Turtle and Partridge lakes were primarily muck with areas of sand, gravel, and rubble along some shores (Figure 4).

Figure 4. Shoal substrates, Turtle and Partridge lakes, 2010.



Types of plants recorded

In 2010, a total of 39 native aquatic plant taxa (types) were recorded in Turtle and Partridge lakes (Appendices 1 and 2) and included eight emergent, five floating-leaved and 26 submerged taxa. Eleven of these taxa were recorded for the first time in 2010. No non-native plants were found during the survey.

The plant community was composed of a mixture of hard water taxa and several taxa that are unique to soft water lakes. Eleven of these taxa were recorded for the first time during the 2010 survey. Most of these newly discovered taxa were not found in high numbers in 2010 and were likely present in previous years but undetected. Similarly, several taxa that were recorded in earlier surveys may still be present in the lakes and their absence from the 2010 survey may simply reflect their sparse occurrence.

Distribution of aquatic plants

Plants occurred throughout the littoral zones of both lakes. Plants were found to a depth of 29 feet in Turtle Lake and to 30 feet in Partridge Lake. Within the 0-30 feet depth zone, 89% of the Partridge Lake sites and 74% of the Turtle Lake sites contained plants. In both lakes, plant occurrence was highest from shore to 10 feet, where at least 89% of sites contained plants (Figure 5). Plant frequency decreased with increasing water depth but plants were still common in the 16 to 30 feet depth zone, 43% of the Turtle Lake sites and 24% of the Partridge Lake sites contained plants in this depth zone.

Figure 5. Aquatic plant frequency vs. water depth.

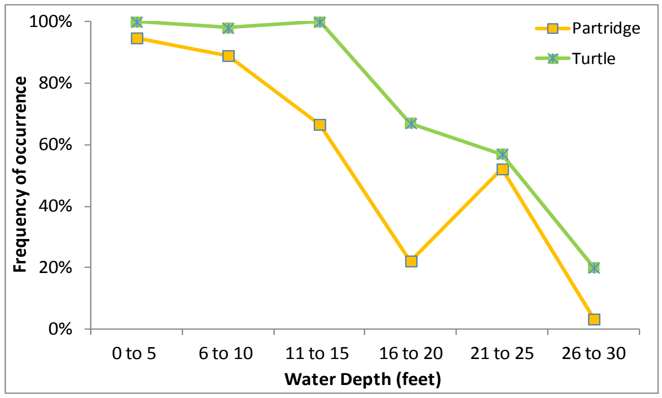
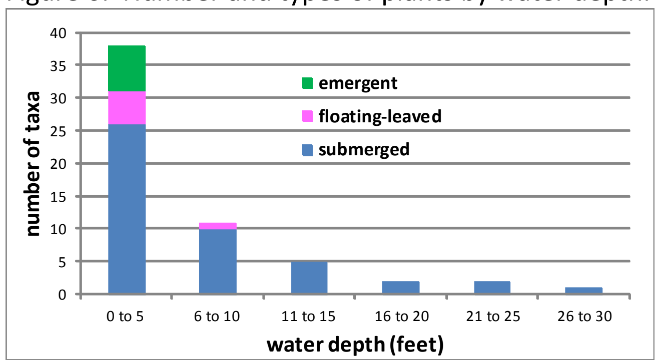


Figure 6. Number and types of plants by water depth.



The highest number of plant taxa was found in the shallow water, in depths less than 6 feet. All 38 taxa found in the lakes were present within this shallow zone and 22 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 one square meter sample site ranged from zero to eight but in depths greater than five feet, on average less than two taxa were found at each site (Figure 7).

Emergent and floating-leaf plant beds

Emergent (Photo 3) and floating-leaf (Photo 4) plant beds covered about 49 acres in both lakes (Figure 7). The largest beds occurred in the northeast bay of Partridge Lake. Commonly

Photo 3. Great blue heron in waterlily bed. Partridge Lake, 2010.

