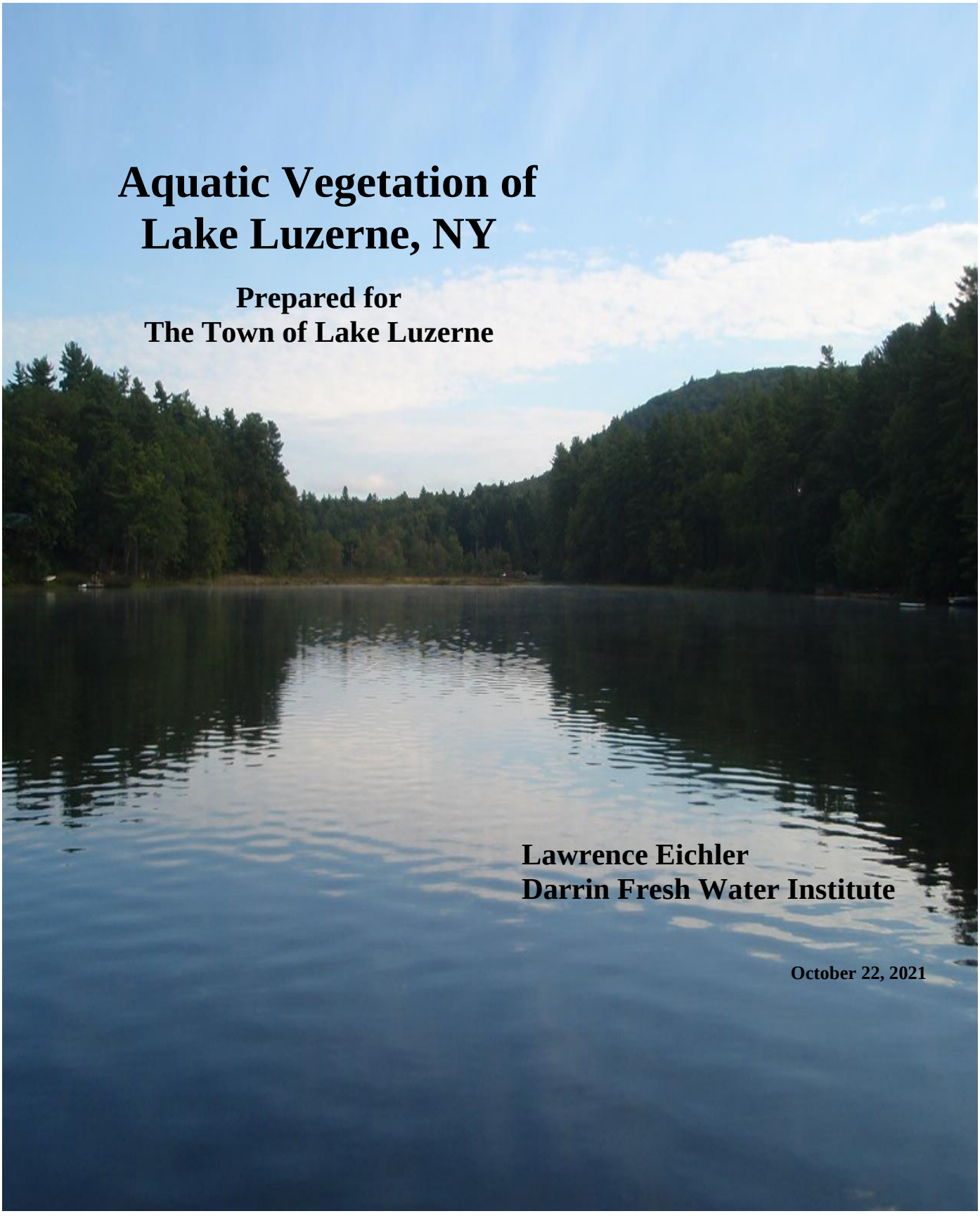

Aquatic Vegetation of Lake Luzerne, NY

Prepared for
The Town of Lake Luzerne

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TABLE OF CONTENTS

Acknowledgements

The author would like to thank Tracy Clothier and Dean Long for their assistance in coordinating lake access, assisting in the upstream surveys and development of the current survey project. Dan Waterhouse of the Town of Lake Luzerne provided the impetus for the current survey.

Background

Quantitative surveys were undertaken for Lake Luzerne, New York, to obtain distribution information on the aquatic plant population with a focus on the invasive aquatic Eurasian watermilfoil, *Myriophyllum spicatum* L. The plant survey was designed to provide data comparable to earlier surveys by the author in 1992, 1998, 2004, 2009, 2010 and 2019. 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 the whole lake, and b) comparison of historical survey results to current conditions, with particular reference to changes in the relative abundance of Eurasian watermilfoil.

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 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. 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. Hand harvesting, diver assisted suction harvesting (DASH) and benthic barrier have been employed over the last decade to manage the expansion of Eurasian watermilfoil.

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), 2007 (King 2007), 2009 (Eichler, 2009), 2010 (Eichler, 2010), 2011 (Allied Biological, 2011), and 2015, 2018 (Schwartzberg, E.G., Hoh, J. and Varin, Z., 2018) and 2019 (Eichler, 2019). The species lists for most surveys are similar. Twenty-seven aquatic plant species were reported in 1989 and 1992, 39 species in 2004, 33 species in both 1998 and 2008, 36 species in 2010 and 40 species in 2019. Between the 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. Additional invasive species, including Curly-leaf Pondweed (*Potamogeton crispus* L.) first reported in 2004 and Brittle Naiad

(*Najas minor*) first reported in 2019, complete the list.

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, Najas guadalupensis, Isoetes echinospora*, and *Vallisneria americana*. 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, 2020). This species is generally found on sandy, wave washed shorelines common to Adirondack lakes. Another species reported for Lake Luzerne is on the NYS Watch List (*Isoetes lacustris*). Its' 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.

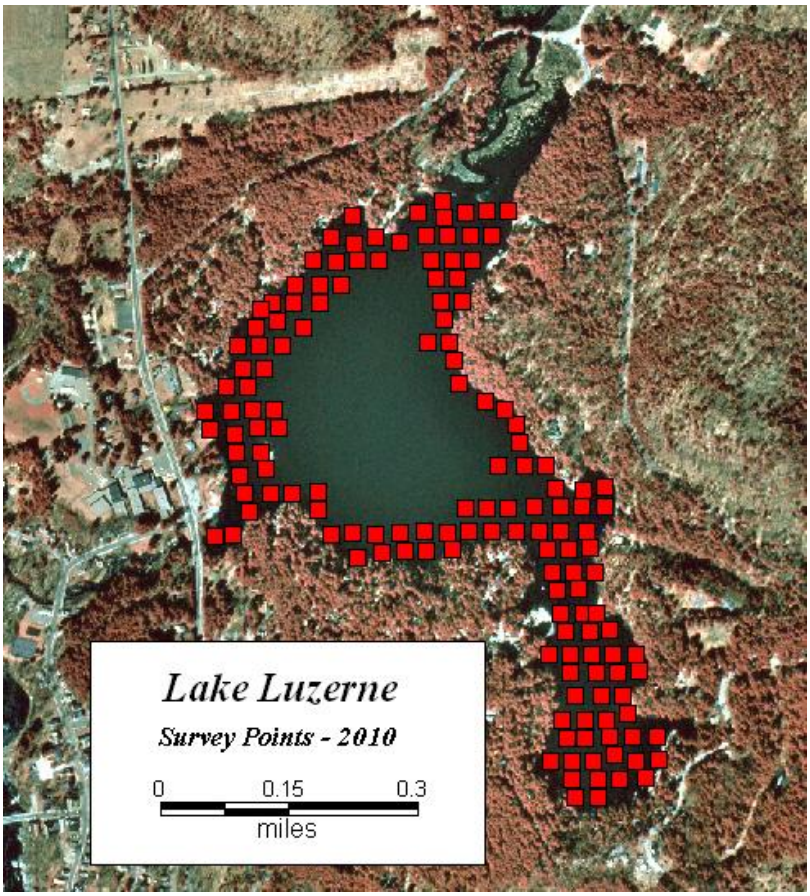
The surficial geology is primarily glacial till, a sand and gravel soil without exposed bedrock. The soil associations are Oakville, Hinckley and Hinckley-Plainfield deposits consisting of loam,

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 159 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 August 31, 2021. Data presented in the summary are on a whole-lake basis and have not been adjusted for the littoral zone only.

Figure 2. Point intercept survey points for Lake Luzerne.



Results and Discussion

Lake Luzerne Open-Lake Survey Results

In August of 2021, the aquatic plant community of Lake Luzerne included thirty-three submersed species, three floating-leaved species, and five emergent species (Table 1). A total of 41 species of aquatic plants were observed with 36 collected by the point intercept survey. Three invasive species (Eurasian watermilfoil) *Myriophyllum spicatum*, (Curly-leaf Pondweed) *Potamogeton crispus* and (BrittleNaiad) *Najas minor* 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.

Species	Common Name	2021	2019	2010	2009	2004
Brasenia schreberi J.F. Gmel	Water Shield	fl	fl	x	x	x
Chara species	Musk Grass	s	s	x	x	x
Elatine minima (Nutt.) Fisch. & C.A. Mey.	Little Elatine	s	s	x	x	x
Eleocharis acicularis (L.) Roemer & Schultes	Spike Rush	e	e	x	x	x
Elodea canadensis Michx.	Waterweed	s	s	x	x	x
Eriocaulon septangulare With.	Pipewort	e	e	x	x	x
Fontinalis sp.	Moss	s	s	x	x	x
Isoetes echinospora Dur.	Quillwort	s	s	x	x	x
Isoetes lacustris L.	Large spored Quillwort			x		x
Lindernia sp.	False Pimpernel	s	s			x
Megalodonta beckii	Water Marigold	s	s	x	x	x
Myriophyllum alterniflorum	Little Milfoil	s	s			x
Myriophyllum sibiricum L.	Northern Milfoil	s	s	x	x	x
Myriophyllum spicatum L.	Eurasian watermilfoil	s	s	x	x	x
Myriophyllum tenellum Kom.	Leafless Milfoil	s	s	x	x	x
Najas flexilis (Willd.) Rostk. & Schmidt.	Naiad	s	s	x	x	x
Najas guadalupensis	Southern Naiad	s	s			
Najas minor	Brittle Naiad	s	s			
Nuphar variegata Engem. Ex Durand	Yellow Water Lily	fl	fl	x	x	x
Nymphaea odorata Ait.	White Water Lily	fl	fl	x	x	x
Pontedaria cordata L.	Pickerelweed	e	e	x	x	x
Potamogeton amplifolius Tuckerm.	Broad leaf Pondweed	s	s	x	x	x
Potamogeton crispus L.	Curly leaf Pondweed	s	s			x
Potamogeton epihydrus Raf.	Ribbon leaf Pondweed	s	s	x	x	x
Potamogeton gramineus L.	Variable Pondweed	s	s			x

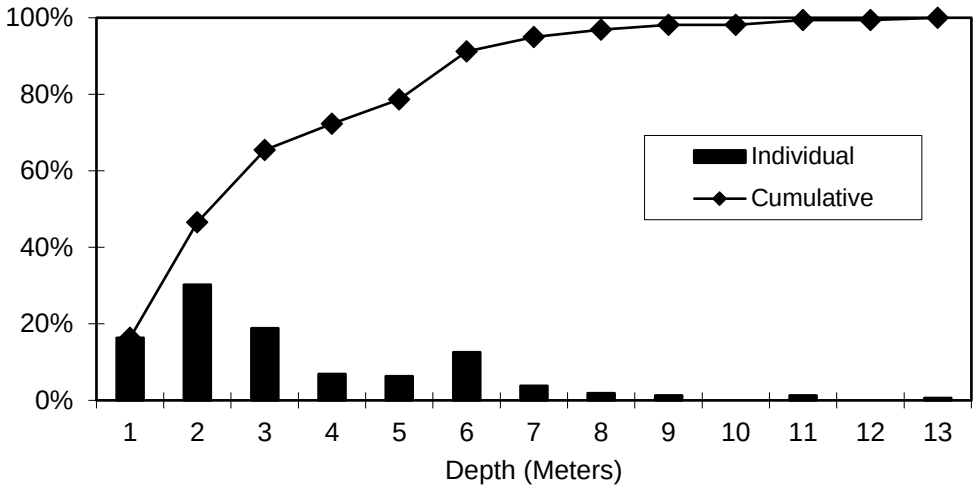
Species	Common Name	2021	2019	2010	2009	2004
Potamogeton illinoensis Morong	Illinois Pondweed	s	s	x	x	x
Potamogeton perfoliatus L.	Heart leaf Pondweed	s	s			x
Potamogeton praelongus Wulfen	White stem Pondweed	s	s	x	x	x
Potamogeton pusillus L.	Narrow leaf Pondweed	s	s	x	x	x
Potamogeton richardsonii (Ar. Benn) Rydb.	Richardsons Pondweed	s	s			x
Potamogeton robbinsii Oakes	Robbins Pondweed	s	s	x	x	x
Potamogeton spirillus Tuckerm.	Small Pondweed			x	x	x
Potamogeton vaseyii Robbins	Vasey's Pondweed	s	s	x	x	x
Potamogeton zosteriformis Fern.	Flat Stem Pondweed	s	s			x
Sagittaria graminea Michx.	Arrowhead	s	s	x	x	x
Scirpus spp.	Rush	s	s	x		
Sparganium sp.	Bur Reed	e	e	x	x	x
Typha latifolia L.	Cattail	e	e	x	x	x
Utricularia intermedia Hayne	Bladderwort	s				x
Utricularia gibba L.	Humped Bladderwort	s	s	x	x	x
Utricularia purpurea Hayne	Purple Bladderwort	s	s	x	x	
Utricularia vulgaris L.	Great Bladderwort	s	s			x
Vallisneria americana L.	Duck Celery	s	s	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 non-target impacts of management should be sensitive to numerous 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 7 meters (16 to 22 feet). While Eurasian watermilfoil occurred throughout Lake Luzerne, dense growth typically was found in depths from 3 to 10 feet. 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

Maps of the distribution of all aquatic plant species for Lake Luzerne are included in Appendix B, Figures B1–B19. 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 41 species of aquatic plants were observed with 36 collected by the point intercept survey. Southern naiad, *Najas guadalupensis,* was the most common species (44% of survey points). Eurasian watermilfoil was a common species lakewide, ranked third by frequency of occurrence (26% of survey points). A number of native species were also commonly observed, including *Potamogeton robbinsii* (33% of survey points), *Chara/Nitella* spp. (21%), *Utricularia purpurea* (21%), *Vallisneria americana* (18%), *Potamogeton praelongus* (16%), *Potamogeton illinoensis* (12%), *Nymphaea odorata* (11%), *Utricularia gibba* (8%), *Brasenia schreberi* (8%), *Najas flexilis* (7%), and *Potamogeton amplifolius* (6%).

