Aquatic Vegetation of
Norway Lake and Games Lake
Kandiyohi County, Minnesota

June 2004 and June 2006

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A note to readers:
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.

Throughout the report there will be tags for two species map. Map 1 shows the non-natives vs. natives. Map 2 shows the common submerged plants found during the surveys.

This report is also available online at:
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Summary

Norway and Games Lakes are connected waterbodies that differ in size, water depth, water clarity and nutrient levels. These lakes also vary in the types, abundance and distribution of aquatic vegetation. An aquatic vegetation survey was conducted in June 2004 and was repeated in June 2006. In both years, surveyors recorded information on water depth and vegetation at 404 sites.

Submerged plants were found to a maximum depth of 10 feet in Norway Lake and within the vegetated zone, plants occurred in 51% of the sites in 2004 and in 38% of the sites in 2006. Plants grew deeper in Games Lake and occurred to 17 feet in 2004 and to 19 feet in 2006. Within the shore to 20 feet depth zone of Games Lake, at least 70% of the sites were vegetated in both years.

A total of 26 aquatic plant taxa were recorded in these lakes. Submerged plants were the most common type with 18 different types occurring in Norway and 14 found in Games. Two floating-leaved and six emergent taxa were also recorded.

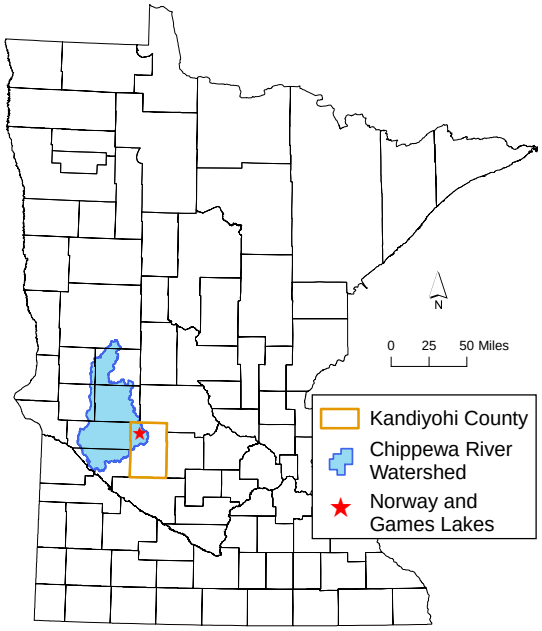
The most common native submerged plants in Norway and Games lakes were: native pondweeds (*Potamogeton* spp. and *Stuckenia pectinata*), northern watermilfoil (*Myriophyllum sibiricum*), muskgrass *(Chara* sp.), and coontail *(Ceratophyllum demersum)*. Two rare species that were recorded in these lakes in the 1930's were not found in 2004 or 2006.

Two non-native submerged plants were found during the surveys. Curly-leaf pondweed (*Potamogeton crispus*) was the most common submerged plant in Games Lake, occurring in 45% of the sites in 2004 and in 48% of the sites in 2006. In both survey years, it was found in less than 5% of the Norway Lake sites. Eurasian watermilfoil (*Myriophyllum spicatum*) was the most common plant found in Norway Lake occurring in 23% of the sites in 2004 and in 15% in 2006. It was primarily found in West Norway Lake and, as of 2006, is has not been located in Games Lake.

Introduction

Norway Lake and Games Lake are located eight miles west of the municipality of New London in Kandiyohi County, Minnesota (Figure 1). The lakes lie at the eastern edge of the Chippewa River Watershed. The lakes sit at the headwaters of Shakopee Creek, which flows into the Chippewa River and ultimately into the Minnesota River at Montevideo.

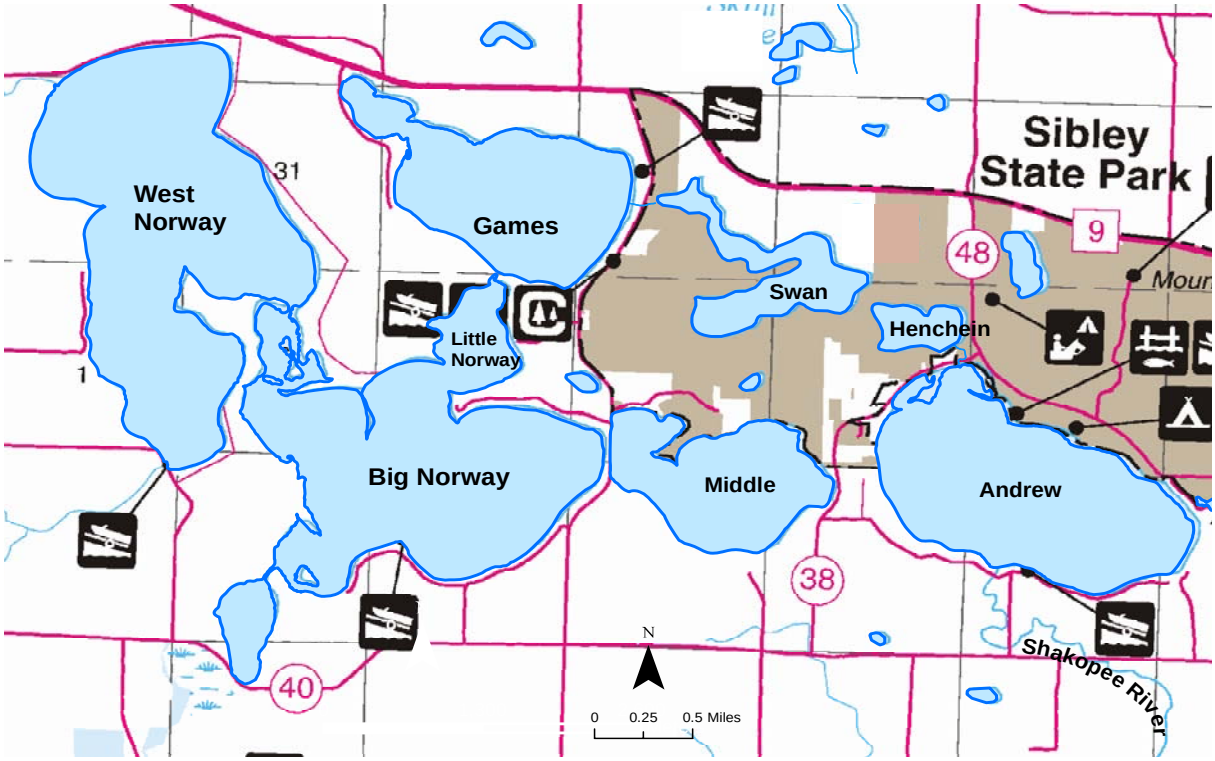
Figure 1. Location of Norway and Games Lakes in Minnesota



