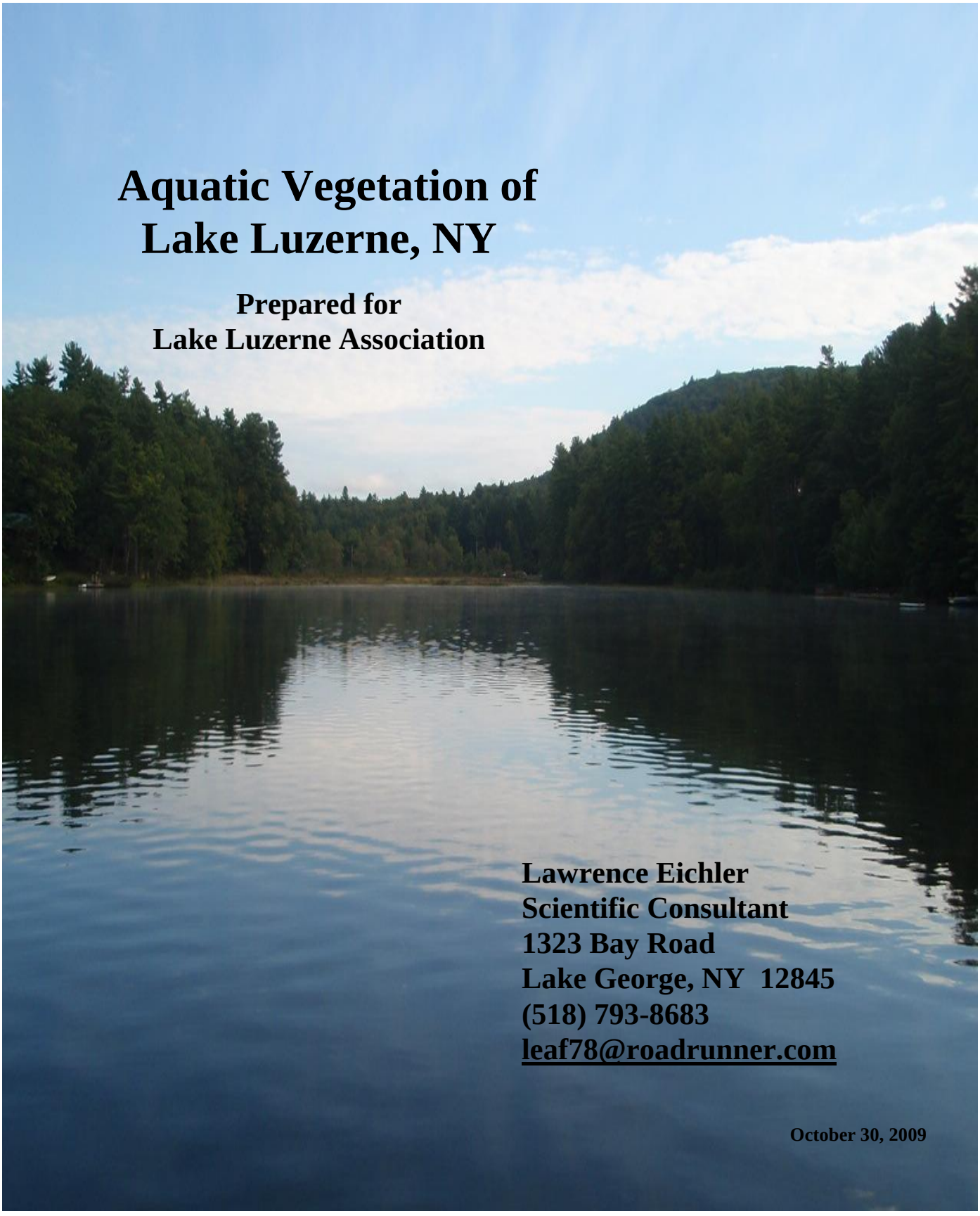

Aquatic Vegetation of Lake Luzerne, NY

Prepared for
Lake Luzerne Association

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October 30, 2009

TABLE OF CONTENTS

Acknowledgements

The author would like to thank Bill Campbell and Bob Sherman of the Lake Luzerne Association for their assistance in coordinating lake access and development of the current survey project.

Background

A quantitative aquatic plant survey was undertaken for Lake Luzerne, New York, to obtain post-treatment data for a sequestered treatment with the aquatic-labeled herbicide triclopyr (Renovate^{TM}). The plant survey was designed to provide data comparable to earlier surveys by the author (Eichler et al. 1989, 1992, 1998, 2004 and 2009). The current program expands on the 2009 effort to include aquatic plant distribution data for the entire lake, not just the southwest cove area which was the subject of the Spring 2010 Renovate treatment and survey efforts from 2009.

The point intercept survey methods employed were designed to meet with NYS DEC Tier III Survey requirements. The survey consisted of: a) frequency of occurrence of all aquatic plant species for points distributed within Lake Luzerne, an expansion of the 2009 effort which only included the southeastern third of the lake, and b) comparison of historical survey results to current conditions, with particular reference to changes in the relative abundance of Eurasian watermilfoil and native species in the area treated with herbicide.

Introduction

Eurasian watermilfoil, *Myriophyllum spicatum* L., an invasive exotic plant species, was first reported in Lake Luzerne, Warren County, New York in 1989. A survey at that time indicated extensive growth of this nuisance species. In 1992, a management program keyed to hand harvesting Eurasian watermilfoil was conducted under the auspices of Warren County and the Town of Luzerne. Post-treatment plant surveys reported that this management program reduced scattered growth of Eurasian watermilfoil, however no attempt was made to address a number of areas of dense growth. Dense growth of Eurasian watermilfoil (beds) covered approximately 1.4 acres (1%) of the lake bottom in 1998 (Eichler and Howe 1998). By 2004, dense growth of Eurasian watermilfoil had expanded to 3.9 acres (4%), with scattered growth reported throughout the remainder of the lake. Hand harvesting and benthic barrier have been employed over the last decade to manage the expansion of Eurasian watermilfoil, however expansive growth in the southeast bay spawned a desire to evaluate additional treatment alternatives.

Surveys of aquatic plants in Lake Luzerne were conducted in 1989 (Eichler and Madsen, 1990), 1992 (Enviromed Assoc., 1992), 1998 (Eichler and Howe, 1998), 2004 (Eichler and Boylen, 2004) and 2009 (Eichler, 2009). The species lists for the five surveys are similar. Twenty-seven aquatic plant species were reported in 1989 and 1992, 39 species in 2004 and 33 species in both 1998 and 2008. Between the five surveys, a total of 41 species of aquatic plants are reported for Lake Luzerne (Table 1). Differences among the surveys are generally in the less common and emergent species. Emergent species may have been intentionally excluded from past surveys due to their presence at the water's edge rather than submersed. For instance, *Typha latifolia* or cattail is a common emergent species, generally associated with marshlands peripheral to the lake. Cattails were not reported prior to 1998. An additional invasive species, Curly-leaf Pondweed (*Potamogeton crispus* L.) was also first reported in 2004.

Common members of the aquatic plant community of Lake Luzerne include macroscopic alga, or charophytes (*Chara/Nitella*), floating-leafed species (*Brasenia, Nuphar* and *Nymphaea*), emergent species (*Sparganium, Sagittaria* and *Pontederia*) and 31 submersed species. Of these species, the dominant plants were *Myriophyllum spicatum, Myriophyllum sibiricum, Sagittaria graminea, Eleocharis acicularis, Potamogeton robbinsii, Najas flexilis, Isoetes echinospora*, and *Vallisneria americana*. This high species richness suggests a healthy aquatic plant population at the present time. The large number of species observed indicates excellent diversity, typical of low-elevation Northeastern lakes (Madsen et al. 1989). For instance, Lake George has 47 submersed species (RFWI et al., 1988) and 32 were observed in Chazy Lake in 2008 (Eichler and Boylen, 2008). In both of these lakes, high diversity is threatened by further growth and expansion of an exotic plant species, Eurasian watermilfoil, which will have negative implications for the health of the lakes as a whole (Madsen et al., 1989, 1990; Eichler and Boylen, 2008).

The composition of the species list for Lake Luzerne is similar to that of other nearby lakes. For instance, all of the species observed in Lake Luzerne have been noted for other regional lakes (Ogden et al, 1973; Madsen et al., 1989, Eichler and Boylen, 2008). Fifteen species are typical for a lake of this type (low elevation, mesotrophic) in New York State (Madsen et al., 1993; Taggett et al. 1990).

One of the plant species known for Lake Luzerne (*Myriophyllum alterniflorum*) is on the New York State Rare Plant list (Young, 2008). This species is generally found on sandy, wave washed shorelines common to Adirondack lakes. While not observed in the southeastern embayment in 2009, this species is historically reported for Lake Luzerne. Three other species reported for Lake Luzerne are on the NYS Watch List (*Isoetes lacustris, Megalodonta beckii* and *Utricularia minor*), however only two, *Megalodonta beckii* and *Utricularia minor*, were reported to occur in the southeastern bay in 2009. Their presence on the watch list may be a result of lack of survey data rather than actual scarcity.

Methods

Survey Site. Lake Luzerne is located at the southern edge of Warren County in the Town of Luzerne. The lake's watershed is located in the foothills of the Adirondack Mountains. Elevations within the watershed range from 623 feet above sea level at the surface of the lake to 1000 feet at the highest elevations.

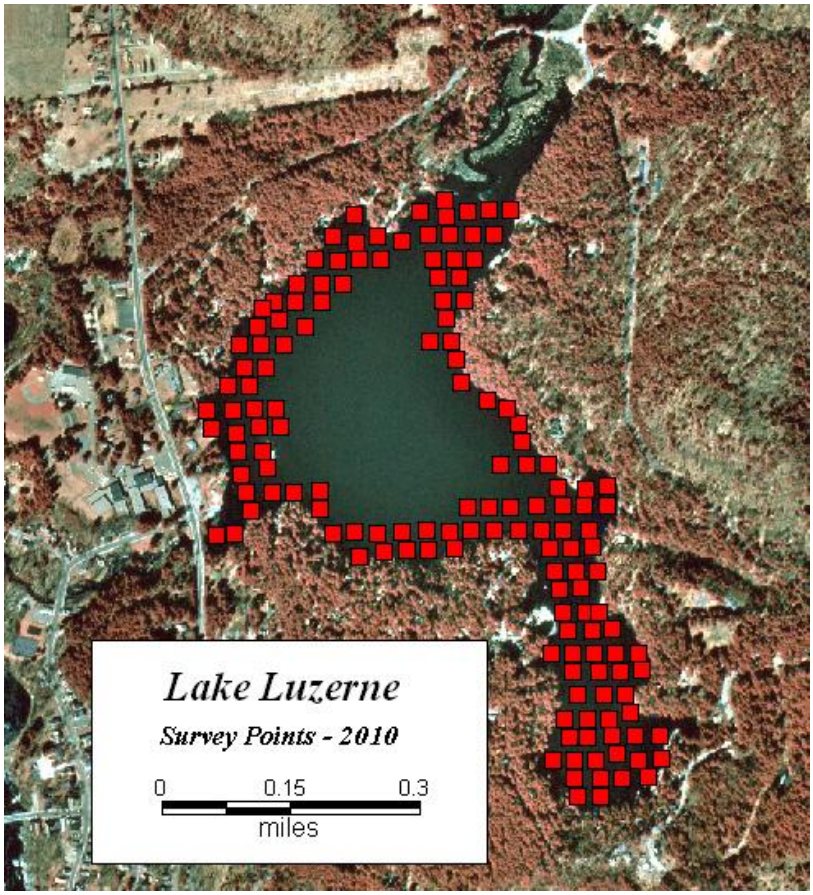
The lake has a surface area of 111 acres and a steeply sloping watershed of 14,109 acres. It is the final link in a chain of lakes including Fourth, Third, and Second Lakes. The lake has a maximum depth of 15.8 meters (52 feet) and a mean depth of 7.3 meters (24 feet). Typical of lakes in the temperate region, it is dimictic, exhibiting both summer and winter thermal stratification. Located on the western margin is the only outlet, which is dammed and used to maintain the level of the lake. The lake is best classified as mesotrophic, which indicates that nutrients necessary for the growth of algae and subsequently the myriad of organisms that feed on these plants, are moderate.

The surficial geology is primarily glacial till, a sand and gravel soil without exposed bedrock. The soil associations are Oakville, Hinckley and Hinckley-Plainfield deposits consisting of loam, fine sands and cobblestones. Drainage in these deposits is rapid and their ability to furnish lime, nitrogen and phosphorus to terrestrial plants is poor. Lake Luzerne is a residential/recreational lake with boating, fishing and swimming as the primary uses. Public access is available via a launch ramp and public beach (Nicks Beach) maintained by the Town of Luzerne.

Species List and Herbarium Specimens. As the lake was surveyed, the occurrence of each aquatic plant species observed in the lake was recorded and adequate herbarium specimens were collected. The authoritative taxonomic reference used was Crow and Hellquist, 2000.

Point Intercept. The frequency and diversity of aquatic plant species were evaluated using a point intercept method (Madsen 1999). At each grid point intersection, water depth and all species present were recorded. 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 152 points (Figure 1) were selected for Lake Luzerne, on a 50 m grid. A differential global positioning system (DGPS) was used to navigate to each point for the survey observation. Point intercept plant frequencies were surveyed on September 16 and September 17, 2010.

Figure 2. Point intercept survey points for Lake Luzerne.



Results and Discussion

Lake Luzerne Open-Lake Survey Results

In September of 2010, the aquatic plant community of Lake Luzerne included twenty-eight submersed species, three floating-leaved species, and five emergent species (Table 1). Two invasive species *Myriophyllum spicatum* and *Potamogeton crispus* were present. Species richness was quite high, with a large number of species occurring in more than 5% of survey points (Table 2). Native species were clearly dominant, however Eurasian watermilfoil (*Myriophyllum spicatum*) was widely distributed. Common native species for Lake Luzerne included *Potamogeton robbinsii, Chara* sp., *Utricularia minor, Utricularia purpurea, Vallisneria americana, Elodea canadensis, Potamogeton vaseyii, Myriophyllum sibiricum, Potamogeton praelongus,* and *Brasenia schreberi*.

Table 1. Species list for Lake Luzerne, September 2010.

Species	Common Name	2010	2009	2004	1998
Brasenia schreberi J.F. Gmel	Water shield	X	X	X	X
Chara/Nitella sp.	muskgrass, chara	X	X	X	
Elatine minima (Nutt.) Fisch. & C.A. Mey.	Little elatine		X	X	
Eleocharis acicularis (L.) Roemer & Schultes	needle spike-rush	X	X	X	X
Elodea canadensis Michx.	elodea	X	X	X	X
*Eriocaulon aquaticum (*Hill) Druce	pipewort	X	X	X	
Fontinalis novae-angliae Sull	moss	X	X	X	
Isoetes echinospora Dur.	Quillwort	X	X	X	X
Isoetes lacustris L.	Quillwort	X		X	X
Megalodonta beckii Torr.	water marigold	X	X	X	X
Myriophyllum alterniflorum L.	little milfoil	X		X	X
Myriophyllum sibiricum L.	Northern milfoil	X	X	X	X
Myriophyllum spicatum L.	Eurasian watermilfoil	X	X	X	X
Myriophyllum tenellum Kom.	Leafless milfoil	X	X	X	X
Najas flexilis (Willd.) Rostk. & Schmidt.	bushy pondweed	X	X	X	X

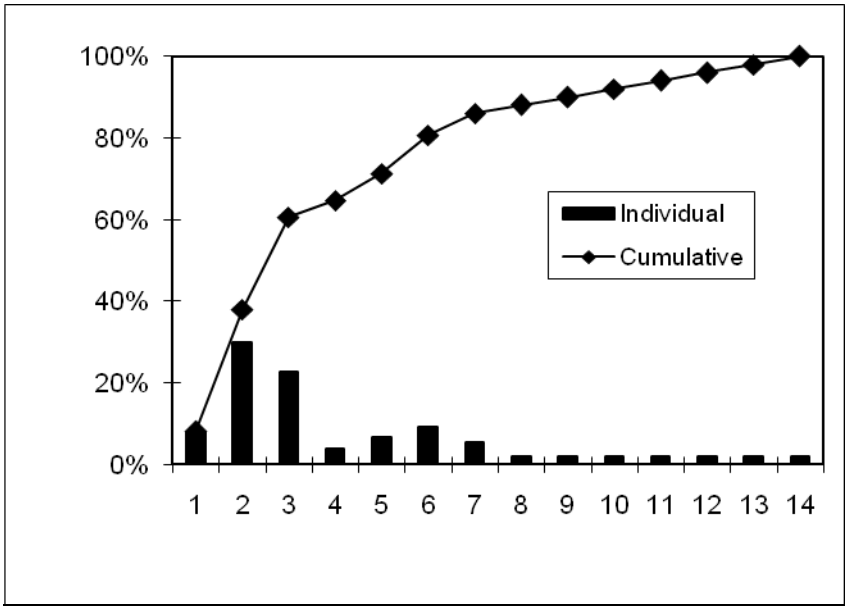
Species	Common Name	2010	2009	2004	1998
Najas guadalupensis (Spreng.) Magnus	southern naiad				X
Nuphar variegata Engelm. Ex Durand	yellow pondlily	X	X	X	X
Nymphaea odorata Ait.	white waterlily	X	X	X	X
Pontederia cordata L.	pickerelweed	X	X	X	X
Potamogeton amplifolius Tuckerm.	broad-leaf pondweed	X	X	X	X
Potamogeton crispus L.	curly-leaf pondweed	X		X	
Potamogeton epihydrus Raf.	ribbon-leaf pondweed	X	X	X	X
Potamogeton gramineus L.	variable-leaf pondweed	X	X	X	X
Potamogeton illinoensis Morong	Illinois pondweed	X	X	X	
Potamogeton perfoliatus L.	clasping pondweed	X		X	
Potamogeton praelongus Wulfen	white-stem pondweed	X	X	X	X
Potamogeton pusillus L.	narrow-leaf pondweed	X	X	X	X
Potamogeton richardsonii (Ar. Benn) Rydb.	Richardsons pondweed		X	X	X
Potamogeton robbinsii Oakes	Robbins pondweed	X	X	X	X
Potamogeton spirillus Tuckerm.	pondweed			X	X
Potamogeton vaseyii Robbins	Vasey's pondweed	X	X	X	X
Potamogeton zosteriformis Fern.	flat-stem pondweed	X		X	X
Sagittaria graminea Michx.	Grassy arrowhead	X	X	X	X
Scirpus sp.	Reed	X			
Sparganium sp.	burreed	X	X	X	X
Typha latifolia L.	Common cattail	X	X	X	X
Utricularia intermedia Hayne	bladderwort		X	X	X
Utricularia minor L.	bladderwort	X	X	X	
Utricularia purpurea Hayne.	bladderwort	X	X	X	
Utricularia vulgaris L.	giant bladderwort	X	X	X	X
Vallisneria americana L.	wild celery	X	X	X	X

Species present and their relative abundance remain comparable to prior survey results. With this diversity and distribution of native species, the test for selectivity should be sensitive to a number of species, and the probability of native plant restoration in areas formerly inhabited by Eurasian watermilfoil should be high following management efforts.

Maximum Depth of Colonization

The littoral zone is the area of the lake bottom supporting rooted aquatic plant growth, and is generally defined by the maximum depth to which sufficient light penetrates to allow for plant growth. In Lake Luzerne, depth distribution of native species remained similar to past surveys with aquatic plant growth observed to a maximum depth of 5.5 meters (16 feet). Macroalgae or charophytes form a carpet at the outer margin of plant growth, in depths from 5 to 6 meters (16 to 19 feet). While Eurasian watermilfoil occurred throughout Lake Luzerne, dense growth typically was found in depths from 3 to 10 feet. In this zone, Eurasian watermilfoil was clearly dominant. Depth distribution of sampling points (Figure 3) was primarily within the littoral zone (less than 6 meters), however most depths in Lake Luzerne were sampled.

Figure 3. Distribution of Lake Luzerne sampling points in 1 meter depth classes.



Species Lists

Results for all point intercept samples are provided in Appendix A. Maps of the distribution of aquatic plant species for the proposed treatment and control areas for Lake Luzerne are included in Appendix B, Figures B1 – B35. These maps are based on the presence of individual species in point intercept samples and the relative abundance of each species within each sample. Species richness in Lake Luzerne was high, with a large number of species occurring in more than 5% of survey points (Table 2). A total of 36 species of aquatic plants were observed with 31 collected

Table 2. Aquatic plant percent frequency by species for Lake Luzerne in 2010 for survey points lakewide (all), in the Renovate treated area (treated) and in the untreated areas of the lake.

Species	All	Treated	Untreated
Brasenia schreberi	7.2%	2.6%	8.9%
Chara species	40.1%	44.7%	39.3%
Eleocharis acicularis	2.6%	5.3%	1.8%
Elodea canadensis	15.8%	13.2%	17.0%
Eriocaulon aquaticum	0.7%		0.9%
Fontinalis sp.	4.6%		6.3%
Isoetes echinospora	2.0%		2.7%
Isoetes lacustris	0.7%		0.9%
Megalodonta beckii	2.0%		0.9%
Myriophyllum alterniflorum	0.7%		2.7%
Myriophyllum sibiricum	9.2%	5.3%	10.7%
Myriophyllum spicatum	24.3%	2.6%	32.1%
Myriophyllum tenellum	2.6%	2.6%	2.7%
Najas flexilis	7.9%	13.2%	6.3%
Nuphar variegata	1.3%	2.6%	0.9%
Nymphaea odorata	4.6%	7.9%	3.6%
Pontedaria cordata	0.7%	2.6%	
Potamogeton amplifolius	1.3%	2.6%	0.9%
Potamogeton crispus	0.7%		0.9%
Potamogeton epihydrus	2.0%	2.6%	1.8%
Potamogeton gramineus	1.3%		1.8%
Potamogeton illinoensis	15.8%	15.8%	16.1%
Potamogeton perfoliatus	1.3%	2.6%	0.9%
Potamogeton praelongus	7.2%	21.1%	2.7%
Potamogeton pusillus	10.5%	5.3%	12.5%
Potamogeton robbinsii	51.3%	86.8%	40.2%
Potamogeton vaseyi	10.5%	21.1%	7.1%
Sagittaria graminea	0.7%		0.9%
Scirpus sp.	0.7%	2.6%	
Sparganium spp.	2.0%	2.6%	1.8%
Utricularia minor	15.1%	21.1%	13.4%
Utricularia purpurea	29.6%	68.4%	17.0%
Utricularia vulgaris	15.8%	21.1%	14.3%
Vallisneria americana	25.7%	34.2%	23.2%

by the point intercept survey. Robbins pondweed, *Potamogeton robbinsii* was the most common species (51% of survey points). Eurasian watermilfoil was also a dominant species ranked sixth by frequency of occurrence lakewide (24% of survey points). A number of native species were also commonly observed, and included *Chara* spp. (40%), *Utricularia purpurea* (30%), *Vallisneria americana* (26%), *Utricularia vulgaris* (16%), *Potamogeton illinoensis* (16%), *Elodea canadensis* (16%), *Utricularia minor* (15%), *Potamogeton vaseyii* (11%), *Myriophyllum sibiricum* (9%), *Potamogeton praelongus* (7%), and *Brasenia schreberi* (7%). In 2009, the pre-treatment survey produced comparable results including: *Potamogeton robbinsii* (58% of survey points), *Chara* spp. (37%), *Utricularia minor* (47%), *Utricularia purpurea* (37%), *Vallisneria americana* (36%), *Elodea canadensis* (31%), *Potamogeton vaseyii* (16%), *Myriophyllum sibiricum* (13%), *Potamogeton praelongus* (10%), and *Brasenia schreberi* (10%). Eurasian watermilfoil was ranked third by frequency of occurrence in 2009 (45% of survey points). Comparing only those points included pre- and post-treatment surveys, Eurasian watermilfoil dropped to 16th by frequency of occurrence in the treated area in 2010, a rank it shared with nine other species.

