Aquatic Vegetation Survey of
Upper, Middle and Lower Cullen Lakes
Crow Wing County, Minnesota
2007

Upper Cullen (DOW 18-0376-00)
Middle Cullen (DOW 18-0377-00)
Lower Cullen (DOW 18-0403-00)

Loon in bulrush bed of Upper Cullen Lake, May 2007

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Muskgrass (*Chara* sp.) (pg. 13) Vic Ramey, U of Florida. Copyright Univ. of Florida 2001. At Univ. of Florida Center for Aquatic Plants: http://aquat1.ifas.ufl.edu/welcome.html.

All other photographs were taken by DNR Ecological Resources 2007 survey crew (Perleberg, Loso, Vacinek and Bulman).

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Summary

Upper, Middle and Lower Cullen Lakes support abundant and diverse aquatic plant communities. A total of 39 native aquatic plant taxa were recorded including ten emergent, four floating-leaved, three free-floating and 22 submerged plants. One non-native species, curly-leaf pondweed (*Potamogeton crispus*) was identified.

Aquatic plants occurred around the entire perimeter of each lake. Emergent beds of wild rice (*Zizania palustris*) and hard-stem bulrush (*Scirpus acutus*) as well as floating-leaf beds of white waterlily (*Nymphaea odorata*) and yellow waterlily (*Nuphar variegata*) covered more than 100 acres in Upper Cullen Lake, about 65 acres in Middle Cullen Lake and about 35 acres in Lower Cullen Lake.

Submerged plants were found to a depth of 17 feet in Upper Cullen Lake and to 20 feet in Middle and Lower Cullen lakes, but in all lakes plant occurrence was sparse beyond the depth of 15 feet. Plant occurrence was greatest in depth less than eleven feet, where vegetation was found in at least 91 percent of the sample sites.

The most frequently occurring submerged species in these lakes were muskgrass (*Chara* sp.) coontail (*Ceratophyllum demersum*), narrow-leaf pondweed (*Potamogeton freisii*), flat-stem pondweed (*Potamogeton zosteriformis*), and northern watermilfoil (*Myriophyllum sibiricum*).

The non-native species, curly-leaf pondweed (*Potamogeton crispus*) occurred in all three lakes, but occurred less frequently than many of the native plant species. It occurred with a frequency of 11 percent in Upper Cullen Lake, one percent in Middle Cullen Lake, and 17 percent in Lower Cullen Lake. Curly-leaf pondweed was most common in water depths of six to 15 feet and often co-occurred with the common native species.

Introduction

The Cullen Lakes, Upper (DOW 18-0376-00), Middle (DOW 18-0377-00) and Lower (DOW 18-0403-00) are located about 1.5 miles north of the city of Nisswa, in Crow Wing County, north-central Minnesota (Figure 1).

The Cullen Lakes occur in the eastern portion of the Crow Wing River Watershed. Upper Cullen Lake receives flow from an inlet at the north end of the lake and the lake drains to Middle Cullen Lake and then to Lower Cullen Lake. Flow continues to Nisswa Lake and then through a series of lakes to Gull Lake (Figure 2). Gull Lake empties to the Gull River, which connects to the Crow Wing River at the southeast corner of the watershed.

Figure 1. Location of the Cullen Lakes Lake in Crow Wing County, Minnesota.

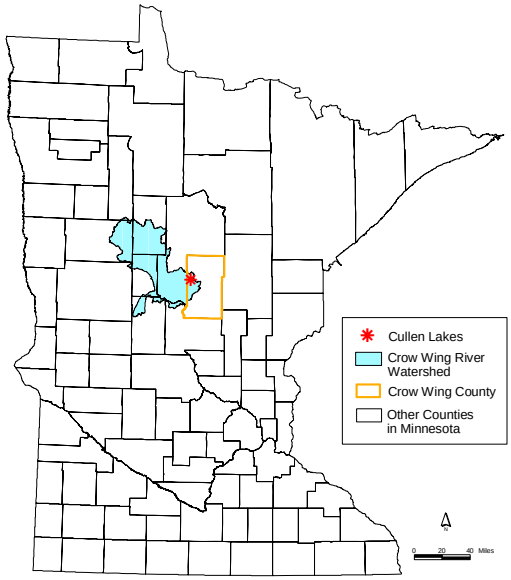
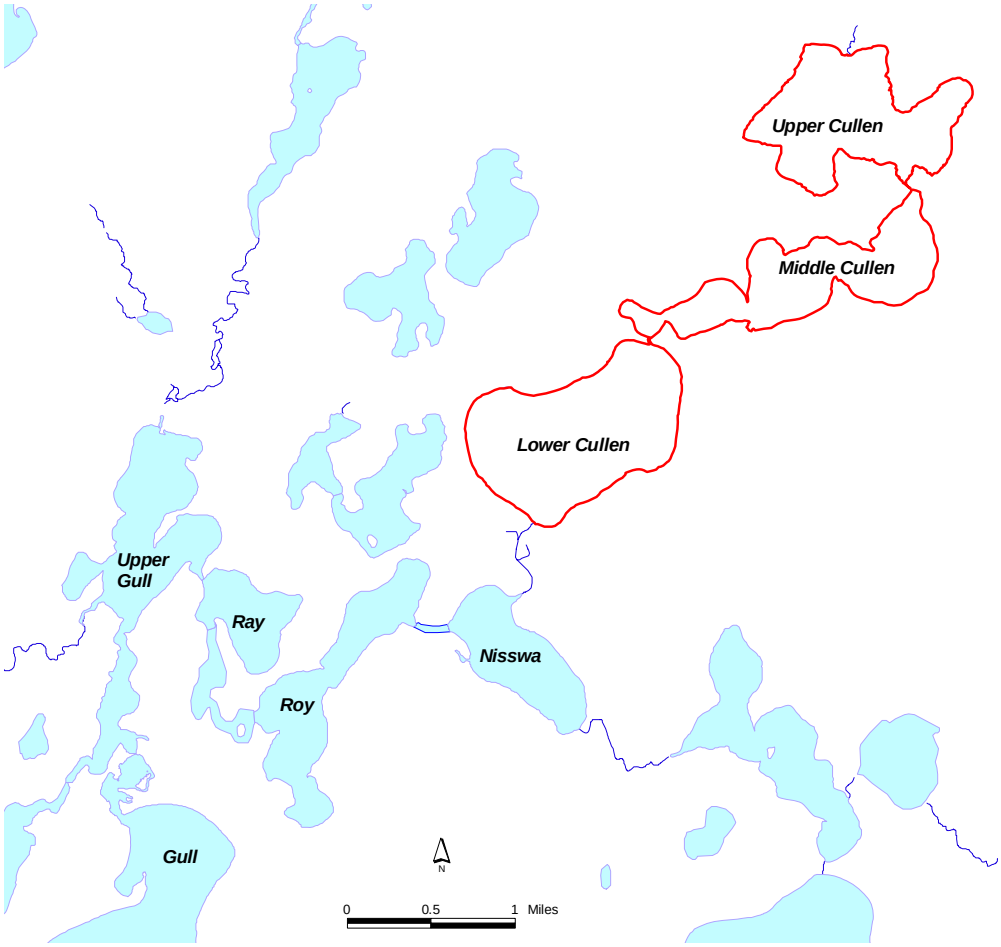


Figure 2. Flow from Cullen Lakes to Gull Lake.

