

**Aquatic Macrophyte Survey of  
Forest Lake, Fond Du Lac Co., Wisconsin**

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## Objectives:

A survey of the aquatic macrophyte community of Forest Lake (T13N, R19E, sec 12) was conducted in July 2004 for the Forest Lake Improvement Association, Inc. The objectives were to determine aquatic macrophyte composition and abundance within Forest Lake at present, with special emphasis on the distribution and abundance of *Myriophyllum spicatum* (Eurasian Watermilfoil). Using these results for 2004, a comparison between the 1993 (Gerber 1993a) and 2004 surveys can now be made. An additional request was made by C. Kendzioriski to collect sediment samples for nutrient, pH and textural analysis to establish a baseline for Forest Lake.

## Methods:

Aquatic macrophyte surveys have been formally assessed for Forest Lake in the past (see Gerber 2000 and Cason 2002). For this 2004 survey, a non-destructive aquatic sampling method was used following Titus (1993). Twenty transects (Fig. 1) were used to assess species composition and abundance. Four, 0.25 m<sup>2</sup> sample units were located along each transect at 0.5 m, 1 m, 2 m, and 3 m depths for a total of 80 sample units for the entire lake as was done in the 1993 survey. Data collection followed Gerber (1993a, 2000).

Frequency, relative frequency, abundance and relative abundance analysis were modified from Titus (1993) and were calculated for the true aquatics (floating-leaved and submersed species) as was done in Gerber (1993a, 2000). Frequency = (# of occurrences/80 sample units)\*100. Relative frequency = frequency/total of species frequency (%). Abundance = sums of abundance scores [1(present), 2(abundant), and 3(common)] for each occurrence in a 0.25 m<sup>2</sup> sample, totaled for all samples. Relative abundance = total abundance/total of species abundance (%).

Eight, 1.5 l sediment samples were collected at a water depth of 2-3m at transects 1, 4, 6, 8, 11, 14, 17, and 19 to assess sediment characteristics. Two, 1.5 l sediment samples were collected in sand blanket deposits in 1 m of water at transects 7 and 20. Coordinates for each sediment collection point were determined using a Cobra GPS 100 by C. Kendzioriski prior to collection. Upon collection, sediments samples were bagged and stored on ice. Sediments were analyzed for texture (% sand, % silt, % clay), pH, organic matter (OM), and nutrients by the University of Wisconsin-Madison, Soil & Plant Analysis Laboratory, 8452 Mineral Point Rd., Verona, WI (608-262-4364).

## Results & Discussion:

Species composition: Differences in species composition were found between the 1993 and 2004 surveys (Table 1). Seven species, *Eleocharis* sp., *Lythrum salicaria*, *Myriophyllum sibiricum*, *M. spicatum*, *Potamogeton foliosus*, *Typha* sp., and *Zosterella dubia* were found along transect lines in 1993 but not in 2004. Three species, *Nuphar variegata*, *Potamogeton illinoensis*, and *Scirpus americanus* were found in the 2004 survey that were not in the 1993 survey. Most interesting however is the lack of both *Myriophyllum sibiricum* (native) and *M. spicatum* (exotic) plants in any of the transect sites in 2004. Both species were listed in a 2002 survey (see Table 3, Cason 2002).

Frequency and abundance calculations: Raw data for the 2004 aquatic macrophyte survey are summarized in Appendix I. The emergent aquatics, *Sagittaria* sp., *Scirpus americanus*, and *S. validus* were removed from the frequency and abundance analysis; therefore, only true aquatics (floating leaved and submersed species) were included as was done for the 1993 survey (see Gerber 2000). Frequency, relative frequency, abundance, and relative abundance data for the true aquatics are summarized in Tables 2-3. The five most frequently found species were also the five most abundant species.

Relative abundance data reveal interesting differences between the 1993 and 2004 surveys (Table 4, Fig. 2):

(1) The five most frequently found and abundant species in the 2004 survey, *Najas flexilis*, *Potamogeton pusillus*, *Chara* sp., *Vallisneria americana*, and *Potamogeton amplifolius*, differ from the 1993 survey in that *Myriophyllum sibiricum* (native) and *Myriophyllum spicatum* (exotic) were not present in the 2004 survey. Both *M. sibiricum* and *M. spicatum* were not found in any of the 2004 transects suggesting a huge decline in both the native and exotic milfoil species. The application of herbicide to Forest Lake has probably had an impact on both of these species since *Myriophyllum* spp. are listed as 'susceptible' species (see Navigate<sup>®</sup> product label, Cason 2002). While the reduction in *M. spicatum* is beneficial to the native flora of Forest Lake, the reduction in the native milfoil species, is unfortunate. Herbicide treatments (chemical) can be effective in the treatment of *M. spicatum*, however, there can be associated disadvantages of chemical treatment (see Hoffman & Kearns 1997).