Table 2. Aquatic plant percent frequency by species for Lake Luzerne.

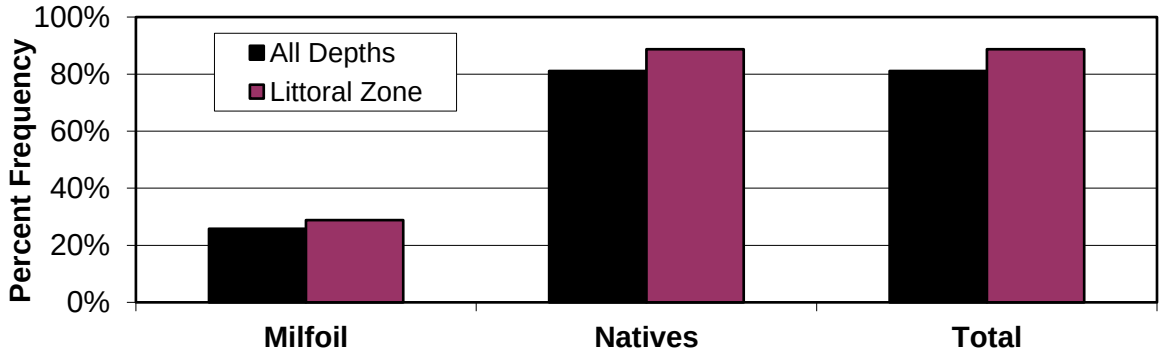
Species	2021	2019	2010	2009	2004
Brasenia schreberi	8.2%	7.1%	7.6%	9.7%	
Chara species	21.4%	37.4%	42.9%	37.1%	77.1%
Eleocharis acicularis (L.) Roemer & Schultes	1.9%	1.9%	2.5%	3.2%	
Elodea canadensis Michx.	2.5%	14.8%	14.3%	30.6%	45.8%
Eriocaulon septangulare	0.6%	0.6%	0.8%	1.6%	
Fontinalis	4.4%	5.2%	6.7%	4.8%	
Isoetes echinospora	0.6%	2.6%	1.7%		
Isoetes lacustris			1.7%		
Myriophyllum alterniflorum	0.6%	0.6%	0.8%		
Megalodonta beckii	2.5%	2.6%	0.8%	4.8%	
Myriophyllum sibiricum	4.4%	7.7%	11.8%	12.9%	47.9%
Myriophyllum spicatum L.	25.8%	32.3%	21.8%	45.2%	60.4%
Myriophyllum tenellum	3.8%	2.6%	3.4%	4.8%	31.3%
Najas flexilis	6.9%	13.5%	10.1%		47.9
Najas guadalupensis	44.0%	25.2%			
Najas minor	0.6%	1.9%			
Nuphar variegata	1.3%	1.9%	0.8%	1.6%	
Nymphaea odorata Ait.	11.3%	9.7%	6.7%	6.5%	
Pontedaria cordata		0.6%		1.6%	
Potamogeton amplifolius	5.7%	7.1%	0.8%	6.5%	
Potamogeton crispus	1.9%	0.6%	0.8%		
Potamogeton epihydrus	1.9%	1.9%	2.5%	1.6%	50.0%
Potamogeton illinoensis	11.9%	21.9%	22.7%	8.1%	
Potamogeton gramineus	5.0%	3.9%			
Potamogeton perfoliatus	0.6%	1.9%			
Potamogeton praelongus	16.4%	9.0%	9.2%	9.7%	
Potamogeton pusillus L.	3.8%	5.8%	14.3%	1.6%	
Potamogeton robbinsii	33.3%	45.2%	57.1%	58.1%	58.3%
Potamogeton vaseyi	2.5%	9.0%	11.8%	16.1%	39.6%
Sagittaria graminea	2.5%	5.2%	0.8%	1.6%	
Scirpus sp.	1.3%	3.2%	0.8%		
Sparganium spp.	4.4%	0.6%	1.7%	3.2%	
Utricularia gibba	8.2%	14.2%	12.6%	46.8%	
Utricularia intermedia	1.3%				
Utricularia purpurea	21.4%	21.9%	37.0%	37.1%	
Utricularia vulgaris	1.9%	9.0%	23.5%		39.6%
Vallisneria americana L.	17.6%	20.0%	26.9%	35.5%	62.5%

In 2019, Robbins pondweed, *Potamogeton robbinsii* was the most common species (45% of survey points). Eurasian watermilfoil was ranked third by frequency of occurrence lakewide (32% of survey points). A number of native species were also commonly observed, and included

Chara spp. (37%), *Najas guadalupensis* (25%), *Utricularia purpurea* (22%), *Potamogeton illinoensis* (22%), *Vallisneria americana* (20%), *Elodea canadensis* (15%), *Utricularia gibba* (14%), *Utricularia vulgaris* (9%), *Potamogeton vaseyii* (9%), *Potamogeton praelongus* (9%), *Myriophyllum sibiricum* (8%), and *Brasenia schreberi* (7%). In 2009, a 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). *Najas guadalupensis*, reported in trace amounts in 1998 and 2011, became a dominant member of the plant community in 2019 and 2021.

Comparing frequency of occurrence between 2019 and 2021 (Table 2), twenty three species showed a decline in frequency of occurrence and 9 species increased. Of the 23 species showing declines, three were native species showing declines of 1% or less. Three native species showed substantial declines over time, *Elodea canadensis, Utricularia vulgaris* and *Utricularia gibba*. 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. One species, *Najas guadalupensis,* was absent prior to 2019 but abundant in the 2019 and 2021 surveys. 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. Lake Luzerne has experienced a similar expansion of this 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.

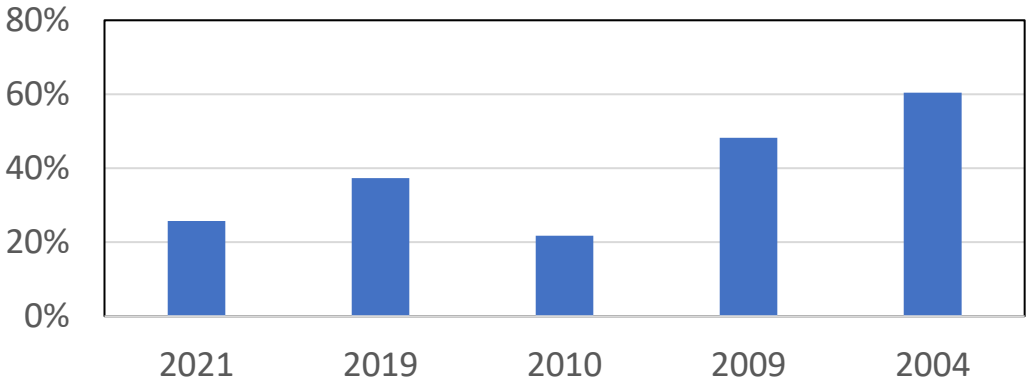
Figure 4. Lake Luzerne frequency of occurrence summaries lakewide in 2021.



Eighty-one percent of whole lake sampling points were vegetated by at least one plant species in 2021 (Figure 4) comparable to the 85%, 84% and 89% reported for 2019, 2010 and 2009,

respectively. In depths of 6 m or less, representing the littoral zone, 89% of survey points contained native species in 2021, while 98% were reported in 2019 and 95% of survey points were reported in both 2009 and 2010 surveys. Eurasian watermilfoil was present in 26% of survey points in 2021, 32% in 2019 and 24% of survey points in 2010, a slight change over 9 years. A general decline in Eurasian watermilfoil abundance was observed between 2004 and 2010 (Figure 5), most likely a result of aquatic plant management efforts.

Figure 5. Lake Luzerne Eurasian watermilfoil frequency of occurrence.



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 2.54 and 2.82 species per sample point, respectively. When comparing only survey points within the littoral zone, native and total species richness remain similar, at 2.82 and 3.14 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.

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

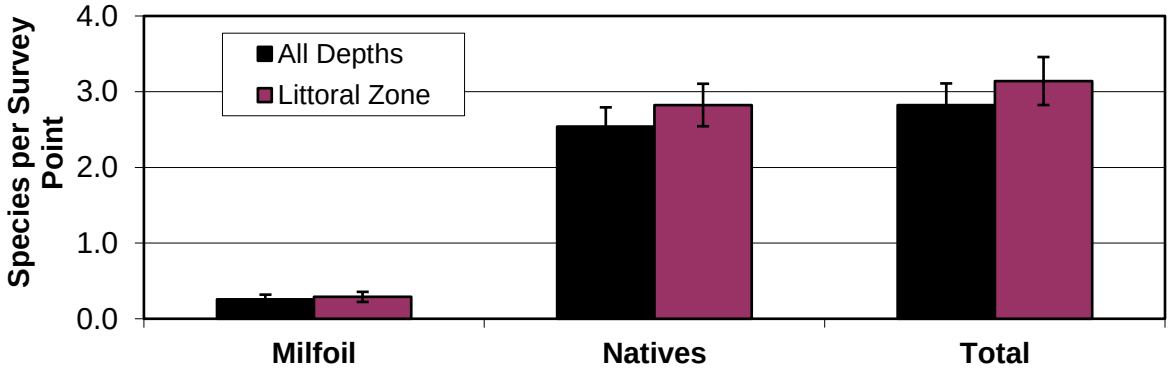


Table 4. Species richness comparison between the 2010 (post-treatment), 2019 and 2021 surveys

Plant Grouping	Water Depth Class	Summary Statistic	Lakewide Surveys		
			2010	2019	2021
Native plant species	Whole Lake (all depths)	Mean	2.94	3.14	2.54
		N	152	155	159
		Std. Error	0.17	0.18	0.15
	Points with depths <6m	Mean	3.35	3.59	2.82
		N	134	134	142
		Std. Error	0.17	0.17	0.16
	Points with depths <2m	Mean	4.5	4.53	3.78
		N	53	58	60
		Std. Error	0.24	0.23	0.24
All plant species	Whole Lake (all depths)	Mean	3.13	3.48	2.82
		N	152	155	159
		Std. Error	0.18	0.20	0.17
	Points with depths <6m	Mean	3.56	3.99	3.14
		N	134	134	142
		Std. Error	0.18	0.19	0.17
	Points with depths <2m	Mean	4.72	4.95	4.25
		N	53	58	60
		Std. Error	0.26	0.25	0.26

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). Native and total species richness declined slightly between 2019 and 2021, while the abundance of Eurasian watermilfoil also declined. Natural interannual variability in species richness may account for these differences.

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 diver assisted suction harvesting. 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, 2009, 2010 and 2019). 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.

Lake Luzerne supports a diverse native plant community with thirty-three 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, greatly reducing Eurasian watermilfoil abundance in this area of the lake. Hand and diver assisted suction harvesting (DASH) have been conducted since that time. A third invasive species, Brittle Naiad (*Najas minor*) was first reported in 2019.

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 41 species were recorded in open-lake surveys of Lake Luzerne in 2021, comparable to previous surveys in 2019 (40 species), 2004 (39 species), 2010 (36 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. The large number of aquatic plant species is a testament to the diversity of habitats present in Lake Luzerne and the exceptional water quality of the lake.

Southern naiad, *Najas guadalupensis*, was the most common species (44% of survey points) in 2021. This species has been reported to reach nuisance levels in area lakes. Eurasian watermilfoil was a common species lakewide, ranked third by frequency of occurrence (26% of survey points). A number of native species were also commonly observed, including *Potamogeton robbinsii* (33% of survey points), *Chara/Nitella* spp. (21%), *Utricularia purpurea* (21%), *Vallisneria americana* (18%), *Potamogeton praelongus* (16%), *Potamogeton illinoensis* (12%), *Nymphaea odorata* (11%), *Utricularia gibba* (8%), *Brasenia schreberi* (8%), *Najas flexilis* (7%), and *Potamogeton amplifolius* (6%).

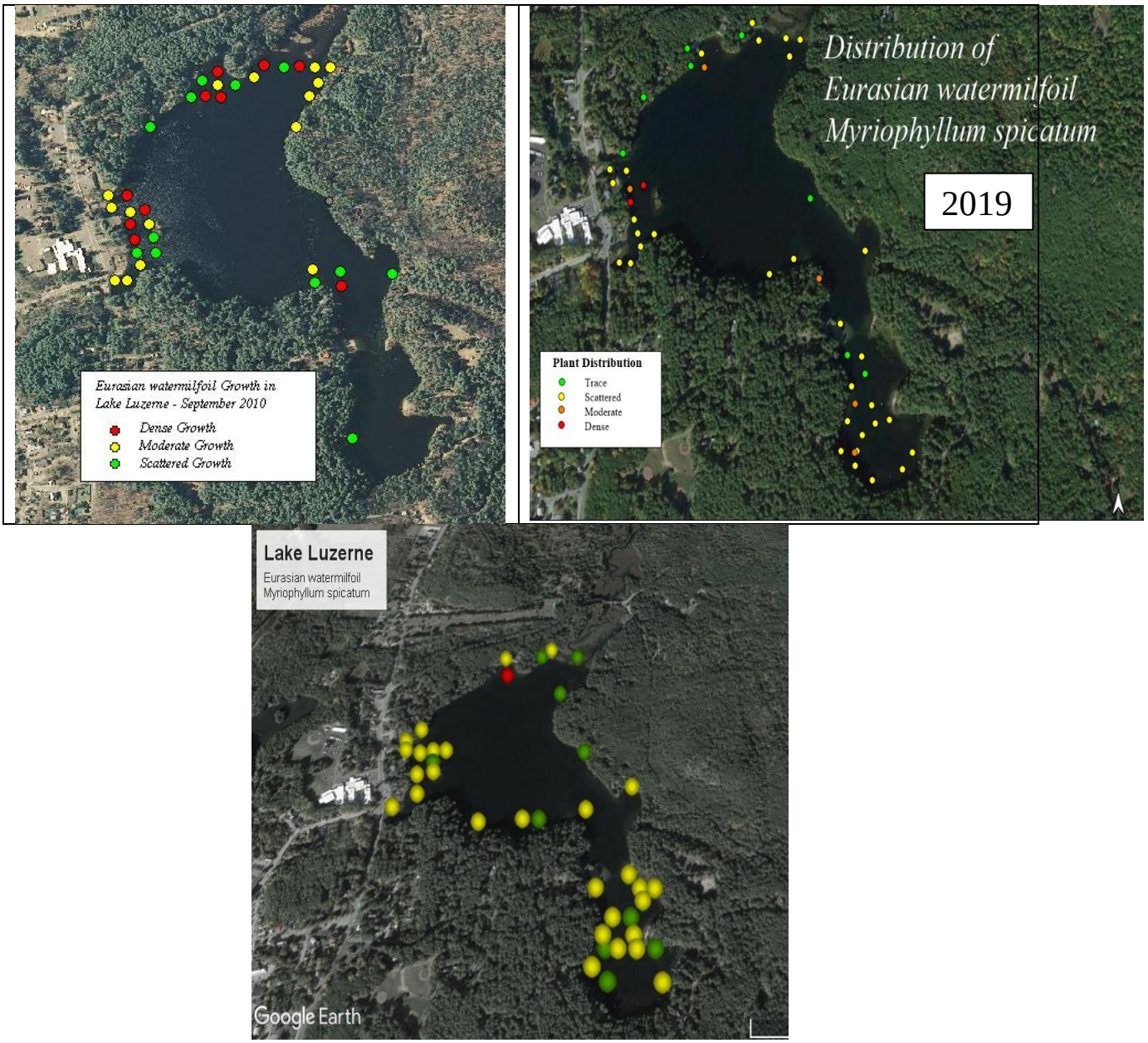
These results are similar to 2019, when Robbins pondweed, *Potamogeton robbinsii* was the most common species (45% of survey points). Eurasian watermilfoil was also dominant in 2019

ranked third by frequency of occurrence (32% of survey points). A number of native species were also commonly observed, including *Chara* spp. (37% of survey points), *Najas guadalupensis* (25%), *Utricularia purpurea* (22%), *Potamogeton illinoensis* (22%), *Vallisneria americana* (20%), *Elodea canadensis* (15%), *Utricularia gibba* (14%), *Utricularia vulgaris* (9%), *Potamogeton vaseyii* (9%), *Potamogeton praelongus* (9%), *Myriophyllum sibiricum* (8%), and *Brasenia schreberi* (7%). These results are quite similar to frequency of occurrence results for the 2010 survey: *Potamogeton robbinsii* (57% of survey points), *Chara* (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%). The preponderance of native species points to the success of the management effort to generally control the growth of Eurasian watermilfoil. The dominance of Southern Naiad (*Najas guadalupensis*), in the 2019 and 2021 surveys suggests a potential for future nuisance levels of growth.

