



**DARRIN**  
Fresh Water Institute

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Lake George, New York  
Adirondack Field Station at Bolton Landing

**Aquatic Vegetation of Burr Pond  
and Lake Horntonia, Vermont**

Prepared By

Lawrence Eichler  
Research Scientist

&

Charles Boylen  
Associate Director

Darrin Fresh Water Institute  
5060 Lakeshore Drive  
Bolton Landing, NY 12814  
(518) 644-3541 (voice) (518) 644-3640  
(fax)  
[eichll@rpi.edu](mailto:eichll@rpi.edu)

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## Background.

Quantitative aquatic plant surveys were undertaken for Burr Pond and Lake Hortonia, Vermont, in September of 2008. Surveys of Lake Hortonia were conducted to obtain post-treatment data for spot treatments with the aquatic-labeled herbicide triclopyr (Renovate 3<sup>TM</sup>). Hand and suction harvesting operations were underway but incomplete on Lake Hortonia at the time of the aquatic plant survey. No treatment of Burr Pond occurred in 2007 or 2008. Aquatic plant surveys were designed to be comparable to annual aquatic plant data collected by the US Army Corps of Engineers in 1999 through 2001 and by the authors in 2003 through 2007. Surveys were conducted in 2003 to prepare for and in 2004 and 2005 to evaluate a treatment program based on application of the herbicide fluridone (SONAR<sup>TM</sup>) in 2004 to control Eurasian watermilfoil (*Myriophyllum spicatum*) in these two lakes.

## Methods

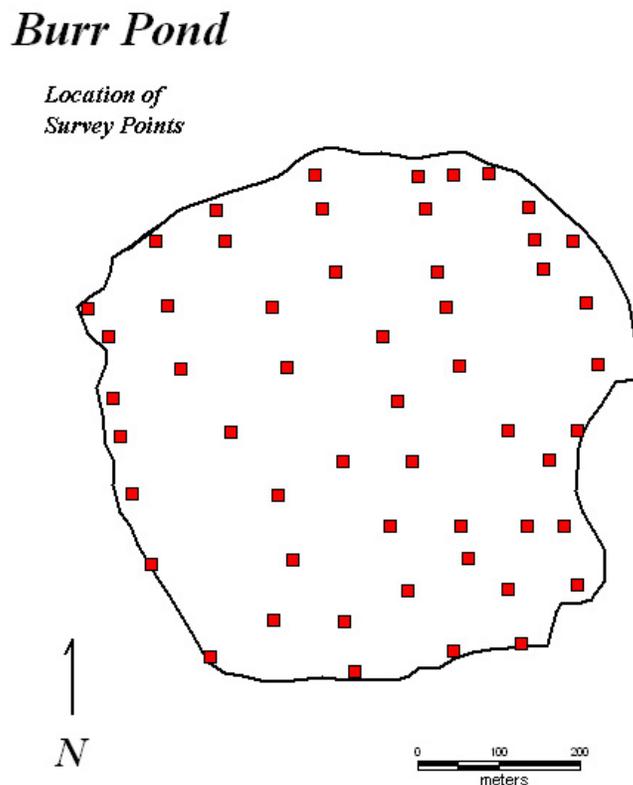
### Survey Sites

**Burr Pond.** Burr Pond is located in Rutland County, Vermont in the town of Sudbury. The pond has a surface area of approximately 35 ha. Burr Pond has a single outlet, which drains to Lake Hortonia. Average water depth is reported to be 3.6 m, with a maximum depth of 6 m (Getsinger et al. 2002). Transparency via secchi disk is reported to be 4.1 m (LHPOA/BPA 1999). In 1998, Burr Pond supported a diverse native plant community with 19 submersed species, 2 native rooted floating-leaf species and 1 native emergent species (LHPOA/BPA 1999). Additional data collections by the US Army Corps reported 22 submersed species, 3 floating-leaved species and 4 emergent species in 1999 through 2001 (Getsinger et al. 2002). Eurasian watermilfoil (*Myriophyllum spicatum*) populations were first confirmed in 1991 and reported to be the dominant aquatic plant species in the lake by the mid-1990's (LHPOA/BPA 1999). Prior to herbicide treatment in 2000, *Myriophyllum spicatum*, was the most common plant species, present in >55% of survey points (Getsinger et al. 2002) and was the only exotic species reported. At the conclusion of post-treatment surveys in August 2001, frequency of occurrence of *Myriophyllum spicatum* had been reduced by 85%, reported in less than 10% of survey points. In a pre-treatment survey in August of 2003, *Myriophyllum spicatum* frequency of occurrence (49% of survey points) approached pre-treatment levels reported in 1999. Following an herbicide treatment in the Spring of 2004, *Myriophyllum spicatum* had been reduced by 40%, reported in less than 29% of survey points. This decline continued in 2005, with *Myriophyllum spicatum* reported in 22% of survey points. The entire shoreline of Burr Pond was treated with the herbicide Renovate 3 in the Spring of 2006 to further reduce *Myriophyllum spicatum* abundance. No treatment occurred in 2007 and limited hand harvesting was employed in 2008.

**Lake Hortonia.** Lake Hortonia is located in Rutland County, Vermont between the towns of Sudbury and Hubbardton. The pond has a surface area of approximately 194 ha. Average water depth is reported to be 5.85 m, with a maximum depth of 19 m (Getsinger et al. 2002). Transparency via secchi disk is reported to be 5.4 m (LHPOA/BPA 1999). In 1998, Lake Hortonia supported a diverse native plant community with 22 submersed species, 2 rooted floating-leaf species and 4 native emergent species reported (LHPOA/BPA 1999). Additional data collections by the US Army Corps reported 24 submersed species, 2 floating-leaved species,

1 floating species and 2 emergent species in 1999 through 2001 (Getsinger et al. 2002). Eurasian watermilfoil (*Myriophyllum spicatum*) populations were first confirmed in 1984 and reported to be problematic by the mid-1990's (LHPOA/BPA 1999). Prior to herbicide treatment in 2000, *Myriophyllum spicatum* was the most common plant species, present in >54% of survey points (Getsinger et al. 2002). A second exotic species, *Potamogeton crispus* (Curly-leaf Pondweed) was also reported. At the conclusion of post-treatment surveys in August 2001, frequency of occurrence of *Myriophyllum spicatum* had been reduced by 85%, with this species reported in only 6% of survey points. In a pre-treatment survey in August of 2003, *Myriophyllum spicatum* was reported in 52% of survey points, comparable to pre-treatment frequency of occurrence reported in 1999. Following an herbicide treatment in the Spring of 2004, *Myriophyllum spicatum* had been reduced by 33%, reported in less than 35% of survey points. *Myriophyllum spicatum* specimens observed in August of 2004 were generally in poor condition. An August of 2005 survey reported *Myriophyllum spicatum* in 2% of survey points. Spot treatments of the shoreline of Lake Hortonia with the herbicide Renovate 3 were conducted in the Spring of 2006 thru 2008 to further reduce *Myriophyllum spicatum* abundance. Hand and suction harvesting were also employed in 2008.

**Figure 1. Map of Burr Pond with point intercept survey locations for 2008.**

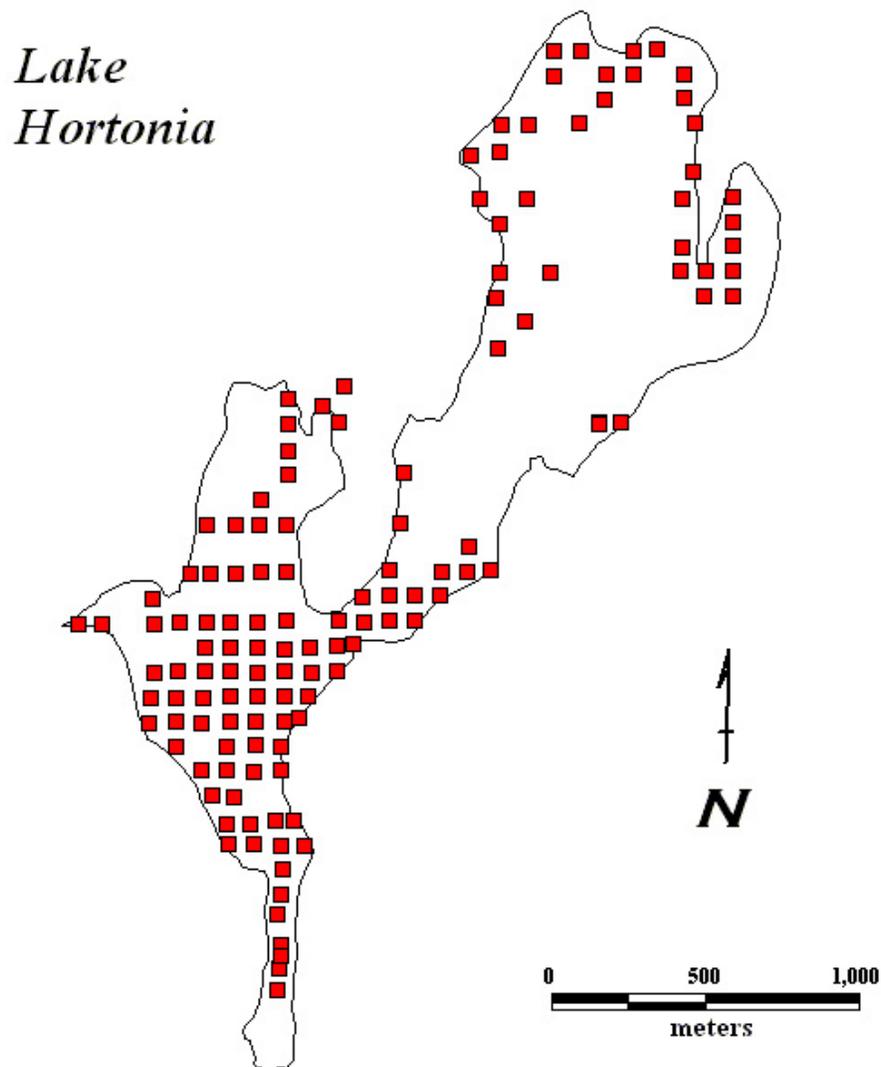


**Species List and Herbarium Specimens.** As the lakes were surveyed, the occurrence of each aquatic plant species observed in the lake was recorded and adequate herbarium specimens were collected. The herbarium specimens were returned to the Darrin Fresh Water Institute, where they were pressed, dried, and mounted (Hellquist 1993). A number of species which were

collected as reference specimens for each lake were not found in line intercept or wetland transect surveys.

**Point Intercept Surveys.** The frequency and distribution of aquatic plant species in each waterbody were evaluated using a point intercept method (Madsen 1999). At each grid point intersection, all species located at that point were recorded, as well as water depth. Water depth was determined with a weighted sounding lead and fiberglass tape measure (Keson, Warrensville, IL). Species were located by a visual inspection of the point and by deploying a rake to the bottom, and examining the plants retrieved. A total of 51 points were selected for Burr Pond (Figure 1), on a 40-m grid and 126 points for Lake Hortonia (Figure 2), on an 80-m grid. Survey points for the 2003 thru 2008 surveys were selected within the littoral zone of each lake, as a subset of points employed in earlier surveys (Getsinger et al. 2002). A number of deepwater points were also sampled. Locations for survey points were determined using

**Figure 2. Map of Lake Hortonia with point intercept survey locations for 2008.**



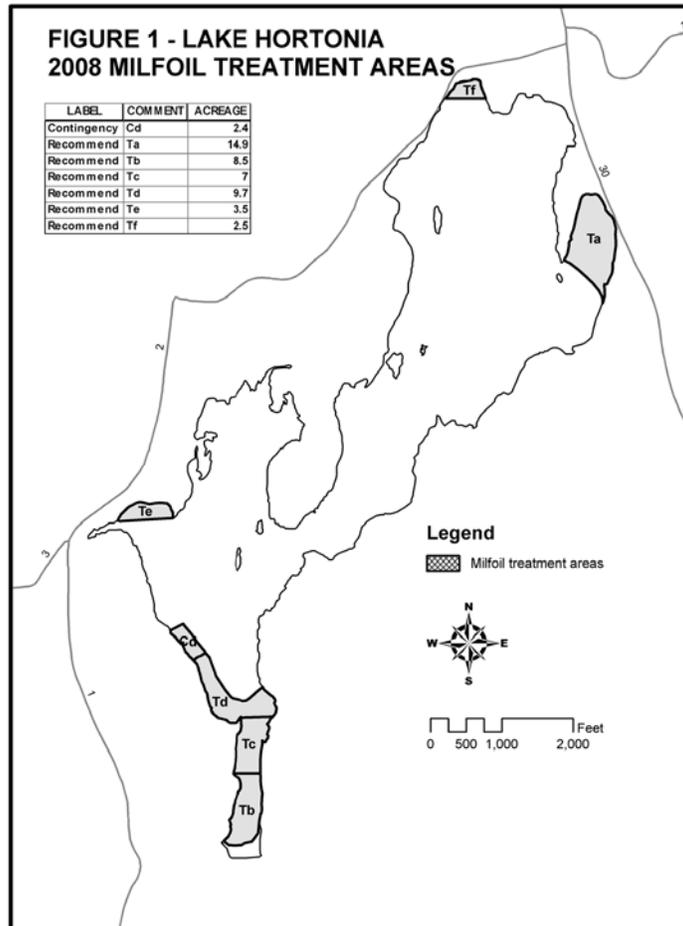
MapInfo Software (MapInfo Corp., Troy, NY). A Trimble Pathfinder (Trimble Corp.,

Sunnyvale, CA) differential global positioning system (DGPS) was used to navigate to each point for the survey observation. Point intercept plant frequencies were surveyed between September 2 and September 4, 2008 for both lakes. Data presented in the summaries are on both a whole-lake basis and adjusted for the littoral zone.

**Wetland Line Transects.** To address concerns with potential impacts of herbicide treatments on wetland communities, one site at each lake was selected to correspond with surveys conducted in 1999 through 2001 by the US Army Corp of Engineers (Getsinger et al. 2002). In Lake Hortonia, a 200-m transect was established, with the endpoints marked by DGPS. In Burr Pond, an 80-m transect was established with physical control of location. For each transect, the line was divided into 1-m segments. Plant species occurring in a 0.1 m<sup>2</sup> quadrat placed at each 1-m segment were recorded (Madsen 1999). Since these transects were in dense *Nymphaea-Nuphar* communities, both transects were observed with the use of a canoe.

**Renovate Treatment – 2008**

*Summary provided by Gerald Smith, Aquatic Control Technology, Inc., Cambridge, MA*



## Results and Discussion

### Burr Pond Open-Lake Survey Results

In September of 2008, the aquatic plant community of Burr Pond included eighteen submersed species, two floating-leaved species, one floating species and five emergent species.

*Myriophyllum spicatum* was the only exotic species reported for Burr Pond. Species richness was quite high, with a number of species occurring in more than 5% of survey points (Table 2). Eurasian watermilfoil increased to the most widely distributed plant (55% of survey points for Burr Pond, up from 23% of survey points in 2007, 4% in 2006, 22% in 2005, 29% in 2004 and 49% in 2003). *Chara* sp. was the most widespread native plant (44% of survey points). A number of native species were also commonly observed. A list of species observed for Burr Pond is provided in Table 1.