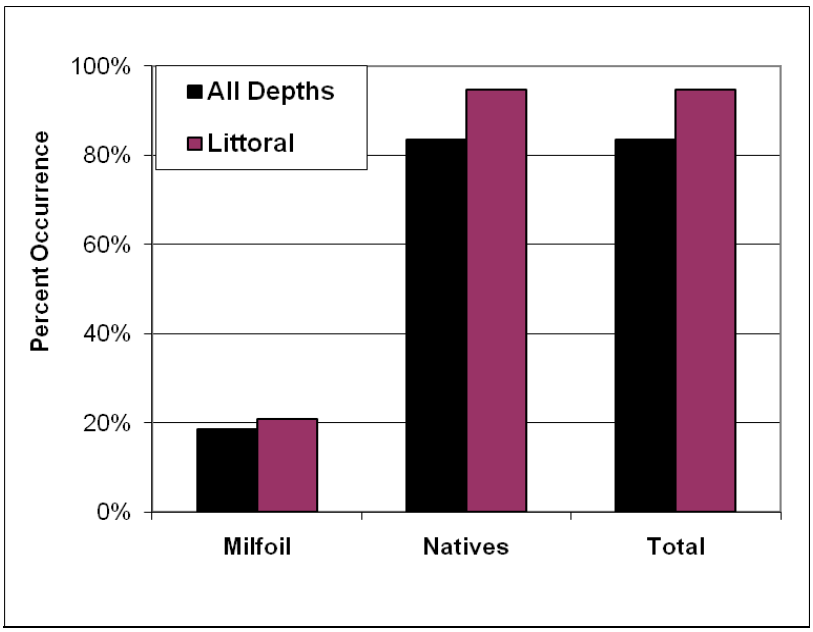
Comparing pre-treatment and post-treatment frequency of occurrence (Table 3), thirteen species showed a decline in frequency of occurrence, 10 species increased and for 5 species no change was recorded relative to the herbicide treatment. Of the thirteen species showing declines, one of the species was Eurasian watermilfoil. Three native species showing declines, *Eriocaulon aquaticum, Fontinalis* sp. and *Megalodonta beckii,* were uncommon in the pre-treatment survey, present in less than 5% of survey points in 2009, and absent in 2010. One of these species, *Megalodonta beckii,* was observed in the treated area post-treatment but was not present in the point intercept survey. Three native species showed substantial declines post-treatment, *Elodea canadensis, Potamogeton amplifolius* and *Utricularia minor*. Getsinger et al. (2002) reported native species experiencing declines following herbicide treatment with fluridone, including *Najas flexilis, Elodea canadensis, Myriophyllum sibiricum, Potamogeton illinoensis,* and *P. zosteriformis,* however he found greater than 50% of survey points remained vegetated with native species during the year of treatment. The majority of these species were observed to increase in frequency of occurrence the following year, after a decline in the year of treatment. Two species, *Utricularia vulgaris* and *Najas flexilis,* were present in limited numbers prior to treatment but much more abundant in post-treatment surveys in 2010. Getsinger et al. (2002) reported a proliferation of *Potamogeton illinoensis* following herbicide treatments, leading several residents to complain of nuisance levels of growth of this native species. Eichler and Boylen (2008) reported increases in frequency of occurrence of *Najas flexilis* and *Elodea canadensis* in two Vermont lakes following triclopyr treatments, however these also returned to pre-treatment levels within one year of treatment. All other differences were in the less common species.

Table 3. Comparison of frequency of abundance from 2009 (pre-treatment) and 2010 (post-treatment) for sample points within the treatment zone.

Species	pre-treatment	post-treatment
Brasenia schreberi	13.2%	2.6%
Chara sp.	36.8%	44.7%
Eleocharis acicularis	5.3%	5.3%
Elodea canadensis	36.8%	13.2%
Eriocaulon aquaticum	2.6%	0.0%
Fontinalis sp.	2.6%	0.0%
Megalodonta beckii	2.6%	0.0%
Myriophyllum sibiricum	13.2%	5.3%
Myriophyllum spicatum	57.9%	2.6%
Myriophyllum tenellum	7.9%	2.6%
Najas flexilis		13.2%
Nuphar variegata	2.6%	2.6%
Nymphaea odorata	10.5%	7.9%
Pontedaria cordata	2.6%	2.6%
Potamogeton amplifolius	10.5%	2.6%
Potamogeton epihydrus	2.6%	2.6%
Potamogeton illinoensis	5.3%	15.8%
Potamogeton perfoliatus		2.6%
Potamogeton praelongus	13.2%	21.1%
Potamogeton pusillus		5.3%
Potamogeton robbinsii	63.2%	86.8%
Potamogeton vaseyi	26.3%	21.1%
Scirpus sp.		2.6%
Sparganium spp.	2.6%	2.6%
Utricularia minor	65.8%	21.1%
Utricularia purpurea	50.0%	68.4%
Utricularia vulgaris		21.1%
Vallisneria americana	39.5%	34.2%

Eighty-four percent of whole lake sampling points were vegetated by at least one plant species in 2010 (Figure 4) comparable to the 89% reported for 2009. In depths of 6 m or less, representing the littoral zone, 95% of survey points contained native species in both 2009 and 2010 surveys. Eurasian watermilfoil was present in45% of survey points in the southeastern embayment in 2009 and 24% of lakewide survey points in 2010. For the treatment zone, Eurasian watermilfoil declined from 48% of survey points in 2009 to 2.6% of survey points in 2010, post-treatment

Figure 4. Lake Luzerne frequency of occurrence summaries lakewide in 2010.



(Figure 5). For the same time period, native and total plant frequency of abundance exceeded 95%, both pre and post-treatment. It is apparent that exotic species, dominated by Eurasian watermilfoil, were clearly less abundant post-treatment while native and total plant frequency of occurrence were largely unchanged when comparing pre- and post-treatment results.

Figure 5. Lake Luzerne frequency of occurrence summaries for the treatment area only.

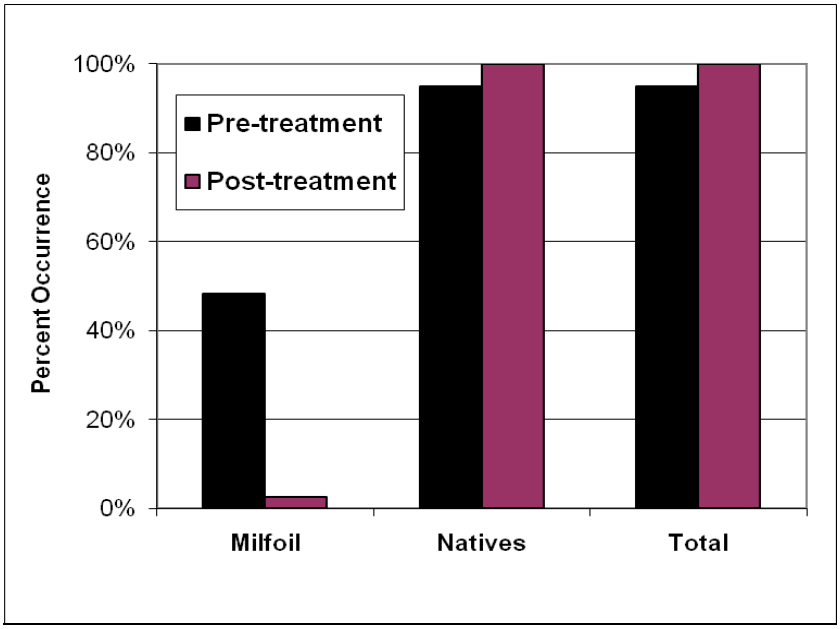


Table 4. Species richness comparison between the 2009 (pre-treatment) and 2010 (post-treatment) surveys

Plant Grouping	Water Depth Class	Summary Statistic	Lakewide Surveys	
			2009	2010
Native plant species	Whole Lake (all depths)	Mean	3.45	2.94
		N	62	152
		Std. Error	0.25	0.17
	Points with depths <6m	Mean	3.69	3.35
		N	58	134
		Std. Error	0.26	0.17
	Points with depths <2m	Mean	4.16	4.5
		N	18	53
		Std. Error	0.38	0.24
All plant species	Whole Lake (all depths)	Mean	3.9	3.13
		N	62	152
		Std. Error	0.29	0.18
	Points with depths <6m	Mean	4.17	3.56
		N	58	134
		Std. Error	0.29	0.18
	Points with depths <2m	Mean	4.74	4.72
		N	18	53
		Std. Error	0.42	0.26

The number of plant species present per sample point, or species richness, is presented in Table 4 and Figure 6. Whole lake native species richness is comparable to total species richness, reported at 2.94 and 3.13 species per sample point, respectively. When comparing only survey points within the littoral zone, native and total species richness remain similar, at 3.35 and 3.56 species per sample point, and within the relative error of the measurement. The use of sampling points predominantly within the littoral zone accounts for the similarity of results. The fact that lake-wide results are comparable pre- and post-treatment is encouraging. Dividing the sampling points between those exclusively within the treatment area and those in the remainder of the lake (control), species richness per survey point was greater in the treated area (Figure 7), even when the presence of Eurasian watermilfoil was substantially reduced. This may be an artifact of the treatment design, since all points within the treatment zone were in water depths of 2.7 meters or less, representing the shallow margin of the littoral zone, an area well documented to support greater species richness.

Figure 6. Lake Luzerne species richness lakewide. Error bars are standard error.

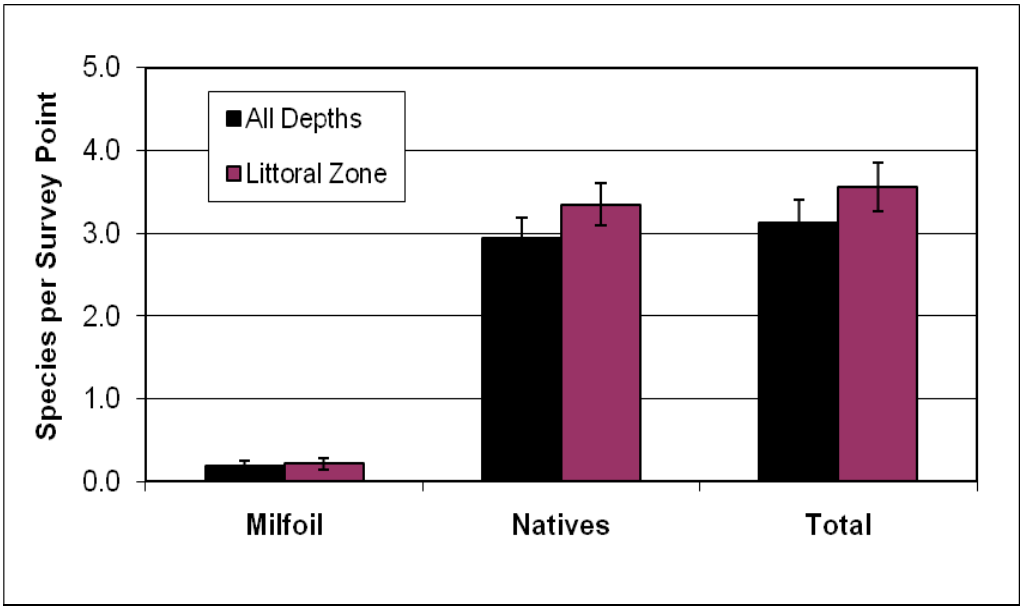
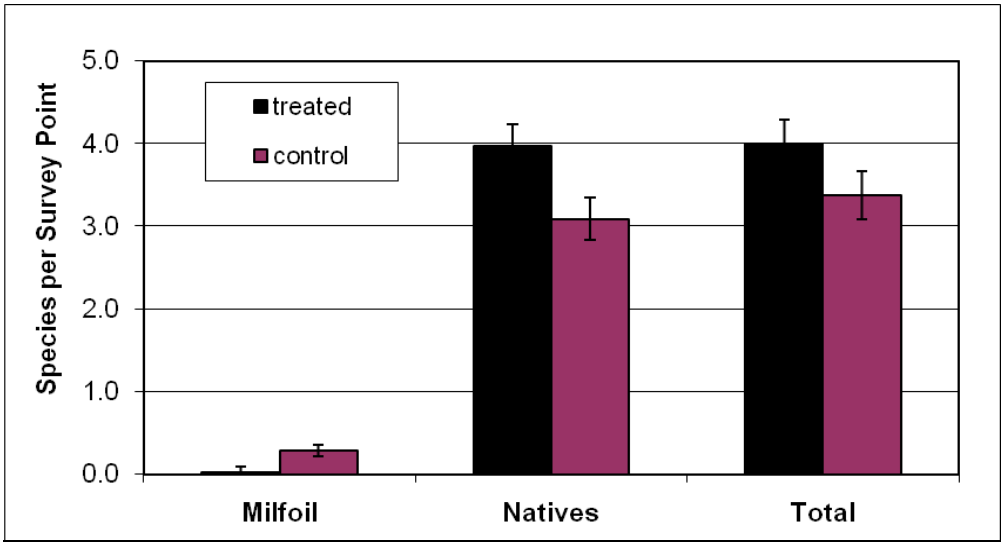
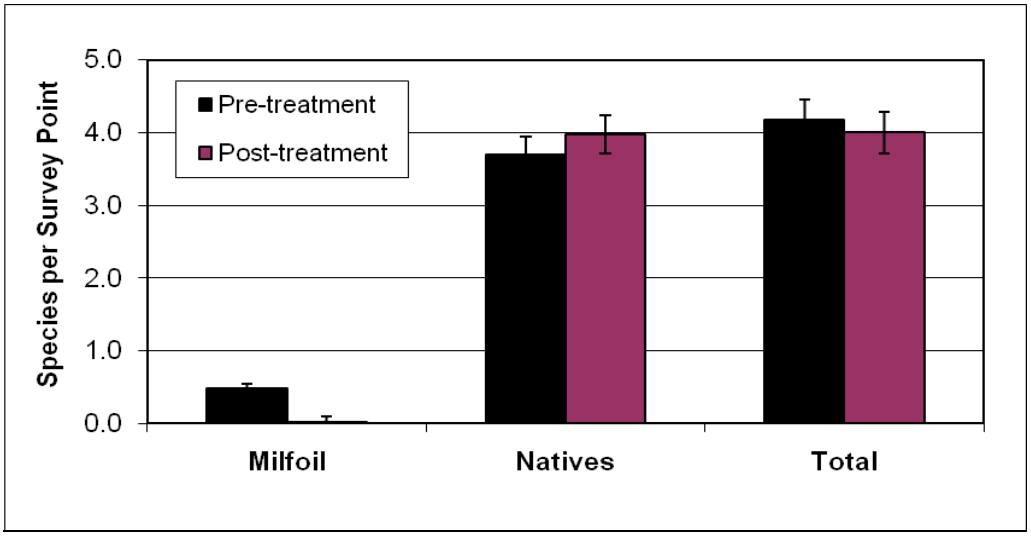


Figure 7. Lake Luzerne species richness for littoral survey points within the treated and untreated areas. Error bars are standard error.



Declines in native species richness following expansive growth of *Myriophyllum spicatum* have been well documented (Madsen et al. 1989, 1991). Conversely, species richness increases in areas where Eurasian watermilfoil growth is reduced (Boylen et al., 1996). Comparing survey points pre-treatment and post-treatment (Figure 8), little or no change in native or total species richness is apparent while Eurasian watermilfoil presence has declined.

Figure 8. Lake Luzerne species richness for littoral survey points pre- and post-treatment. Error bars are standard error.



Summary

Quantitative aquatic plant surveys were undertaken for Lake Luzerne, New York, to obtain post-treatment data for a Eurasian watermilfoil (*Myriophyllum spicatum* L.) management program based on a sequestered treatment with the herbicide triclopyr (Renovate^{TM}). The point intercept survey methods employed were designed to meet with NYS DEC Tier III Survey requirements. The current plant survey was designed to provide data comparable to earlier surveys by the author (Eichler et al. 1989, 1992, 1998, 2004 and 2009). The survey consisted of: a) frequency of occurrence of all aquatic plant species for points distributed throughout the lake, and b) comparison of historical survey results to current conditions, with particular reference to changes in the relative abundance of Eurasian watermilfoil. Aquatic plant distribution data for the entire lake, not just the southwest cove area, was included in the 2010 assessment.

Lake Luzerne supports a diverse native plant community with twenty-eight submersed species, three floating-leaved species, and five emergent species. An exotic, invasive aquatic plant species, Eurasian watermilfoil (*Myriophyllum spicatum*) was first confirmed in Lake Luzerne in 1989. Periodic hand harvesting efforts were conducted, however by 2004 Eurasian watermilfoil had expanded its coverage. The presence of a second invasive plant species, Curly-leaf Pondweed (*Potamogeton crispus* L.), was confirmed in 2004. In order to address the expanded growth of Eurasian watermilfoil, benthic barrier was incorporated in 2005. Continued expansive growth of Eurasian watermilfoil in the southeast bay spawned a desire to evaluate additional treatment alternatives. Permits were acquired and a sequestered treatment with the herbicide triclopyr (Renovate^{TM}) was conducted in the Spring of 2010.

One year post-treatment, species richness in Lake Luzerne remains quite high, with a large number of species occurring in more than 5% of survey points. A total of 36 species were recorded in open-lake surveys of Lake Luzerne in 2010, comparable to previous surveys in 2004 (39 species), 1998 and 2009 (33 species), and 1989 - 1992 (27 species). Between all surveys, a total of 41 species of aquatic plants are reported for Lake Luzerne.

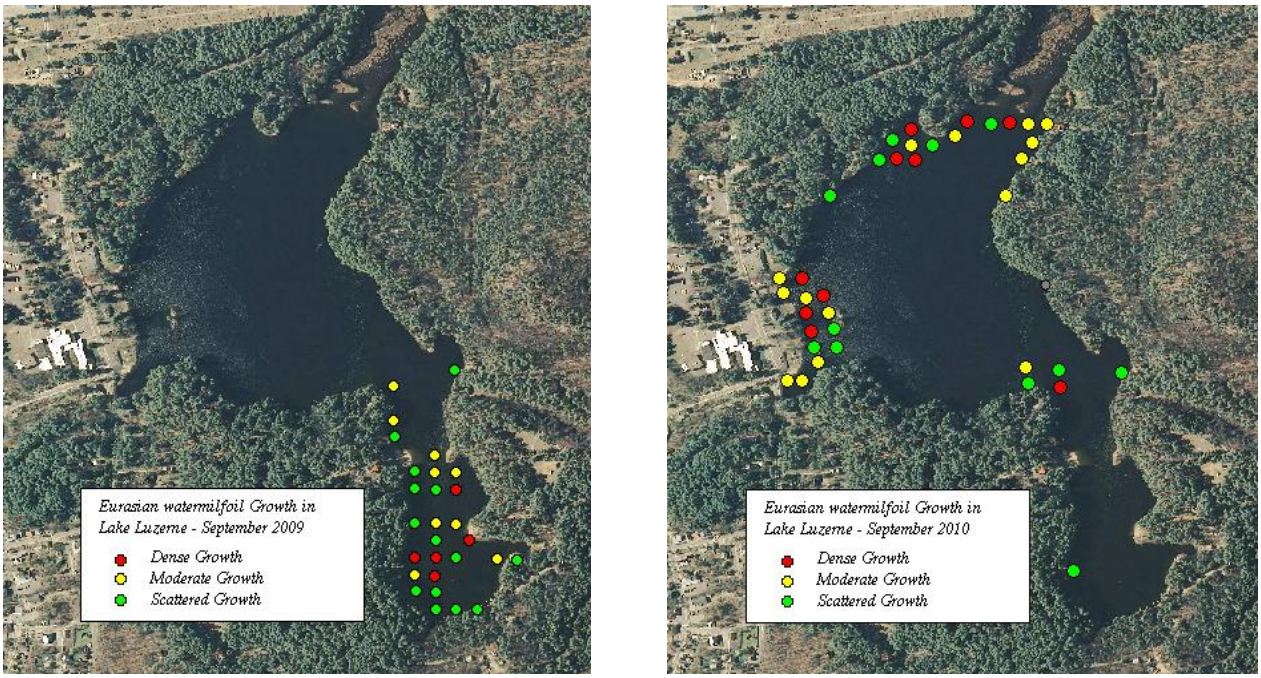
Robbins pondweed, *Potamogeton robbinsii* was the most common species (58% of survey points). Eurasian watermilfoil was also a dominant species ranked sixth by frequency of occurrence (24% of survey points). A number of native species were also commonly observed, and included *Chara* spp. (40% of survey points), *Utricularia purpurea* (30%), *Vallisneria americana* (26%), *Utricularia vulgaris* (16%), *Potamogeton illinoensis* (16%), *Elodea canadensis* (16%), *Utricularia minor* (15%), *Potamogeton vaseyii* (11%), *Myriophyllum sibiricum* (9%), *Potamogeton praelongus* (7%), and *Brasenia schreberi* (7%). These results are quite similar to frequency of occurrence results for the 2009 pre-treatment survey: *Chara* spp. (37% of survey points), *Utricularia minor* (47%), *Utricularia purpurea* (37%), *Vallisneria americana* (36%), *Elodea canadensis* (31%), *Potamogeton vaseyii* (16%), *Myriophyllum sibiricum* (13%), *Potamogeton praelongus* (10%), and *Brasenia schreberi* (10%).

Eighty-four percent of whole lake sampling points were vegetated by at least one plant species in 2010 comparable to the 89% reported for 2009. In depths of 6 m or less, representing the littoral

zone, 95% of survey points contained native species in both 2009 and 2010 surveys. Eurasian watermilfoil was present in45% of survey points in the southeastern embayment and adjacent areas in 2009 and 24% of lakewide survey points in 2010. For survey points exclusively within the treatment zone, Eurasian watermilfoil declined from 48% of survey points in 2009 to 2.6% of survey points in 2010, post-treatment.

