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Aquatic Vegetation of Burr Pond and Lake Hortonia, Vermont

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Background.

Quantitative aquatic plant surveys were undertaken for Burr Pond and Lake Hortonia, Vermont, in August of 2004 to obtain post-treatment data for whole-lake treatments with the aquatic-labeled herbicide fluridone (SONAR^{TM}). Aquatic plant surveys were designed to be comparable to aquatic plant data collected by the US Army Corps of Engineers in 1999 through 2001 and by the author in 2003. Surveys were conducted in 2003 to prepare for and in 2004 to evaluate a treatment program based on application of the herbicide fluridone (SONAR^{TM}) 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.

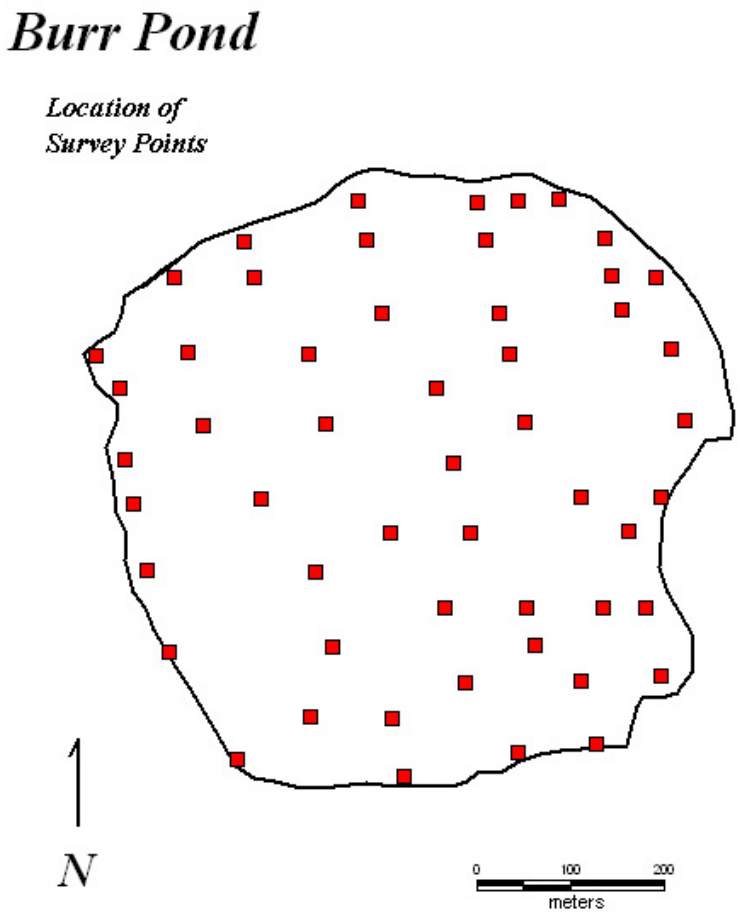
Lake Hortonia. Lake Hortonia is located in Rutland County, Vermont between the towns of Sudbury and Hubbardton. The pond has a surface area of approximately 194 ha. Average water depth is reported to be 5.85 m, with a maximum depth of 19 m (Getsinger et al. 2002). Transparency via secchi disk is reported 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.

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,

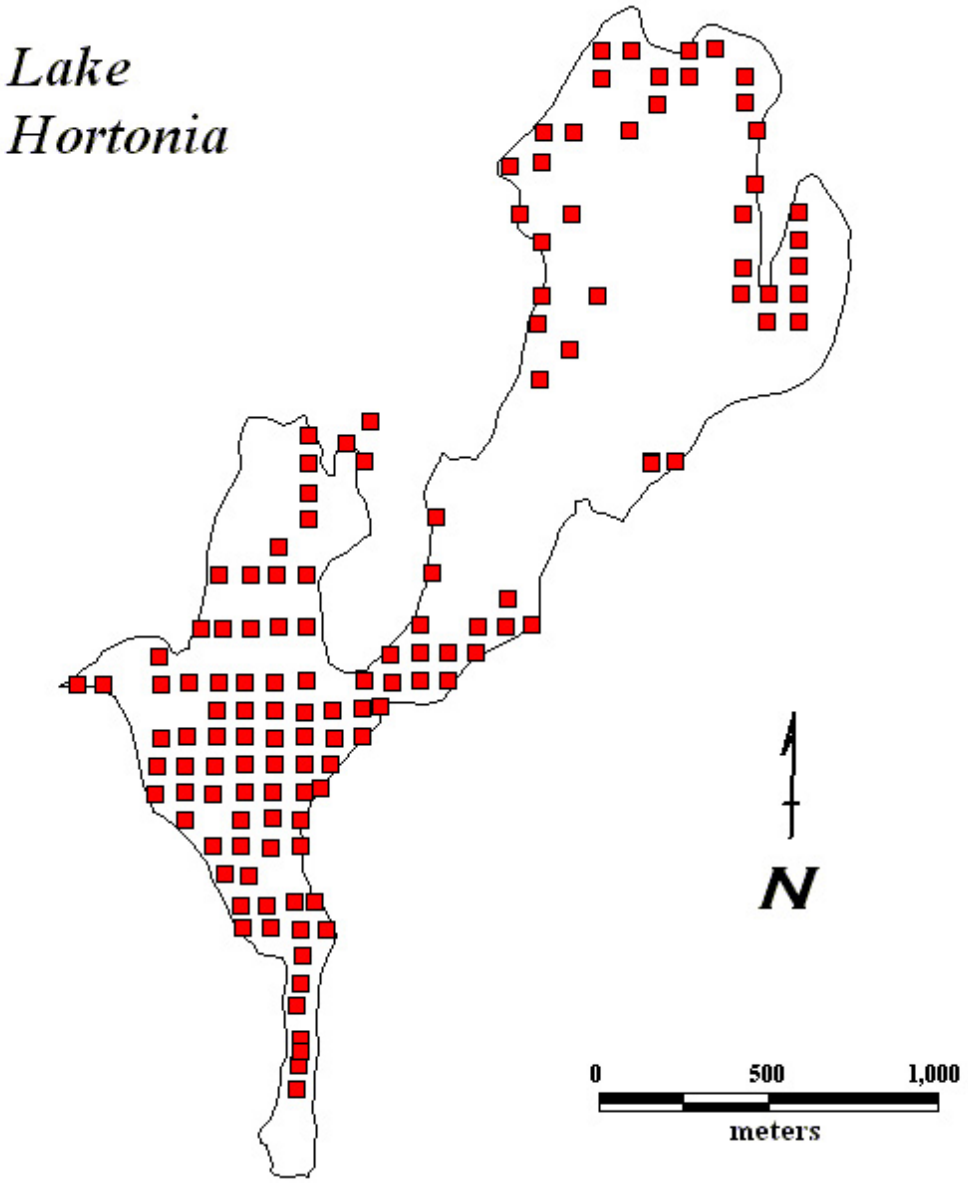
Figure 1. Map of Burr Pond with point intercept survey locations for 2004.



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 and 2004 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 MapInfo Software (MapInfo Corp., Troy, NY). A Trimble Pathfinder (Trimble Corp., Sunnyvale, CA) differential global positioning system (DGPS), was used to navigate to each

Figure 2. Map of Lake Hortonia with point intercept survey locations for 2004.



point for the survey observation. Point intercept plant frequencies were surveyed between August 31 and September 3, 2004 for both lakes. Data presented in the summaries are on both a

whole-lake basis and adjusted for the littoral zone.

Wetlands 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^2 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.

Results and Discussion

Burr Pond Open-Lake Survey Results

In August of 2004, the aquatic plant community of Burr Pond included thirteen submersed species, two floating-leaved species, one floating species and seven 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 declined to the second most widely distributed plant (29% of survey points for Burr Pond, down from 49% of survey points in 2003) with *Chara* sp. the most widespread (37% 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, August 2004.