(2) The native *Zosterella dubia* is listed as a 'susceptible' species to this herbicide and was not found in any of the 2004 survey transects, however it's relative abundance was low in the 1993 survey and could have been missed in this survey. *Zosterella dubia* was listed in a 2002 survey (see Table 3, Cason 2002). *Ceratophyllum demersum*, listed as a 'slightly to moderately resistant' true aquatic species (see Navigate<sup>®</sup> product label, Cason 2002) was found both in the 1993 and 2004 survey.

(3) While neither *Myriophyllum sibiricum* and *M. spicatum* was found along transects, fragments of both species were found along the shoreline in several parts of the lake. Most of the *M. spicatum* fragments were dead however, several fragments had green stems and leaves attached to what looked like dead material. **These fragments have the potential to recolonize either species in Forest Lake.** Unfortunately, the vast majority of fragments seen were *M. spicatum*. In addition, dead stems of *M. spicatum* were also observed in about 2-3 m water depth in the NE part of the lake (in the area of transects 2 and 3, see Fig 1). No growing *M. spicatum* plants were found underwater in this area after repeated dives.

(4) There was a large increase in the relative abundance of *Najas flexilis*, *Potamogeton pusillus*, and *Potamogeton amplifolius*, all native species. With the reduction in *Myriophyllum* species, other species have grown in areas formerly occupied by *Myriophyllum*. The increase in native plant abundance is preferred. It is interesting to note the increase in *Najas flexilis* on the north side of the lake. This is an area where

*Najas flexilis* was planted (see Gerber 1993b) and has become well established in the last 10 years.

Sediment analysis results are summarized in Appendices II & III. These data can be used to establish baseline sediment parameters for the lake.

In conclusion, herbicide treatments appeared to have been very effective in reducing exotic milfoil growth, at least for the short term. No large, healthy *M. spicatum* plants were observed along transects during this survey, however, it should be noted that small, healthy stem fragments (as described above) were found on the shore of the lake. Presumably, these fragments have the potential to recolonize the lake. It is recommended that the plants in Forest Lake continue to be monitored to determine 1) if and where *M. spicatum* is growing and 2) the health and abundance of native aquatics for the entire lake in general. Monitoring and prevention of *M. spicatum* reestablishment is the best method for control (Hoffman & Kearns 1997). Monitoring milfoil sites using snorkeling or scuba equipment provides a good visual assessment of milfoil growth and distribution. Milfoil management is a site-specific process. Different treatment strategies (i.e., mechanical, chemical, biological) for milfoil have been outlined in Hoffman & Kearns (1997). Each strategy has its advantages and disadvantages.

#### References:

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- Gerber, D.T. 1993a. Aquatic plant survey for Forest Lake, Fond du Lac Co., Wisconsin, USA.
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- Gleason, H.A. & A. Cronquist. 1991. Manual of vascular plants of Northeastern United States and adjacent Canada. New York Botanic Garden, Bronx, NY.
- Hoffman, R. & K. Kearns (editors). 1997. Wisconsin manual of control recommendations for ecologically invasive plants. Revised edition. Bureau of Endangered Resources. Dept of Natural Resources. Madison, WI.
- Titus, J.E. 1993. Submersed macrophyte vegetation and distribution with lakes: line transect sampling. Lake and Reserv. Manage. 7: 155-164.