Whole lake native species richness in 2010 was comparable to total species richness, reported at 2.94 and 3.13 species per sample point, respectively. For 2009, whole lake native species richness was reported at 3.45 and 3.89 species per sample point respectively. When comparing only survey points within the littoral zone for 2010, native and total species richness remained similar, at 3.35 and 3.56 species per sample point, and within the relative error of the measurement. The use of sampling points predominantly within the littoral zone accounts for the similarity of results. The fact that lake-wide results are comparable pre- and post-treatment is encouraging. Dividing the sampling points between those exclusively within the treatment area and those in the remainder of the lake (control), species richness per survey point was greater in the treated area, even when the presence of Eurasian watermilfoil was substantially reduced.

Figure 9. Distribution of Eurasian watermilfoil (*Myriophyllum spicatum*) in the 2009 (pre-treatment) survey of the southeastern cove of Lake Luzerne and the 2010 (post-treatment) survey of all of Lake Luzerne.



One of the plant species in Lake Luzerne (*Myriophyllum alterniflorum*) is on the New York State Rare Plant list (Young, 2008). This species is generally found on sandy, wave washed shorelines common to Adirondack lakes. While not observed in the southeastern embayment in 2009, this

species was reported for Lake Luzerne in 2010 outside the treated area. Three other species present in Lake Luzerne are on the NYS Watch List (*Isoetes lacustris, Megalodonta beckii* and *Utricularia minor*), however only two, *Megalodonta beckii* and *Utricularia minor*, were reported to occur in the treated area. Their presence on the watch list may be a result of lack of survey data rather than actual scarcity. Both are common species in moderately productive lakes and ponds in our region. *Utricularia minor*, with its small thread-like growth form may be overlooked by surveys. *Megalodonta beckii* is frequently mis-identified as the more common coontail (*Ceratophyllum demersum*). Both of these species declined in frequency of occurrence between pre- and post-treatment surveys. Declines in these species have been observed in other surveys relative to herbicide treatments (Gettsinger et al. 2002, Eichler and Boylen 2009), however both species have returned to pre-treatment levels within one year of treatment.

Eurasian watermilfoil growth dominated the southeastern cove of Lake Luzerne in 2009, present as both scattered plants and dense growth prior to treatment (Figure 9). In the 2010 post-treatment survey, only a single stem of Eurasian watermilfoil was recorded in the treatment area (Figure 9). Frequency of occurrence for Eurasian watermilfoil plants within the treatment zone declined from 58% of survey points pre-treatment to 3% post-treatment. The remainder of Lake Luzerne supported extensive growth of Eurasian watermilfoil in 2010. The current survey results should continue to provide a baseline from which to assess future impacts of both Eurasian watermilfoil growth and management activities.

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Appendix A. Aquatic plant distribution and location of survey points for Lake Luzerne, NY.

Abundance Codes:
1 = trace, fingerful on rake
2 = sparse growth, handful on rake
3 = moderate growth, rake full of plants
4 = dense growth, difficult to bring into boat

Species Codes:

Code	*Species*	Common Name	Code	*Species*	Common Name
BS	*Brasenia schreberi*	Water Shield	PA	*Potamogeton amplifolius*	Broad leaf Pondweed
CH	*Chara species*	Musk Grass	PB	*Potamogeton crispus*	Curly-leaf Pondweed
EA	*Eleocharis acicularis*	Spike Rush	PE	*Potamogeton epihydrus*	Ribbon leaf Pondweed
EC	*Elodea canadensis*	Waterweed	PG	*Potamogeton gramineus*	Variable Pondweed
ES	*Eriocaulon aquaticum*	Pipewort	PI	*Potamogeton illinoensis*	Illinois Pondweed
FN	*Fontinalis sp.*	Moss	PP	*Potamogeton perfoliatus*	Clasping leaf Pondweed
IE	*Isoetes echinospora*	Quillwort	PR	*Potamogeton robbinsii*	Robbins Pondweed
IL	*Isoetes lacustris*	Large Spore Quillwort	PU	*Potamogeton pusillus*	Narrow-leaf Pondweed
MB	*Megalodonta beckii*	Water Marigold	PW	*Potamogeton praelongus*	White stem Pondweed
MA	*Myriophyllum alterniflorum*	Little Milfoil	PV	*Potamogeton vaseyii*	Vasey's Pondweed
ME	*Myriophyllum sibiricum*	Northern Milfoil	SA	*Sparganium spp.*	Bur Reed
MS	*Myriophyllum spicatum*	Eurasian watermilfoil	SG	*Sagittaria graminea*	Arrowhead
MT	*Myriophyllum tenellum*	Leafless Milfoil	SS	*Scirpus* sp.	Rush
NV	*Nuphar variegata*	Yellow Water Lily	UM	*Utricularia minor*	Bladderwort
NF	*Najas flexilis*	Water Naiad	UP	*Utricularia purpurea*	Purple Bladderwort
NO	*Nymphaea odorata*	White Water Lily	UV	*Utricularia vulgaris*	Giant Bladderwort
NV	*Nuphar variegata*	Yellow Pond Lily	VA	*Vallisneria americana*	Duck Celery
PC	*Pontedaria cordata*	Pickerelweed			

GPS	longit.	latitude	Depth (m)	BS	CH	EA	EC	ES	FN	IE	IL	MA	MB	ME	MS	MT	NF	NV	NO	PA	PB	PC	PE	PG	PI	PP	PR	PU	PV	PW	SA	SG	UM	UP	UV	VA	SS
1	-73.827	43.318	0.6	3	2														2								2						2				
2	-73.827	43.318	1.3		2												2																	2			
3	-73.737	43.012	1.0		3		2																		2		2		2					2		2	
4	-73.831	43.327	3.0												2								2				2										
5	-73.836	43.323	2.2																															3			
6	-73.738	43.011	1.1		1														3						2			2	2				2			
7	-73.739	43.011	0.9														2								2		2	2	2					2			
8	-73.737	43.011	1.2		3										1	2	3												2						2		
9	-73.836	43.325	14.6																																		
10	-73.836	43.324	8.8																																		
11	-73.739	43.011	1.8												3												4									2	
12	-73.835	43.326	7.8																																		
14	-73.833	43.326	1.2		2									2	3				2				2				2								2	2	
15	-73.831	43.321	0.2																								2				2	2			2	
16	-73.831	43.321	1.0		2		2																				2						1			2	
18	-73.831	43.322	1.8		1																				2		2						1				
19	-73.831	43.322	4.6												1																						
20	-73.831	43.322	7.0																																		
21	-73.836	43.326	9.9																																		
22	-73.830	43.317	5.0		3																																
23	-73.830	43.318	2.3				2								2												2		2				1	2		2	
24	-73.830	43.318	1.9																								2		2				2	2		2	

GPS	longit.	latitude	Depth (m)	BS	CH	EA	EC	ES	FN	IE	IL	MA	MB	ME	MS	MT	NF	NV	NO	PA	PB	PC	PE	PG	PI	PP	PR	PU	PV	PW	SA	SG	UM	UP	UV	VA	SS
25	-73.830	43.318	1.9														2										2								2	2	
26	-73.830	43.319	0.8			1								2				2									1						2				
27	-73.830	43.319	1.0		2	2	1									4											1						3			2	
28	-73.830	43.320	1.2		2														2									2						2		2	
29	-73.830	43.320	1.7		2		2															2			3		2			2				2			
30	-73.830	43.320	1.0																																		
31	-73.830	43.321	3.5		2		2							3																							
32	-73.830	43.321	5.5		1																													1			
33	-73.830	43.321	5.9		3																																
34	-73.830	43.322	4.9		2				2																												
35	-73.830	43.322	4.1																																		
36	-73.829	43.317	2.0																								2		3					2		2	2
37	-73.829	43.317	2.1		2																						2							2			
38	-73.829	43.317	2.7																						3		3							2			
39	-73.829	43.318	2.0																								3			2				2			
40	-73.829	43.318	2.2																						1		3			2				2	2		
41	-73.829	43.318	2.5																				2				2							3	2		
42	-73.829	43.319	1.9																								2		2					3	2	2	
43	-73.834	43.327	1.7	2	2									2	2										2		1						2				
44	-73.829	43.320	2.1		2									2												2	2			2							
45	-73.829	43.320	1.8				2																				3		1				1			2	
46	-73.829	43.320	1.7		1												2										2							1		2	
47	-73.829	43.321	4.5		2				1					1													2										

GPS	longit.	latitude	Depth (m)	BS	CH	EA	EC	ES	FN	IE	IL	MA	MB	ME	MS	MT	NF	NV	NO	PA	PB	PC	PE	PG	PI	PP	PR	PU	PV	PW	SA	SG	UM	UP	UV	VA	SS
48	-73.829	43.321	5.1																																		
49	-73.829	43.321	6.0																																		
50	-73.829	43.322	4.9		2				3																												
51	-73.829	43.322	3.6		1		2																			2										
52	-73.829	43.322	1.1										2													3									2	
53	-73.829	43.317	1.3																						3		3							1			
54	-73.829	43.317	3.0																								4							1			
55	-73.829	43.318	3.0																								4							1			
56	-73.829	43.318	2.0		2																						4							2			
57	-73.829	43.318	2.2		3																						2			2				3	2		
58	-73.829	43.319	2.0														2								3		2							2		2	
59	-73.835	43.322	5.8																																		
60	-73.829	43.320	1.9																								3			2				2			
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62	-73.829	43.321	1.2																								2	2									
64	-73.829	43.321	2.0				2						2														2							1		1	
65	-73.832	43.325	6.0		1																																
66	-73.829	43.322	1.5																															1			
67	-73.829	43.322	1.8		2		2								1												2									2	
68	-73.829	43.322	1.7	2																							2							2		2	
69	-73.828	43.317	0.4		2																								2		1					1	
70	-73.828	43.317	2.8		1																						2						1				
71	-73.828	43.318	4.1																								2										

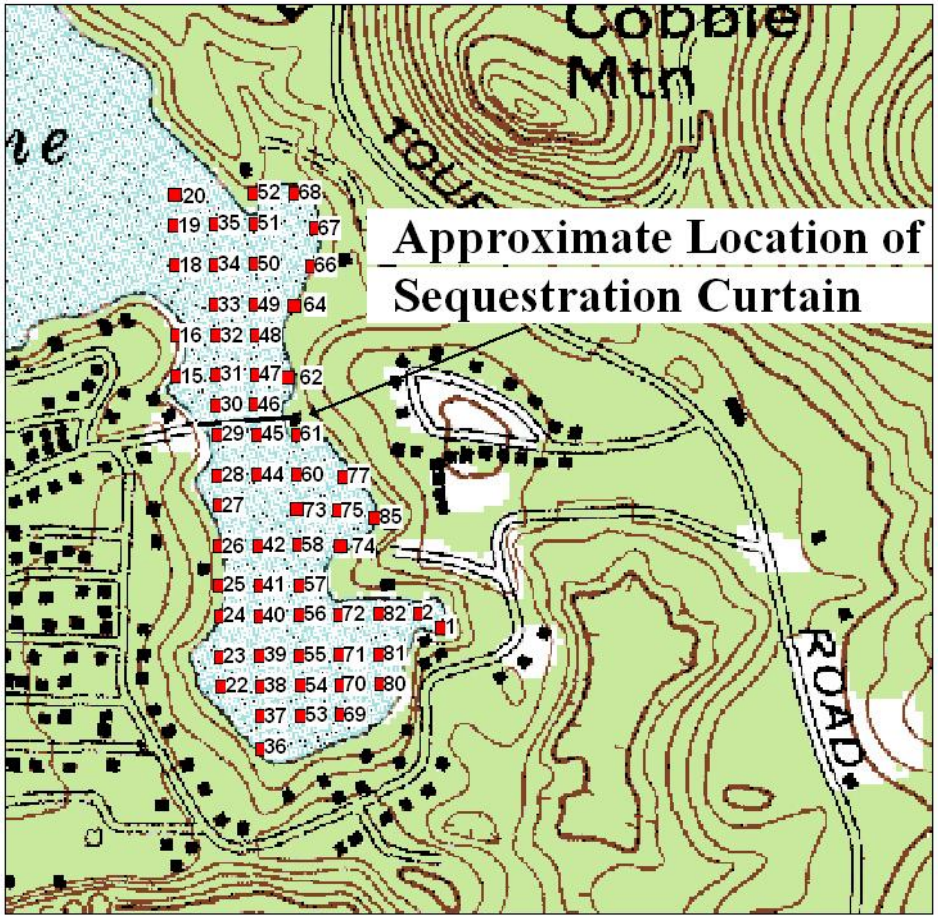
GPS	longit.	latitude	Depth (m)	BS	CH	EA	EC	ES	FN	IE	IL	MA	MB	ME	MS	MT	NF	NV	NO	PA	PB	PC	PE	PG	PI	PP	PR	PU	PV	PW	SA	SG	UM	UP	UV	VA	SS
72	-73.828	43.318	0.3																								3								2		
73	-73.829	43.319	2.1																						4		2								2		
74	-73.828	43.319	1.3		3																						2	2	3							2	
75	-73.828	43.319	1.9		2												2										3			2				2	2		
76	-73.834	43.326	5.8																																		
77	-73.828	43.319	2.0																	2							2			2				2			
78	-73.832	43.327	1.9											3	1												3							2			
79	-73.832	43.327	1.6																								2		2					3		2	
80	-73.828	43.317	2.2																														2	2		2	
81	-73.828	43.318	2.3		2		2																				2							2			
82	-73.828	43.318	2.6																								2		2					2	2	2	
83	-73.832	43.327	1.7		3										4																			2	2	2	
84	-73.831	43.327	0.7											2	3												2				1		1				
85	-73.828	43.319	0.8		2														2								2							2			
86	-73.737	43.011	1.7		2										3												3		2					3		2	
87	-73.836	43.322	5.6																																		
88	-73.832	43.325	1.6	2		2																		2												2	
89	-73.832	43.325	4.0																								2						1				
90	-73.832	43.326	9.2																																		
91	-73.832	43.326	1.2	2	2	1	2							2	3			3										2						1		2		
92	-73.831	43.322	1.8		1										4					2						2	1										
93	-73.835	43.326	11.2																																		
94	-73.738	43.011	1.2	2	2										4	2	2										2		1					3			

GPS	longit.	latitude	Depth (m)	BS	CH	EA	EC	ES	FN	IE	IL	MA	MB	ME	MS	MT	NF	NV	NO	PA	PB	PC	PE	PG	PI	PP	PR	PU	PV	PW	SA	SG	UM	UP	UV	VA	SS
95	-73.833	43.327	2.9				2																				3										
96	-73.834	43.327	2.2												3										2		2	1		2			1		2	2	
97	-73.835	43.322	4.3		2																							2									
98	-73.831	43.323	1.4											2																					2	2	
99	-73.835	43.322	8.0		1																																
100	-73.831	43.323	6.8		1																																
101	-73.833	43.327	5.6		2																						2										
102	-73.831	43.322	3.0		1				1																												
103	-73.831	43.322	2.2												3										3		2							2	2		
104	-73.832	43.322	6.3																																		
105	-73.832	43.327	3.8																						1			1									
106	-73.831	43.324	6.8		2																																
107	-73.835	43.322	5.2		2																																
108	-73.832	43.322	4.5		2		2							3																					2		
109	-73.832	43.322	2.5						2					1														2							2		
110	-73.831	43.322	2.0		1										1																						
111	-73.831	43.322	5.1		2																																
112	-73.834	43.326	2.7												4										3					2			1		1		
113	-73.831	43.327	1.0		1		2						2	3	3										2		2								2		
114	-73.832	43.321	1.0		3		2			2																		2					2				
115	-73.833	43.321	5.8		2																																
116	-73.833	43.321	6.0		1				1																												
117	-73.835	43.326	2.1		1										4		2																	1		2	

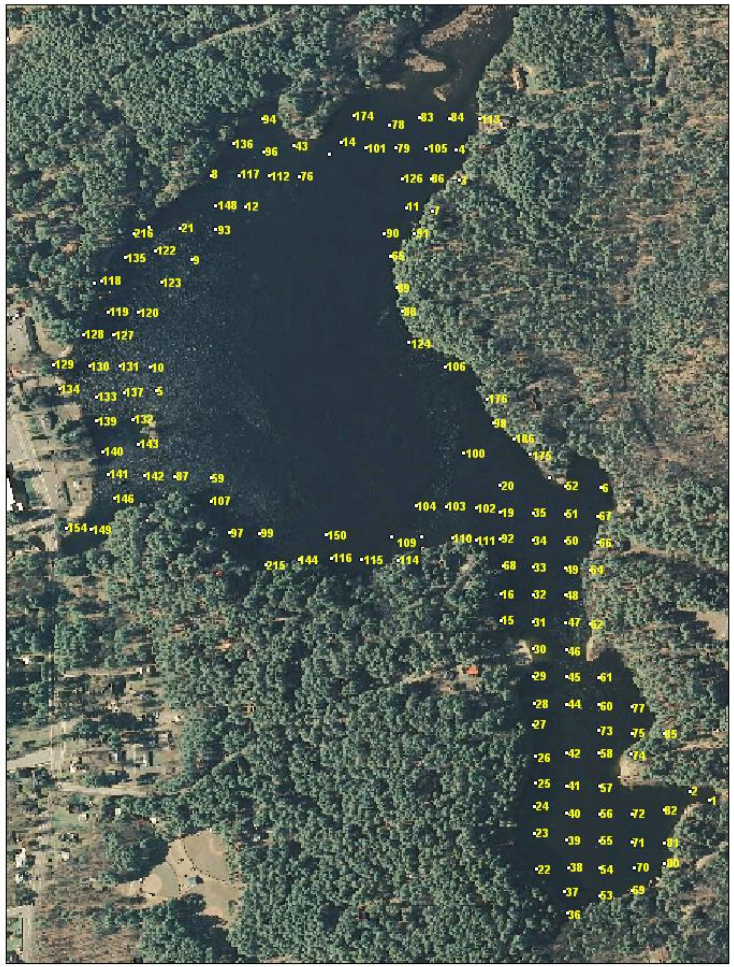
GPS	longit.	latitude	Depth (m)	BS	CH	EA	EC	ES	FN	IE	IL	MA	MB	ME	MS	MT	NF	NV	NO	PA	PB	PC	PE	PG	PI	PP	PR	PU	PV	PW	SA	SG	UM	UP	UV	VA	SS
118	-73.837	43.325	2.9																														1		2		
119	-73.837	43.324	2.8																														1		2		
120	-73.837	43.324	8.9																																		
121	-73.837	43.325	7.2																																		
122	-73.836	43.325	9.4																																		
123	-73.836	43.325	12.3																																		
124	-73.832	43.324	6.2																															1			
125	-73.739	43.011	1.1		2												2										2		2						2	
126	-73.832	43.326	6.0																																		
127	-73.837	43.324	5.9		1				1																												
128	-73.837	43.324	2.1																3						2												
129	-73.838	43.324	2.0	2											3						1						2								2	
130	-73.837	43.324	2.8												4												3									
131	-73.837	43.324	6.2		2																																
132	-73.837	43.323	2.2				2								3																						
133	-73.837	43.323	2.6				2								3										3		2							2		
134	-73.838	43.323	0.6					2				1			2				2														1			2	
135	-73.837	43.325	2.7								4																										
136	-73.835	43.327	1.5		2										1	1	2										2	1							1	
137	-73.837	43.323	3.6												4										2		2							2		
139	-73.837	43.323	2.5				2								4												2	2								
140	-73.837	43.323	2.2				2								4												4							2		
141	-73.837	43.322	2.3				2								1												2	3							2	

GPS	longit.	latitude	Depth (m)	BS	CH	EA	EC	ES	FN	IE	IL	MA	MB	ME	MS	MT	NF	NV	NO	PA	PB	PC	PE	PG	PI	PP	PR	PU	PV	PW	SA	SG	UM	UP	UV	VA	SS
142	-73.836	43.322	3.6				2								1										4		2						1				
143	-73.837	43.323	1.6	2	2										1													2									
144	-73.834	43.321	0.8							1				2										2									3			2	
146	-73.837	43.322	2.7												3												2	2									
148	-73.835	43.326	4.9																								1										
149	-73.837	43.322	1.6	2			2								3										2		2						2				
150	-73.833	43.322	6.8																																		
154	-73.838	43.322	1.2	2			2			2					3																				2	2	
162	-73.836	43.326	6.1																																		
174	-73.833	43.327	2.0												4										1		2			2							
175	-73.830	43.323	4.5																																		
176	-73.831	43.323	1.9		3																						2								2	2	
186	-73.830	43.322	6.0		4																																
215	-73.834	43.321	0.4																																		
216	-73.837	43.325	1.7	2											1										2												

Topographic map showing the approximate locations of the 2009 survey points with GPS number for the proposed treatment area and the adjacent portion of Lake Luzerne, NY.