Species Name	Common Name	Burr Pond		Lake Hortonia	
		Lake	Wetland	Lake	Wetland
Brasenia schreberi J.F. Gmel.	water shield			X	
Ceratophyllum demersum L.	coontail	X	X	X	X
Chara sp.	muskgrass, chara	X	X	X	X
Cyperus sp.	sedge				X
Eleocharis acicularis (L.) Roemer & Schultes	needle spike-rush	X			X
Elodea canadensis Michx.	elodea	X		X	
Equisetum sp.	horsetail	X			
Hypericum sp.	St. John's-wort				X

Species Name	Common Name	Burr Pond		Lake Hortonia	
		Lake	Wetland	Lake	Wetland
Lemna minor L.	duckweed		X		X
Ludwigia palustris (L.) Ell.	marsh purslane				X
Lythrum salicaria L.	purple loosestrife		X		X
Megalodonta beckii Greene formerly *Bidens beckii* Torr. Ex Spreng	water marigold			X	
Myriophyllum sibiricum Kom.	northern watermilfoil			X	X
Myriophyllum spicatum L.	Eurasian watermilfoil	X	X	X	X
Najas flexilis (Willd.) Rostk. & Schmidt.	bushy pondweed			X	X
Nuphar advena (Ait.) Ait. f.	yellow pondlily	X	X	X	X
Nymphaea odorata Ait.	white waterlily	X	X	X	X
Polygonum sp.	smartweed			X	X
Pontederia cordata L.	pickerelweed	X		X	X
Potamogeton amplifolius Tuckerm.	largeleaf pondweed	X		X	
Potamogeton epihydrus Raf.	ribbon-leaf pondweed				X
Potamogeton gramineus L.	variable-leaf pondweed	X		X	X
Potamogeton illinoensis Morong.	Illinois pondweed	X	X	X	X
Potamogeton natans L.	floating-leaf pondweed	X		X	X
Potamogeton praelongus Wulfen	white-stem pondweed			X	
Potamogeton pusillus L.	small			X	

Species Name	Common Name	Burr Pond		Lake Hortonia	
		Lake	Wetland	Lake	Wetland
	pondweed				
Potamogeton robbinsii Oakes	Robbins' pondweed	X		X	X
Potamogeton zosteriformis Fern.	flat-stem pondweed	X			X
Ranunculus longirostris Godron	white watercrow-foot			X	
Scirpus sp.	bulrush	X			X
Scirpus validus Vahl	softstem bulrush	X			
Sparganium sp.	burreed	X	X	X	X
Sphagnum sp.	sphagnum			X	X
Spirodela polyrhiza (L.) Schlieden	great duckweed		X		X
Stuckenia pectinata (L.) Borner *formerly Potamogeton pectinatus*	sago pondweed			X	
Utricularia gibba L.	humped bladderwort	X	X	X	X
Utricularia minor L.	small bladderwort			X	X
Utricularia vulgaris L.	great bladderwort		X	X	X
Vallisneria americana L.	wild celery	X	X	X	X
*Zosterella dubia (*Jacq.) Small *formerly Heteranthera dubia* Jacq.	water stargrass	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. 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.

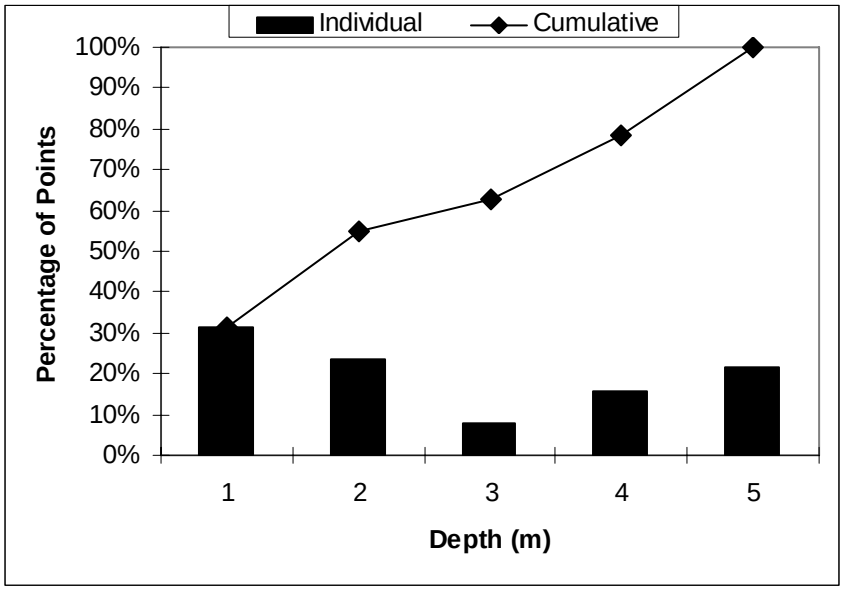


Table 2. Burr Pond percent frequency of occurrence data.
Results for 1999 through 2001 are derived from Getsinger et al. (2002).

Species	Survey Year				
	August-04	**August-03**	**August-01**	**August-00**	**August-99**
Ceratophyllum demersum	5.9%	3.9%	0.5%	2.6%	3.1%
Chara sp.	37.3%	15.7%	36.1%	36.6%	29.0%
Eleocharis acicularis	2.0%	2.0%			
Elodea canadensis		5.9%	0.5%	9.4%	10.0%
Megalodonta beckii					0.5%
Myriophyllum sibiricum					4.2%
Myriophyllum spicatum	29.4%	49.0%	9.4%	40.8%	58.0%
Najas flexilis		11.8%	13.1%		11.0%
Nuphar advena	2.0%	3.9%	6.3%	4.7%	4.7%
Nymphaea odorata	2.0%	9.8%	4.2%	9.4%	8.9%
Potamogeton amplifolius	2.0%		1.6%	2.1%	1.1%
Potamogeton gramineus	2.0%	5.9%	4.7%	5.2%	16.2%
Potamogeton illinoensis	2.0%	3.9%	4.7%		19.9%
Potamogeton natans		2.0%	0.5%	0.5%	0.5%
Potamogeton nodosus			0.5%		
Potamogeton robbinsii	2.0%	3.9%	7.9%	6.3%	2.1%
Potamogeton zosteriformis	2.0%		4.7%	3.1%	6.8%
Ranunculus longirostris				0.5%	0.5%
Scirpus validus	2.0%	2.0%			
Sparganium americanum	2.0%		0.5%	1.6%	
Stuckenia pectinata			0.5%		1.1%
Typha sp.	2.0%	2.0%			
Utricularia gibba	15.7%	13.7%	3.7%	5.2%	3.1%
Utricularia vulgaris			0.5%		1.1%
Vallisneria americana	23.5%	19.6%	8.4%	10.5%	18.0%
Zosterella dubia	9.8%	5.9%	3.7%	6.3%	1.1%

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 – A7. Charophytes were the most abundant species, present in 37% of all samples collected. *Myriophyllum spicatum* was the second most abundant aquatic plant species occurring in Burr Pond, reported in 29% of samples collected. Common native species for Burr Pond included *Vallisneria americana* (24%), *Utricularia gibba* (16%), *Zosterella dubia* (10%), *Ceratophyllum demersum* (6%), *Potamogeton gramineus* (2%), *Potamogeton robbinsii* (2%) and *Potamogeton amplifolius* (2%).

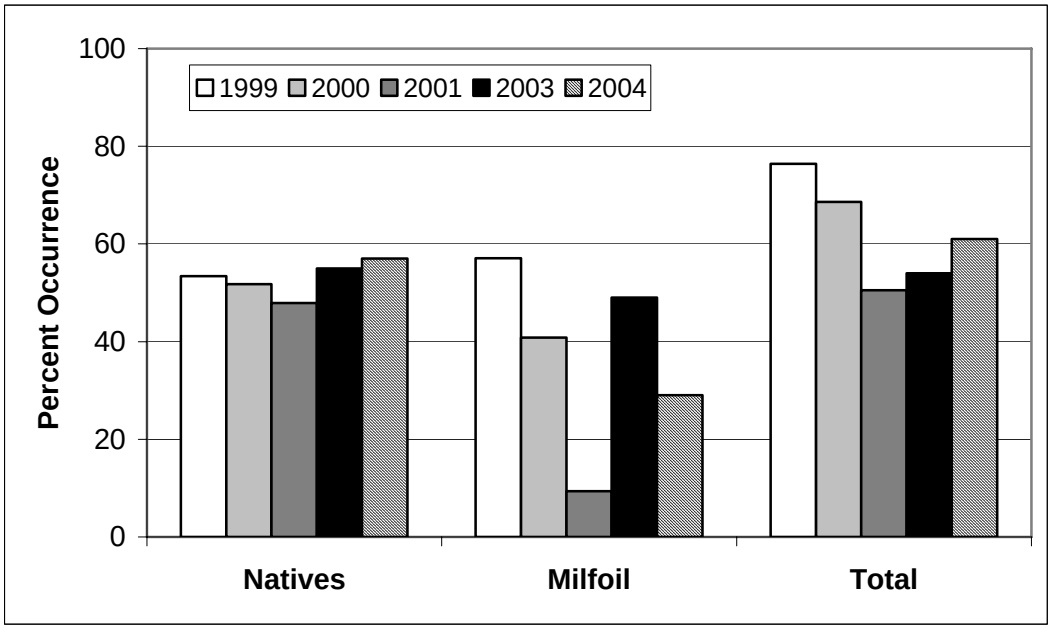
A total of 17 species were recorded in open lake surveys of Burr Pond in 2003 and 2004. These results are comparable to previous surveys (Getsinger et al. 2002) in 2001 (20 species), 2000 (16 species) and 1999 (21 species). No previously unreported species were encountered in 2004. Species absent from the 2004 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.

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. 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 in 2003 and 2004 (3.9% and 2.0% of survey points, respectively), but had not returned to pretreatment frequency of occurrence. Another of the large pondweeds (*Potamogeton amplifolius)* was absent in 2003, but returned to pre-treatment levels of abundance in 2004. One species was absent from both the 2003 and 2004 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).

Fifty-seven percent of whole lake sampling points were vegetated by at least one native plant species (Figure 4), 87% of survey points with depths less than 4 m (Figure 5) and 95% of survey points less than 2 meters depth yielded native aquatic plants. Eurasian watermilfoil was present in 29% of whole lake survey points, and 48% 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 5 surveys at from 48 to 57% 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%). 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 following herbicide application (Figure 4).