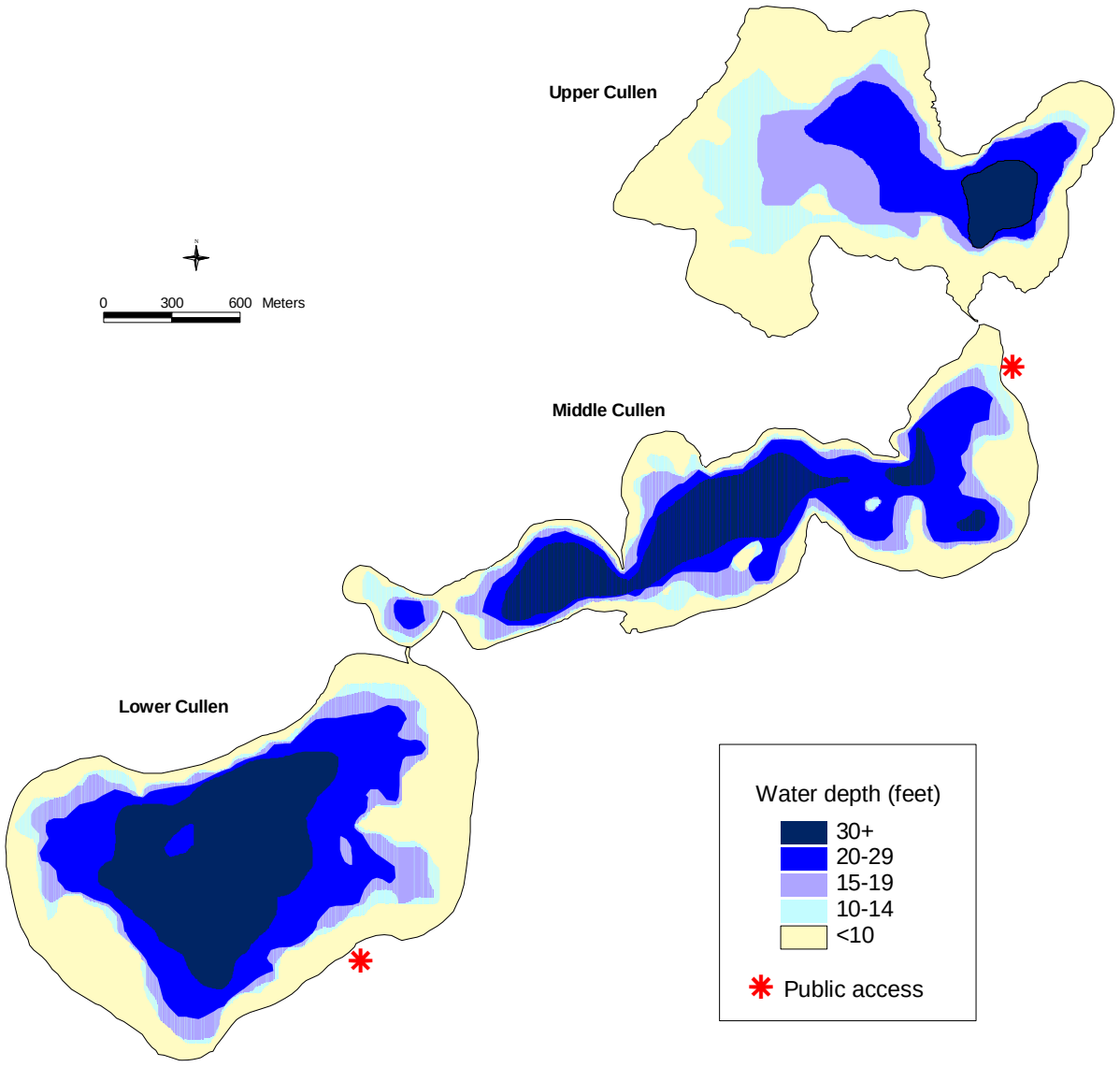


The Cullen Lakes cover a total of 1,329 surface acres. Upper Cullen is 435 acres, Middle Cullen is 382 acres and Lower Cullen is the largest at 512 acres. Maximum depths range from 48 feet for Middle Cullen, 40 feet for Upper Cullen, to 39 feet on Lower Cullen (Figure 3).

The shoreline of the Cullen Lakes are primarily forested and development varies from moderate on Middle and Lower Cullen to light development on Upper Cullen. There is a public boat launch on Lower and Middle Cullen. Access to Upper Cullen is through a privately owned boat launch or through the channel from Middle Cullen.

The Cullen Lakes vary in trophic status. Upper Cullen is classified as eutrophic, or nutrient rich and Middle and Lower are classified as mesotrophic, or moderately nutrient enriched lakes (MPCA 2007). The mid-summer Secchi disk reading, which estimates the amount of sunlight that penetrates the water column, ranged from about nine feet on Upper Cullen to about 13 feet

Figure 3. Depth contours of Cullen lakes, Crow Wing County.



on Middle Cullen and Lower Cullen. These estimates are based on mean summer Secchi disc readings from 1997 through 2006 (MPCA 2007).

Objectives

The purpose of this vegetation survey was to provide a quantitative description of the spring 2007 plant population of the Cullen Lakes. Specific objectives included:

1) Describe the shoal sediments of the lakes
2) Estimate the maximum depth of rooted vegetation
3) Estimate the percent of the lake occupied by rooted vegetation
4) Record the aquatic plant species that occur in the lakes
5) Estimate the abundance of common species
6) Develop distribution maps for the common species

Methods

Floating-leaf and emergent vegetation

Many of the near-shore, shallow areas of the Cullen Lakes contain extensive beds of emergent and floating-leaf vegetation. To avoid damage to these plant beds, surveyors did not motor into these sites. Field surveys to map emergent vegetation were conducted by DNR Fisheries staff in 2003 and surveyors mapped bulrush beds in the field by motoring around the lakeside perimeter of major bulrush beds. In 2007, aerial photographs were used to delineate beds of floating-leaved vegetation.

In-lake vegetation survey

A vegetation survey of Cullen Lakes was conducted in late May and early June 2007. Surveys were conducted on May 24 and 30 for Lower Cullen Lake, May 31 for Middle Cullen Lake, and June 4 and 5 for Upper Cullen Lake. A Point-intercept survey method was used and followed the methods described by Madsen (1999). Survey waypoints were created using a Geographic Information System (GIS) computer program and downloaded into a Global Positioning System (GPS) receiver. Survey points were spaced 65 meters apart, resulting in about one survey point per acre. Two field crews, each consisting of one boat and two surveyors, conducted the survey. In the field, surveyors infrequently found vegetation beyond a depth of 15 feet and therefore sampled all survey points between shore and 20 feet and only a selected number of points in deeper water. A total of 704 points were surveyed (Figure 4, Table 1).

Figure 4. 2007 vegetation survey sites on Cullen Lakes.