**Table 1. Species list for Burr Pond and Lake Hortonia, September 2008.**

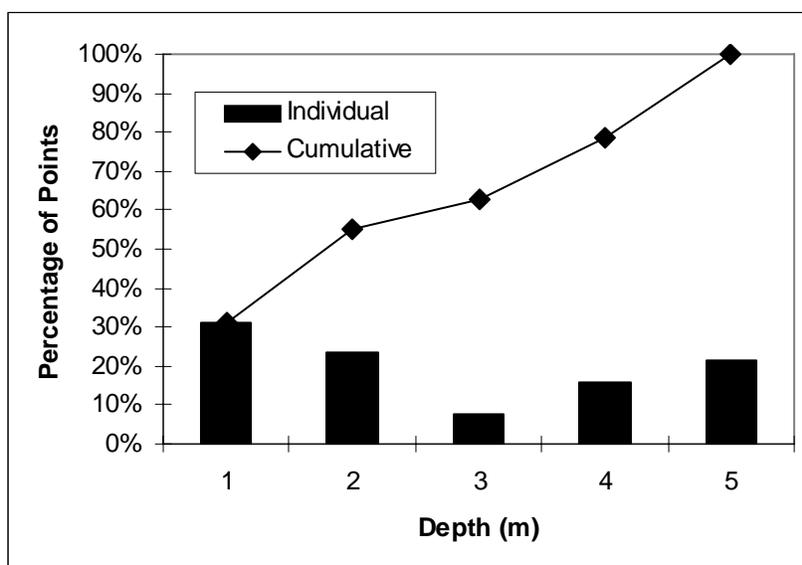
Species Name	Common Name	Burr Pond		Lake Hortonia	
		Lake	Wetland	Lake	Wetland
<i>Brasenia schreberi</i>	Water shield			X	
<i>Ceratophyllum demersum</i> L.	coontail	X	X	X	X
<i>Chara</i> sp.	muskgrass, chara	X	X	X	X
<i>Eleocharis acicularis</i> (L.) Roemer & Schultes	needle spike-rush			X	
<i>Elodea canadensis</i> Michx.	elodea	X	X	X	X
<i>Heteranthera dubia</i> Jacq. ( <i>Zosterella dubia</i> )	water stargrass	X	X	X	X
<i>Lemna minor</i> L.	duckweed		X		X
<i>Lemna trisulca</i> L.	duckweed				X
<i>Megalodonta (Bidens) beckii</i> Torr.	water marigold			X	
<i>Myriophyllum sibiricum</i> Kom.	northern watermilfoil			X	X
<i>Myriophyllum spicatum</i> L.	Eurasian watermilfoil	X	X	X	
<i>Najas flexilis</i> (Willd.) Rostk. & Schmidt.	bushy pondweed	X	X	X	X
<i>Nuphar advena</i> (Ait.) Ait. f.	yellow pondlily	X	X	X	X

Species Name	Common Name	Burr Pond		Lake Hortonia	
		Lake	Wetland	Lake	Wetland
<i>Nymphaea odorata</i> Ait.	white waterlily	X	X	X	X
<i>Polygonum</i> sp.	smartweed		X	X	
<i>Pontederia cordata</i> L.	pickerelweed	X	X	X	X
<i>Potamogeton amplifolius</i> Tuckerm.	largeleaf pondweed	X		X	
<i>Potamogeton crispus</i> L.	curlyleaf pondweed			X	X
<i>Potamogeton epihydrus</i> Raf.	ribbon-leaf pondweed	X		X	X
<i>Potamogeton gramineus</i> L.	variable-leaf pondweed	X		X	
<i>Potamogeton illinoensis</i> Morong.	Illinois pondweed	X	X	X	X
<i>Potamogeton natans</i> L.	floating-leaf pondweed			X	X
<i>Potamogeton (Stukenia) pectinatus</i> L.	sago pondweed			X	
<i>Potamogeton praelongus</i> Wulfen	white-stem pondweed			X	
<i>Potamogeton pusillus</i> L.	small pondweed	X	X	X	
<i>Potamogeton robbinsii</i> Oakes	Robbins' pondweed	X		X	
<i>Potamogeton zosteriformis</i> Fern.	flat-stem pondweed	X		X	X
<i>Ranunculus longirostris</i> Godron	white watercrowfoot		X	X	
<i>Scirpus</i> sp.	bulrush	X		X	X
<i>Sparganium</i> sp.	burreed		X	X	X
<i>Sphagnum</i> sp.	sphagnum			X	X
<i>Typha</i> sp.	cattail	X	X	X	X
<i>Utricularia gibba</i> L.	humped bladderwort	X	X	X	
<i>Utricularia minor</i> L.	small bladderwort		X	X	X
<i>Utricularia vulgaris</i> L.	great bladderwort	X	X	X	X
<i>Vallisneria americana</i> L.	wild celery	X	X	X	X

## Maximum Depth of Colonization

Maximum depth of rooted aquatic plant growth was similar for the two lakes, with the littoral zone extending to a maximum depth of 4 m. Depth distribution of sampling points (Figure 3) and maximum depth of colonization by aquatic plants in Burr Pond was comparable to that reported for earlier studies (Getsinger et al. 2002). A bladderwort, *Utricularia gibba*, was reported for a single sample in a depth of 4.5 m in 2003. This weakly rooted species may have drifted to this location and may not be able to survive. Specimens of *Chara* sp. were observed in a single sample from 4.7 m depth in Burr Pond in 2004 thru 2007. Numerous dead stems of *Chara* sp. were collected in water depths of 4.0 to 4.5 m. These results suggest the presence of an anaerobic hypolimnion in Burr Pond during summer stratification, after plant propagules have produced mature plants. *Chara* sp. was able to survive and grow in hypolimnetic depths during the Spring and early Summer, prior to anaerobic conditions developing. As the period of summer stratification progresses, anaerobic conditions generally move higher in the water column, resulting in the death of the *Chara* sp. growing there.

**Figure 3. Depth Distribution of Burr Pond Sampling Points in 1 meter depth classes.**



## Species Lists

Maps of the distribution of aquatic plant species and groups of species (i.e. Broad-leaf Pondweeds) for Burr Pond are included in Appendix A, Figures A1 – A10. Charophytes were the most abundant native species, present in 44% of all samples collected. *Myriophyllum spicatum* was the most abundant aquatic plant species occurring in Burr Pond, reported in 55% of samples collected. Common native species for Burr Pond included *Utricularia gibba* (32%), *Vallisneria americana* (28%), *Potamogeton illinoensis* (26%), *Najas flexilis* (19%), *Elodea canadensis* (19%), *Potamogeton gramineus* (9%), *Nuphar advena* (9%), *Potamogeton pusillus* (8%), and *Nymphaea odorata* (8%).

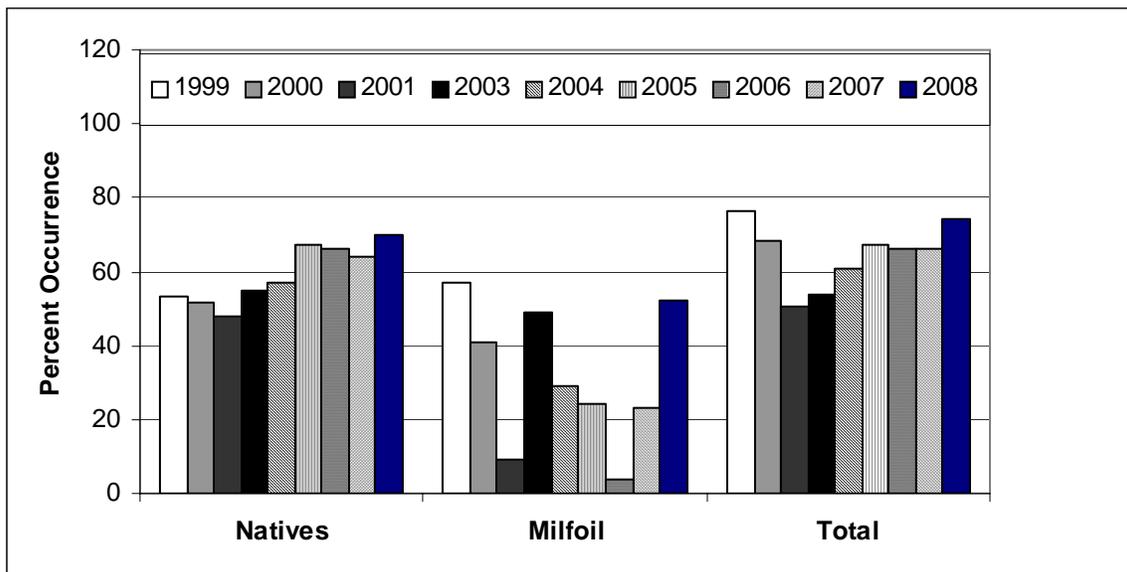
**Table 2. Burr Pond percent frequency of occurrence data.**  
**Results for 1999 through 2001 are derived from Getsinger et al. (2002).**

Species Name	August Surveys								
	1999	2000	2001	2003	2004	2005	2006	2007	2008
<i>Ceratophyllum demersum</i>	3.1%	2.6%	0.5%	3.9%	5.9%		1.9%	1.9%	1.9%
<i>Chara sp.</i>	29.0%	36.6%	36.1%	15.7%	37.3%	44.4%	48.1%	47.2%	45.3%
<i>Eleocharis acicularis</i>				2.0%	2.0%				1.9%
<i>Elodea canadensis</i>	10.0%	9.4%	0.5%	5.9%				17.0%	18.9%
<i>Megalodonta beckii</i>	0.5%								
<i>Myriophyllum sibiricum</i>	4.2%								
<i>Myriophyllum spicatum</i>	58.0%	40.8%	9.4%	49.0%		22.2%	3.7%	22.6%	54.7%
<i>Najas flexilis</i>	11.0%		13.1%	11.8%		16.7%	16.7%	34.0%	18.9%
<i>Nuphar advena</i>	4.7%	4.7%	6.3%	3.9%	2.0%	3.7%	3.7%	1.9%	9.4%
<i>Nymphaea odorata</i>	8.9%	9.4%	4.2%	9.8%	2.0%	11.1%	9.3%	9.4%	7.5%
<i>Potamogeton amplifolius</i>	1.1%	2.1%	1.6%		2.0%				
<i>Potamogeton epihydrus</i>							1.9%		
<i>Potamogeton gramineus</i>	16.2%	5.2%	4.7%	5.9%	2.0%		1.9%	13.2%	9.4%
<i>Potamogeton illinoensis</i>	19.9%		4.7%	3.9%	2.0%	1.9%	25.9%	11.3%	26.4%
<i>Potamogeton natans</i>	0.5%	0.5%	0.5%	2.0%		1.9%			1.9%
<i>Potamogeton nodosus</i>			0.5%						
<i>Potamogeton pusillus</i>						1.9%	7.4%	5.7%	7.5%
<i>Potamogeton robbinsii</i>	2.1%	6.3%	7.9%	3.9%	2.0%	5.6%	7.4%	7.5%	5.7%
<i>Potamogeton zosteriformis</i>	6.8%	3.1%	4.7%		2.0%	13.0%	3.7%	15.1%	5.7%
<i>Ranunculus longirostris</i>	0.5%	0.5%							1.9%
<i>Scirpus sp.</i>				2.0%	2.0%	1.9%	1.9%		1.9%
<i>Sparganium americanum</i>		1.6%	0.5%		2.0%				
<i>Stukenia pectinatus</i>	1.1%		0.5%			1.9%			
<i>Typha sp.</i>				2.0%	2.0%				1.9%
<i>Utricularia gibba</i>	3.1%	5.2%	3.7%	13.7%	15.7%	27.8%	40.7%	35.8%	32.1%
<i>Utricularia minor</i>						1.9%			
<i>Utricularia vulgaris</i>	1.1%		0.5%				3.7%	1.9%	
<i>Vallisneria americana</i>	18.0%	10.5%	8.4%	19.6%	23.5%	22.2%	29.6%	26.4%	28.3%
<i>Zosterella dubia</i>	1.1%	6.3%	3.7%	5.9%	9.8%	13.0%	9.3%	9.4%	3.8%

A total of 20 species were recorded in open lake surveys of Burr Pond in 2008, similar to the 17 species in 2003 and 2006 and sixteen species recorded in 2004, 2005 and 2007. These results are comparable to previous surveys (Getsinger et al. 2002) in 2001 (20 species), 2000 (16 species) and 1999 (21 species). No previously unreported species for Burr Pond were encountered in 2008. Species absent from the 2008 survey but present in prior surveys were generally either present in only a single survey year or relatively uncommon in prior surveys

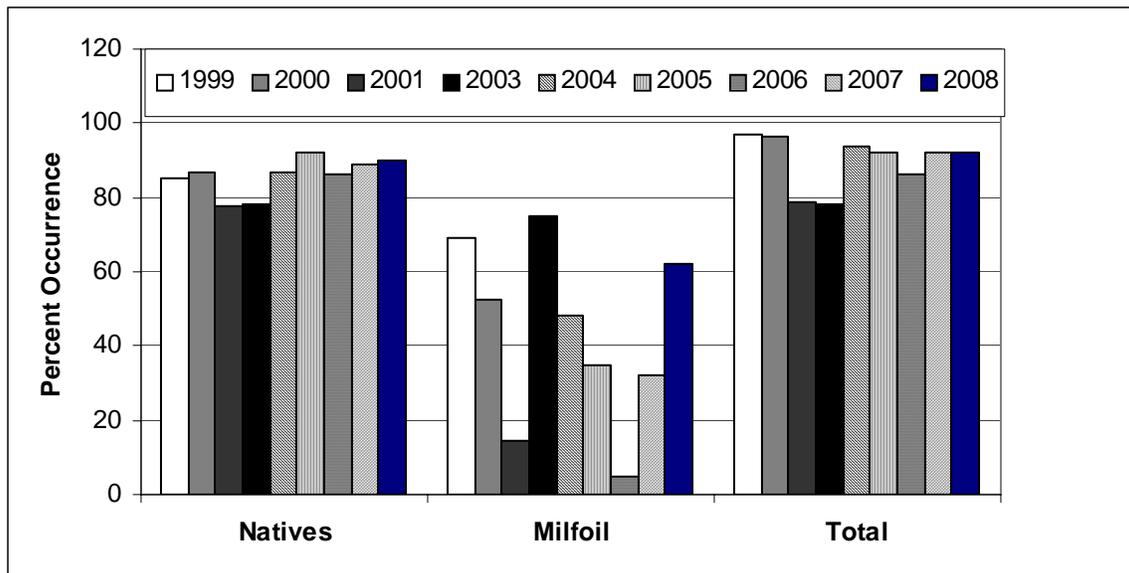
(<1% of survey points). Two exceptions were *Najas flexilis* and *Elodea canadensis*, frequently occurring species absent in post-treatment surveys in 2004. Getsinger et al. reported declines in *Najas flexilis* and *Elodea canadensis* in the year following treatment (2000), however this species returned to levels comparable to pretreatment in the following year (2001) and continued at similar levels of abundance in 2003. *Najas flexilis* had returned to pre-treatment levels by 2005 and remained common in 2006 thru 2008. *Elodea canadensis* remained absent thru 2006 however in 2007 and 2008, it was reported at levels exceeding pretreatment.

Significant reductions in frequency of occurrence of seven native species were reported following fluridone application in 2001 (Getsinger 2002). Four of these species (*Ceratophyllum demersum*, *Elodea canadensis*, *Najas flexilis*, and *Vallisneria americana*) were found at pretreatment levels in 2003. Two species (*Ceratophyllum demersum* and *Vallisneria americana*) continued to be found at pre-treatment levels in 2004 while the remaining two were absent in the post-treatment survey of 2004. In 2005, *Najas flexilis*, and *Vallisneria americana* were found at pretreatment levels, while *Ceratophyllum demersum* and *Elodea canadensis* were absent. Getsinger et al. (2002) reported a significant decline in the Broad-leaved Pondweeds (*Potamogeton amplifolius*, *P. illinoensis* and *P. gramineus*) following herbicide treatment in both Burr Pond and Lake Hortonia. One species, *Potamogeton illinoensis*, was frequently reported at reduced levels in 2003 thru 2005 (3.9%, 2.0% and 1.9% of survey points, respectively), but returned to pretreatment frequency of occurrence in 2006. Another of the large pondweeds (*Potamogeton amplifolius*) was absent in 2003 and 2005, but returned to pre-treatment levels of abundance in 2004. Since 2004, this species has been absent. One species was consistently absent from post treatment surveys, *Myriophyllum sibiricum*. This species was not commonly observed in prior surveys, and is reported to be sensitive to the aquatic herbicide fluridone (Smith and Pullman 1997).



**Figure 4. Burr Pond frequency of occurrence summaries for sampling points of all water depths.**

Seventy percent of whole lake sampling points were vegetated by at least one native plant species (Figure 4), 90% of survey points with depths less than 4 m (Figure 5) and 100% of survey points less than 2 meters depth yielded native aquatic plants. Eurasian watermilfoil was present in 52% of whole lake survey points, and 62% of survey points less than 4 m water depth, representing the littoral zone or zone of aquatic plant growth. Native species frequency on a whole lake basis has remained relatively stable over the 9 surveys at from 48 to 70% of survey points for all water depths. Eurasian watermilfoil frequency of occurrence declined rapidly between 1999 (57%) and 2001 (9%) as a result of herbicide application prior to the 2000 survey. However, by 2003 frequency of occurrence had returned to near 1999 levels (49%). In 2004, during the year of treatment, Eurasian watermilfoil frequency of occurrence once again declined (29%). This decline continued into 2005, one year post treatment, with a Eurasian watermilfoil frequency of occurrence of 22%. Spot treatments in 2006 further reduced Eurasian watermilfoil frequency of occurrence to 4%. With no treatment in 2007 and 2008, Eurasian watermilfoil frequency of occurrence once again increased (23% and 52%, respectively). Total plant frequency of occurrence reflects the decline in Eurasian watermilfoil growth between 1999 and 2001 following herbicide application. An increase in total plant frequency of occurrence was observed between 2001 and 2003, with this increase continuing in 2004. Total plant frequency of occurrence has remained stable from 2005 through 2007 (Figure 4), even though a additional herbicide treatments occurred in 2004 and 2006. A slight increase in overall frequency of occurrence was observed in 2008.