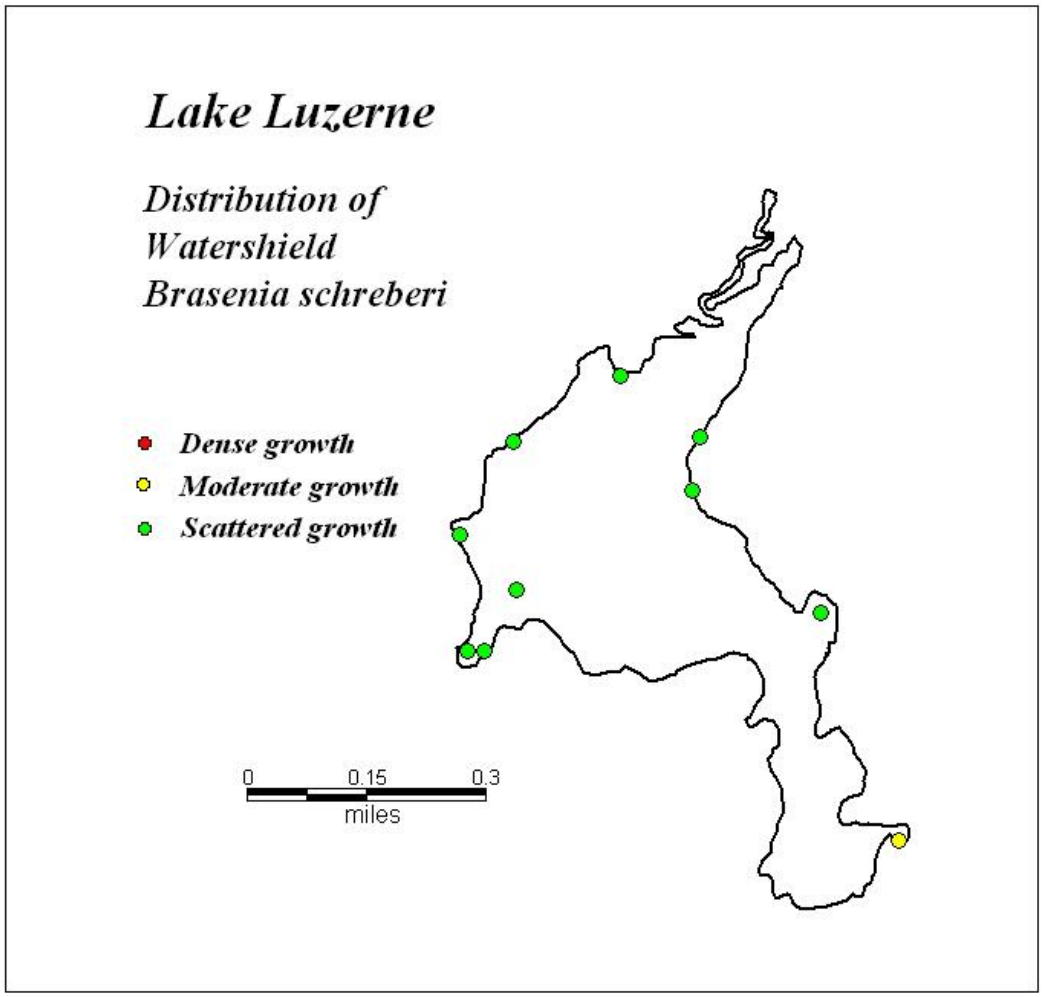


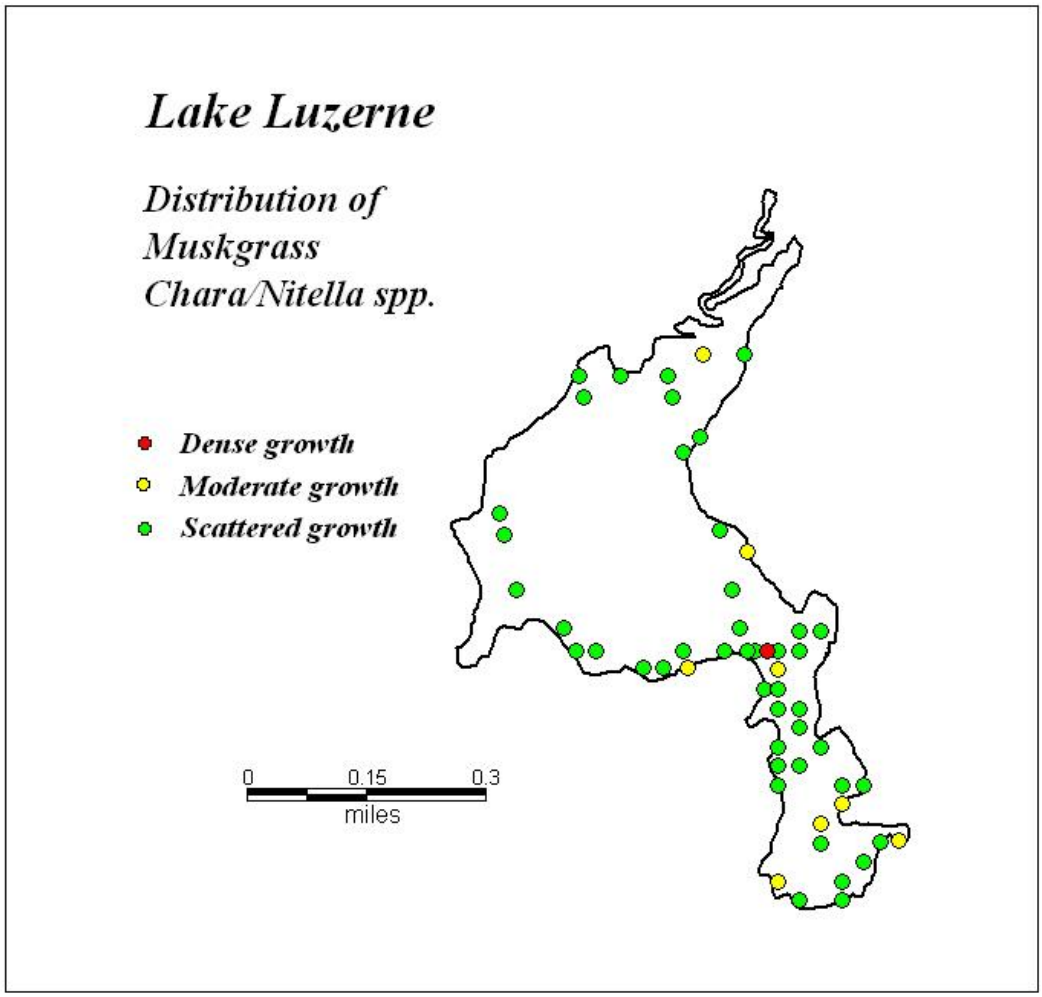
Topographic map showing the approximate locations of the 2010 survey points with GPS number for Lake Luzerne, NY.

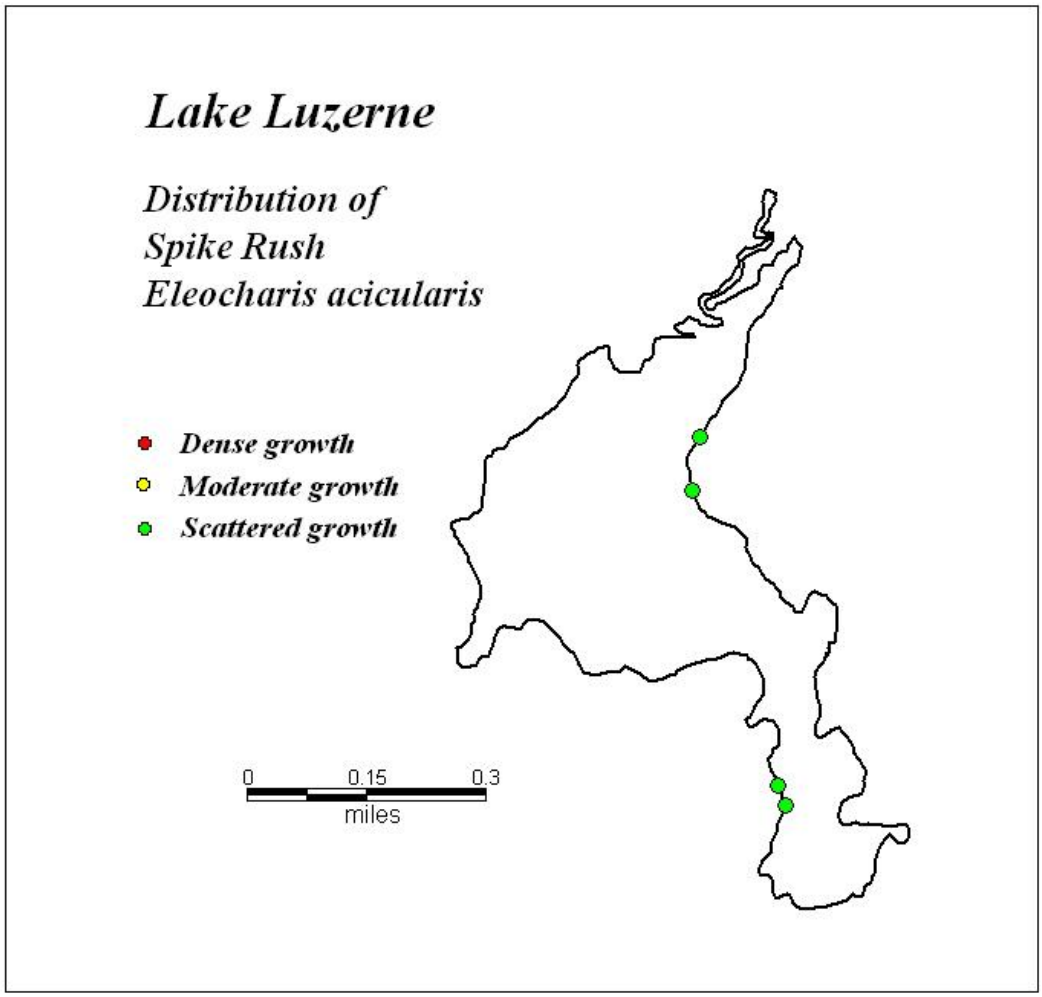


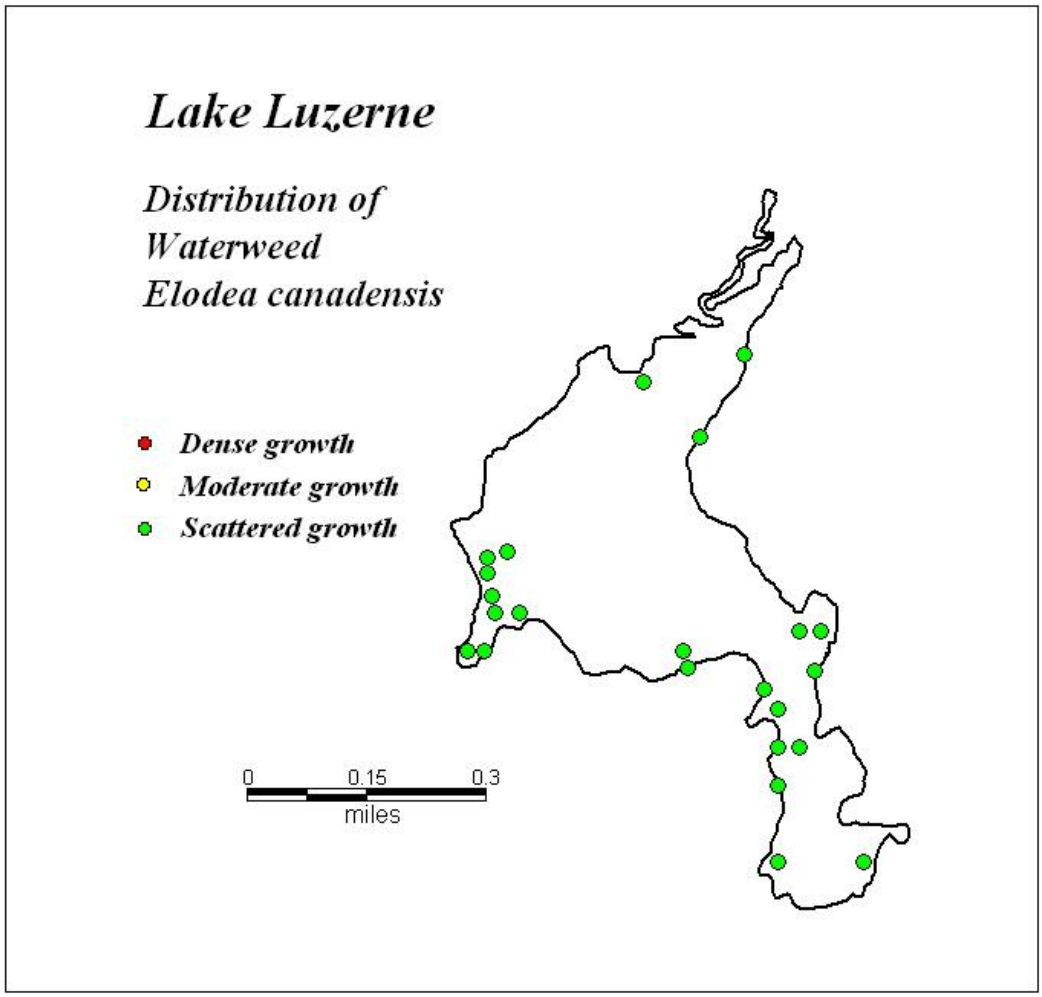
Appendix B.

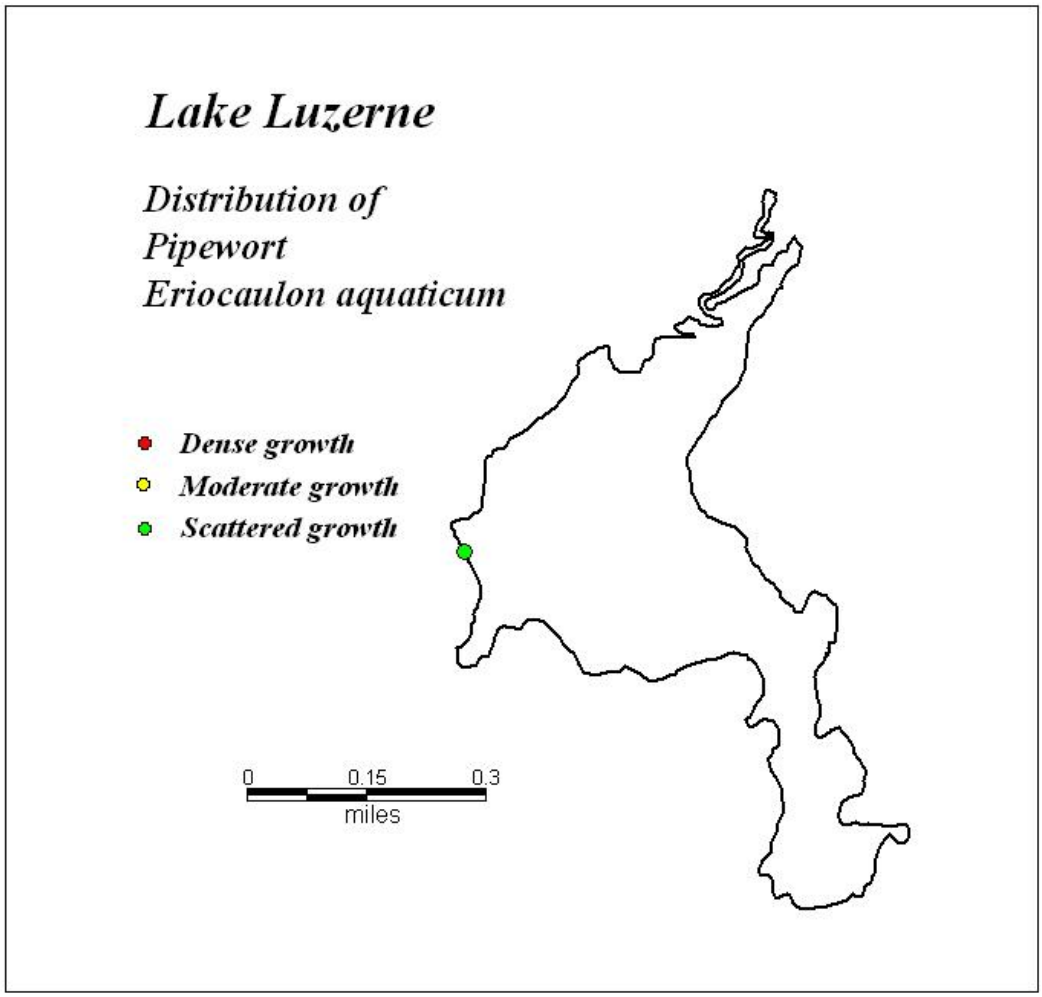
Aquatic Plant Distribution Maps for Lake Luzerne Based on Point Intercept Survey Data

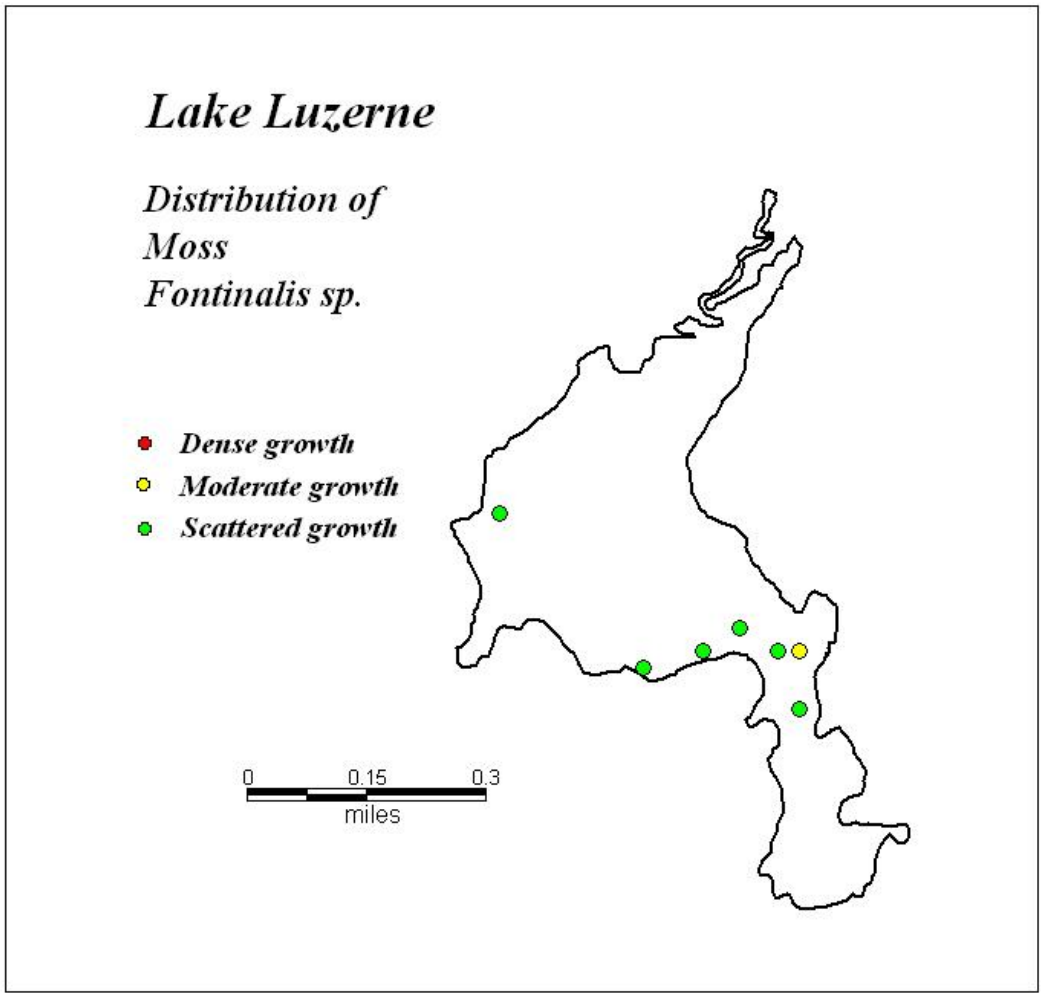

Lake Luzerne
Distribution of
Watershield
Brasenia schreberi
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

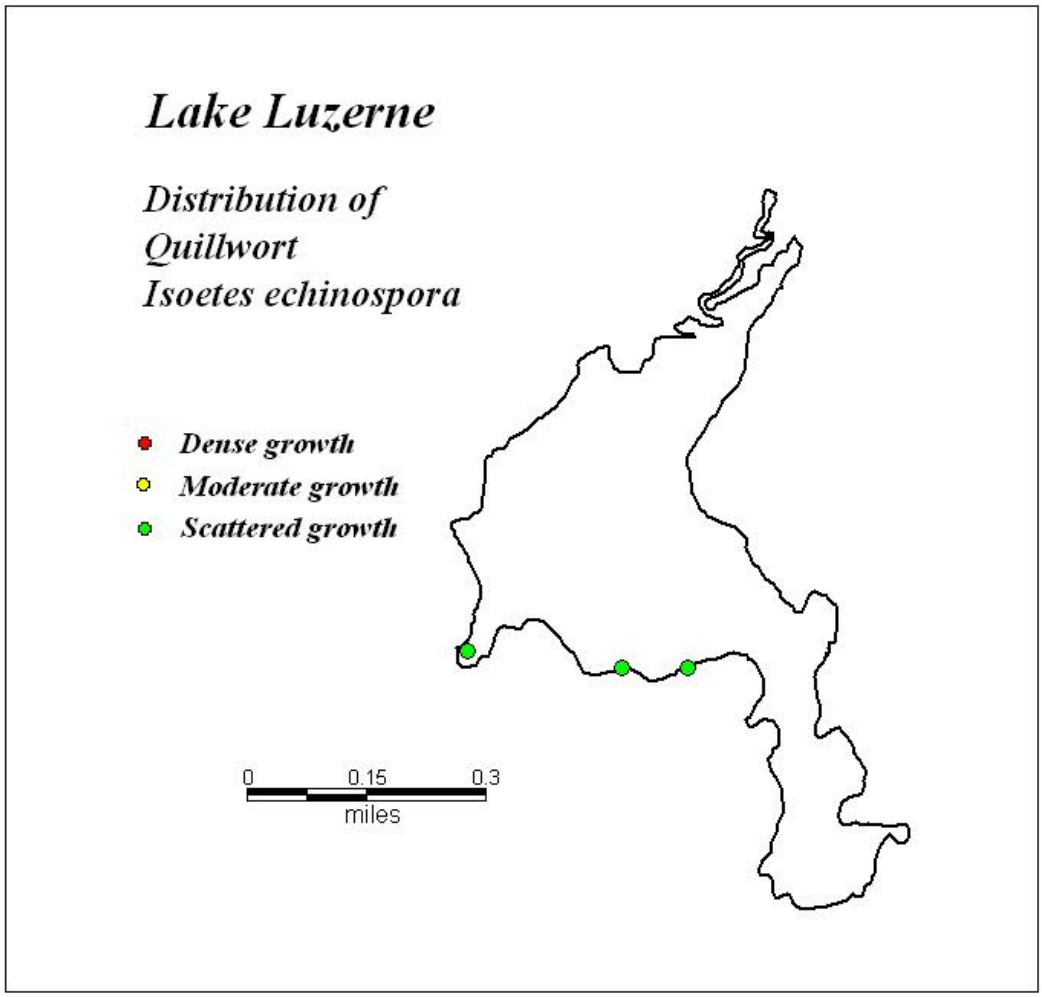

Lake Luzerne
Distribution of
Muskgrass
Chara/Nitella spp.
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