Norway Lake is the headwater lake to a chain of lakes (Figure 2). Flow enters West Norway Lake from two county ditches and an outlet channel at Little Norway connects to Games Lake. A dam at the outlet of Games Lake controls water levels in both Norway and Games lakes (Runholt et al. 1995). Water flows out of Games Lake through Swan, Henchein and Andrew lakes and then to Shakopee Creek.

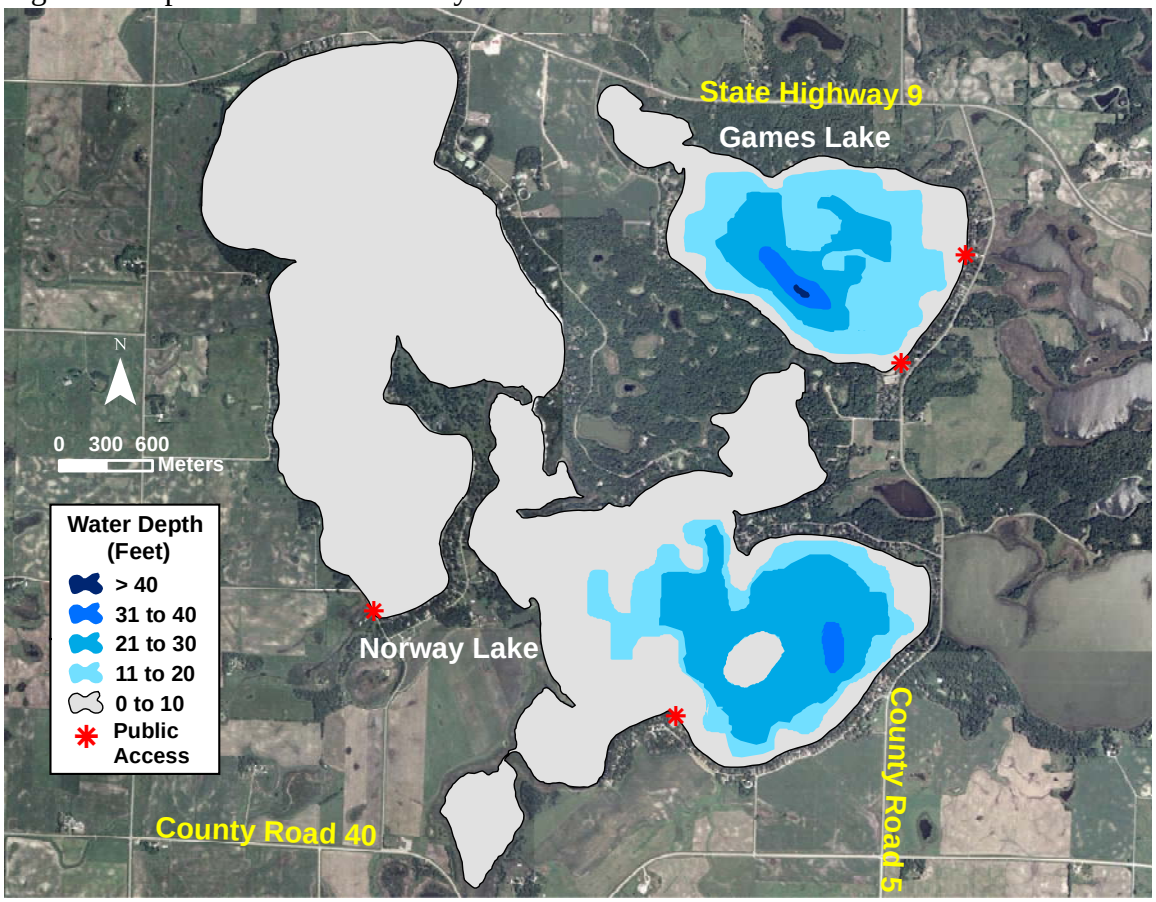
Norway Lake has a total surface area of about 2,344 acres and consists of three distinct basins: West Norway (1,179 acres), Big Norway (1,055 acres) and Little Norway (110 acres) (Figure 2).

Figure 2. Chain of lakes that includes Norway and Games lakes.



West Norway and Little Norway basins are entirely shallow (less than 10 feet in depth) and Big Norway has a maximum depth of 33 feet (Figure 3). Games Lake is 515 acres in area with a maximum depth of 42 feet (Figure 3).

Figure 3. Depth contours of Norway and Games Lakes.



Land use around these lakes is dominated by agricultural row crops and feedlots, with portions remaining in upland hardwood forests and wetlands. The southern shore of Norway Lake and most of West Norway Bay are bordered by agricultural and grasslands. Upland deciduous forest borders most of the Games Lake shoreline with small portions of the shoreline abutting agricultural land. While several homes and cabins are located on Games Lake, portions of the shoreline remain undeveloped.