**Figure 5. Burr Pond frequency of occurrence summaries for sampling points less than 4 meters water depth.**

For survey points within the littoral zone, water depth less than 4 m (Figure 5), results similar to whole lake surveys are reported. The expected relationship of greater frequency of occurrence of aquatic plants with shallower water depth is consistent with that reported by Getsinger et al. (2002), where frequency of occurrence values in the littoral zone ranged from 78 to 87% of survey points. As with whole lake survey points, Eurasian watermilfoil frequency of occurrence

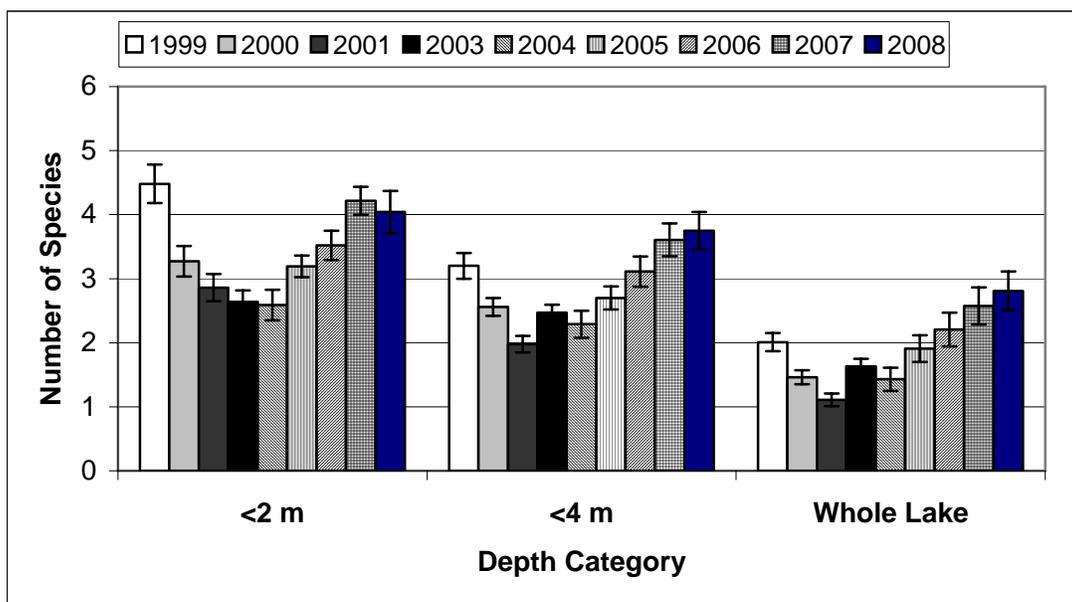
declined rapidly between 1999 (69%) and 2001 (15%) as a result of herbicide application prior to the 2000 survey. However, for the 2003 survey, frequency of occurrence of Eurasian watermilfoil in the littoral zone of Burr Pond had increased to 75%, exceeding 1999 pretreatment levels. Post-treatment results in 2004 showed a decline to 48% of survey points similar to levels reported in the year of treatment by Getsinger et al. (2002). The decline continued in 2005, one year post treatment, with Eurasian watermilfoil present in 35% of survey points. Spot treatments with Renovate in 2006 caused a further decline in Eurasian watermilfoil frequency of occurrence to 5% of survey points within the littoral zone. With no treatment in 2007 and 2008, Eurasian watermilfoil frequency of occurrence increased steadily (32% and 62%, respectively).

**Table 3. Burr Pond species richness comparison between the current open-lake survey and surveys conducted by the US Army Corps of Engineers (Getsinger et al., 2002).**

Plant Grouping	Water Depth Class	Summary Statistic	August Surveys								
			1999	2000	2001	2003	2004	2005	2006	2007	2008
Native plant species	Whole Lake (all depths)	Mean	1.43	1.05	1.02	1.22	1.14	1.65	2.17	2.35	2.28
		N	191	191	191	51	51	51	51	51	51
		Std. Error	0.14	0.11	0.11	0.2	0.18	0.21	0.26	0.29	0.26
	Points with depths <4m	Mean	2.51	2.04	1.83	1.84	1.81	2.32	3.06	3.29	3.08
		N	103	84	95	32	31	32	32	32	32
		Std. Error	0.2	0.21	0.17	0.2	0.21	0.18	0.24	0.26	0.26
	Points with depths <2m	Mean	3.84	2.69	2.61	2	2.09	2.7	3.44	3.89	3.40
		N	44	48	49	24	22	25	25	25	25
		Std. Error	0.30	0.29	0.27	0.2	0.24	0.17	0.23	0.22	0.29
All plant species	Whole Lake (all depths)	Mean	2.01	1.46	1.11	1.63	1.43	1.91	2.21	2.57	2.81
		N	191	191	191	51	51	51	51	51	51
		Std. Error	0.15	0.13	0.12	0.24	0.21	0.24	0.27	0.31	0.30
	Points with depths <4m	Mean	3.20	2.56	1.98	2.47	2.29	2.7	3.11	3.61	3.75
		N	103	84	95	32	31	32	32	32	32
		Std. Error	0.21	0.23	0.19	0.23	0.23	0.24	0.29	0.32	0.29
	Points with depths <2m	Mean	4.48	3.27	2.86	2.64	2.59	3.19	3.52	4.21	4.04
		N	44	48	49	24	22	25	25	25	25
		Std. Error	0.30	0.32	0.30	0.22	0.24	0.25	0.33	0.34	0.33

Species richness results for all survey years are presented in Table 3 and Figure 6. Whole lake native species richness has remained fairly stable at slightly more than one species per survey point, ranging from 1.02 species in 2001 to 2.35 species per sample point in 2007. In 2008 whole lake native species richness was 2.28 species per survey point. For survey points exclusively within the littoral zone (depths less than 4 meters), a decline in native species richness was observed between the 1999 pretreatment survey (2.5 species per sample) and post-treatment surveys (range 1.83 to 2.04 species per sample). The decline in species richness from 1999 to 2001, and subsequent increase from 2001 to 2003, may be the result of changes in the frequency of occurrence of Eurasian watermilfoil. Native species richness in the littoral zone has remained stable post-treatment at approximately 2 species per survey point in the entire littoral zone (depths less than 4 meters) prior to 2006. In 2004, species richness in the littoral

zone was 1.81 species per sample, nearly identical to the 1.83 and 1.84 species per sample reported in 2001 and 2003 respectively. In 2005, native species richness in the littoral zone was 2.32 species per sample, approaching the 1999 pretreatment richness of 2.51 species per sample. In 2006 thru 2008, native species richness exceeded 3 species per sample point, once again largely due to *Potamogeton illinoensis* and *Elodea canadensis*. In the shallow portion of the littoral zone, depths less than 2 meters, species richness in 2004 (2.09 species per sample) was similar to the results for the entire littoral zone in 2003 (2.0 species per sample), but less than the approximately 2.6 species per survey point reported in post-treatment surveys in 2000 and 2001. From 2005 thru 2007, native species richness in the shallow portion of the littoral zone increased steadily from 2.7 to 3.44 and ultimately 3.89 species per sample, respectively. Richness stabilized in 2008. As expected, species richness in the littoral zone and its shallow fringe was higher than whole lake species richness.



**Figure 6. Burr Pond species richness for native species in open-lake surveys. Error bars are standard error of the mean.**

**Wetlands Transects.** The wetland community in Burr Pond differed from the open-lake littoral plant community, although many individual species were represented in both (Tables 1 & 4). In the Burr Pond wetland (Table 4), the most common species were *Myriophyllum spicatum* (76%), *Nuphar advena* (60%), *Ceratophyllum demersum* (53%), *Lemna minor* (44%), *Elodea canadensis* (28%), *Nymphaea odorata* (23%), *Potamogeton pusillus* (17%), *Vallisneria americana* (13%), *Utricularia gibba* (11%), and *Potamogeton illinoensis* (9%). The substantial increase in the abundance of Eurasian watermilfoil in the Burr Pond wetland in 2003 was of concern. Placement of this transect was by verbal description and the recollection of local residents, thus additional ‘open-lake points’ may have been included, accounting for a portion of the increase. Frequency of occurrence of *Myriophyllum spicatum* in the Burr Pond wetland was highly variable between early survey years (1999-2001), ranging from 5% to 34% of survey points. Maximum frequency of occurrence (78% of survey points) was observed in 2003.

Frequency of occurrence of Eurasian watermilfoil declined to 65% of survey points in 2004, 41% of survey points in 2005 and 35% of survey points in 2006. With no treatments in 2007 or 2008, The frequency of occurrence of Eurasian watermilfoil continued to increase (56% and 76% of survey points, respectively).

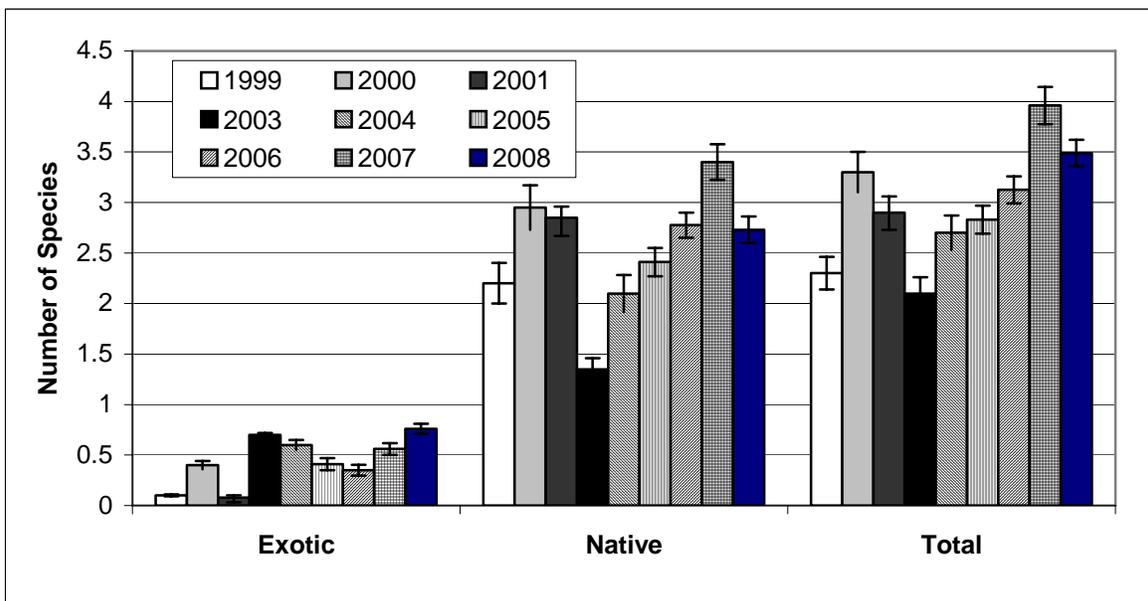
**Table 4. Frequency of occurrence for all species and all survey years for the Burr Pond wetland transect.**

Species	August Surveys								
	1999	2000	2001	2003	2004	2005	2006	2007	2008
<i>Brasenia schreberi</i>						2.5%			
<i>Ceratophyllum demersum</i>	72.5%	71.3%	70.0%	26.3%	33.8%	30.0%	32.5%	45.3%	53.3%
<i>Ceratophyllum echinatum</i>	2.5%				3.8%				
<i>Chara sp.</i>				5.0%	7.5%				
<i>Elodea canadensis</i>	3.8%	12.5%	10.0%				6.3%	46.7%	28.0%
<i>Lemna minor</i>					13.8%	13.8%	15.0%	9.3%	44.0%
<i>Myriophyllum spicatum</i>	8.8%	33.8%	5.0%	77.5%	65.0%	41.3%	35.0%	56.0%	76.0%
<i>Najas flexilis</i>		1.3%				2.5%	6.3%	30.7%	
<i>Nuphar advena</i>	72.5%	73.8%	70.0%	50.0%	48.8%	60.0%	45.0%	34.7%	60.0%
<i>Nymphaea odorata</i>	33.8%	28.8%	51.3%	12.5%	45.0%	17.5%	22.5%	26.7%	22.7%
<i>Polygonum sp.</i>						7.5%	2.5%		
<i>Potamogeton diversifolius</i>		3.8%							
<i>Potamogeton epihydrus</i>	2.5%								
<i>Potamogeton foliosus</i>			1.3%		3.8%				
<i>Potamogeton gramineus</i>				1.3%				18.7%	
<i>Potamogeton illinoensis</i>		2.5%		2.5%	7.5%	12.5%	48.8%	20.0%	9.3%
<i>Potamogeton nodosus</i>			1.3%						
<i>Potamogeton pusillus</i>						11.3%	10.0%	24.0%	17.3%
<i>Potamogeton spirillus</i>			8.8%						
<i>Potamogeton robbinsii</i>								7.0%	1.3%
<i>Potamogeton zosteriformes</i>						12.5%		6.7%	1.3%
<i>Ranunculus longirostris</i>						1.3%	12.5%	5.3%	1.3%
<i>Sparganium sp.</i>				2.5%	3.8%		1.3%	2.7%	1.3%
<i>Spirodela polyrhiza</i>	16.3%	50.0%		1.3%					
<i>Typha sp.</i>						3.8%	1.3%		
<i>Utricularia geminascapa</i>			7.5%						
<i>Utricularia gibba</i>		2.5%	10.0%	1.3%	1.3%	16.3%	1.3%	8.0%	10.7%
<i>Utricularia intermedia</i>		7.5%							
<i>Utricularia minor</i>	1.3%	11.3%	7.5%	6.3%		6.3%	2.5%		
<i>Utricularia vulgaris</i>	1.3%	11.3%	22.5%	13.8%	26.3%	11.3%	6.3%		6.7%
<i>Vallisneria americana</i>				7.5%	8.8%	20.0%	51.3%	38.7%	13.3%
<i>Zosterella dubia</i>			3.8%		7.5%	12.5%	12.5%	22.7%	

The number of species recorded for the wetland transect in Burr Pond has been relatively constant, ranging from 10 in 1999 to 18 in 2006. Species present however, have been variable from year to year, with a total of 31 species recorded between the 7 surveys. Differences have

generally been in the less common species, less than 2% frequency of occurrence, or in species represented in only one (9 species) or two (7 species) survey years. Six species were reported in the 2005 wetland survey for the first time; *Brasenia schreberi*, *Polygonum sp.*, *Potamogeton pusillus*, *Potamogeton zosteriformis*, *Ranunculus longirostris*, and *Typha sp.* Nearly all are native species common to the region. No previously unreported species were encountered in 2006, but *Potamogeton robbinsii* appeared in 2007 and 2008. Eurasian watermilfoil abundance in the wetland transect increased substantially in 2003, more than double the greatest frequency previously reported in 2000. The dramatic increase in the abundance of Eurasian watermilfoil was accompanied by a decline in species richness (Figure 7). In 2004, Eurasian watermilfoil frequency of occurrence declined to 65% from the 2003 high of 78%. This decline continued in 2005 and 2006, to 41% and 35% of survey points, respectively. A resurgence of Eurasian watermilfoil frequency of occurrence to 56% of survey points in 2007 and 70% of survey points in 2008 was observed.

Total species richness in the Burr Pond wetland ranged from a high of 4.0 species per survey point in 2007 to a low of 2.1 species per survey point in 2003. In 2004 and 2005, total species richness was similar at 2.7 and 2.8 species per survey point, with a steady increase continuing in 2006 and 2007. Native species richness also declined sharply from a high of 3 species per sample in 2000 to a low of 1.3 species per sample in 2003. In 2004, native species richness was 2.1 species per survey point and this increase continued in 2005 through 2007, with 2.4, 2.8 and 3.4 species per survey point, respectively. Declines in native species richness following expansive growth of *Myriophyllum spicatum* have been well documented (Madsen et al. 1988, 1991). Conversely, species richness is reported to increase in areas where Eurasian watermilfoil growth is reduced (Boylen et al., 1996).



