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Fresh Water Institute

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Aquatic Vegetation of Lake Iroquois and Sunset Pond, Chittenden County, Vermont

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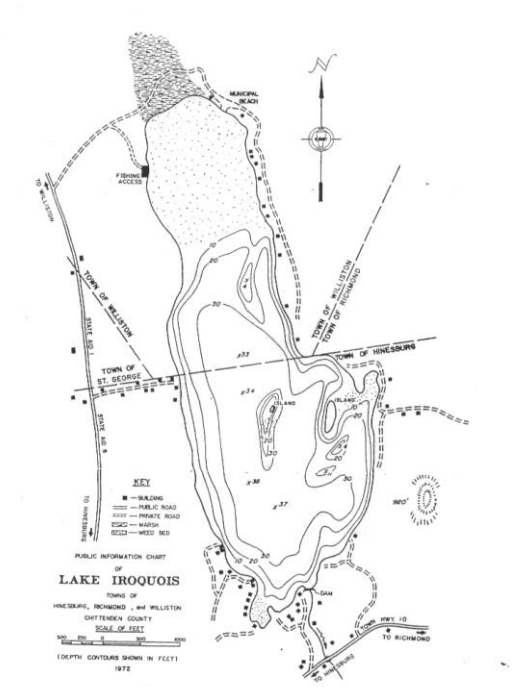
Background.

At the request of the Lake Iroquois Association, quantitative aquatic plant surveys were undertaken for Lake Iroquois and Sunset Pond, Vermont. The surveys consisted of frequency of occurrence and relative abundance data for all aquatic plant species present in points distributed throughout both lakes. The Point-Intercept Rake Toss method presently used by the US Army Corps of Engineers and others was employed. The assessment ultimately will include the distribution and density of existing aquatic plant communities, the extent of exotic species infestation and a review of ongoing management efforts to control Eurasian watermilfoil (*Myriophyllum spicatum*).

Methods

Survey Sites

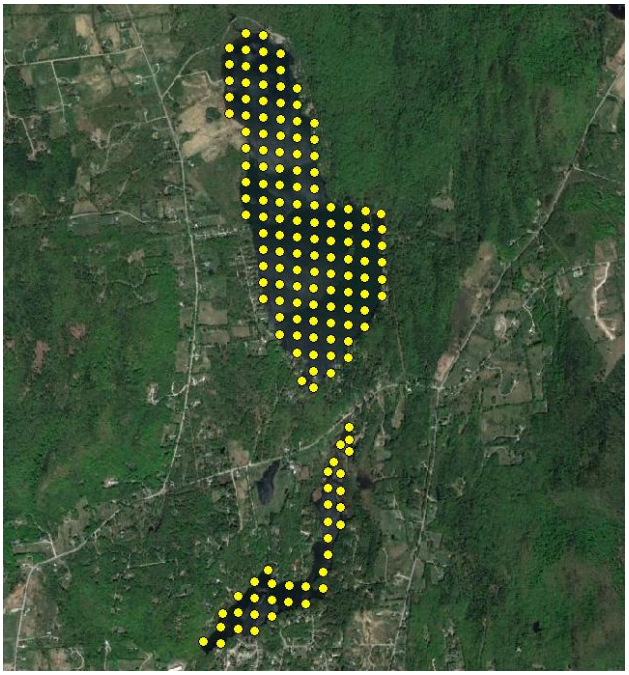


Lake Iroquois. Lake Iroquois is located in Chittenden County, in the towns of Hinesburg, Richmond and Williston. The lake has a surface area of approximately 244 acres with a watershed area of 2198 acres. Lake Iroquois has a single outlet with a control structure, however no lake level control is possible. Maximum water depth is reported to be 37 ft with average water depth of 19 feet (VTDEC 2016a). Secchi disk transparency in 2015 averaged 12 ft (3.8 m; VT DEC 2015). Lake Iroquois is classified as eutrophic based on phosphorous and chlorophyll concentrations, indicating that nutrient levels are sufficient to support dense growth of planktonic algae and aquatic plants. Two aquatic invasive aquatic plant species are reported for Lake Iroquois, Eurasian watermilfoil (*Myriophyllum spicatum*) and Curly-leaf Pondweed (*Potamogeton crispus*) (VT DEC 2016b). VT DEC records indicate that Eurasian watermilfoil was first confirmed in 1991 while curly-leaf pondweed was present in 1984. An aquatic plant survey of Lake Iroquois in September of 2014 reported over 70 acres of dense Eurasian watermilfoil growth (Knoecklein 2015). A total of 45 aquatic plant species have been reported for Lake Iroquois in multiple surveys since 1984, however a 2014 survey only reported 23 species. Loss of native species is a commonly reported phenomenon in lakes with severe infestation by Eurasian watermilfoil and/or other invasive aquatic plant species (Madsen et al. 1991). Hand harvesting efforts began on Lake Iroquois during 2008 to control the dense growth of Eurasian watermilfoil. The aquatic weevil (*Euhrychiopsis lecontei*) population of the lake was supplemented in 2008 and 2009 in an effort to provide a biocontrol agent for Eurasian watermilfoil. The extensive growth of Eurasian watermilfoil reported in 2014 suggested a more extensive management effort was necessary. In 2016, diver assisted suction harvesting (DASH) of Eurasian watermilfoil was employed in the

boat launch area and near the LIRD beach. Over a period of 2 weeks, divers harvested over 5000 gallons of Eurasian watermilfoil. Benthic barriers (mats) were installed in 2017 to maintain the areas harvested by DASH in 2016. Residents remained concerned that current Eurasian watermilfoil growth was exceeding the capacity of the existing management effort.

Sunset Pond. Sunset or Lower Pond is located in Chittenden County in the Town of Hinesburg. The lake has a surface area of approximately 58 acres with a watershed area of 3422 acres (including the Lake Iroquois basin). Sunset Pond has a single outlet. Maximum water depth is reported to be 10 ft (3 meters, VTDEC 2016a). Sunset Pond is classified as eutrophic based on phosphorous and chlorophyll concentrations, indicating that nutrient levels are sufficient to support dense growth of planktonic algae and aquatic plants. Two invasive aquatic plant species are reported for Sunset Pond, Eurasian watermilfoil (*Myriophyllum spicatum*) and Yellow Iris (*Iris pseudacorus*) (VT DEC 2016b). VT DEC records indicate that Eurasian watermilfoil and Yellow Iris were first reported in 2008.

Figure 1. Map of Lake Iroquois and Sunset Pond with potential point intercept survey locations for 2017.



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

***Point Intercept Surveys*.** The frequency and diversity of aquatic plant species were evaluated using a point intercept method (Madsen 1999). At each grid point intersection, all species located at that point were recorded, as well as water depth. 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 35 points were selected for Sunset Pond, and 102 points were surveyed for Lake Iroquois, based on a 100 m grid (Figure 1). A global positioning system (GPS) was used to navigate to each point for the survey observation. Point intercept plant frequencies were surveyed on September 12, 2017 at a time of maximum aquatic plant abundance. Data presented in the summary are on a whole-lake basis, and have not been adjusted for the littoral zone only.

Relative abundance in the Point Intercept surveys. To characterize relative abundance of each of the species identified in the point intercept survey, a scale developed by Cornell University and the US Army Corps of Engineers was employed. For each rake toss, the relative abundance of each plant species collected was recorded based on a rating scale (see below). Maps of the distribution of each species by its relative abundance are included in Appendices A & B.

Relative abundance scale based on US Army Corp/Cornell methods.

Code	Rating	Abundance
0	no plants	
1	trace growth of plants	fingerful on rake
2	sparse growth of plants	handful on rake
3	medium growth of plants	rakeful of plants
4	dense growth of plants	difficult to bring into boat

Results and Discussion

Lake Iroquois Survey Results

In September of 2017, the aquatic plant community of Lake Iroquois included twenty-two submersed species, two floating-leaved species, and six emergent species (Table 1) and included some species observed but not collected in the point intercept survey. Nineteen species were present in the point intercept portion of the 2017 surveys, slightly less than the 23 reported in 2014, however a greater number of survey points were included in 2014. Combining the results of all surveys, a total of 45 species of aquatic plants have been reported for Lake Iroquois, however many of these would be classified as wetland species not captured by the current survey techniques. This number of species greatly exceeds the 15 species typically reported for moderately productive lakes in our region and indicates good water quality and a variety of habitat types. Eurasian watermilfoil (*Myriophyllum spicatum)* and curly-leaf pondweed (*Potamogeton crispus*) were the only exotic species reported in Lake Iroquois. Species richness was quite high, with a number of species occurring in more than 5% of survey points (Table 2). Duck celery (*Vallisneria americana*) and coontail (*Ceratophyllum demersum)* were the most common plants (28% of survey points). Eurasian watermilfoil (*Myriophyllum spicatum*) was present in 24% of survey points. A number of native species were also commonly observed. Other common native species for Lake Iroquois included, *Elodea canadensis* (23 % of survey points), *Zosterella dubia* (21%), *Chara/Nitella* (20%), *Najas flexilis* (15%), *Nymphaea odorata* (12%), and *Potamogeton praelongus* (10%). One of the species present in Lake Iroquois, Humped Bladderwort (*Utricularia gibba*) is found on Vermont's rare plant list (VT DEC 2012).

Table 1. Species lists for Lake Iroquois and Sunset Pond.
Species in red are invasive.

Species Name	Common Name	Lake Iroquois	Sunset Pond
Brasenia schreberi	Water shield	fl	fl
Ceratophyllum demersum L.	coontail	s	s
Chara sp.	muskgrass, chara	s	s
Eleocharis acicularis (L.) Roemer & Schultes	needle spike-rush	e	e
Elodea canadensis Michx.	elodea	s	s
Hydrocharis morsus-ranae	European frogbit		fl
Isoetes echinospora Dur.	quillwort	e	e
Lemna minor L.	duckweed		f
Lemna trisulca L.	duckweed	s	s
Megalodonta (Bidens) beckii Torr.	water marigold	s	s
Myriophyllum spicatum L.	Eurasian watermilfoil	s	s
Najas flexilis (Willd.) Rostk. & Schmidt.	bushy pondweed	s	s
Najas guadalupensis L.	southern naiad	s	
Nymphaea odorata Ait.	white waterlily	fl	fl
Polygonum amphibium	smartweed	e	e

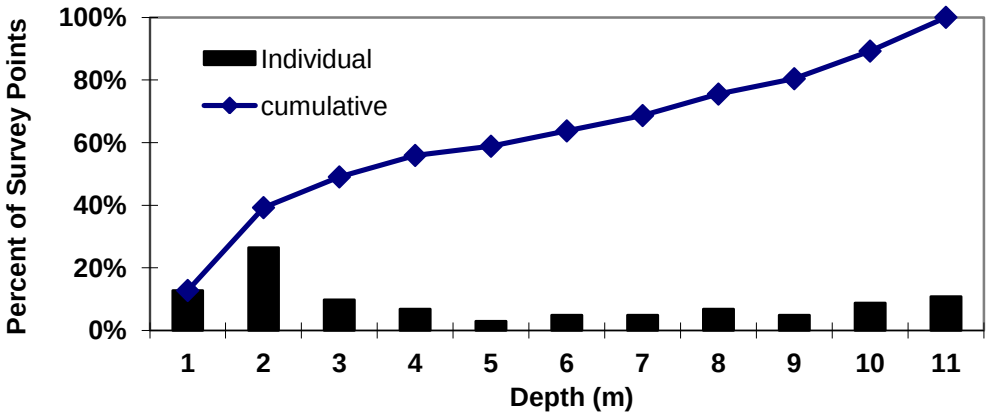
Species Name	Common Name	Lake Iroquois	Sunset Pond
Pontederia cordata L.	pickerelweed	e	e
Potamogeton amplifolius Tuckerm.	large-leaf pondweed	s	s
Potamogeton crispus L.	curly-leaf pondweed	s	
Potamogeton foliosus Raf.	pondweed	s	s
Potamogeton natans L.	floating-leaf pondweed		s
Potamogeton perfoliatus L.	clasping-leaf pondweed	s	s
Potamogeton praelongus Wulfen	white-stem pondweed	s	s
Potamogeton pusillus L.	small pondweed	s	s
Potamogeton richardsonii Oakes	Richardsons' pondweed	s	s
Potamogeton spirillus Tuckerm.	pondweed	s	s
Potamogeton zosteriformis Fern.	flat-stem pondweed	s	s
Ranunculus longirostris Godron	white watercrowfoot	s	s
Sparganium sp.	burreed	e	e
Typha sp.	cattail	e	e
Utricularia gibba L.	humped bladderwort	s	s
Utricularia vulgaris L.	great bladderwort	s	s
Vallisneria americana L.	wild celery	s	s
Zosterella dubia (Jacq.) Small	water stargrass	s	s

f=floating fl=floating leaved e=emergent s=submersed

Maximum Depth of Colonization

Maximum depth of rooted aquatic plant growth, termed the littoral zone, extended to a depth of approximately 5.0 meters (16 feet) in Lake Iroquois. The littoral zone is defined by the presence of rooted aquatic plants, for Lake Iroquois it extends from the lakeshore to a depth of 5 meters. The majority of survey points were in the littoral zone (Figure 2), providing a reasonable representation of the aquatic plant population of Lake Iroquois.

Figure 2. Depth Distribution of Lake Iroquois Sampling Points in 1 meter depth classes.



Species Lists

Maps of the distribution of aquatic plant species for Lake Iroquois are included in Appendix A. Frequency of occurrence results are presented in Table 2. Eurasian watermilfoil (*Myriophyllum spicatum*) was present in 24% of survey points. A number of native species were also commonly observed. Common native species for Lake Iroquois included *Vallisneria americana* (28% of survey points), *Ceratophyllum demersum* (28%), *Elodea canadensis* (23%), *Zosterella dubia* (21%), *Chara/Nitella* (20%), *Najas flexilis* (15%), *Nymphaea odorata* (12%), and *Potamogeton praelongus* (10%).

Table 2. Lake Iroquois percent frequency of occurrence data.

Species Name	Common Name	Lake Iroquois
Ceratophyllum demersum L.	coontail	27.5%
Chara sp.	muskgrass, chara	19.6%
Eleocharis acicularis (L.) Roemer & Schultes	needle spike-rush	4.9%
Elodea canadensis Michx.	elodea	22.5%
Isoetes echinospora Dur.	quillwort	1.0%
Lemna trisulca L.	duckweed	2.9%
Myriophyllum spicatum L.	Eurasian watermilfoil	23.5%
Najas flexilis (Willd.) Rostk. & Schmidt.	bushy pondweed	14.7%
Najas guadalupensis L.	southern naiad	1.0%
Nymphaea odorata Ait.	white waterlily	11.8%
Polygonum amphibium	smartweed	1.0%
Potamogeton amplifolius Tuckerm.	largeleaf pondweed	5.9%
Potamogeton crispus L.	curlyleaf pondweed	2.0%
Potamogeton foliosus Raf.	pondweed	6.9%
Potamogeton perfoliatus L.	clasping-leaf pondweed	2.9%
Potamogeton praelongus Wulfen	white-stem pondweed	9.8%
Potamogeton pusillus L.	small pondweed	6.9%
Potamogeton richardsonii Oakes	Richardsons' pondweed	4.9%
Potamogeton spirillus Tuckerm.	pondweed	1.0%
Potamogeton zosteriformis Fern.	flat-stem pondweed	6.9%
Ranunculus longirostris Godron	white watercrowfoot	5.9%
Sparganium sp.	burreed	1.0%
Typha sp.	cattail	1.0%
Utricularia gibba L.	humped bladderwort	2.0%
Utricularia vulgaris L.	great bladderwort	3.9%
Vallisneria americana L.	wild celery	28.4%
Zosterella dubia (Jacq.) Small	water stargrass	20.6%

Fifty-four percent of whole lake sampling points were vegetated by at least one native plant species (Figure 3), 92% of survey points with depths less than 5 m (Figure 4) and 98% of survey points with depths less than 2 meters depth yielded native aquatic plants in 2017. In 2017, Eurasian watermilfoil was present in 24% of whole lake survey points, and 42% of survey points less than 5 m water depth, representing the littoral zone or zone of aquatic plant growth.