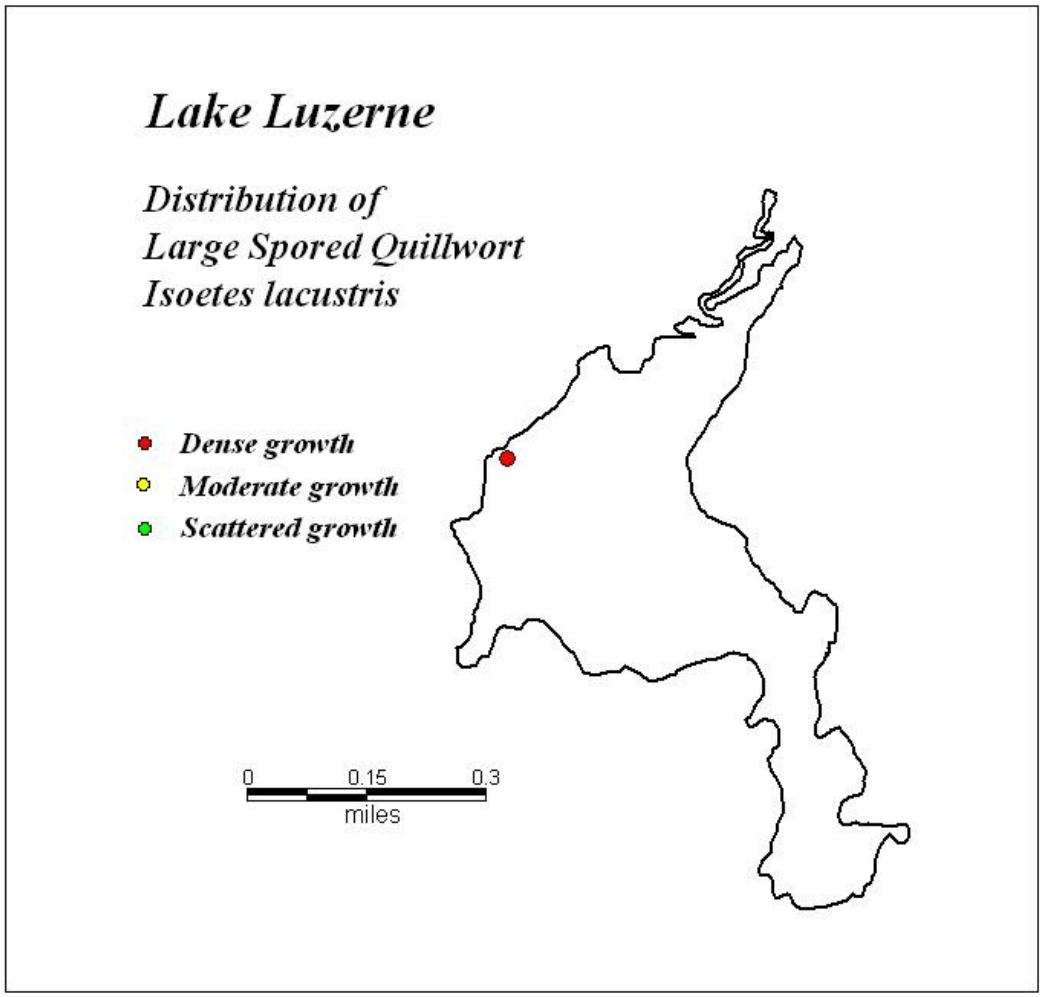

Lake Luzerne
Distribution of
Spike Rush
Eleocharis acicularis
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

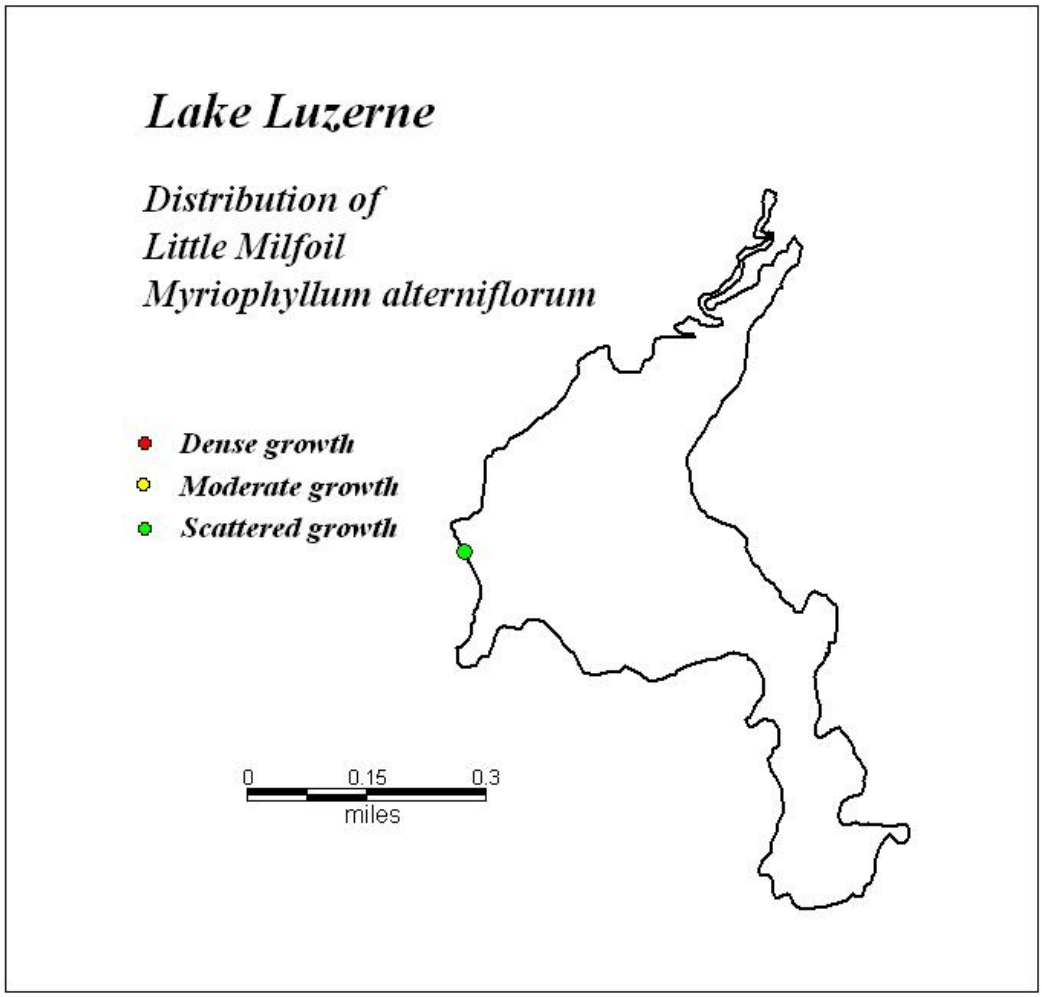

Lake Luzerne
Distribution of
Waterweed
Elodea canadensis
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

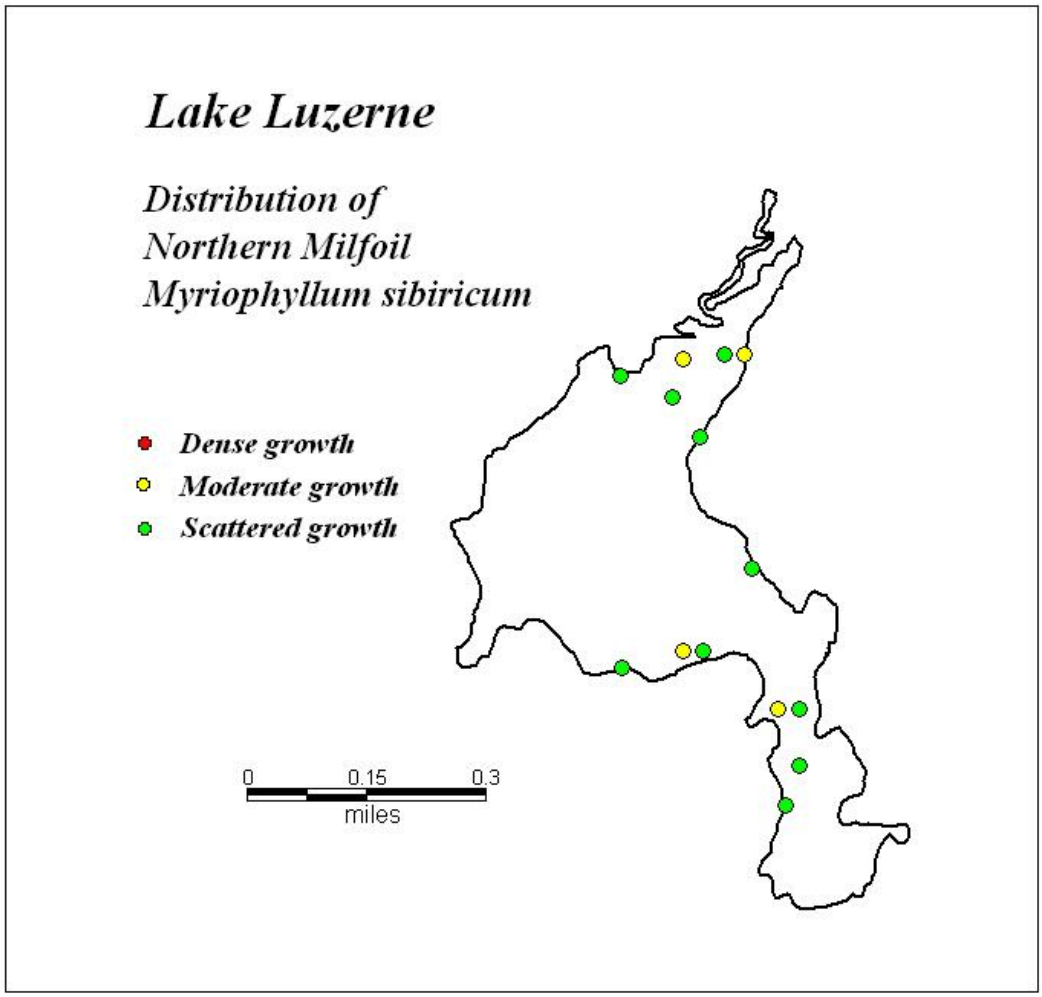

Lake Luzerne
Distribution of
Pipewort
Eriocaulon aquaticum
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

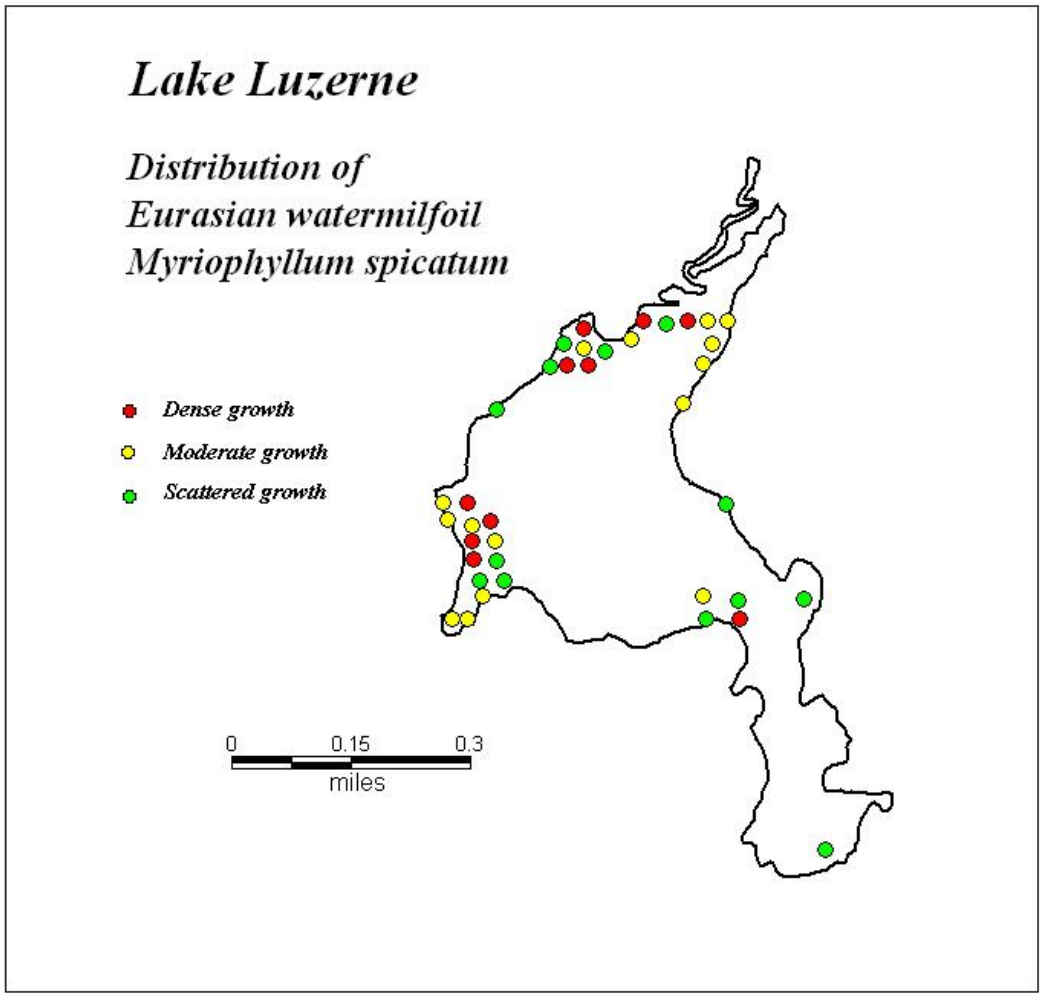

Lake Luzerne
Distribution of
Moss
Fontinalis sp.
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

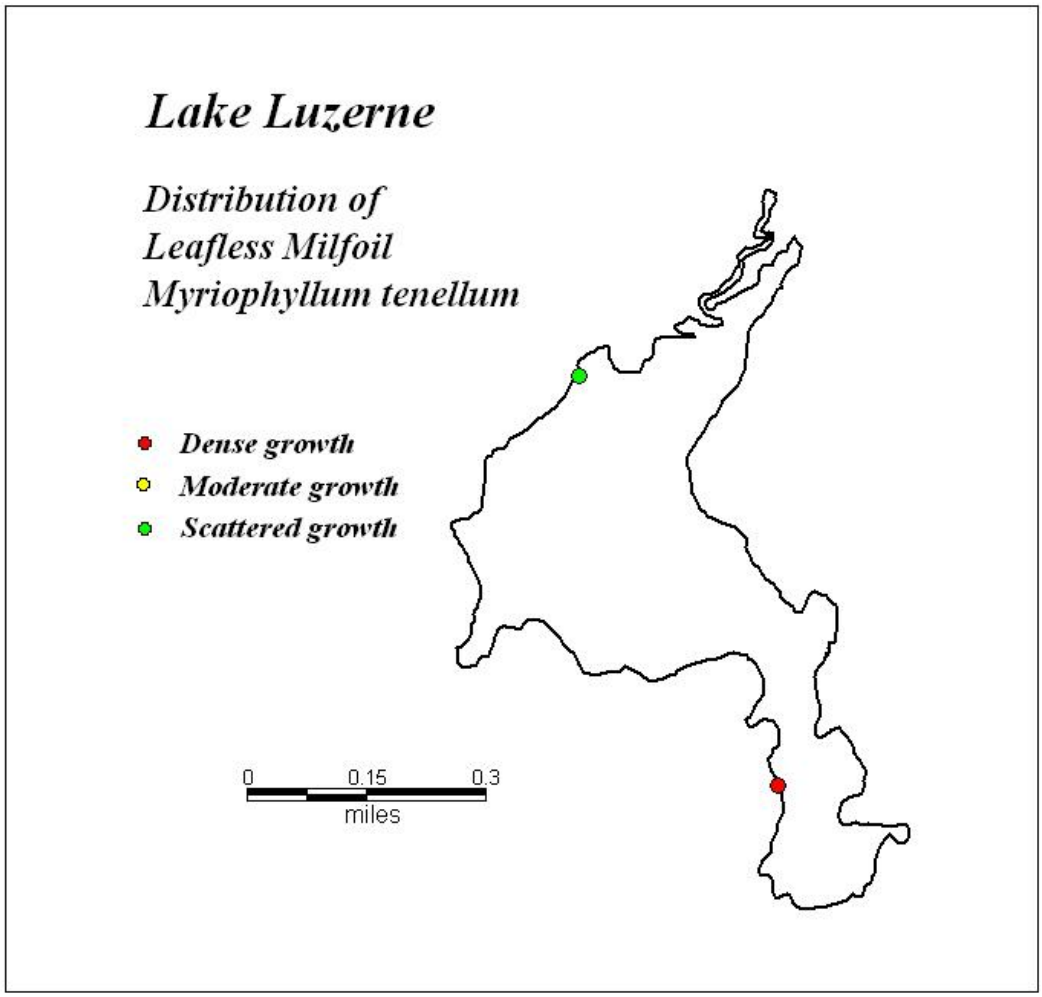

Lake Luzerne
Distribution of
Quillwort
Isoetes echinospora
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

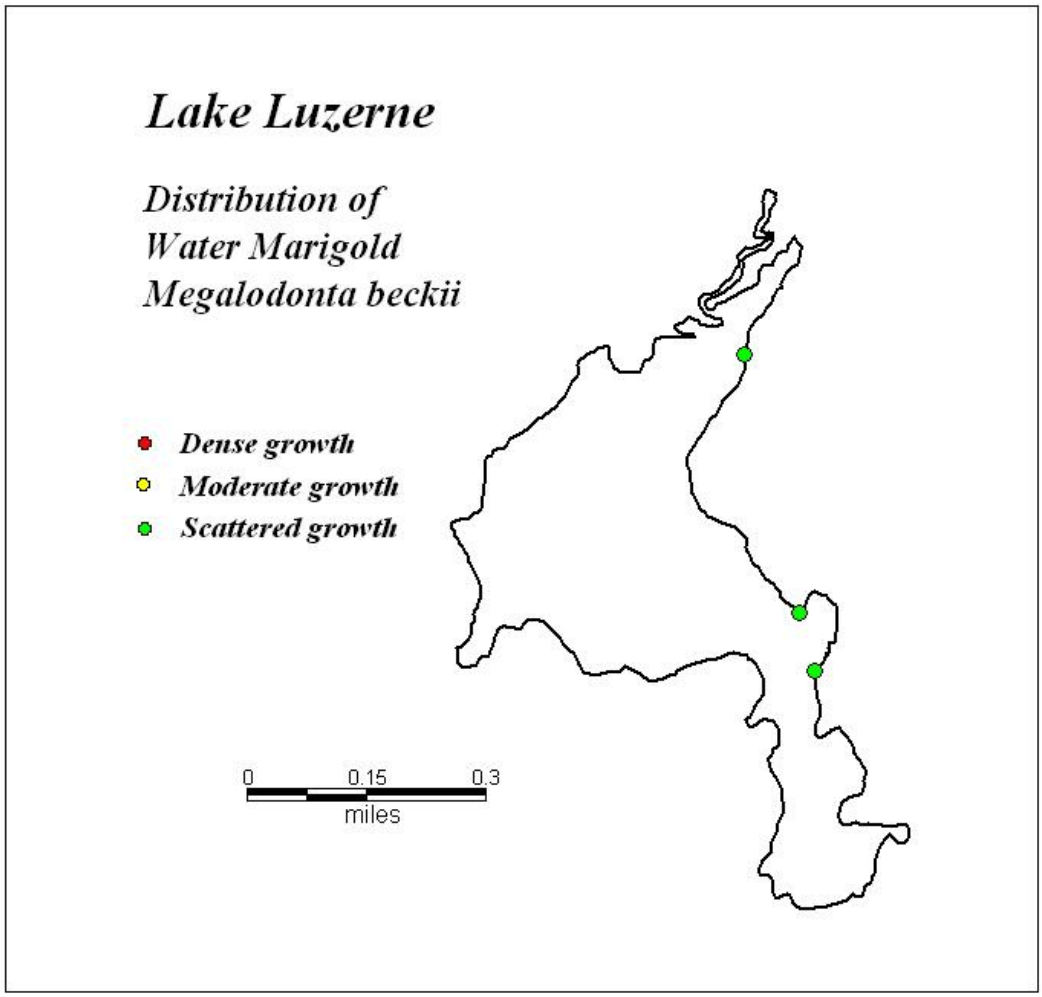

Lake Luzerne
Distribution of
Large Spored Quillwort
Isoetes lacustris
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

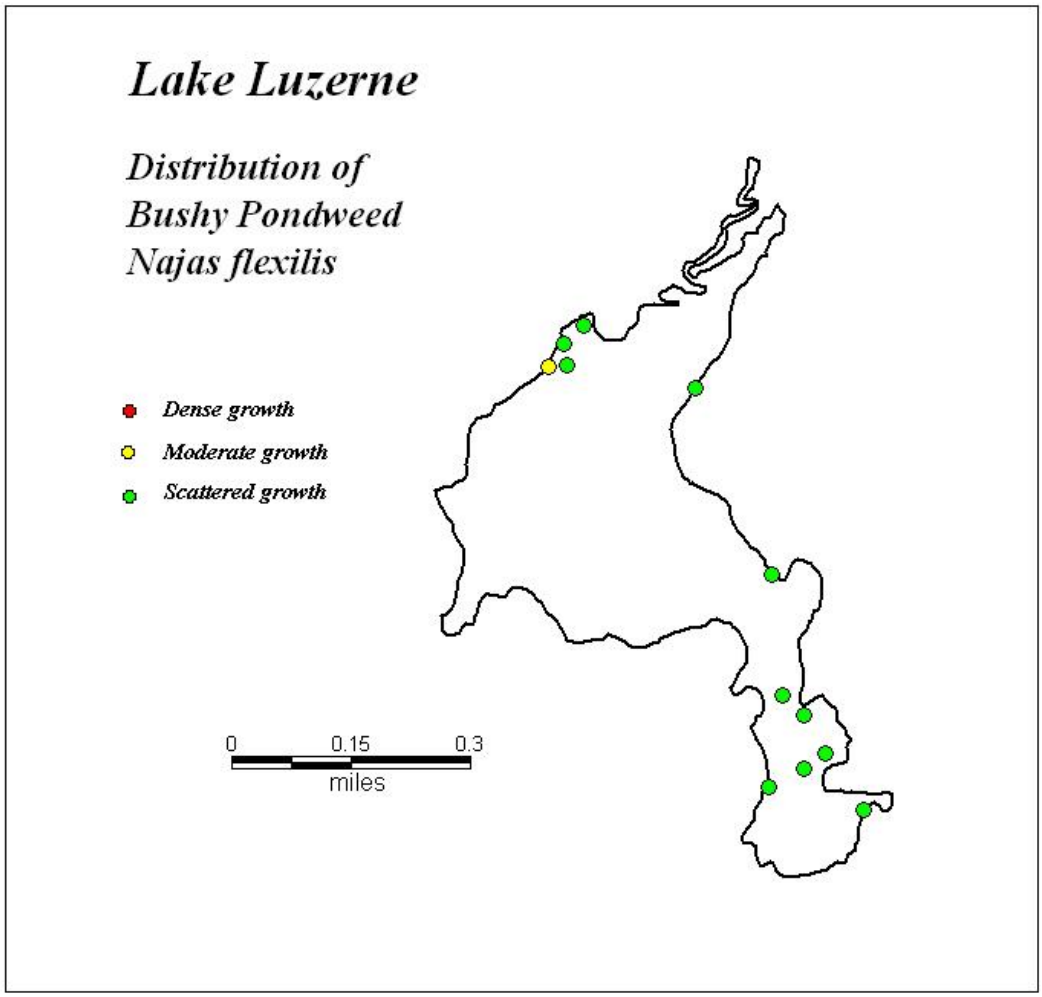

Lake Luzerne
Distribution of
Little Milfoil
Myriophyllum alterniflorum
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