**Figure 7. Burr Pond wetland transect species richness.**  
**Error bars are standard error of the mean.**

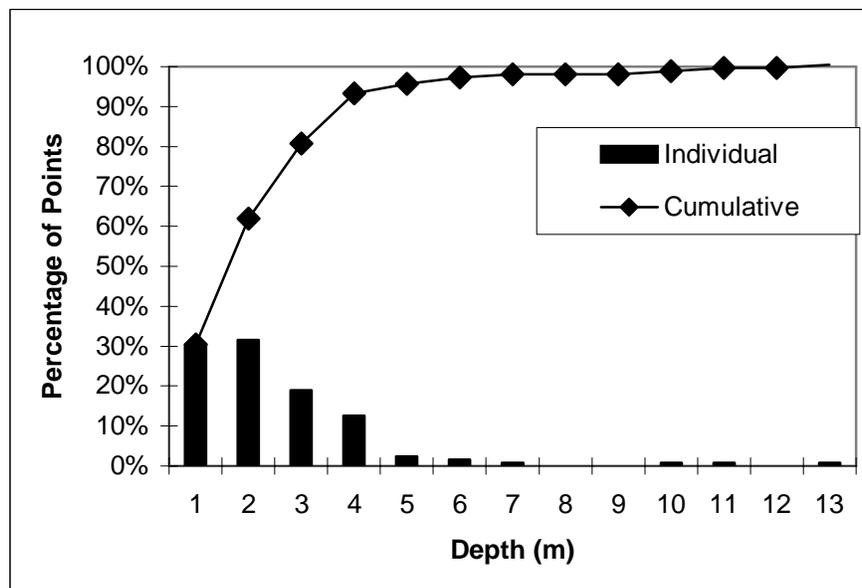
## Lake Hortonia Open-Lake Survey Results

In September of 2008, the aquatic plant community of Lake Hortonia included twenty-five submersed species, three floating-leaved species, two floating species and eight emergent species (Table 1). Two submersed exotic species were observed in Lake Hortonia, *Myriophyllum spicatum* and *Potamogeton crispus*. Species richness was quite high, with a large number of species occurring in more than 5% of survey points (Table 5). Eurasian watermilfoil was the third most widely distributed aquatic plant, reported for 35.8% of survey points for Lake Hortonia. In 2008, the macroalga *Chara* sp. was the most widely distributed species in Lake Hortonia, found in 58% of survey samples. A number of native species were also commonly observed, with a list of species for Lake Hortonia provided in Table 1.

### Maximum Depth of Colonization

Maximum depth of rooted aquatic plant growth for Lake Hortonia was similar to that reported for Burr Pond, with the littoral zone extending to a maximum depth of 4 m. In Lake Hortonia, no viable plant specimens were collected in water depths greater than 4 m, however some decomposing plant material was collected in depths of 6 m. Depth distribution of sampling points (Figure 8) and maximum depth of colonization by aquatic plants in Lake Hortonia was comparable to that reported for earlier studies (Getsinger et al. 2002), with some exceptions. The shallowest water depth interval, 1 m or less, accounted for 32% of survey points in the 2003 and 2004 surveys, but represented less than 5% of survey points in prior surveys. The maximum depth of survey points was 13 m in the surveys by the current author (2003 – 2008), while prior surveys (1999 – 2001) included survey points to a depth of 18 m. In selecting the subset of survey points to include in the current surveys, the majority of survey points employed in previous surveys with water depth greater than the littoral zone depth of 4 m were excluded.

**Figure 8. Depth Distribution of Lake Hortonia Sampling Points in 1-meter depth classes.**



## Species Lists

Maps of the distribution of aquatic plant species for Lake Hortonia are included in Appendix B, Figures B1 – B12. *Chara* sp. was the most abundant aquatic plant species occurring in Lake Hortonia in 2008, reported in 58% of samples collected. *Myriophyllum spicatum* frequency of occurrence increased to 36% of samples collected, up from 23% in 2007, 1.4% in 2006, 2% in 2005, 52% in 2003 and 35% reported in 2004. For Lake Hortonia, other common native species included *Potamogeton illinoensis* (45%), *V. americana* (34%), *Najas flexilis* (31%), *P. robbinsii* (22%), *Elodea canadensis* (16%), *Utricularia gibba* (12%), and *Zosterella dubia* (9%).

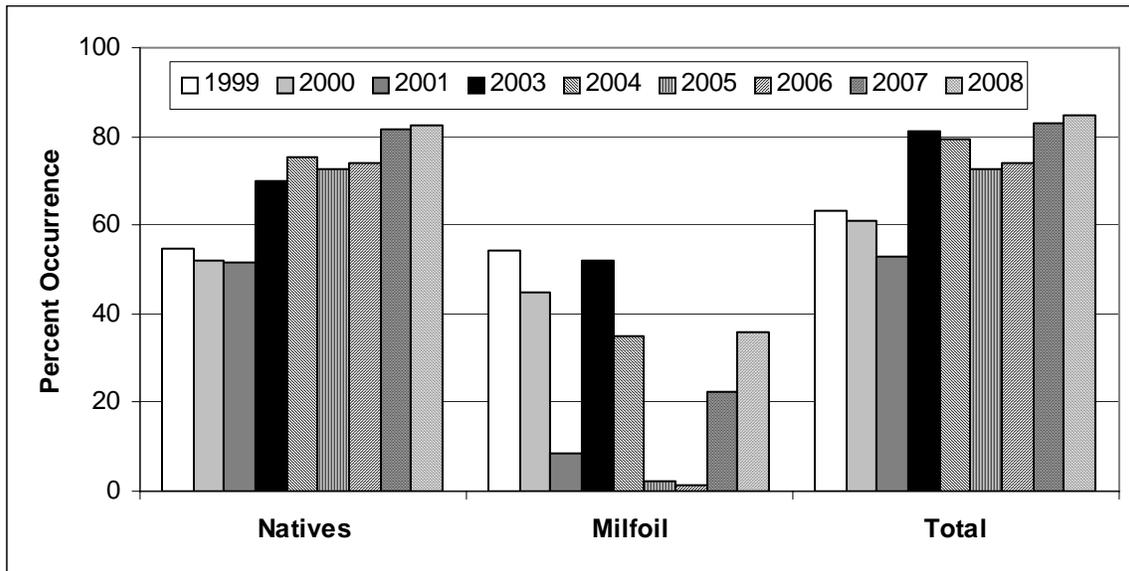
A total of 25 species were recorded in open-lake surveys of Lake Hortonia in 2008. These results are comparable to the 2006 survey results (22 species) and previous surveys (Eichler et al. 2004; Getsinger et al. 2002) in 2004 and 2005 (19 species), 2003 (23 species), 2001 (23 species), 2000 (19 species) and 1999 (21 species). Species absent from the 2008 survey but present in prior surveys were generally either present in only a single survey year or were relatively uncommon in prior surveys (<1% of survey points). Two exceptions were *Potamogeton illinoensis* and *Najas flexilis*. Getsinger et al. (2002) reported a significant decline in the Broad-leaved Pondweeds (*Potamogeton amplifolius*, *P. illinoensis* and *P. gramineus*) following herbicide treatment in both Burr Pond and Lake Hortonia. Significant reductions in frequency of occurrence of eleven native species were reported following fluridone application in 2000. One of these species (*Vallisneria americana*) was found at pretreatment levels in 2003 and 2004, however a decline was noted in 2005. Getsinger et al. reported a decline in *Najas flexilis* in the year following treatment (2000), however this species returned to levels comparable to pretreatment in the following year (2001) and increased in abundance in 2003. *Najas flexilis* declined in 2004 in the year of treatment and was absent in 2005. As with prior treatment cycles, the second year post treatment (2006), *Najas flexilis* frequency of occurrence exceeded pre-treatment (1999) levels and remained common in 2007. Three species, *Utricularia gibba*, *Elodea canadensis*, and *Potamogeton illinoensis*, were frequently reported in 2003 (4.8%, 5.6% and 22.2% of survey points, respectively), had not returned to pretreatment frequency of occurrence by 2006 but did so by 2007. Two of these species (*Utricularia gibba* and *Elodea canadensis*) increased in frequency of occurrence in 2004, the year of treatment, however both declined in 2005, one-year post treatment. *Potamogeton illinoensis* approached pre-treatment levels in 2006 and exceeded pre-treatment levels in 2007 and 2008. One species, *Potamogeton zosteriformis*, was relatively uncommon during all surveys, but present in moderate numbers in 2003, declined in abundance in 2004 and 2006 and increased in abundance in 2005, 2007 and 2008. Three species were absent from 2003 surveys, *Potamogeton amplifolius*, *Potamogeton gramineus* and *Ceratophyllum demersum*. *Potamogeton amplifolius* was relatively rare in 1999 thru 2001 and absent since then. *Potamogeton gramineus* was typically absent in the year of treatment but recovered the following year. and *Ceratophyllum demersum* increased in frequency of occurrence in 2004, was absent in 2005 and returned in 2006 but has been absent since then. Two species (*Chara* sp. and *Potamogeton robbinsii*) were found to occur more frequently in 2003 thru 2008 than in the pretreatment survey of 1999.

**Table 5. Lake Hortonia percent frequency of occurrence data.**  
**Results for 1999 through 2001 are derived from Getsinger et al. (2002).**

Species Name	Lake Hortonia August Surveys								
	1999	2000	2001	2003	2004	2005	2006	2007	2008
<i>Brasenia schreberi</i>				1.6%					
<i>Ceratophyllum demersum</i>	8.7%	3.3%			3.2%		2.9%		
<i>Chara sp.</i>	17.0%	25.8%	33.4%	34.1%	54.0%	53.7%	62.5%	55.6%	57.7%
<i>Eleocharis acicularis</i>									0.7%
<i>Elodea canadensis</i>	15.0%	1.0%	1.7%	5.6%	7.9%	0.7%	1.4%	10.5%	16.1%
<i>Megalodonta (Bidens) beckii</i>	0.7%			0.8%	0.8%		1.4%		
<i>Myriophyllum sibiricum</i>	3.3%		1.0%	0.8%	0.8%			2.3%	2.2%
<i>Myriophyllum spicatum</i>	55.0%	44.8%	6.0%	51.6%	34.9%	2.2%	1.4%	22.6%	35.8%
<i>Najas flexilis</i>	2.3%		4.7%	16.7%	1.6%		12.2%	23.3%	31.4%
<i>Nuphar advena</i>	2.0%	1.3%	2.3%	0.8%	2.4%	0.7%	0.7%	0.8%	0.7%
<i>Nymphaea odorata</i>	10.0%	10.4%	13.0%	5.6%	3.2%	5.1%	5.0%	3.8%	7.3%
<i>Potamogeton amplifolius</i>	3.0%	3.0%	1.0%						
<i>Potamogeton crispus</i>			4.3%	0.8%		0.7%	2.2%	3.8%	1.5%
<i>Potamogeton epihydrus</i>									0.7%
<i>Potamogeton gramineus</i>	10.0%	5.0%	1.0%		0.8%			1.5%	3.6%
<i>Potamogeton illinoensis</i>	38.8%	15.1%	12.4%	22.2%	9.5%	1.5%		33.1%	44.5%
<i>Potamogeton natans</i>	2.0%			<1%	0.8%	0.7%	25.2%	1.5%	4.4%
<i>Potamogeton oakesianus</i>	1.0%						0.7%	0.0%	
<i>Potamogeton praelongus</i>	3.7%			0.8%	0.8%	1.5%		2.3%	4.4%
<i>Potamogeton pusillus</i>				0.8%		4.4%	2.9%	3.0%	2.9%
<i>Potamogeton robbinsii</i>	11.7%	11.0%	11.4%	15.1%	21.4%	22.8%	23.0%	21.8%	21.9%
<i>Potamogeton zosteriformis</i>	3.0%	2.3%	7.0%	1.6%		6.6%	2.9%	8.3%	7.3%
<i>Ranunculus longirostris</i>			1.0%				0.7%		1.4%
<i>Sparganium sp.</i>				3.2%			0.7%		
<i>Sphagnum sp.</i>				0.8%	1.6%	1.5%			2.1%
<i>Stuckenia (Potamogeton) pectinata</i>	5.7%	0.7%	6.7%	3.2%		8.8%	5.8%	9.8%	6.6%
<i>Utricularia gibba</i>	11.4%	12.7%	4.3%	4.8%	17.5%	5.1%	7.9%	12.0%	11.7%
<i>Utricularia minor</i>				2.4%	2.4%	5.1%		1.5%	1.5%
<i>Utricularia vulgaris</i>	2.3%	3.3%	4.7%	0.8%	1.6%	3.7%	7.2%	3.0%	3.6%
<i>Vallisneria americana</i>	23.7%	10.4%	11.4%	20.6%	19.8%	11.0%	21.6%	32.3%	34.3%
<i>Zosterella (Heteranthera) dubia</i>	6.4%	4.0%	9.4%	7.9%	5.6%	5.1%	2.9%	12.0%	8.8%

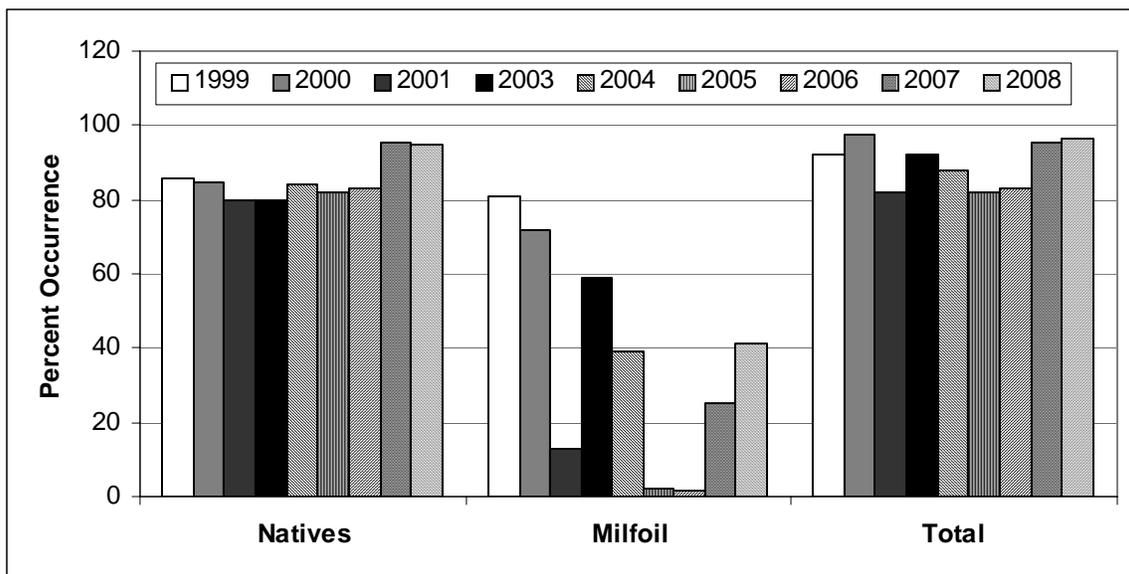
In 2008, eighty-three percent of whole lake sampling points were vegetated by at least one native plant species (Figure 9), 95% of survey points with depths less than 4 meters (Figure 10) and 100% of survey points less than 2 meters depth yielded native aquatic plants. Eurasian

watermilfoil was present in 36% of whole lake survey points, 41% of survey points less than 4 meters water depth and 50% of survey points less than 2 meters water depth.



**Figure 9. Lake Hortonia frequency of occurrence summaries for sampling points of all water depths.**

Native species frequency has remained relatively stable over the 9 surveys at from 52 to 83% of survey points for all water depths, even with exclusion of many of the survey points outside the littoral zone during the 2003 thru 2008 surveys. Eurasian watermilfoil frequency of occurrence



**Figure 10. Lake Hortonia frequency of occurrence summaries for sampling points within the littoral zone (<4 m water depth).**

declined rapidly between 1999 (54%) and 2001 (8%) as a result of herbicide application prior to the 2000 survey, however by 2003 frequency of occurrence had returned to near 1999 levels (52%). A similar decline in Eurasian watermilfoil frequency of occurrence during the treatment year was observed in 2004 (35%) and one year post treatment in 2005 (2%). Treatments in 2006 further reduced the occurrence of Eurasian watermilfoil to the lowest levels for any survey year (1.4% of survey points). Total plant frequency of occurrence reflects the decline in Eurasian watermilfoil growth between 2003 and 2004, with further reduction observed in 2005 and 2006, the year following treatments. Renovate 'spot treatments' in 2007 and 2008 limited regrowth of Eurasian watermilfoil in treated areas but substantial growth was observed in untreated areas.