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



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.

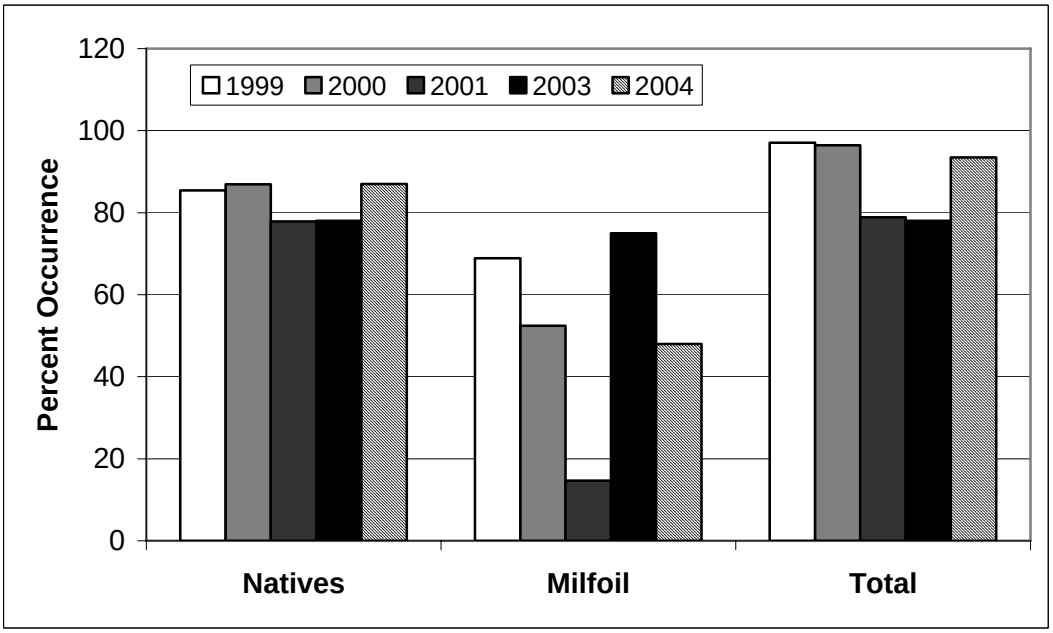


Figure 5. Burr Pond frequency of occurrence summaries for sampling points less than 4 meters water depth.

(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).

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
Native plant species	Whole Lake (all depths)	Mean	1.43	1.05	1.02	1.22	1.14
		N	191	191	191	51	51
		Std. Error	0.14	0.11	0.11	0.2	0.18
	Points with depths <4m	Mean	2.51	2.04	1.83	1.84	1.81
		N	103	84	95	32	31
		Std. Error	0.2	0.21	0.17	0.2	0.21
	Points with depths <2m	Mean	3.84	2.69	2.61	2.00	2.09
		N	44	48	49	24	22
		Std. Error	0.30	0.29	0.27	0.2	0.24
All plant species	Whole Lake (all depths)	Mean	2.01	1.46	1.11	1.63	1.43
		N	191	191	191	51	51
		Std. Error	0.15	0.13	0.12	0.24	0.21
	Points with depths <4m	Mean	3.20	2.56	1.98	2.47	2.29
		N	103	84	95	32	31
		Std. Error	0.21	0.23	0.19	0.23	0.23
	Points with depths <2m	Mean	4.48	3.27	2.86	2.64	2.59
		N	44	48	49	24	22
		Std. Error	0.30	0.32	0.30	0.22	0.24

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 1.43 species per sample point in 1999. In 2004 whole lake species richness was 1.14 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). 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 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. As expected, species richness in the littoral zone and its shallow fringe was higher than whole lake species richness.

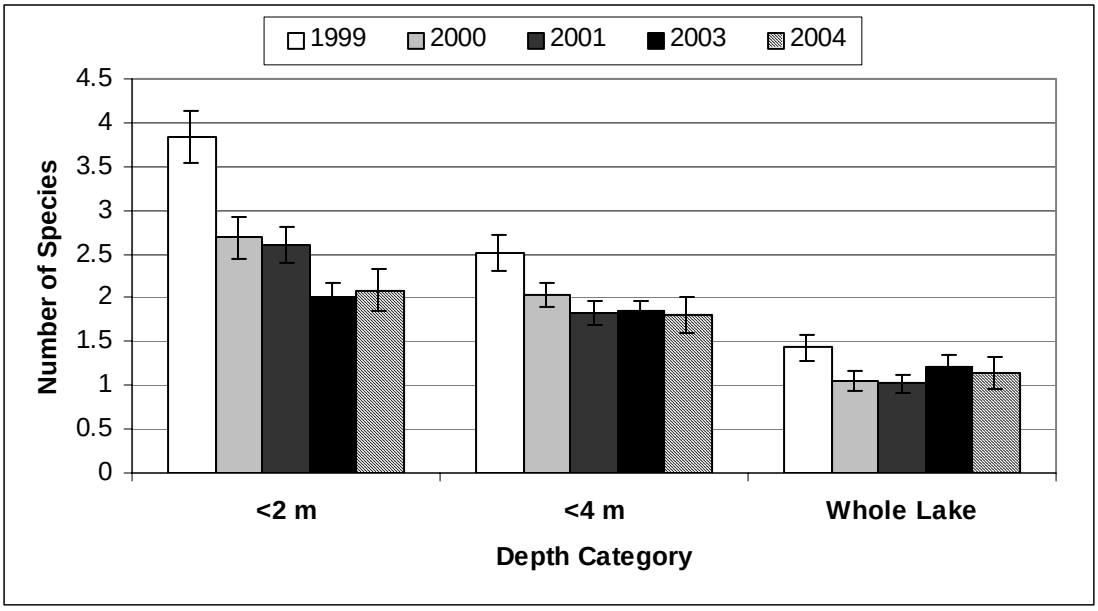


Figure 6. Burr Pond species richness for native species in open-lake surveys. Error bars are standard error of the mean.

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* (65%), *Nuphar advena* (49%), *Ceratophyllum demersum* (34%), *Nymphaea odorata* (45%) and *Utricularia vulgaris* (26%). The substantial increase in the abundance of Eurasian watermilfoil in the Burr Pond wetland is 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 the 1999 through 2001 survey years, 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.

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

Species	August Surveys				
	2004	2003	2001	2000	1999
Ceratophyllum demersum	33.8%	30.0%	70.0%	71.3%	72.5%
Ceratophyllum echinatum	3.8%				2.5%
Chara sp.	7.5%	5.0%			
Elodea canadensis			10.0%	12.5%	3.8%
Lemna minor	13.8%				
Myriophyllum spicatum	65.0%	77.5%	5.0%	33.8%	8.8%
Najas flexilis				1.3%	
Nuphar advena	48.8%	50.0%	70.0%	73.8%	72.5%
Nymphaea odorata	45.0%	12.5%	51.3%	28.8%	33.8%
Potamogeton diversifolius				3.8%	
Potamogeton epihydrus					2.5%
Potamogeton foliosus	3.8%		1.3%		
Potamogeton gramineus		1.3%			
Potamogeton illinoensis	7.5%	2.5%		2.5%	
Potamogeton nodosus			1.3%		
Potamogeton spirillus			8.8%		
Sparganium americanum	3.8%	2.5%			
Spirodela polyrhiza		1.3%		50.0%	16.3%
Utricularia geminascapa			7.5%		
Utricularia gibba	1.3%	1.3%	10.0%	2.5%	
Utricularia intermedia				7.5%	
Utricularia minor		6.3%	7.5%	11.3%	1.3%
Utricularia vulgaris	26.3%	16.3%	22.5%	11.3%	1.3%
Vallisneria americana	8.8%	7.5%			
Zosterella dubia	7.5%		3.8%		

The number of species recorded for the wetland transect in Burr Pond has been relatively constant, ranging from 10 in 1999 to 14 in 2004. Species present however, have been variable from year to year, with a total of 24 species recorded between the 5 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). One species was reported in the 2004 wetland survey for the first time, *Lemna minor*, a native species common to the region. 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%.

Total species richness in the Burr Pond wetland ranged from a high of 3.3 species per survey

point in 2000 to a low of 2.1 species per survey point in 2003. In 2004, total species richness was 2.7 species per survey point. 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. Declines in native species richness following expansive growth of *Myriophyllum spicatum* have been well documented (Madsen et al. 1988, 1991).