Eighty-one percent of whole lake sampling points were vegetated by at least one plant species in 2021 comparable to the 85% reported in 2019, 84% reported in 2010 and 89% reported for 2009. In depths of 6 m or less, representing the littoral zone, 89% of survey points contained native species in 2021, while 98% were reported in 2019 and 95% of survey points were reported in both 2009 and 2010 surveys. Eurasian watermilfoil was present in 26% of survey points in 2021, 32% in 2019 and 24% of survey points in 2010, a slight change over 9 years. Regrowth of Eurasian watermilfoil in the southeastern embayment, which was treated with herbicide in 2010, largely accounted for the difference.

In 2021, whole lake native species richness was comparable to total species richness, reported at 2.54 and 2.82 species per sample point, respectively. When comparing only survey points within the littoral zone, native and total species richness remain similar, at 2.82 and 3.14 species per sample point, and within the relative error of the measurement. Similar results were reported in 2019, at 3.14 and 3.48 species per sample point, respectively. For 2010, whole lake native species richness was reported at 2.94 and 3.13 species per sample point respectively. When comparing only survey points within the littoral zone for 2019, native and total species richness remained similar, at 3.59 and 3.99 species per sample point. The use of sampling points predominantly within the littoral zone accounts for the similarity of results. The fact that lake-wide species richness is comparable between the 3 surveys is likely due to ongoing aquatic plant management efforts, given that declines in native species richness following unchecked growth of *Myriophyllum spicatum* have been well documented (Madsen et al. 1989, 1991).

Figure 7. Distribution of Eurasian watermilfoil (*Myriophyllum spicatum*) in the 2010, 2019 and 2021 surveys of Lake Luzerne.



One of the plant species in Lake Luzerne (*Myriophyllum alterniflorum*) is on the New York State Rare Plant list (Young, 2020). This species is generally found on sandy, wave washed shorelines common to Adirondack lakes. This species was reported for Lake Luzerne in 2010, 2019 and 2021. One other species reported in Lake Luzerne is on the NYS Watch List (*Isoetes lacustris*). *Isoetes lacustris* was absent in the 2019 and 2021 surveys. This species is small in size and difficult to sample effectively with the current survey techniques.

Eurasian watermilfoil growth has dominated several areas of Lake Luzerne for many years, including the outlet area, inlet area and the southeastern cove. The southeast cove of Lake Luzerne was treated with herbicide in 2010, and only a single stem of Eurasian watermilfoil was recorded in the post-treatment survey (Figure 7). 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. Since 2010, a general decline in relative abundance of Eurasian watermilfoil has occurred, most likely due to management efforts, while frequency of occurrence has increased slightly. The increase is almost exclusively found in the southeastern embayment due to Eurasian watermilfoil recovery since the 2010 herbicide treatment. 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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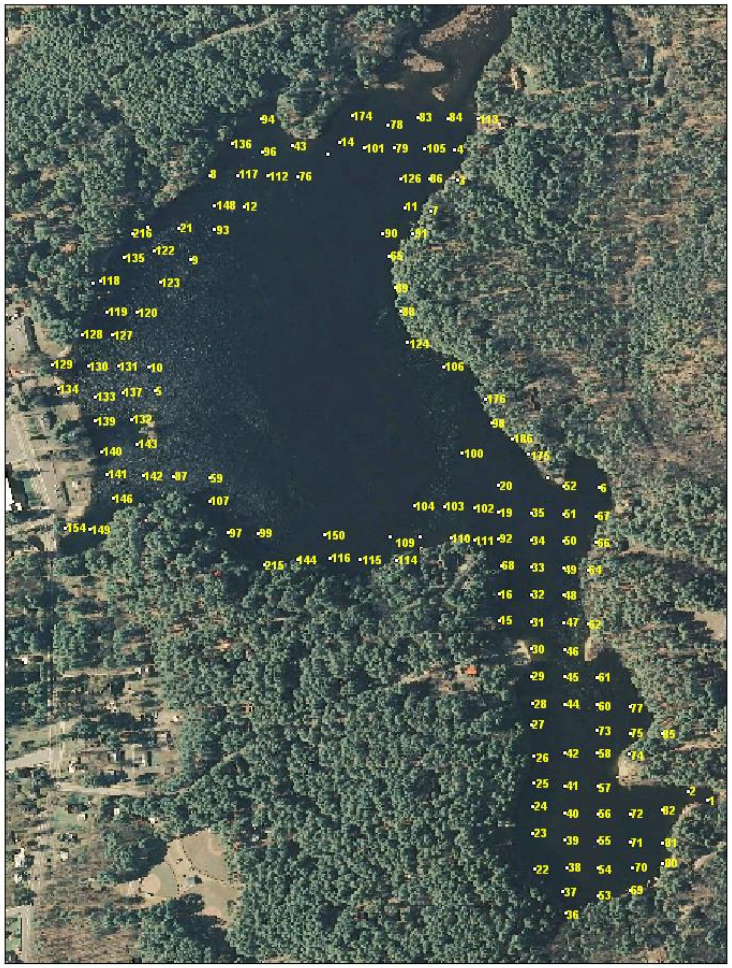
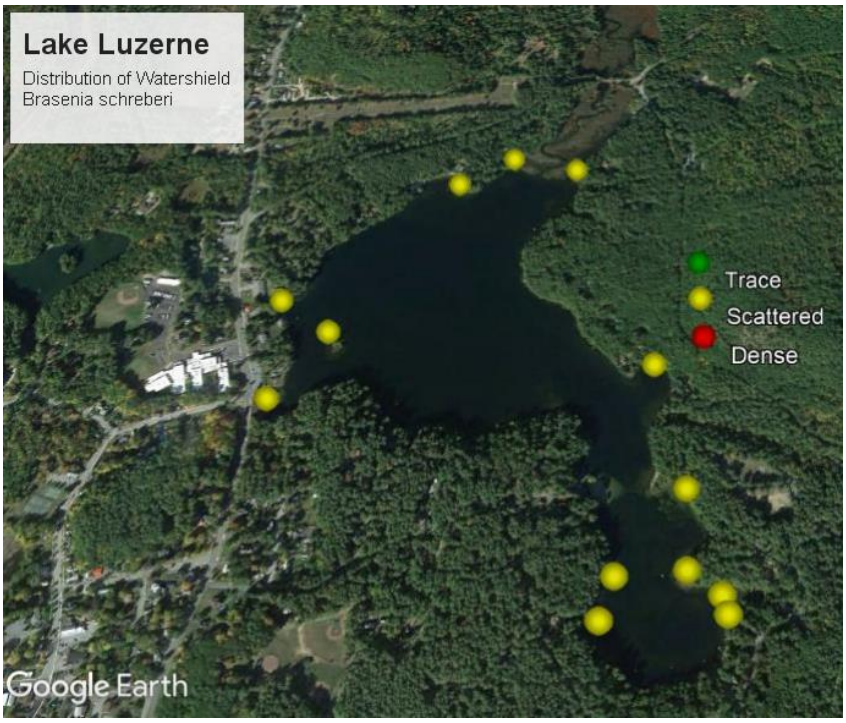
Appendix A.

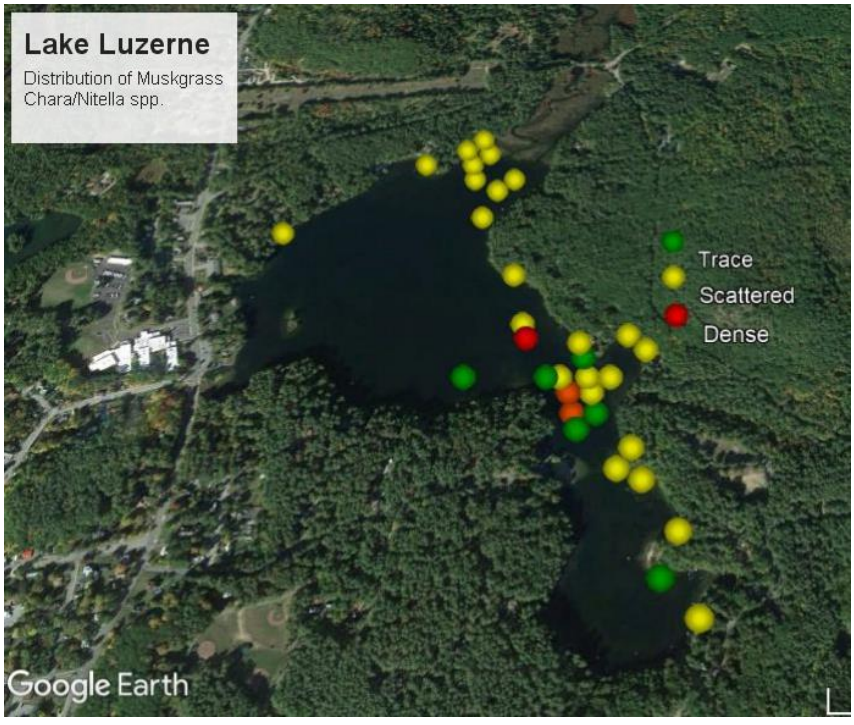
Topographic map showing the approximate locations of the 2021 survey points with GPS number for Lake Luzerne, NY.

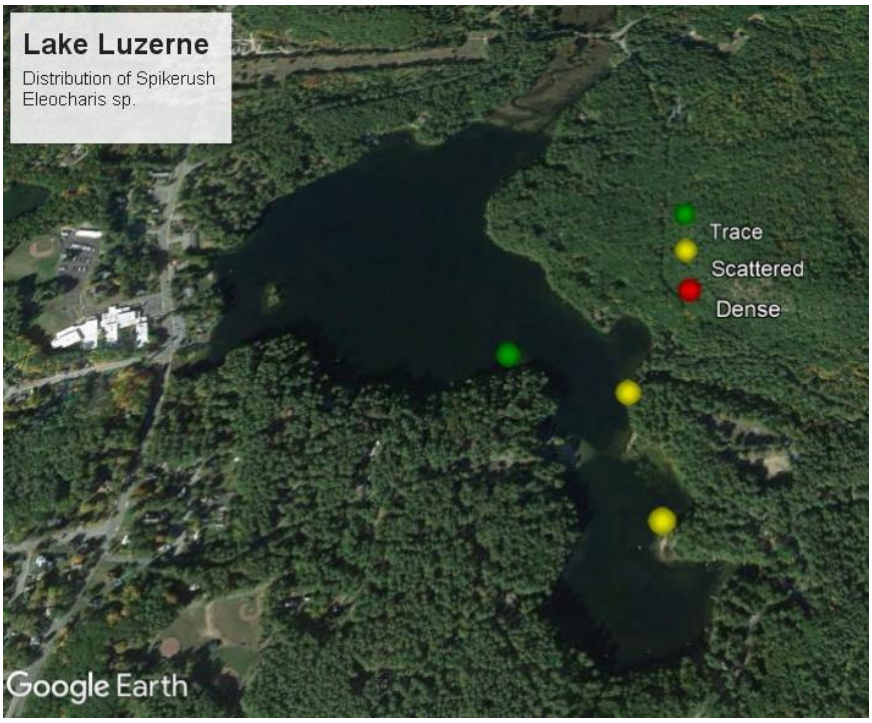


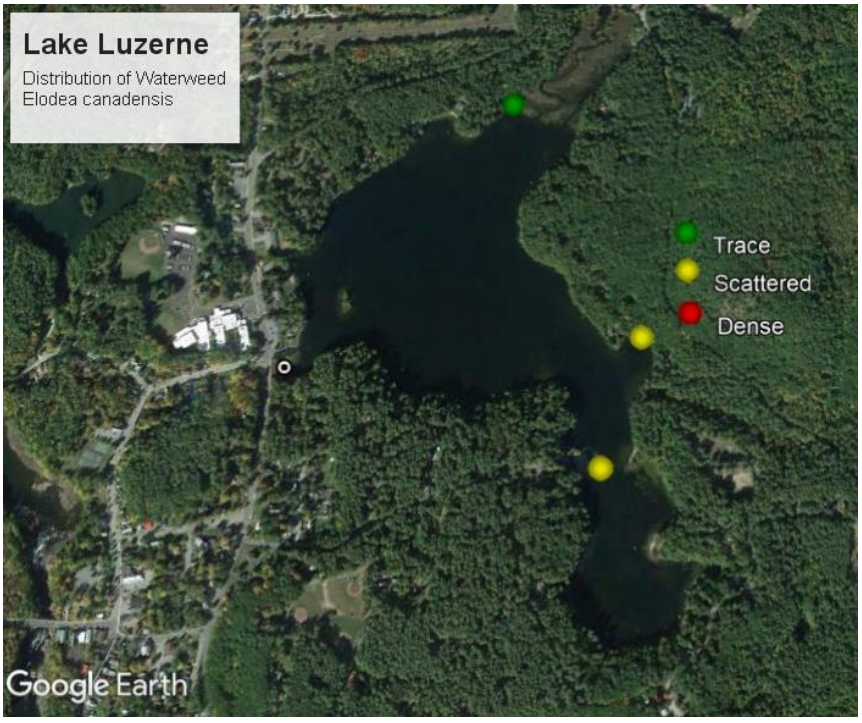
Appendix B.