Norway and Games lakes are described as eutrophic (high nutrients) but they differ in water clarity and aquatic plant growth. West Norway basin is windswept and turbid with blue-green algae blooms common during late summer (MnDNR Fisheries Lake Files). Mean summer water clarity in Big and Little Norway basins ranges from about three to five feet (MPCA 1998-2008) and aquatic plant growth is moderate to abundant. Games Lake mean summer water clarity ranges from about seven to nine feet (MPCA 1998-2008) and aquatic plant growth is common in this lake.

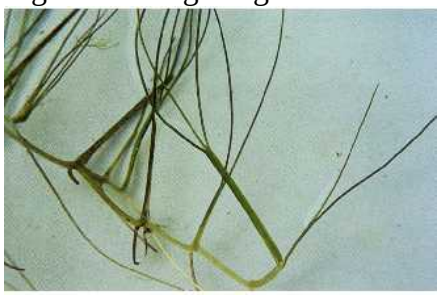
Two rare plant species were historically present in these lakes but have not been found since the 1930's. Spiny naiad (*Najas marina*; Figure 4) and widgeon grass (*Ruppia maritima*; Figure 5) are submerged, native aquatic plants that are listed as rare species of Special Concern in Minnesota. These plants are typically restricted to western Minnesota lakes with high alkalinity, high conductivity and high pH. Spiny naiad was documented in Norway Lake in 1930 and widgeon grass was confirmed in Norway and Games lakes in 1937 (MnDNR Natural Heritage Program database).

Figure 4. Spiny naiad

Photo: USACE Aquatic Plant Info System http://el.erdc.usace.army.mil/aqua/apis

Two non-native, submerged aquatic plants have been found in these lakes. Curly-leaf pondweed (*Potamogeton crispus*) has been documented in both Norway and Games lakes. Eurasian watermilfoil (*Myriophyllum spicatum*) was first recorded in Norway Lake in 2001 but, to date, has not been documented in Games Lake.

Figure 5. Widgeon grass



Edward G. Voss. USDA NRCS. 1992. *Western wetland flora: Field office guide to plant species*. West Region, Sacramento. Courtesy of USDA NRCS Wetland Science Institute.

Objectives

The purpose of the 2004 and 2006 surveys of Norway Lake and Games Lake was to describe the aquatic plant community including:

1) Estimate the maximum depth of vegetation
2) Estimate the percent of each lake occupied by vegetation
3) Record the aquatic plant species that occur in each lake
4) Estimate frequencies of occurrence of individual species
5) Develop maps of the distribution of the common species

Data from the 2004 and 2006 vegetation surveys can be used to monitor annual changes in the native and non-native plant species composition and may also be used to guide vegetation management decisions.

Methods

Point-Intercept vegetation surveys were conducted on Norway and Games lakes on June 14-16 and 21, 2004 and June 7-8, 2006 following the methodology described by Madsen (1999).

A Geographic Information System (GIS) was used to generate sample points across the lake surface. On Norway Lake, sample points were placed using a 150 meter by 150 meter (500 feet by 500 feet) grid and surveyors sampled to a depth of 15 feet. On Games Lake, sample points were placed using a 125 meter by 125 meter (400 feet by 400 feet) grid and surveyors sampled to a depth of 20 feet.

Survey point locations were uploaded into a Global Positioning System (GPS) unit, which 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 eight feet and an electronic depth finder in water depths greater than eight feet. The surveyors recorded all plant species found within a one meter squared sample site at the pre-designated side of the boat. A double-headed weighted garden rake (Figure 6), attached to a rope, was used to survey vegetation not visible from the surface.

Figure 6. sampling rake

Surveyors used the same sampling grid in both survey years but some sites were not surveyed in both years because of water depth or accessibility (Figure 7). Only sites that were surveyed in both years were used in analyses. In Norway Lake, 313 sites were sampled within the vegetated zone (0 to 10 feet depth) in both survey years and in Games Lake, 91 sites within the vegetated zone (0 to 20 feet depth) were sampled in both years (Table 1). 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.

Figure 7. Vegetation survey sites in Norway and Games Lakes, 2004 and 2006.