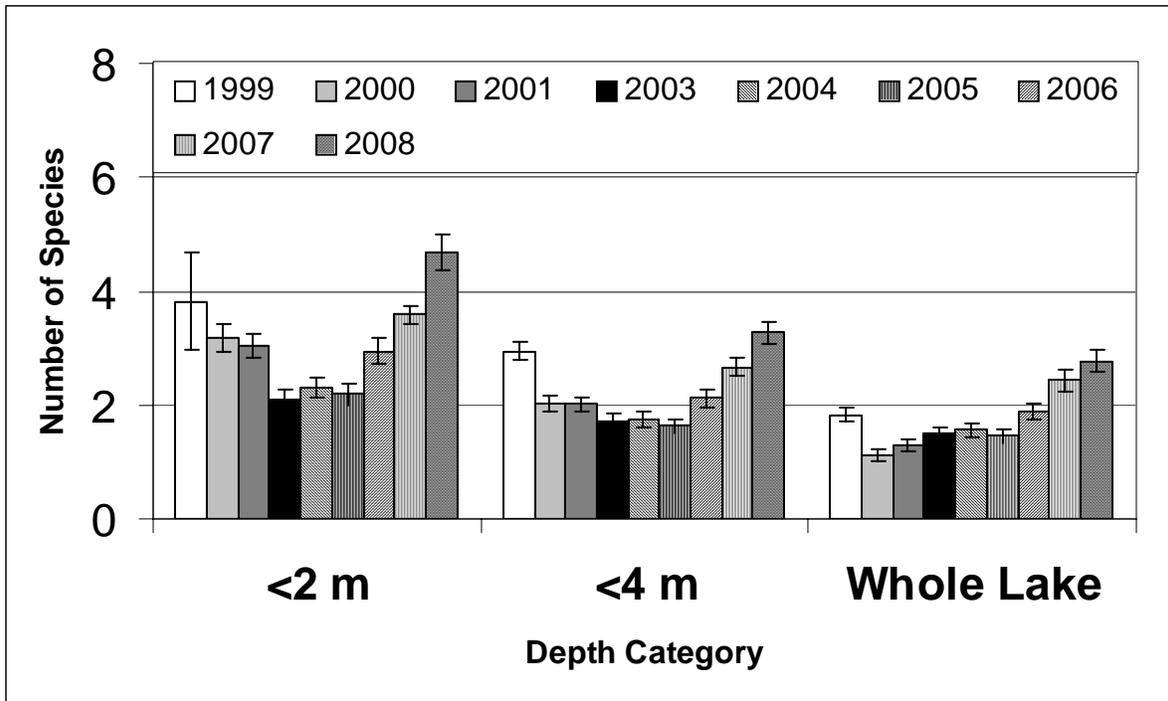
The increase in percent occurrence of all species groups in 2003 thru 2008 (Figure 9) may be an artifact of the change in number of survey points. The 2003 thru 2008 surveys excluded many of the survey points from prior surveys located outside the littoral zone. Reviewing survey points within the littoral zone, water depth less than 4 meters (Figure 10), results similar to prior surveys are reported. Percent occurrence values for native species within the littoral zone ranged from 80 to 96% of survey points. In the littoral zone, Eurasian watermilfoil frequency of occurrence declined rapidly between 1999 (81%) and 2001 (13%) as a result of herbicide application prior to the 2000 survey, however by the 2003 survey frequency of occurrence (59%) once again approached 1999 levels. Eurasian watermilfoil frequency of occurrence declined between 2003 (pre-treatment) and 2004 (year of treatment), with year of treatment Eurasian watermilfoil frequency of occurrence 39% of survey sites. In 2005, one year post treatment, Eurasian watermilfoil decline continued with 2% frequency of occurrence at survey sites. In 2006, the first year of 'spot treatments' with Renovate 3, Eurasian watermilfoil decline continued with 1.4% frequency of occurrence at survey sites. In 2007 and 2008, spot treatments continued, however Eurasian watermilfoil abundance increased lake-wide, with a frequency of occurrence at survey sites of 36%. It should be noted that the increase on EWM growth was primarily in non-treated areas.

Species richness results for all survey years are presented in Table 6. Whole lake native plant species richness has remained fairly stable at 1.1 to 2.8 species per survey point (Figure 11). For survey points exclusively within the littoral zone (depths less than 2 and 4 meters), a decline in species richness was observed between pre-treatment (1999 and 2003 survey years) and post-treatment surveys. Native species richness in the littoral zone has remained stable post-treatment at between 2 and 3 species per survey point in the entire littoral zone (depths less than 4 meters). In the shallow portion of the littoral zone, depths less than 2 m, native species richness was similar to the results for the entire littoral zone in 2003, but less than the approximately 3 species per survey point reported in surveys in 2000 and 2001. Native species richness in the shallow portion of the littoral zone increased slightly in 2004 (2.31 species per survey point), declined slightly in 2005 (2.19 species per survey point) and increased in 2006 thru 2008 (2.95, 3.59 and 4.67 species per survey point, respectively). Species richness for all species in the whole of Lake Hortonia averaged 2.4 species per sample in 1999 prior to treatment. Post-treatment surveys in 2000 and 2001 reported 1.67 and 1.4 species per sample, respectively. The 2003 survey reported 2.01 species per sample; however, this increase may be attributable to the expansion of Eurasian watermilfoil growth. The 2004 post-treatment survey reported 1.91 species per sample, with the decline from 2003 attributable to a reduction in the growth of Eurasian watermilfoil. The decline

**Table 6. Species richness comparison between all survey years for Lake Hortonia.**

Plant	Water Depth	Summary	August Surveys								
Grouping	Class	Statistic	1999	2000	2001	2003	2004	2005	2006	2007	2008
Native plant species	Whole Lake (all depths)	Mean	1.83	1.12	1.28	1.5	1.56	1.45	1.88	2.44	2.77
		N	299	299	299	126	126	126	126	126	126
		Std. Error	0.13	0.11	0.1	0.12	0.13	0.12	0.15	0.16	0.19
	Points with depths <4m	Mean	2.95	2.03	2.01	1.72	1.75	1.63	2.12	2.66	3.28
		N	182	169	190	108	112	112	112	112	112
		Std. Error	0.17	0.14	0.13	0.13	0.13	0.13	0.15	0.16	0.19
	Points with depths <2m	Mean	3.82	3.19	3.05	2.08	2.31	2.19	2.95	3.59	4.67
		N	93	73	94	43	55	55	55	55	55
		Std. Error	0.86	0.24	0.21	0.18	0.18	0.2	0.22	0.20	0.31
All plant species	Whole Lake (all depths)	Mean	2.38	1.67	1.41	2.01	1.91	1.47	1.9	2.66	3.13
		N	299	299	299	126	126	126	126	126	126
		Std. Error	0.15	0.11	0.11	0.13	0.15	0.12	0.15	0.17	0.20
	Points with depths <4m	Mean	3.76	2.75	2.21	2.3	2.14	1.66	2.14	2.90	3.69
		N	182	169	190	108	112	112	112	112	112
		Std. Error	0.18	0.15	0.15	0.13	0.15	0.13	0.15	0.17	0.21
	Points with depths <2m	Mean	4.68	3.99	3.41	2.78	2.84	2.23	2.97	3.86	5.17
		N	93	73	94	43	55	55	55	55	55
		Std. Error	0.28	0.24	0.22	0.17	0.2	0.2	0.22	0.21	0.32

continued, with 1.47 species per survey point reported in 2005. The steep decline in the abundance of Eurasian watermilfoil may in part account for this decline. In 2006, species richness increased to 1.9 species per survey point even with declining Eurasian watermilfoil frequency of occurrence. Rapid increases in the frequency of occurrence of *Potamogeton illinoensis* and *Chara* spp. may be responsible. In 2007 and 2008, species richness once again increased lakewide, but this increase was due, at least in part, to the increase in the presence of Eurasian watermilfoil.



**Figure 11. Lake Hortonia species richness for native species.**  
**Error bars are standard error of the mean.**

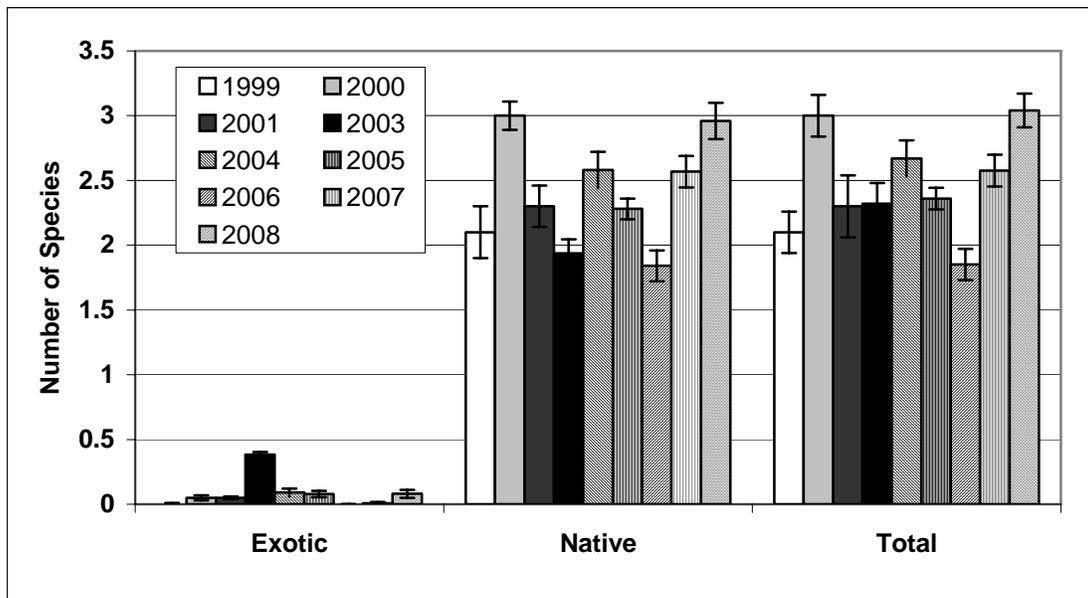
**Wetlands Transects.** The wetland community differed from the whole-lake littoral plant community, although many individual species were represented in both (Tables 1 & 7). In the Lake Hortonia wetland, the most common species were *Myriophyllum sibiricum* (80%), *Nymphaea odorata* (64%), *Utricularia gibba* (31%), *Ceratophyllum demersum* (24%), *Lemna minor* (20%), *Utricularia minor* (17%), *Utricularia vulgaris* (14%), *Sphagnum* (14%), and *Myriophyllum spicatum* (8%).

**Table 7. Frequency of occurrence for all species and all survey years in the Lake Hortonia wetland transect.**

Species	August Surveys								
	1999	2000	2001	2003	2004	2005	2006	2007	2008
<i>Bidens cernua</i>			2.0%						
<i>Carex sp.</i>		1.0%							
<i>Ceratophyllum demersum</i>	1.0%			17.5%	20.0%	11.4%	6.1%	12.0%	23.7%
<i>Chara sp.</i>	0.5%		0.5%		5.0%		1.8%		
<i>Cyperus sp.</i>	0.5%								
<i>Eleocharis spp.</i>	7.0%			6.5%	2.0%				
<i>Elodea canadensis</i>				1.5%			0.9%	0.8%	3.5%
<i>Epilobium glandulosum</i>	1.0%								
<i>Hypericum sp.</i>	1.0%								
<i>Juncus pelocarpus</i>		2.5%							
<i>Lemna minor</i>	1.5%			1.0%	9.0%	1.8%	13.2%	21.6%	20.2%
<i>Lemna trisulca</i>							1.8%	0.8%	3.5%
<i>Ludwigia palustris</i>	1.0%								
<i>Lythrum salicaria</i>	1.5%	1.5%							
<i>Myriophyllum sibiricum</i>		1.5%	7.0%	26.5%	30.0%	9.6%	8.8%	41.6%	79.8%
<i>Myriophyllum spicatum</i>		0.5%	0.5%	38.5%	9.0%	7.9%			7.9%
<i>Najas flexilis</i>					1.0%		0.9%	9.6%	4.4%
<i>Nuphar variegata</i>	7.5%	49.0%	53.5%	9.5%	5.0%	0.9%	11.4%	1.6%	0.9%
<i>Nymphaea odorata</i>	95.0%	99.0%	98.0%	80.0%	78.0%	91.2%	52.6%	93.6%	64.0%
<i>Polygonum sp.</i>					1.0%				
<i>Pontederia cordata</i>					4.0%			0.8%	
<i>Potamogeton crispus</i>							0.8%		
<i>Potamogeton epihydrus</i>				3.0%	3.0%	8.8%	6.1%	1.6%	3.5%
<i>Potamogeton gramineus</i>	1.0%			1.0%					
<i>Potamogeton illinoensis</i>				8.0%	2.0%		9.6%	13.6%	5.3%
<i>Potamogeton natans</i>				3.0%	1.0%	4.4%	4.4%	0.8%	1.8%
<i>Potamogeton robbinsii</i>	0.5%		3.0%	7.0%					1.8%
<i>Potamogeton zosteriformes</i>					7.0%	15.8%	4.4%	1.6%	7.0%

Species	August Surveys								
	1999	2000	2001	2003	2004	2005	2006	2007	2008
<i>Scirpus sp.</i>				6.5%					
<i>Sparganium sp.</i>				1.0%				0.8%	0.8%
<i>Sphagnum sp.</i>	1.0%				15.0%	7.0%			14.0%
<i>Spirodela polyrhiza</i>	2.0%								0.9%
<i>Utricularia gibba</i>	11.0%	37.0%	51.0%	2.5%	13.0%				30.7%
<i>Utricularia intermedia</i>		13.5%		1.0%					
<i>Utricularia minor</i>	50.5%	27.5%	1.5%	1.0%	14.0%	34.2%	17.5%	24.0%	16.7%
<i>Utricularia vulgaris</i>	28.0%	68.0%	41.5%	13.5%	45.0%	39.5%	44.7%	23.2%	14.0%
<i>Vallisneria americana</i>				7.0%	1.0%			3.2%	
<i>Zosterella dubia</i>				1.5%	2.0%	3.5%	2.6%	5.6%	

As with the Burr Pond wetland, a major expansion of Eurasian watermilfoil in the Lake Hortonia wetland was reported in 2003, however Eurasian watermilfoil abundance declined substantially in the Lake Hortonia wetland in both 2004 and 2005. Following the Renovate treatment in 2006, Eurasian watermilfoil was absent from the wetland survey in 2006 and 2007. In 2008, northern milfoil, *Myriophyllum sibiricum*, dominated but growth of Eurasian watermilfoil was observed.



**Figure 12. Lake Hortonia wetland species richness.**  
**Error bars are standard error of the mean.**

In 2008, a total of 20 species were found along the wetland transect in Lake Hortonia. The number of species recorded for the wetland transect in Lake Hortonia has ranged from 18 in

1999 and 2007 to 11 species in 2000, 10 species in 2001, 21 species in 2003 and 2004, 13 species in 2005 and 16 species in 2006. Species present have been variable from year to year, with a total of 36 species recorded between the 9 surveys. Differences have generally been in the less common species, less than 2% frequency of occurrence, or in species represented in only a single survey year (14 species). Four species were reported in 2004 wetland surveys for the first time, *Najas flexilis*, *Polygonum* sp., *Pontederia cordata* and *Potamogeton zosteriformis*. All four species were previously reported for Lake Hortonia. No previously unreported species were observed since 2004. Eurasian watermilfoil abundance in the wetland transect increased substantially in 2003, more than double the greatest frequency previously reported in 2000. This dramatic increase in the abundance of *Myriophyllum spicatum* was accompanied by a decline in native species richness (Figure 12), while total species richness remained virtually unchanged from 2001. In the 2004 post-treatment survey, *Myriophyllum spicatum* frequency of occurrence declined from 2003 while native and total species richness increased. The wetland area was treated with Renovate in 2006, and *Myriophyllum spicatum* was absent. Total and native species richness was also lower than previously recorded in 2006. *Myriophyllum spicatum* remained absent in 2007 and native species richness returned to pre-treatment levels. In 2008, regrowth of Eurasian watermilfoil was observed however native species richness approached the maximum value reported in 2000 of  $3.00 \pm 0.22$  species per survey point.

## Summary

Quantitative aquatic plant surveys were undertaken for Burr Pond and Lake Hortonia, Vermont, in September of 2008. Surveys of Lake Hortonia were conducted to obtain post-treatment data for spot treatments with the aquatic-labeled herbicide triclopyr (Renovate 3™). Hand and suction harvesting operations were underway but incomplete on Lake Hortonia at the time of the aquatic plant survey. No treatment of Burr Pond occurred in 2008. Aquatic plant surveys were designed to be comparable to annual aquatic plant data collected by the US Army Corps of Engineers in 1999 through 2001 and by the authors in 2003 through 2007. Surveys were conducted in 2003 to prepare for and in 2004 and 2005 to evaluate a treatment program based on application of the herbicide fluridone (SONAR™) in 2004 to control Eurasian watermilfoil (*Myriophyllum spicatum*) in these two lakes.

The frequency and distribution of aquatic plant species in each waterbody were evaluated using a point intercept method based on a differential global positioning system of grid points. To address concerns with potential impacts on wetland communities, one site at each lake was selected for line intercept transects to characterize the wetland aquatic plant communities present.