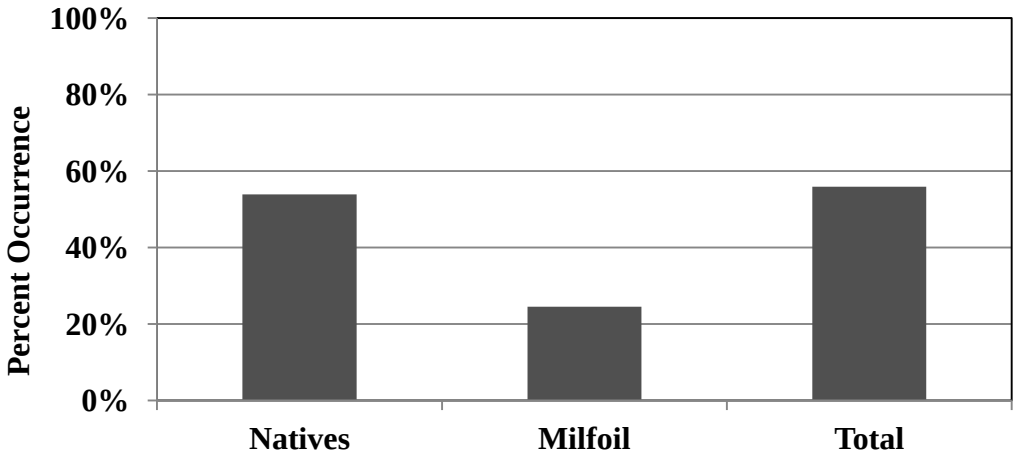


Figure 3. Lake Iroquois frequency of occurrence summaries.

For survey points within the littoral zone, water depth less than 5 m (Figure 4), results similar to whole lake surveys are reported. The expected relationship of greater frequency of occurrence of aquatic plants with shallower water depth is consistent with that reported by other regional studies. Littoral zone frequency of occurrence values were dominated by native species (Figure 3) and similar to nearby lakes (Getsinger et al. 2002).

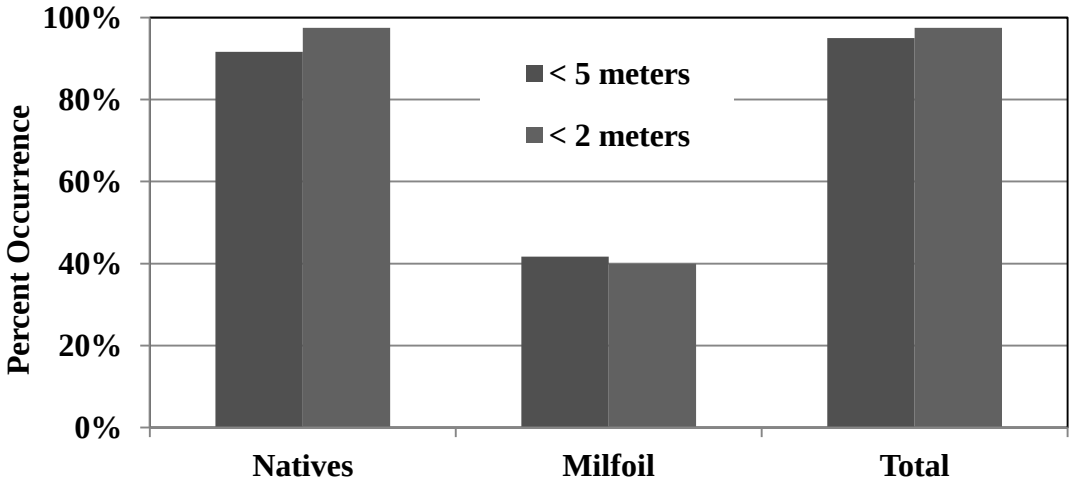


Figure 4. Lake Iroquois frequency of occurrence summaries for sampling points less than 5 and 2 meters water depth.

Table 3. Lake Iroquois species richness comparison.

Plant Grouping	Water Depth Class	Summary Statistic	Survey Result
Native plant species	Whole Lake (all depths)	Mean	2.13
		N	102
		Std. Error	0.25
	Points with depths <5m	Mean	3.62
		N	60
		Std. Error	0.30
	Points with depths <2m	Mean	4.50
		N	50
		Std. Error	0.31
All plant species	Whole Lake (all depths)	Mean	2.40
		N	102
		Std. Error	0.27
	Points with depths <5m	Mean	4.08
		N	60
		Std. Error	0.30
	Points with depths <2m	Mean	4.90
		N	50
		Std. Error	0.31

Species richness results are presented in Table 3 and Figure 5. Whole lake native species richness in 2017 was 2.13 species per sample point. Species richness in this range is comparable to other nearby lakes (Eichler 2016). For survey points exclusively within the littoral zone (depths less than 5 meters), native species richness was 3.62 species per survey point (Figure 6). As expected, species richness in the littoral zone and its shallow fringe was higher than whole lake species richness.

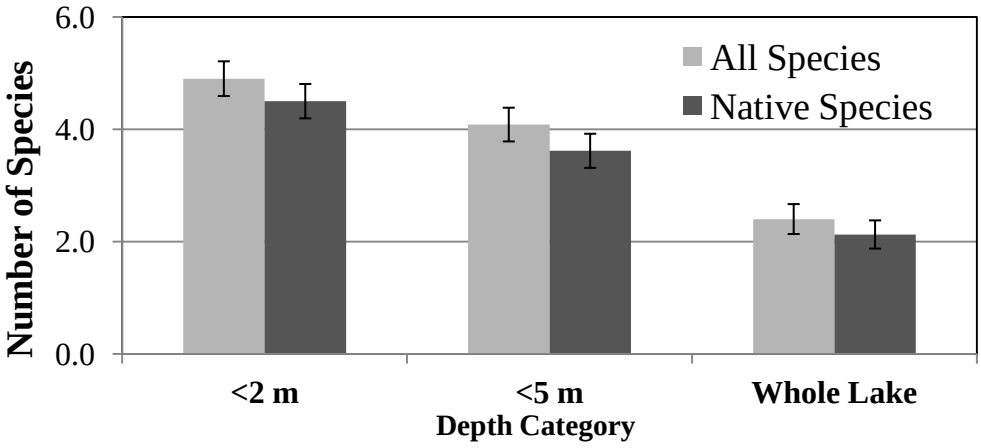


Figure 5. Lake Iroquois species richness.
Error bars are standard error of the mean.

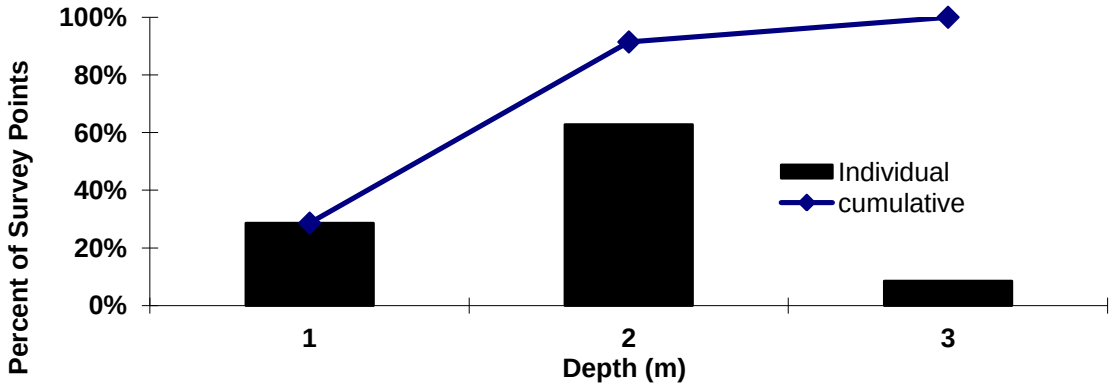
Sunset Pond Survey Results

In September of 2017, the aquatic plant community of Sunset Pond included twenty-one submersed species, three floating-leaved species, one free floating species and six emergent species (Table 1). One new invasive species, European frogbit (*Hydrocharis morsus-ranae*) was reported for Sunset Pond in 2017. For the point intercept survey, a total of 19 species were reported in 2017. None of the species reported for Sunset Pond were on Vermont's rare plant list. Species richness was quite high, with a large number of species occurring in more than 5% of survey points (Table 5). For Sunset Pond, Eurasian watermilfoil (*Myriophyllum spicatum*) was present in 43% of survey points and European frogbit (*Hydrocharis morsus-ranae*) was present in 6% of survey points.

Maximum Depth of Colonization

Plants were present at all depths in Sunset Pond where the maximum depth observed was slightly over 2 meters (6.5 ft). The majority of survey points were in water depths of 2 meters or less (Figure 6).

Figure 6. Depth Distribution of Sunset Pond Sampling Points in 1-meter depth classes.



Species Lists

Maps of the distribution of aquatic plant species for Sunset Pond are included in Appendix B. Frequency of occurrence results are presented in Table 4. Waterweed (*Elodea canadensis)* was the most common species, present in 80% of survey points. Eurasian watermilfoil (*Myriophyllum spicatum*) was found in 43% of survey points. A number of native species were commonly observed. Other common native species for Sunset Pond included *Nymphaea odorata* (60% of survey points), *Potamogeton zosteriformis* (49%), *Zosterella dubia* (31%), *Najas flexilis* (17%), *Ranunculus longirostris* (17%), *Sparganium* (14%), and *Potamogeton pusillus* (11%).

Table 4. Sunset Pond percent frequency of occurrence data.

Species Name	Common Name	Sunset Pond
Ceratophyllum demersum L.	coontail	74.3%
Eleocharis acicularis (L.) Roemer & Schultes	needle spike-rush	5.7%
Elodea canadensis Michx.	elodea	80.0%
Hydrocharis morsus-ranae	European frogbit	5.7%
Megalodonta (Bidens) beckii Torr.	water marigold	8.6%
Myriophyllum spicatum L.	Eurasian watermilfoil	42.9%
Najas flexilis (Willd.) Rostk. & Schmidt.	bushy pondweed	17.1%
Nymphaea odorata Ait.	white waterlily	60.0%
Polygonum amphibium	smartweed	11.4%
Potamogeton amplifolius Tuckerm.	largeleaf pondweed	14.3%
Potamogeton foliosus Raf.	pondweed	11.4%
Potamogeton natans L.	floating-leaf pondweed	2.9%
Potamogeton praelongus Wulfen	white-stem pondweed	2.9%
Potamogeton pusillus L.	small pondweed	11.4%
Potamogeton zosteriformis Fern.	flat-stem pondweed	48.6%
Ranunculus longirostris Godron	white watercrowfoot	17.1%
Sparganium sp.	burreed	14.3%
Typha sp.	cattail	8.6%
Zosterella dubia (Jacq.) Small	water stargrass	31.4%

All of the lake sampling points were vegetated by at least one native plant species (Figure 7), and Eurasian watermilfoil was present in 43% of whole lake survey points.

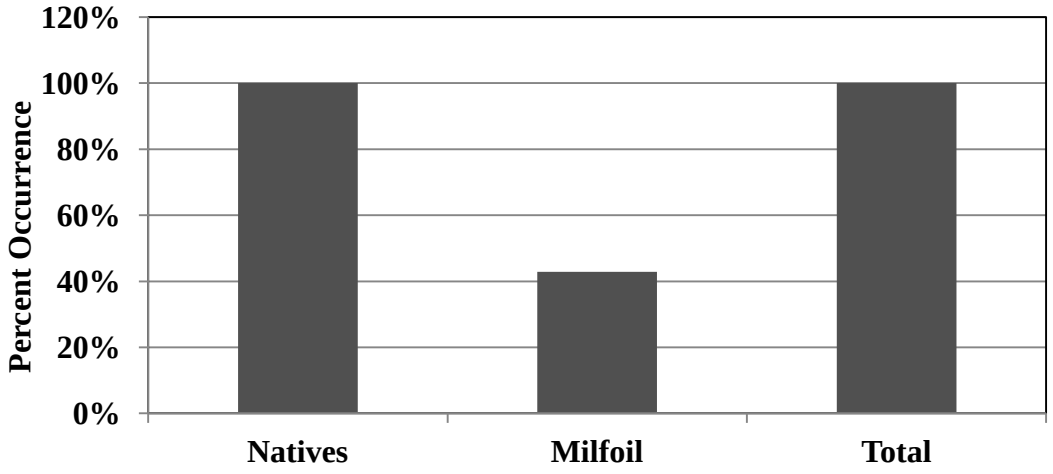


Figure 7. Sunset Pond frequency of occurrence summaries.

Species richness results for Sunset Pond are presented in Table 5. Whole lake native plant species richness was 4.03 species per survey point, similar to that reported for the shallow margins of the littoral in Lake Iroquois. Species richness in this range is comparable to other regional lakes (Eichler et al. 2016).

Table 5. Sunset Pond species richness comparison.

Plant Grouping	Water Depth Class	Summary Statistic	Survey Result
Native plant species	Whole Lake (all depths)	Mean	4.03
		N	35
		Std. Error	0.26
All plant species	Whole Lake (all depths)	Mean	4.69
		N	35
		Std. Error	0.25

Summary

Quantitative aquatic plant surveys were undertaken for Lake Iroquois and Sunset Pond, Vermont, in September of 2017. Surveys were designed to obtain post-treatment data following aquatic plant management efforts employing hand harvesting for Eurasian watermilfoil control. The frequency and distribution of aquatic plant species in each lake were evaluated using a point intercept method based on a differential global positioning system of grid points. The assessment generated the information necessary to: 1) evaluate the effectiveness of the aquatic plant management efforts, 2) determine the impact of the management efforts on non-target aquatic plant species, and 3) provide data for comparison of post-treatment conditions to prior survey information.

Eurasian watermilfoil (*Myriophyllum spicatum*) populations were first reported in 1990 in Lake Iroquois and confirmed in 1991. Eurasian watermilfoil was first confirmed in Sunset Pond in 2008. Hand harvesting by skin and SCUBA divers has been the basis of the program for most years since the formation of the lake association in 2007. The aquatic weevil (*Euhrychiopsis lecontei*) population of the lake was supplemented in 2008 and 2009 in an effort to provide a biocontrol agent for Eurasian watermilfoil. Approximately 70 acres of Lake Iroquois was reported to support dense growth of Eurasian watermilfoil in 2014. Diver assisted suction harvesting in 2016 harvested over 5000 gallons of Eurasian watermilfoil from 2 locations.

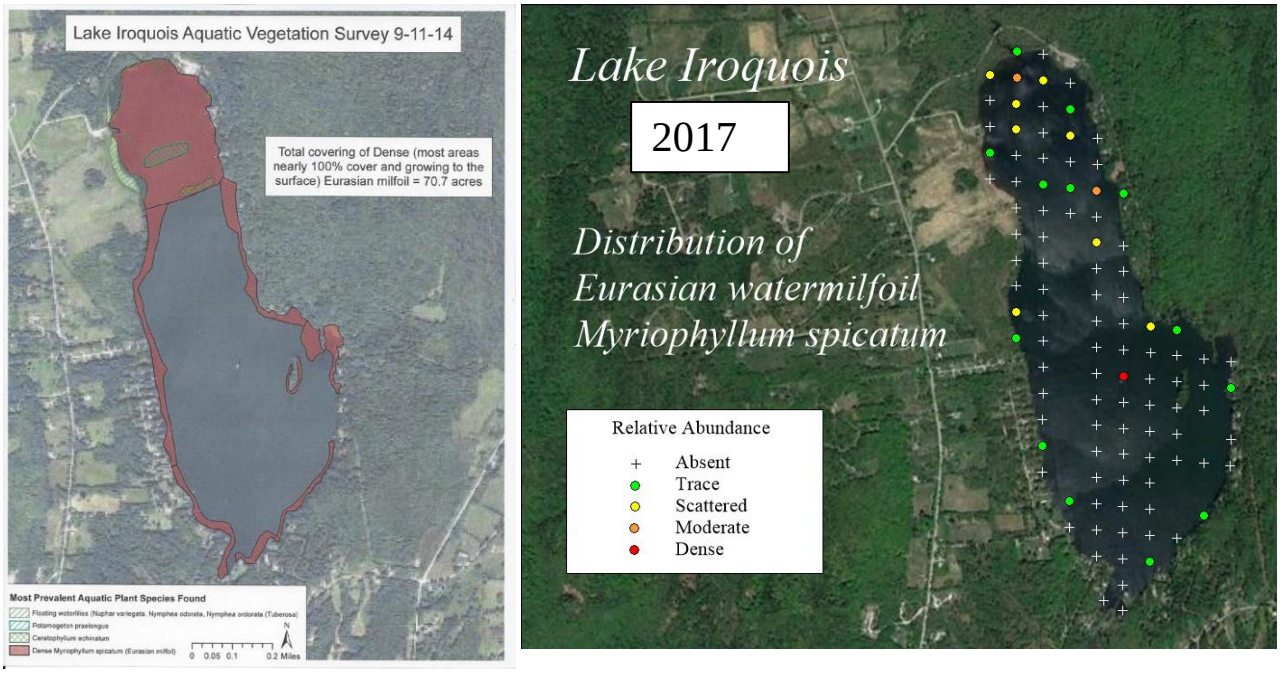
The aquatic plant community of Lake Iroquois includes twenty-two submersed species, two floating-leaved species, and six emergent species, similar to the 23 reported in 2014. This number of species greatly exceeds the 15 species typically reported for moderately productive lakes in our region and indicates good water quality and a variety of habitat types. One of the species present in Lake Iroquois, Humped Bladderwort (*Utricularia gibba*) is found on Vermont's rare plant list (VT DEC 2012). Eurasian watermilfoil was present in 24% of survey points in 2017, a decline from the dense growth reported for over 67% of the littoral zone in 2014 (Figure 8). The density of Eurasian watermilfoil growth has also declined, with most points described as dense growth in 2014 reduced to scattered or moderate growth in 2017.