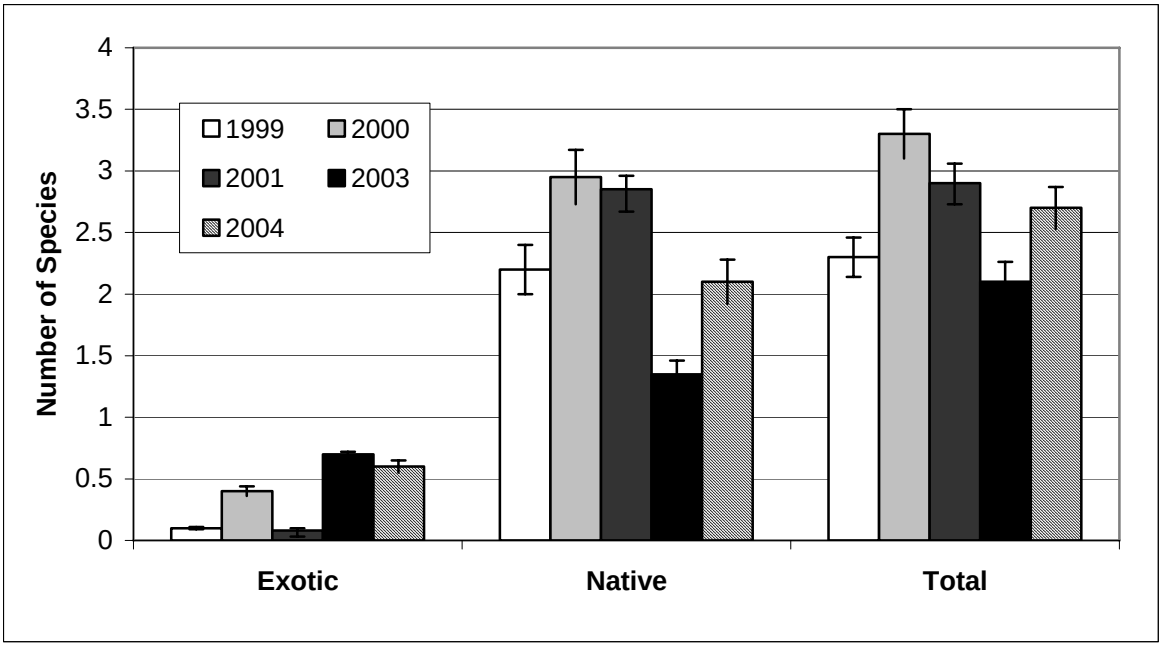


Figure 7. Burr Pond wetland transect species richness. Error bars are standard error of the mean.

Lake Hortonia Open-Lake Survey Results

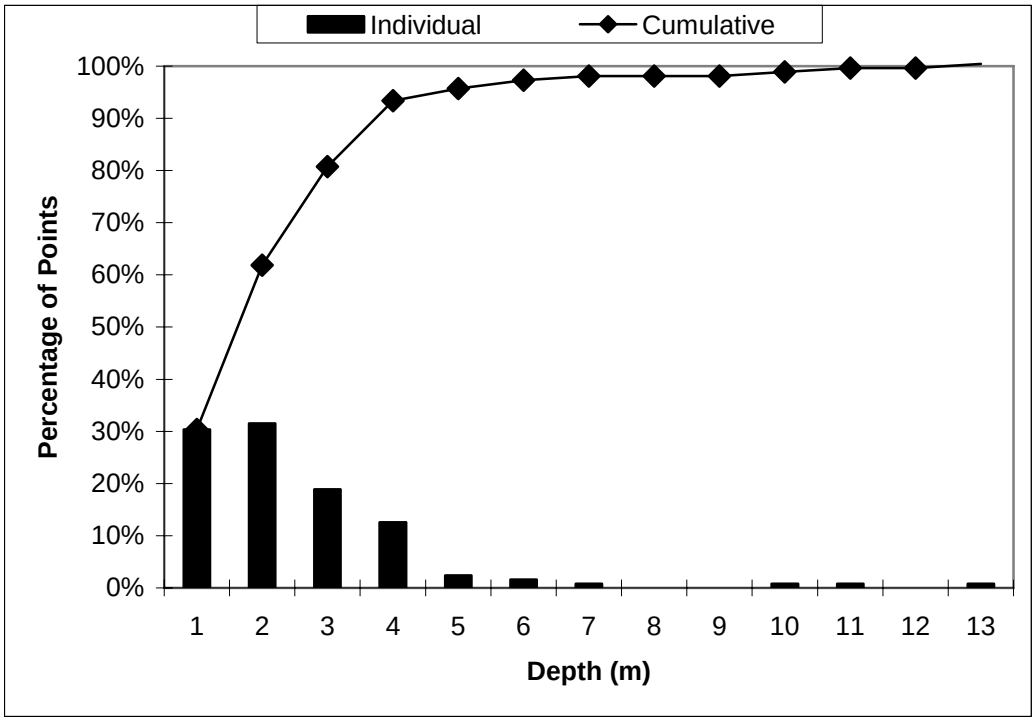
In August of 2004, the aquatic plant community of Lake Hortonia included twenty-five submersed species, three floating-leaved species, two floating species and nine emergent species (Table 1). One submersed exotic species was observed in Lake Hortonia, *Myriophyllum spicatum*. A second exotic species, *Potamogeton crispus*, observed in previous surveys was absent in 2004. 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 second the most widely distributed aquatic plant, reported for 35% of survey points for Lake Hortonia, and only exceeded in distribution by *Chara* sp., found in 54% 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.

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



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 2003 and 2004 surveys, while prior surveys included survey points to a depth of 18 m. In selecting the subset of survey points to include in the 2003 and 2004 surveys, the majority of survey points employed in previous surveys with water depth greater than the littoral zone depth of 4 m were excluded.

Species Lists

Maps of the distribution of aquatic plant species and groups of species (i.e. Broad-leaf Pondweeds) for Lake Hortonia are included in Appendix B, Figures B1 – B9. Chara sp. was the most abundant aquatic plant species occurring in Lake Hortonia in 2004, reported in 54% of samples collected. *Myriophyllum spicatum* frequency of occurrence had declined to 35% of samples collected from 52% reported in 2003. For Lake Hortonia, other common native species included *Potamogeton robbinsii* (21%), *Vallisneria americana* (20%), *Utricularia gibba* (18%), *Potamogeton illinoensis* (10%), *Elodea canadensis* (8%), *Zosterella dubia* (6%), and *Nymphaea*

odorata (3%).

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				
	Aug-04	Aug-03	Aug-01	Aug-00	Aug-99
Brasenia schreberi		1.6			
Ceratophyllum demersum	3.2		0.3	3.3	8.7
Chara sp.	54.0	34.1	33.4	25.8	17.0
Elodea canadensis	7.9	5.6	1.7	1.0	15.0
Fontinalis flos-aquae	1.6				
Megalodonta (Bidens) beckii	0.8	0.8	0.3		0.7
Myriophyllum sibiricum	0.8	0.8	1.0		3.3
Myriophyllum spicatum	34.9	51.6	6.0	44.8	55.0
Najas flexilis	1.6	16.7	4.7		2.3
Nuphar advena	2.4	0.8	2.3	1.3	2.0
Nymphaea odorata	3.2	5.6	13.0	10.4	10.0
Potamogeton amplifolius			1.0	3.0	3.0
Potamogeton crispus		0.8	4.3	0.3	
Potamogeton gramineus	0.8		1.0	5.0	10.0
Potamogeton illinoensis	9.5	22.2	12.4	15.1	38.8
Potamogeton natans	0.8	<0.1		0.3	2.0
Potamogeton oakesianus					1.0
Potamogeton praelongus	0.8	0.8	0.3	0.3	3.7
Potamogeton pusillus		0.8			
Potamogeton robbinsii	21.4	15.1	11.4	11.0	11.7
Potamogeton zosteriformis		1.6	7.0	2.3	3.0
Ranunculus longirostris			1.0		
Sphagnum sp.		0.8			
Sparganium sp.		3.2	0.3		
Stuckenia (Potamogeton) pectinata		3.2	6.7	0.7	5.7
Utricularia gibba	17.5	4.8	4.3	12.7	11.4
Utricularia minor	2.4	2.4			
Utricularia vulgaris	1.6	0.8	4.7	3.3	2.3
Vallisneria americana	19.8	20.6	11.4	10.4	23.7
Zosterella (Heteranthera) dubia	5.6	7.9	9.4	4.0	6.4

A total of 20 species were recorded in open-lake surveys of Lake Hortonia in 2004. These results are comparable to the 2003 survey results (23 species) and previous surveys (Getsinger

2002) in 2001 (23 species), 2000 (19 species) and 1999 (21 species). In 2004, one new native species was encountered, *Fontinalis flos-aquae*, a species common to the region. Species absent from the 2004 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 *Potamogeton zosteriformis*. 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. 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. Three species, *Utricularia gibba, Elodea canadensis, Potamogeton illinoensis,* were frequently reported in 2003 (4.8%, 5.6% and 22.2% of survey points, respectively), but had not returned to pretreatment frequency of occurrence. Two of these species (*Utricularia gibba* and *Elodea canadensis)* increased in frequency of occurrence in 2004, the year of treatment. One species was relatively uncommon during all surveys, but present in moderate numbers in 2003 (*Potamogeton zosteriformis),* declined in abundance in 2004. Three species were absent from 2003 surveys, *Potamogeton amplifolius, Potamogeton gramineus* and *Ceratophyllum demersum. Potamogeton amplifolius* and *Potamogeton gramineus* were relatively rare in 2004, however *Ceratophyllum demersum* increased in frequency of occurrence. Two species (*Chara sp.* and *Potamogeton robbinsii*) were found to occur more frequently in 2003 and 2004 than in the pretreatment survey of 1999.