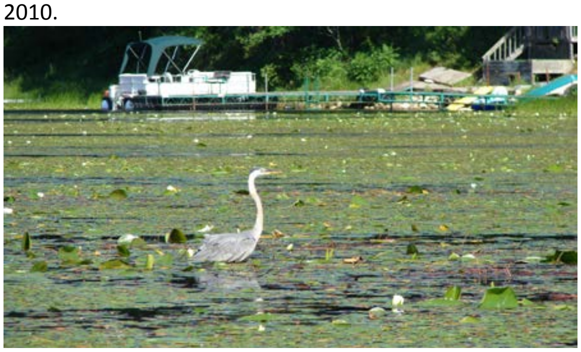
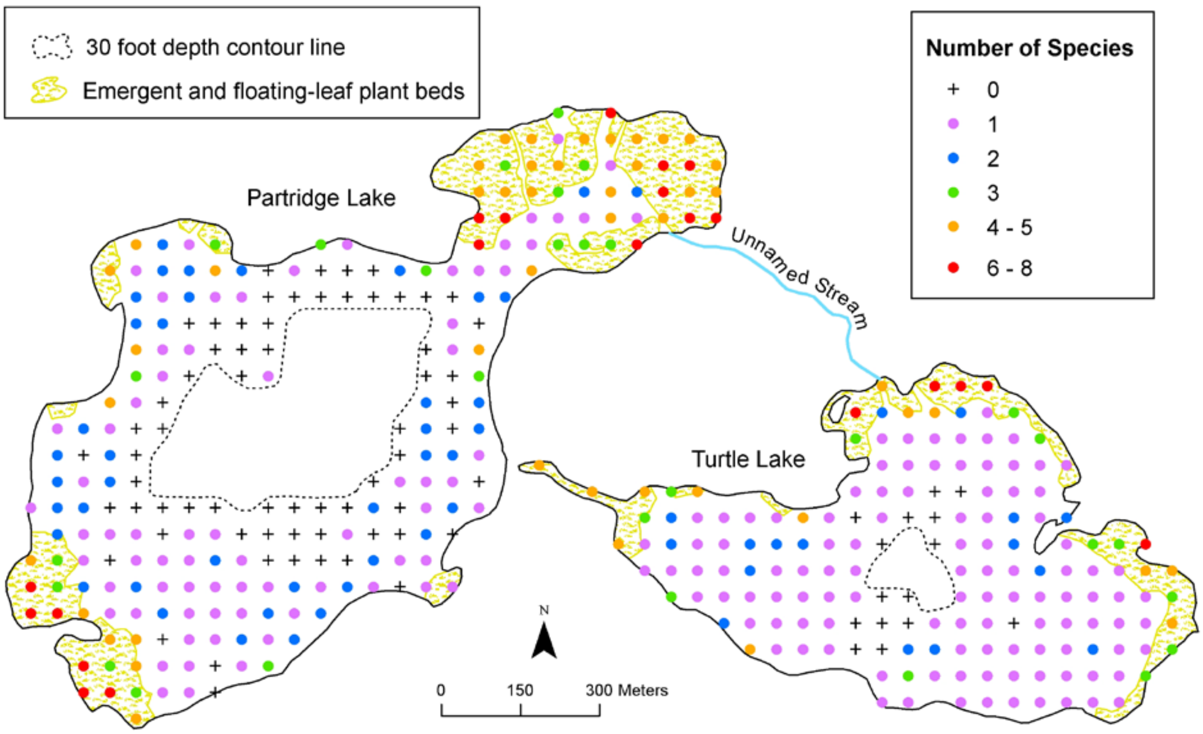


Photo 4. Emergent plants along Partridge Lake shoreline, 2010

occurring species included arrowhead (*Sagittaria* sp.), burreed (*Sparganium* sp.), bulrush (*Schoenoplectus* sp.), watershield (*Brasenia schreberi*), white waterlily (*Nymphaea odorata*), and yellow waterlily (*Nuphar variegata*). These plants were primarily restricted to water depths less than six feet.

Figure 7. Number of plant species at each sample site, Turtle and Partridge lakes, 2010.