Species richness in Lake Iroquois was quite high, with a number of species occurring in more than 5% of survey points. Fifty four percent of sampling points were vegetated by at least one native plant species. The large number of points supporting native plant species suggests that Lake Iroquois is a prime candidate for recovery of its native plant population following management of Eurasian watermilfoil. Native species richness in the littoral zone was 3.62 species per sample in 2017, at the high end of species richness values for other regional lakes, which ranged from 1.79 to 4.00 species per sample.

Common native species for Lake Iroquois included wild celery (*Vallisneria americana,* 28% of survey points), coontail (*Ceratophyllum demersum*, 28%), waterweed (*Elodea canadensis,* 23%), water stargrass (*Zosterella dubia,* 21%), muskgrass (*Chara/Nitella,* 20%), bushy pondweed (*Najas flexilis,* 15%), white waterlily (*Nymphaea odorata,* 12%), and white-stem pondweed *(Potamogeton praelongus,* 10%). Native species results are generally comparable to those reported in 2014 with a few exceptions. In 2014, *Ceratophyllum echinatum* was one of the most abundant species, but absent in 2017. A very similar, common native species, *Ceratophyllum*

demersum, remains dominant in Lake Iroquois. Declines in most native species are observed as a result of invasion and canopy formation by Eurasian watermilfoil. .

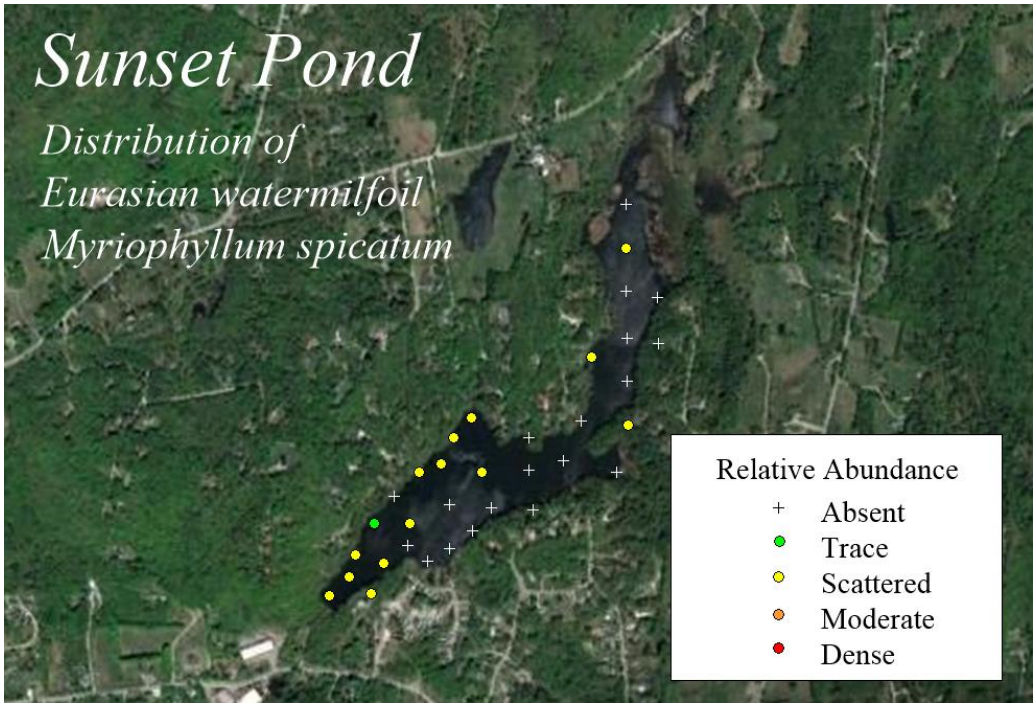
Figure 8. Distribution of Eurasian watermilfoil in Lake Iroquois.



For Sunset Pond, the aquatic plant community consisted of twenty-one submersed species, three floating-leaved species, one free floating species and six emergent species. One new invasive species, European frogbit (*Hydrocharis morsus-ranae*) was reported for Sunset Pond in 2017. None of the species reported for Sunset Pond were on Vermont's rare plant list. For Sunset Pond, Eurasian watermilfoil (*Myriophyllum spicatum*) was present in 43% of survey points (Figure 9). Common native species for Sunset Pond included waterweed (*Elodea canadensis,* 80% of survey points*),* white waterlily *(Nymphaea odorata,* 60%) flat-stem pondweed (*Potamogeton zosteriformis,* 49%), water stargrass (*Zosterella dubia,* 31%), bushy pondweed (*Najas flexilis,* 17%), white watercrowfoot (*Ranunculus longirostris,* 17%), burreed (*Sparganium,*14%), and small pondweed (*Potamogeton pusillus,* 11%). With this diversity and distribution of native species, the test for treatment selectivity should be sensitive to a number of species, and native plant restoration in areas formerly inhabited by Eurasian watermilfoil should be rapid following management efforts. The dominant species present were all reported in prior surveys.

Eurasian watermilfoil growth in both Lake Iroquois and Sunset Pond was present primarily as scattered and moderate density growth in September of 2017, while the native plant populations appear robust and similar to other regional lakes. One area of dense growth of Eurasian watermilfoil for Lake Iroquois was observed around the mid-lake rocky island. Comparing survey results in 2014 and 2017, Eurasian watermilfoil has declined in Lake Iroquois, even without extensive management efforts. Shifts in plant growth from year to year are common,

Figure 9. Distribution of Eurasian watermilfoil in Sunset Pond.



particularly with new invaders like Eurasian watermilfoil. These shifts are often attributed to changing weather patterns, plant disease outbreaks or differences in the abundance of plant predators. For Sunset Pond, Eurasian watermilfoil dominated the northwest cove and south end of the lake, while scattered growth was observed in the remainder of the lake. The distribution of a newly discovered invasive species such as European frogbit in Sunset Pond should also be monitored. This species can spread by vegetative (fragments) and seed dispersal routes. It is known to grow densely at the shallow margins of plant growth and crowd out native species.

Management Review

The Eurasian watermilfoil management effort at Lake Iroquois and Sunset Pond is an ongoing activity. Establishment of an effective lake association was a critical first step. The association appears to be effective, well organized, adequately funded and strongly motivated. An educated lake community is a valuable asset. Data collection to understand the options for management of invasive aquatic plants is well underway. With only a review of annual reports, brief discussions with program managers, and the results of the Fall plant survey, I offer the following suggestions. Given the level of the current program, I anticipate that most if not all of these recommendations have been considered and many are currently being employed.

Prevention

1. Maintain or consider expanding the 'Greeter' program. Prevention is the most cost effective mechanism for invasive aquatic species (IAS) control. Enforce clean, drain and dry whenever possible.
2. Expand boat washing. Mandatory boat washing is becoming more common as regulatory agencies shoulder more of the costs for invasive species management. A quick review of the lakes visited by boaters prior to launching into central Vermont lakes includes sources for zebra mussels (Lake Champlain, Lake George, Glen Lake), asian clams (Lake George), and spiny waterfleas (Lake George, Lake Champlain). The larval stages of these species, and in some cases the adults, are too small for visual inspections to capture.
3. Discourage lake users from feeding waterfowl. Large collections of waterfowl increase the likelihood of nuisance plant and animal introductions via waterfowl transport. It also has other benefits, such as reducing the spread of swimmers itch, other forms of contact dermatitis, and additional public health concerns.

Education

1. Take full advantage of the educational materials available through the VT DEC, Lake Champlain Basin Program, Federation of Vermont Lakes and Ponds (FOVLAP) and others. Developing the support of residents and visitors greatly enhances prevention efforts and can provide additional inputs to monitoring activities.
2. Maximize community involvement through social media such as webpages, newsletters and others. Lake Iroquois Association has a well organized and frequently updated webpage.
3. Lake associations must band together to have the required political clout to maintain programs to manage lakes. Several excellent "umbrella" groups are the North American Lake Management Society (NALMS), the Aquatic Plant Management Society (APMS) and its Northeast Chapter (NEAPMS) and the Federation of Vermont Lakes and Ponds (FOVLAP). All publish informational

newsletters and brochures, and memberships are available both for lake associations and individuals.

Management

1. The current combination of physical and biological techniques employed by the Lake Iroquois Milfoil Management Program indicates an awareness of integrated milfoil management. Consider all available options for milfoil control, and combine the techniques chosen into an integrated management effort both lake-wide and on a site by site basis. Given the lake-wide growth of Eurasian watermilfoil, consideration of whole lake herbicide treatments is warranted.
2. Consider intensive efforts (i.e. herbicides, larger hand pulling crew sizes or more volunteer teams) to transition from a management to a maintenance condition. Once milfoil abundance is reduced through intense management efforts, levels can be maintained with limited annual efforts. Consider new ways to use existing resources. For example, some lakes have had success using larger dive teams with surface support (i.e. kayaks or canoes) to hand harvest areas of dense growth typically considered too large for this type of effort. Continued use of diver assisted suction harvesting (DASH) teams may be a viable option.
3. Prioritize harvest to manage sites most likely to produce fragments for in-lake dispersal (i.e. high traffic zones, high wave action areas, waterfowl areas).
4. Consider reducing visits to sites which produce very few milfoil plants to once every other season freeing divers to focus on areas of dense growth.
5. Consider benthic barrier for difficult to harvest sites, such as gravel or deep soft silty sediments. Sand bags can be substituted for stakes in very hard or very soft substrates to secure the barrier material.
6. Initial indications are that the weevil augmentation for Iroquois Lake has not controlled Eurasian watermilfoil growth nor resulted in an increase in the overall weevil population, however assessment of weevil density and the extent of weevil damage should be continued. This type of control effort may take several years to become established.

Monitoring and Assessment

1. Take advantage of volunteers to make visual inspections of the littoral zone for the presence of IAS. Judging by the number of volunteer hours and the description of milfoil mapping efforts, it appears that you are making use of volunteers.
2. Employ monitoring results to refine management efforts based on density of growth of IAS and site specific conditions. For example, use benthic barrier or ‘spot’ herbicide treatments for very dense growth or where site conditions make suction harvesting difficult. Benthic barrier has been demonstrated to kill milfoil

in about 6 weeks, so barrier can be recovered and used at another location in a single season, if needed. Employ suction harvesting on moderate to dense growth areas and use hand harvesting in scattered growth areas or as a "clean-up" of areas originally harvested by other means. Select dense sites with large fragmentation potential to be harvested first, with more remote sites with less milfoil growth saved for later in the season. Employ mechanical and physical techniques to extend the period between herbicide applications.

3. Conduct extensive surveys of the plant community periodically to confirm visual inspections, detect any additional invasive aquatic species, evaluate the effectiveness of current management efforts, and detect any unintended impacts to native (non-target) species.