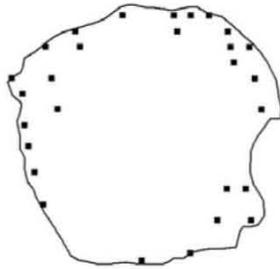
In September of 2008, two years post-treatment, the aquatic plant community of Burr Pond included eighteen submersed species, two floating-leaved species, one floating species and five emergent species. *Myriophyllum spicatum* continued to be the only exotic species reported. Species richness remained quite high, with a large number of species occurring in more than 5% of survey points. Seventy percent of whole lake sampling points were vegetated by at least one native plant species, 89% of survey points with depths less than 4 m and 100% of survey points less than 2 m depth yielded native aquatic plants. Native species richness in the littoral zone was 3.08 species per sample, a slight decrease from the 3.29 species per sample reported in 2007 and nearly identical 3.06 species per sample reported in 2006. Eurasian watermilfoil increased to the most widely distributed plant (55% of survey points for Burr Pond), and a large number of native species were commonly observed. Common native species for Burr Pond included *Chara* sp., *Utricularia gibba*, *Vallisneria americana*, *Potamogeton illinoensis*, *Najas flexilis*, *Zosterella dubia*, *Nymphaea odorata*, *Potamogeton robbinsii* and *Potamogeton pusillus*. Eurasian watermilfoil was present in 55% of whole lake survey points, and 62% of survey points in the littoral zone. While Eurasian watermilfoil distribution (Figure 13) within Burr Pond had declined steadily post-treatment (2004 and 2005), it still remained widely distributed one year after fluridone application. In September of 2006, following a Spring treatment of the shoreline areas of Burr Pond with Renovate, frequency of occurrence of Eurasian watermilfoil was at its lowest reported levels of any survey to date. With no treatment in 2007 or 2008, Eurasian watermilfoil frequency of occurrence rebounded sharply to near pre-treatment levels.

The wetland community in Burr Pond differed from the open-lake littoral plant community, although many individual species were represented in both. In the Burr Pond wetland, the most common species were *Myriophyllum spicatum* (76%), *Nuphar advena* (60%), *Ceratophyllum demersum* (53%), *Lemna minor* (44%), *Elodea canadensis* (28%), *Nymphaea odorata* (23%), *Potamogeton pusillus* (17%), *Vallisneria americana* (13%), *Utricularia gibba* (11%), and *Potamogeton illinoensis* (9%). Eurasian watermilfoil frequency of occurrence in the Burr Pond

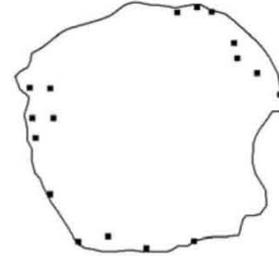
wetland decreased from a high of 78% of survey points in 2003 to 65% of survey points in 2004, 41% in 2005 and 35% in 2006. Some recovery in EWM abundance was observed in 2007 and full recovery to 76% of survey points was observed in 2008.

**Figure 13. Distribution of Eurasian watermilfoil (*Myriophyllum spicatum* L) in Burr Pond**

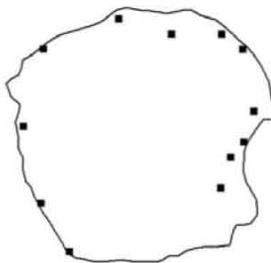
**Eurasian watermilfoil  
Burr Pond 2003  
Pre Treatment**



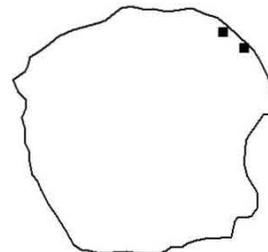
**Eurasian watermilfoil  
Burr Pond 2004  
Year Of Treatment**



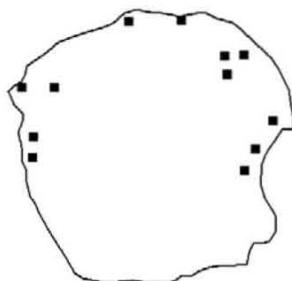
**Eurasian watermilfoil  
Burr Pond 2005  
1 Year Post Treatment**



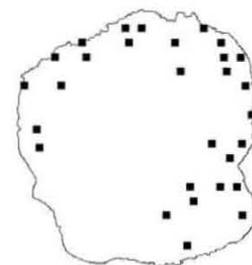
**Eurasian watermilfoil  
Burr Pond 2006  
Year of Treatment**



**Eurasian watermilfoil  
Burr Pond 2007  
1 Yr Post-Treatment**



**Eurasian watermilfoil  
Burr Pond 2008  
2 Yrs Post-Treatment**

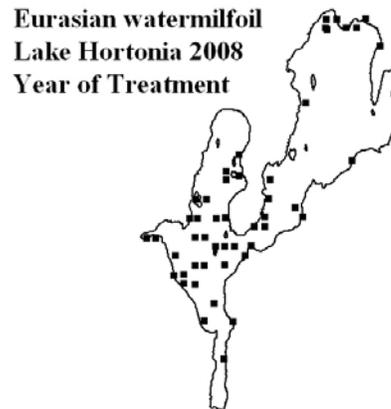
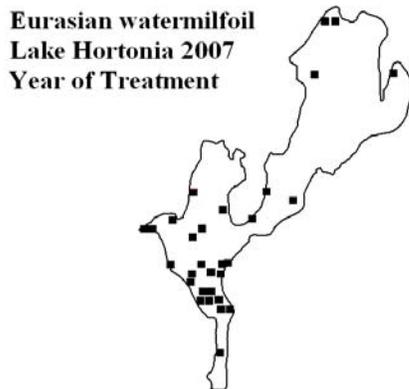


In September of 2008, the aquatic plant community of Lake Hortonia included twenty-five submersed species, three floating-leaved species, two floating species and eight emergent species. Two submersed exotic species were observed in Lake Hortonia, *Myriophyllum spicatum* and *Potamogeton crispus*. Eurasian watermilfoil increased to the third most widely distributed aquatic plant, present in 36% of survey points. For Lake Hortonia, common native species included *Chara* sp., *Potamogeton illinoensis*, *Potamogeton robbinsii*, *Vallisneria americana*, *Najas flexilis*, *Elodea canadensis*, *Utricularia gibba*, and *Zosterella dubia*. A total of 25 species were recorded in open-lake surveys of Lake Hortonia in 2008, comparable to previous surveys in 2001 (23 species), 2000, 2004 and 2005 (19 species), 1999 and 2007 (21 species), and 2003 (23 species). In 2008, eighty-three percent of whole lake sampling points were vegetated by at least one native plant species, 95% of survey points with depths less than 4 meters and 100% of survey points less than 2 meters depth yielded native aquatic plants. Eurasian watermilfoil was present in 36% of whole lake survey points, 41% of survey points less than 4 meters water depth and 50% of survey points less than 2 meters water depth. Species richness for all species in the open-lake survey of Lake Hortonia averaged 2.4 species per sample in 1999 prior to treatment. Post-treatment surveys in 2000 and 2001 reported 1.67 and 1.4 species per sample, respectively. The 2003 pre-treatment survey reported 2.01 species per sample, however this increase may be attributable to the expansion of Eurasian watermilfoil growth. The post-treatment surveys in 2004 and 2005 reported 1.91 and 1.47 species per sample, respectively. In 2006, whole lake surveys reported 1.9 species per sample point. In 2007 and 2008, species richness once again increased lakewide, but this increase was due, at least in part, to the increase in the presence of Eurasian watermilfoil.

In 2008, a total of 20 species were found along the wetland transect in Lake Hortonia. The number of species recorded for the wetland transect in Lake Hortonia has ranged from 18 in 1999 and 2007 to 11 species in 2000, 10 species in 2001, 21 species in 2003 and 2004, 13 species in 2005 and 16 species in 2006. Species present have been variable from year to year, with a total of 36 species recorded between the 5 surveys. In the Lake Hortonia wetland, the most common species were *Nymphaea odorata*, *Utricularia vulgaris*, *Utricularia minor*, *Nuphar variegata*, *Myriophyllum sibiricum*, *Potamogeton zosteriformis*, *Ceratophyllum demersum*, *Potamogeton epihydrus* and *Potamogeton natans*. Eurasian watermilfoil percent frequency for the Lake Hortonia wetland transect increased substantially in 2003 (39%), compared to less than 1% in prior surveys. Post-treatment (2004 and 2005) Eurasian watermilfoil percent frequency for the Lake Hortonia wetland transect decreased to 9% and 8% frequency of occurrence, respectively. The wetland area adjacent to the public boat launch area was treated with Renovate in the Spring of 2006. Eurasian watermilfoil was absent from the September 2006 and 2007 wetland transects. In 2008, northern milfoil, *Myriophyllum sibiricum*, dominated but Eurasian watermilfoil was observed in 8% of survey points. The increase in the abundance of Eurasian watermilfoil in 2003 was accompanied by a decline in native species richness (1.9 species per sample), while total species richness remained virtually unchanged (2.3 species per sample). Total species richness in 2004 and 2005 was 2.7 and 2.4 species per sample, respectively while native species richness was comparable at 2.6 and 2.3 species per sample. Total species richness in 2007 was 2.58 species per sample and native species richness was comparable at 2.57 species per sample. In 2008, regrowth of Eurasian watermilfoil was observed however native species richness approached the maximum value reported in 2000 of  $3.00 \pm 0.22$  species per survey point.

In Burr Pond, Lake Hortonia and their associated wetlands, Eurasian watermilfoil expanded rapidly after the final post-treatment surveys of 2001 conducted by the US Army Corps of Engineers. Eurasian watermilfoil was the most abundant species in the open waters of both lakes, and in the deeper portions of the Burr Pond wetland in pre-treatment surveys in August of 2003. Frequency of occurrence of Eurasian watermilfoil had also increased substantially in the Lake Hortonia wetland in 2003. In August of 2004, the year of treatment for both lakes, Eurasian watermilfoil frequency of occurrence declined by 32% in the open water of Lake Hortonia and 40% in the open water of Burr Pond when compared to 2003 pre-treatment data. In the wetland areas, Eurasian watermilfoil frequency of occurrence declined by 17% for Burr Pond and 77% for Lake Hortonia following whole lake treatment. In August of 2005, one year post-treatment for both lakes, Eurasian watermilfoil frequency of occurrence declined by 94% in the open water of Lake Hortonia (Figure 14) and 17% in the open water of Burr Pond (Figure 13) when compared to 2004 year of treatment data. The presence of scattered populations of Eurasian watermilfoil in Lake Hortonia and more extensive growth in Burr Pond (22% of survey points in 2005) prompted spot herbicide (Renovate) treatments in the Spring of 2006. In September of 2006, the year of treatment for both lakes, Eurasian watermilfoil frequency of occurrence declined to 4% of survey points in the open water of Burr Pond (Figure 13) and 1.4% of survey points in the open water of Lake Hortonia (Figure 14). With no treatment since 2006 in Burr Pond, Eurasian watermilfoil has continued to expand its coverage, approaching pre-treatment levels in 2008. In Lake Hortonia, spot treatments continued in 2007 and 2008, however Eurasian watermilfoil abundance increased lake-wide, with a frequency of occurrence at survey sites of 36%. It should be noted that the increase on EWM growth was primarily in non-treated areas. While some native species experienced declines following herbicide treatment with fluridone, including *Najas flexilis*, *Elodea canadensis*, *Myriophyllum sibiricum*, *Potamogeton illinoensis*, and *P. zosteriformis*, greater than 50% of survey points remained vegetated with native species during the year of treatment. The majority of these species were observed to survive the year of treatment and increase in frequency of occurrence after a decline in the year of treatment. One notable change in growth in 2006 thru 2008 was the proliferation of *Potamogeton illinoensis* in both Burr Pond and Lake Hortonia, leading several residents to complain of nuisance levels of growth of this species.

**Figure 14. Distribution of Eurasian watermilfoil (*Myriophyllum spicatum* L) in Lake Hortonia**



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## Acknowledgements

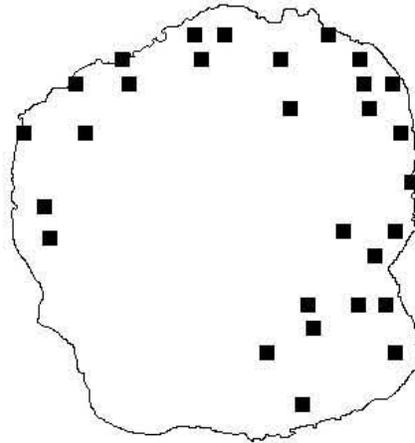
The authors would like to acknowledge Mr. David Weaver of the Lake Hortonia Property Owners Association for their assistance in coordinating lake access and development of the current survey project.