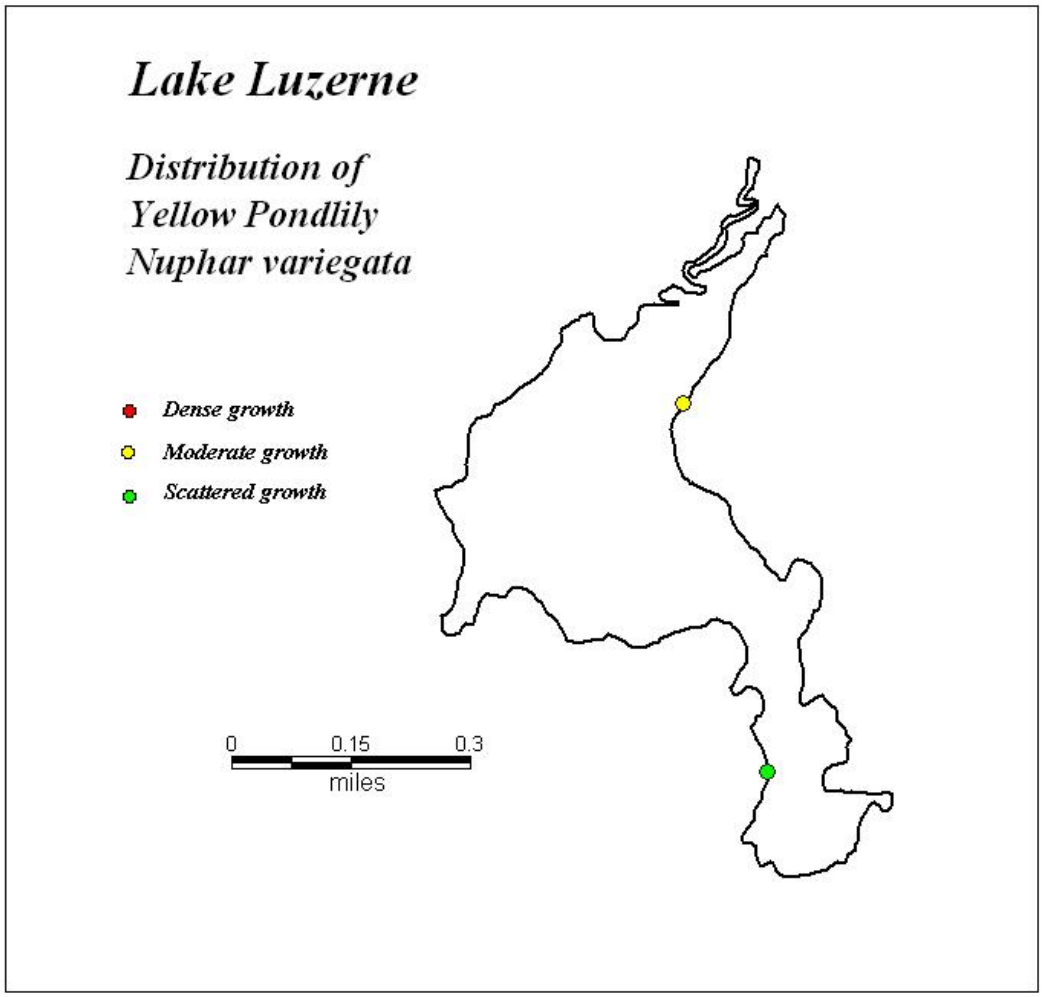

Lake Luzerne
Distribution of
Northern Milfoil
Myriophyllum sibiricum
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

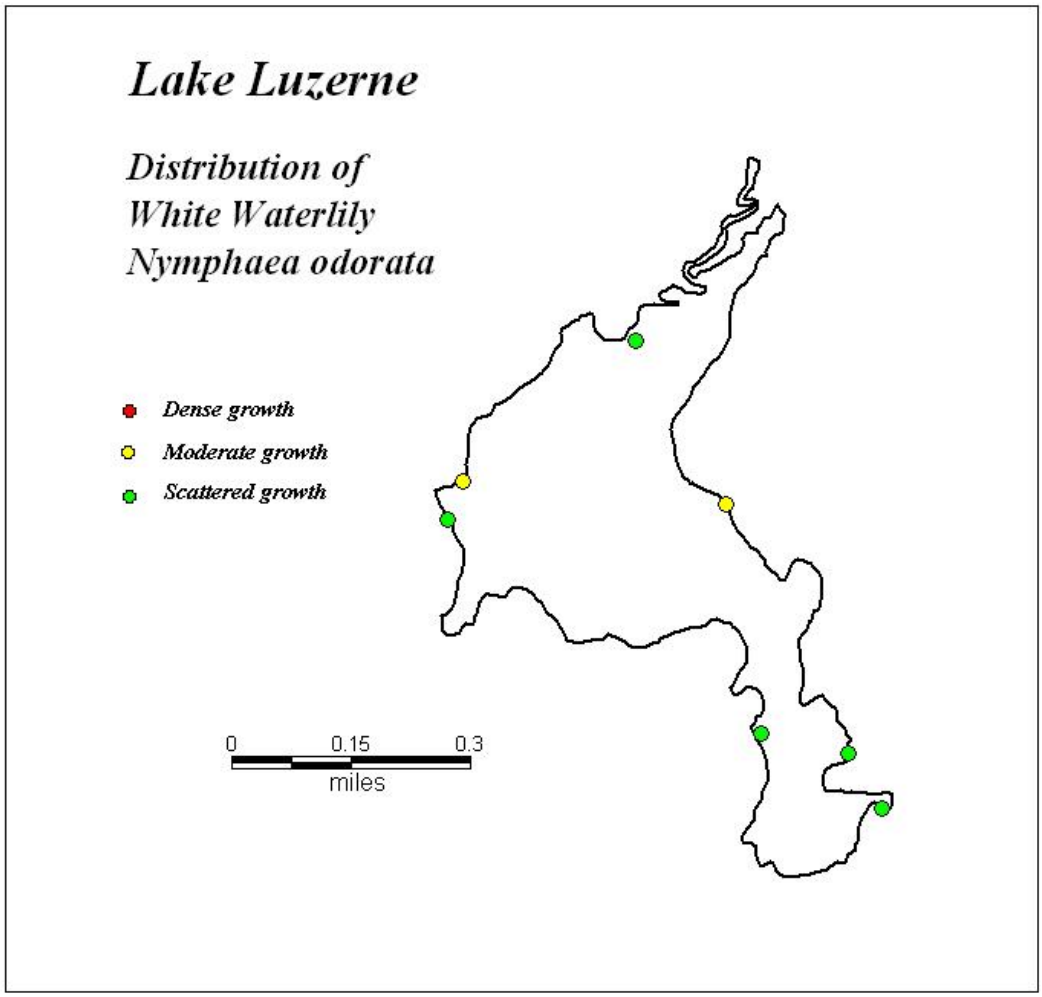

Lake Luzerne
Distribution of
Eurasian watermilfoil
Myriophyllum spicatum
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

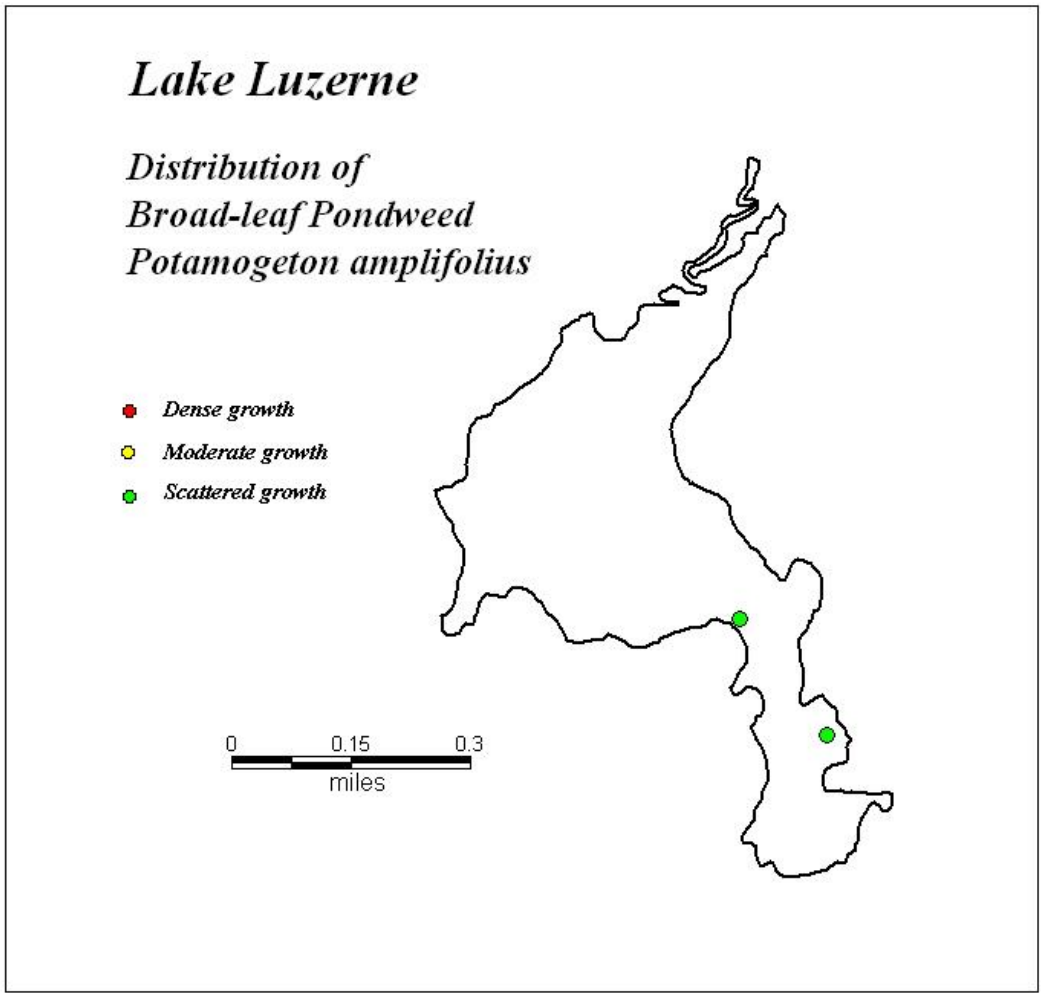

Lake Luzerne
Distribution of
Leafless Milfoil
Myriophyllum tenellum
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

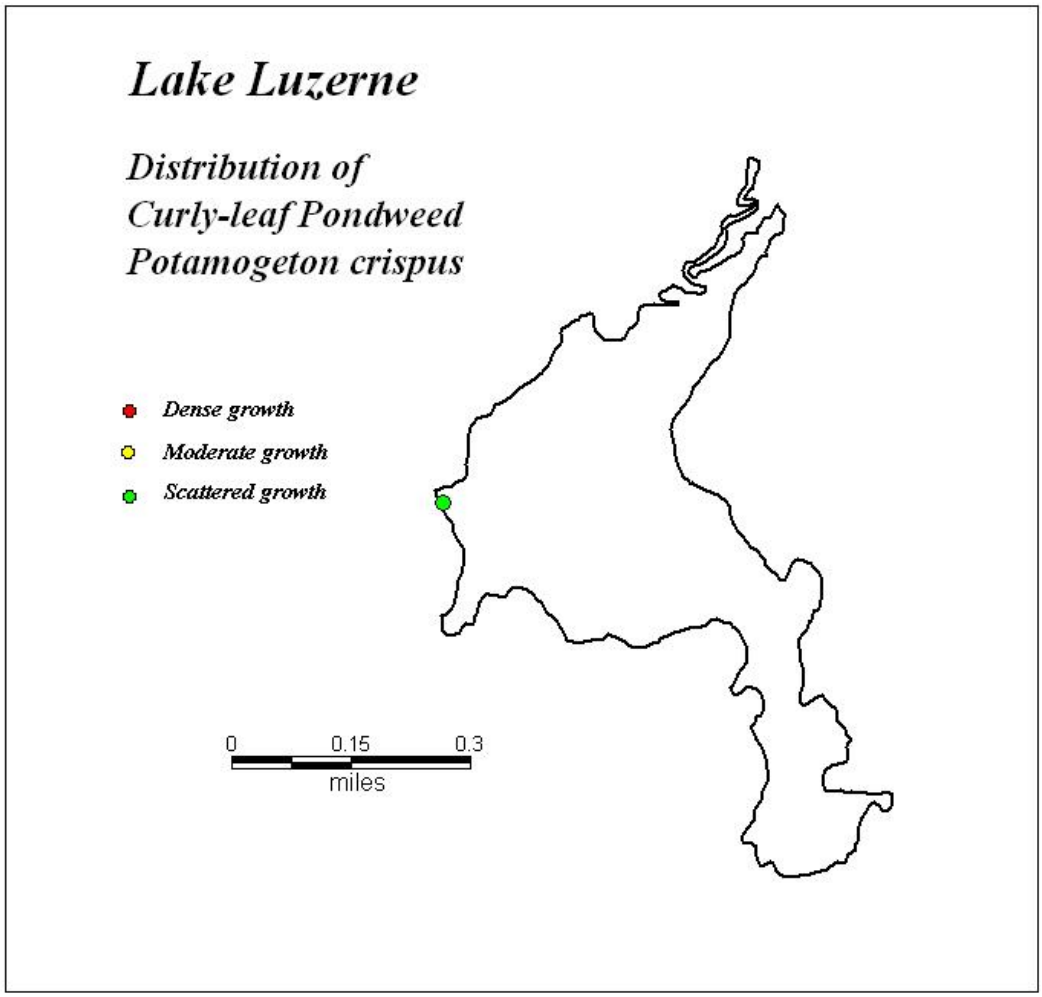

Lake Luzerne
Distribution of
Water Marigold
Megalodonta beckii
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

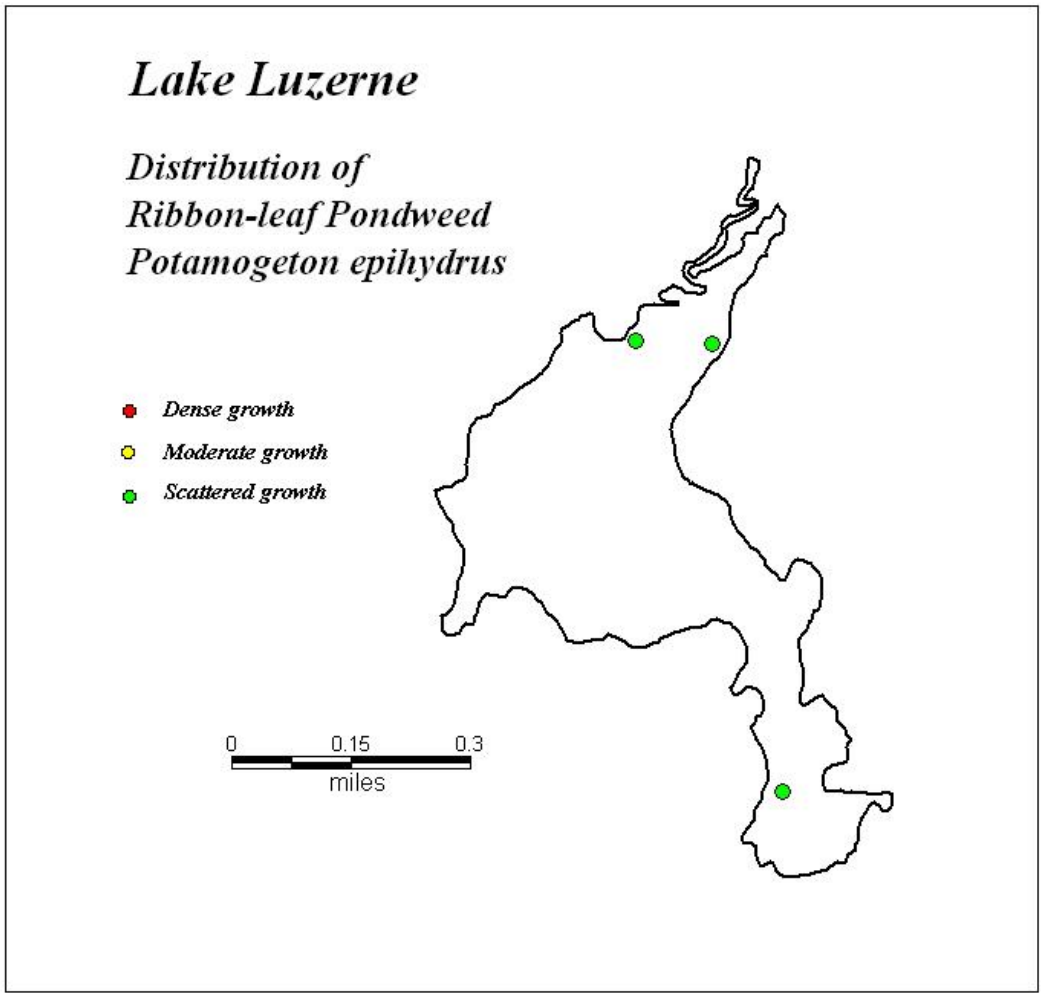

Lake Luzerne
Distribution of
Bushy Pondweed
Najas flexilis
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

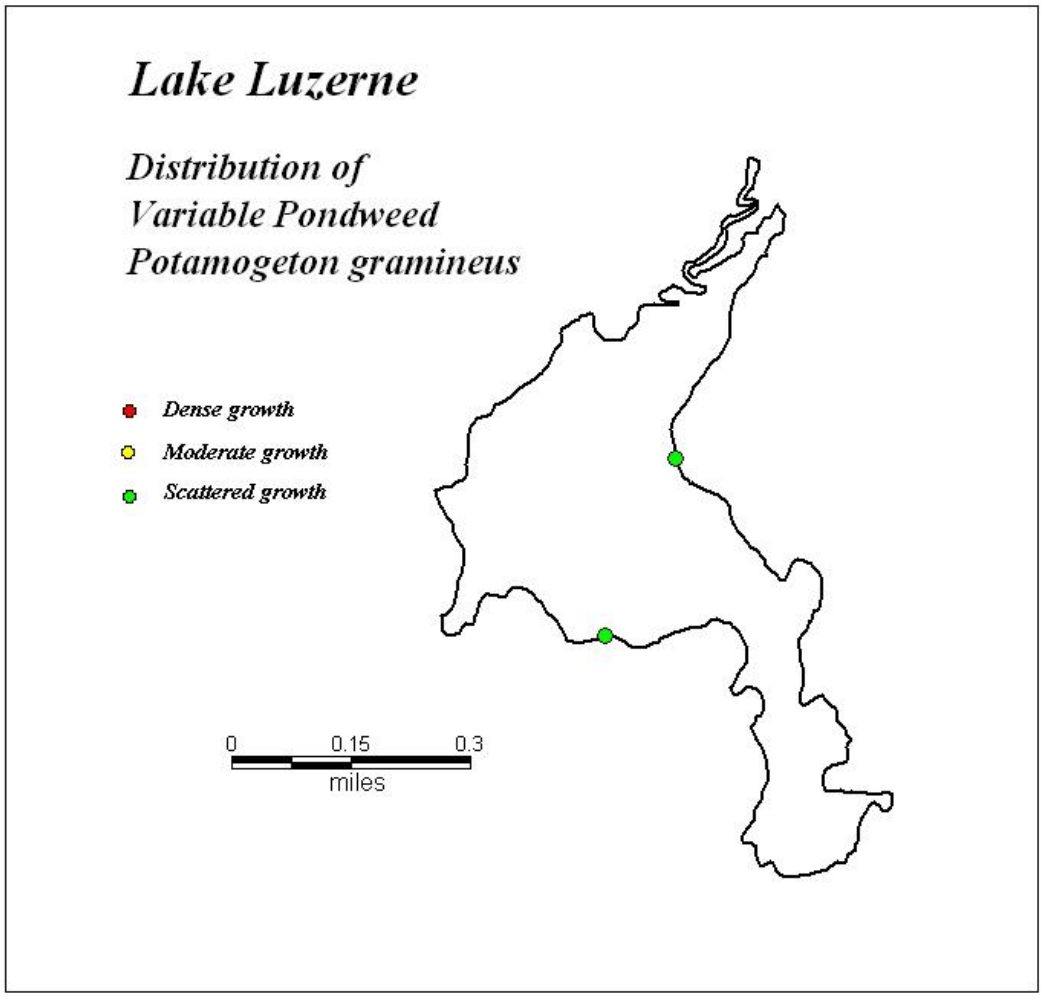

Lake Luzerne
Distribution of
Yellow Pondlily
Nuphar variegata
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

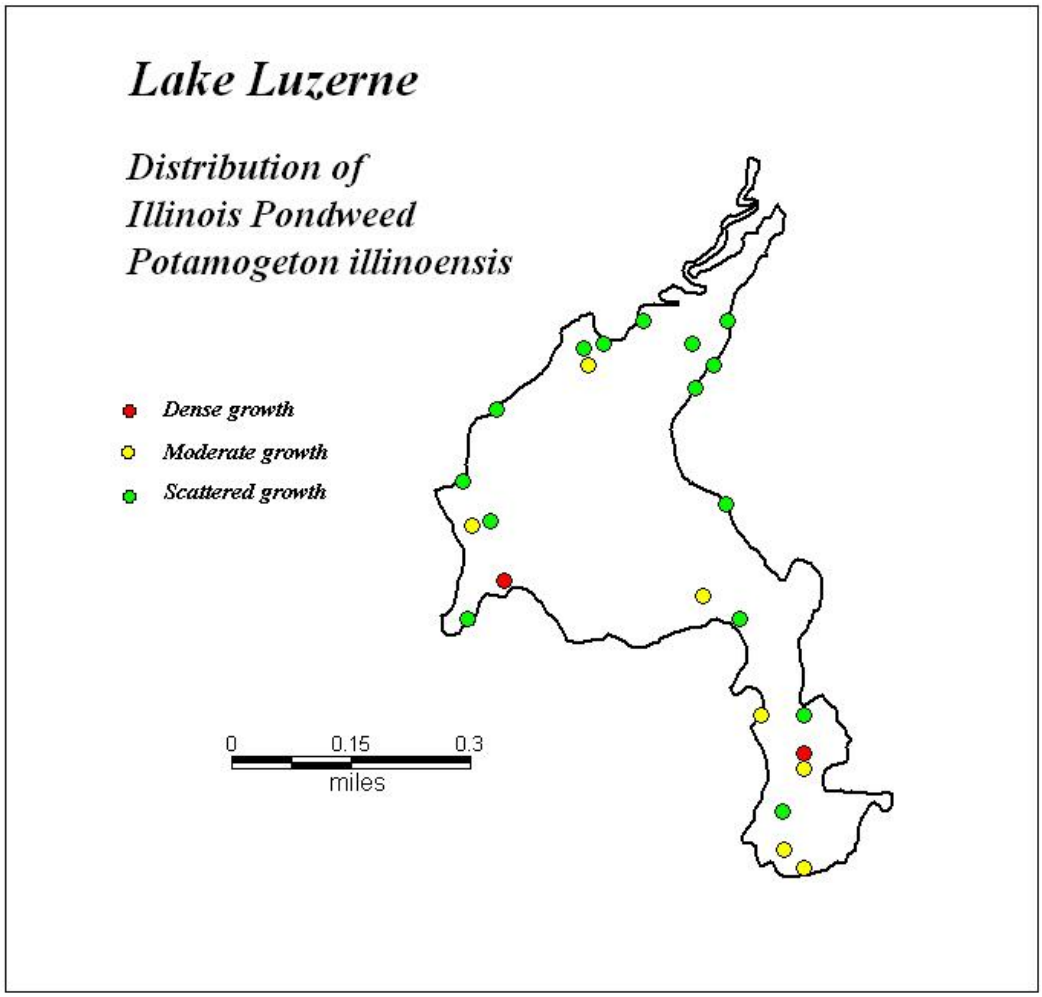

Lake Luzerne
Distribution of
White Waterlily
Nymphaea odorata
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