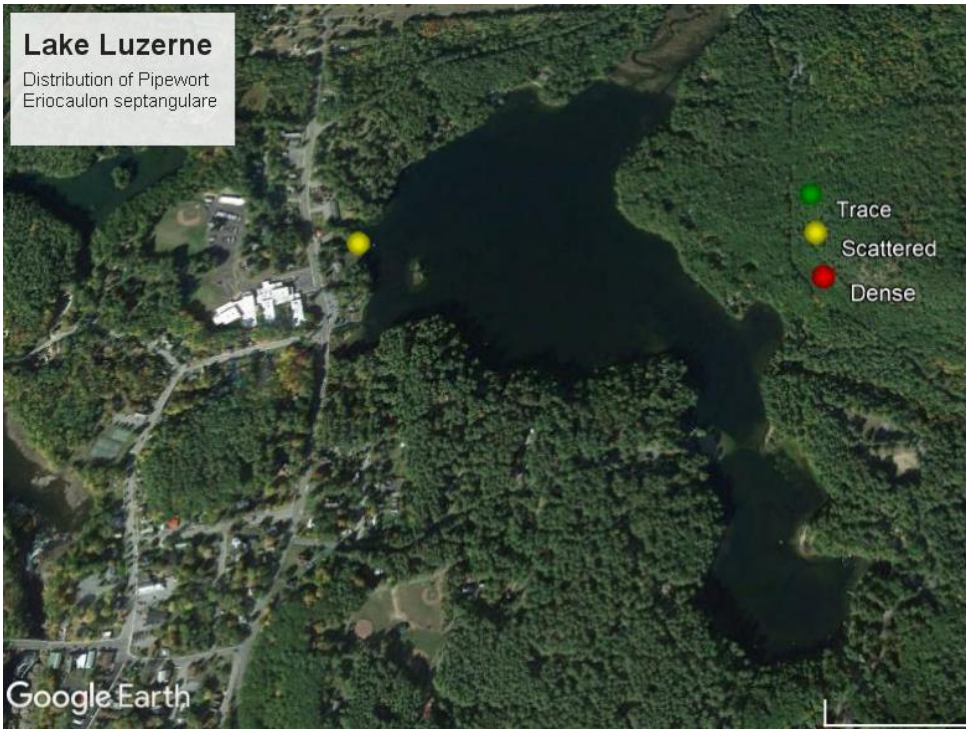
Aquatic Plant Distribution Maps for Lake Luzerne Based on Point Intercept Survey Data

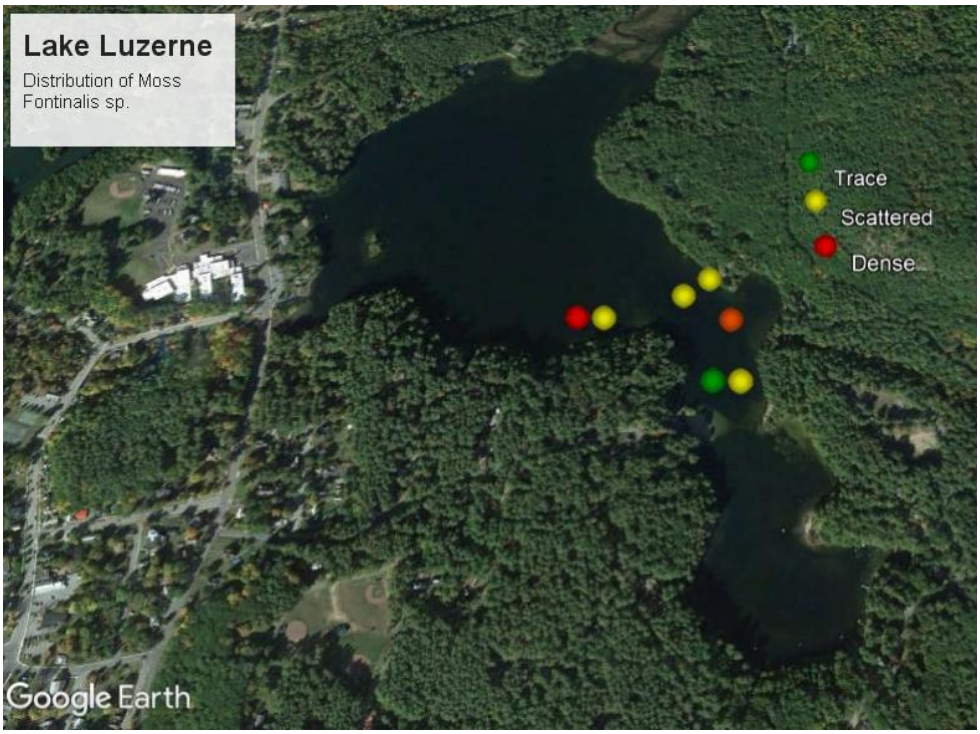

Lake Luzerne
Distribution of Watershield
Brasenia schreberi
Trace
Scattered
Dense
Google Earth

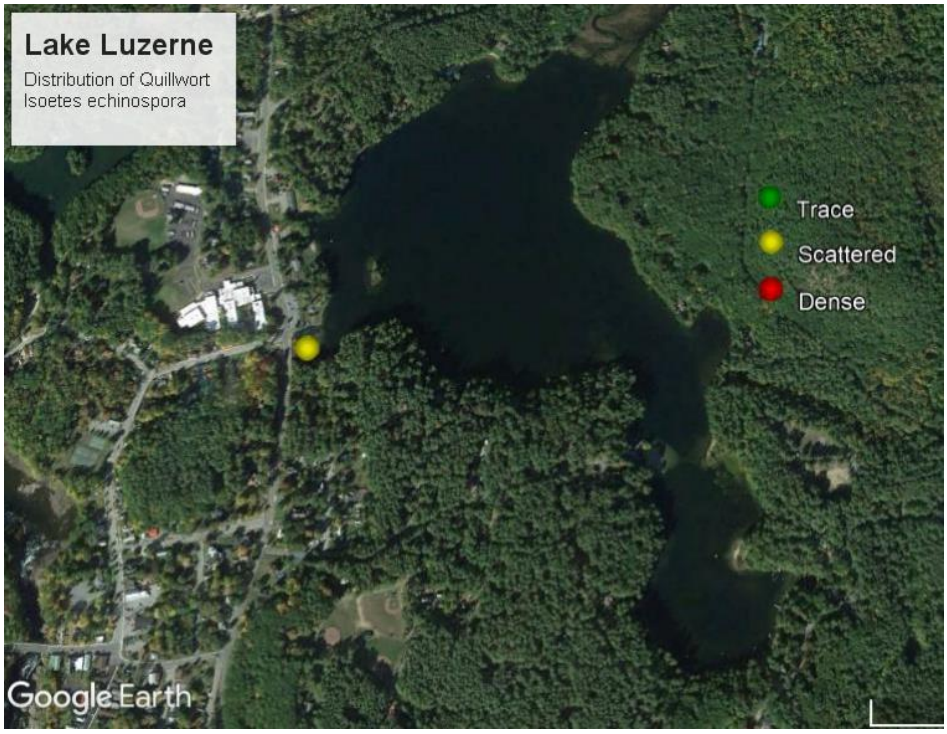

Lake Luzerne
Distribution of Muskgrass
Chara/Nitella spp.
Trace
Scattered
Dense
Google Earth

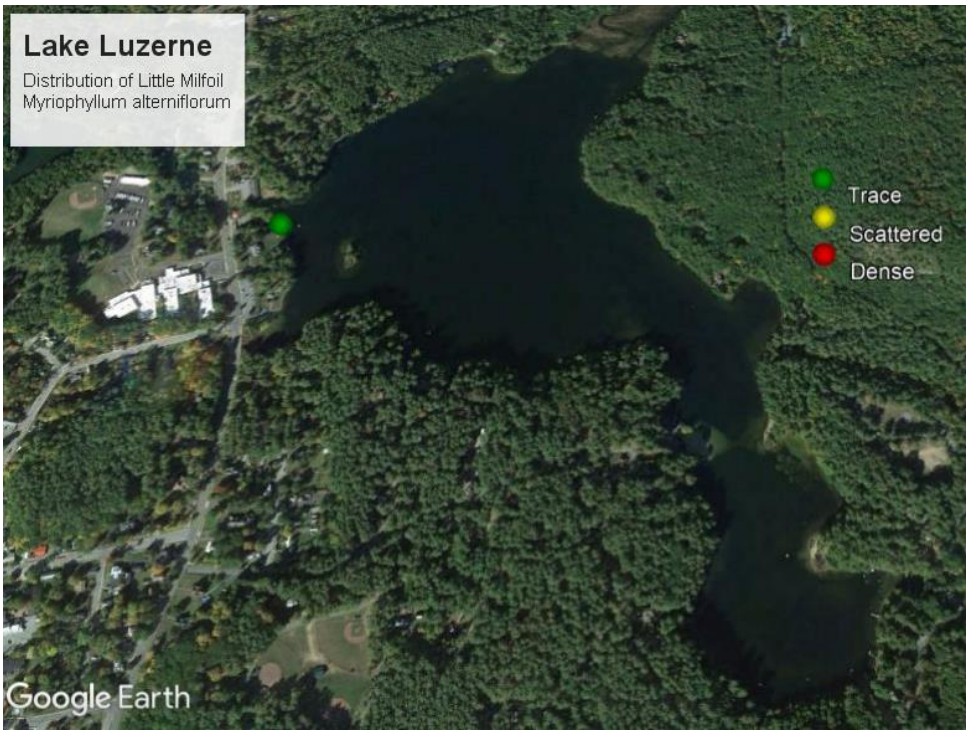

Lake Luzerne
Distribution of Spikerush
Eleocharis sp.
Trace
Scattered
Dense
Google Earth

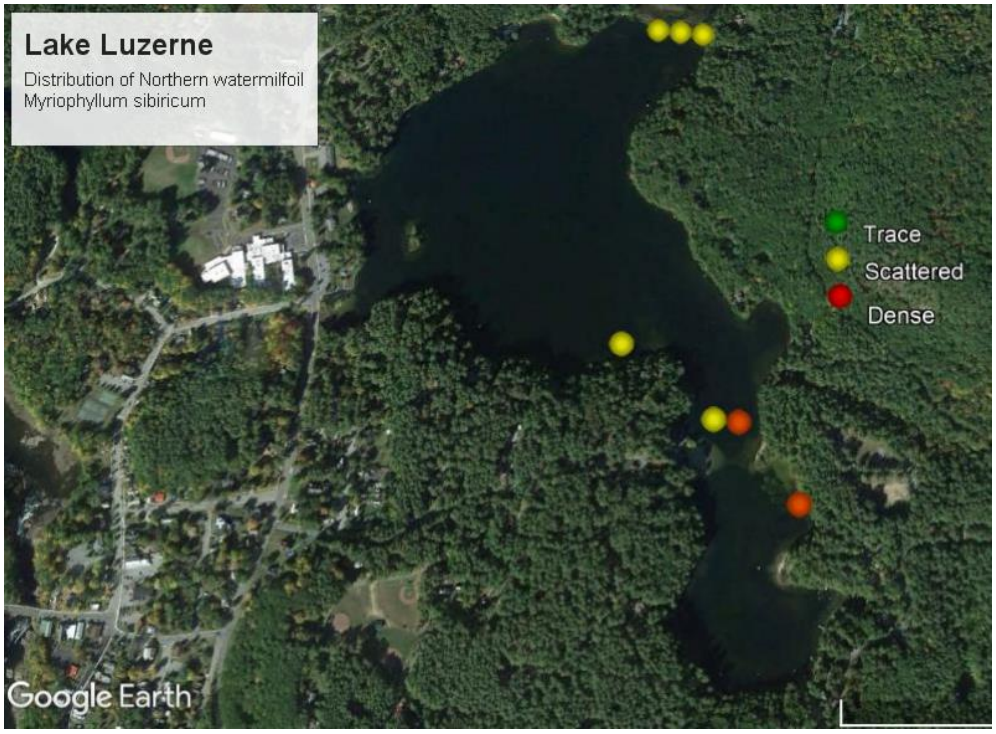

Lake Luzerne
Distribution of Waterweed
Elodea canadensis
Trace
Scattered
Dense
Google Earth

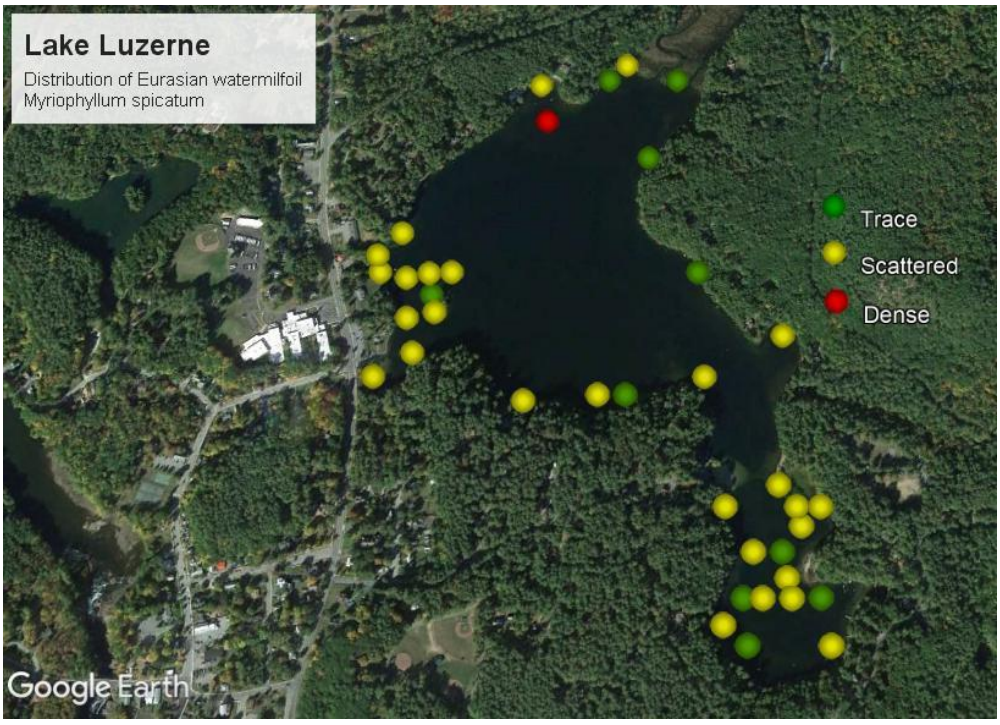

Lake Luzerne
Distribution of Pipewort
Eriocaulon septangulare
Trace
Scattered
Dense
Google Earth