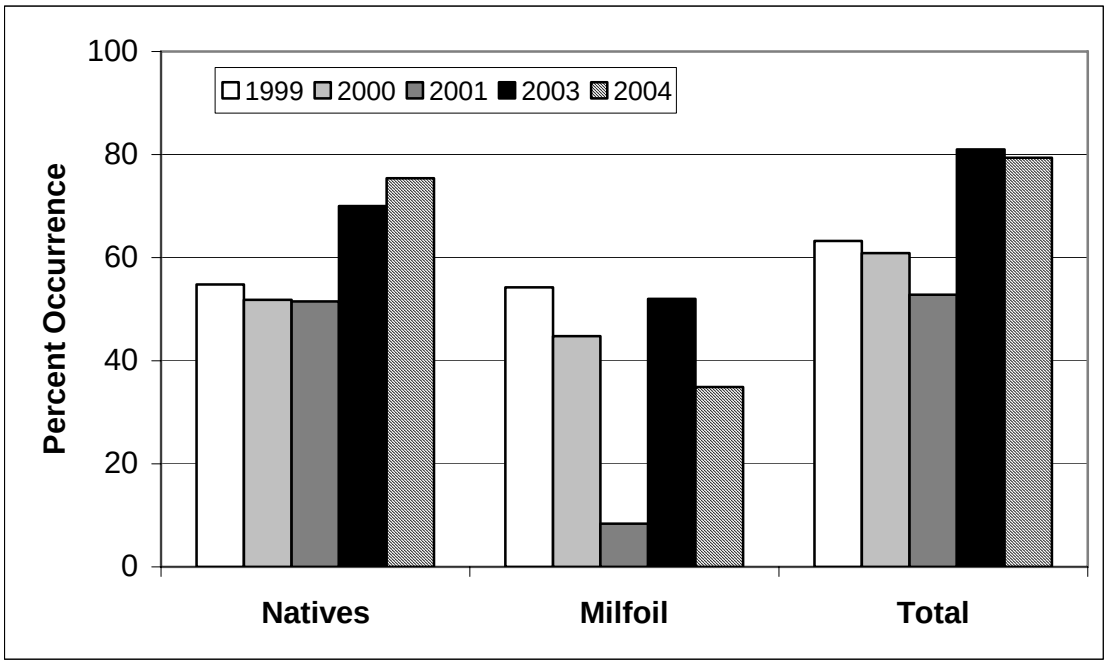


Figure 9. Lake Hortonia frequency of occurrence summaries for sampling points of all water depths.

In 2004, seventy-five percent of whole lake sampling points were vegetated by at least one native plant species (Figure 9), 84% of survey points with depths less than 4 meters (Figure 10) and 96% of survey points less than 2 meters depth yielded native aquatic plants. Eurasian watermilfoil was present in 35% of whole lake survey points, 39% of survey points less than 4 meters water depth and 53% of survey points less than 2 meters water depth.

Native species frequency has remained relatively stable over the 5 surveys at from 52 to 75% of survey points for all water depths, even with exclusion of many of the survey points outside the littoral zone during the 2003 and 2004 surveys. Eurasian watermilfoil frequency of occurrence 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%). Total plant frequency of occurrence reflects the decline in Eurasian watermilfoil growth between 2003 and 2004, with further reduction expected in the year following treatment.

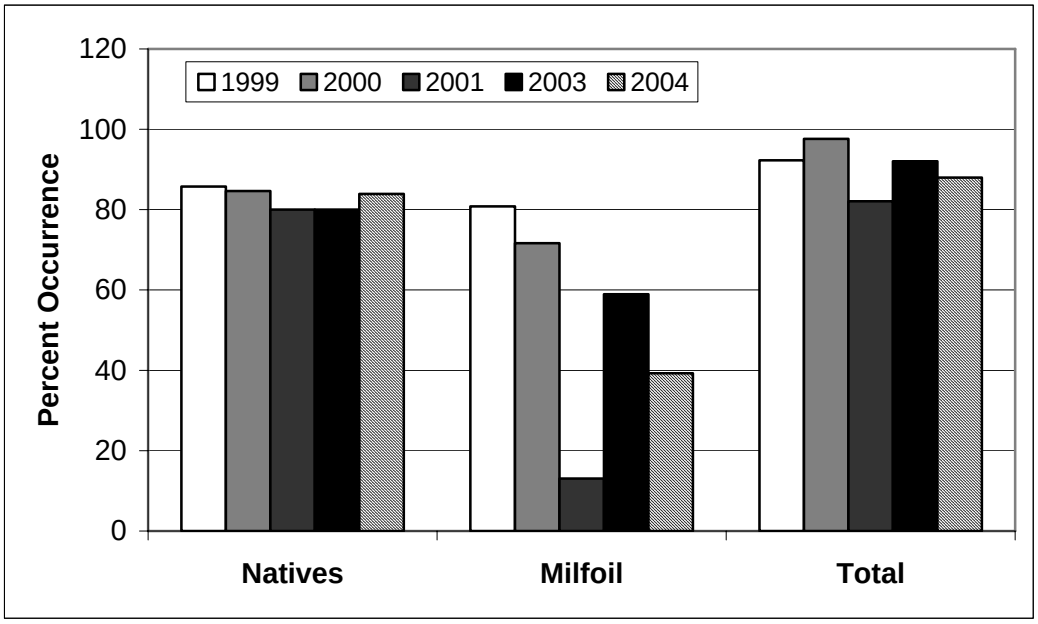


Figure 10. Lake Hortonia frequency of occurrence summaries for sampling points within the littoral zone (<4 m water depth).

The increase in percent occurrence of all species groups in 2003 and 2004 (Figure 9) may be an artifact of the change in number of survey points. The 2003 and 2004 surveys excluded many of the survey points from prior surveys located outside the littoral zone in water depths greater than 4 meters. Reviewing surveys 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 86% 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. For the littoral zone, 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.

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 1.8 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 approximately 2 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). Species richness for all species in the whole of Lake Hortonia averaged 2.4 species per sample in 1999

Table 6. Species richness comparison between the current survey and prior surveys for Lake Hortonia.

Plant Grouping	Water Depth Class	Summary Statistic	August Surveys				
			1999	2000	2001	2003	2004
Native plant species	Whole Lake (all depths)	Mean	1.83	1.12	1.28	1.50	1.56
		N	299	299	299	126	126
		Std. Error	0.13	0.11	0.1	0.12	0.13
	Points with depths <4m	Mean	2.95	2.03	2.01	1.72	1.75
		N	182	169	190	108	112
		Std. Error	0.17	0.14	0.13	0.13	0.13
	Points with depths <2m	Mean	3.82	3.19	3.05	2.08	2.31
		N	93	73	94	43	55
		Std. Error	0.86	0.24	0.21	0.18	0.18
All plant species	Whole Lake (all depths)	Mean	2.38	1.67	1.41	2.01	1.91
		N	299	299	299	126	126
		Std. Error	0.15	0.11	0.11	0.13	0.15
	Points with depths <4m	Mean	3.76	2.75	2.21	2.30	2.14
		N	182	169	190	108	112
		Std. Error	0.18	0.15	0.15	0.13	0.15
	Points with depths <2m	Mean	4.68	3.99	3.41	2.78	2.84
		N	93	73	94	43	55
		Std. Error	0.28	0.24	0.22	0.17	0.20

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.

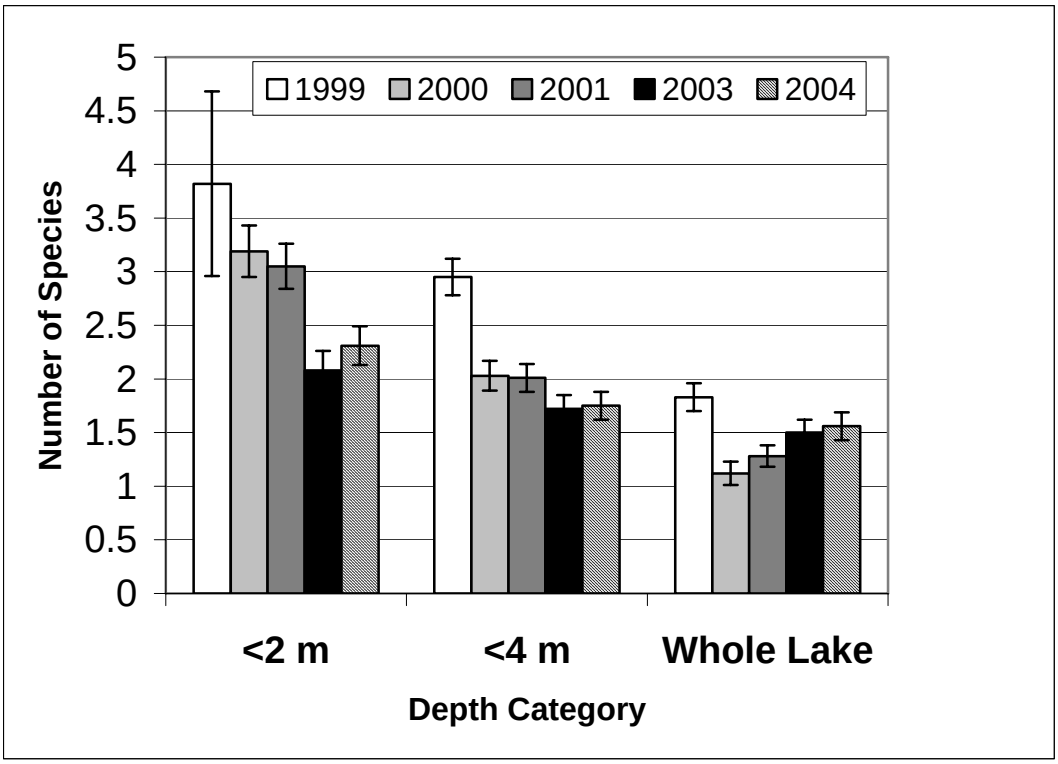


Figure 11. Lake Hortonia species richness for native species. Error bars are standard error of the mean.