# **Appendix A**

## **Burr Pond Aquatic Plant Distribution Maps**

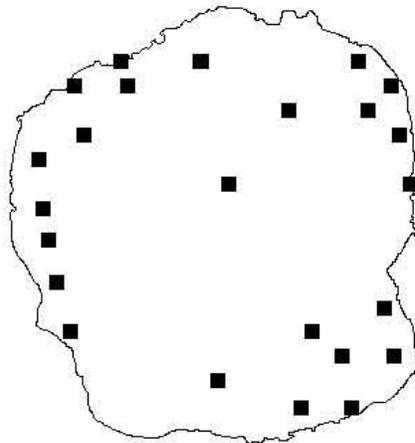
*Burr Pond 2008*

*Distribution of  
Myriophyllum spicatum*



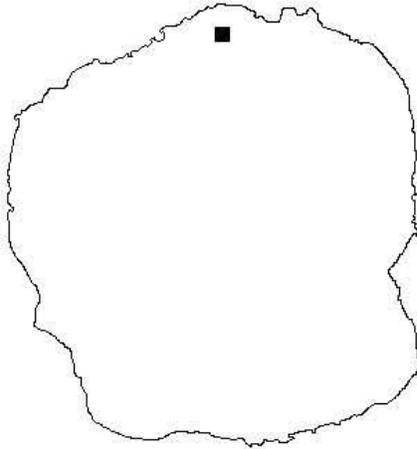
*Burr Pond 2008*

*Distribution of  
Chara sp.*



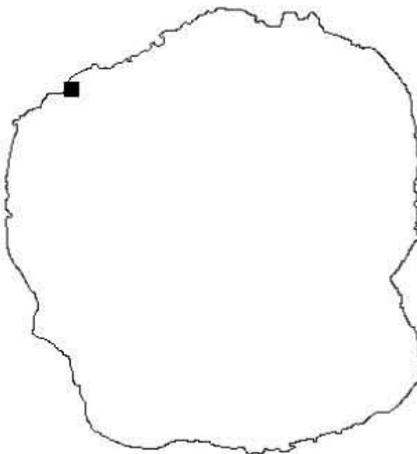
*Burr Pond 2008*

*Distribution of  
Ceratophyllum demersum*



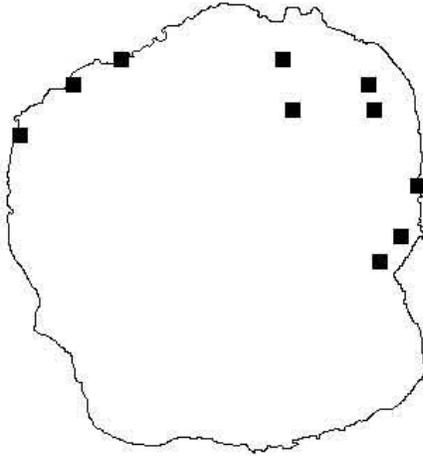
*Burr Pond 2008*

*Distribution of  
Eleocharis acicularis*



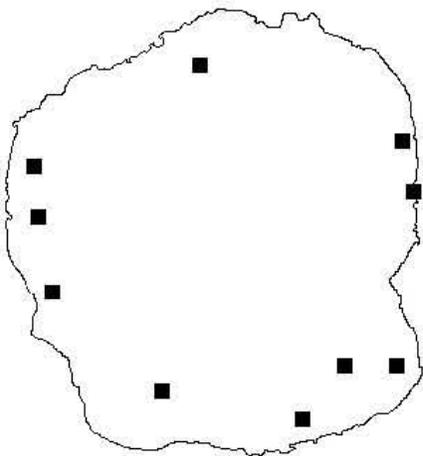
*Burr Pond 2008*

*Distribution of  
Elodea canadensis*



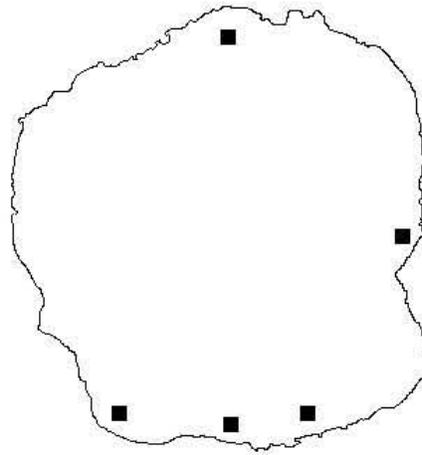
*Burr Pond 2008*

*Distribution of  
Najas flexilis*



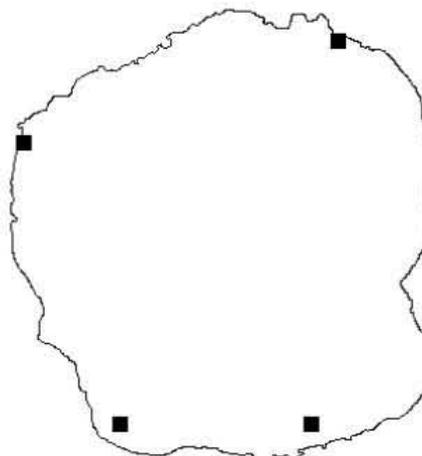
*Burr Pond 2008*

*Distribution of  
Nuphar advena*



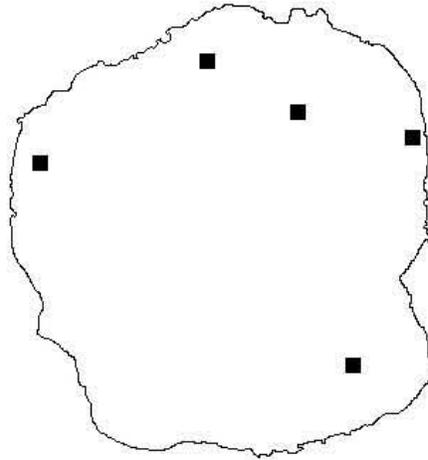
*Burr Pond 2008*

*Distribution of  
Nymphaea odorata*



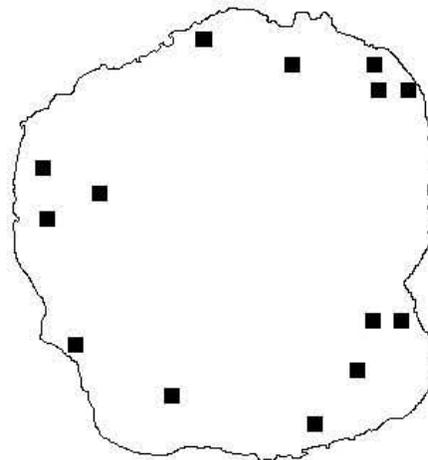
*Burr Pond 2008*

*Distribution of  
Potamogeton gramineus*



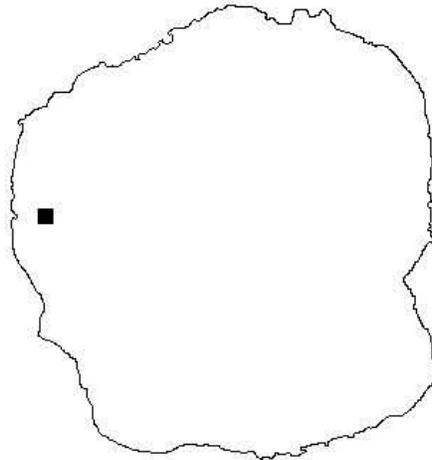
*Burr Pond 2008*

*Distribution of  
Potamogeton illinoensis*



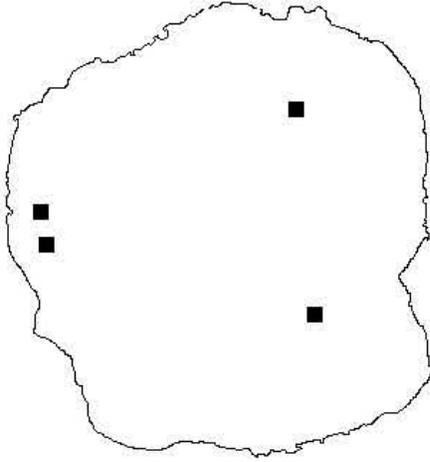
*Burr Pond 2008*

*Distribution of  
Potamogeton natans*



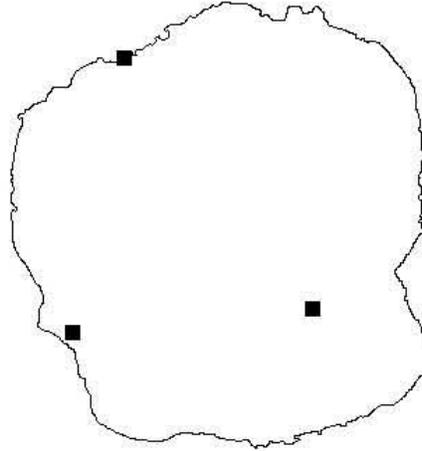
*Burr Pond 2008*

*Distribution of  
Potamogeton pusillus*



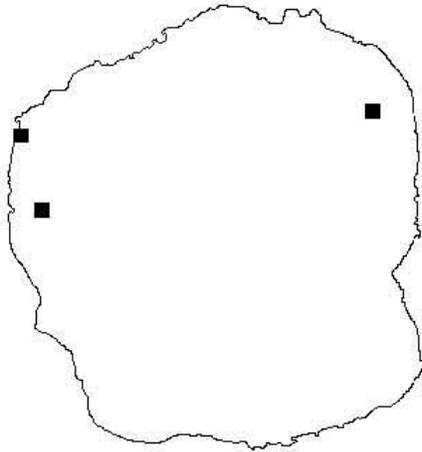
*Burr Pond 2008*

*Distribution of  
Potamogeton robbinsii*



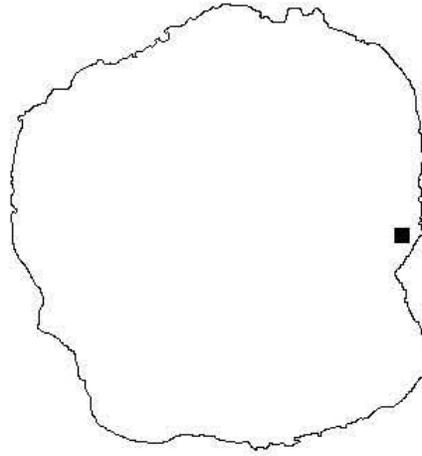
*Burr Pond 2008*

*Distribution of  
Potamogeton zosteriformis*



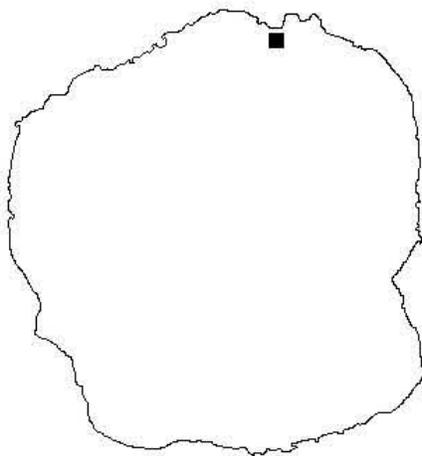
*Burr Pond 2008*

*Distribution of  
Ranunculus longirostris*



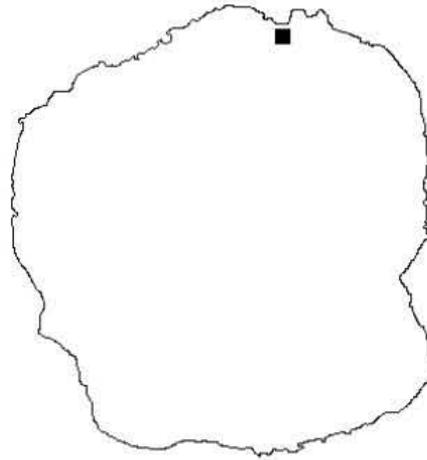
*Burr Pond 2008*

*Distribution of  
Scirpus subterminalis*



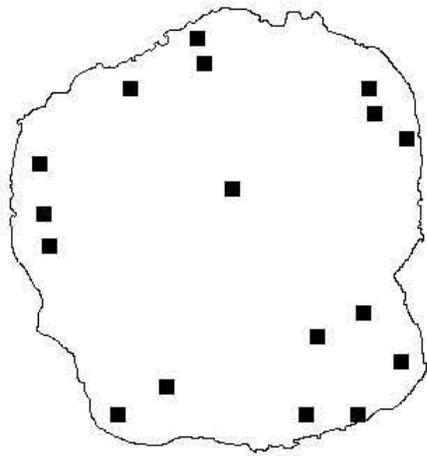
*Burr Pond 2008*

*Distribution of  
Typha sp.*



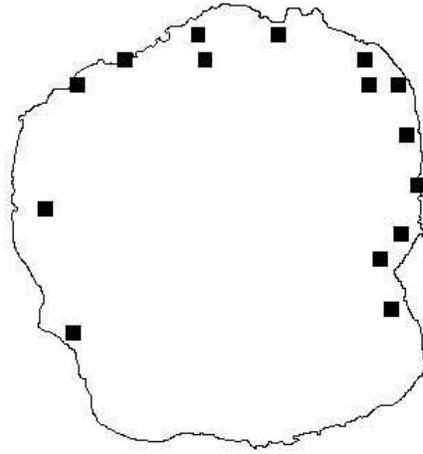
*Burr Pond 2008*

*Distribution of  
Utricularia gibba*



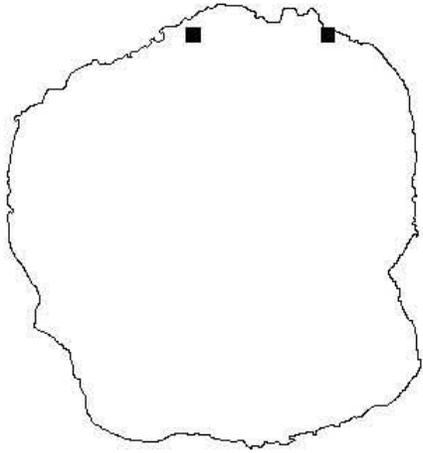
*Burr Pond 2008*

*Distribution of  
Vallisneria americana*



*Burr Pond 2008*

*Distribution of  
Zosterella dubia*



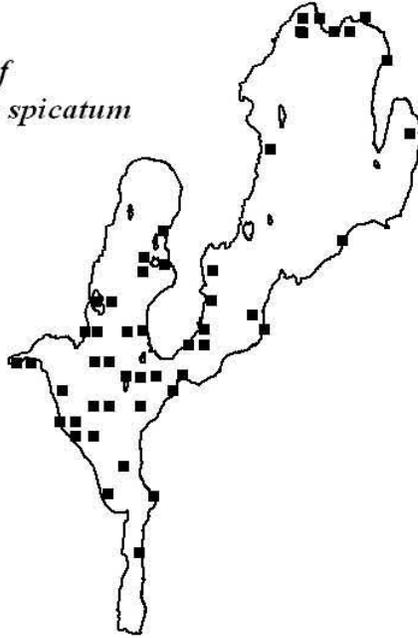


## **Appendix B**

### **Lake Hortonia Aquatic Plant Distribution Maps**

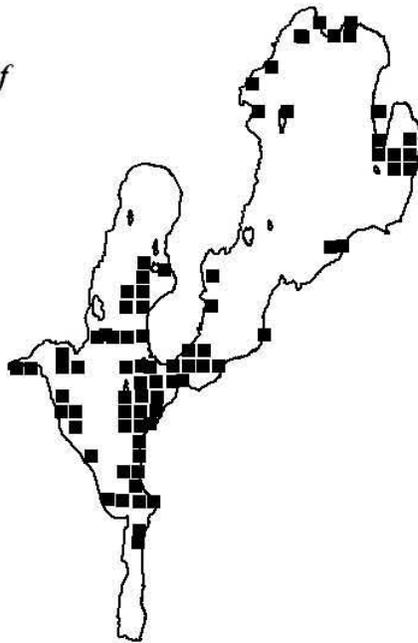
*Lake Hortonia 2008*

*Distribution of  
Myriophyllum spicatum*



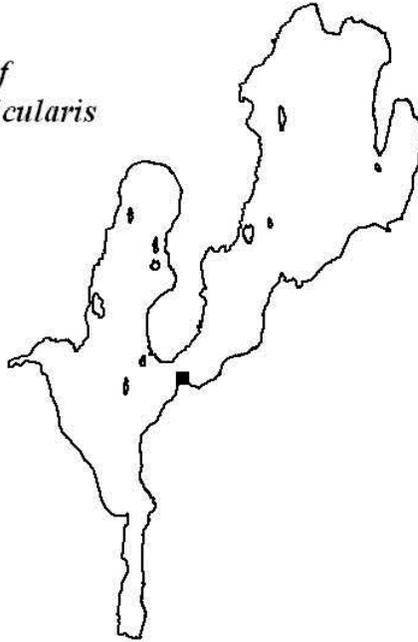
*Lake Hortonia 2008*

*Distribution of  
Chara sp.*



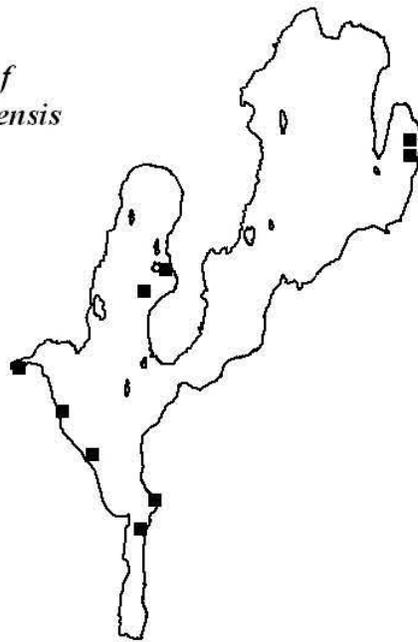