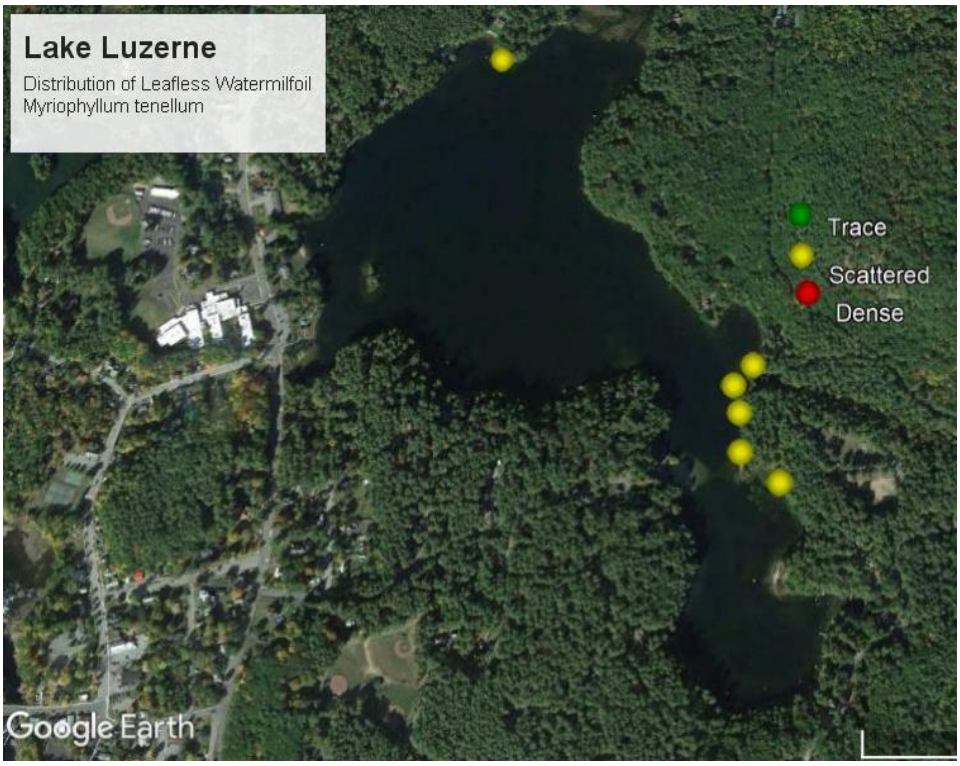

Lake Luzerne
Distribution of Moss
Fontinalis sp.
Trace
Scattered
Dense
Google Earth

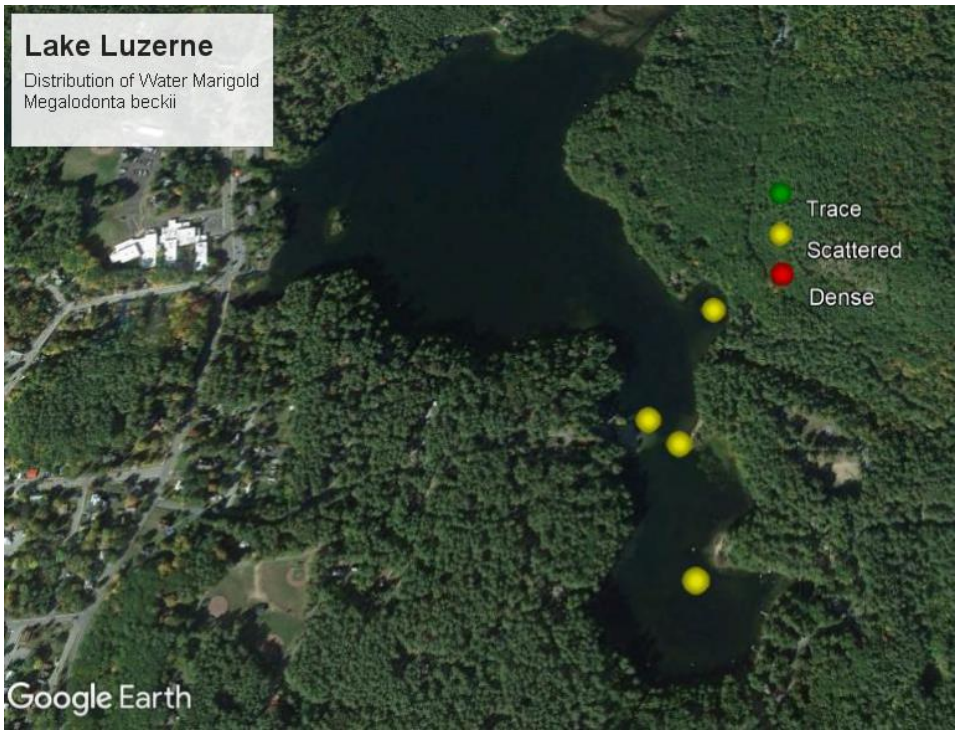

Lake Luzerne
Distribution of Quillwort
Isoetes echinospora
Trace
Scattered
Dense
Google Earth

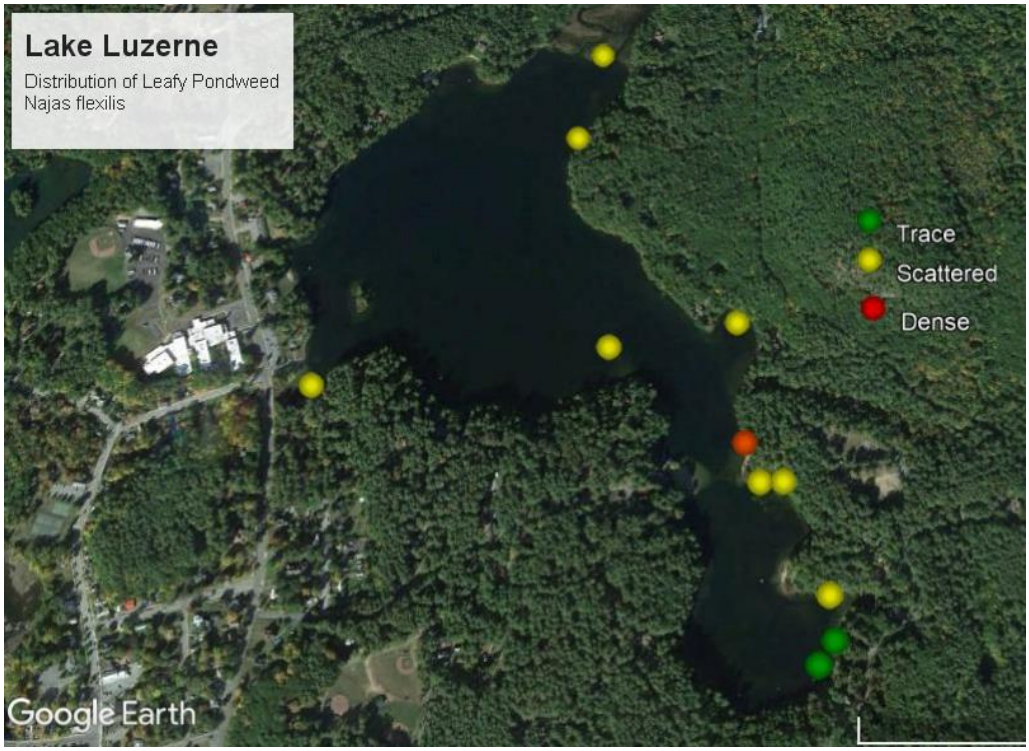

Lake Luzerne
Distribution of Little Milfoil
Myriophyllum alterniflorum
Trace
Scattered
Dense
Google Earth

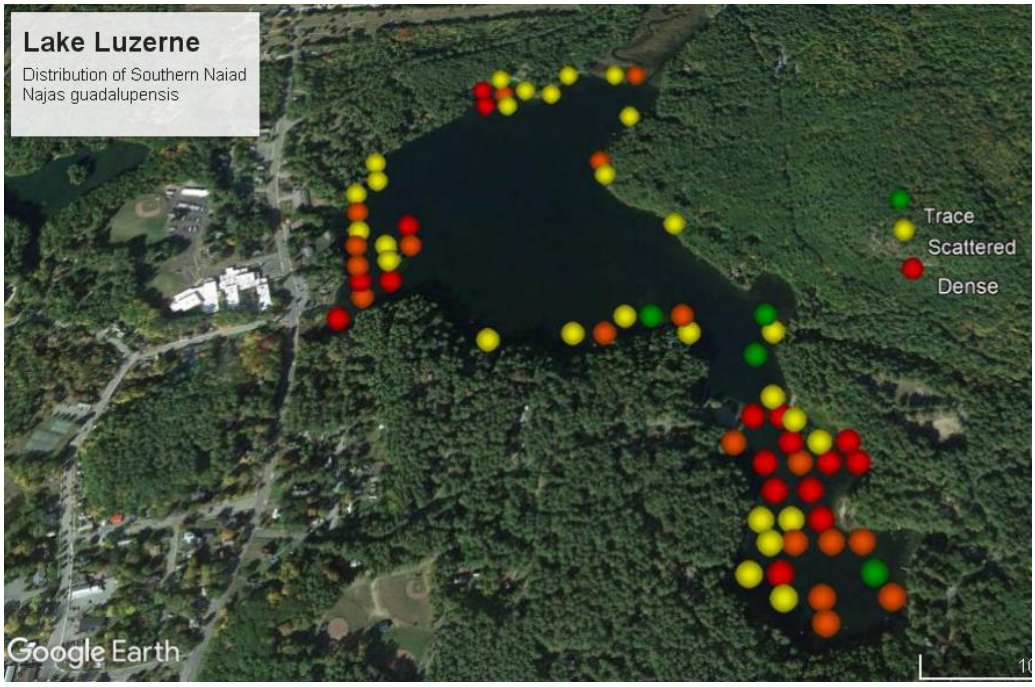

Lake Luzerne
Distribution of Northern watermilfoil
Myriophyllum sibiricum
Trace
Scattered
Dense
Google Earth


Lake Luzerne
Distribution of Eurasian watermilfoil
Myriophyllum spicatum
Trace
Scattered
Dense
Google Earth


Lake Luzerne
Distribution of Leafless Watermilfoil
Myriophyllum tenellum
Trace
Scattered
Dense
Google Earth

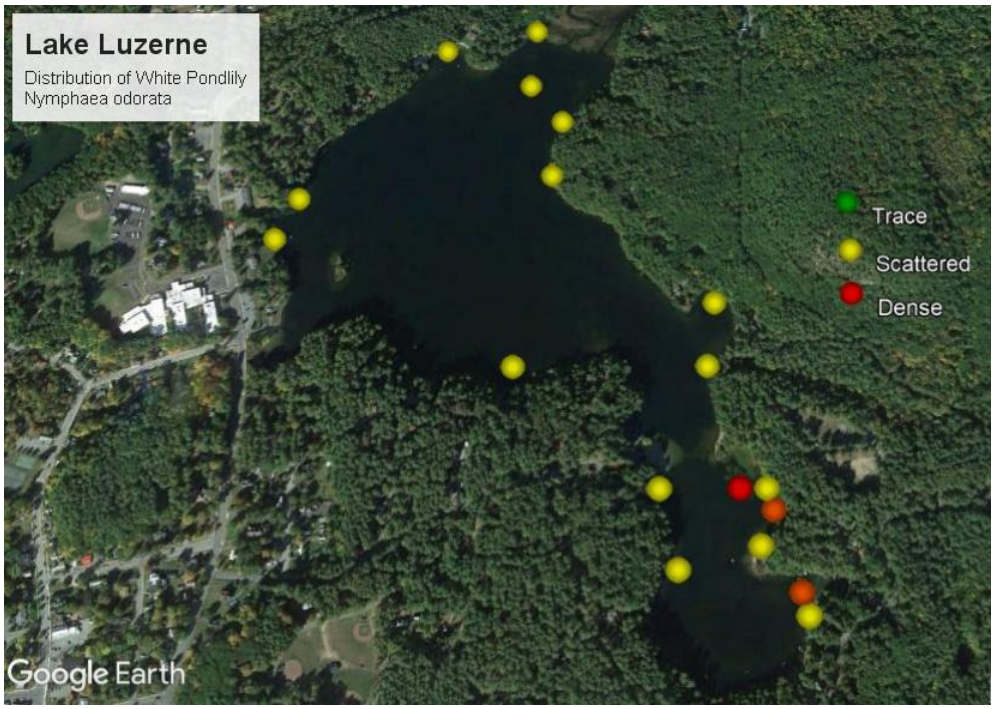

Lake Luzerne
Distribution of Water Marigold
Megalodonta beckii
Trace
Scattered
Dense
Google Earth

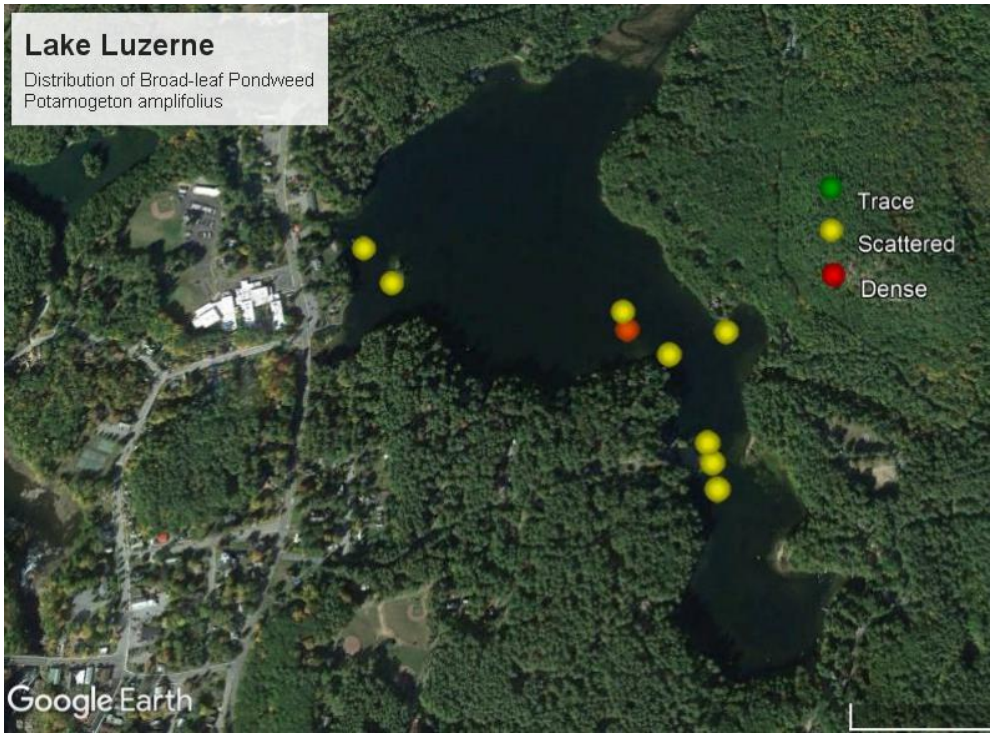

Lake Luzerne
Distribution of Leafy Pondweed
Najas flexilis
Trace
Scattered
Dense
Google Earth