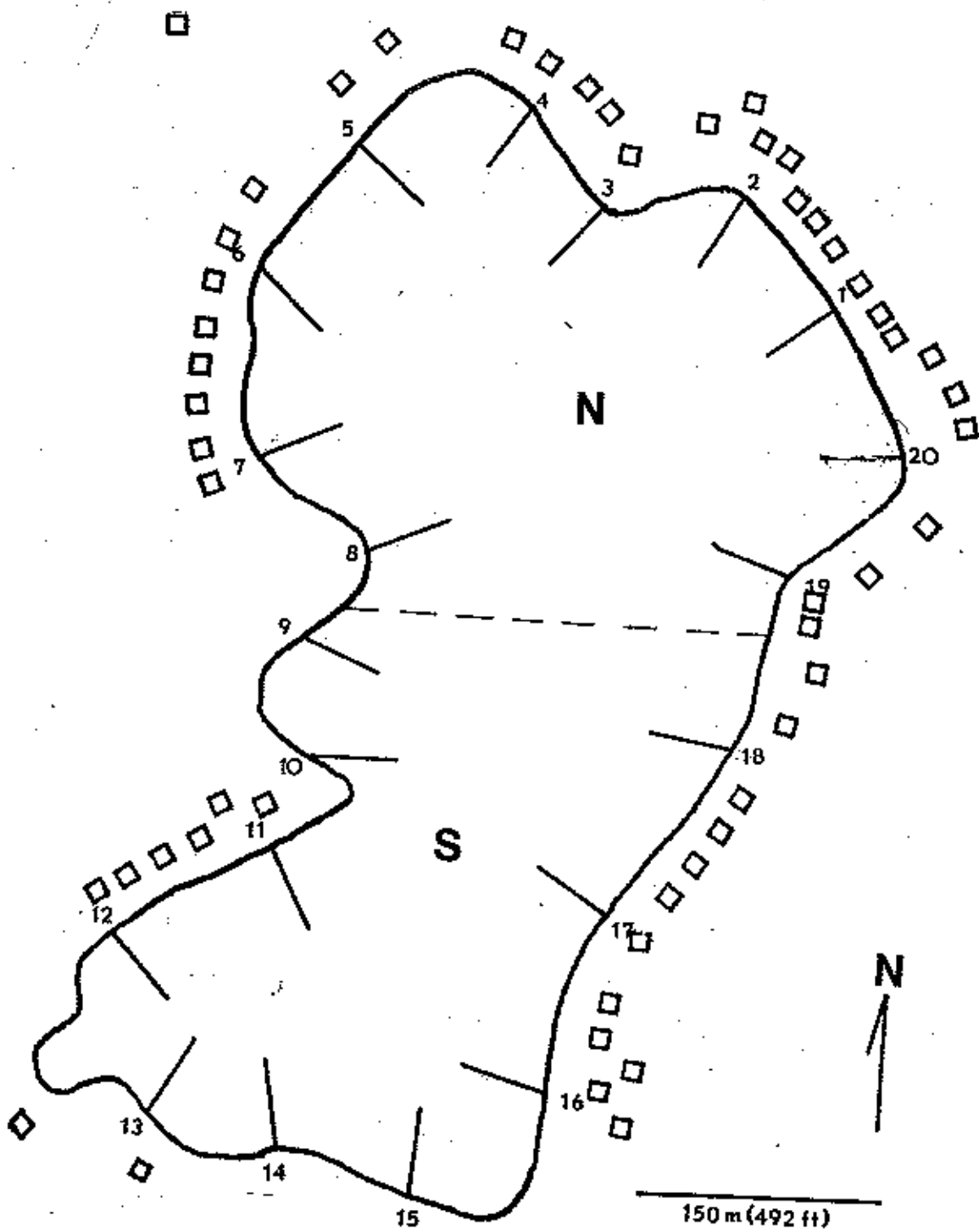


Figure 1. Transect locations for Forest Lake. Squares represent cottages.