Submerged plants

Photo 5. Robbin's pondweed

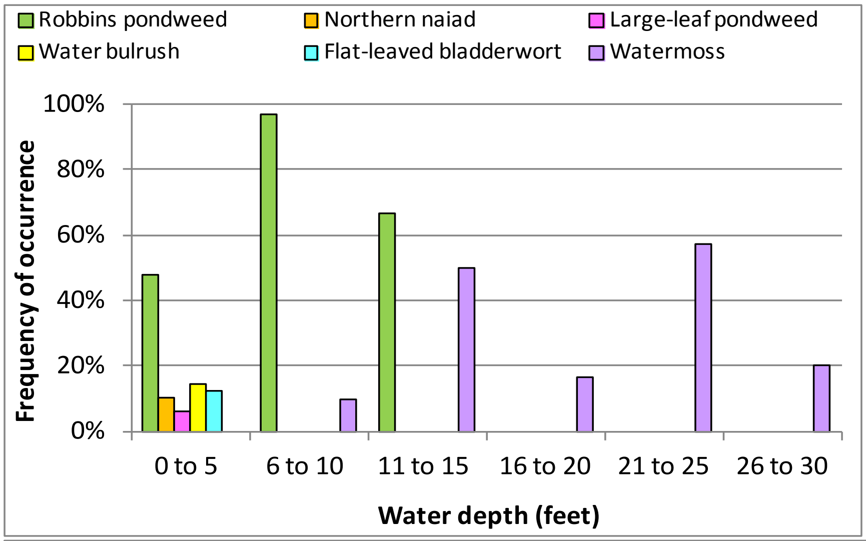
Robbin's pondweed (*Potamogeton robbinsii*) (Photo 5) was the most frequently occurring submerged plant in both lakes, occurring in 69% of the Turtle Lake sites and in 47% of the Partridge Lake sites. This perennial plant forms leaves that grown entirely beneath the water surface and often lies prostrate on the lake bottom. It may form flowers that extend above the water surface. In both lakes, Robbin's pondweed was found to a depth of 15 feet and was the most frequently occurring plant in this shallow zone (Figure 8).

Photo 6. Watermoss

Picture source: www.awc.america.com

Watermoss (Photo 6) was present in 11% of the Turtle Lake sites and in 5% of the Partridge Lake sites. In both lakes, it was the most frequently occurring plant in deep water (greater than 15 feet) (Figure 8). This plant does not form roots or flowers and grows entirely beneath the water surface.

Figure 8. Common aquatic plants in Turtle (Top) and Partridge (Bottom) lakes, 2010.



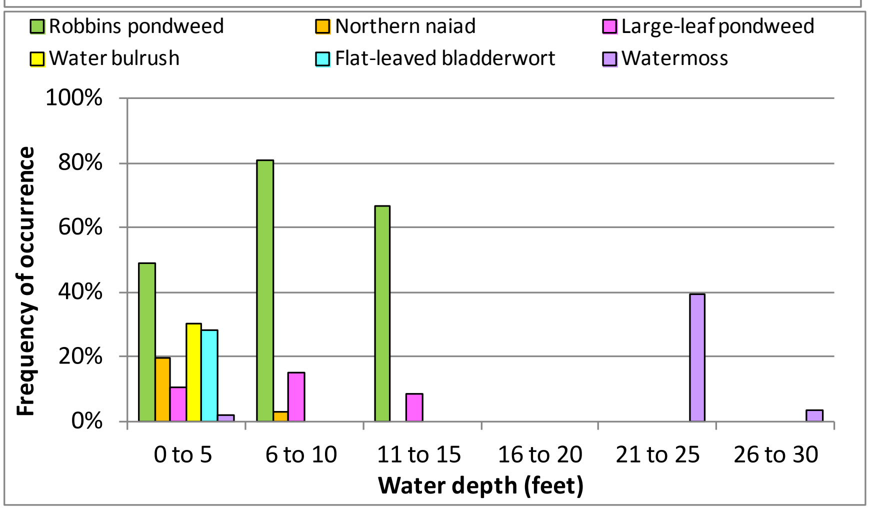


Photo 7. Water bulrush

Other submerged plants that were common in these lakes included water bulrush (*Schoenoplectus subterminalis*) (Photo 7), bladderworts (*Utricularia* spp.), and a variety of pondweeds (*Potamogeton* spp. and *Najas* spp). These species were primarily found in depths less than six feet.

Also present in these lakes were unique "rosette-forming" submerged plants that are adapted to soft water lakes. These species are often overlooked because of their small size but they are important indicators of the lake conditions. In a study of northern Wisconsin lakes, Borman (2007) 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. Some examples of these species include quillwort (*Isoetes* sp.) (Photo 8), waterwort (*Elatine minima*) (Photo 9), leafless watermilfoil (*Myriophyllum tenellum*) (Photo 10) and pipewort (*Eriocaulon aquaticum*) (Photo 11).