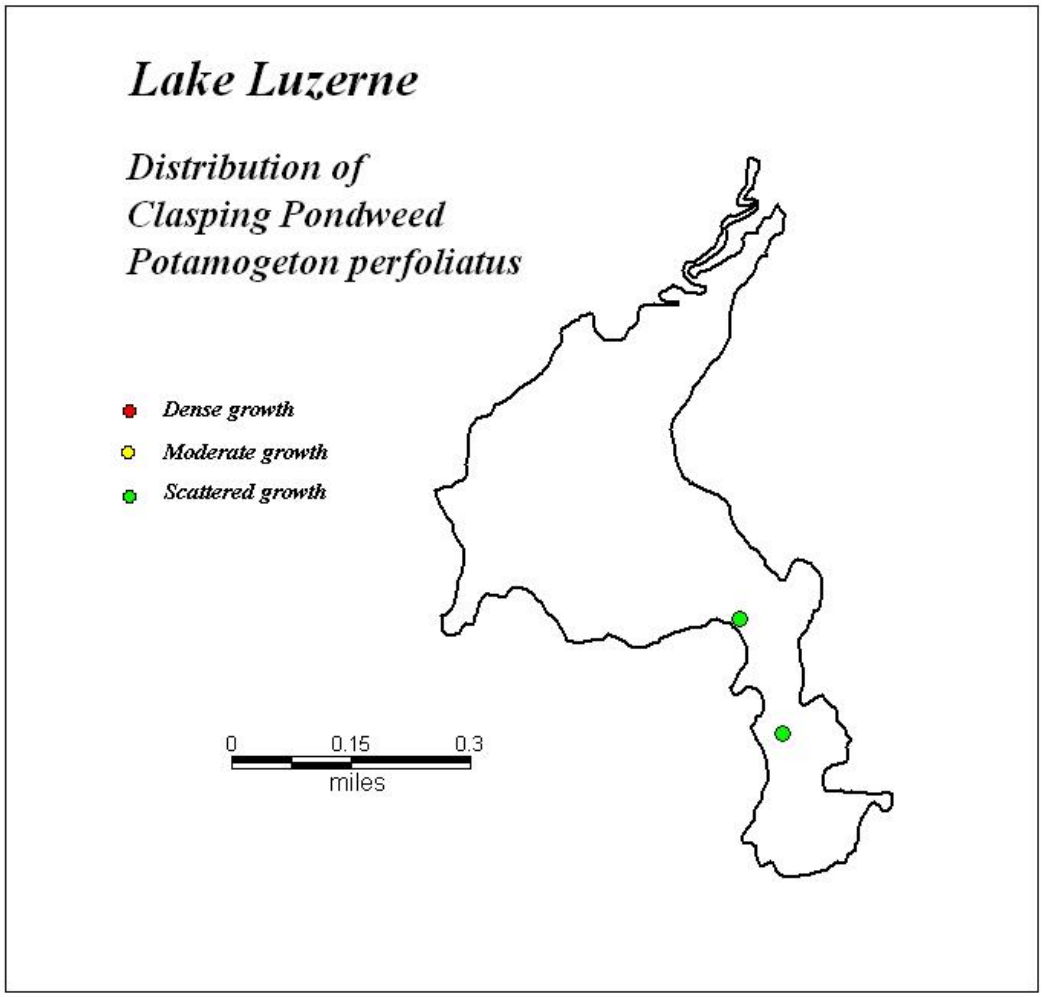

Lake Luzerne
Distribution of
Broad-leaf Pondweed
Potamogeton amplifolius
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

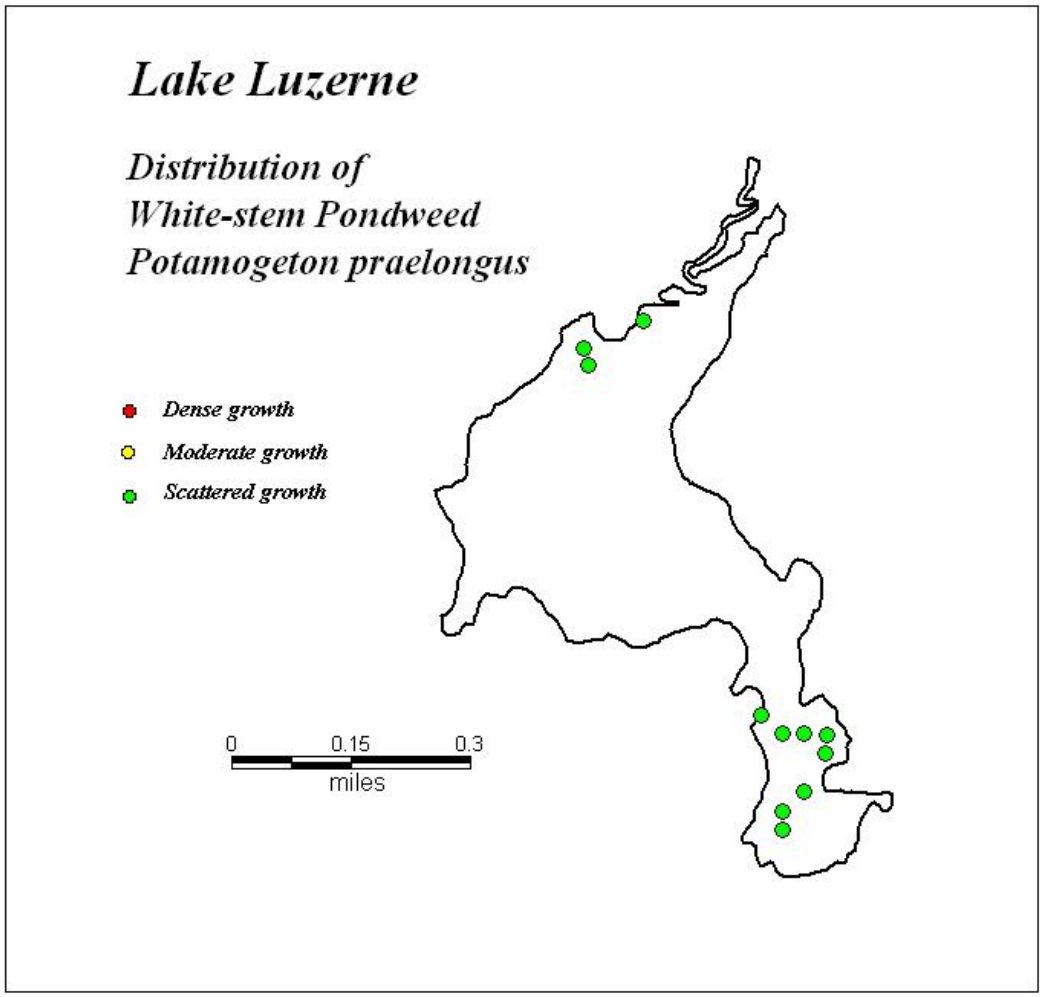

Lake Luzerne
Distribution of
Curly-leaf Pondweed
Potamogeton crispus
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

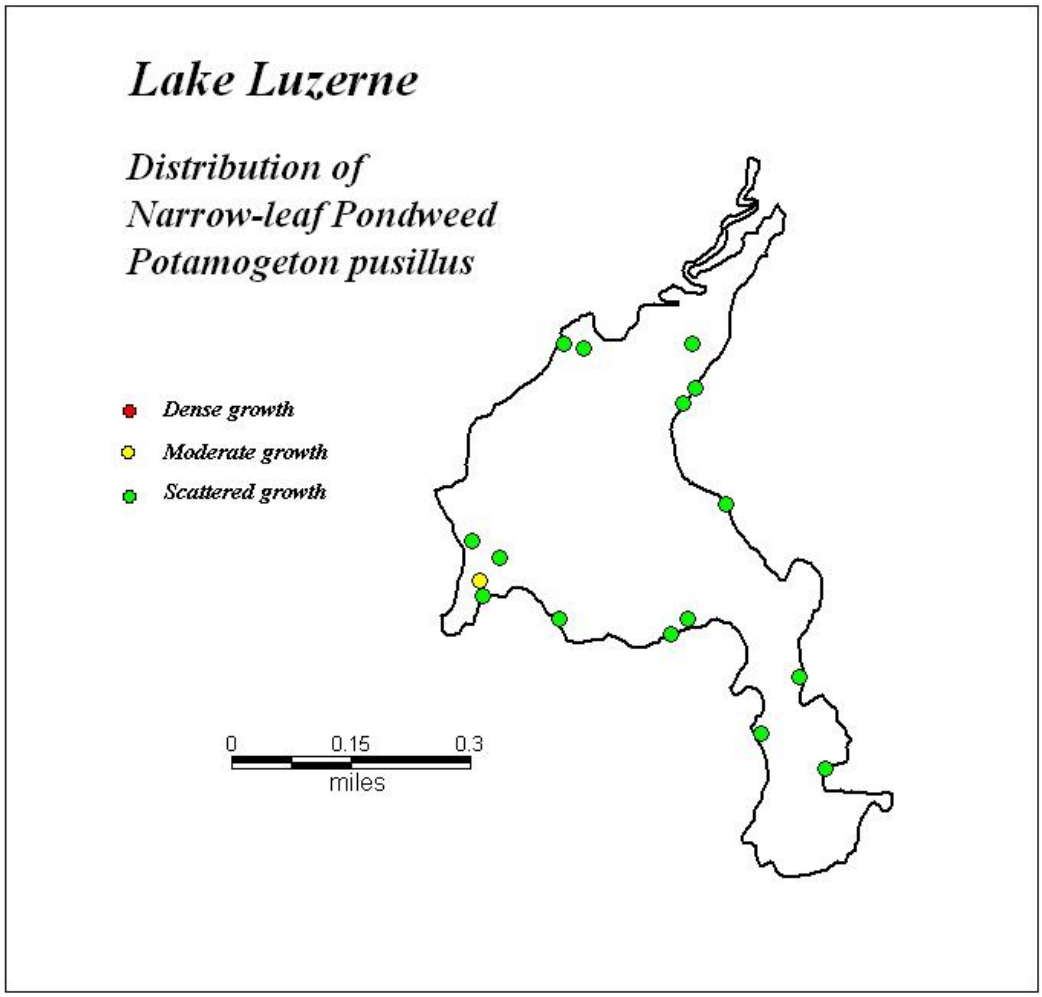

Lake Luzerne
Distribution of
Ribbon-leaf Pondweed
Potamogeton epihydrus
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

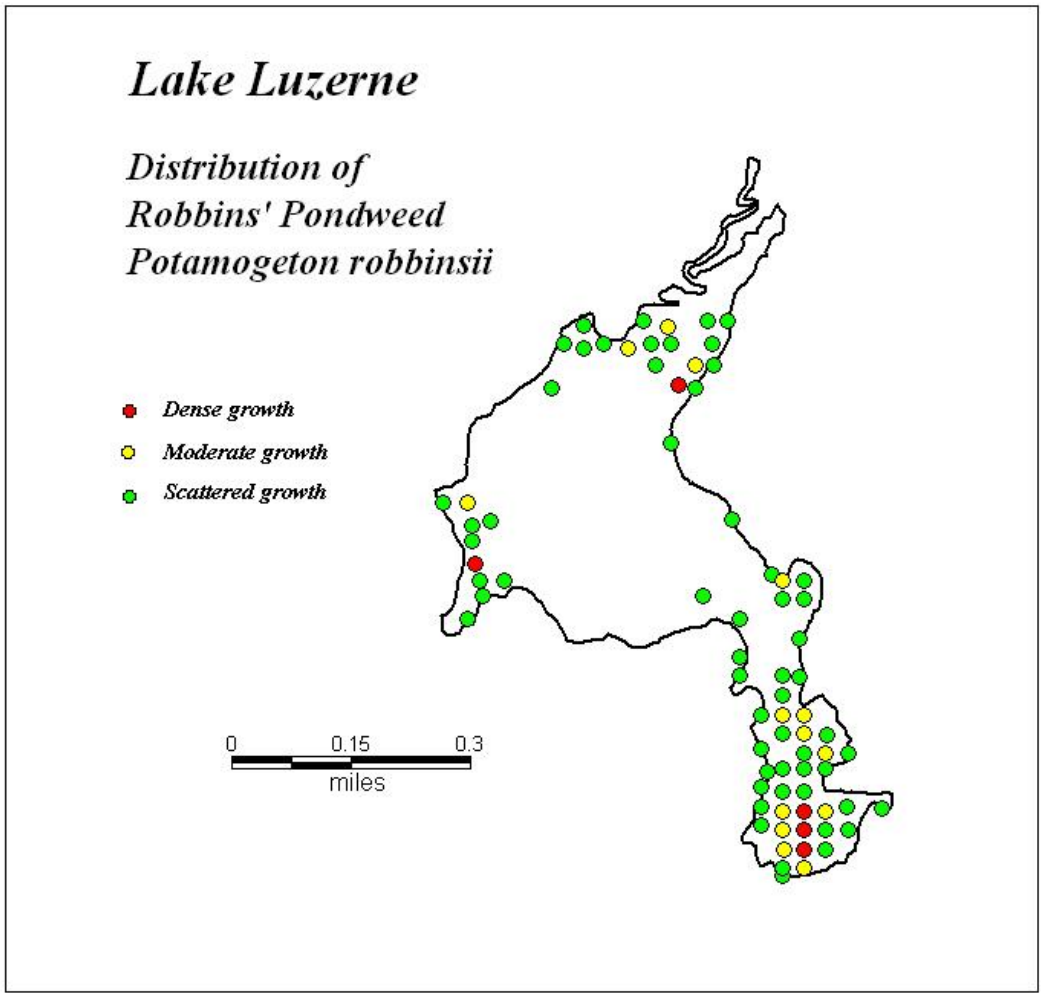

Lake Luzerne
Distribution of
Variable Pondweed
Potamogeton gramineus
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

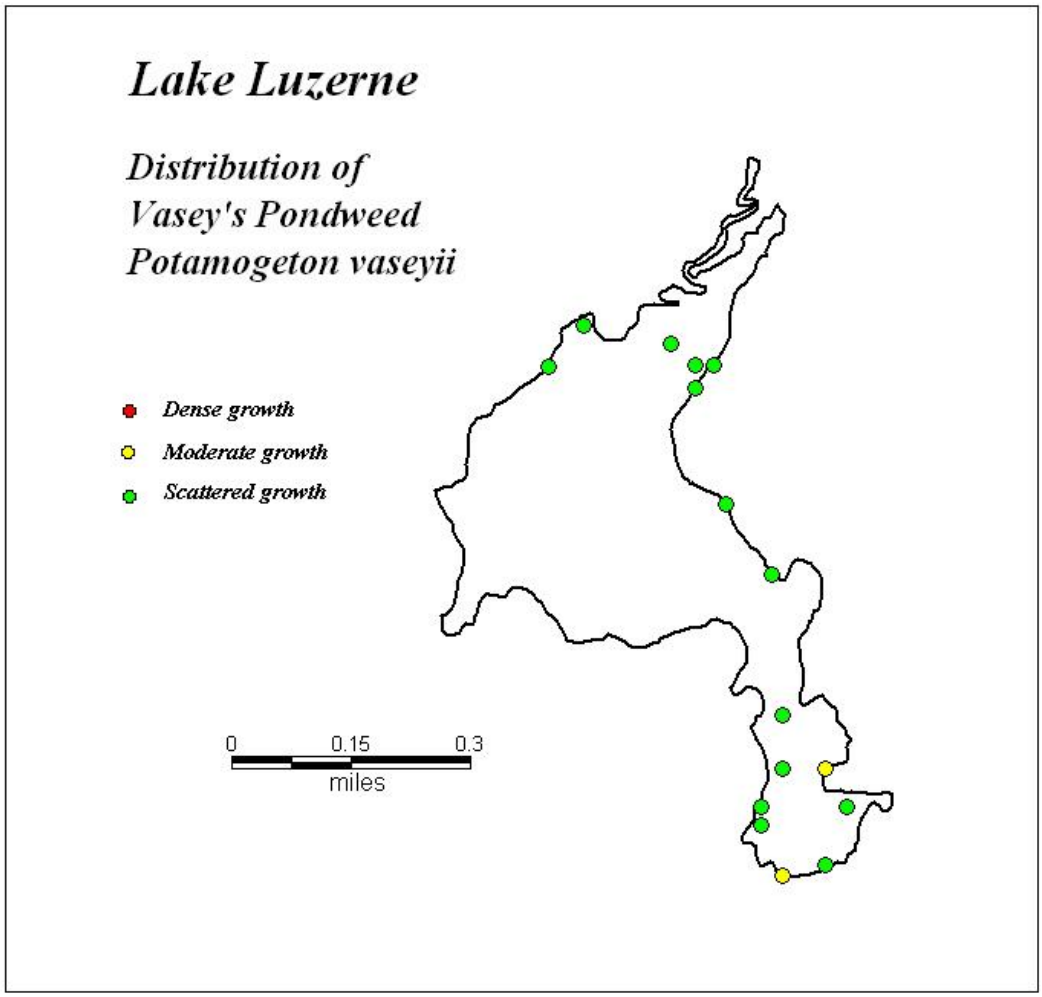

Lake Luzerne
Distribution of
Illinois Pondweed
Potamogeton illinoensis
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

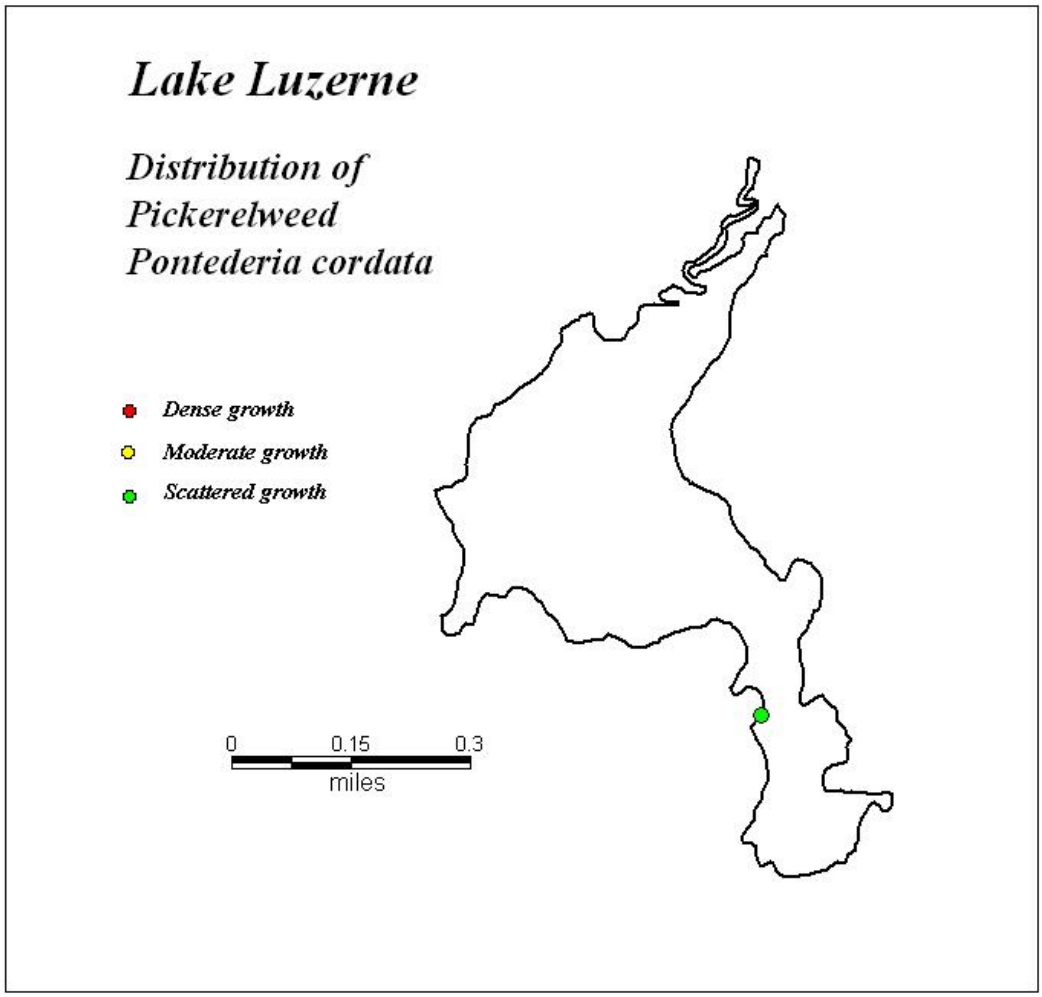

Lake Luzerne
Distribution of
Clasping Pondweed
Potamogeton perfoliatus
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