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Acknowledgements

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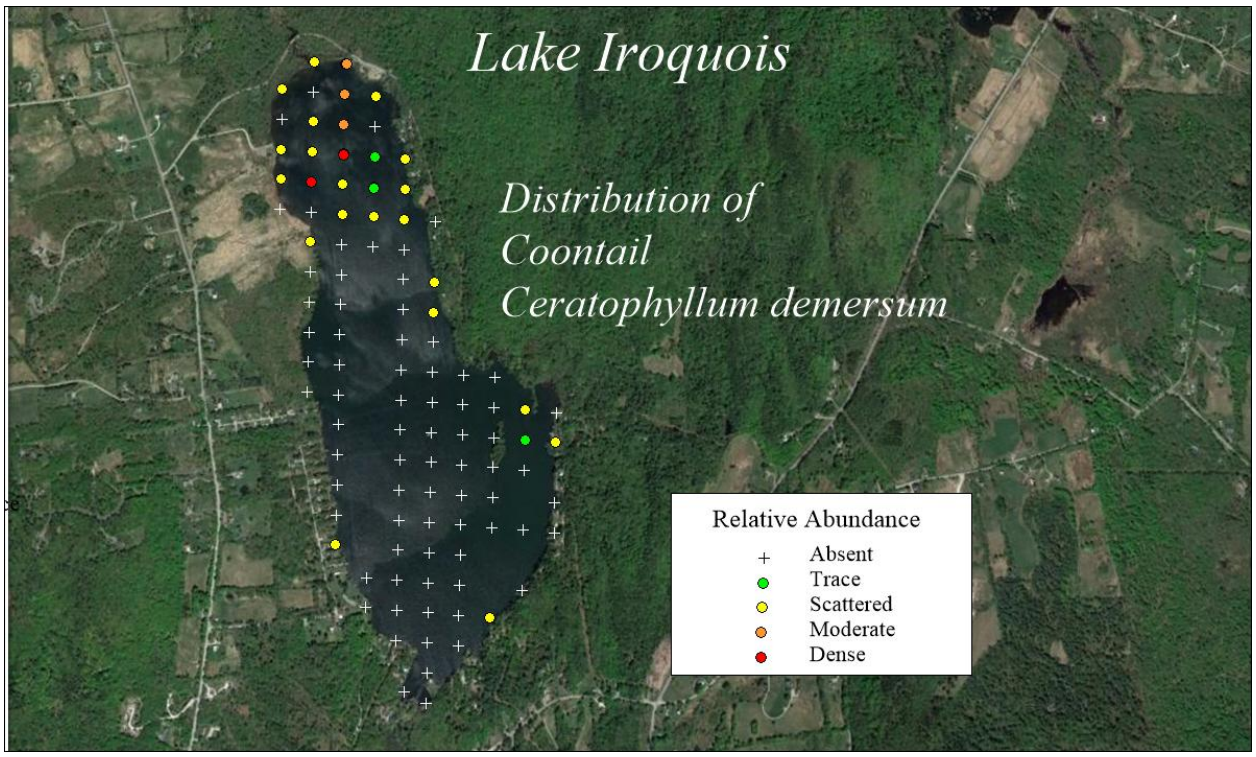
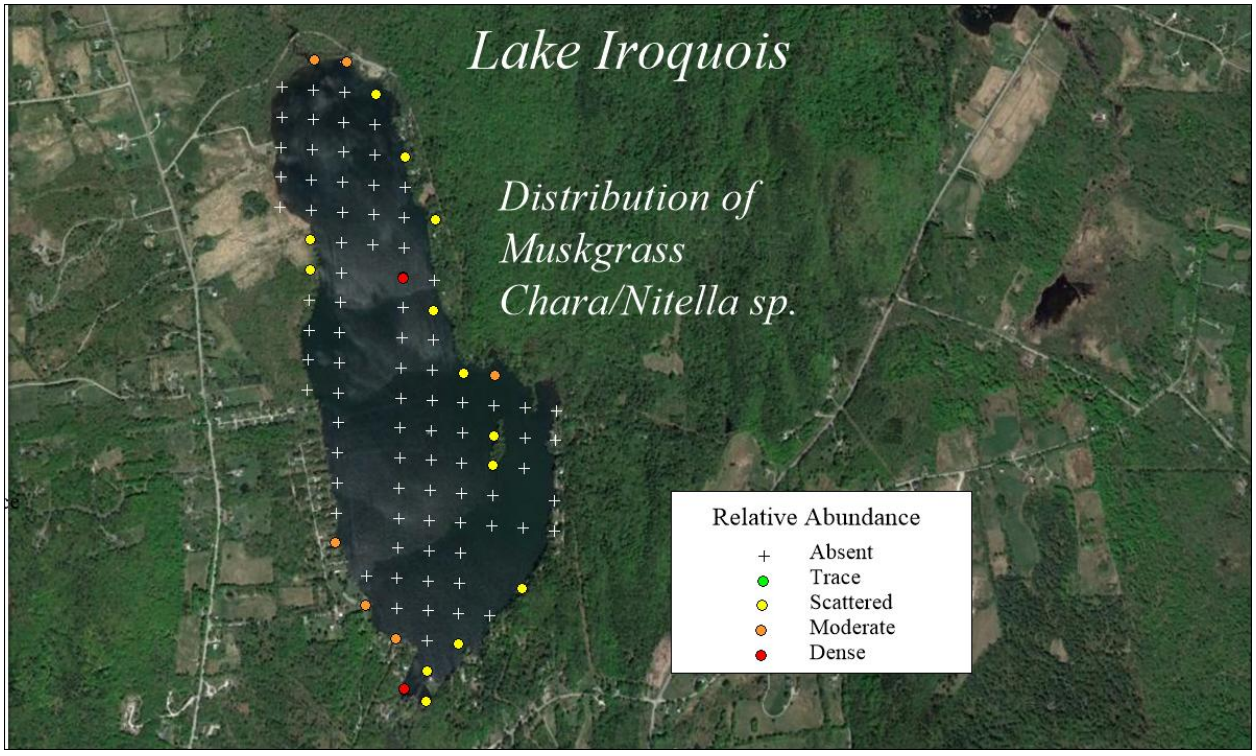
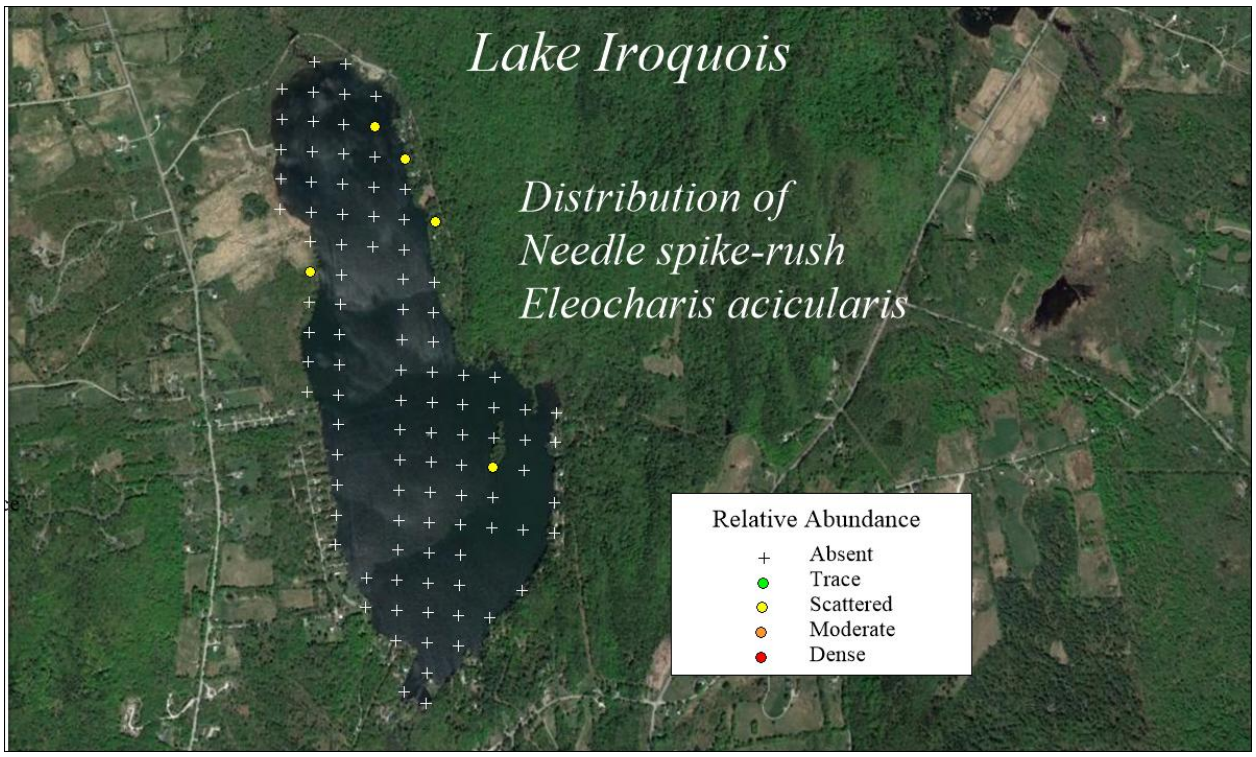
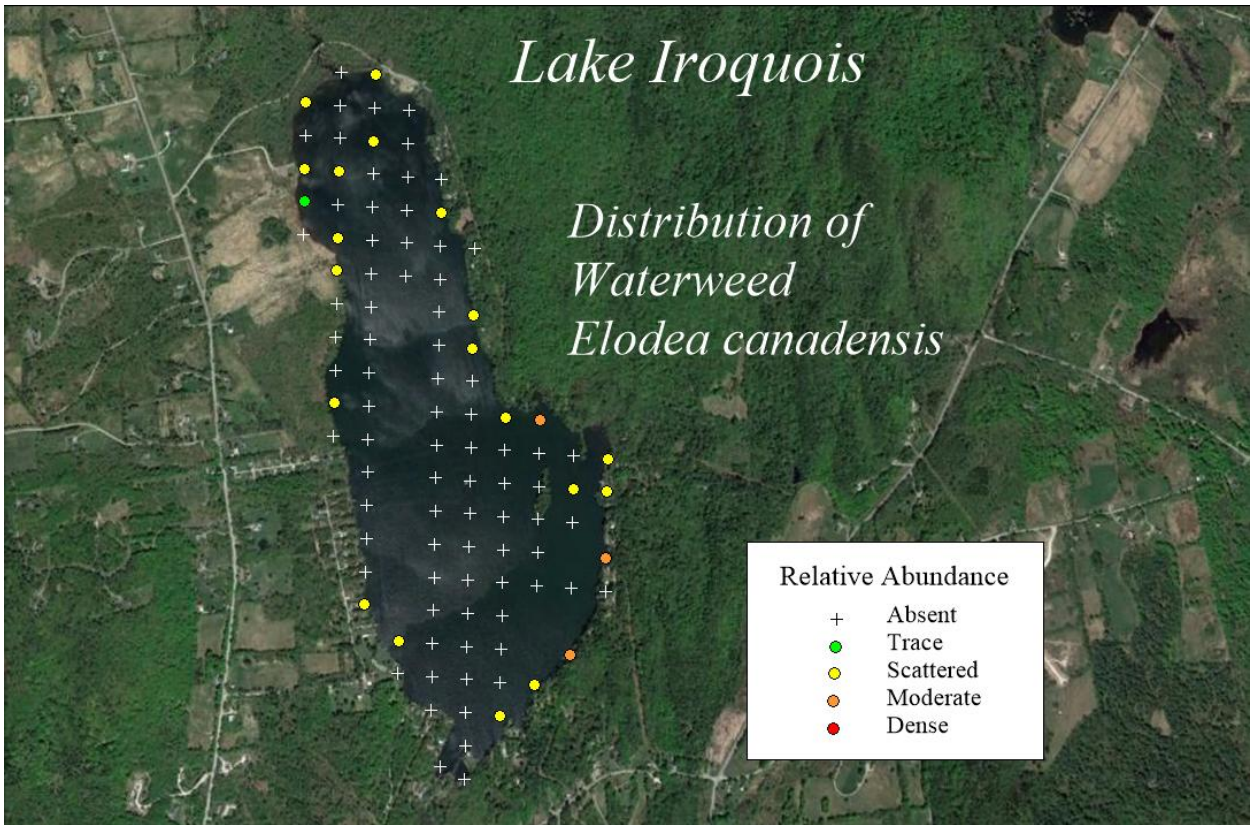
Appendix A

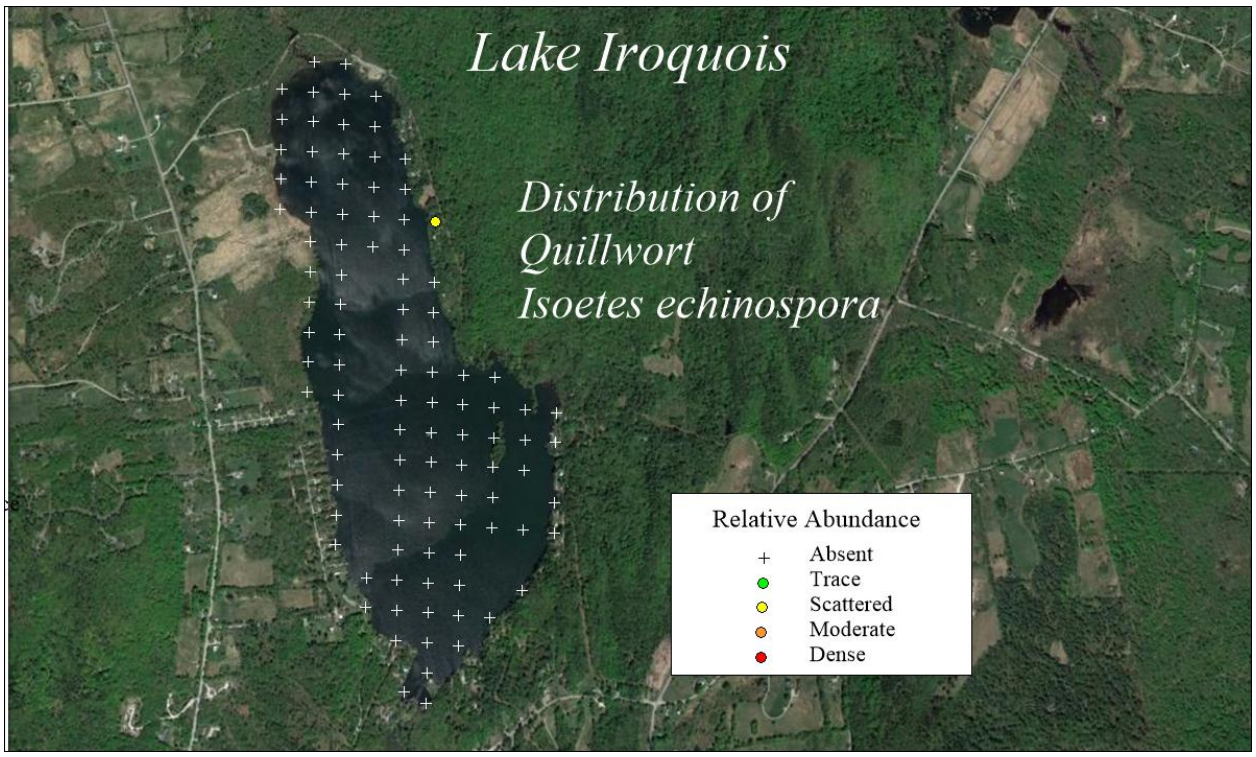
Lake Iroquois Aquatic Plant Distribution Maps

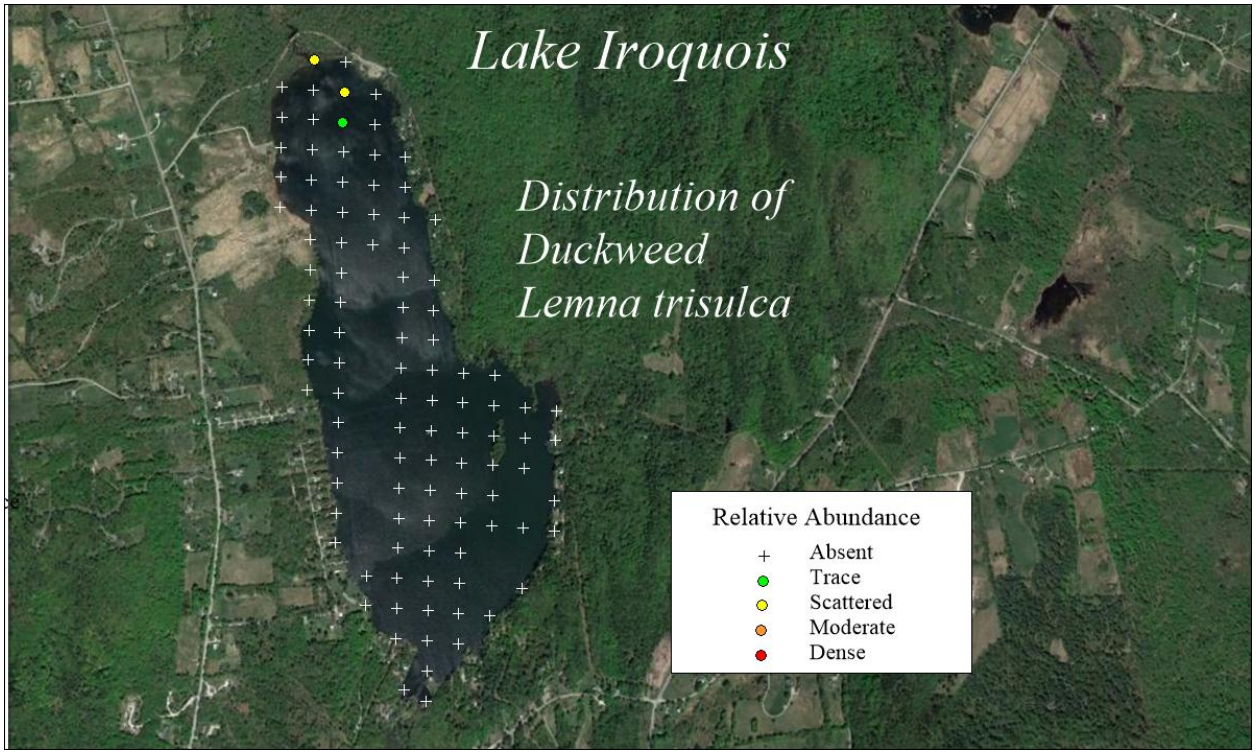

Lake Iroquois
Distribution of
Coontail
Ceratophyllum demersum
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense

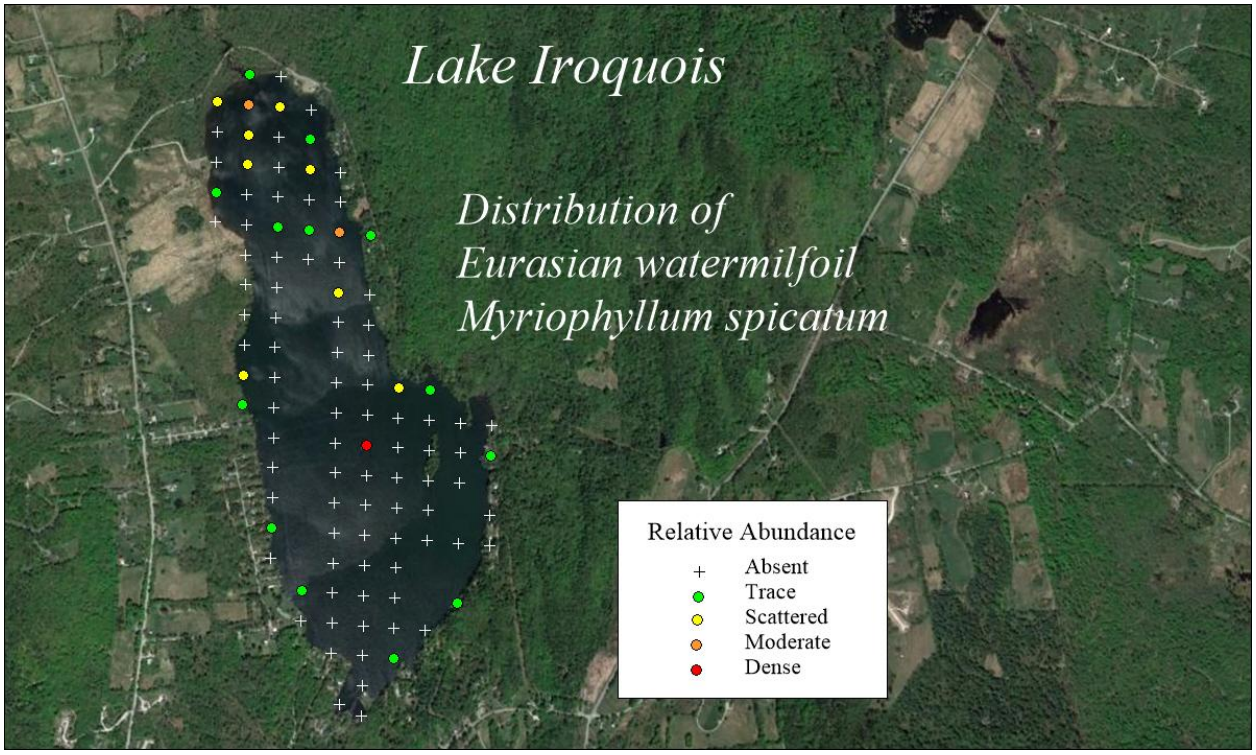

Lake Iroquois
Distribution of
Muskgrass
Chara/Nitella sp.
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense


Lake Iroquois
Distribution of
Needle spike-rush
Eleocharis acicularis
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense


Lake Iroquois
Distribution of
Waterweed
Elodea canadensis
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense


Lake Iroquois
Distribution of
Quillwort
Isoetes echinospora
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense


Lake Iroquois
Distribution of
Duckweed
Lemna trisulca
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense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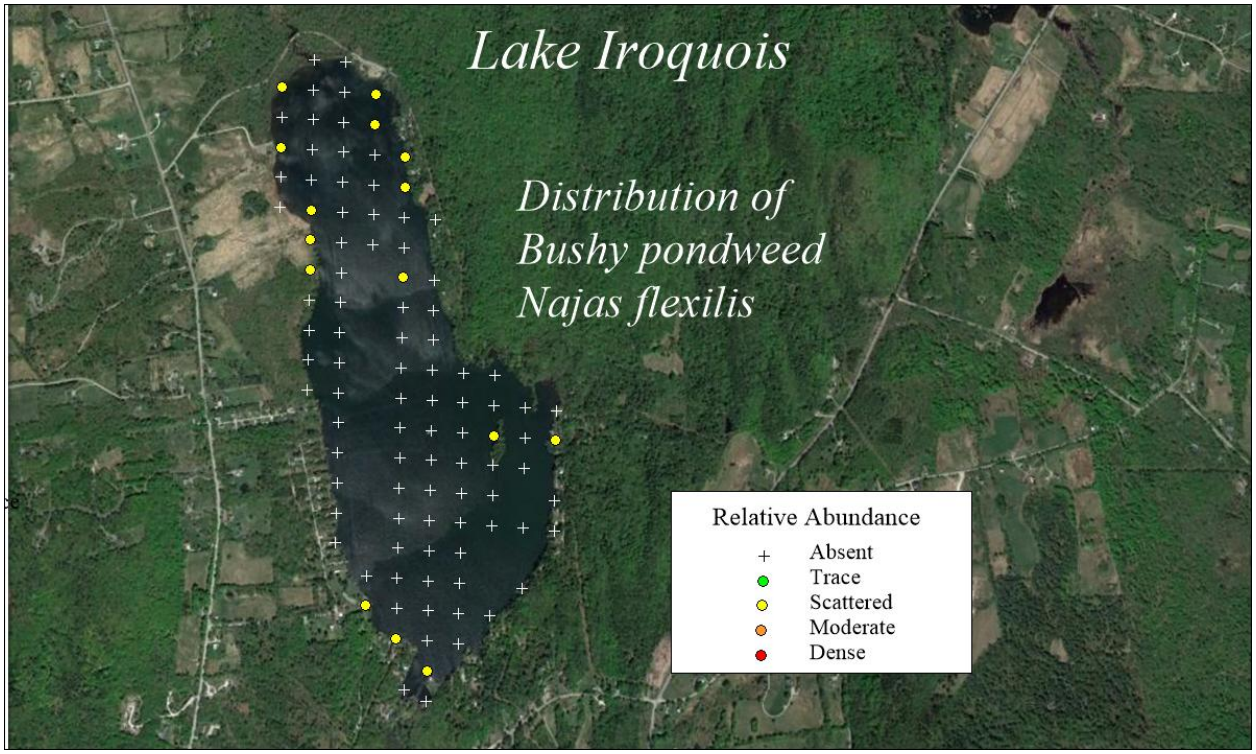
Distribution of
Eurasian watermilfoil
Myriophyllum spicatum
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense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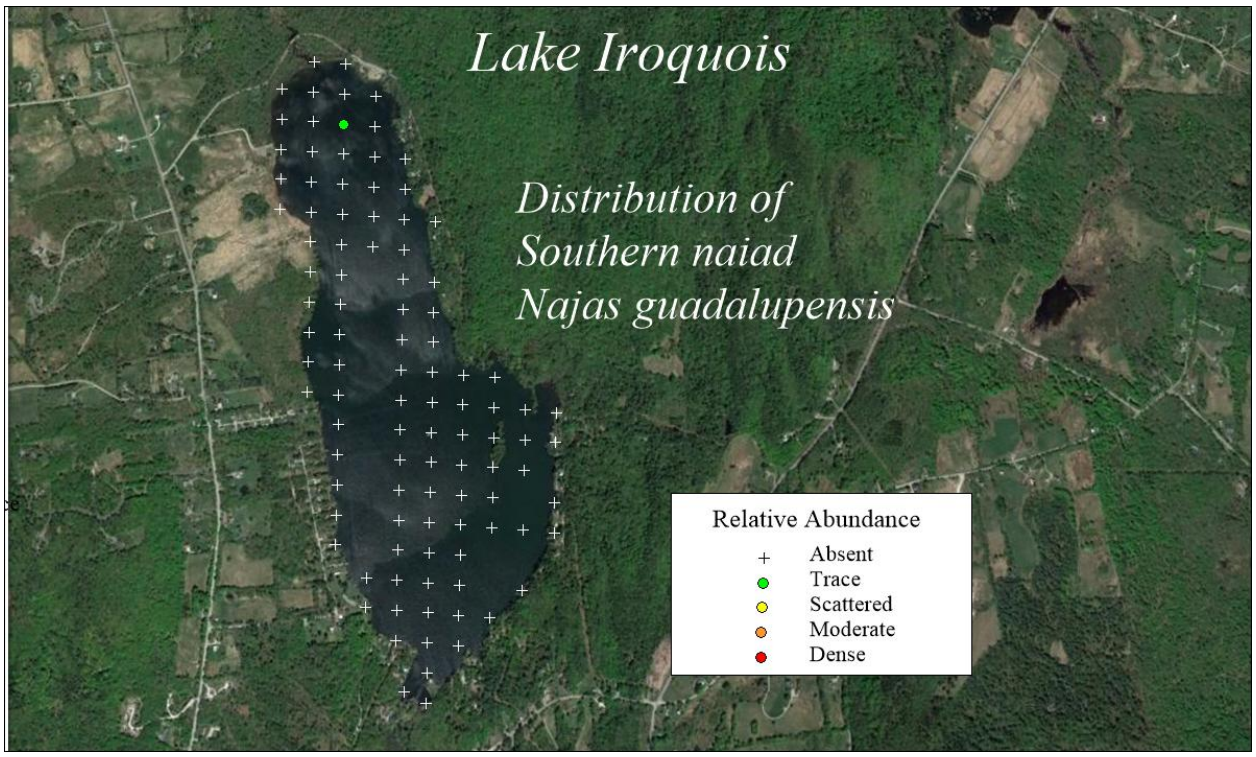
Distribution of
Bushy pondweed
Najas flexilis
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense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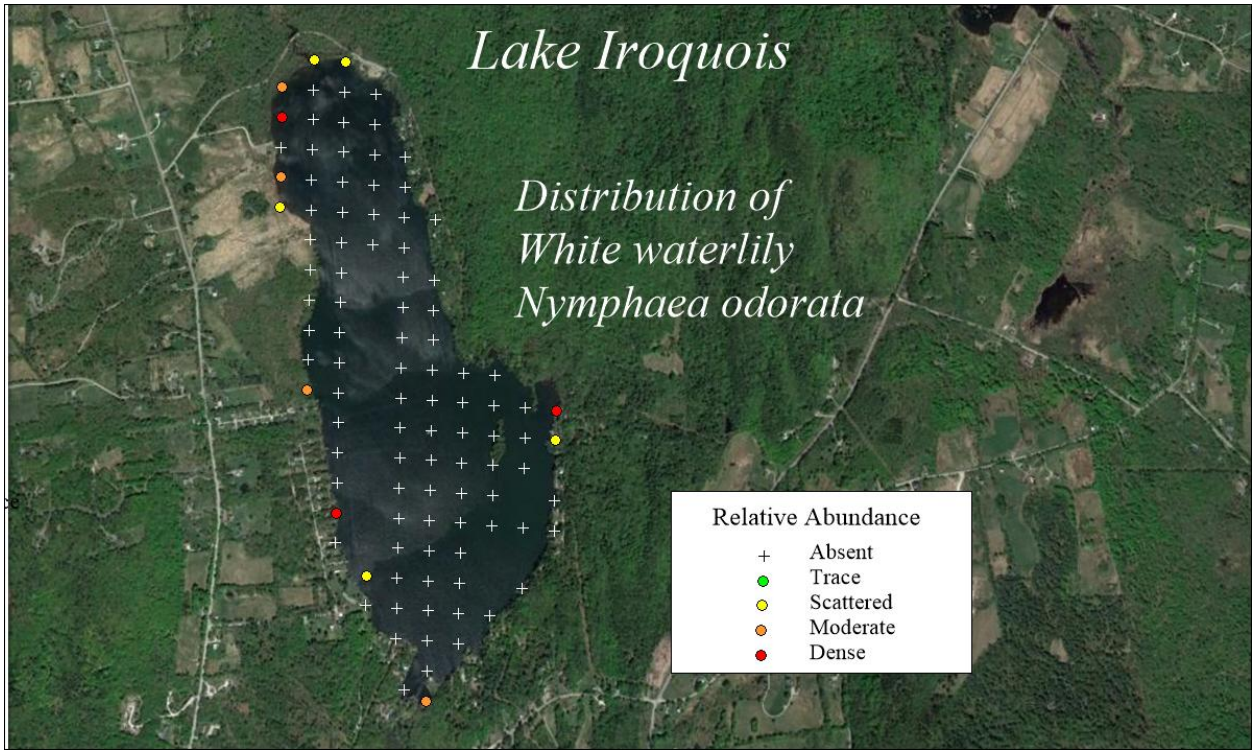
Distribution of
Southern naiad
Najas guadalupensis
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense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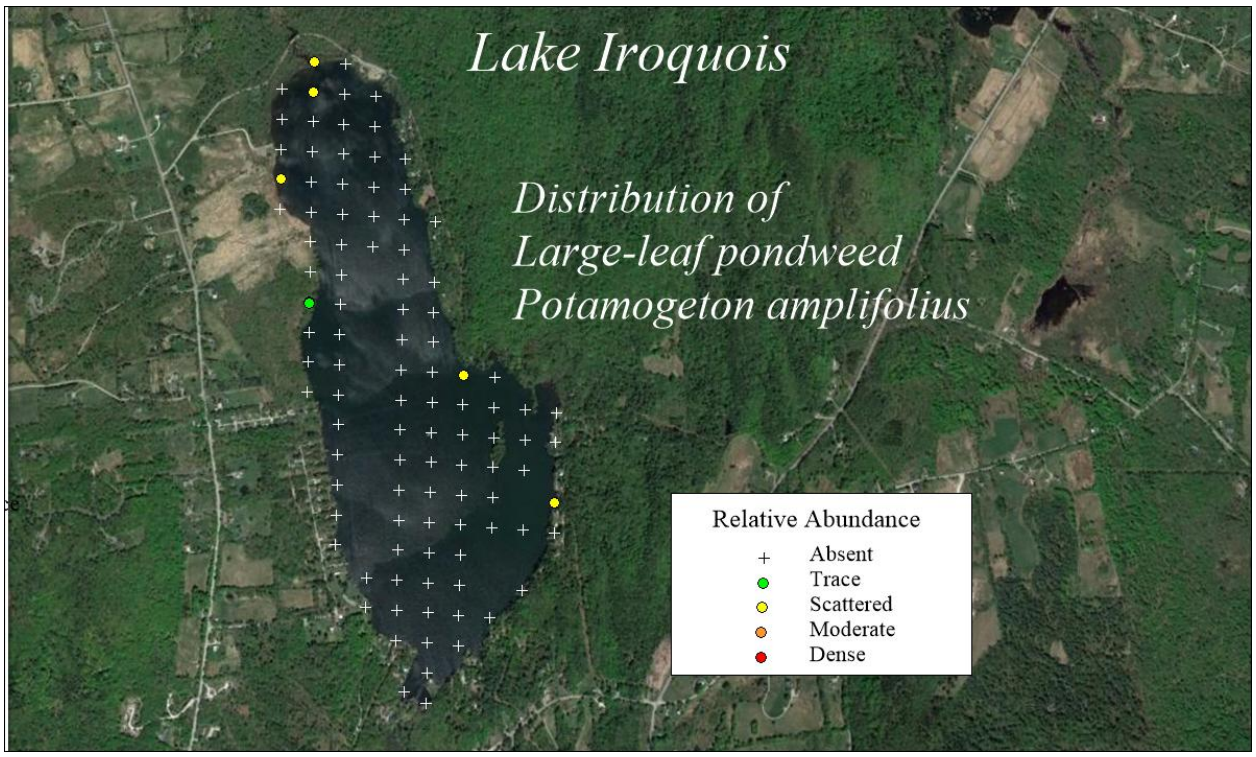
Distribution of
White waterlily
Nymphaea odorata
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense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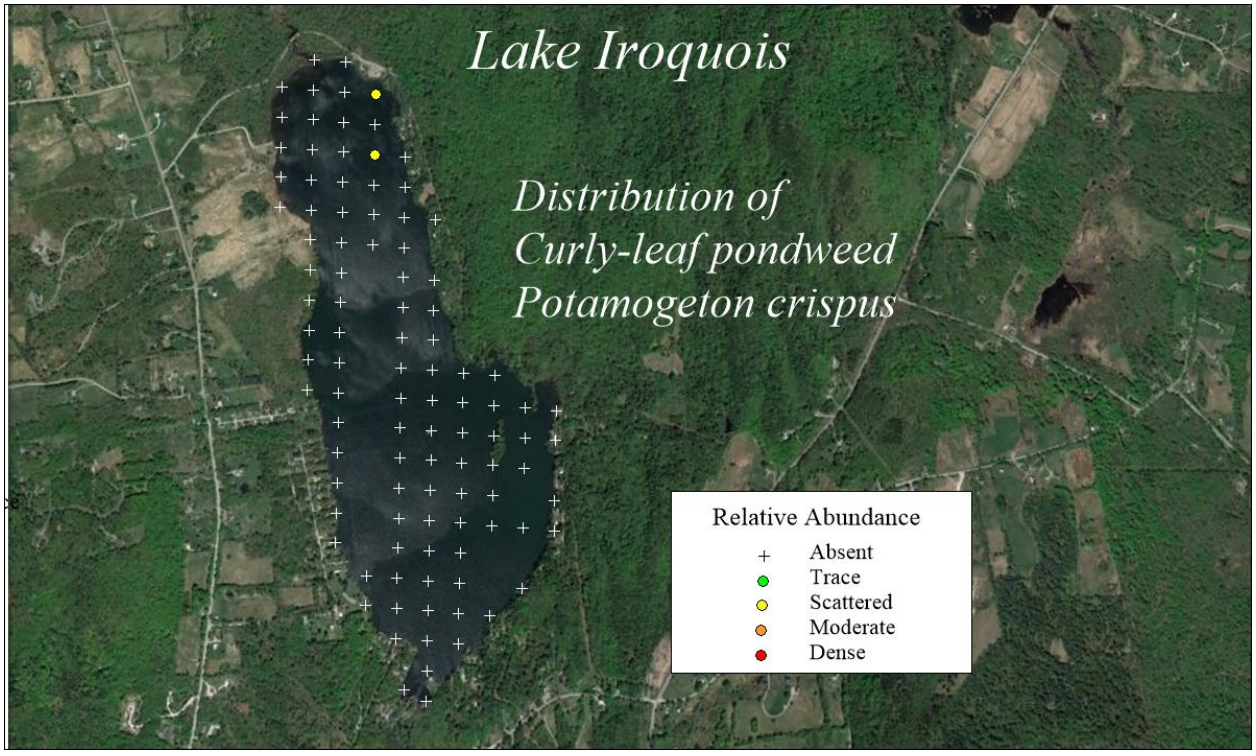
Distribution of
Large-leaf pondweed
Potamogeton amplifolius