Photo 8. Quillwort

photo: gobotany.newenglandwild.org

Photo 9. Waterwort

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

Photo 10. Leafless milfoil

Photo: Gary Fewless, U of WI Stevens Point Herbarium

Photo 11. Pipewort

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 pondweeds). In Partridge and Turtle lakes, 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).

Aquatic plant community dynamics

Within a lake, types and amounts of aquatic plants are influenced by a variety of factors. In shallow lakes like Partridge and Turtle, most of the basin has the potential to support abundant plant growth but within the lakes differences in water clarity, substrate, wave activity and human activity can result in different types and amounts of vegetation. Currently in these lakes, two submerged species dominate the plant communities with Robbin's pondweed more common in shallow water and watermoss frequently found in deeper water. 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 these lakes prior to development. But, 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. The current presence of these soft-water plants in these lakes indicates that the water quality is likely being maintained.

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 some plants lack a winter dormant phase, in summers following heavy snow and/or ice cover on lakes, they may occur at lower abundance. However, during mild winters, some species remain 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.

Humans can impact aquatic plant communities directly by destroying vegetation with herbicide or by mechanical means. For information on the laws pertaining to aquatic plant management, click here: MnDNR APM Program or contact your local DNR office. Motorboat activity in vegetated areas can be particularly harmful for species such as bulrush and waterlilies. Shoreline and watershed development can also indirectly influence aquatic plant growth if it results in changes to the overall water quality and clarity. Herbicide and mechanical control of aquatic plants can directly impact the aquatic plant community. Limiting these types of activities can help protect native aquatic plant species and in turn, reduce the potential for non-native plants to invade and expand in a lake.

The abundant and diverse native aquatic plant communities of Turtle and Partridge lakes provide critical fish and wildlife habitat and other lake benefits. (Click here for more information on: value of aquatic plants).

Literature Cited

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

Borman, S.C., 2007. Aquatic Plant Communities and Lakeshore Land Use: Changes Over 70 Years in Northern Wisconsin Lakes. Ph.D. Dissertation. University of Minnesota, St. Paul, Minnesota.

Borman, S.C., S.M. Galatowitsch, and R.M. Newman. 2009. The effects of species immigrations and changing conditions on isoetid communities. Aquatic Botany 91: 143-150.

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

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

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

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

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

MnTaxa. 2012. Minnesota State checklist of vascular plants. Minnesota Department of Natural Resources, Division of Ecological and Water Resources, St. Paul. Updated April 2011. Available on Internet: http://www.dnr.state.mn.us/eco/mcbs/plant_lists.html

MPCA. 2011. Minnesota Pollution Control Agency. St. Paul, MN. Lake Water Quality Assessment Program. Lake Water Quality Data Search website: http://www.pca.state.mn.us/water/lkwqSearch.cfm (accessed March 2012)

Murphy, K.J., Rørslett, B., Springuel, I., 1990. Strategy analysis of submerged lake macrophyte communities, an international example. Aquat. Bot. 36, 303–323

Appendix 1. Aquatic plants of Turtle Lake (1995-2010)

Submerged and free-floating plants

	Common Name	Scientific Name	1995	2010
Large algae and moss	Muskgrass	*Chara* sp.		2
	Stonewort	*Nitella* sp.		3
	Watermoss	*Not identified to genus*		11
Rooted needle-leaf plants	Smallest waterwort	*Elatine minima*	X	
	Needlerush	*Eleocharis acicularis*		2
	Pipewort	*Eriocaulon aquaticum*	X	2
	Braun's quillwort	*Isoetes echinospora*	X	
	Leafless watermilfoil	*Myriophyllum tenellum*	X	2
	Creeping spearwort	*Ranunculus flammula*	X	
	Water bulrush	*Schoenoplectus subterminalis*		4
Rooted leafy plants	Water marigold	*Bidens beckii*	X	
	Coontail	*Ceratophyllum demersum*	X	
	Hornwort	*Ceratophyllum echinatum*		2
	Canada waterweed	*Elodea canadensis*	X	1
	Bushy pondweed	*Najas flexilis*	X	
	Very slender naiad	*Najas gracillima*	X	3
	Very Small pondweed	*Potamogeton pusillus*	X	*1
	Snail-seed pondweed	*Potamogeton spirillus*	X	
	Large-leaf pondweed	*Potamogeton amplifolius*	X	2
	Ribbon-leaved pondweed	*Potamogeton epihydrus*	X	1
	Variable pondweed	*Potamogeton gramineus*	X	
	White-stem pondweed	*Potamogeton praelongus*		1
	Robbin's pondweed	*Potamogeton robbinsii*	X	69
	Wild celery	*Vallisneria americana*	X	4
Free-drifting submerged	Humped bladderwort	*Utricularia gibba*	X	2
	Flat-leaved bladderwort	*Utricularia intermedia*	X	4
	Lesser bladderwort	*Utricularia minor*		2
	Greater bladderwort	*Utricularia vulgaris*	X	4
Free-floating	Turion forming duckweed	*Lemna turionifera*	X	
		Total	21	20