Wetlands Transects. Wetland communities differed from whole-lake littoral plant communities, although many individual species were represented in both (Tables 1 & 3). In the Lake Hortonia wetland, the most common species were *Nymphaea odorata* (78%), followed by *Utricularia vulgaris* (45%), *Myriophyllum sibiricum* (30%), *Ceratophyllum demersum* (20%), *Sphagnum* (15%), *Utricularia minor* (14%), *Utricularia gibba* (13%), *Myriophyllum spicatum* (9%), *Lemna minor* (9%), *Potamogeton zosteriformis* (7%), and *Nuphar advena* (5%). As with the Burr Pond wetland, a major expansion of Eurasian watermilfoil in the Lake Hortonia wetland was reported in 2003. Eurasian watermilfoil abundance declined substantially in the Lake Hortonia wetland in 2004.

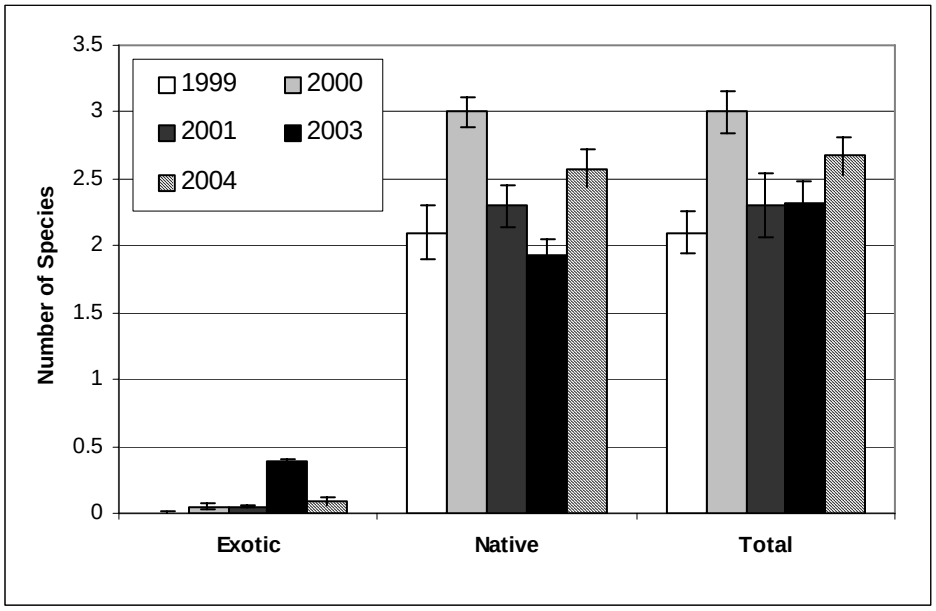
The number of species recorded for the wetland transect in Lake Hortonia has ranged from 18 in 1999 to 11 species in 2000, 10 species in 2001, and 21 species in 2003 and 2004. Species present have been variable from year to year, with a total of 36 species recorded between the 5 surveys. Differences have generally been in the less common species, less than 2% frequency of occurrence, or in species represented in only a single survey year (15 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. Eurasian watermilfoil abundance in the wetland transect increased substantially in 2003, more than double the greatest frequency previously reported in 2000. This dramatic

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

Species	August Surveys				
	2004	2003	2001	2000	1999
Bidens cernua			2.0%		
Carex sp.				1.0%	
Ceratophyllum demersum	20.0%	17.5%			1.0%
Chara sp.	5.0%		0.5%		0.5%
Cyperus sp.					0.5%
Eleocharis spp.	2.0%	6.5%			7.0%
Elodea canadensis		1.5%			
Epilobium glandulosum					1.0%
Hypericum sp.					1.0%
Juncus pelocarpus				2.5%	
Lemna minor	9.0%	1.0%			1.5%
Ludwigia palustris					1.0%
Lythrum salicaria				1.5%	1.5%
Myriophyllum sibiricum	30.0%	26.5%	7.0%	1.5%	
Myriophyllum spicatum	9.0%	38.5%	0.5%	0.5%	
Najas flexilis	1.0%				
Nuphar advena	5.0%	9.5%	53.5%	49.0%	7.5%
Nymphaea odorata	78.0%	80.0%	98.0%	99.0%	95.0%
Polygonum sp.	1.0%				
Pontederia cordata	4.0%				
Potamogeton epihydrus	3.0%	3.0%			
Potamogeton gramineus		1.0%			1.0%
Potamogeton illinoensis	2.0%	8.0%			
Potamogeton natans	1.0%	3.0%			
Potamogeton robbinsii		7.0%	3.0%		0.5%
Potamogeton zosteriformis	7.0%				
Scirpus sp.		6.5%			
Sparganium sp.		1.0%			
Sphagnum sp.	15.0%				1.0%
Spirodela polyrhiza					2.0%
Utricularia gibba	13.0%	2.5%	51.0%	37.0%	11.0%
Utricularia intermedia		1.0%		13.5%	
Utricularia minor	14.0%	1.0%	1.5%	27.5%	50.5%
Utricularia vulgaris	45.0%	13.5%	41.5%	68.0%	28.0%
Vallisneria americana	1.0%	7.0%			
Zosterella dubia	2.0%	1.5%			

increase in the abundance of Eurasian watermilfoil 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, Eurasian watermilfoil frequency of occurrence declined from 2003 while native and total species richness increased.

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



Summary

Quantitative aquatic plant surveys were undertaken for Burr Pond and Lake Hortonia, Vermont, in August 2003 to obtain pretreatment data and in August 2004 for post-treatment data collection relative to whole-lake treatments with the aquatic-labeled herbicide fluridone (SONAR^{TM}). Aquatic plant surveys were designed to be comparable to data collected by the US Army Corps of Engineers in 1999 through 2001. US Army Corps of Engineers surveys were conducted to prepare for and evaluate a treatment program based on application of the herbicide fluridone (SONAR^{TM}) in 2000 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 August of 2004, the year of treatment, the aquatic plant community of Burr Pond included thirteen submersed species, two floating-leaved species, one floating species and seven emergent species. *Myriophyllum spicatum* continued to be the only exotic species reported for Burr Pond. Species richness remained quite high, with a large number of species occurring in more than 5% of survey points. Fifty-seven percent of whole lake sampling points were vegetated by at least one native plant species, 87% of survey points with depths less than 4 m and 95% of survey

points less than 2 m depth yielded native aquatic plants. Native species richness in the littoral zone was 1.81 species per sample, nearly identical to the 1.84 species per sample reported in 2003. Eurasian watermilfoil declined to the second most widely distributed plant (29% 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., *Vallisneria americana, Utricularia gibba*, *Nymphaea odorata*, *Potamogeton gramineus*, *Zosterella dubia*, *Potamogeton robbinsii* and *Potamogeton illinoensis*. Eurasian watermilfoil was present in 29% of whole lake survey points, and 48% of survey points in the littoral zone.

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*, *Nuphar advena*, *Nymphaea odorata, Ceratophyllum demersum*, and *Utricularia vulgaris*. 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.

In August of 2004, the aquatic plant community of Lake Hortonia included twenty-five submersed species, three floating-leaved species, two floating species and nine emergent species (Table 1). One submersed exotic species was observed in Lake Hortonia, *Myriophyllum spicatum*. A second exotic species, *Potamogeton crispus*, observed in pre-treatment surveys in 2003 was absent. Eurasian watermilfoil declined to the second most widely distributed aquatic plant, present in 35% of survey points. For Lake Hortonia, common native species included *Chara* sp., *Potamogeton illinoensis, Vallisneria americana, Najas flexilis, Potamogeton robbinsii*, *Zosterella dubia*, *Nymphaea odorata*, *Elodea canadensis*, and *Utricularia gibba*. A total of 20 species were recorded in open-lake surveys of Lake Hortonia in 2004, comparable to previous surveys in 2001 (23 species), 2000 (19 species) 1999 (21 species), and 2003 (23 species). Seventy-five percent of whole lake sampling points were vegetated by at least one native plant species, 84% of survey points with depths less than 4 meters and 96% of survey points less than 2 meters depth yielded native aquatic plants. In 2004 surveys, Eurasian watermilfoil was present in 35% of whole lake survey points, 39% of survey points less than 4 meters water depth and 53% 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 survey in 2004 reported 1.91 species per sample.