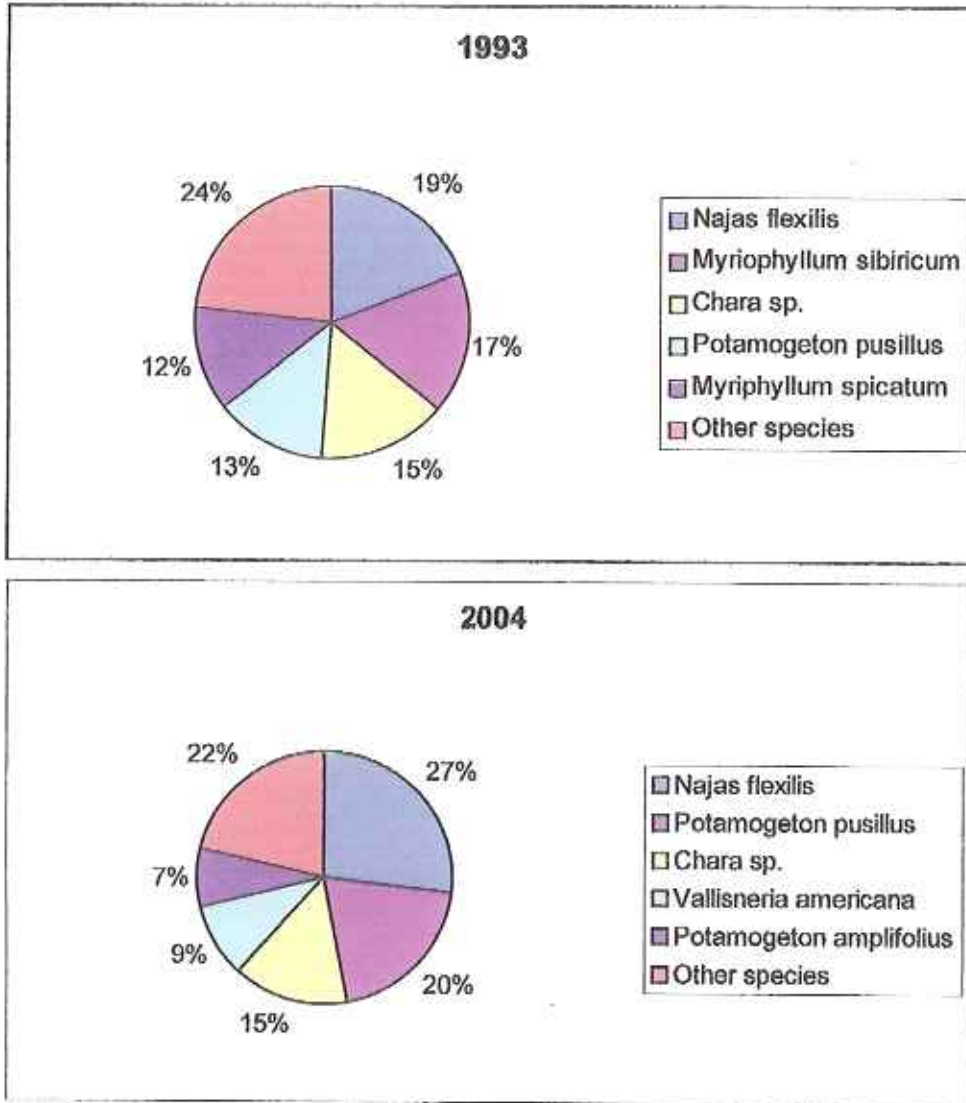


Figure 2. Relative abundance of top 5 most abundance species from 1993 and 2004 surveys for Forest Lake.

Table 1. A comparison of species found in Forest Lake, Fond du Lac Co., Wisconsin during plant surveys in 1993 (Gerber 1993) and 2004 (this report). Only species found within sampling transects are listed. Nomenclature (scientific names) follows Gleason and Cronquist (1991).

Species Scientific (Common) names	'93	'04
<i>Ceratophyllum demersum</i> (Coontail)	X	X
<i>Chara</i> sp. (Muskgrass)	X	X
<i>Eleocharis</i> sp. (Spike-rush)	X	
<i>E. acicularis</i> (Spike-rush)	X	X
<i>Lythrum salicaria</i> (Purple Loosestrife)	X	
<i>Myriophyllum sibiricum</i> (Northern Water-milfoil)	X	
<i>M. spicatum</i> (Eurasian Water-milfoil)	X	
<i>Najas flexilis</i> (Bushy Pondweed)	X	X
<i>Nuphar variegata</i> (Yellow Water Lily)		X
<i>Nymphaea odorata</i> (White Water Lily)	X	X
<i>Polygonum amphibium</i> (Water Smartweed)	X	X
<i>Potamogeton amplifolius</i> (Large-leafed Pondweed)	X	X
<i>P. foliosus</i> (Leafy Pondweed)	X	
<i>P. gramineus</i> (Variable-leaf Pondweed)	X	X
<i>P. illinoensis</i> (Illinois Pondweed)		X
<i>P. natans</i> (Floating-leaf Pondweed)	X	X
<i>P. pectinatus</i> (Sago Pondweed)	X	X
<i>P. pusillus</i> (Slender Pondweed)	X	X
<i>P. zosteriformis</i> (Flat-stemmed Pondweed)	X	X
<i>Sagittaria</i> sp. (Arrowhead)	X	X
<i>Scirpus americanus</i> (Olney-threesquare)		X
<i>S. validus</i> (Soft-stem Bulrush)	X	X
<i>Typha</i> (Cattail)	X	
<i>Vallisneria americana</i> (Water-celery)	X	X
<i>Zosterella dubia</i> (Water Star-grass)	X	
<b>Total</b>	<b>22</b>	<b>18</b>

Table 2. Frequency and relative frequency (Rel. Freq.) data for 1993 (taken from Gerber 2000) and 2004 surveys of floating-leafed and submersed species for Forest Lake, Fond du Lac Co., WI. Frequency = (# of occurrences/80 sample units)\*100. Relative frequency = frequency/total of species frequency (%). Blank cells indicate species not found during survey. Data sorted by Rel. Freq. of 2004 results.