*Lake Hortonia 2008*

*Distribution of  
Eleocharis acicularis*



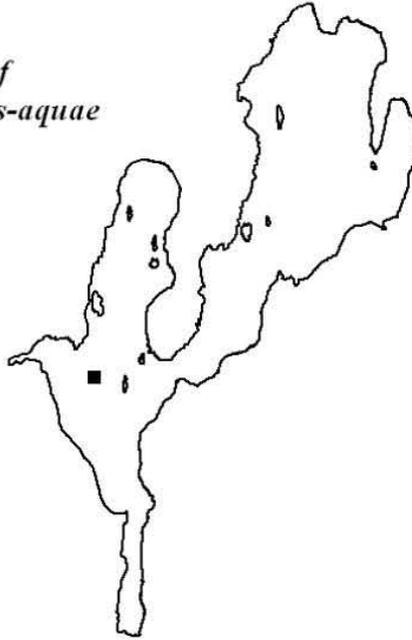
*Lake Hortonia 2008*

*Distribution of  
Elodea canadensis*



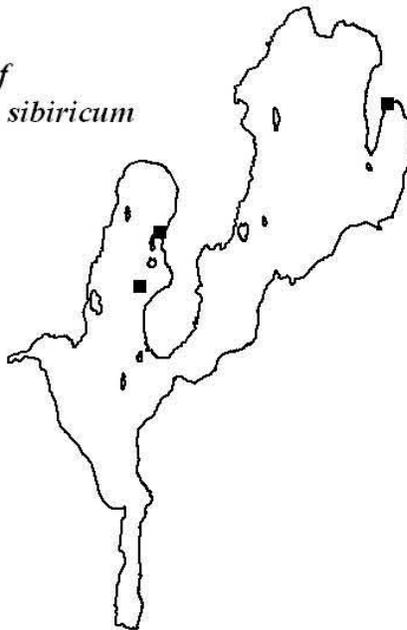
*Lake Hortonia 2008*

*Distribution of  
Fontinalis flos-aquae*



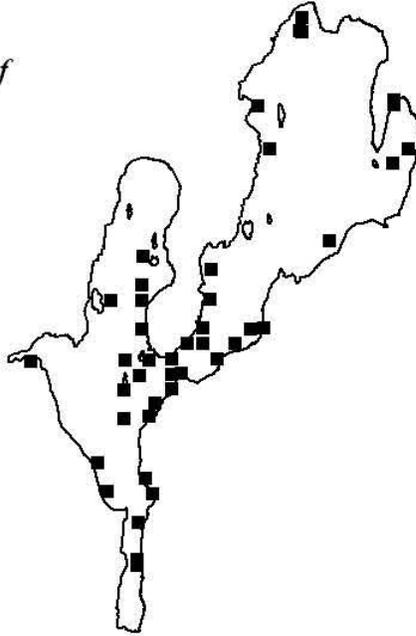
*Lake Hortonia 2008*

*Distribution of  
Myriophyllum sibiricum*



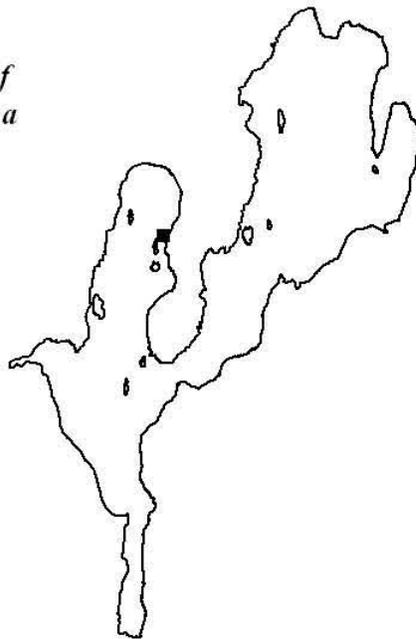
*Lake Hortonia 2008*

*Distribution of  
Najas flexilis*



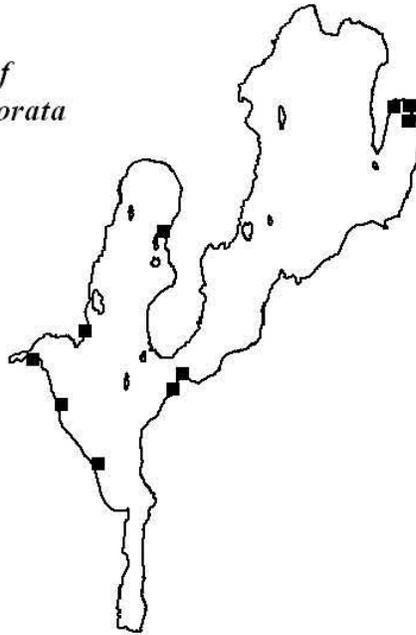
*Lake Hortonia 2008*

*Distribution of  
Nuphar advena*



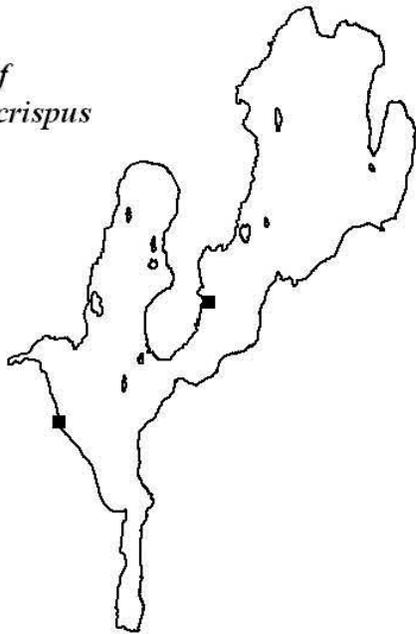
*Lake Hortonia 2008*

*Distribution of  
Nymphaea odorata*



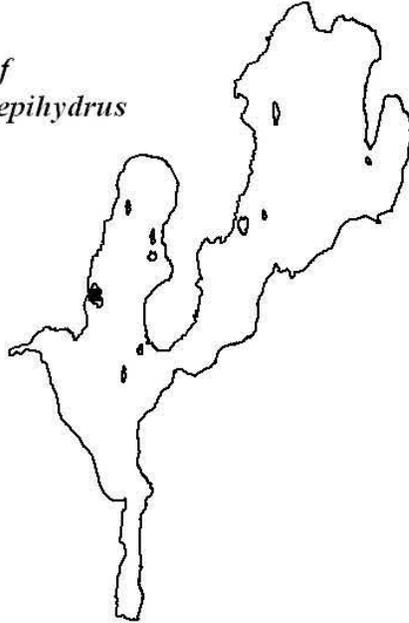
*Lake Hortonia 2008*

*Distribution of  
Potamogeton crispus*



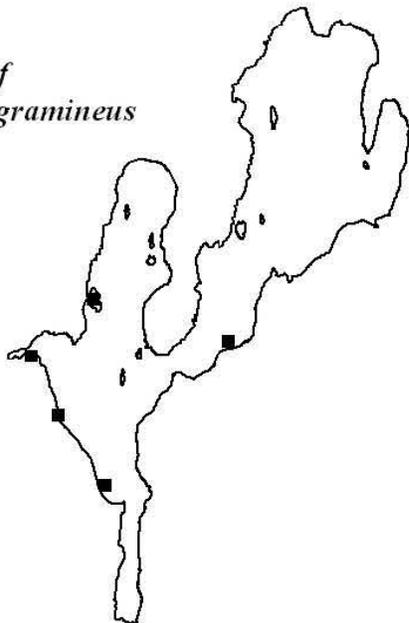
*Lake Hortonia 2008*

*Distribution of  
Potamogeton epihydrus*



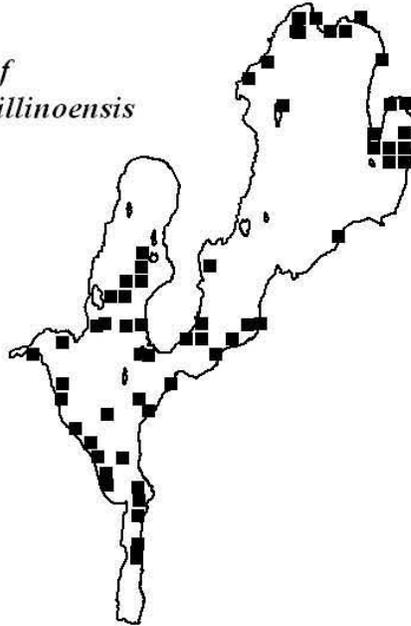
*Lake Hortonia 2008*

*Distribution of  
Potamogeton gramineus*



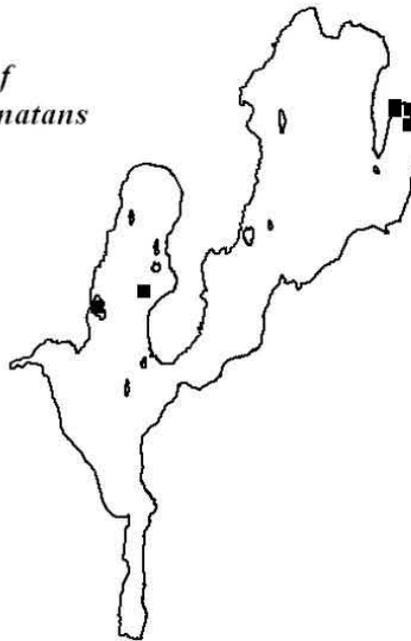
*Lake Hortonia 2008*

*Distribution of  
Potamogeton illinoensis*



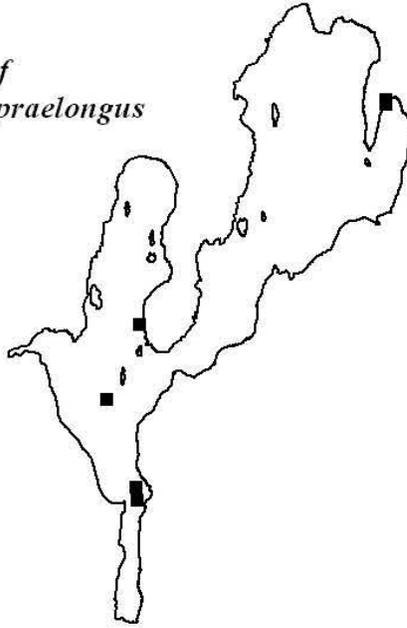
*Lake Hortonia 2008*

*Distribution of  
Potamogeton natans*



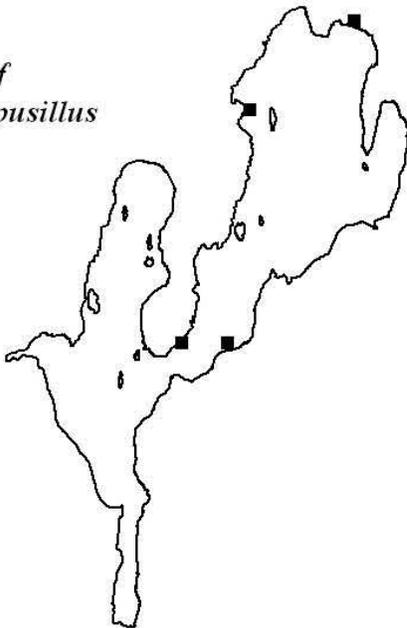
*Lake Hortonia 2008*

*Distribution of  
Potamogeton praelongus*



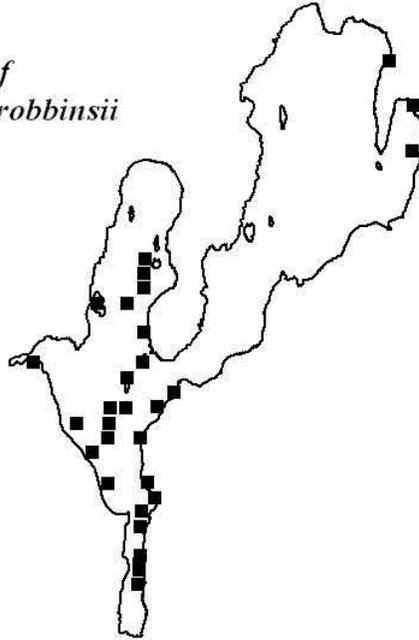
*Lake Hortonia 2008*

*Distribution of  
Potamogeton pusillus*



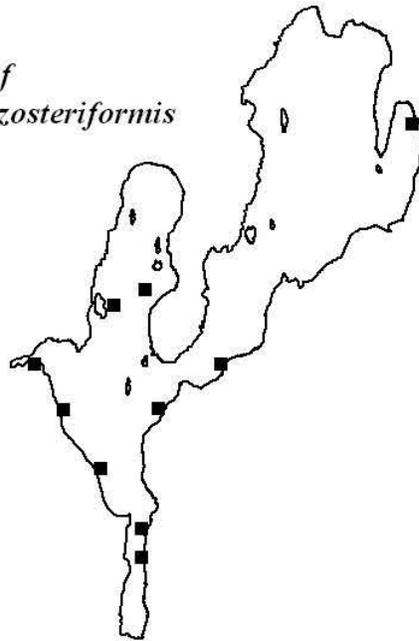
*Lake Hortonia 2008*

*Distribution of  
Potamogeton robbinsii*



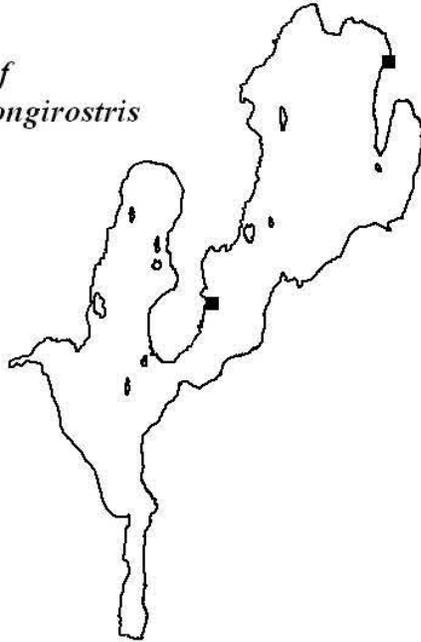
*Lake Hortonia 2008*

*Distribution of  
Potamogeton zosteriformis*



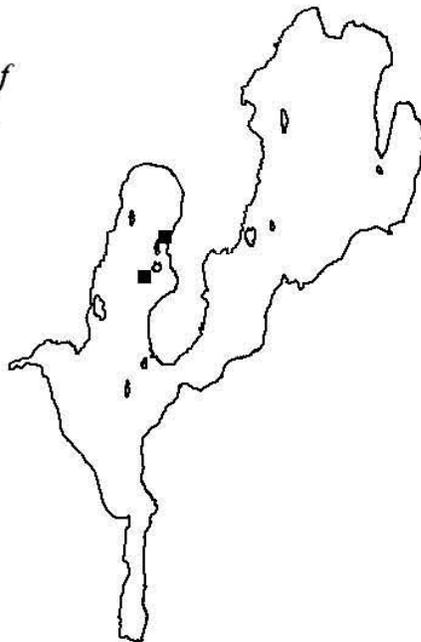
*Lake Hortonia 2008*

*Distribution of  
Ranunculus longirostris*



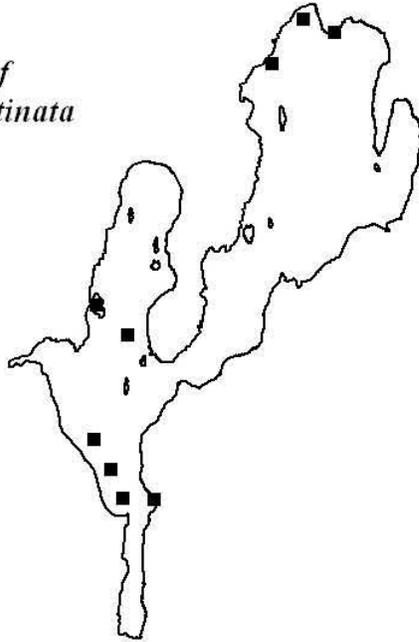
*Lake Hortonia 2008*

*Distribution of  
Sphagnum sp.*



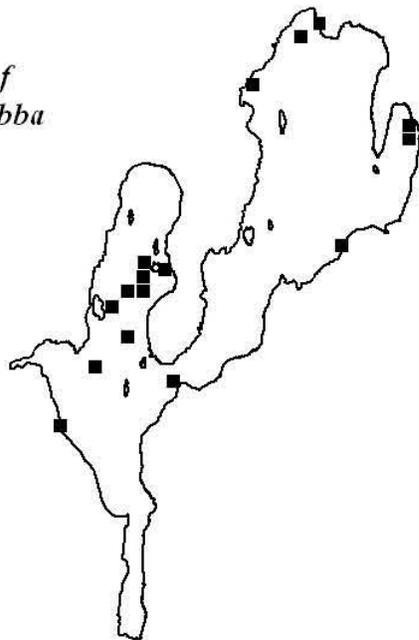
*Lake Hortonia 2008*

*Distribution of  
Stuckenia pectinata*



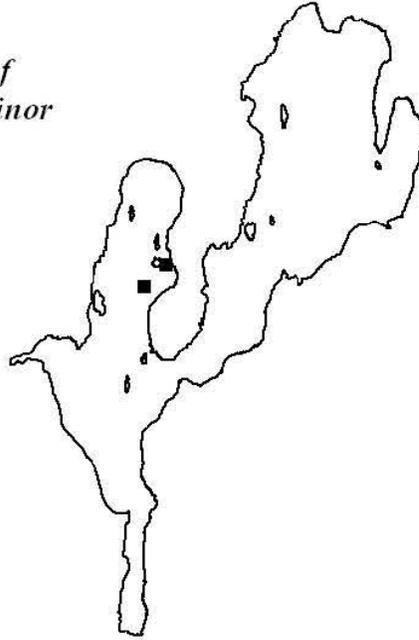
*Lake Hortonia 2008*

*Distribution of  
Utricularia gibba*



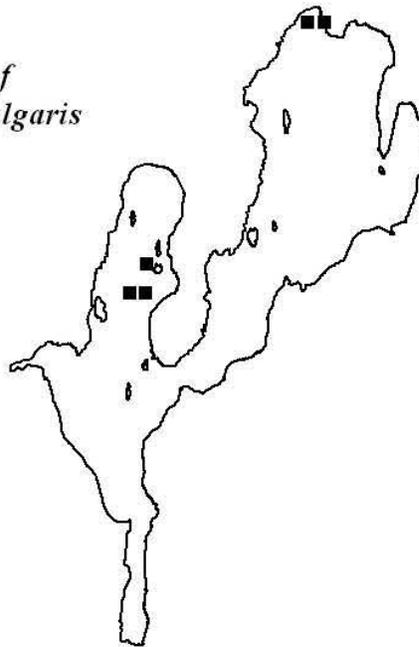
**Lake Hortonia 2008**

*Distribution of  
Utricularia minor*



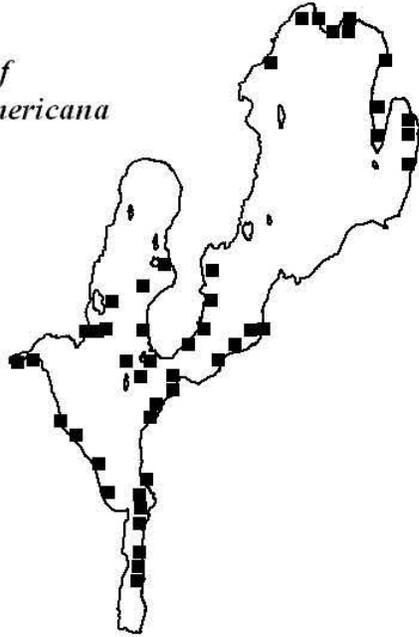
**Lake Hortonia 2008**

*Distribution of  
Utricularia vulgaris*



*Lake Hortonia 2008*

*Distribution of  
Vallisneria americana*



*Lake Hortonia 2008*

*Distribution of  
Zosterella dubia*