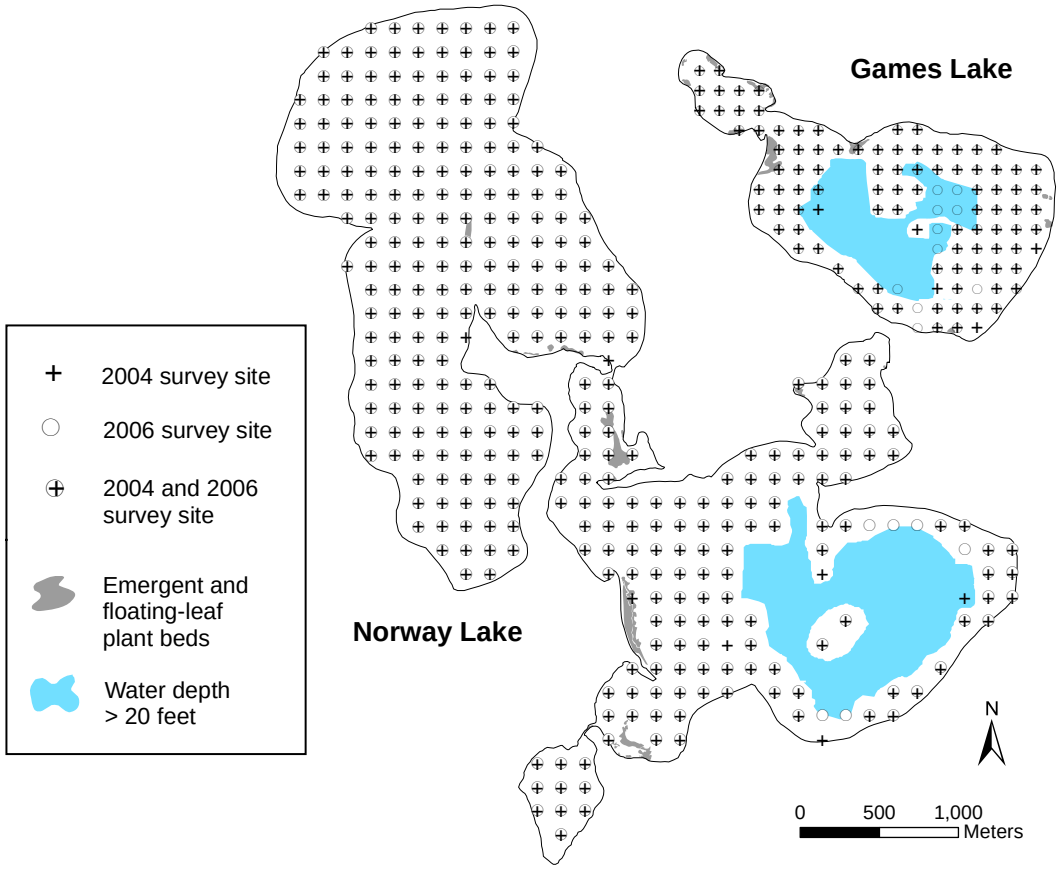


Table 1. Sampling effort by water depth. Includes only those sites sampled in both 2004 and 2006 within the vegetated zone of each lake.

	Norway		Games	
Water depth interval	2004	2006	2004	2006
0 to 5	76	105	20	20
6 to 10	237	208	22	24
11 to 15	n/a	n/a	21	18
16 to 20 feet	n/a	n/a	28	29
Total	313	313	91	91

Frequency was calculated for the entire vegetated zone: 0 to 10 feet in Norway Lake and 0 to 20 feet in Games Lake.

Example: In Norway Lake there were 313 sample sites within the 0 to 10 feet depth zone. In 2006, coontail (*Ceratophyllum demersum*) occurred in 21 of those sites.
Frequency of coontail in 0 to 10 feet zone of Norway Lake in 2006 = 21/313 (*100) = 7%

Sampling points were also grouped by water depth and separated into five feet increment depth zones for analysis (Table 1). Nomenclature followed Crow and Hellquist (2000). Voucher specimens were collected for most plant species.

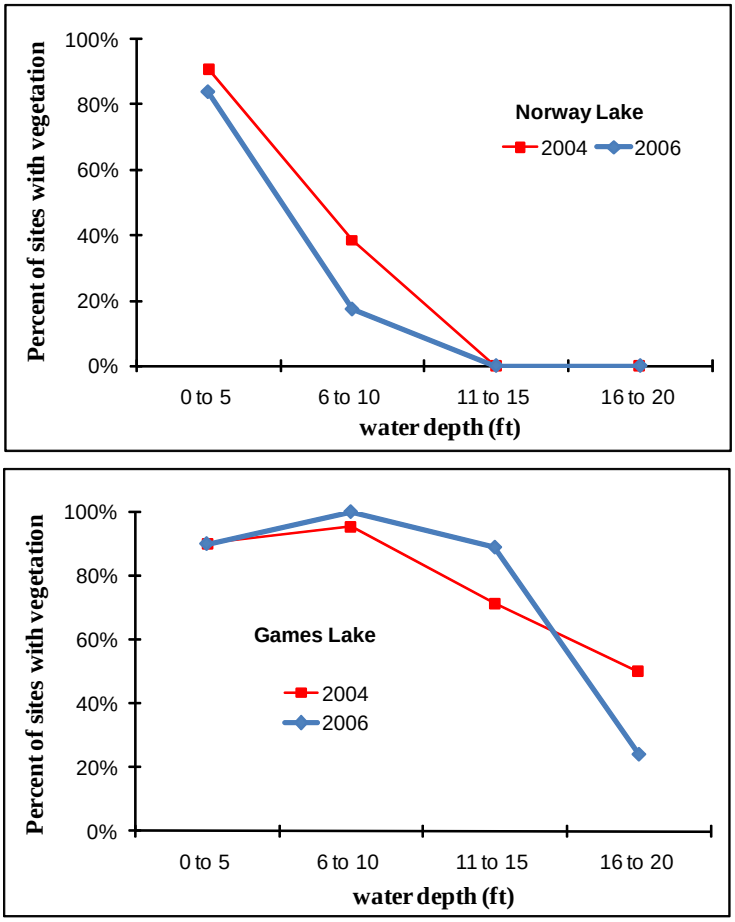
Results / Discussion

Distribution of vegetation by water depth

In Norway Lake, plants occurred to a depth of 10 feet in both survey years. Within the shore to 10 feet depth zone, 51% of the sites contained vegetation in 2004 and 38% were vegetated in 2006 (Table 2). Plants were most frequent in the depth zone from shore to five feet, where more than 80% of the sites contained plants (Figure 8).

In Games Lake, plants were found to a depth of 17 feet in 2004 and to 19 feet in 2006. At least 70% of the sites were vegetated in both years (Table 2). Plants were most frequent in the shore to fifteen feet depth zone, where at least 85% of the sites contained plants (Figure 8).

Figure 8. Plant frequency vs. water depth in Norway and Games Lake, June 2004 and 2006.



Number and types of plant species found and distribution by water depth

A total of 26 aquatic plant taxa were recorded in Norway Lake (Table 2) and 16 taxa were found in Games Lake (Table 3). Submerged plants were the most common type found with 18 different types occurring in Norway and 14 in Games. Two floating-leaved and six emergent taxa were also recorded.