Species	Frequency 1993	Frequency 2004	Rel. Freq 1993	Rel. Freq 2004
<i>Najas flexilis</i>	47.6	46.2	19.9	22.0
<i>Chara sp.</i>	27.5	30	11.5	14.3
<i>Potamogeton pusillus</i>	22.6	25	9.4	11.9
<i>Vallisneria americana</i>	25.1	25	10.5	11.9
<i>Potamogeton amplifolius</i>	6.3	20	2.6	9.5
<i>Ceratophyllum demersum</i>	6.3	12.5	2.6	6.0
<i>Nymphaea odorata</i>	6.3	12.5	2.6	6.0
<i>Potamogeton pectinatus</i>	6.3	10	2.6	4.8
<i>Potamogeton zosteriformis</i>	8.8	10	3.7	4.8
<i>Potamogeton gramineus</i>	10	7.5	4.2	3.6
<i>Potamogeton illinoensis</i>		3.8		1.8
<i>Eleocharis acicularis</i>	2.6	2.5	1.1	1.2
<i>Potamogeton natans</i>	3.8	2.5	1.6	1.2
<i>Nuphar variegata</i>		1.2		0.6
<i>Polygonum amphibium</i>	2.5	1.2	1	0.6
<i>Myriophyllum sibiricum</i>	33.8		14.1	
<i>Myriophyllum spicatum</i>	26.3		11	
<i>Potamogeton foliosus</i>	1.3		0.5	
<i>Zosterella dubia</i>	2.6		1.1	
<b>Total</b>	<b>239.7</b>	<b>209.9</b>	<b>100</b>	<b>100</b>



Table 3. Abundance and relative abundance (Rel. Abund.) data for 1993 (taken from Gerber 2000) and 2004 surveys of floating-leafed and submersed species for Forest Lake, Fond du Lac Co., WI. Abundance = sums of abundance scores [1(present), 2(abundant), and 3(common)] for each occurrence in a 0.25 m<sup>2</sup> sample, totaled for all samples. Relative abundance = total abundance/total of species abundance (%). Blank cells indicate species not found during survey. **Data sorted by Rel. Abund. of 2004 results.**

Species	Abundance	Abundance	Rel. Abund.	Rel. Abund.
	1993	2004	1993	2004
<i>Najas flexilis</i>	57	73	19.1	27.0
<i>Potamogeton pusillus</i>	40	54	13.4	20.0
<i>Chara sp.</i>	45	40	16.1	14.8
<i>Vallisneria americana</i>	23	25	7.7	9.3
<i>Potamogeton amplifolius</i>	5	20	1.7	7.4
<i>Nymphaea odorata</i>	5	11	1.7	4.1
<i>Potamogeton pectinatus</i>	5	11	1.7	4.1
<i>Ceratophyllum demersum</i>	6	10	2.0	3.7
<i>Potamogeton zosteriformis</i>	7	9	2.3	3.3
<i>Potamogeton gramineus</i>	8	7	2.7	2.6
<i>Eleocharis acicularis</i>	3	3	1.0	1.1
<i>Potamogeton illinoensis</i>		3		1.1
<i>Potamogeton natans</i>	3	2	1.0	0.7
<i>Nuphar variegata</i>		1		0.4
<i>Polygonum amphibium</i>	2	1	0.7	0.4
<i>Myriophyllum sibiricum</i>	50		16.7	
<i>Myriophyllum spicatum</i>	37		12.4	
<i>Potamogeton foliosus</i>	1		0.3	
<i>Zosterella dubia</i>	2		0.7	
<b>Total</b>	<b>299</b>	<b>270</b>	<b>100</b>	<b>100</b>

Table 4. Abundance and relative abundance (Rel. Abund.) data sorted for 1993 (taken from Gerber 2000) for comparison with 2004 survey of floating-leafed and submersed species for Forest Lake, Fond du Lac Co., WI. Abundance = sums of abundance scores [1(present), 2(abundant), and 3(common)] for each occurrence in a 0.25 m<sup>2</sup> sample, totaled for all samples. Relative abundance = total abundance/total of species abundance (%). Blank cells indicate species not found during survey.

Species	Abundance		Rel. Abund.	
	1993	2004	1993	2004
<i>Najas flexilis</i>	57	73	19.1	27.0
<i>Myriophyllum sibiricum</i>	50		16.7	
<i>Chara</i> sp.	45	40	15.1	14.8
<i>Potamogeton pusillus</i>	40	64	13.4	20.0
<i>Myriophyllum spicatum</i>	37		12.4	
<i>Vallisneria americana</i>	23	25	7.7	9.3
<i>Potamogeton gramineus</i>	8	7	2.7	2.6
<i>Potamogeton zosteriformis</i>	7	9	2.3	3.3
<i>Ceratophyllum demersum</i>	6	10	2.0	3.7
<i>Nymphaea odorata</i>	5	11	1.7	4.1
<i>Potamogeton amplifolius</i>	5	20	1.7	7.4
<i>Potamogeton pectinatus</i>	5	11	1.7	4.1
<i>Eleocharis acicularis</i>	3	3	1.0	1.1
<i>Potamogeton natans</i>	3	2	1.0	0.7
<i>Polygonum amphibium</i>	2	1	0.7	0.4
<i>Zosterella dubia</i>	2		0.7	
<i>Potamogeton foliosus</i>	1		0.3	
<i>Nuphar variegata</i>		1		0.4
<i>Potamogeton illinoensis</i>		3		1.1
<b>Total</b>	<b>299</b>	<b>270</b>	<b>100</b>	<b>100</b>