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense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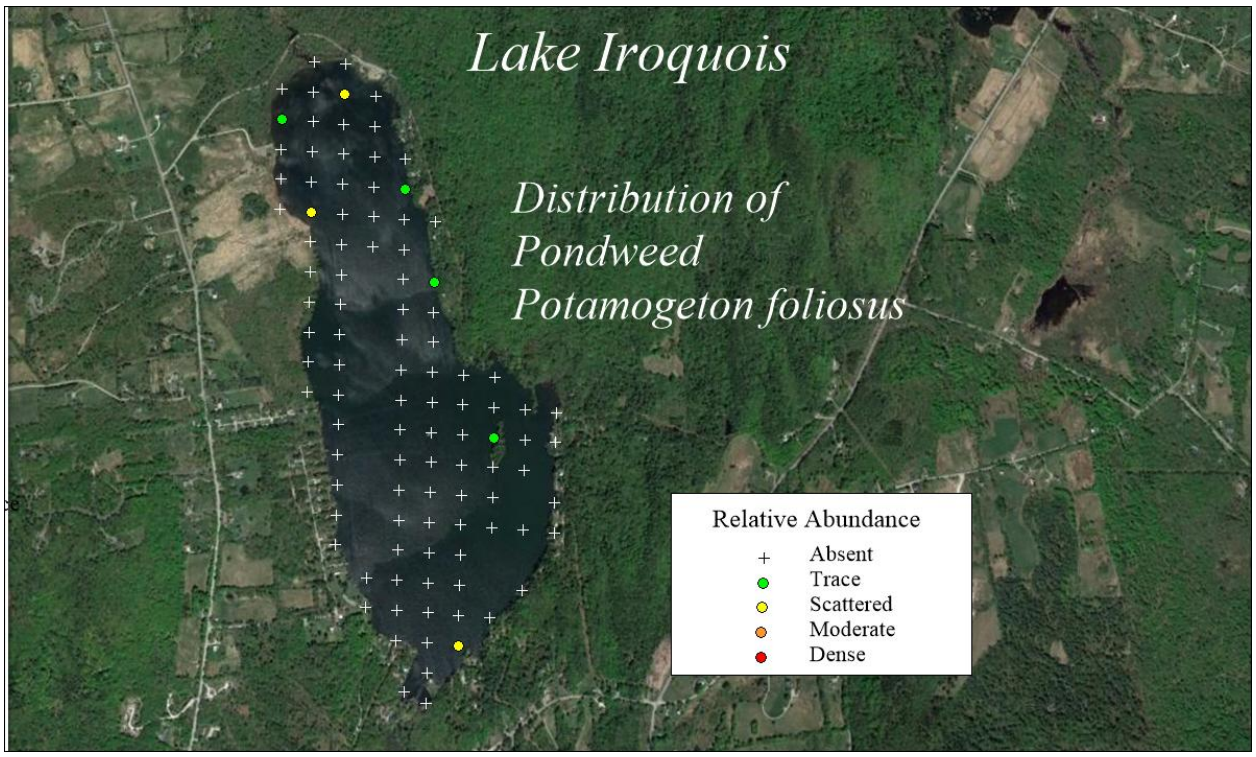
Distribution of
Curly-leaf pondweed
Potamogeton crispus
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense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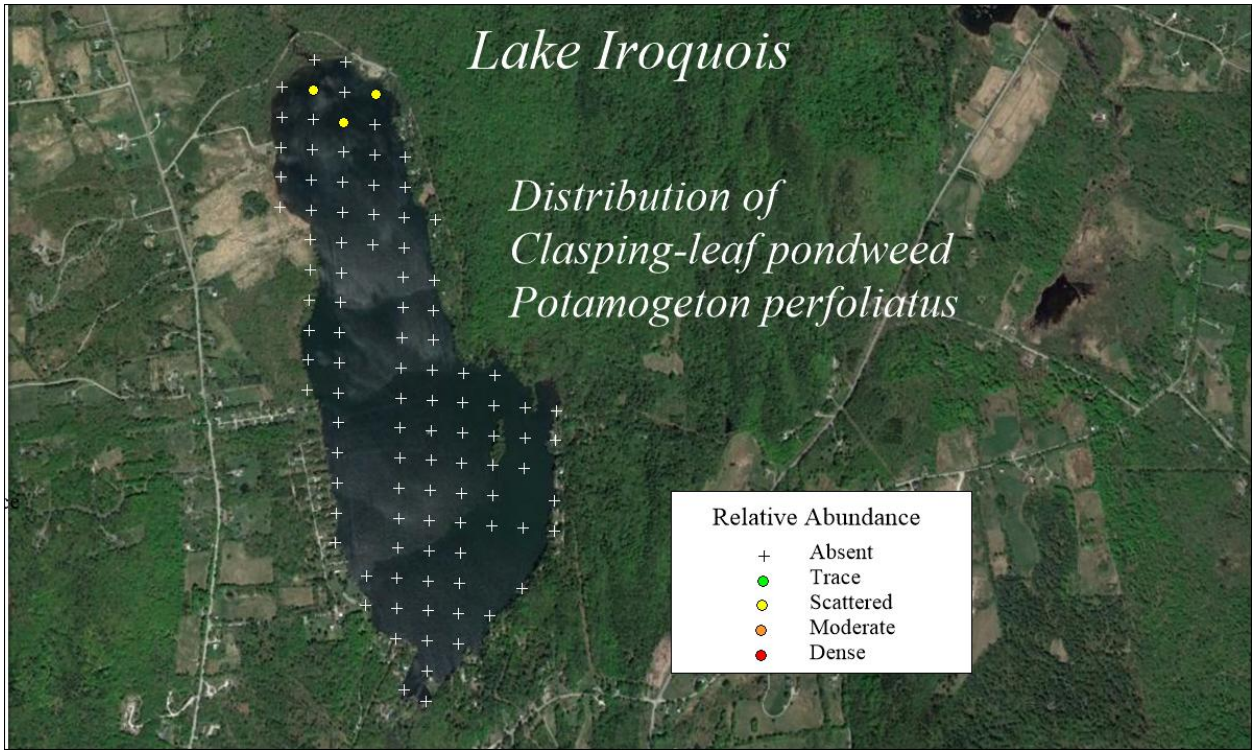
Distribution of
Pondweed
Potamogeton foliosus
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense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Distribution of
Clasping-leaf pondweed
Potamogeton perfoliatus
Relative Abundance
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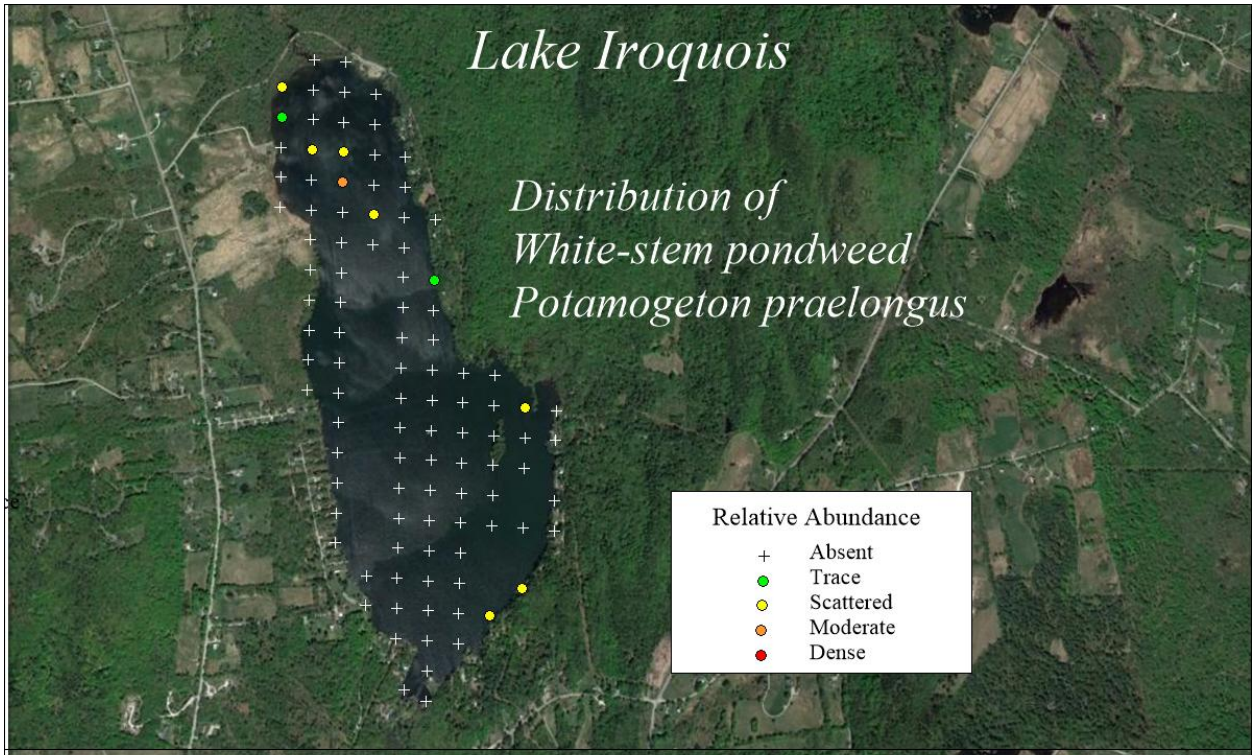
Trace
Scattered
Moderate
Dense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Distribution of
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Relative Abundance
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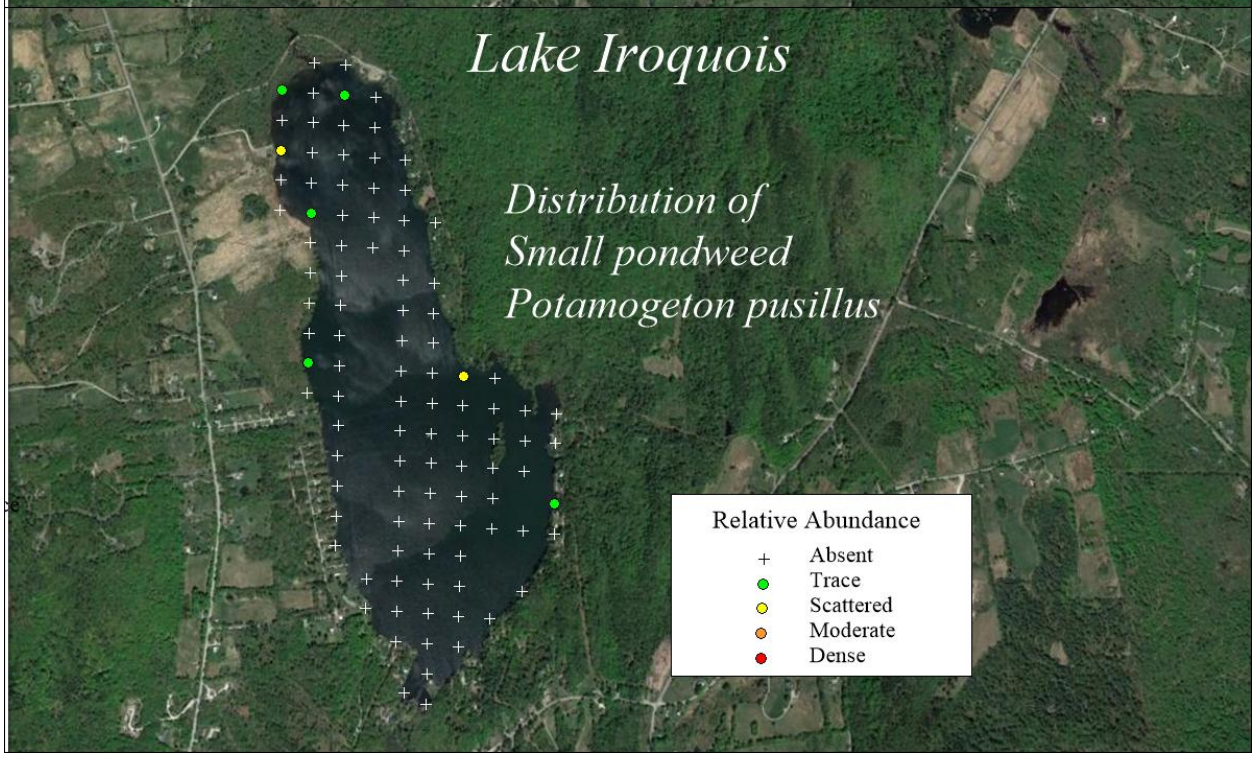
Moderate
Dense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Distribution of
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Relative Abundance
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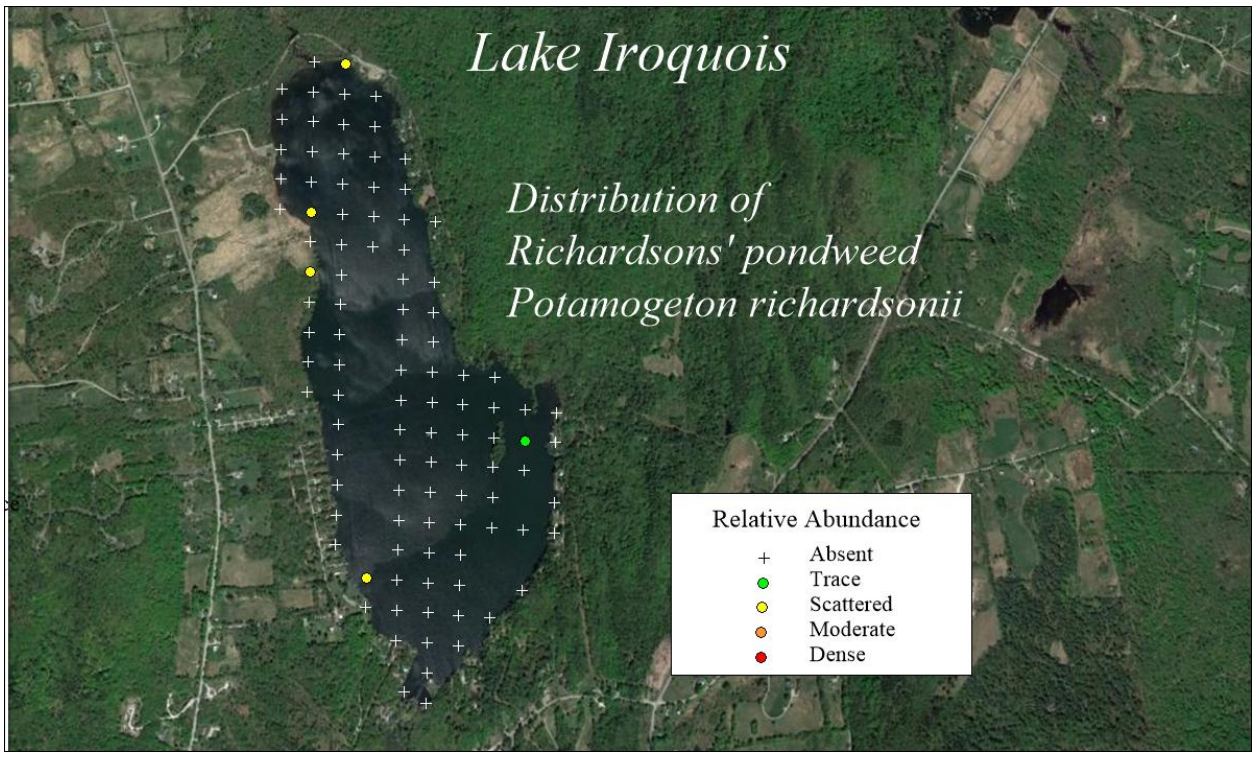
Dense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Distribution of
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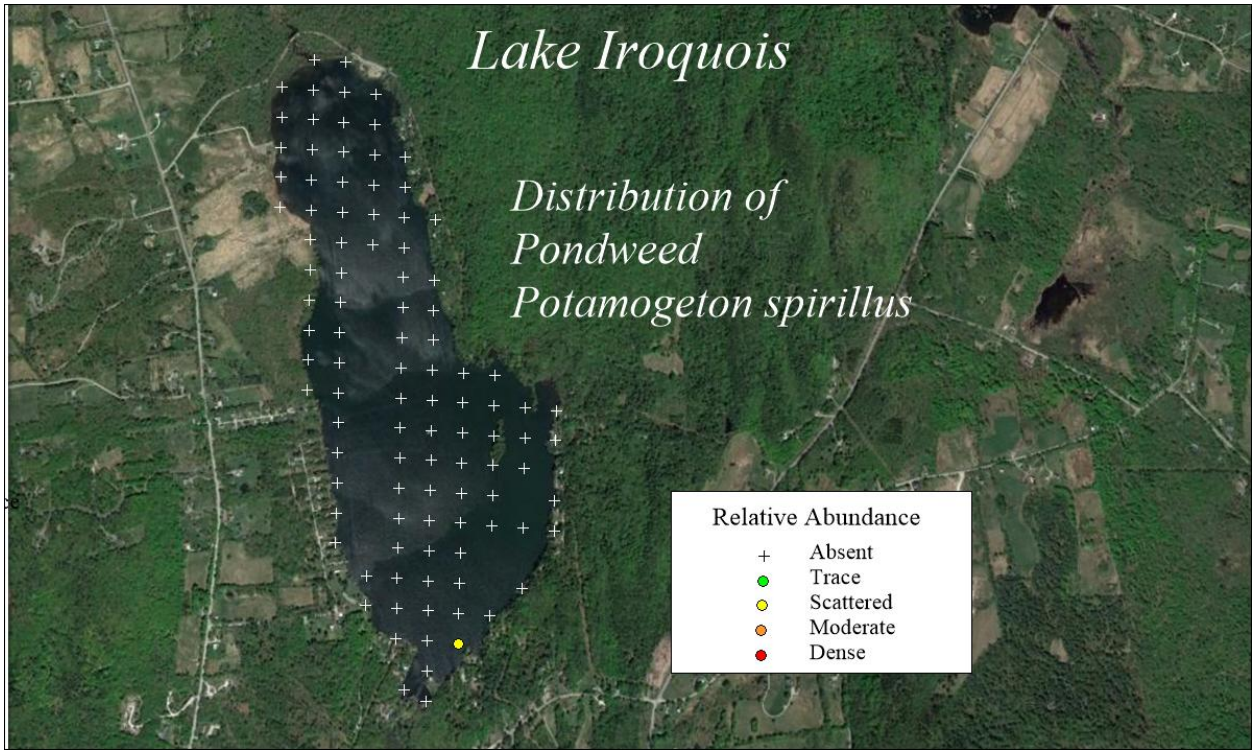
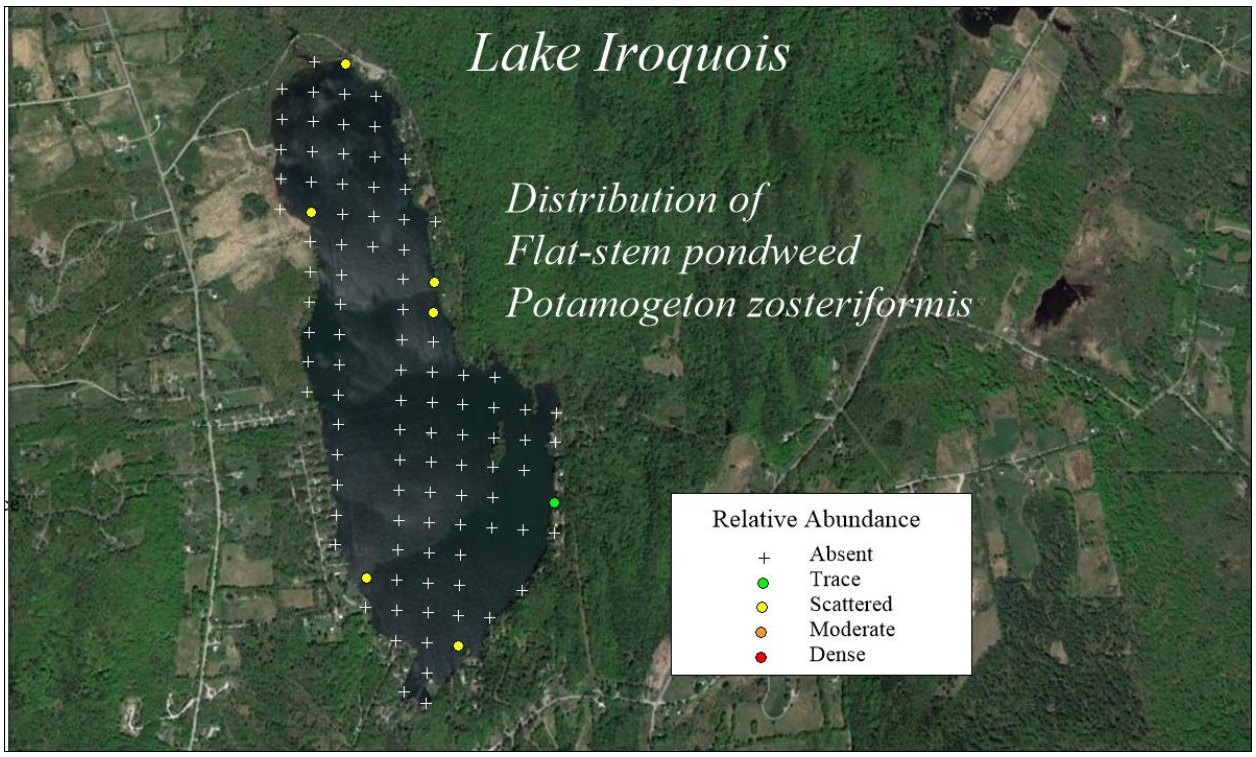
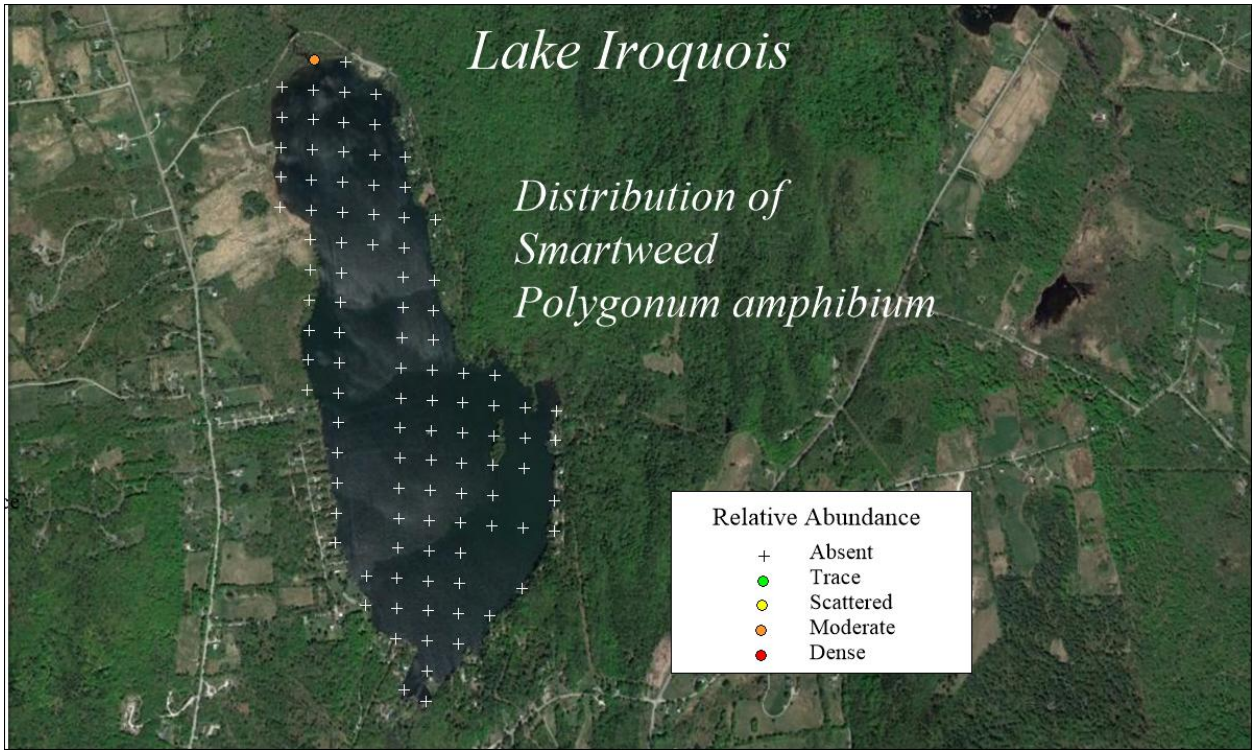
Potamogeton richardsonii
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense