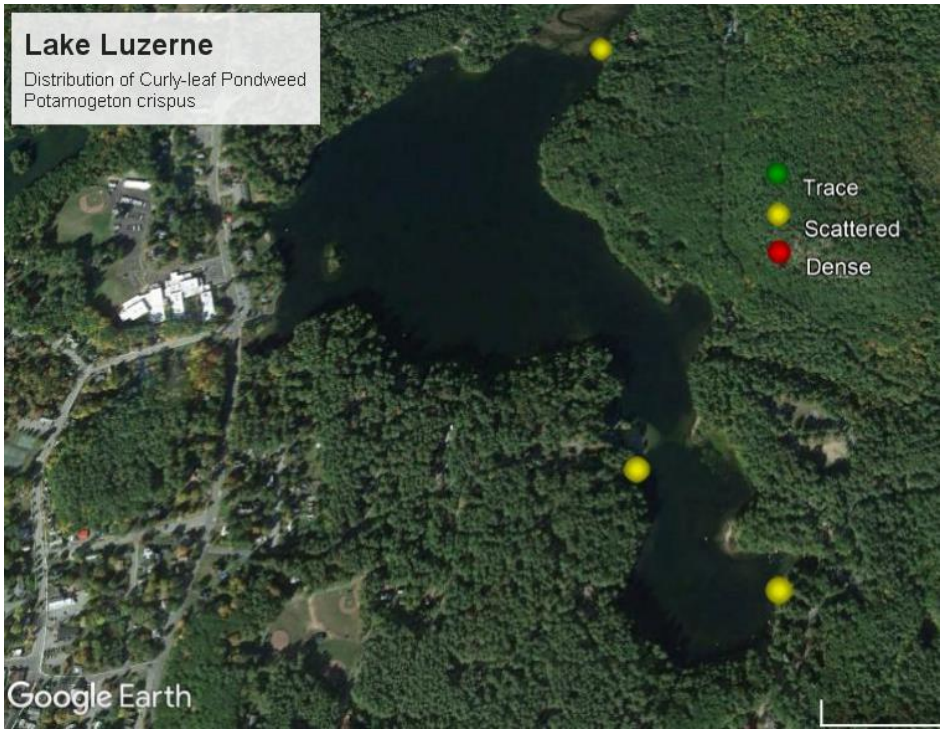

Lake Luzerne
Distribution of Southern Naiad
Najas guadalupensis
Trace
Scattered
Dense
Google Earth

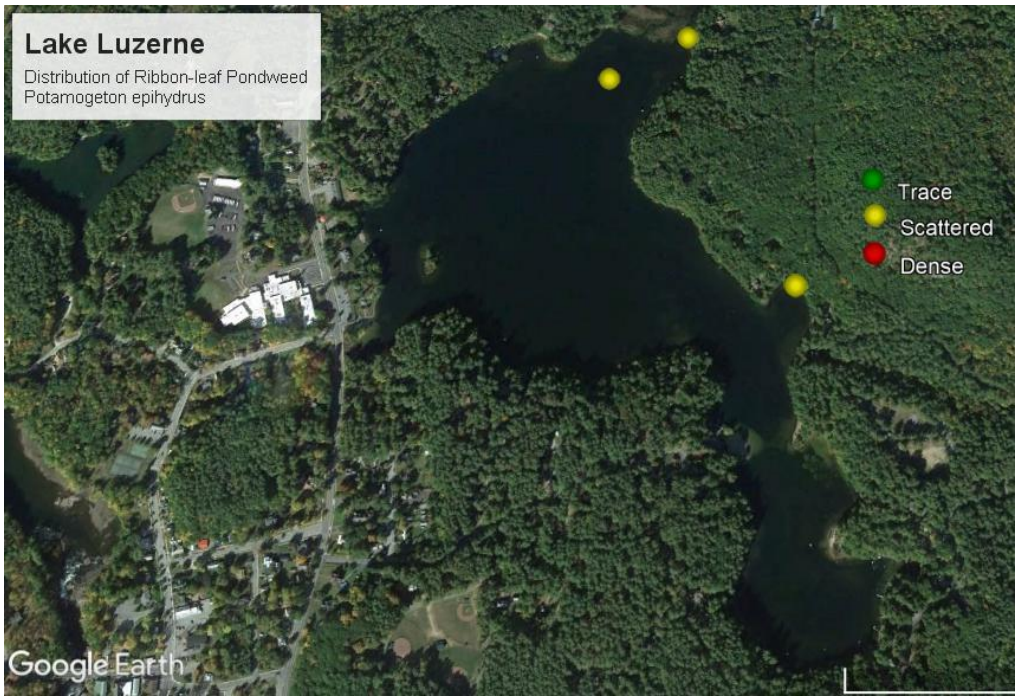

Lake Luzerne
Distribution of Brittle Naiad
Najas minor
Trace
Scattered
Dense
Google Earth

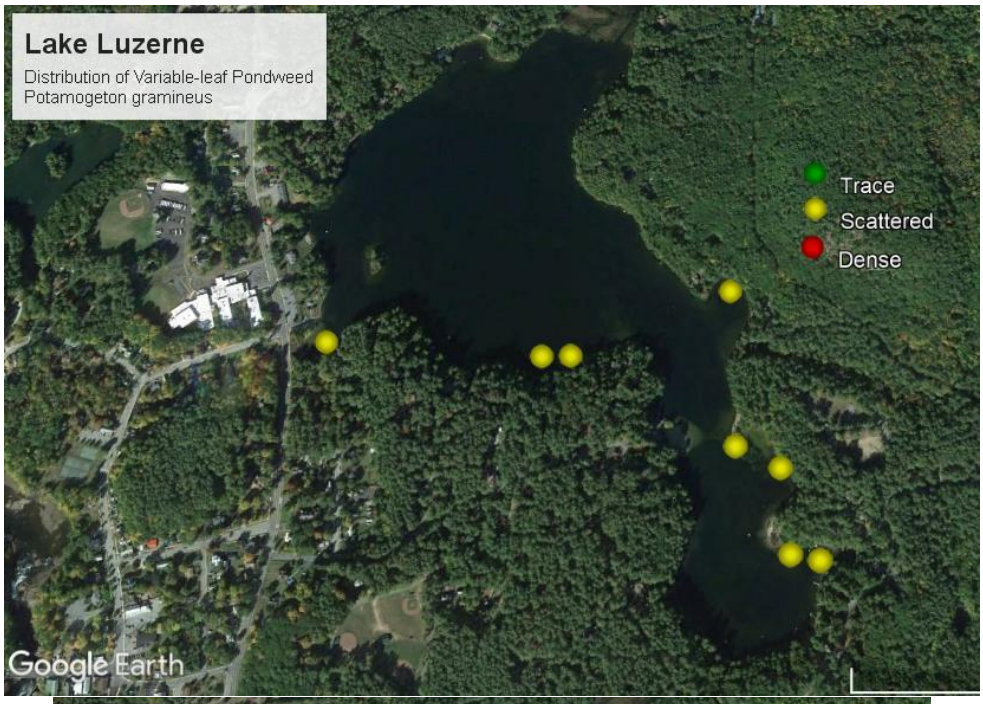

Lake Luzerne
Distribution of Yellow Pondlily
Nuphar variegata
Trace
Scattered
Dense
Google Earth

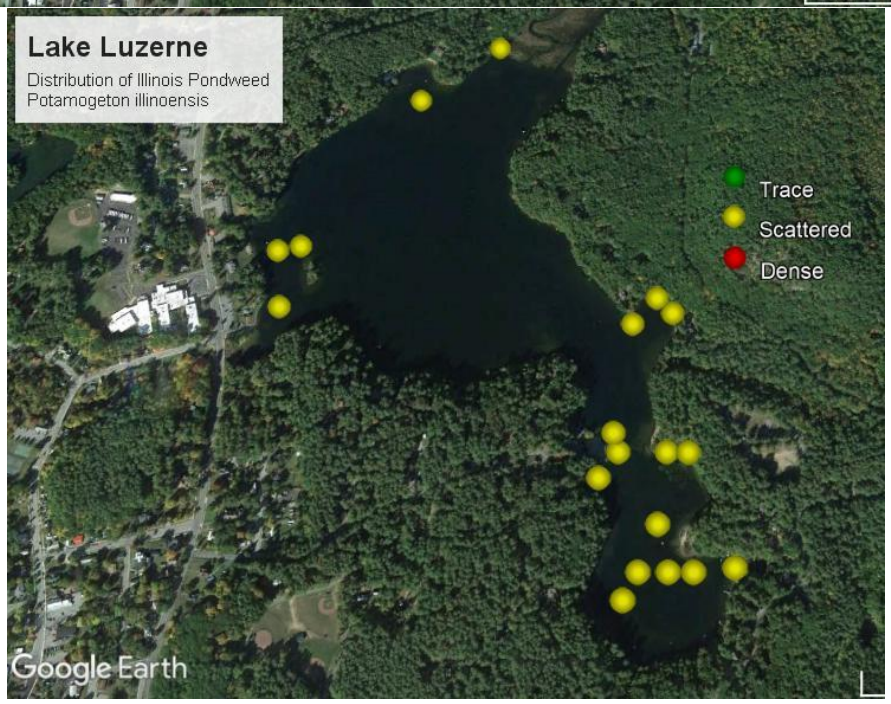

Lake Luzerne
Distribution of White Pondlily
Nymphaea odorata
Trace
Scattered
Dense
Google Earth

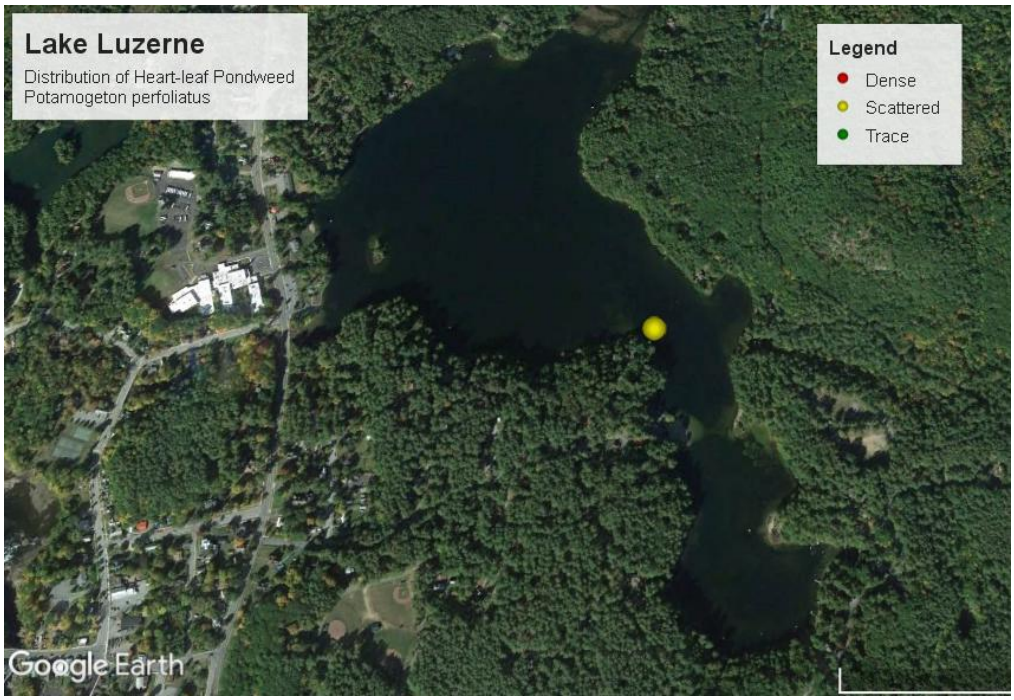

Lake Luzerne
Distribution of Broad-leaf Pondweed
Potamogeton amplifolius
Trace
Scattered
Dense
Google Earth

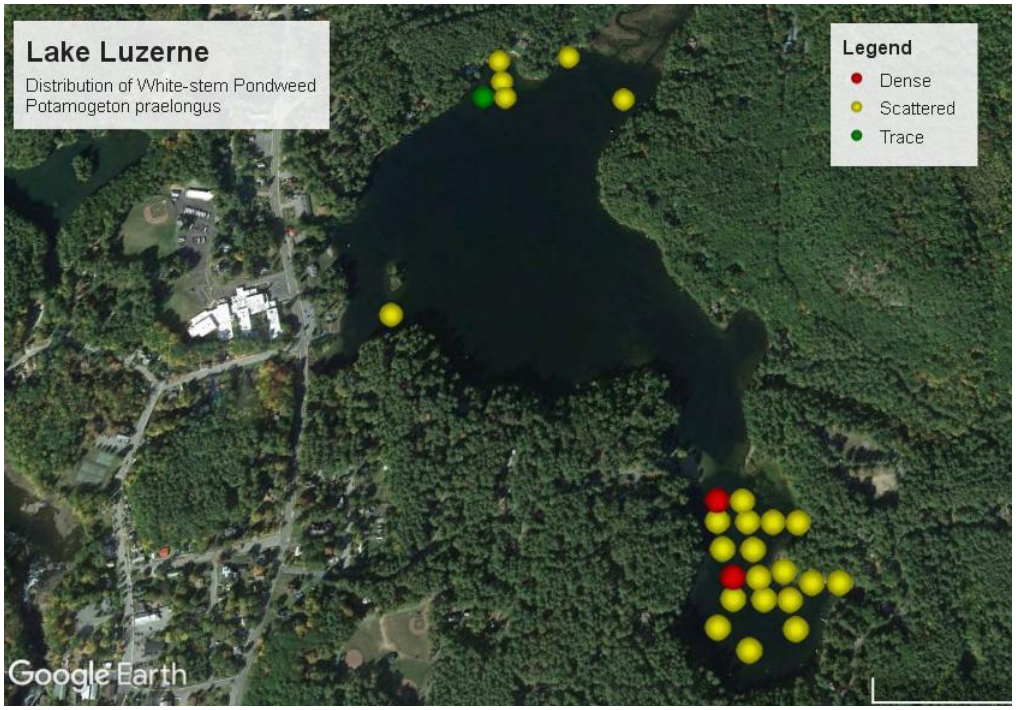

Lake Luzerne
Distribution of Curly-leaf Pondweed
Potamogeton crispus
Trace
Scattered
Dense
Google Earth