The number of species recorded for the wetland transect in Lake Hortonia has ranged from 18 in 1999 to 11 species in 2000, 10 species in 2001 and 21 species in 2003 and 2004. 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*, *Myriophyllum sibiricum, Ceratophyllum demersum, Sphagnum, Utricularia minor, Utricularia gibba*, *Myriophyllum spicatum, Lemna minor, Potamogeton zosteriformis*, and *Nuphar advena*. Eurasian watermilfoil percent frequency for the Lake Hortonia wetland transect increased substantially in 2003 (39%), compared to less than 1% in prior surveys. Pos-treatment (2004) Eurasian watermilfoil percent frequency for the Lake Hortonia wetland transect

decreased to 9% frequency of occurrence. 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 has remained virtually unchanged (2.3 species per sample). Total species richness in 2004 was 2.7 species per sample and native species richness was comparable at 2.6 species per sample.

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. Based on previous herbicide applications in 2000, Eurasian watermilfoil frequency of occurrence can be expected to decline further in 2005. While some native species experienced declines following herbicide treatment, 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.

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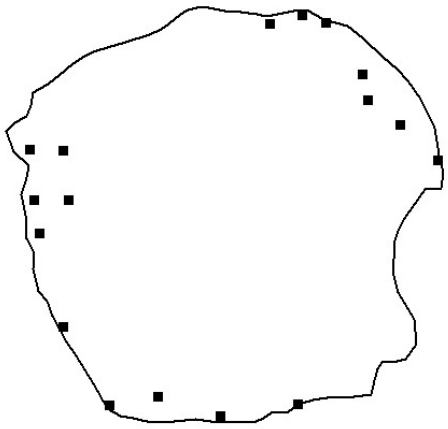
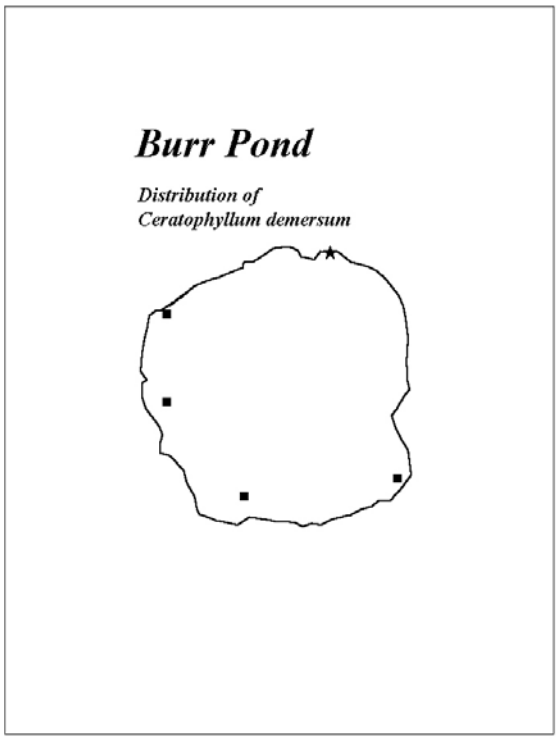
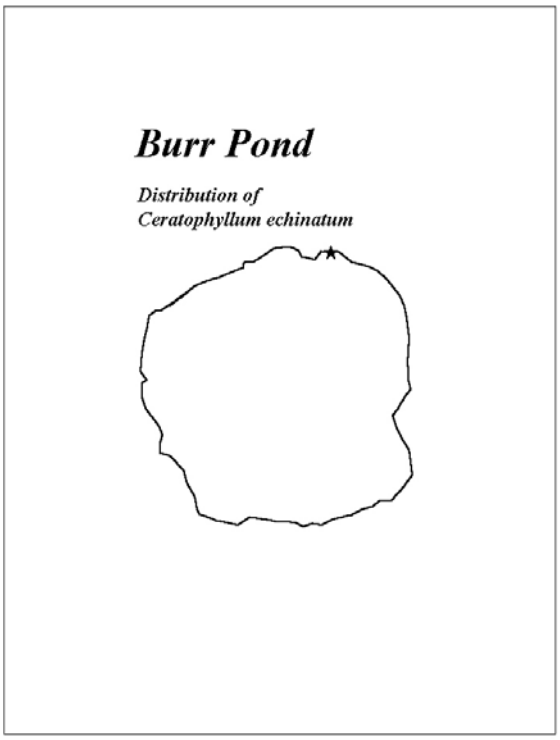
Appendix A

Burr Pond Aquatic Plant Distribution Maps

Eurasian watermilfoil
Burr Pond 2004
Year Of Treatment

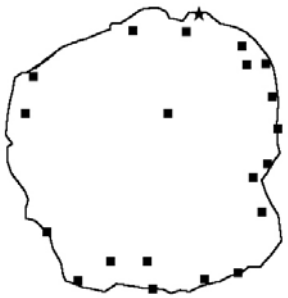



Burr Pond
Distribution of
Ceratophyllum demersum


Burr Pond
Distribution of
Ceratophyllum echinatum

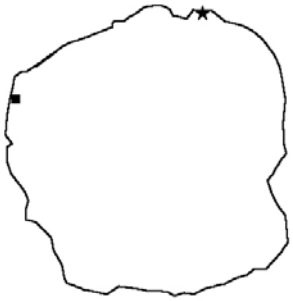
Burr Pond

Distribution of
Chara sp.



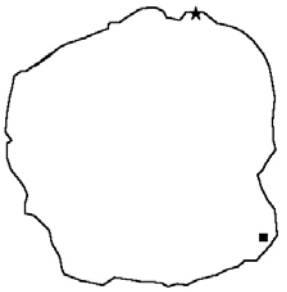
Burr Pond

Distribution of
Eleocharis acicularis



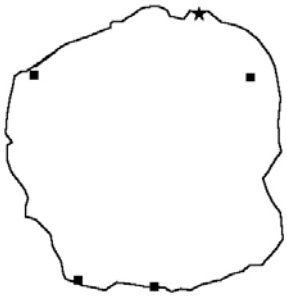
Burr Pond

Distribution of
Nymphaea odorata



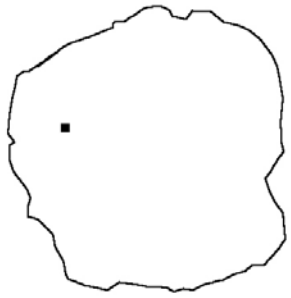
Burr Pond

Distribution of Broad-leaf Pondweeds
(Potamogeton amplifolius, P. gramineus
& P. illinoensis)



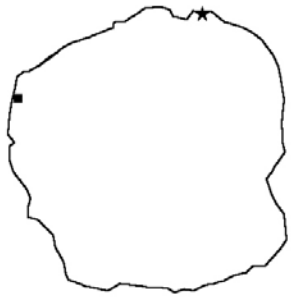
Burr Pond

Distribution of Potamogeton robbinsii



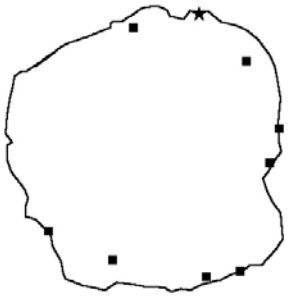
Burr Pond

Distribution of
Scirpus sp.