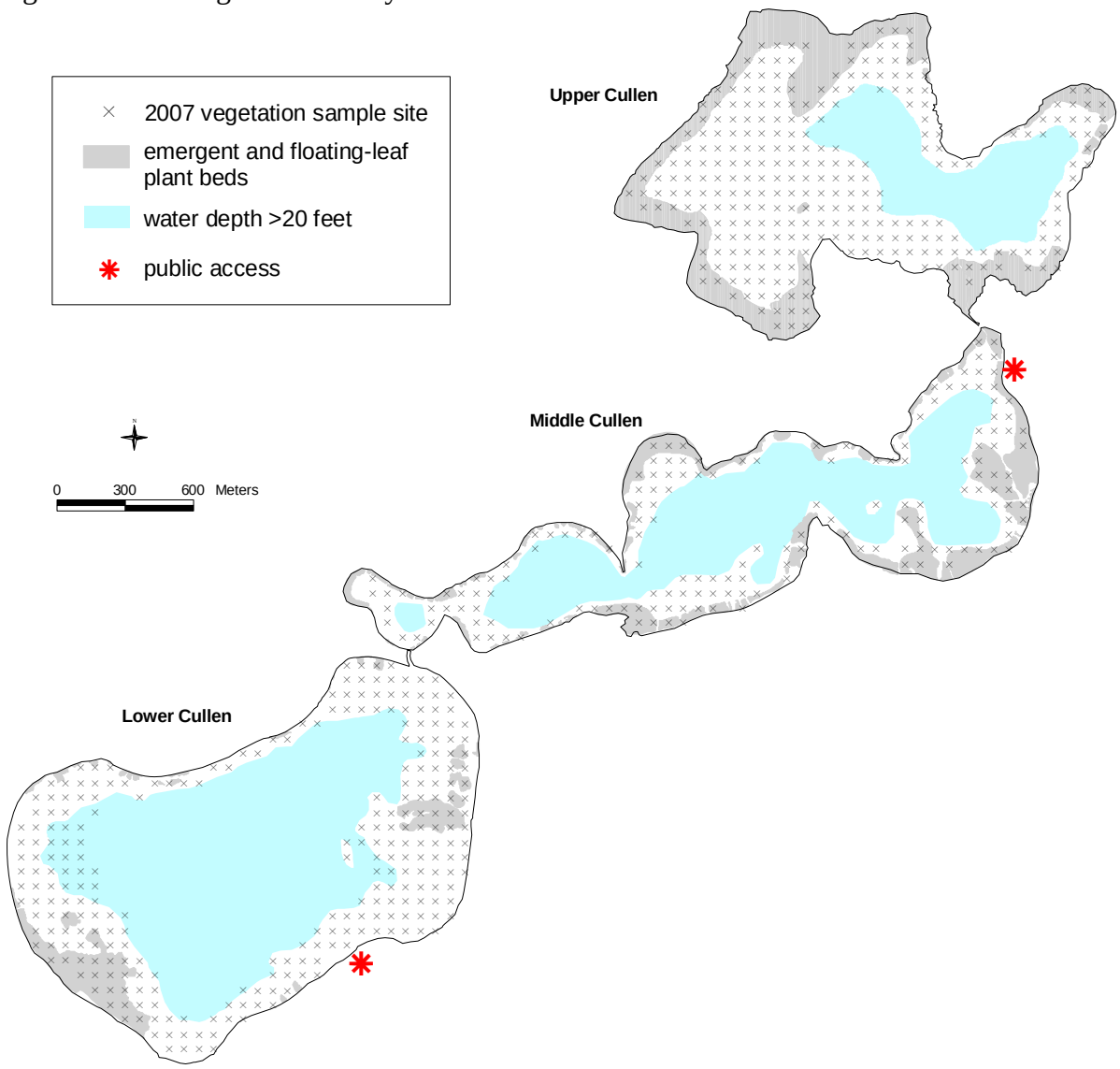


Table 1. Sampling effort by water depth, Cullen Lakes, 2007.

Depth interval in feet	Number of sample points			
	Lower	Middle	Upper	all
0 to 5	122	63	103	288
6 to 10	52	18	67	137
11 to 15	24	30	60	114
16 to 20	56	52	57	165
Total number of sample points	254	163	287	704

The 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 to the nearest foot using a measuring stick in water depths less than eight feet and an electronic depth finder in depths greater than eight feet. The surveyors recorded all plant species found within a one meter square sample site at the pre-designated side of the boat. A double-headed, weighted garden rake, attached to a rope was used to survey vegetation not visible from the surface (Figure 5). At each sample site where water depth was six feet or less, surveyors described the bottom substrate using standard substrate classes (Table 2).

Figure 5. Sampling rake.

Table 2. Substrate classes

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

Plant identification and nomenclature followed Crow and Hellquist (2000). Voucher specimens were collected for most plant species and are stored at the MnDNR in Brainerd. Data were entered into a Microsoft Access database and frequency of occurrence was calculated for each species as the number of sites in which a species occurred divided by the total number of sample sites.

Frequency was calculated for the entire area from shore to 20 feet and sampling points were also grouped by water depth and separated into four depth zones for analysis (Table 1).

Example:

In Upper Cullen Lake there were 287 samples sites in the zone from shore to the 20 feet depth.

Muskgrass (*Chara* sp.) occurred in 60 of those sites.

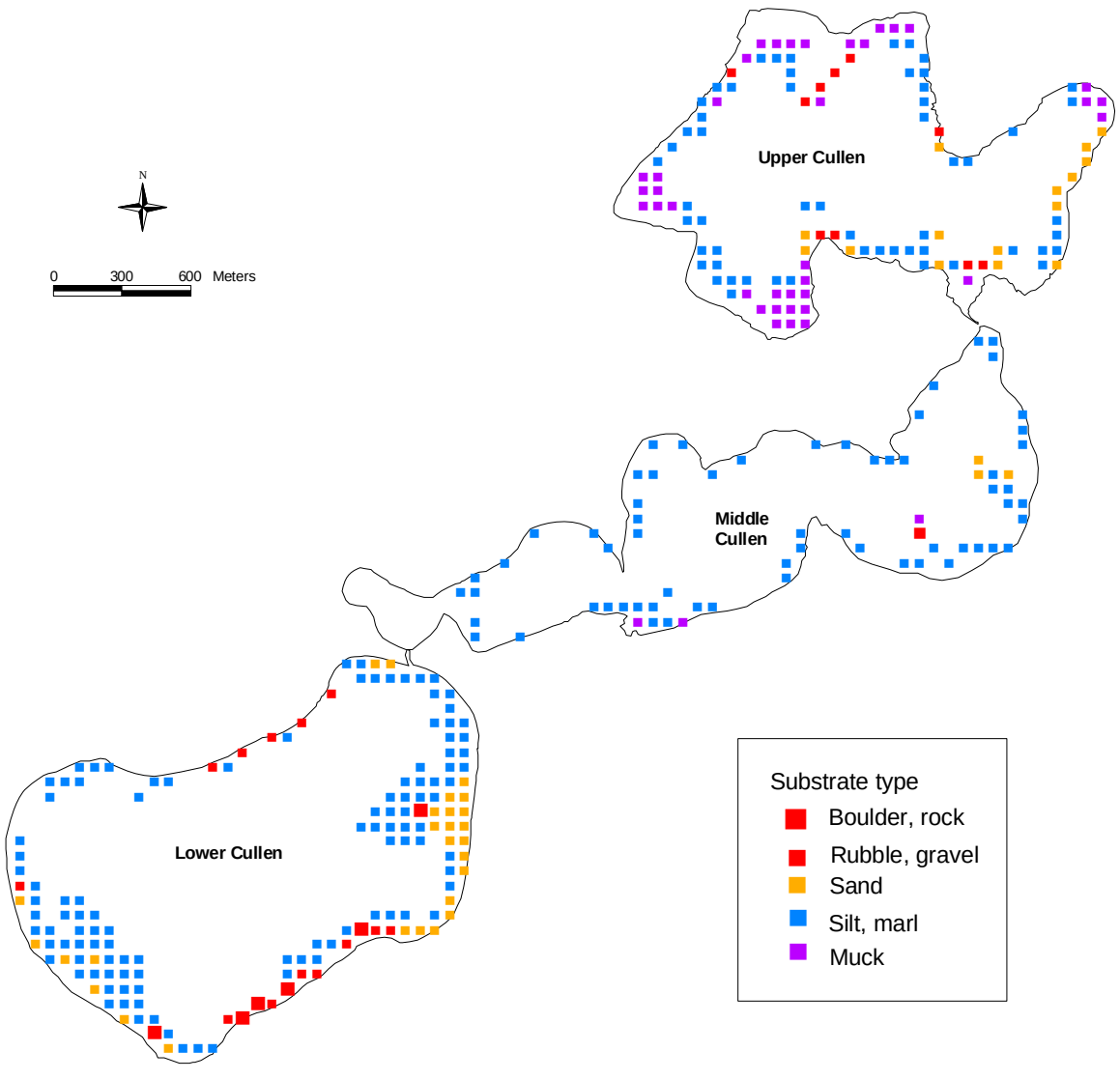
Frequency of muskgrass in the shore to 20 feet depth zone = 60/287 (*100) = 21 %

Results

Shoal substrates

Shallow water sites (shore to a water depth of six feet) had predominantly soft substrates of silt, marl or muck. Hard substrates of boulder, rock, rubble, gravel and/or sand were scattered around Upper and Lower Cullen lakes and at a few sites on the east side of Middle Cullen (Figure 6).