**Appendix 1.** Raw data from 2004 aquatic macrophyte survey.

Transect # 1: compass direction - 240° SW (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Najas flexilis</i>	x		

Depth: 1m

<i>Najas flexilis</i>	x		
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Depth: 2m

<i>Chara sp.</i>			x
<i>Vallisneria americana</i>	x		

Depth: 3m

<i>Ceratophyllum demersum</i>	x		
<i>Potamogeton pectinatus</i>			x
<i>Vallisneria americana</i>			x

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 2: compass direction - 220° SW (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Ceratophyllum demersum</i>	x		

Depth: 1m

<i>Chara sp.</i>			x
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Depth: 2m

<i>Najas flexilis</i>			x
<i>Potamogeton amplifolius</i>		x	
<i>Vallisneria americana</i>	x		

Depth: 3m

<i>Najas flexilis</i>			x
<i>Potamogeton amplifolius</i>		x	
<i>P. illinoensis</i>	x		

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 3: compass direction - 240° SW (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Potamogeton gramineus</i>	x		

Depth: 1m

<i>Chara sp.</i>		x	
<i>Potamogeton gramineus</i>	x		

Depth: 2m

<i>Chara sp.</i>			x
<i>Potamogeton gramineus</i>		x	

Depth: 3m

<i>Chara sp.</i>	x		
<i>Najas flexilis</i>			x

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 4: compass direction - 210° S (see Fig. 1)

Water depth: 0.5m

Species:	present	abundant	common
<i>Ceratophyllum demersum</i>	x		
<i>Najas flexilis</i>		x	
<i>Scirpus americanus</i>	x		

Depth: 1m

<i>Najas flexilis</i>		x	
<i>Nymphaea odorata</i>	x		
<i>Potamogeton amplifolius</i>	x		
<i>P. zosteriformis</i>	x		

Depth: 2m

<i>Ceratophyllum demersum</i>	x		
<i>Najas flexilis</i>			x
<i>Potamogeton zosteriformis</i>	x		
<i>Vallisneria americana</i>	x		

Depth: 3m

<i>Najas flexilis</i>			x
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Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 5: compass direction - 120° SE (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Nymphaea odorata</i>	x		

Depth: 1m

<i>Najas flexilis</i>	x		
<i>Vallisneria americana</i>	x	--	

Depth: 2m

<i>Chara sp.</i>	x		
<i>Potamogeton gramineus</i>	x		
<i>Vallisneria americana</i>		x	

Depth: 3m

<i>Chara sp.</i>		x	
<i>Najas flexilis</i>			x
<i>Vallisneria americana</i>	x		

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 6: compass direction - 140° SE (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Chara sp.</i>		x	

Depth: 1m

<i>Chara sp.</i>			x
<i>Najas flexilis</i>	x		
<i>Vallisneria americana</i>	x		

Depth: 2m

<i>Ceratophyllum demersum</i>	x		
<i>Najas flexilis</i>	x		
<i>Potamogeton gramineus</i>	x		
<i>Vallisneria americana</i>		x	

Depth: 3m

<i>Potamogeton pectinatus</i>	x		
<i>P. zosteriformis</i>	x		

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.



Transect # 7: compass direction - 80° NE (see Fig. 1)

Water depth: 0.5m

Species:                              present              abundant              common

No plants present

Depth: 1m

*Najas flexilis*                      x

Depth: 2m

*Ceratophyllum demersum*      x

*Najas flexilis*    x

*Vallisneria Americana*          x

Depth: 3m

*Najas flexilis*    x

*Potamogeton pectinatus*      x

*Vallisneria americana*                                      x

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 8: compass direction - 60° NE (see Fig. 1)

Water depth: 0.5m

Species:                      present              abundant              common

No plants present

Depth: 1m

<i>Chara sp.</i>		x	
<i>Najas flexilis</i>		x	
<i>Potamogeton pectinatus</i>	x		

Depth: 2m

<i>Potamogeton amplifolius</i>	x		
<i>P. illinoensis</i>	x		
<i>P. pusillus</i>			x
<i>Vallisneria americana</i>	x		