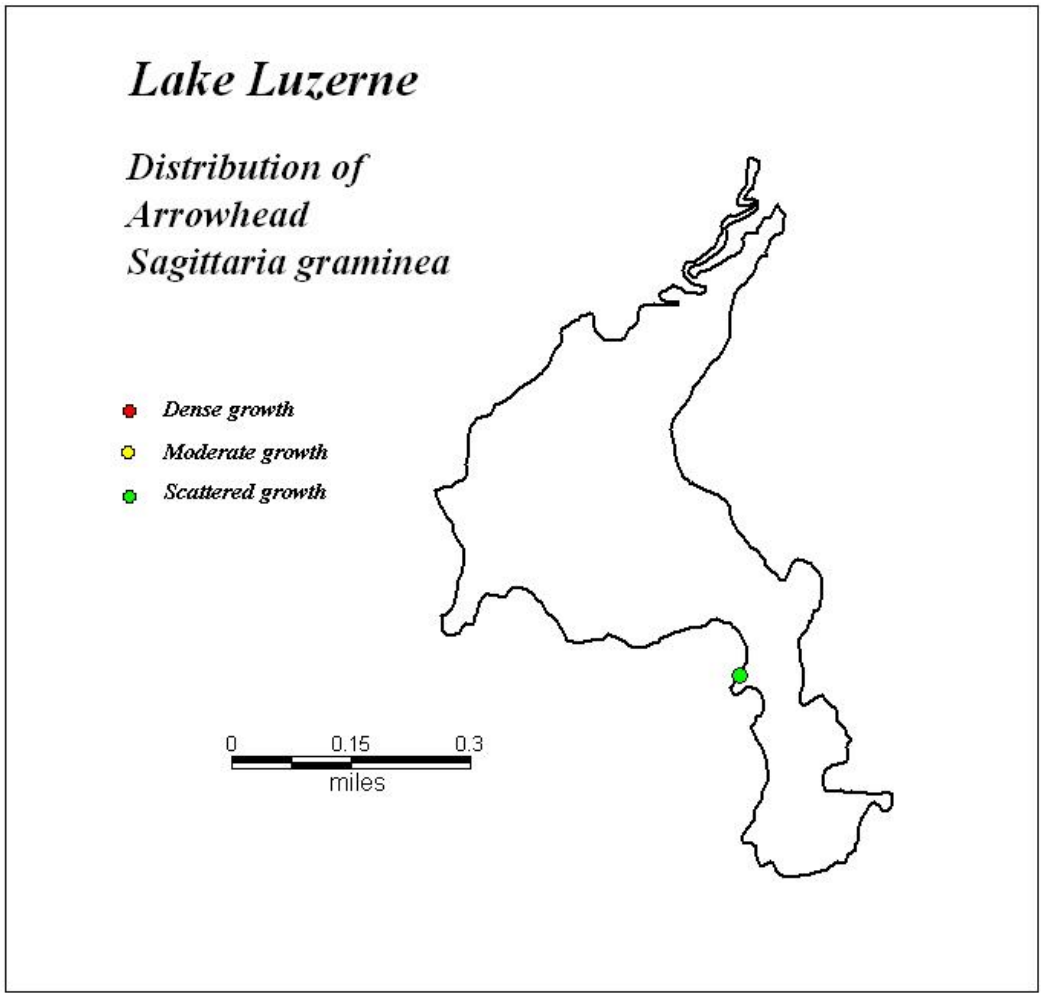

Lake Luzerne
Distribution of
White-stem Pondweed
Potamogeton praelongus
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

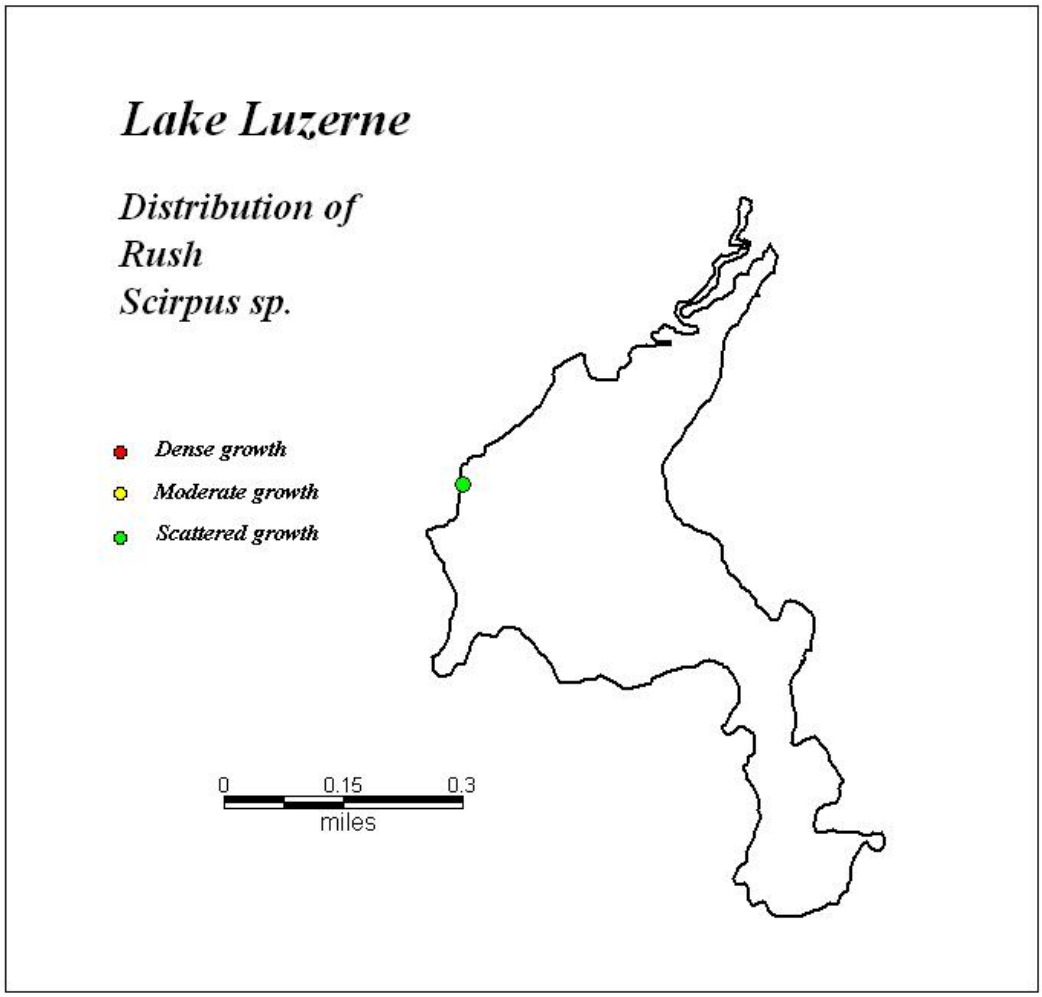

Lake Luzerne
Distribution of
Narrow-leaf Pondweed
Potamogeton pusillus
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

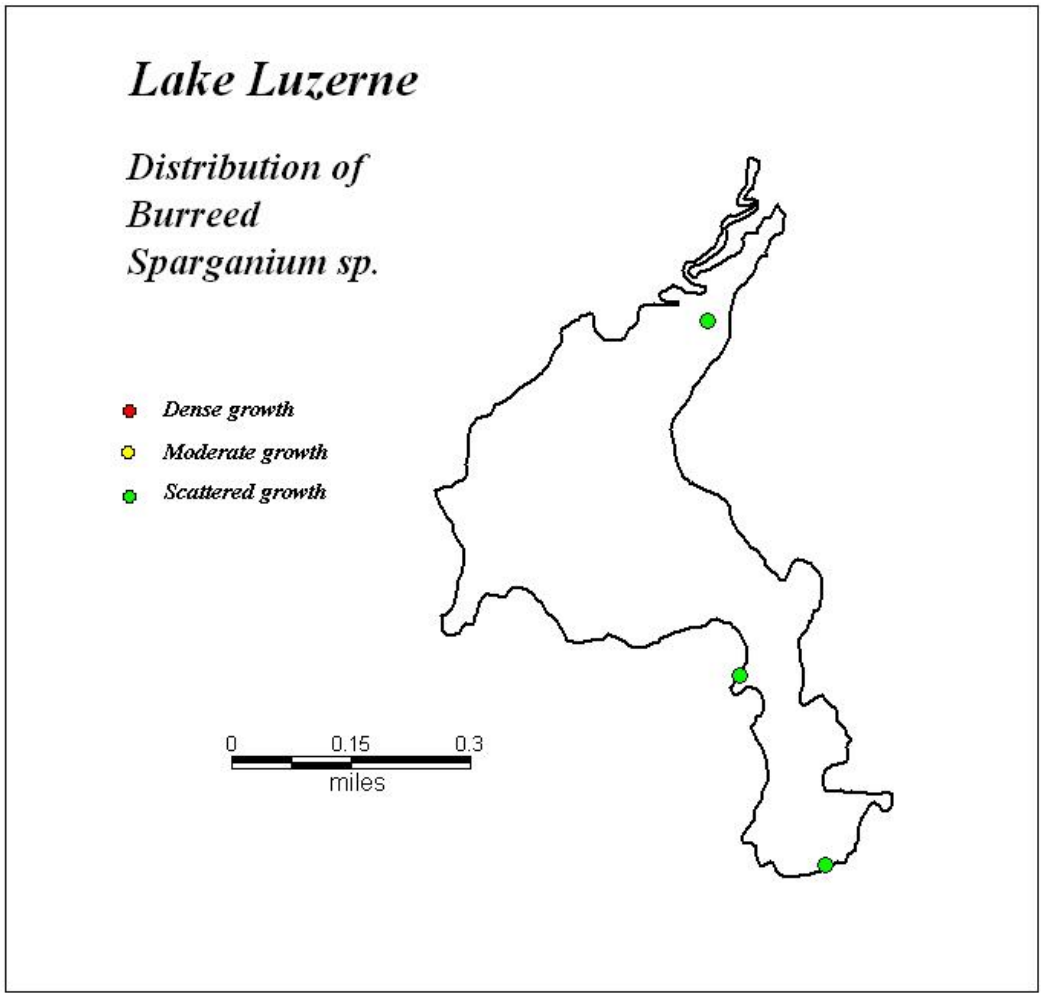

Lake Luzerne
Distribution of
Robbins' Pondweed
Potamogeton robbinsii
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

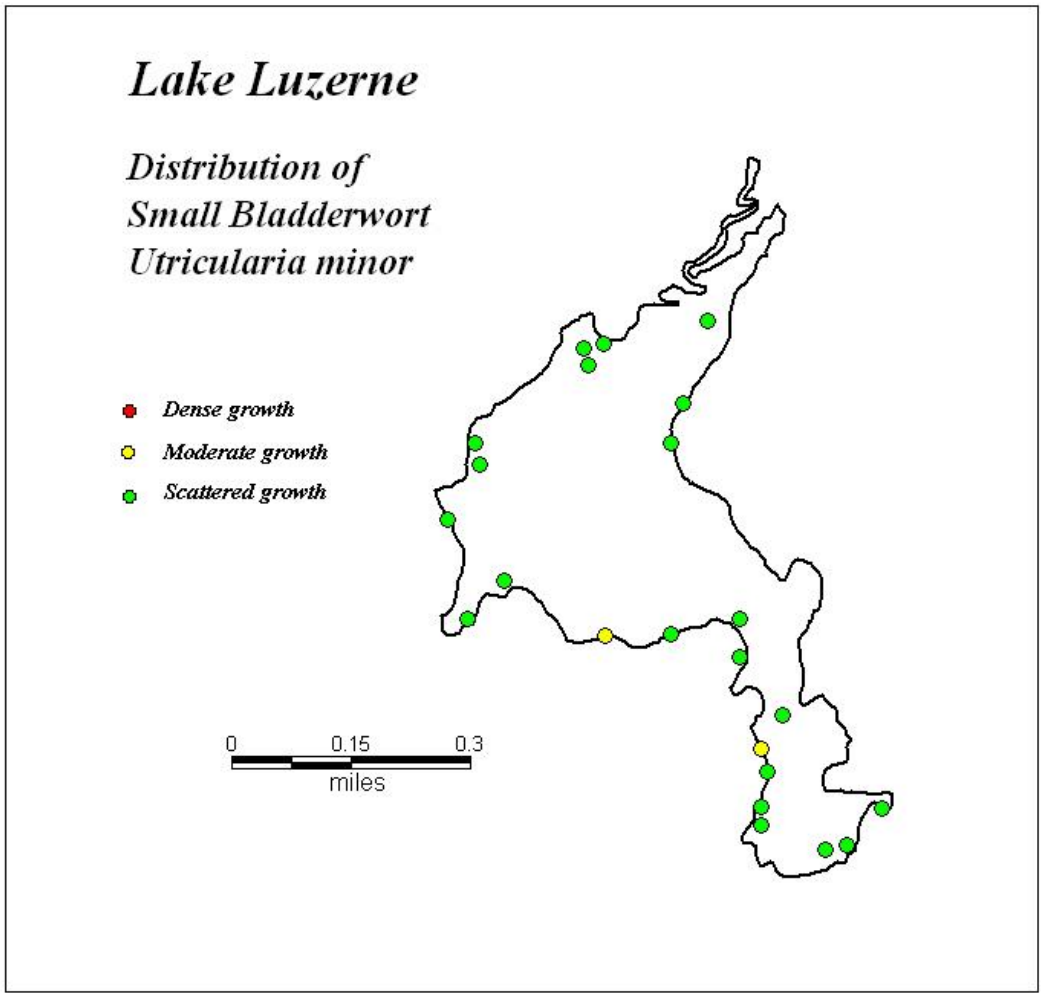

Lake Luzerne
Distribution of
Vasey's Pondweed
Potamogeton vaseyii
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

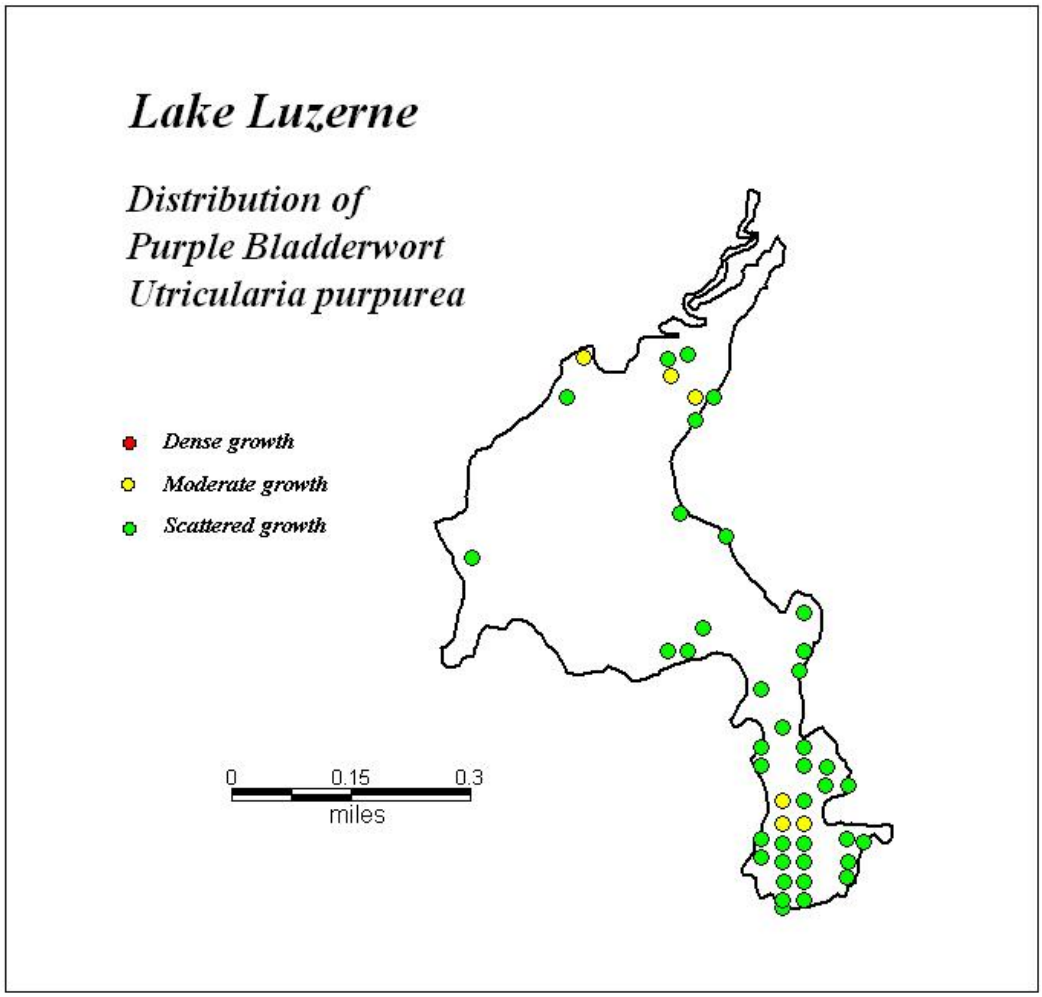

Lake Luzerne
Distribution of
Pickerelweed
Pontederia cordata
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

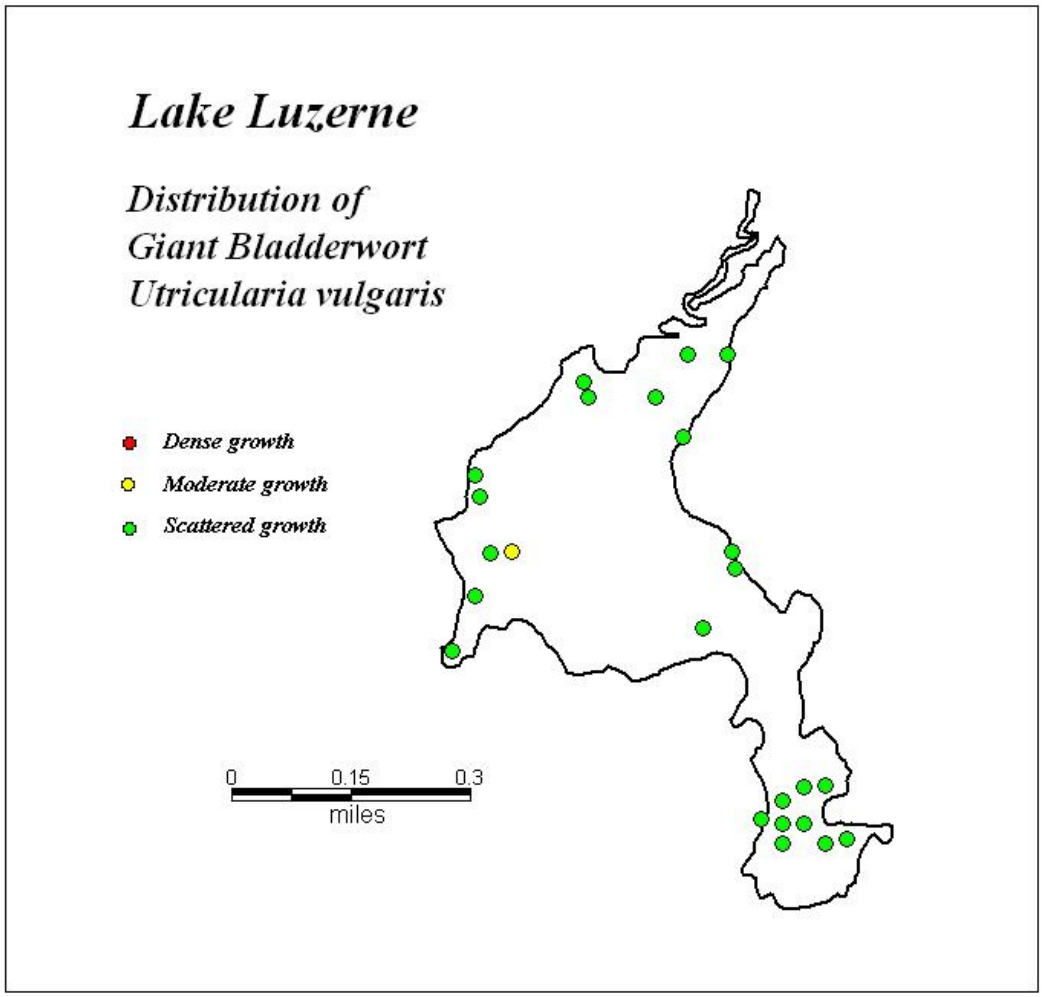

Lake Luzerne
Distribution of
Arrowhead
Sagittaria graminea
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles

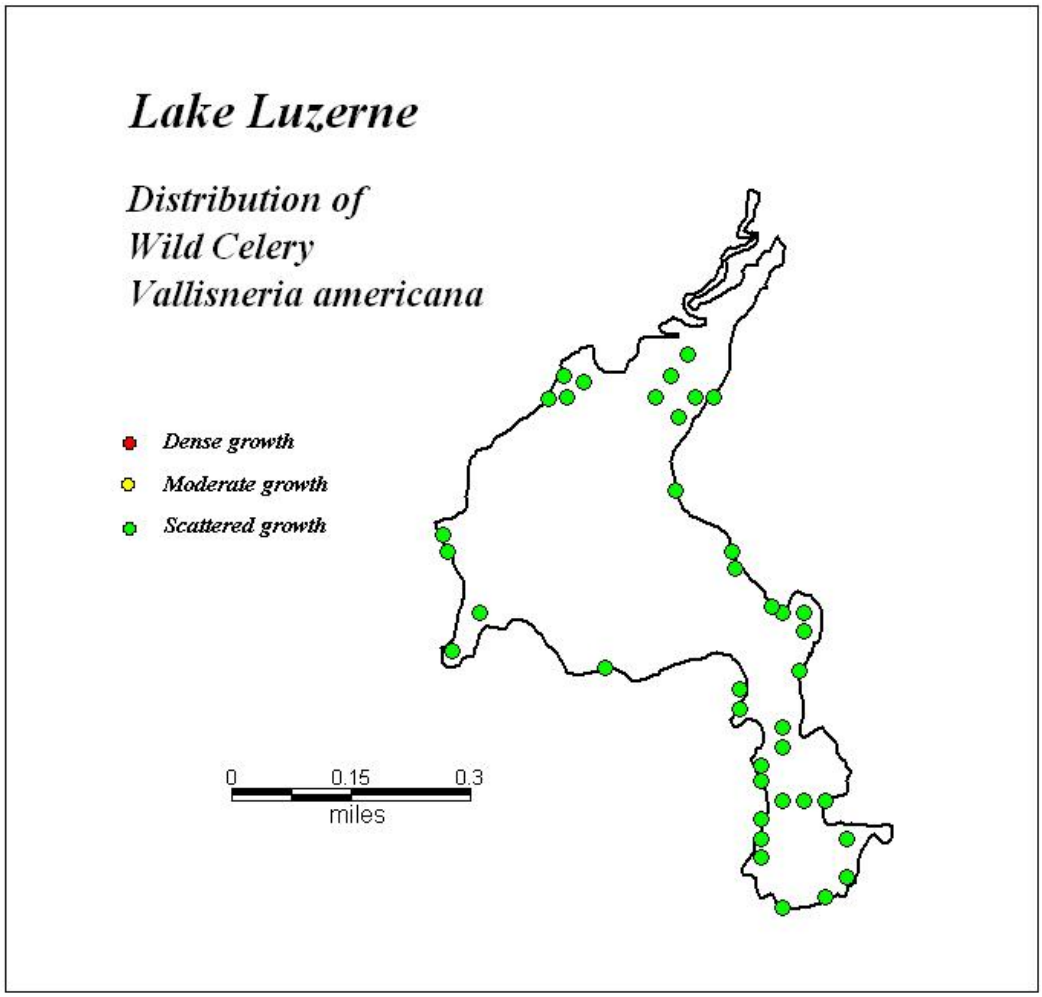

Lake Luzerne
Distribution of
Rush
Scirpus sp.
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles


Lake Luzerne
Distribution of
Burreed
Sparganium sp.
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles


Lake Luzerne
Distribution of
Small Bladderwort
Utricularia minor
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles


Lake Luzerne
Distribution of
Purple Bladderwort
Utricularia purpurea
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles


Lake Luzerne
Distribution of
Giant Bladderwort
Utricularia vulgaris
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles


Lake Luzerne
Distribution of
Wild Celery
Vallisneria americana
Dense growth
Moderate growth
Scattered growth
0
0.15
0.3
miles