Figure 6.



Number and types of plants recorded

A total of 39 native aquatic plant taxa were recorded in the Cullen Lakes including ten emergent, four floating-leaved, three free-floating and 22 submerged plants (Table 3). Submerged plants included two types of large algae, an aquatic moss, and numerous flowering plants. One non-native species, curly-leaf pondweed (*Potamogeton crispus*) was identified.

Table 3. Frequency of aquatic plants in Cullen Lakes, May, 2007.

Life Form	Common Name	Scientific Name	Frequency of occurrence			
			All Lakes	Upper Cullen	Middle Cullen	Lower Cullen
SUBMERGED	Muskgrass	*Chara sp.*	29	21	33	36
	Coontail	*Ceratophyllum demersum*	29	26	35	26
	Narrowleaf pondweed	*Potamogeton freisii*[1]	22	17	25	24
	Flat-stem pondweed	*Potamogeton zosteriformis*	22	18	30	20
	Northern watermilfoil	*Myriophyllum sibiricum*	16	4	18	27
	Curly-leaf pondweed	*Potamogeton crispus*	12	11	1	17
	Canada waterweed	*Elodea canadensis*	7	5	10	7
	Whitestem pondweed	*Potamogeton praelongus*	6	2	6	10
	Water stargrass	*Zosterella dubia*	4	1	7	6
	Greater bladderwort	*Utricularia vulgaris*	3	7	2	---
	Illinois pondweed	*Potamogeton illinoensis*	2	1	---	4
	Large-leaf pondweed	*Potamogeton amplifolius*	1	---	1	3
	Clasping-leaf pondweed	*Potamogeton richardsonii*	1	---	1	2
	White water buttercup	*Ranunculus aquatilis*	1	---	1	1
	Sago pondweed	*Stuckenia pectinata*	1	---	1	1
	Water marigold	*Megaladonta beckii*	<1	---	---	<1
	Bushy pondweed	*Najas flexilis*	<1	---	---	<1
	Stonewort	*Nitella sp.*	<1	---	2	---
	Variable pondweed	*Potamogeton gramineus*	<1	---	p	1
	Robbin's pondweed	*Potamogeton robbinsii*	<1	---	---	<1
	Flat-leaved bladderwort	*Utricularia intermedia*	<1	---	1	---
	Water celery	*Vallisneria americana*	<1	---	1	---
	Water moss	*Not identified to genus*	<1	---	---	1
Free-floating	Star duckweed	*Lemna trisulca*	2	2	3	---
	Lesser duckweed	*Lemna minor*	<1	---	1	---
	Greater duckweed	*Spirodela polyrhiza*	<1	---	1	---
FLOATING	Yellow waterlily	*Nuphar variegata*	7	11	9	<1
	White waterlily	*Nymphaea odorata*	4	4	11	1
	Watershield	*Brasenia schreberi*	<1	---	<1	---
	Floating-leaf pondweed	*Potamogeton natans*	<1	<1	p	---
EMERGENT	Bulrush	*Scirpus acutus*[2]	11	14	12	6
	Wild Rice	*Zizania palustris*	10	15	10	4
	Needlegrass	*Eleocharis* sp.	1	---	---	2
	Spikerush	*Eleocharis* sp.	<1	---	1	---
	Horsetail	*Equisetum* sp.	2	---	2	---
	Arrowhead	*Sagittaria latifolia*[3]	<1	---	3	<1
	Burreed	*Sparganium* sp.	<1	---	1	<1
	Water arum	*Calla palustris*	<1	---	p	---
	Giant Cane	*Phragmites australis*	<1	---	---	---
	Cattail	*Typha* sp.	<1	<1	1	---

Frequency of occurrence = percent of sample sites within the shore to 20 ft water depth zone in which a species occurred.

--- = not recorded during survey

p = present during survey but not found within sample sites

[1] *Potamogeton freisii* was positively identified but there may have been one or more additional "narrow-leaf" pondweed species present that were grouped with this species.

[2] *Scirpus acutus* was positively identified but there may have been one or more additional "bulrush" species present that were grouped with this species

[3] *Sagittaria latifolia* was positively identified but there may have been one or more "arrowhead" species present that were grouped with this species.

Plant abundance and distribution

Approximately 50 percent of Lower and Middle Cullen lakes and 80 percent of Upper Cullen Lake are less than 20 feet in depth (Figure 3) and can potentially support aquatic vegetation. Within those shallow areas, during the spring 2007 survey, vegetation occurred in 68 percent of the Upper Cullen Lake sites, 71 percent of the Middle Cullen Lake sites and 73 percent of the Lower Cullen Lake sites. Aquatic plants occurred around the entire perimeter of the lakes and plants extended lakeward as far as 300 meters in areas such as the southwest bays and north end of Upper Cullen, the east shore of Middle Cullen and the east and west sides of Lower Cullen (Figure 7). Plants were found to a depth of 17 feet in Upper Cullen Lake and to 20 feet in Middle and Lower Cullen lakes, but plant occurrence was sparse beyond the depth of 15 feet (Figure 8). In all three lakes, plant occurrence was greatest in depth less than eleven feet, where vegetation was found in at least 91 percent of the sample sites.