The majority of plants recorded are native to Minnesota. The non-native plant, curly-leaf pondweed, was present in both lakes and the non-native plant, Eurasian watermilfoil, was found in Norway Lake. The rare species, spiny naiad and widgeon grass, were not found.

The zone from shore to a depth of five feet contained the greatest number of plant taxa and all life forms (submerged, floating-leaf and emergent) occurred at this depth interval in both lakes (Figure 9). Only submerged (native and non-native) plants were found in depths greater than five feet. No plants were found beyond the ten feet depth in Norway Lake. In Games Lake, only four native submerged and one non-native submerged plant taxa were found beyond the 15 feet depth.

Table 2. Aquatic Plants of Norway Lake, June 2004 and June 2006

Life Forms	Common Name		Scientific Name	% occurrence within shore to 10 feet depth zone	
				2004	2006
SUBMERGED	Pondweeds	Curly-leaf pondweed	*Potamogeton crispus*	4	2
		Sago pondweed	*Stuckenia pectinata*	12	8
		Flat-stem pondweed	*Potamogeton zosteriformis*	2	2
		Fries' pondweed	*Potamogeton friesii***	<1	5
		Clasping-leaf pondweed	*Potamogeton richardsonii*	1	3
		White-stem pondweed	*Potamogeton praelongus*	---	<1
		Illinois pondweed	*Potamogeton illinoensis*	Present	1
		Large-leaf pondweed	*Potamogeton amplifolius*	Present	---
	Watermilfoils	Eurasian watermilfoil	*Myriophyllum spicatum*	23	15
		Northern watermilfoil	*Myriophyllum sibiricum*	6	8
	Large Algae	Muskgrass	*Chara* sp.	16	14
		Coontail	*Ceratophyllum demersum*	7	7
		Greater bladderwort	*Utricularia vulgaris*	1	1
		Wild celery	*Vallisneria americana*	<1	3
		Bushy pondweed	*Najas flexilis*	1	5
		Water stargrass	*Zosterella dubia*	---	1
		Canada waterweed	*Elodea canadensis*	Present	---
		White water buttercup	*Ranunculus aquatilis*	Present	---
FLOATING-LEAVED		Floating-leaf pondweed	*Potamogeton natans*	1	1
		Yellow waterlily	*Nuphar variegata*	<1	---
EMERGENT		Bulrush	*Scirpus* sp.	1	1
		Cattail	*Typha* sp	<1	---
		Spikerush	*Eleocharis* sp.	Present	---
		Giant Cane	*Phragmites* sp.	Present	---
		Arrowhead	*Sagittaria cuneata****	Present	---
		Wild rice	*Zizania palustris*	Present	---
			Number of sample sites	313	313
			Percent of sites with vegetation	51%	41%

"---" means plant was not found in that year

present indicates plant was found during survey but did not occur within a specific sample site.

** *Potamogeton friesii* was identified in the lake but it is not known whether all narrow-leaf pondweed plants were *P. friesii*.

*** *Sagittaria cuneata* was identified in the lake but it is not known whether all arrowheads were *S. cuneata*.

Table 3. Aquatic plants of Games Lake, June 2004 and June 2006.

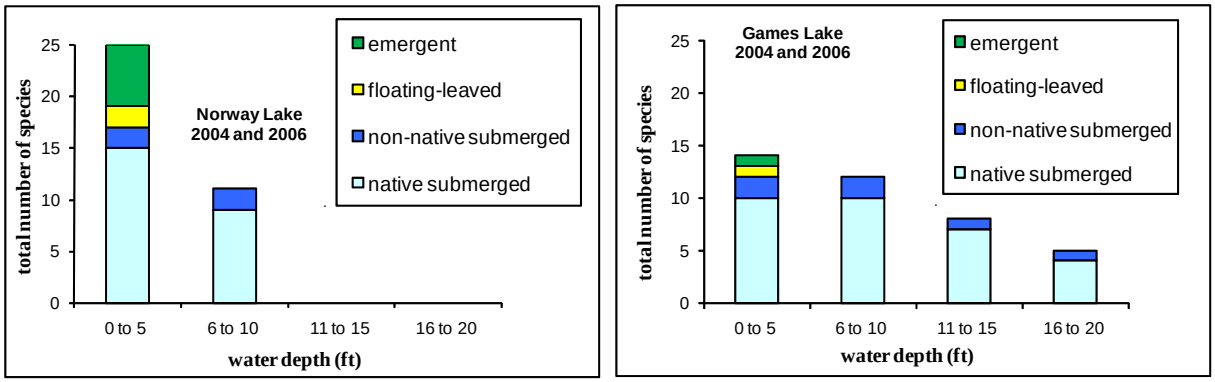
				% occurrence within shore to 20 feet depth zone	
Life Forms		**Common Name**	**Scientific Name**	**2004**	**2006**
SUBMERGED	Pondweeds	Curly-leaf pondweed	*Potamogeton crispus*	48	45
		Flat-stem pondweed	*Potamogeton zosteriformis*	23	15
		Fries' pondweed	*Potamogeton friesii**	19	22
		Sago pondweed	*Stuckenia pectinata*	14	5
		Clasping-leaf pondweed	*Potamogeton richardsonii*	9	8
		White-stem pondweed	*Potamogeton praelongus*	3	5
		Illinois pondweed	*Potamogeton illinoensis*	---	7
	Watermilfoils	Northern watermilfoil	*Myriophyllum sibiricum*	32	15
	Large Algae	Muskgrass	*Chara* sp.	16	16
		Stonewort	*Nitella* sp.	2	---
		Coontail	*Ceratophyllum demersum*	13	19
		Greater bladderwort	*Utricularia vulgaris*	8	11
		Wild celery	*Vallisneria americana*	1	8
		Bushy pondweed	*Najas flexilis*	---	2
FLOATING -LEAVED		Floating-leaf pondweed	*Potamogeton natans*	2	2
EMERGENT		Cattail	*Typha* sp	present	present
			Number of sample sites	91	91
			Percent of sites with vegetation	75%	71%

"---"means plant was not found in that year

present indicates plant was found during survey but did not occur within a specific sample site.