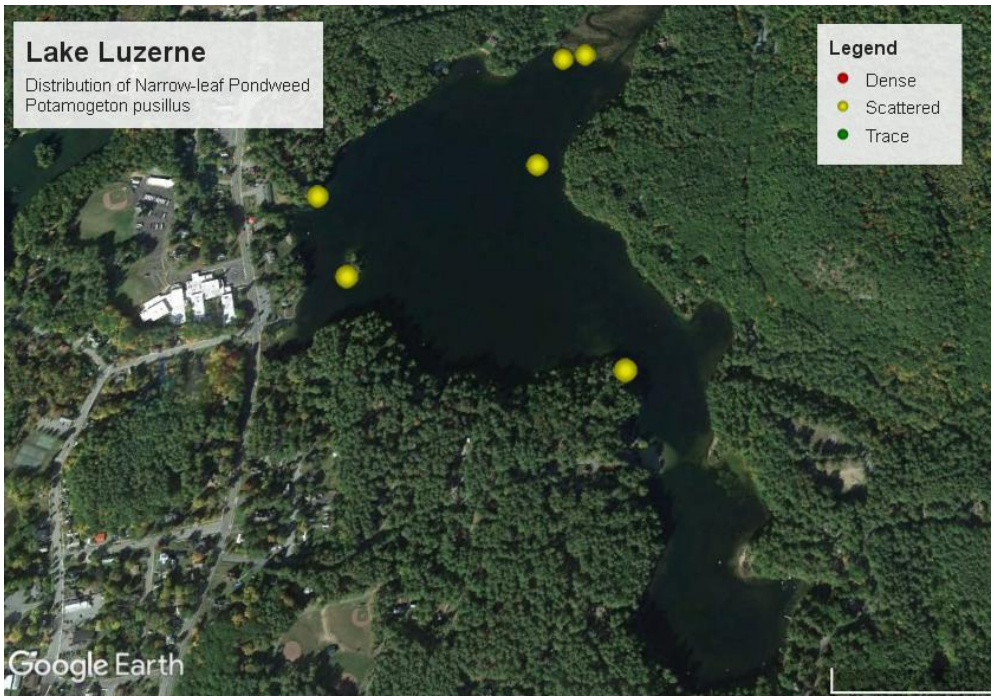

Lake Luzerne
Distribution of Ribbon-leaf Pondweed
Potamogeton epihydrus
Trace
Scattered
Dense
Google Earth

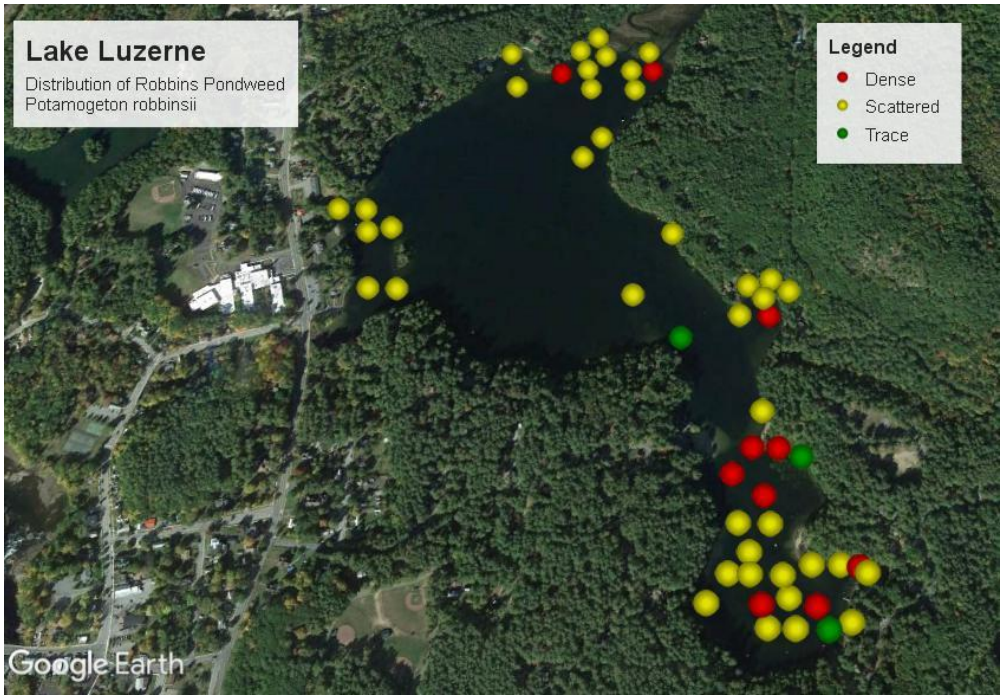

Lake Luzerne
Distribution of Variable-leaf Pondweed
Potamogeton gramineus
Trace
Scattered
Dense
Google Earth

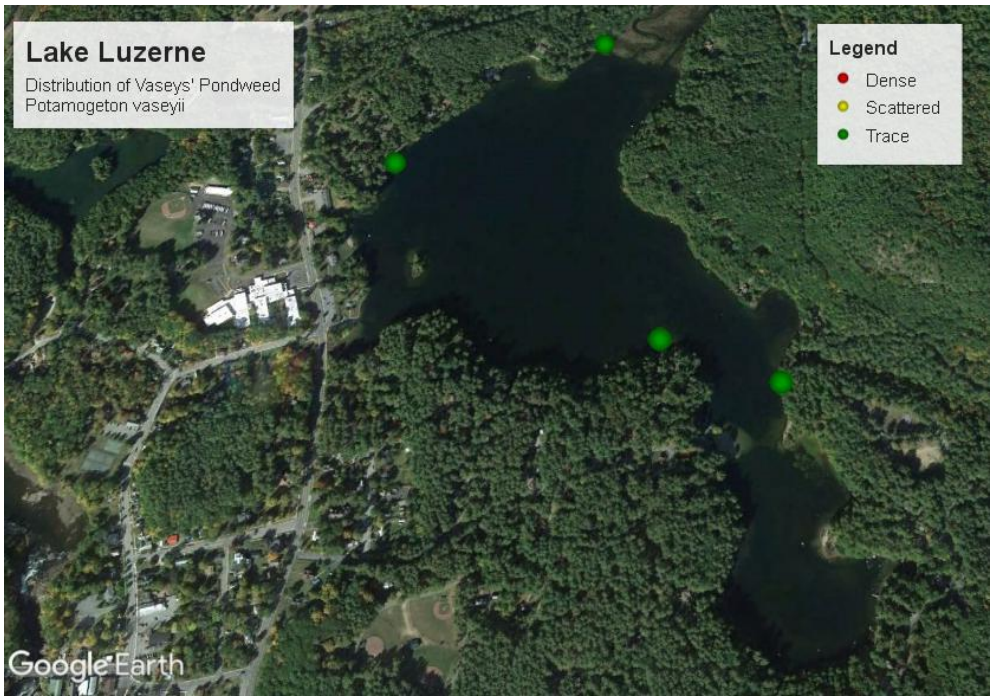

Lake Luzerne
Distribution of Illinois Pondweed
Potamogeton illinoensis
Trace
Scattered
Dense
Google Earth

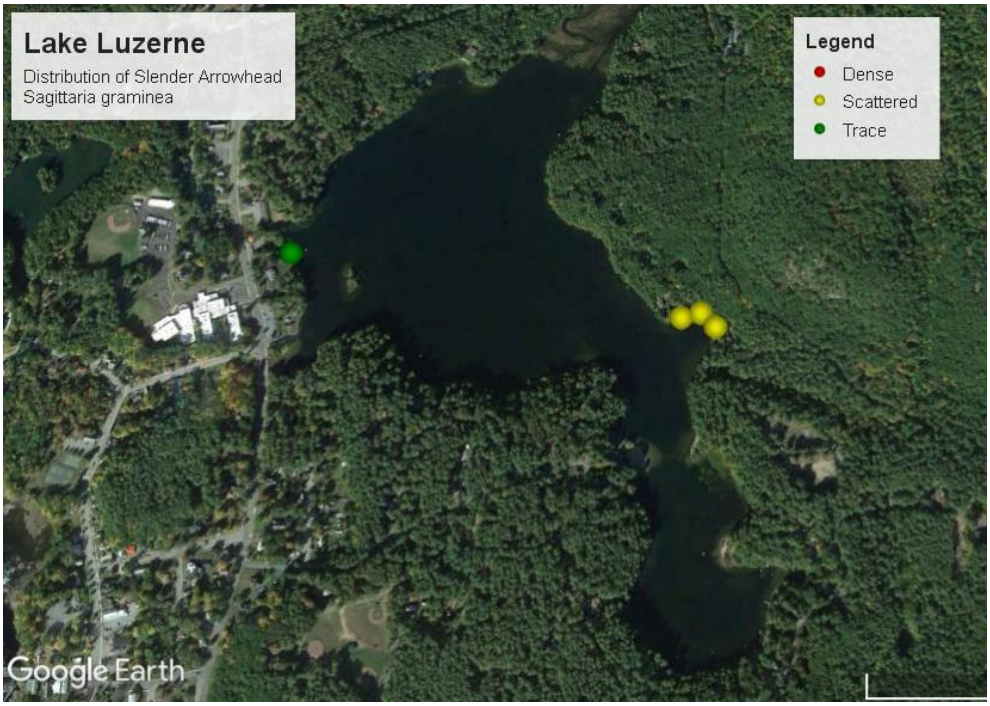

Lake Luzerne
Distribution of Heart-leaf Pondweed
Potamogeton perfoliatus
Legend
Dense
Scattered
Trace
Google Earth

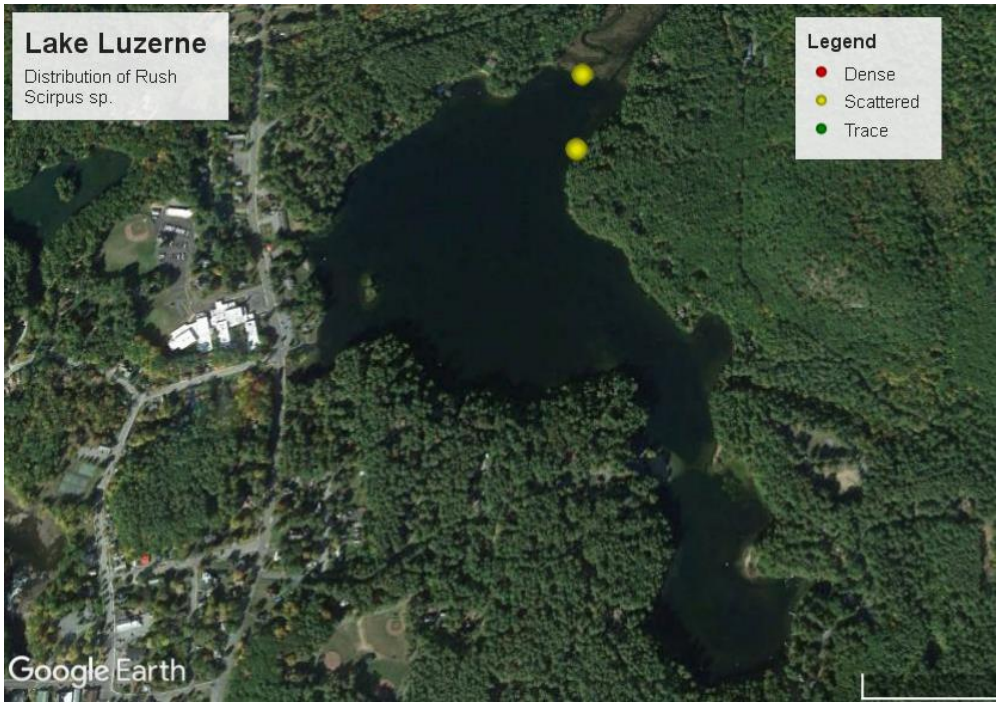

Lake Luzerne
Distribution of White-stem Pondweed
Potamogeton praelongus
Legend
Dense
Scattered
Trace
Google Earth

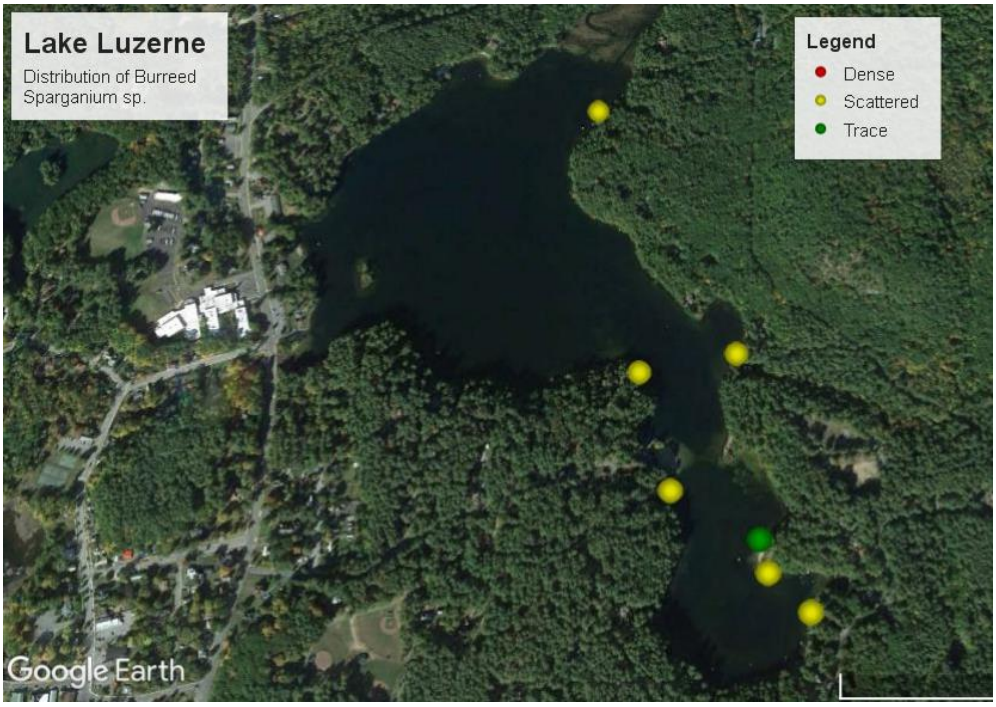

Lake Luzerne
Distribution of Narrow-leaf Pondweed
Potamogeton pusillus
Legend
Dense
Scattered
Trace
Google Earth