Figure 7. Aquatic plant distribution in Cullen Lakes, May 2007

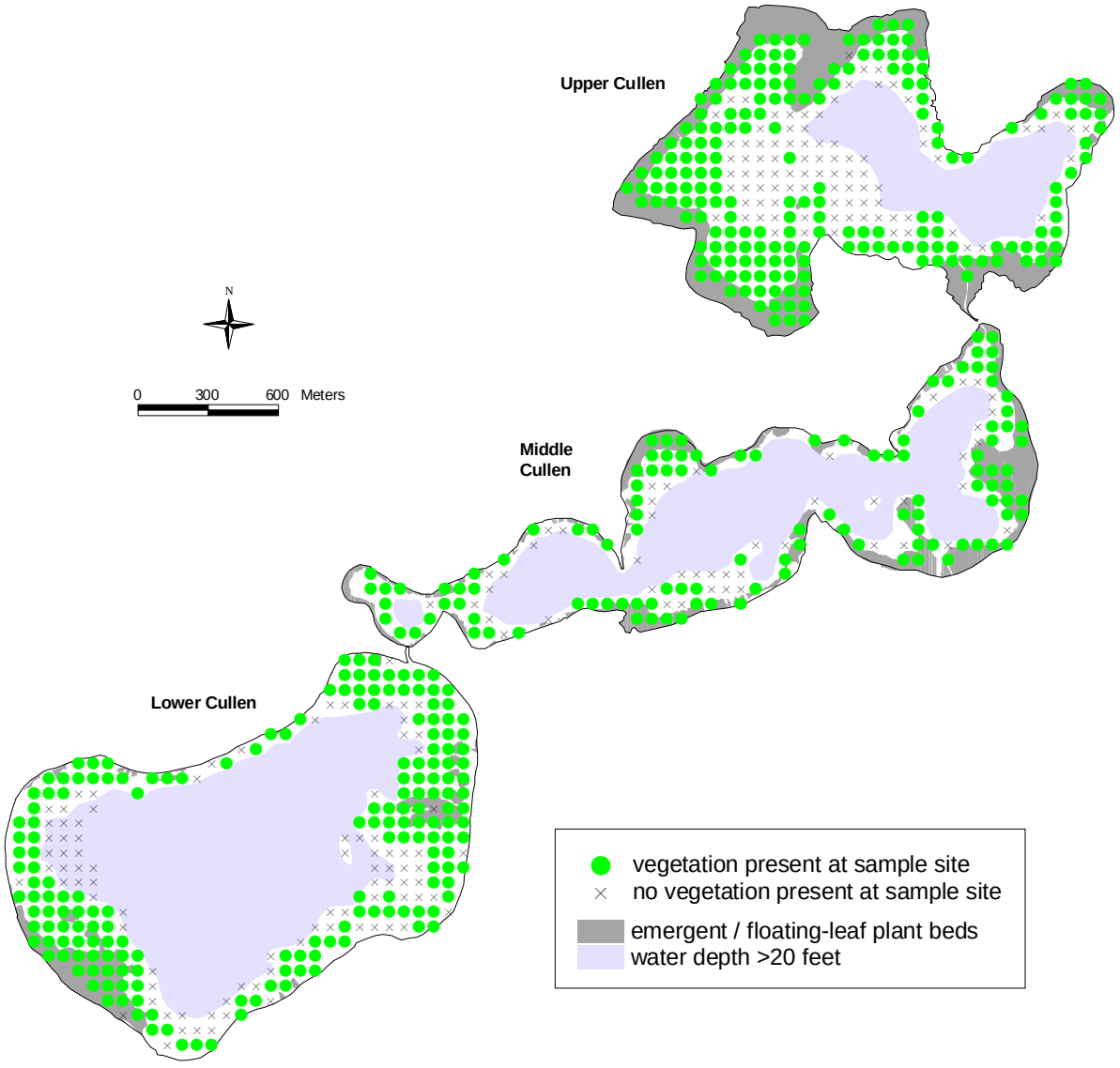
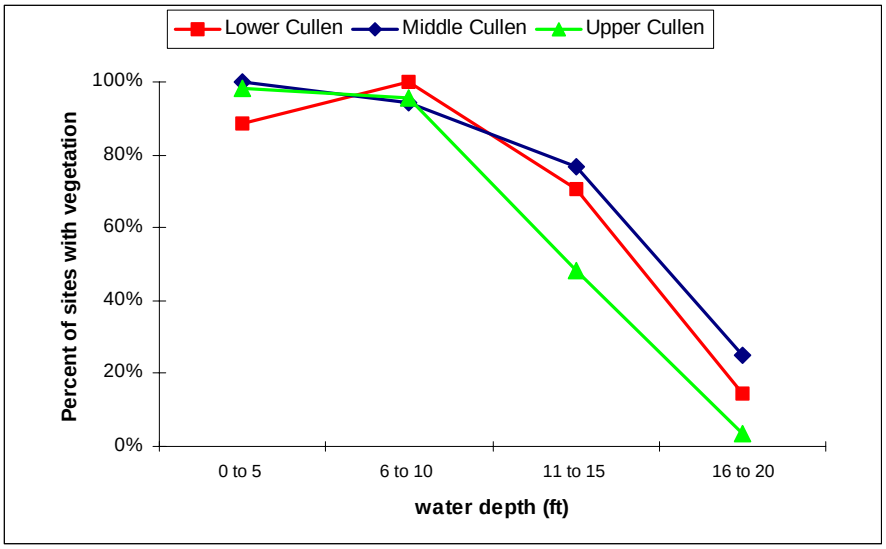
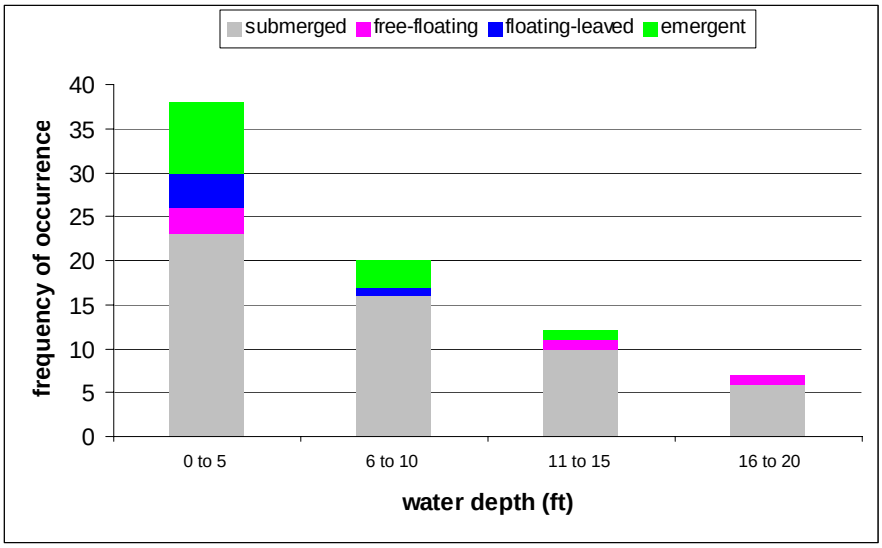


Figure 8. Plant abundance vs. water depth. Cullen Lakes, May 2007



The highest number of plant taxa was found from shore to a depth of five feet and most species were restricted to water depths less than six feet (Figure 9). Only six submerged species and one free-floating species were found in depths greater than 15 feet.

Figure 9. Number of plant taxa vs. water depth. Cullen Lakes, May 2007.



Emergent and floating-leaved species

Emergent and floating-leaf plant beds were most common in Upper Cullen Lake, where about 110 acres were delineated compared to 67 acres on Middle Cullen Lake and 37 acres on Lower Cullen Lake (Figure 7).

Common emergent species were Wild rice (*Zizania palustris*) (Figure 10) and Hardstem bulrush (*Scirpus acutus*) (Figure 11) and floating-leaf plants included Yellow waterlily (*Nuphar variegata*) and White waterlily (*Nymphaea odorata*). During the May 2007 field survey, wild rice was primarily in the early floating-leaf stage and waterlilies had just begun to reach the water surface.

Figure 10. Floating-leaf stage of Wild rice (*Zizania palustris*) and White waterlily (*Nymphaea odorata*), Middle Cullen Lake, May 2007

Bulrush, wild rice and other emergent aquatic plants offer shelter for insects and young fish as well as food, cover and nesting material for waterfowl, marsh birds and muskrats. Waterlily beds provide similar benefits and also provide shade for fish and frogs. Emergent and floating-leaf plants help buffer the shoreline from wave action and their root systems stabilize the lake bottom.

Figure 11. Bulrush (*Scirpus acutus*) in Middle Cullen Lake, May 2007

Common submerged species

The most frequently occurring submerged species in these lakes were muskgrass (*Chara* sp.) coontail (*Ceratophyllum demersum*), narrow-leaf pondweed (*Potamogeton freisii*), flat-stem pondweed (*Potamogeton zosteriformis*), and northern watermilfoil (*Myriophyllum sibiricum*). The non-native species, curly-leaf pondweed (*Potamogeton crispus*) occurred in all three lakes, but was not among the most frequently sampled plants in any of the lakes.

Muskgrass (*Chara* sp.) (Figure 12) was the most frequent species in Lower Cullen Lake, where it was found in 36 percent of the sample sites and was the second-most common species in Middle and Upper Cullen lakes, occurring in 33 and 21 percent of the sites, respectively (Table 3). It was widespread around the shorelines of all the lakes (Figure 13). In all three lakes, muskgrass dominated the shallow zone to a depth of five feet, where it was found in at least 50 percent of the sites (Figure 14).

Figure 12. Muskgrass (*Chara* sp.)

Muskgrass is a submerged, macroscopic algae that is common in many hardwater Minnesota lakes. It is named for its characteristic musky odor. Because muskgrass is an algae and does not form true stems, it is a low growing plant, often found entirely beneath the water surface where it

Figure 13. Distribution of common submerged species in Cullen Lakes, May-June 2007.