Floating-leaved plants

	Common Name	Scientific Name	1995	2010
Rooted floating-leaved	Water-shield	*Brasenia schreberi*	X	17
	Yellow waterlily	*Nuphar variegata*	X	1
	White waterlily	*Nymphaea odorata*	X	13
	Floating-leaf smartweed	*Persicaria amphibia*	X	
	Floating leaf pondweed	*Potamogeton natans*	X	1
	Floating-leaf burreed	*Sparganium fluctuans*		2
		Total	5	5

Appendix 1. Aquatic plants of Turtle Lake (1995-2010) (cont'd)

Emergent plants

	Common Name	Scientific Name	1995	2010
Narrow-leaf emergents	Spikerush	*Eleocharis palustris*	X	
	Horsetail	*Equisetum fluviatile*	X	1
	Three-square bulrush	*Schoenoplectus pungens*		1
	Soft-stem bulrush	*Schoenoplectus tabernaemontani*	X	
Broad-leaf emergents	Broad-leaved arrowhead	*Sagittaria latifolia*	X	4
	Giant burreed	*Sparganium eurycarpum*	X	
	Broad-leaf cattail	*Typha latifolia*		X
		Total	5	4

1995 (August 14) – Karen Myhre, Minnesota County Biological Survey, Ecological Services, MnDNR.
2010 (July 15) – Donna Perleberg, Stephanie Simon, Nick Whichello, Zach Van Dyne, Ecological and Water Resources, MnDNR.

Appendix 2. Aquatic plants of Partridge Lake (1973-2010)

Submerged plants

	Common Name	Scientific Name	1973	1996	2000	2010
Large algae and moss	Muskgrass	*Chara* sp.			1	<1
	Stonewort	*Nitella* sp.			3	5
	Watermoss	*Not identified to genus*			1	5
Rooted needle-leaf plants	Smallest waterwort	*Elatine minima*		X		
	Needlerush	*Eleocharis acicularis*			P	4
	Pipewort	*Eriocaulon aquaticum*		X	1	2
	Quillwort	*Isoetes* sp.		X		2
	Leafless watermilfoil	*Myriophyllum tenellum*		X		2
	Water bulrush	*Schoenoplectus subterminalis*			2	12
Rooted leafy plants	Water marigold	*Bidens beckii*			7	2
	Coontail	*Ceratophyllum demersum*	X	X	1	
	Hornwort	*Ceratophyllum echinatum*				<1
	Canada waterweed	*Elodea canadensis*	X	X	15	7
	Water star-grass	*Heteranthera dubia*		X		1
	Whorled watermilfoil	*Myriophyllum verticillatum*	*X	X	1	<1
	Bushy pondweed	*Najas flexilis*		X	2	<1
	Very slender naiad	*Najas gracillima*		X		9
	Two-cupped pondweed	*Potamogeton bicupulatus*		X	**5	1
	Very small pondweed	*Potamogeton pusillus*		X		
	Snail-seed pondweed	*Potamogeton spirillus*		X		
	Vasey's pondweed	*Potamogeton vaseyi*		X		
	Large-leaf pondweed	*Potamogeton amplifolius*		X	15	9
	Ribbon-leaved pondweed	*Potamogeton epihydrus*		X	1	
	Variable pondweed	*Potamogeton gramineus*			12	3
	White-stem pondweed	*Potamogeton praelongus*			7	2
	Robbin's pondweed	*Potamogeton robbinsii*		X	59	47
	Flat-stem pondweed	*Potamogeton zosteriformis*	X			
	Wild celery	*Vallisneria americana*		X	1	8
Free-drifting submerged	Humped bladderwort	*Utricularia gibba*		X		2
	Flat-leaved bladderwort	*Utricularia intermedia*		X	4	11
	Lesser bladderwort	*Utricularia minor*			2	7
	Greater bladderwort	*Utricularia vulgaris*		X	1	4
Free-floating	Turion Forming Duckweed	*Lemna turionifera*		X		
		Total	4	22	21	25