Depth: 3m

<i>Najas flexilis</i>			x
<i>Potamogeton amplifolius</i>	x		
<i>P. zosteriformis</i>	x		

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 9: compass direction - 110° SE (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Eleocharis acicularis</i>		x	
<i>Scirpus americanus</i>	x		

Depth: 1m

<i>Nymphaea oderata</i>	x		
<i>Vallisneria americana</i>	x		

Depth: 2m

<i>Chara sp.</i>	x		
<i>Najas flexilis</i>	x		
<i>Nymphaea oderata</i>	x		
<i>Potamogeton pusillus</i>			x
<i>P. zosteriformis</i>	x		

Depth: 3m

<i>Potamogeton amplifolius</i>	x		
<i>P. pusillus</i>			x

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 10: compass direction - 90° E (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Chara sp.</i>	x		
<i>Polygonum amphibium</i>	x		
<i>Scirpus validus</i>	x		

Depth: 1m

<i>Nymphaea odorata</i>		x	
<i>Potamogeton pusillus</i>			x
<i>Vallisneria americana</i>	x		

Depth: 2m

<i>Potamogeton amplifolius</i>		x	
<i>P. pusillus</i>			x

Depth: 3m

<i>Potamogeton amplifolius</i>	x		
<i>P. pusillus</i>			x

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 11: compass direction - 170° SE (see Fig. 1)

Water depth: 0.5m

Species:	present	abundant	common
<i>Najas flexilis</i>	x		
<i>Nymphaea oderata</i>	x		

Depth: 1m

<i>Najas flexilis</i>		x	
<i>Nymphaea oderata</i>	x		

Depth: 2m

<i>Najas flexilis</i>			x
<i>Potamogeton pectinatus</i>	x		
<i>Vallisneria americana</i>	x		

Depth: 3m

<i>Chara sp.</i>		x	
<i>Najas flexilis</i>			x

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transsect # 12: compass direction - 130° SE (see Fig. 1)

Water depth: 0.5m

Species: present abundant common

No plants present

Depth: 1m

*Najas flexilis* x

Depth: 2m

*Najas flexilis* x

*Potamogeton pectinatus* x

*Vallisneria americana* x

Depth: 3m

*Najas flexilis* x

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transsect # 13: compass direction - 50° NE (see Fig. 1)

Water depth: 0.5m

Species:                      present          abundant          common

No plants present

Depth: 1m

*Nymphaea odorata*              x

*Vallisneria americana*          x

Depth: 2m

*Chara sp.*                              x

*Potamogeton pectinatus*          x

*Vallisneria americana*          x

Depth: 3m

*Potamogeton pusillus*    x

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 14: compass direction - 340° NW (see Fig. 1)

Water depth: 0.5m

Species:	present	abundant	common
<i>Najas flexilis</i>	x		
<i>Potamogeton illinoensis</i>	x		

Depth: 1m

<i>Najas flexilis</i>	x		
<i>Nuphar variegata</i>	x		
<i>Potamogeton pusillus</i>			x

Depth: 2m

<i>Potamogeton natans</i>	x		
<i>P. pusillus</i>			x

Depth: 3m

<i>Potamogeton pusillus</i>			x
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Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.



Transect # 15: compass direction - 0° N (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Najas flexilis</i>	x		
<i>Potamogeton amplifolius</i>	x		
<i>P. zosteriformis</i>	x		

Depth: 1m

<i>Chara sp.</i>	x		
<i>Najas flexilis</i>	x		
<i>Nymphaea oderata</i>	x		

Depth: 2m

<i>Potamogeton amplifolius</i>	x		
<i>P. pusillus</i>	x		

Depth: 3m

<i>Potamogeton amplifolius</i>	x		
<i>P. pusillus</i>			x

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 16: compass direction - 280° NW (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Eleocharis acicularis</i>	x		

Depth: 1m

<i>Najas flexilis</i>	x		
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<i>Nymphaea odorata</i>	x		
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Depth: 2m

<i>Chara sp.</i>	x		
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<i>Potamogeton pusillus</i>	x		
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<i>Vallisneria americana</i>	x		
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Depth: 3m

<i>Potamogeton pusillus</i>			x
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Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 17: compass direction - 290° NW (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Chara sp.</i>	x		
<i>Najas flexilis</i>	x		

Depth: 1m

<i>Ceratophyllum demersum</i>	x		
<i>Potamogeton pusillus</i>			x

Depth: 2m

<i>Potamogeton amplifolius</i>	x		
<i>P. pusillus</i>			x

Depth: 3m

<i>Potamogeton amplifolius</i>	x		
<i>P. pusillus</i>			x

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 18: compass direction - 270° W (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Potamogeton natans</i>	x		
<i>P. pectinatus</i>		x	
<i>Sagitaria sp.</i>	x		