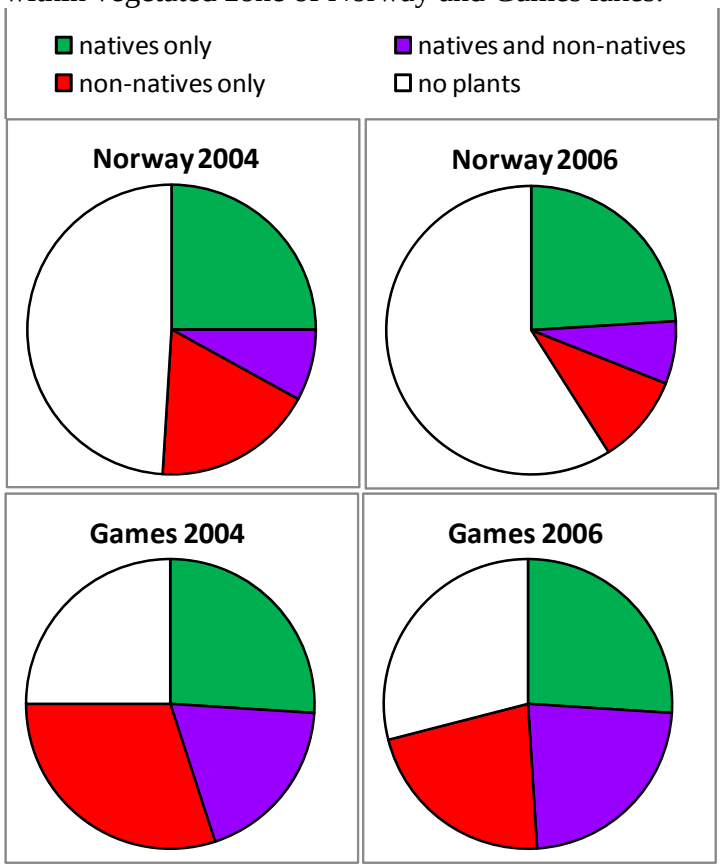
**Potamogeton friesii* was identified in the lake but it is not known whether all narrow-leaf pondweed plants were *P. friesii*.

Figure 9. Number of species found at each water depth interval in Norway and Games lakes.



Native vs. Non-native Plants
During both survey years, within the vegetated zone of each lake (0 to 10 feet in Norway Lake, 0 to 20 feet in Games Lake), about 25% of the sites contained only native vegetation (Figure 10). In Norway Lake, less than 30% of the sites contained non-native plants or a mix of natives and non-natives. In Games Lake, at least 45% of the sites contained non-natives or a mix of natives and non-natives (Map 1).

Figure 10. Occurrence of native and non-native plants within vegetated zone of Norway and Games lakes.



Abundance and Distribution of Common Submerged Plants
Submerged plants have leaves that grow below the water surface but some species also have the ability to form floating and/or emergent leaves, particularly in shallow, sheltered sites. Submerged plants may be firmly attached to the lake bottom by roots or rhizomes, or they may drift freely with the water current. This group includes flowering plants that produce flowers above or below the water surface, as well as non-flowering plants such as large algae.

The most common submerged plants in Norway and Games lakes were: native pondweeds (*Potamogeton* spp. and *Stuckenia pectinata*), curly-leaf pondweed (*Potamogeton crispus*), Eurasian watermilfoil (*Myriophyllum spicatum*), northern watermilfoil (*Myriophyllum sibiricum*), muskgrass *(Chara* sp.), and coontail *(Ceratophyllum demersum).*

Pondweeds (*Potamogeton* spp. and *Stuckenia*) are one of the largest groups of submerged plants in Minnesota lakes. These plants are rooted perennials and their rhizomes may form mats on the lake bottom that help consolidate soil (Arber 1920). Pondweeds have opposite, entire leaves and form cigar-shaped flowers that emerge above the water surface. Many pondweed species over-winter as hardy rhizomes while other species produce tubers, specialized winter buds, or remain "evergreen" under the ice. Seeds and tubers of pondweeds are an important source of waterfowl food (Fassett 1957). 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 inhabit a wide range of aquatic sites and species vary in their water chemistry and substrate preferences and tolerance to turbidity. There are over 35 species of pondweeds in Minnesota and they vary in leaf shapes and sizes.

Eight native pondweed species were located in Norway Lake and seven were found in Games Lake. Narrow-leaf pondweeds were most common and included Sago pondweed (*Stuckenia pectinata*) (Figure 11), flat-stem pondweed (*Potamogeton zosteriformis*) (Figure 12), and Fries' pondweed (*Potamogeton friesii*). Several species of broad-leaf pondweeds, such as clasping-leaf pondweed (*Potamogeton richardsonii*) (Figure 13) also occurred in each lake. In both lakes, native pondweeds were scattered around the shoreline and were most common in depths less than ten feet (Map 2, Figure 14). In 0 to 10 feet depth zone of Games Lake, native pondweeds were present in at least 60% of the sites, but in the same depth zone of Norway Lake they occurred in about 15% of the sites.