Appendix 2. Aquatic plants of Partridge Lake (1973-2010) (cont'd)

Floating-leaved plants

	Common Name	Scientific Name	1973	1996	2000	2010
Rooted floating-leaved	Water-shield	*Brasenia schreberi*	X	X	6	18
	Yellow waterlily	*Nuphar variegata*	X	X	4	10
	White waterlily	*Nymphaea odorata*	X	X	4	14
	Floating-leaf smartweed	*Persicaria amphibia*		X	P	
	Floating-leaf pondweed	*Potamogeton natans*			1	<1
	Floating-leaf burreed	*Sparganium fluctuans*	X		1	1
		Total	4	4	6	5

Emergent plants

<table>
<tr><td></td><td>Common Name</td><td>Scientific Name</td><td>1973</td><td>1996</td><td>2000</td><td>2010</td></tr>
<tr><td rowspan="5">Narrow-leaf emergents</td><td>Three-way sedge</td><td>Dulichium arundinaceum</td><td></td><td>X</td><td>P</td><td></td></tr>
<tr><td>Spikerush</td><td>Eleocharis palustris</td><td>*X</td><td>X</td><td>*1</td><td>*<1</td></tr>
<tr><td>Horsetail</td><td>Equisetum fluviatile</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td>Hard-stem bulrush</td><td>Schoenoplectus acutus</td><td>X</td><td>X</td><td rowspan="2">*1</td><td rowspan="2">*1</td></tr>
<tr><td>Soft-stem bulrush</td><td>Schoenoplectus tatabernaemontani</td><td></td><td>X</td></tr>
<tr><td rowspan="6">Broad-leaf emergents</td><td>Arum leaved arrowhead</td><td>Sagittaria cuneata</td><td rowspan="3">*X</td><td></td><td rowspan="3">*2</td><td rowspan="3">*<1</td></tr>
<tr><td>Broad-leaved arrowhead</td><td>Sagittaria latifolia</td><td>X</td></tr>
<tr><td>Stiff wapato</td><td>Sagittaria rigida</td><td>X</td></tr>
<tr><td>Green fruited burreed</td><td>Sparganium emersum</td><td></td><td>X</td><td>1</td><td></td></tr>
<tr><td>Cattail</td><td>Typha sp.</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td>Wild rice</td><td>Zizania palustris</td><td>X</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>Total</td><td>6</td><td>7</td><td>5</td><td>3</td></tr>
</table>

I = introduced
P= Present in lake but not found in any sample sites
*not confirmed to species level
**species were grouped together for analyses

1973 (July 11-12) – Steve Kirch (Crew Leader), Kit Nelson, Division of Game and Fish, Section of Fisheries, MnDNR.
1996 (August 6) – Karen Myhre, Minnesota County Biological Survey, Ecological Services, MnDNR.
2000 (July 10) – Donna Perleberg, Ecological Services, MnDNR.
2010 (July 15) – Donna Perleberg, Stephanie Simon, Nick Whichello, Zach Van Dyne, Ecological and Water Resources, MnDNR.

Glossary

Within this glossary, text that appears in blue underline is a hypertext link to a web page where additional information is provided. If you are connected to the Internet, you can click on the blue underlined text to link to those web pages.