Depth: 1m

<i>Chara sp.</i>		x	
<i>Najas flexilis</i>	x		
<i>Potamogeton pusillus</i>	x		

Depth: 2m

<i>Potamogeton amplifolius</i>	x		
<i>P. pusillus</i>			x

Depth: 3m

<i>Chara sp.</i>		x	
<i>Najas flexilis</i>			x
<i>Potamogeton amplifolius</i>	x		
<i>Vallisneria americana</i>	x		

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 19: compass direction - 280° NW (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Chara sp.</i>	x		
<i>Sagittaria sp.</i>	x		

Depth: 1m

<i>Chara sp.</i>	x		
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Depth: 2m

<i>Chara sp.</i>	x		
<i>Potamogeton amplifolius</i>		x	
<i>P. pusillus</i>			x

Depth: 3m

<i>Chara sp.</i>			x
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Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Transect # 20: compass direction - 270° W (see Fig. 1)

Water depth: 0.5m

Species:	<u>present</u>	<u>abundant</u>	<u>common</u>
<i>Potamogeton gramineus</i>	x		

Depth: 1m

<i>Ceratophyllum demersum</i>	x		
<i>Chara sp.</i>	x		
<i>Najas flexilis</i>		x	
<i>Potamogeton zosteriformis</i>	x		

Depth: 2m

<i>Ceratophyllum demersum</i>	x		
<i>Najas flexilis</i>			x
<i>Potamogeton zosteriformis</i>		x	

Depth: 3m

<i>Ceratophyllum demersum</i>	x		
<i>Najas flexilis</i>			x
<i>Potamogeton zosteriformis</i>	x		

Abundance code: (1) present: indicates species is represented by 1 to several plants within 0.25m sampling area; (2) abundant: indicates species is represented by several plants to half of sampling area covered; (3) common: indicates dense growth within sampling area.

Appendix II. Physical analysis of 10 sediment samples in Forest Lake.

Transsect site	GPS	% Sand	% Silt	% Clay	Texture designation
1	N43 36.566 W88 09.863	93	4	3	Sand
4	N43 36.652 W88 10.055	44	43	13	Loam
6	N43 36.581 W88 10.125	80	15	5	Loamy Sand
8	N43 36.476 W88 10.096	14	67	19	Silt Loam
11	N43 36.385 W88 10.112	11	49	40	Silty Clay Loam
14	N43 36.292 W88 10.098	19	67	1	Silt Loam
17	N43 36.383 W88 09.936	27	55	18	Silt Loam
19	N43 36.490 W88 09.888	80	15	5	Loamy Sand
7 (sandy area)	N43 36.545 W88 10.174	97	1	2	Sand
20 (sandy area)	N43 36.528 W88 09.804	97	1	2	Sand

**Appendix III.** Mineral content analysis of 10 sediment samples in Forest Lake. Results reported on a 'dry weight' basis. Unit: 1,000 ppb = ppm = mg/kg = mg/liter. 1% = 10,000 ppm. The UW Soil and Plant Analysis Lab OA/QC protocol includes verifying results primarily based on instrument performance, duplicate analysis and elemental recovery based on reference materials. Please contact lab for details or additional requests (Acct. #558231).

Transect site	P	K	Ca	Mg	S	Zn	B	Mn
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1	156	410	95449	51785	589	13	4	94
4	334	1202	75095	45077	973	38	8	132
6	165	482	62395	34112	617	15	4	79
8	613	1835	45953	23377	3879	106	12	151
11	737	2141	14566	8044	2140	59	16	281
14	475	1614	9916	4584	3409	75	17	118
17	396	1368	13721	4363	2087	42	12	99
19	226	483	67064	34850	848	26	5	87
7 (sandy area)	125	344	88858	49664	171	8	4	89
20 (sandy area)	123	301	73162	41234	192	13	3	74

Transect site	Fe	Cu	Al	Na	pH	O.M.	Solids
	ppm	ppm	ppm	ppm		%	%
1	3638	3.7	2101	201	7.9	0.7	67.6
4	7287	10.3	8699	233	7.5	9.9	21.7
6	3994	4.1	3073	173	8.0	3.1	42.3
8	10134	17.5	11888	208	7.5	18.0	11.4
11	11219	12.9	13542	157	7.6	34.9	3.9
14	8929	10.1	12220	142	7.2	32.8	9.3
17	8216	9.5	10272	167	7.7	26.8	8.7
19	4416	4.2	3245	187	8.0	3.3	41.8
7 (sandy area)	3776	3.6	1928	208	8.2	0.6	81.2
20 (sandy area)	3769	2.8	1868	189	8.3	0.3	86.3