Figure 11. Sago pondweed

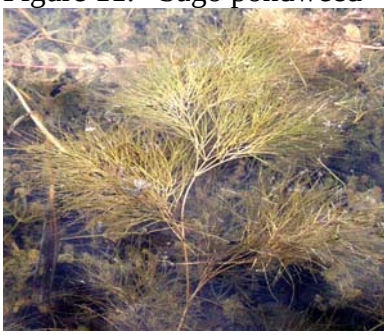
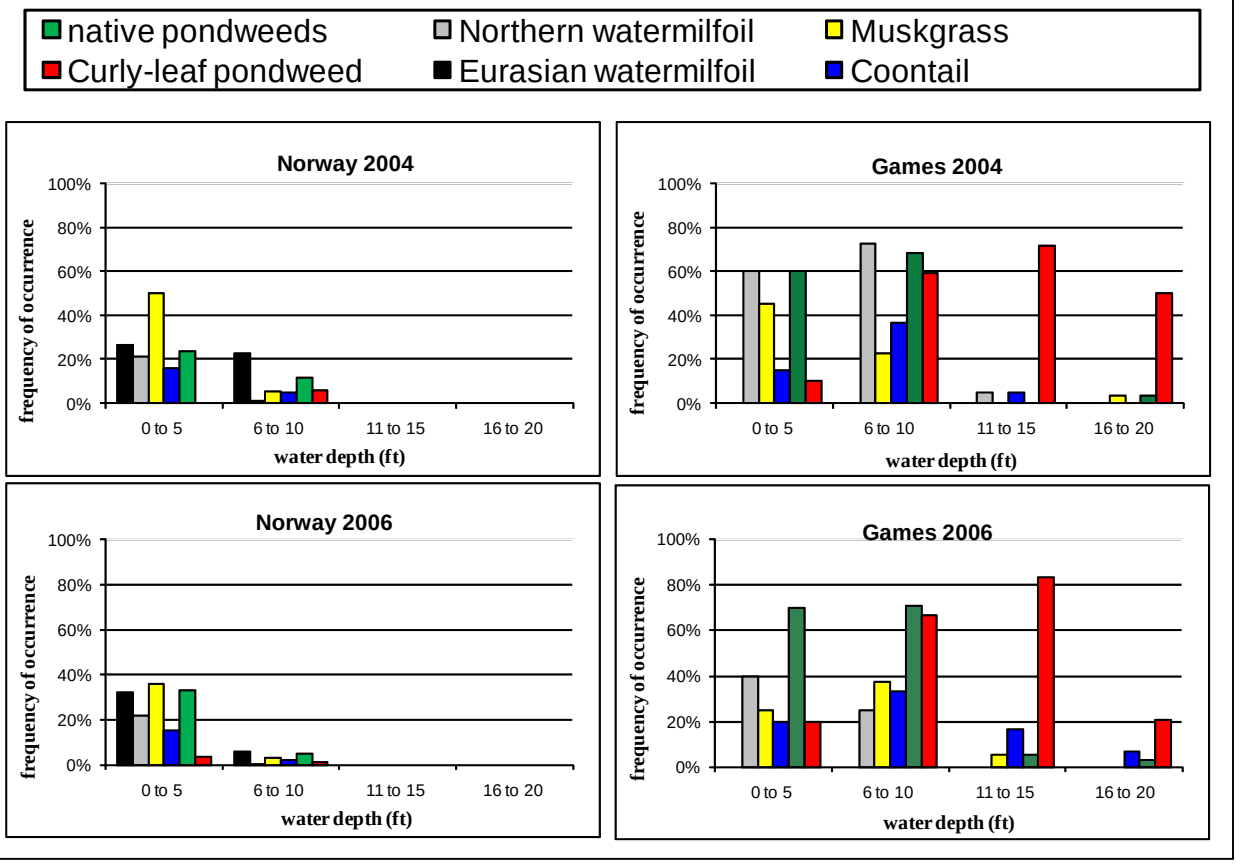


Figure 12. Flat-stem pondweed

Figure 13. Clasping-leaf pondweed

Photo: Vic Ramey: ©2001 Univ of Florida/ IFAS Center for Aquatic and Invasive Plants

Figure 14. Frequency of common submerged plants by water depth.



Curly-leaf pondweed (*Potamogeton crispus*) (Figure 15) is closely related to the native pondweeds but it is not native to Minnesota. This 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 (MnDNR Invasive Species Program 2008). Like many native submerged plants, it is perennial but 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. 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 break off and fall to the substrate. Turions remain dormant through the summer and germinate into new plants in early fall (Catling and Dobson 1985).

Figure 15. Curly-leaf pondweed

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.

Curly-leaf pondweed was the most abundant plant in Games Lake, occurring in 45% of the 2004 sites and in 48% of the 2006 sites (Table 3). It was most frequent in the six to 15 feet depth zone and was one of only four species to occur in depths greater than 15 feet in this lake (Figure 14). Curly-leaf pondweed was found around the entire perimeter of Games Lake at many sites it was the only plant found (Map 1 and 2).

In Norway Lake, curly-leaf pondweed was present in only 4% of the 2004 sites and in 2% of the 2006 sites (Table 2). It was found to a maximum depth of seven feet in this lake and occurred at scattered locations around the shoreline (Map 1 and 2).

Northern watermilfoil (*Myriophyllum sibiricum*) (Figure 16) is a rooted, perennial submerged plant with finely dissected, feather-shaped leaves. It may reach the water surface, particularly in depths less than ten feet and its flower stalk extends above the water surface. It spreads primarily by stem fragments and over-winters by hardy rootstalks and winter buds. Northern watermilfoil is not tolerant of turbidity and grows best in clear water lakes.

Figure 16. Northern watermilfoil

Northern watermilfoil was found in 5% of Norway Lake survey sites in 2004 and 7% of the sites in 2006 (Table 2). In Games Lake, northern watermilfoil was one of the more frequently observed submerged plants, occurring in 31% of the 2004 survey sites and in 14% of the 2006 sites (Table 3). It was found in water depths of ten feet and less in

both lakes (Figure 14). It was common in the shallow areas on the north end of Games Lake and the west shore of Big Norway Lake (Map 2).