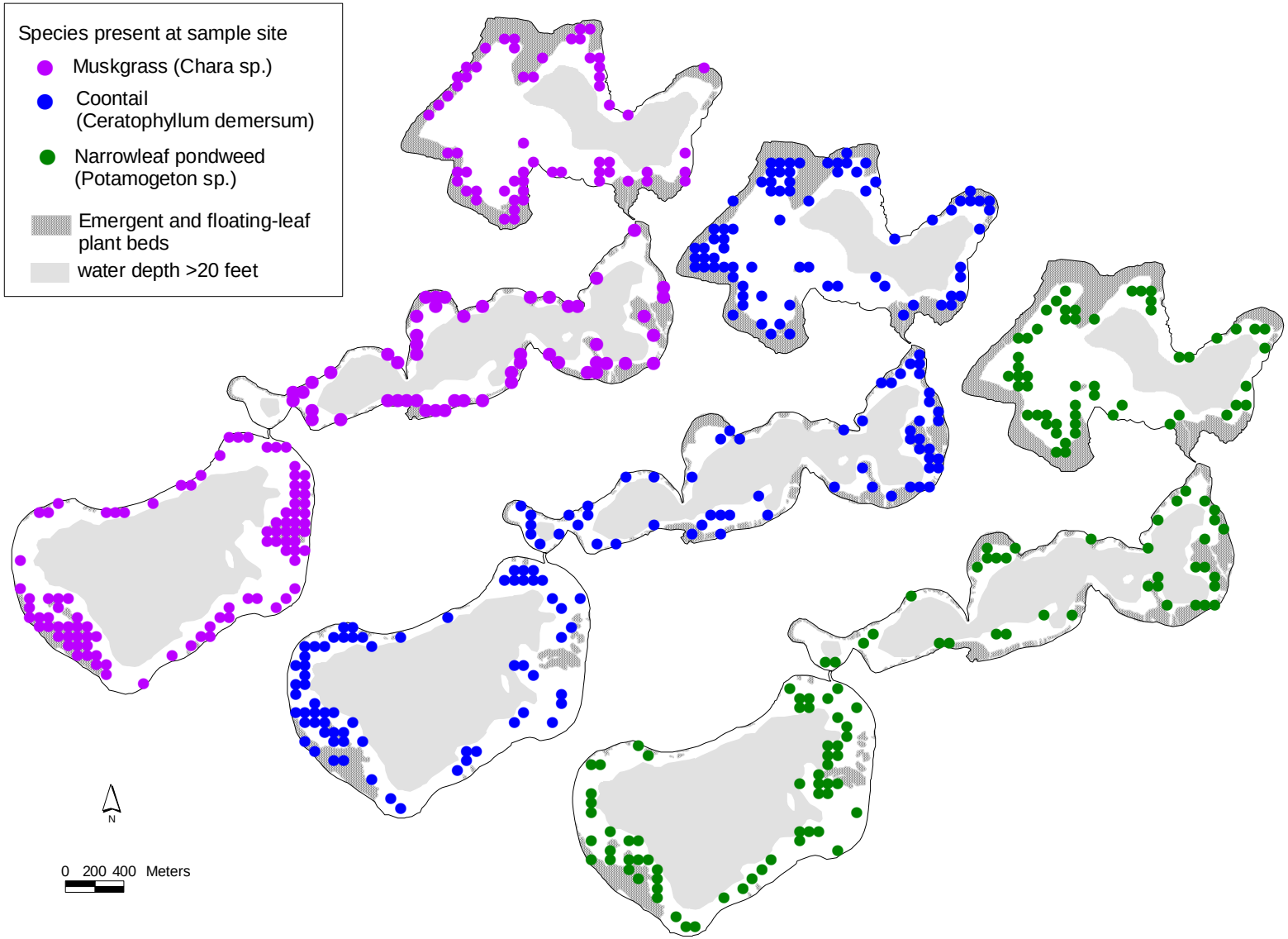


Figure 13. Distribution of common submerged species in Cullen Lakes, May-June 2007 (cont'd).

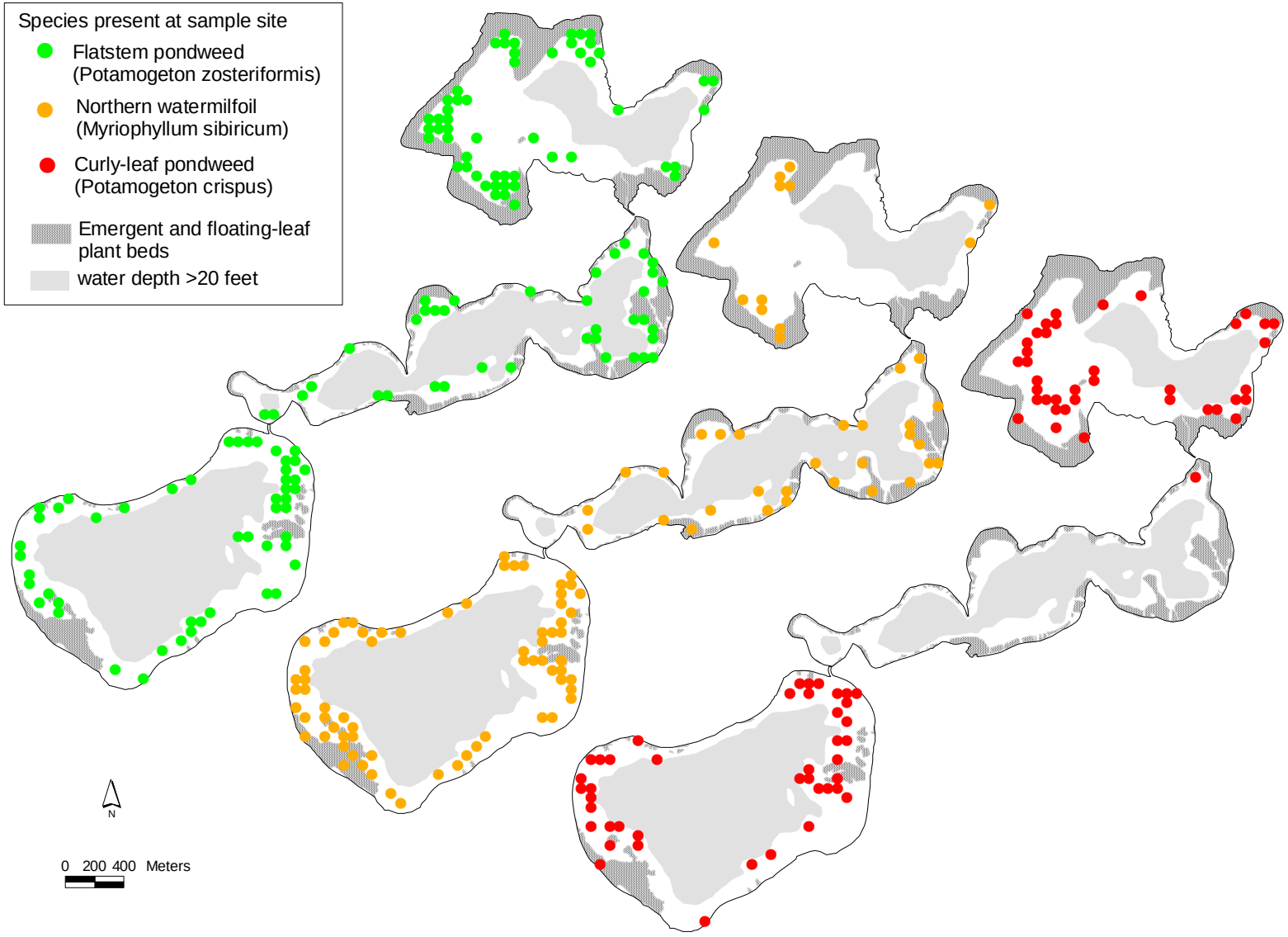
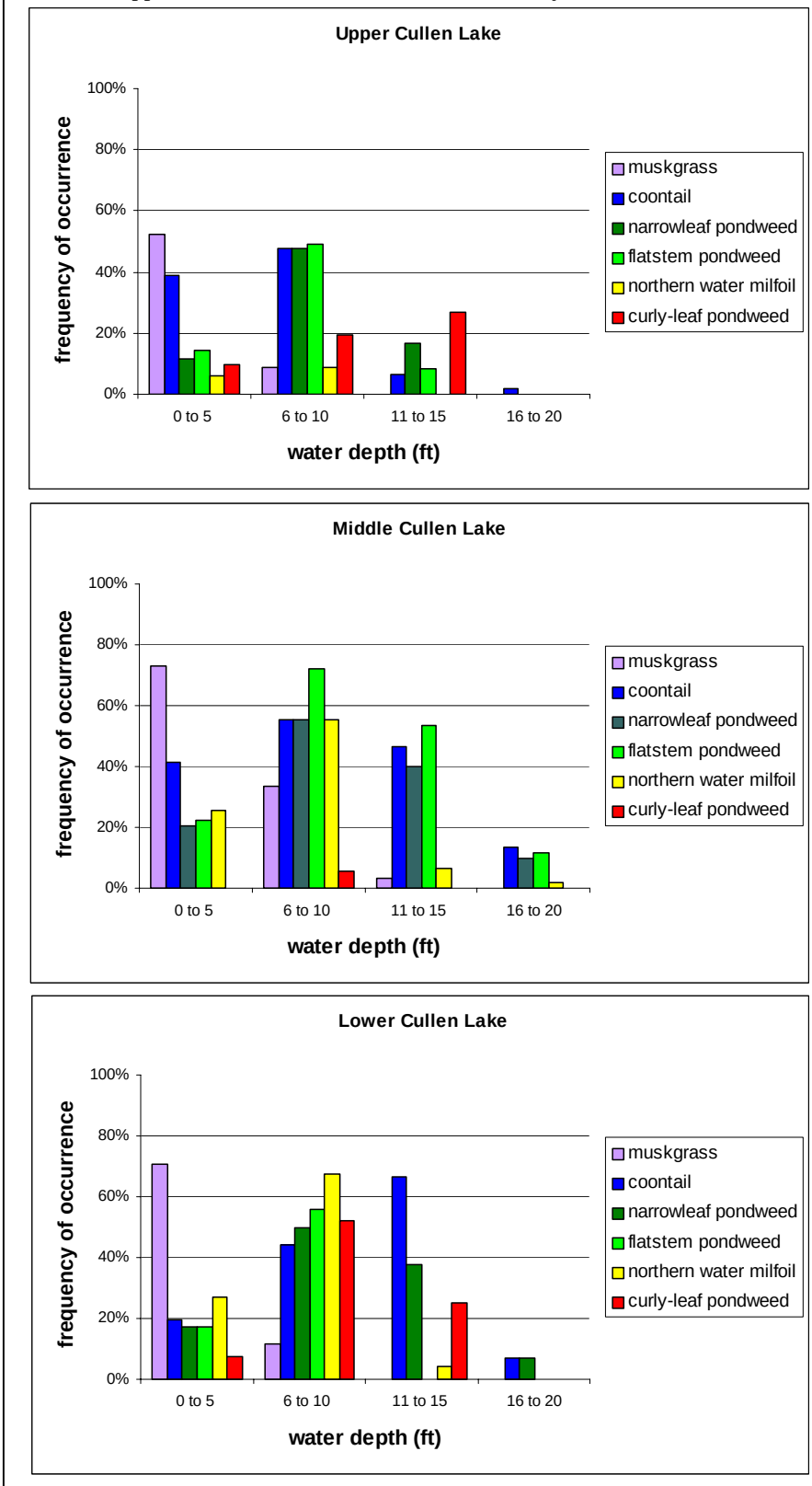