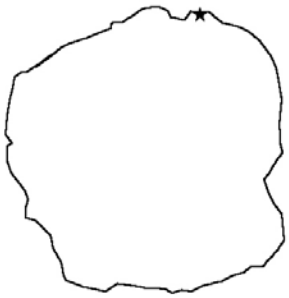
Burr Pond

Distribution of
Utricularia gibba



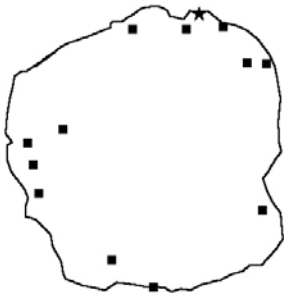
Burr Pond

Distribution of
Utricularia vulgaris



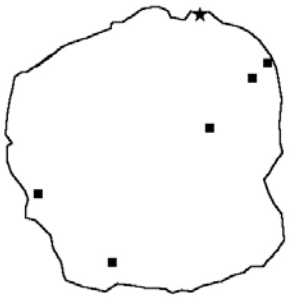
Burr Pond

Distribution of
Vallisneria americana



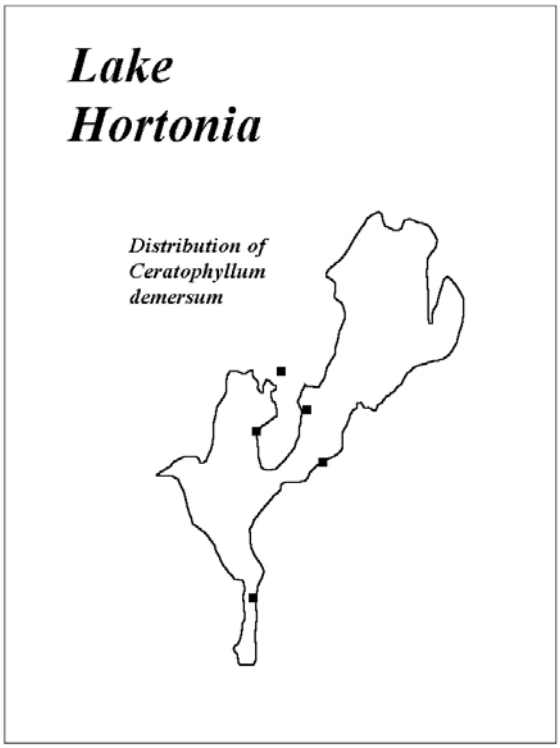
Burr Pond

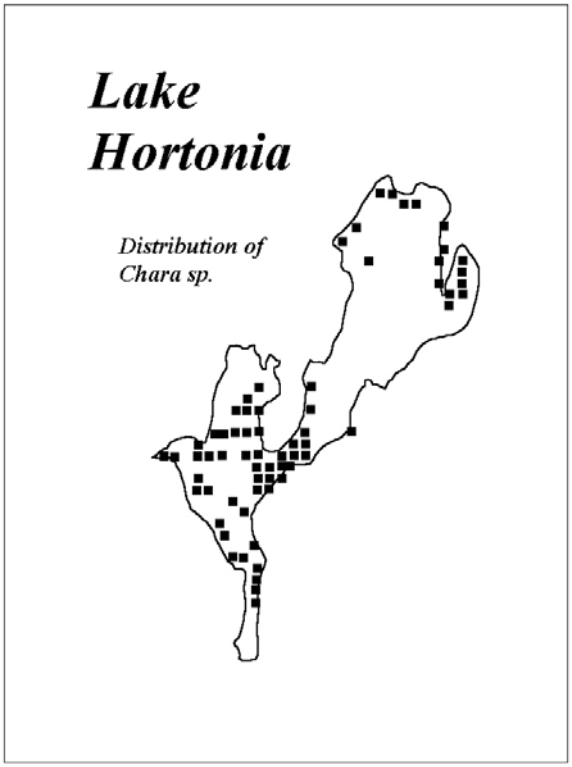
Distribution of
Zosterella dubia

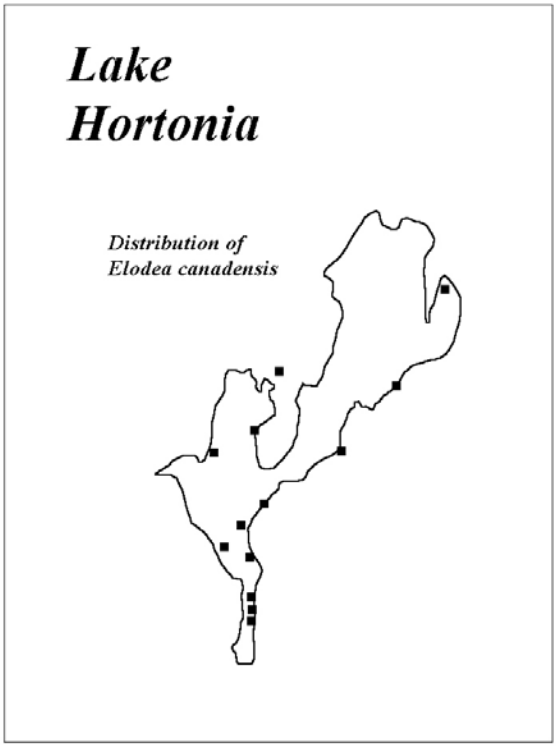


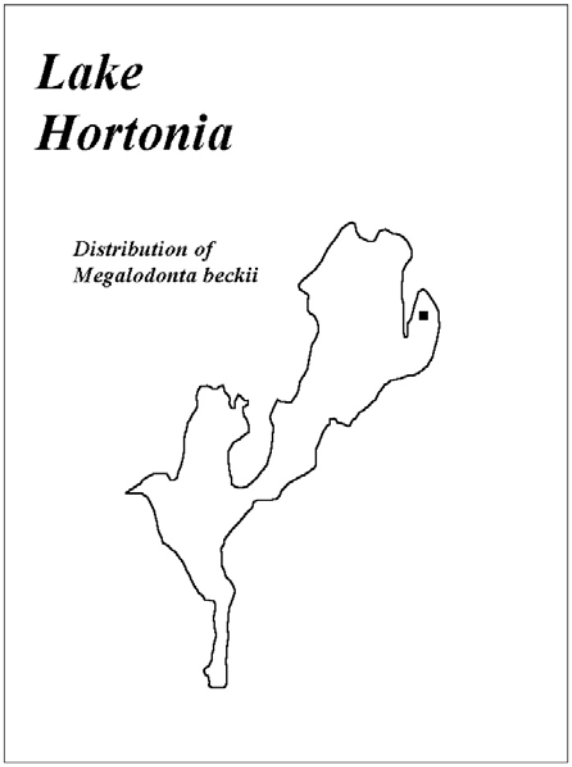
Appendix B

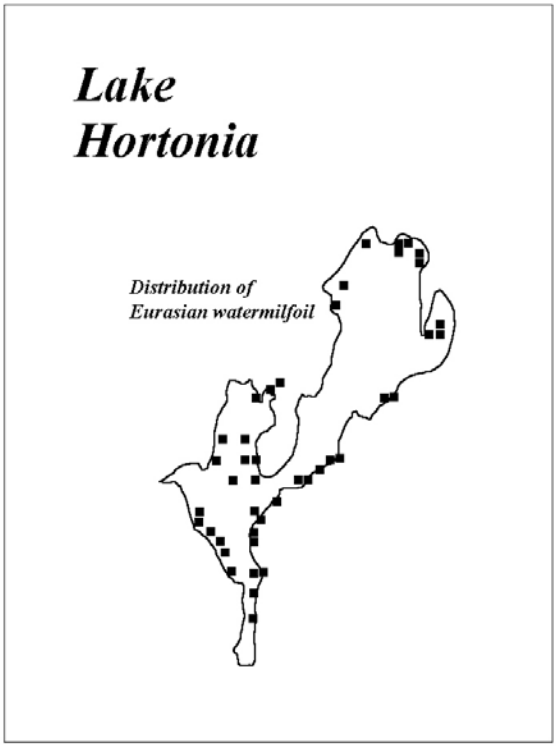
Lake Hortonia Aquatic Plant Distribution Maps




Lake
Hortonia
Distribution of
Chara sp.


Lake
Hortonia
Distribution of
Elodea canadensis


Lake
Hortonia
Distribution of
Megalodonta beckii


Lake
Hortonia
Distribution of
Eurasian watermilfoil

Lake Hortonia

Distribution of Najas flexilis

Lake Hortonia

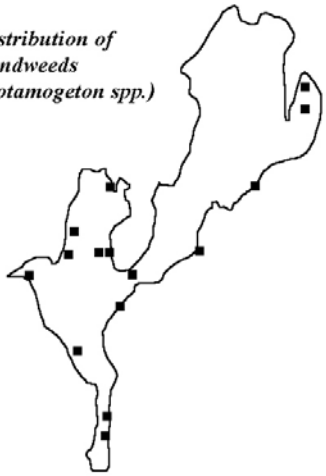
Distribution of Pad Forming Species (Nuphar & Nymphaea)

Lake Hortonia

Distribution of Potamogenton robbinsii

Lake Hortonia

Distribution of Pondweeds (Potamogeton spp.)

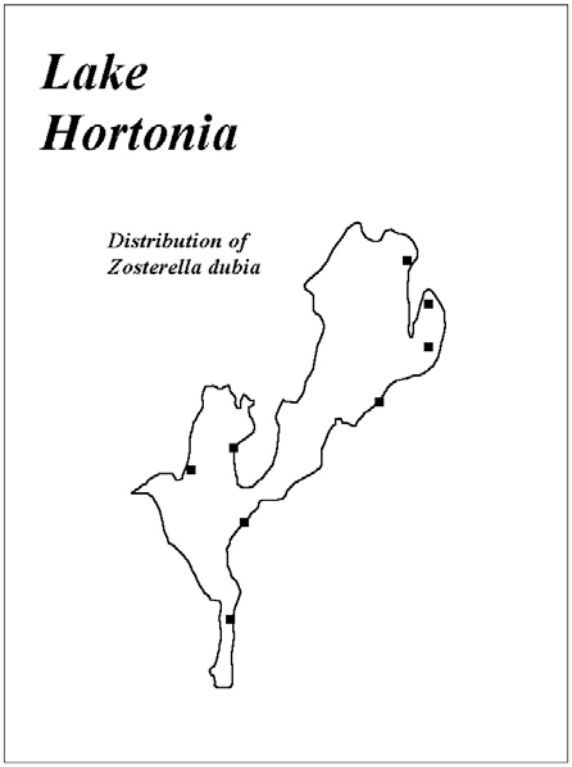


Lake Hortonia

Distribution of Utricularia spp.

Lake Hortonia

Distribution of Vallisneria americana


Lake
Hortonia
Distribution of
Zosterella dubia