Eurasian watermilfoil (*Myriophyllum spicatum*) (Figure 17) is closely related to northern watermilfoil and is also a rooted, submerged perennial plant with finely divided leaves. There are several native watermilfoil plants in Minnesota, but Eurasian watermilfoil has been introduced into the state. For information on how to distinguish the non-native, Eurasian watermilfoil from the native northern watermilfoil, click here: identification. Eurasian watermilfoil is adapted to survive in lower light levels than many native aquatic plants but still requires adequate light for growth.

Figure 17. Eurasian watermilfoil

In 2001, Eurasian watermilfoil was first documented in Norway Lake. By 2004, it was the most common submerged plant and occurred 23% of sample sites; in 2006 it was found in 15% of the sites (Table 2). In both years it was found in water depths less than ten feet (Figure 14) and was primarily restricted to West Norway basin (Map 2). Eurasian watermilfoil was not found in Games Lake in either survey year.

Coontail (*Ceratophyllum demersum*) (Figure 18) grows entirely submerged and its roots are only loosely anchored to the lake bottom. It is adapted to a broad range of lake conditions and is tolerant of higher turbidity and can grow in muck substrates. Coontail is perennial and can overwinter as a green plant under the ice and then begins new growth early in the spring, spreading primarily by stem fragmentation. The finely divided leaves of this plant provide a home for insects valuable as fish food.

Figure 18. Coontail

In Norway Lake, coontail occurred in 7% of survey sites in both years (Table 2) and was restricted to depths of ten feet and less (Figure 14). It was more frequent in Games Lake, occurring with a frequency of 13% in 2004 and 19% in 2006 (Table 3). Coontail was found to a depth of 17 feet in Games Lake but was most common in the 6 to 10 feet depth zone (Figure 14). Coontail often co-occurred with northern watermilfoil (Map 2).

Muskgrass (*Chara* sp.) (Figure 19) is a macroscopic, or large, algae that is common in many hard water lakes in Minnesota. It has a brittle texture and a characteristic “musky” odor. Because muskgrass does not form true stems, it is a low-growing plant, often found entirely beneath the water surface where it may form low “carpets” on the lake bottom.

Figure 19. Muskgrass

Muskgrass is adapted to a variety of substrates and is often the first taxa to colonize open areas of lake bottom where it can act as a sediment stabilizer. Beds of muskgrass can provide important fish spawning and nesting habitat

Muskgrass occurred in about 15% of the survey sites in both lakes but was restricted to depths of five feet and less in Norway and could be found in deeper depths in Games Lake (Figure 14). Muskgrass often occurred in mixed beds with other submerged species, but could also be found growing in areas where no other plants occurred (Map 2).

Factors influencing the aquatic plant communities of Norway and Games Lakes

Light availability is one of the primary factors that influences the types and abundance of aquatic plants in lakes. Greater water clarity in Games Lake allows submerged vegetation to grow to nearly twice the depth than where plants were found in Norway Lake.

The differences in water clarity also impact the types of plants that occur in these lakes. The submerged plant species commonly found in Norway Lake: Eurasian watermilfoil and sago pondweed are tolerant of turbid waters (Nichols 1999). Flat-stem pondweed and northern watermilfoil, which were common in Games Lake but not in Norway, are not tolerant of high turbidity (Nichols 1999).

Curly-leaf pondweed is tolerant of turbidity (Nichols 1999) and therefore might be expected to grow more abundantly in Norway Lake. It is interesting to note that in Games Lake, curly-leaf pondweed grows most frequently in water depths greater than five feet. It is possible that the presence of native plants in the shallower water helps limit the growth of curly-leaf. Similarly in Norway Lake, native plants may limit curly-leaf growth in shallow water and excessive turbidity may limit its growth in deeper waters. The occurrence of native aquatic beds in Big Norway and Games Lakes may also help limit the growth of Eurasian watermilfoil.

The 2004 and 2006 vegetation surveys give a “snapshot” of Norway and Games lakes plant community conditions. Data collected during these surveys can be compared to future quantitative surveys to better estimate how the plant community may be changing. Monitoring changes in aquatic plant communities can help reflect changes in the overall water quality of the lake and watershed.

In general, factors that may lead to change in native and non-native aquatic plant communities include:

- **Change in water clarity**
  Light availability is a significant factor limiting plant distribution and abundance. The amount of light available to submersed aquatic plants is typically dependent on both water clarity and depth. Excess nutrients, such as elevated phosphorus levels, often result in nuisance algal levels that contribute to decreased water clarity. If water clarity increases, native and non-native submerged vegetation may occur in deeper areas of these lakes.
- **Snow and ice cover**
  Curly-leaf pondweed, in particular, may fluctuate in abundance in response to snow and ice cover. Many native submerged plants also have the ability to grow under the ice,

particularly if there is little snow cover and sunlight reaches the lake bottom. In years following low snow cover, and/or in years with shorter ice over periods, 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 bushy pondweed (*Najas* sp.*)* are annuals and are dependent on the previous years' seed set for regeneration.
- **Aquatic plant management activities**
  Herbicide and mechanical control of aquatic plants can directly impact the aquatic plant community. Monitoring these control activities can help insure that non-target species are not negatively impacted.
- **Shoreland management activities**
  Disturbances to the aquatic environment can be minimized through the use of shoreline best management practices. These include minimizing activities that contribute to eutrophication (high-nutrient lake with poor water quality due to nuisance algal blooms) such as fertilizing lawns and malfunctioning septic systems, both of which add nutrients to a lake. Additionally, shoreline vegetation restoration projects can provide a buffer zone between the lake and developed residential areas. Benefits include minimizing soil erosion from wave action while the plants uptake excess nutrients that may otherwise flow into the lake.

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