Water quality terms

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

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

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

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

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

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

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

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

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

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

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

Plant identification terms

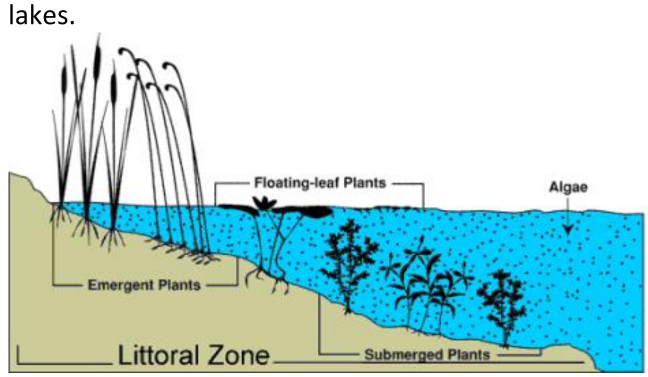
Species is a term to define a group of plants that are capable of interbreeding and producing fertile offspring in nature. Botanists assign a scientific name to each species that is a combination of the genus and species. As an example, red oak and bur oak are both species within the "Oak" genus. Red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

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

Plant growth form terms

Aquatic plants can be divided into four groups or "life forms" based on whether the main portion of the plant occurs above, on, or below the water surface. These life forms: emergent, floating-leaved, free-floating and submerged plants (Figure A), often favor certain water depth zones around the lake but overlap occurs with one life form grading into another. Each life form group has unique functions and values.

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



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

Floating-leaf plants such as waterlilies, are anchored in the lake bottom with leaves and flowers that float on the water surface. Root systems of these plants form extensive networks that take up nutrients and help consolidate and stabilize bottom substrate. Beds of floating-leaf plants help buffer the shoreline from wave action, offer shade and shelter for insects, young fish, and frogs and provide food, cover and nesting material for waterfowl, marsh birds and muskrat.

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

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

Pondweeds (*Potamogeton* spp. and *Stuckenia* spp.) are the largest group of submerged aquatic plants in Minnesota lakes with about 25 different species considered native to the state. These perennial plants are anchored to the lake bottom by underground rhizomes. Some species of pondweeds may form specialized floating leaves, while others grow entirely submerged below the water surface. Depending on water clarity and depth, any pondweed may produce flowers that extend above the water. Pondweed seeds and tubers are an important source of waterfowl food (Fassett 1957) and the foliage of pondweeds is food for a variety of marsh birds, shore birds and wildlife and provides shelter, shade and spawning sites for a range of fish species (Borman et al. 2001). Pondweeds are often named and described based on their leaf shape and size. Some pondweed species have very specific habitat requirements while others can grow in a wide range of lake conditions. Certain species have the ability to form submerged and floating leaves while others form only submerged leaves. The vegetative portions of pondweeds can be highly variable depending on water levels, water flow and other habitat conditions. If flowers or fruits are not present, pondweeds can be difficult to identify to the species level.

Plant abundance terms

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

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

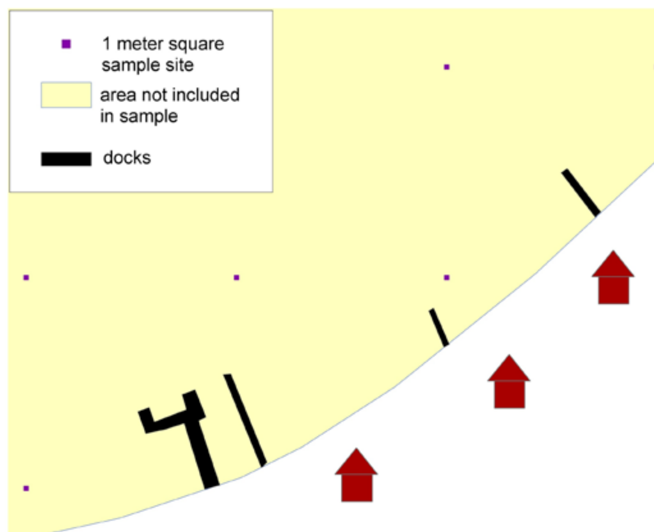
For this report, frequency of occurrence was calculated as the percent of sites, within a specific depth zone, where a plant species was detected. Unless otherwise noted, frequency values were calculated for the 0 to 30 feet depth zone.

Example:

In Partridge Lake there were 243 sample sites in the 0-30 feet depth zone.
Canada waterweed occurred in 17 sites.
Frequency of Canada waterweed in the 0-30 feet zone = (17/243)*100 =7%

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

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



Other measures of "abundance" include:

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

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

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