Figure 14. Frequency of common aquatic plant species vs. water depth.
Upper, Middle and Lower Cullen Lakes, May-June 2007.



may form low "carpets" on the lake bottom. Muskgrass is adapted to variety of substrates and is often the first species to grow in open areas of lake bottom where it can act as a sediment stabilizer. Beds of muskgrass provide critical cover and food, particularly for young fish. It is also a good food source for waterfowl. Invertebrates found within beds of muskgrass provide additional grazing for fish and waterfowl.

Figure 15. Coontail (*Ceratophyllum demersum*)

Coontail (*Ceratophyllum demersum*) (Figure 15) was the most frequently occurring species in Upper and Middle Cullen lakes where it was found in 26 percent and 35 percent of the sites, respectively, and in Lower Cullen Lake it occurred in 26 percent of the sites (Table 3).

Coontail is the most common submerged flowering plant in Minnesota. This perennial grows entirely submerged and is adapted to a broad range of lake conditions, including turbid water. It is often found growing in deeper water than other native species because it is more tolerant of low light conditions. Coontail was widespread in all three lakes (Figure 13) and grew at deeper depths than muskgrass. In Upper Cullen Lake, coontail was common to a depth of ten feet and in Middle Cullen and Lower Cullen lakes, it was common to 15 feet (Figure 14). Coontail was one of only seven species to occur in depths greater than 15 feet and was the most frequent species at this depth zone, occurring in seven percent of the sites.

Figure 16. Narrow-leaf pondweed (*Potamogeton friesii*)

Like muskgrass, the finely dissected leaves of coontail provide habitat for invertebrates and its dense growth form is excellent cover for fish.

Narrow-leaf pondweed (*Potamogeton freisii*) (Figure 16) was found in 22 percent of all sites sampled in the Cullen lakes (Table 3). Like coontail, this plant is adapted to lower light levels and often co-occurred with coontail (Figure 13). It was most common in six to 15 feet water depths (Figure 14) and was the second most frequently sampled species in depths greater than 15 feet where it occurred in five percent of the sites.

Figure 17. Flat-stem pondweed (*Potamogeton zosteriformis*)

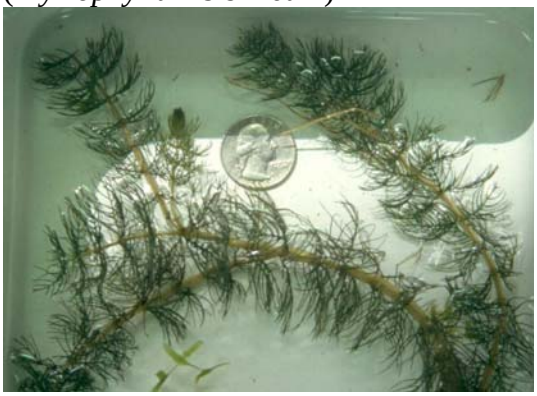
Flat-stem pondweed (*Potamogeton zosteriformis*) (Figure 17) is related to and resembles narrow-leaf pondweed but its leaves are flattened, wider and longer than narrow-leaf pondweed. Flat-stem pondweed occurred in 22 percent of the Cullen Lake sites (Table 3) and was found in similar

locations and depths as flat-stem pondweed (Figures 13 and 14).

Narrow-leaf and flat-stem pondweeds are both rooted, perennial plants with grass-like leaves. These pondweeds grow entirely submerged except for the flower and fruit stalks which emerge out of the water. Waterfowl feed on the fruits and tubers of these plants and pondweed foliage is important fish cover.

Northern watermilfoil (*Myriophyllum sibiricum*) (Figure 18) was found in 16 percent of the Cullen lakes sites and was most common in Middle and Lower Cullen lakes (Table 3, Figure 13). It was most frequent in water depths of six to 10 feet and at this depth it was found in more than 50 percent of sites in Middle and Lower Cullen lakes (Figure 14).