Lake Iroquois
Distribution of
Pondweed
Potamogeton spirillus
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense


Lake Iroquois
Distribution of
Flat-stem pondweed
Potamogeton zosteriformis
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense


Lake Iroquois
Distribution of
Smartweed
Polygonum amphibium
Relative Abundance
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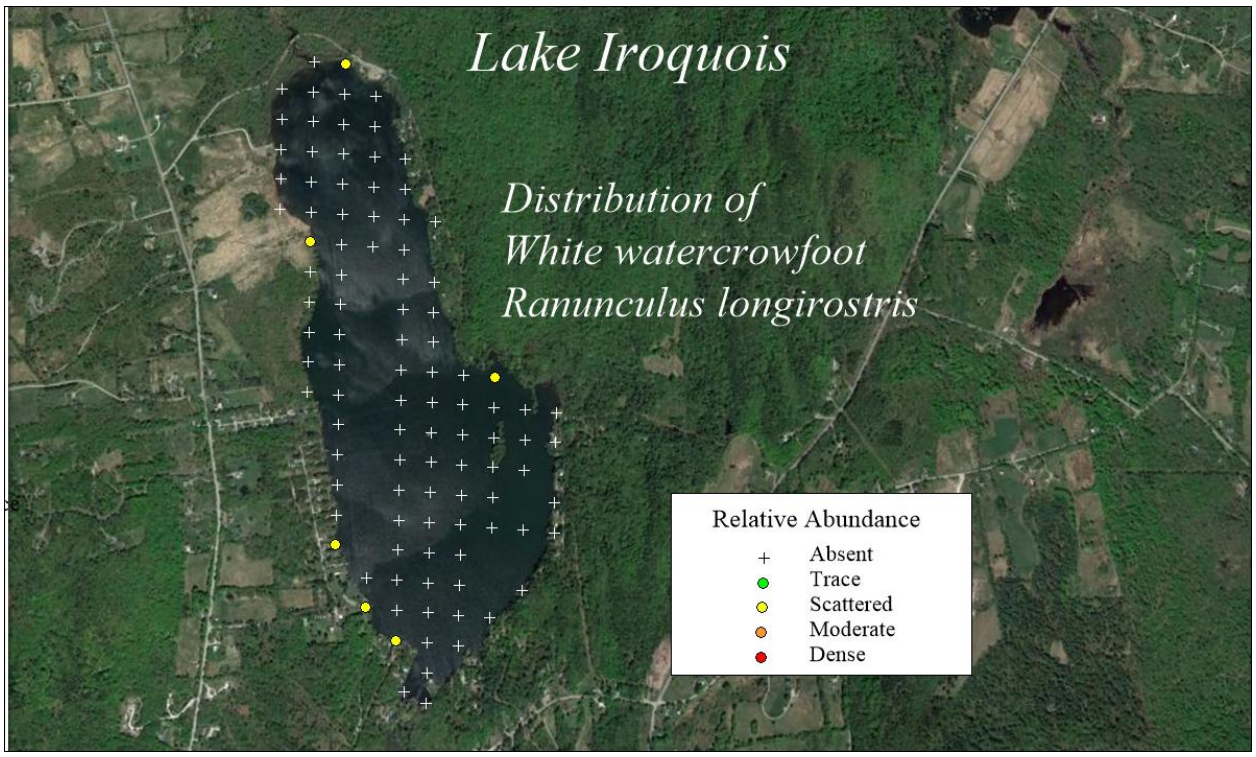
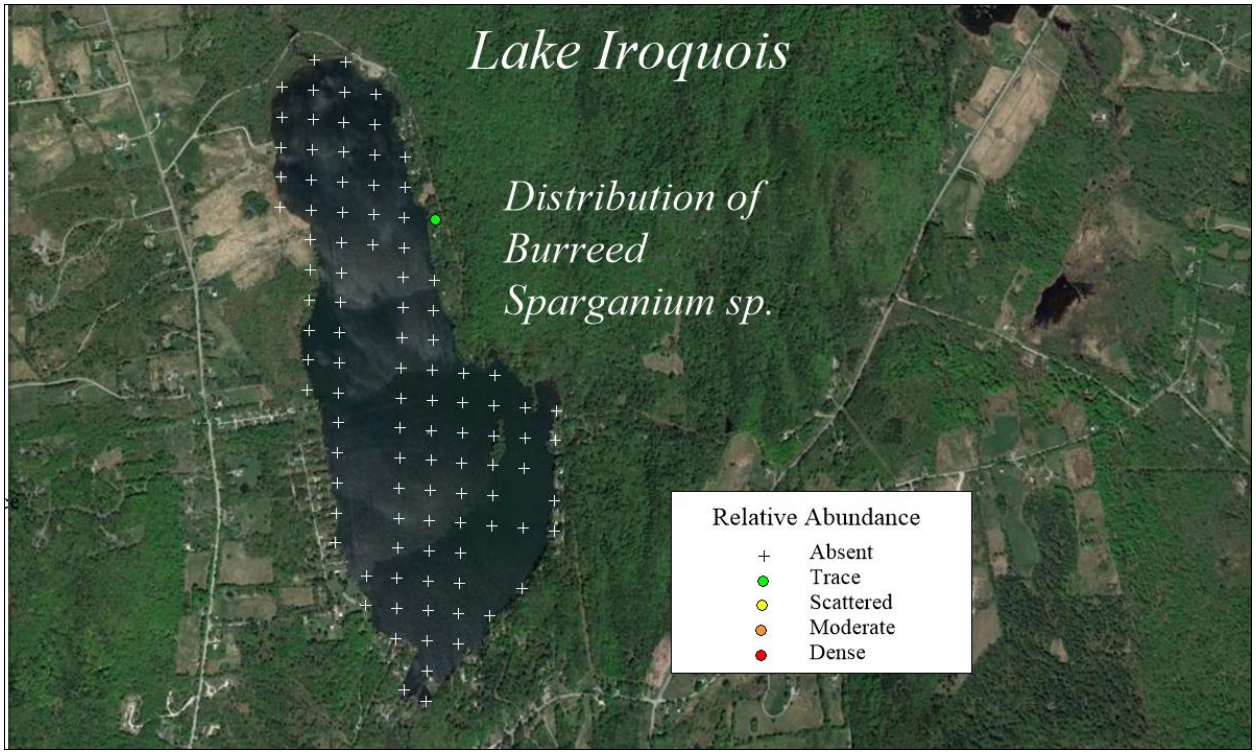
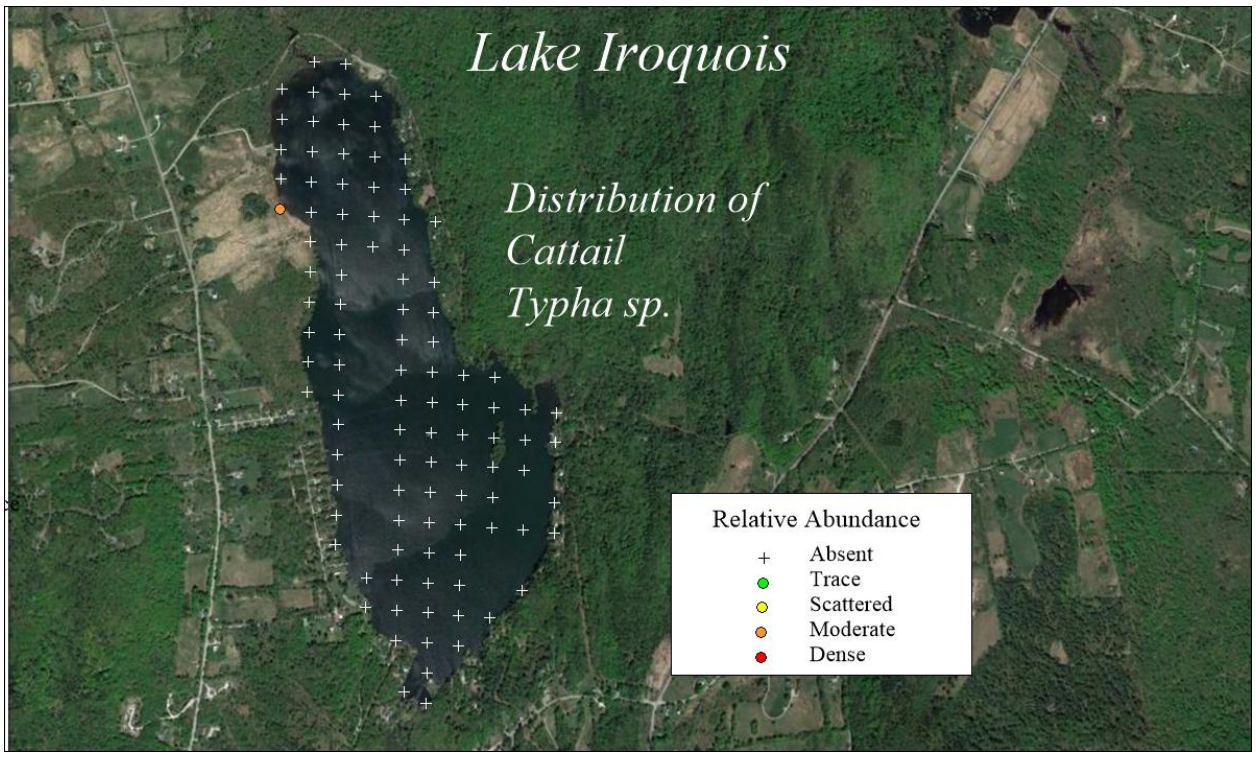
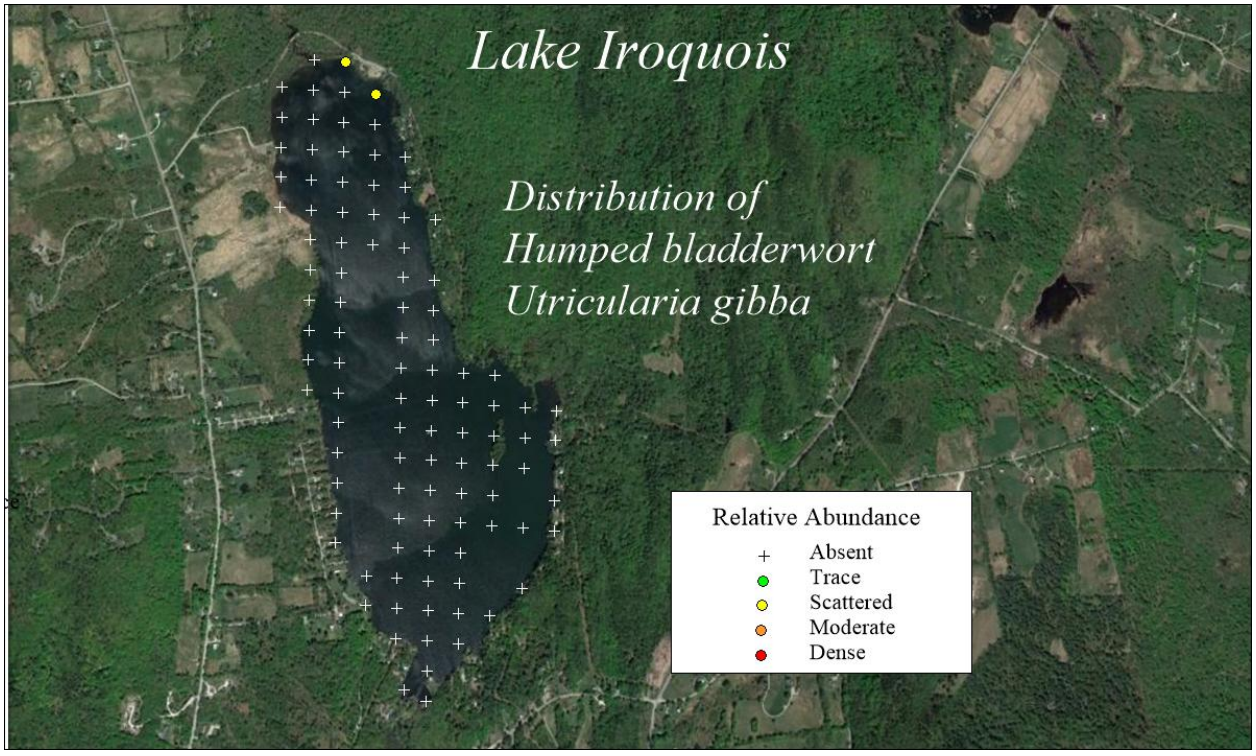
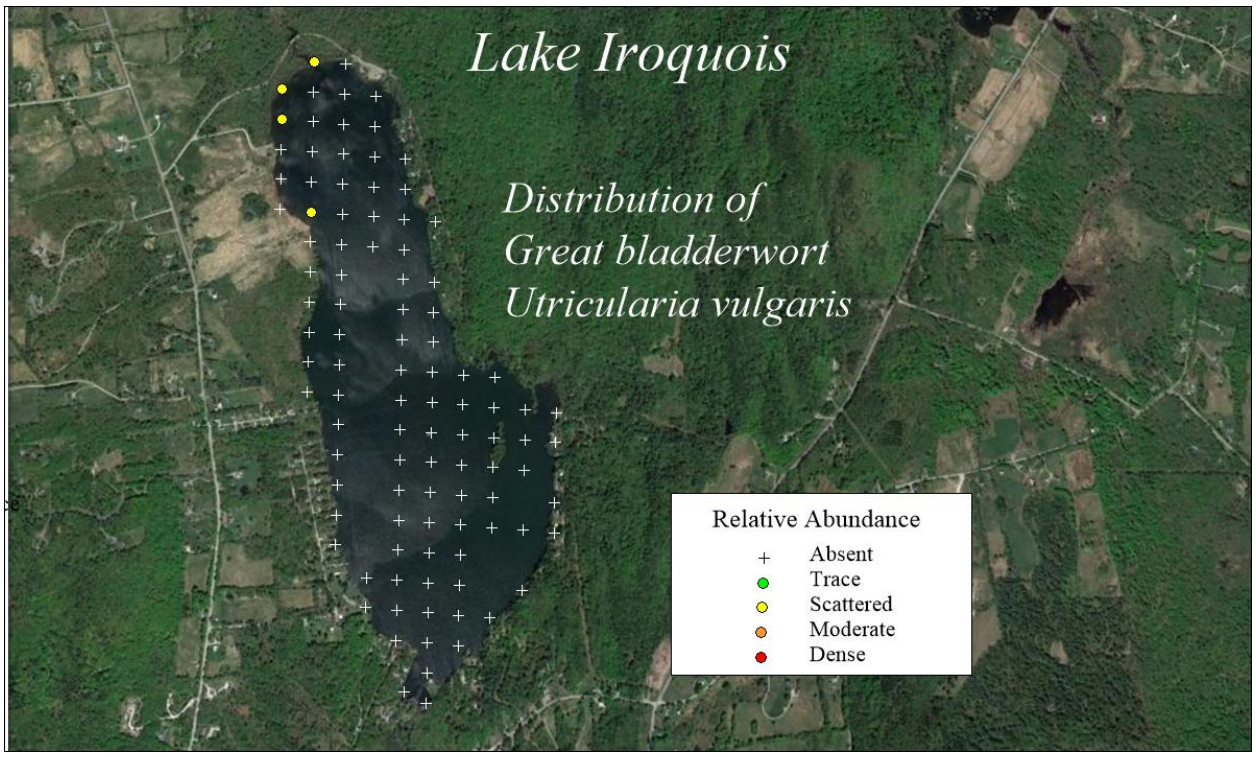
Trace
Scattered
Moderate
Dense