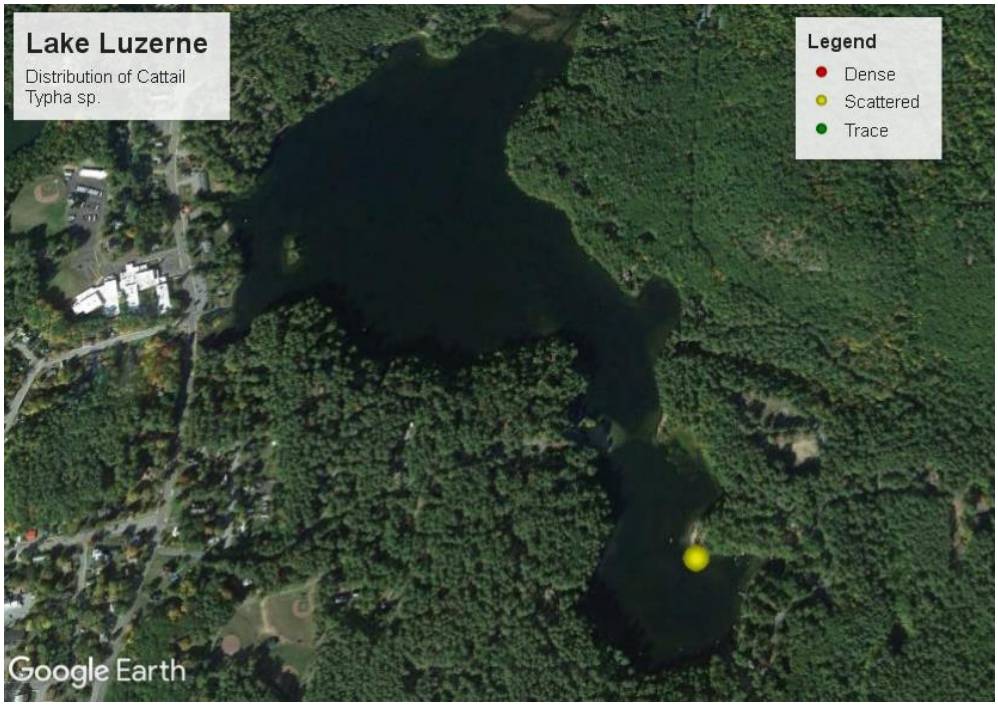

Lake Luzerne
Distribution of Robbins Pondweed
Potamogeton robbinsii
Legend
Dense
Scattered
Trace
Google Earth

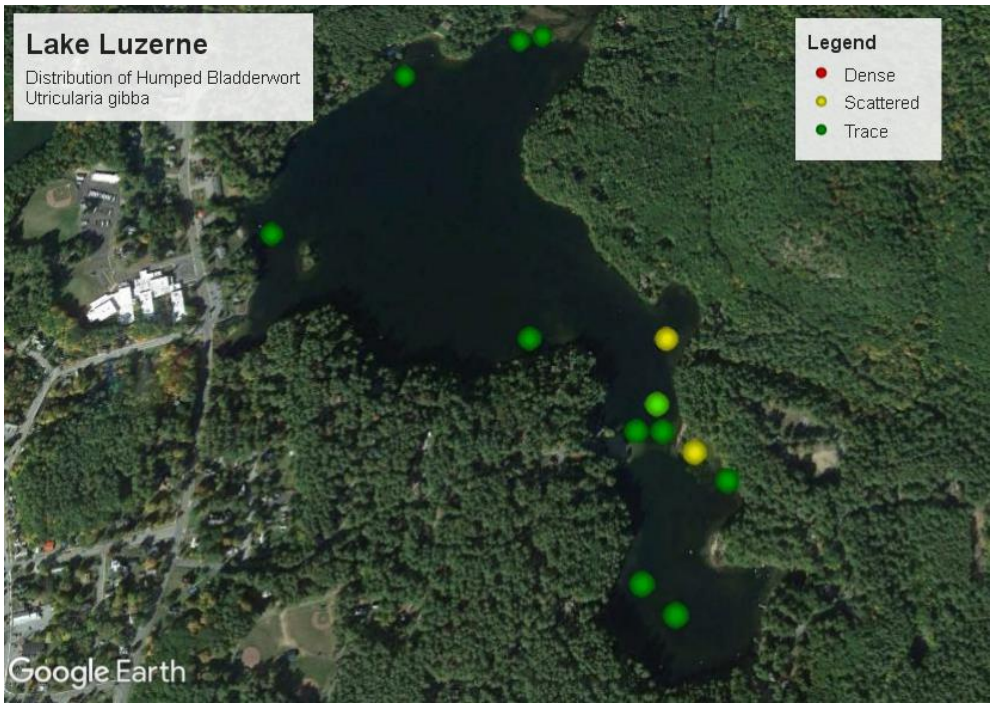

Lake Luzerne
Distribution of Vaseys' Pondweed
Potamogeton vaseyii
Legend
Dense
Scattered
Trace
Google Earth

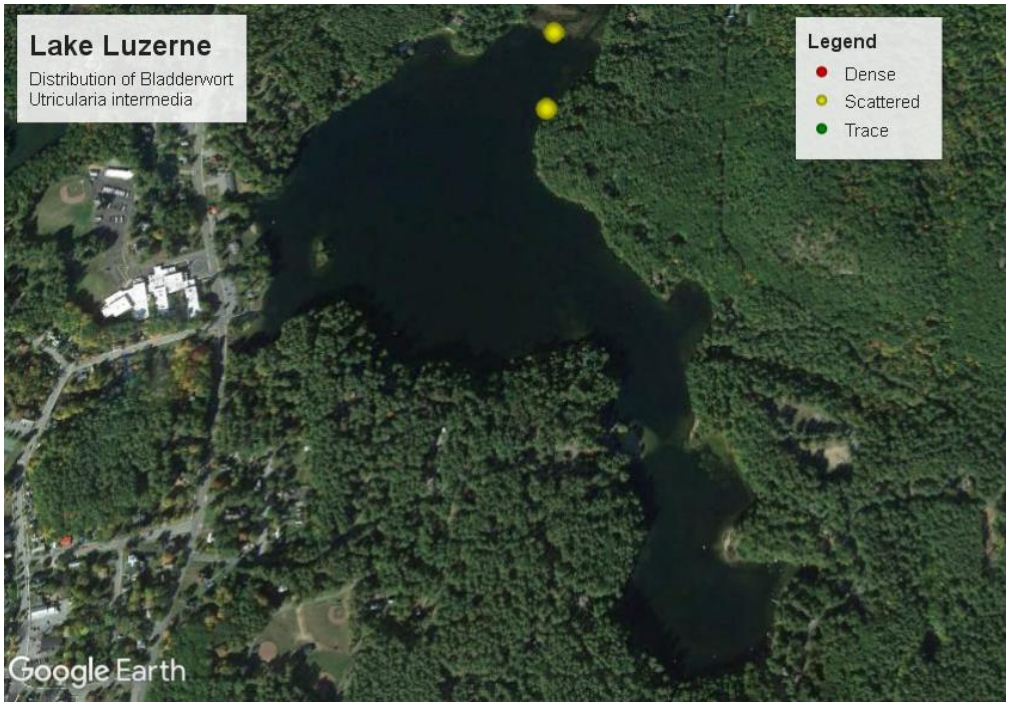

Lake Luzerne
Distribution of Slender Arrowhead
Sagittaria graminea
Legend
Dense
Scattered
Trace
Google Earth

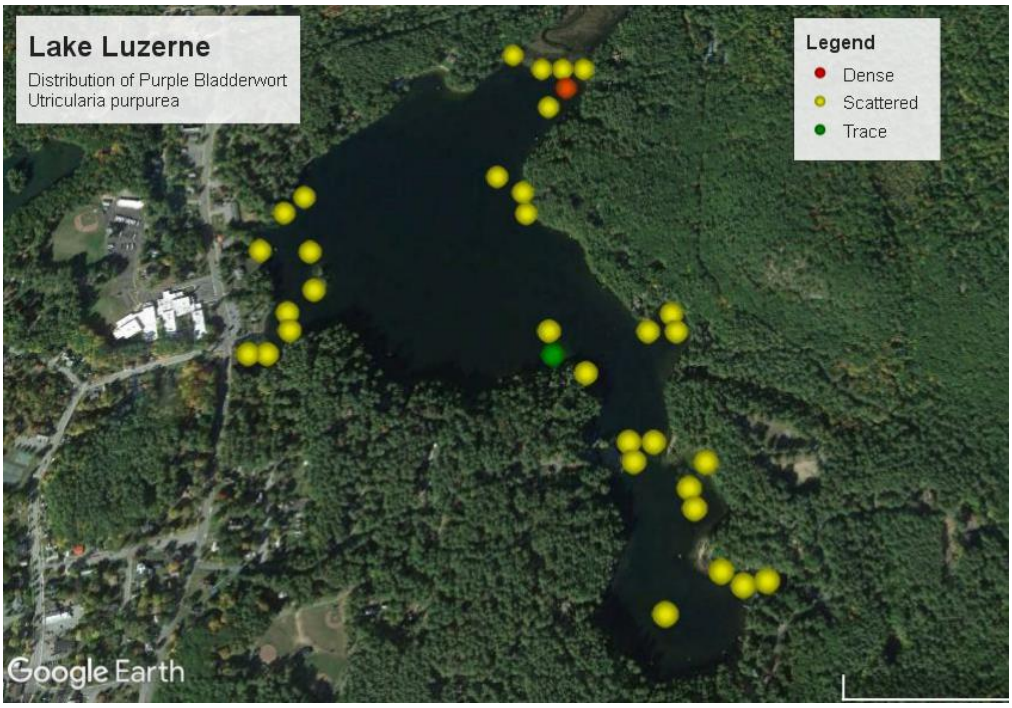

Lake Luzerne
Distribution of Rush
Scirpus sp.
Legend
Dense
Scattered
Trace
Google Earth

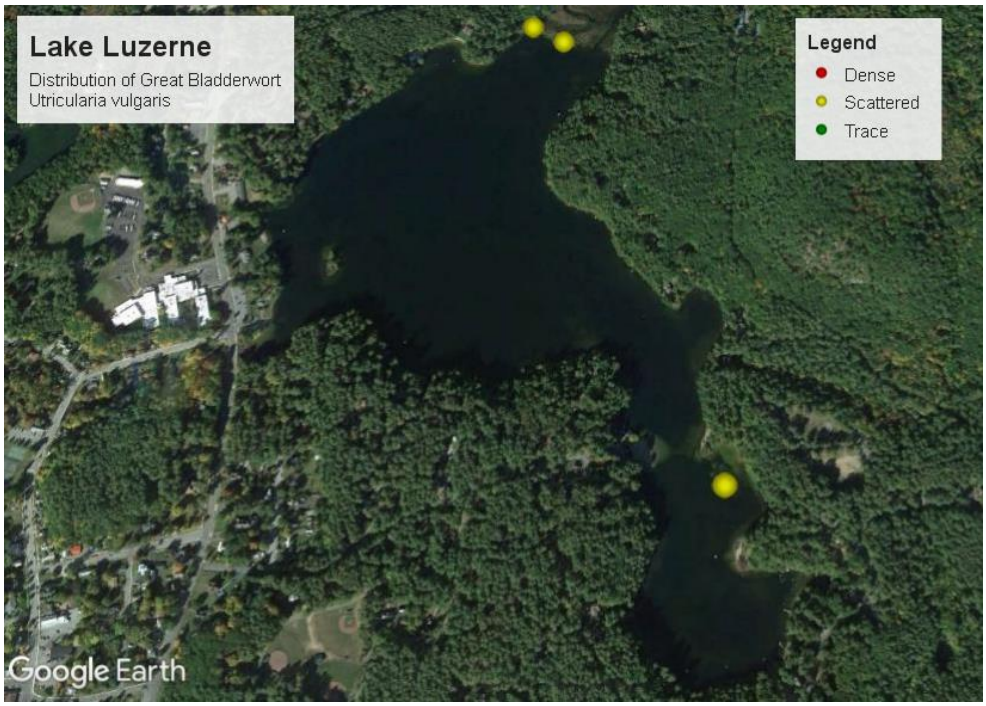

Lake Luzerne
Distribution of Burreed
Sparganium sp.
Legend
Dense
Scattered
Trace
Google Earth

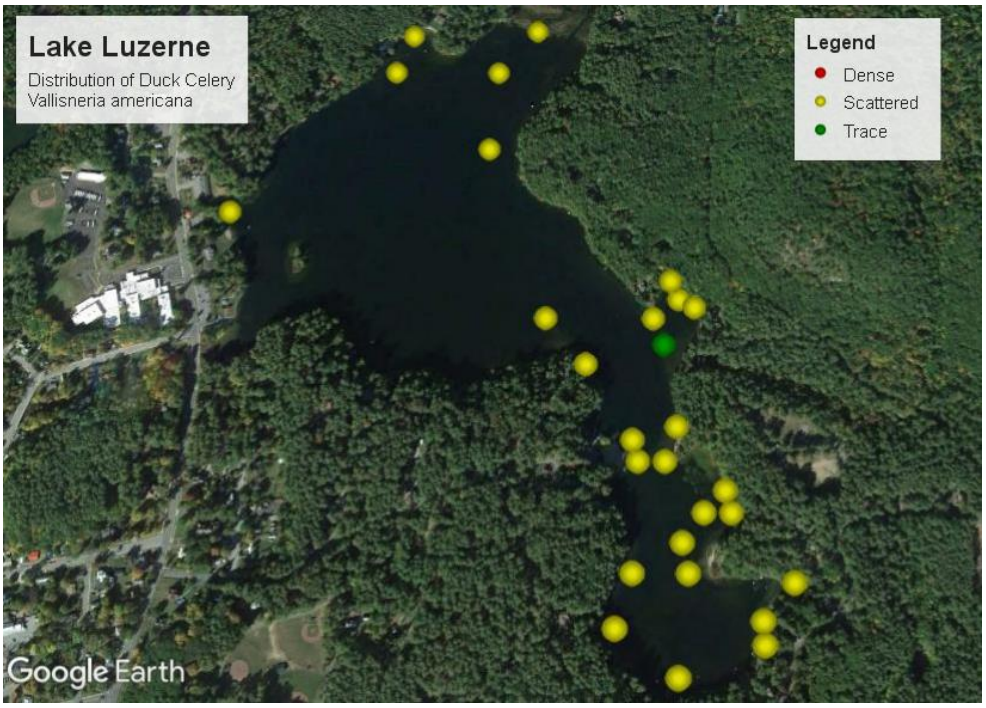

Lake Luzerne
Distribution of Cattail
Typha sp.
Legend
Dense
Scattered
Trace
Google Earth


Lake Luzerne
Distribution of Humped Bladderwort
Utricularia gibba
Legend
Dense
Scattered
Trace
Google Earth


Lake Luzerne
Distribution of Bladderwort
Utricularia intermedia
Legend
Dense
Scattered
Trace
Google Earth


Lake Luzerne
Distribution of Purple Bladderwort
Utricularia purpurea
Legend
Dense
Scattered
Trace
Google Earth


Lake Luzerne
Distribution of Great Bladderwort
Utricularia vulgaris
Legend
Dense
Scattered
Trace
Google Earth


Lake Luzerne
Distribution of Duck Celery
Vallisneria americana
Legend
Dense
Scattered
Trace
Google Earth