Figure 18. Northern watermilfoil (*Myriophyllum sibiricum*)



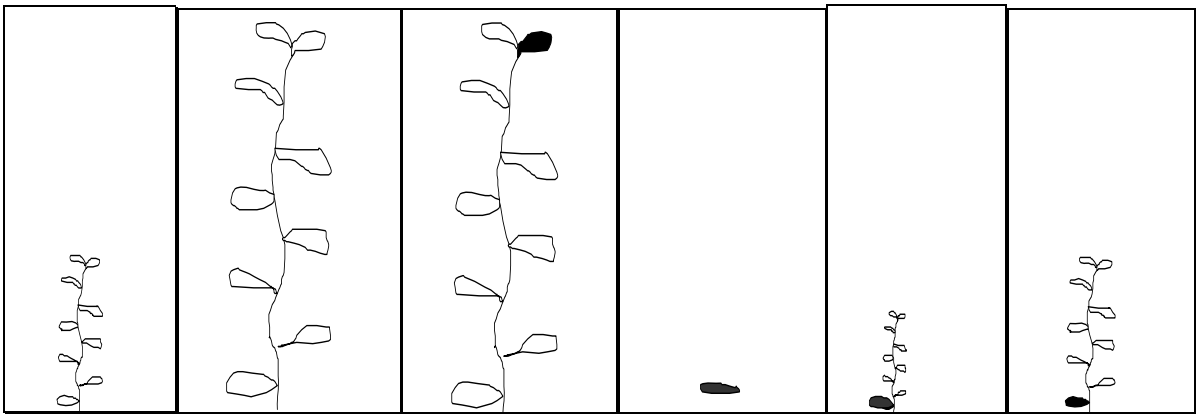
This perennial submerged species prefers soft substrates and is not tolerant of turbidity. Like coontail, it has finely dissected leaves but can be distinguished by its feather-shaped leaves that are characteristics of watermilfoil plants. Northern watermilfoil is native to Minnesota and provides valuable fish and wildlife habitat.

Curly-leaf pondweed (*Potamogeton crispus*) was present in 12 percent of the Cullen lakes sites. It occurred with a frequency of 11 percent in Upper Cullen Lake, one percent in Middle Cullen Lake, and 17 percent in Lower Cullen Lake (Table 3). Curly-leaf pondweed was most common in water depths of six to 15 feet (Figure 14) and often co-occurred with the common native species (Figure 13, 19).

Curly-leaf pondweed is a non-native, submerged plant that has been present in Minnesota since at least 1910 (Moyle and Hotchkiss 1945) and is now found in at least 700 Minnesota lakes (Invasive Species Program 2005). Like many native submerged plants, it is perennial but it has a unique life cycle that may provide a competitive advantage over native species. Curly-leaf pondweed is actually dormant during late summer and begins new growth in early fall (Fig. 20). Winter foliage is produced and continues to grow under ice (Wehrmeister and Stuckey 1978). Curly-leaf reaches its maximum growth in May and June, when water temperatures are still too low for most native plant growth. In late spring and early summer, curly-leaf plants form structures called “turions” which are hardened stem tips that

Figure 19. Curly-leaf pondweed (*Potamogeton crispus*) growing with white waterlilies in Middle Cullen Lake, May 2007.

Figure 20. Life cycle of Curly-leaf pondweed (*Potamogeton crispus*).



Winter	**Spring**	**Late Spring**	**Summer**	**Fall**	**Winter**
Plants continue Growing Under ice	Plants reach maximum growth	Plants die back and form turions	Turions remain dormant	Turions germinate	New plants sprout from turions

break off and fall to the substrate (Figure 20). Turions remain dormant through the summer and germinate into new plants in early fall (Catling and Dobson 1985).

The foliage of curly-leaf pondweed does provide some fish and wildlife habitat, but it may also create problems in some lakes, or in areas of some lakes. During its peak growth in spring, curly-leaf may reach the water surface at certain depths and create dense mats. These dense growths may compete with native vegetation and can also cause problems for recreational lake users.

Figure 21. Turions forming at tips of curly-leaf plants

Discussion

The Cullen Lakes support abundant and diverse native plant communities. Native vegetation provides critical habitat for fish and invertebrates, buffers the shorelines from wave action, and stabilizes sediments and utilizes nutrients that would otherwise be available for algae. (Click here for more information on: value of aquatic plants).

Higher mid-summer water clarity in Middle and Lower Cullen lakes may allow plants to grow to a greater depth than in Upper Cullen Lake, but in general the plant communities of these lakes are quite similar. The native plant species observed in the Cullen lakes are also commonly found in other central Minnesota lakes with similar water clarity and chemistry.

Because the spring 2007 survey was conducted before peak aquatic plant growth, it is important to note that the mid-summer 2007 distribution and abundance of some of the native species may be greater than that observed in May and early June. Specifically, the mid-summer abundance of bushy pondweed (*Najas flexilis*) was likely greater than that found during spring because bushy pondweed is an annual plant that sprouts from seed later in the summer (unlike most native aquatic plants which are perennial). Nevertheless, the results from the spring 2007 vegetation survey provide a good general representation of the native plant community composition.

The non-native, curly-leaf pondweed is probably not a recent invader in the Cullen Lakes. It has been present in Minnesota for at least 100 years and common in central Minnesota lakes for at least the past 20 years. Although curly-leaf pondweed has invaded these lakes, it does not dominate in any of the Cullen lakes. As comparison, in other Minnesota lakes surveyed during spring, using the same methodology, curly-leaf pondweed frequency ranged from five percent (Little Birch Lake, Todd County) to 68 percent (Big Swan Lake, Todd County) (Table 4).

Table 4. Comparison of curly-leaf pondweed (Potamogeton crispus) abundance in Minnesota lakes surveyed during spring. *Frequency of occurrence calculated for sites within the shore to 20 feet water zone

Lake	County	Survey Year	Percent of sites* where curly-leaf pondweed occurred
Middle Cullen	Crow Wing	2007	1
Little Birch	Todd	2004	5
Toad	Becker	2006	8
Upper Mission	Crow Wing	2005	10
Shamineau	Morrison	2005	10
Upper Cullen	Crow Wing	2007	11
Round	Crow Wing	2006	15
Lower Cullen	Crow Wing	2007	17
Crookneck	Morrison	2005	23
Lower Mission	Crow Wing	2005	25
Dixon	Itasca	2004	30
Pierz-Fish	Morrison	2005	30
Platte	Crow Wing	2003	40
Fishtrap	Morrison	2005	40
Alexander	Morrison	2007	40
Julia	Sherburne	2004	41
Crow Wing	Crow Wing	2007	46
Osakis	Todd	2005	50
Big Swan	Todd	2004	68

In lakes where curly-leaf occurrence reaches 30 percent or more of the shallow zone, the plant can cause greater nuisances as it occupies extensive areas of the lake. In lakes where curly-leaf frequency is less than 20 percent, it may form smaller, localized beds but creates fewer lakewide problems for boaters. During the May 2007 survey, areas of matted curly-leaf pondweed were observed in some areas of Upper, Middle and Lower Cullen Lakes. However, the location and extent of matted curly-leaf pondweed may fluctuate from year to year in lakes. For more information on biology and management of curly-leaf pondweed see page 51 in this report: MnDNR Invasive Species Annual Report.

Monitoring changes in aquatic plant community

The types and amounts of aquatic vegetation that occur within a lake are influenced by a variety of factors including water clarity and water chemistry. 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 from the 2007 Cullen Lakes vegetation survey can also be used to monitor annual changes in the native and non-native plant species composition. In general, factors that may lead to change in native and non-native aquatic plant communities include:

- Change in water clarity
  If water clarity in the Cullen Lakes increases, submerged vegetation may be more common at depths greater than 15 feet.
- Snow and ice cover
  Curly-leaf pondweed, in particular, may fluctuate in abundance in response to snow cover. 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, curly-leaf and some native submerged plants may increase in abundance.
- Water temperatures / length of growing season
  In years with cool spring temperatures, submerged plants may be less abundant than in years with early springs and prolonged warm summer days.
- Natural fluctuation in plant species
  Many submerged plants are perennial and regrow in similar locations each year. However, a few species such as wild rice (*Zizania palustris*) and bushy pondweed (*Najas flexilis*) are annuals and are dependant on the previous years seed set for regeneration.
- Aquatic plant management activities
  Humans can impact aquatic plant communities directly by destroying vegetation with herbicide or by mechanical means. For information on the laws pertaining to aquatic plant management: MnDNR APM Program. Motorboat activity in vegetated areas can be particularly harmful for species 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. Herbicide and mechanical control of aquatic plants can directly impact the aquatic plant community. These control activities should be monitored to reduce potential negative impacts to non-target species.

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