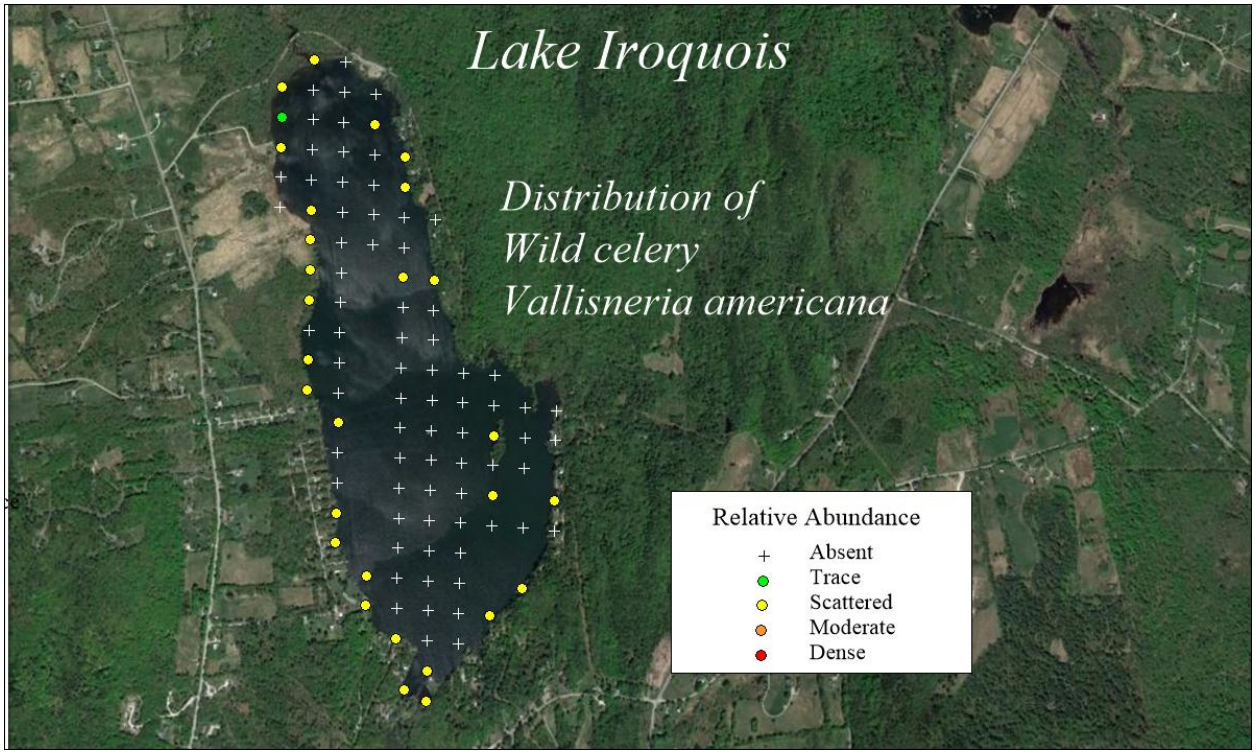

Lake Iroquois
Distribution of
White watercrowfoot
Ranunculus longirostris
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense

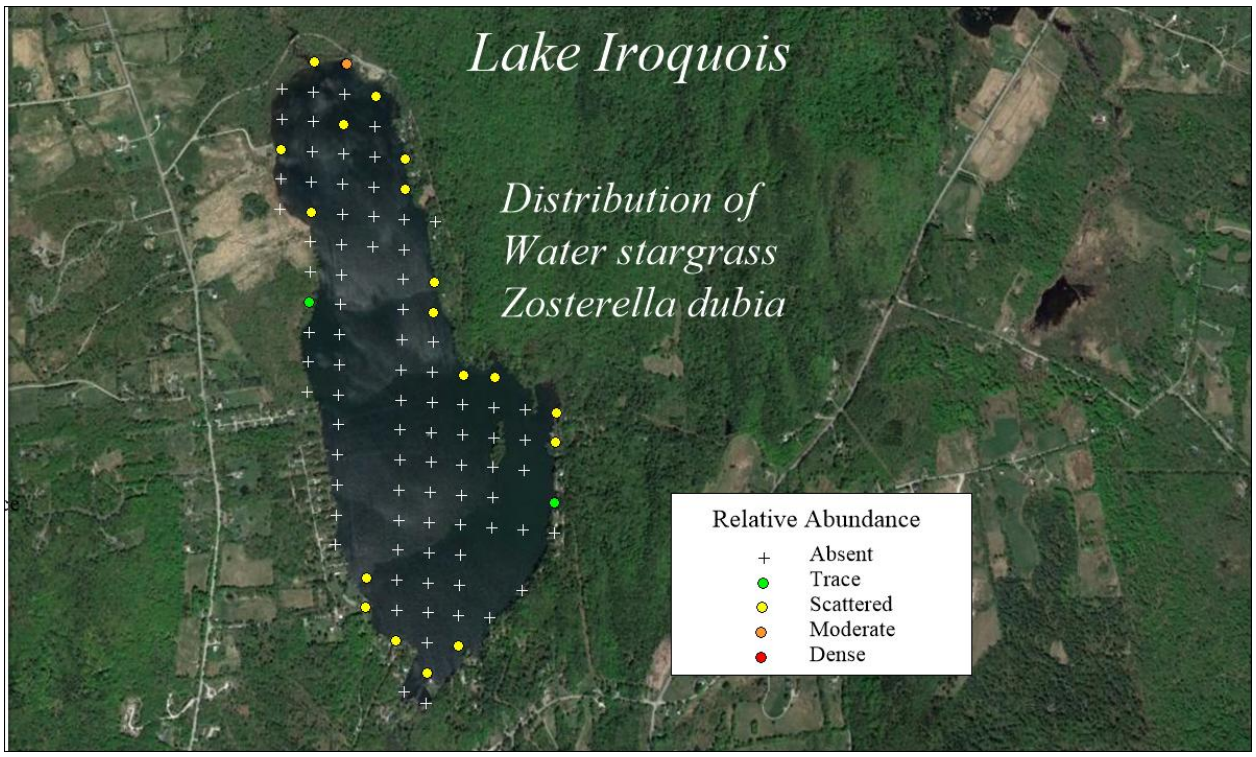

Lake Iroquois
Distribution of
Burreed
Sparganium sp.
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense


Lake Iroquois
Distribution of
Cattail
Typha sp.
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense


Lake Iroquois
Distribution of
Humped bladderwort
Utricularia gibba
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense

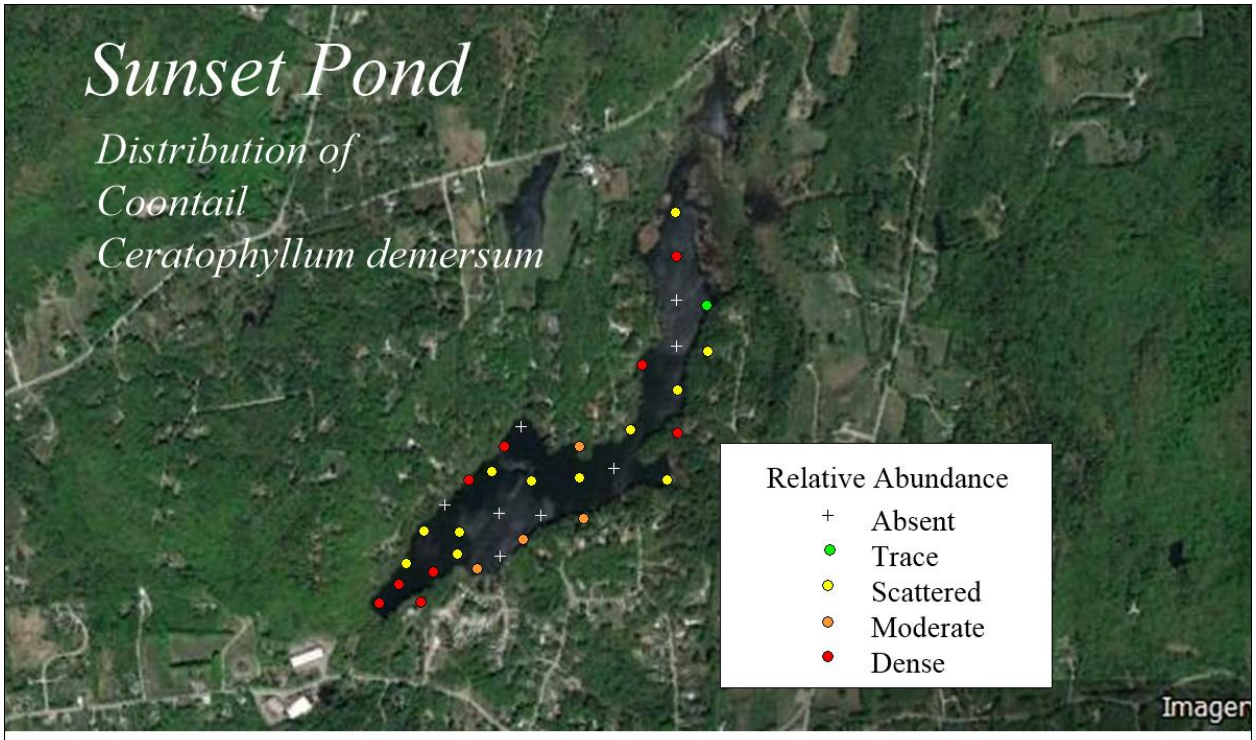

Lake Iroquois
Distribution of
Great bladderwort
Utricularia vulgaris
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense

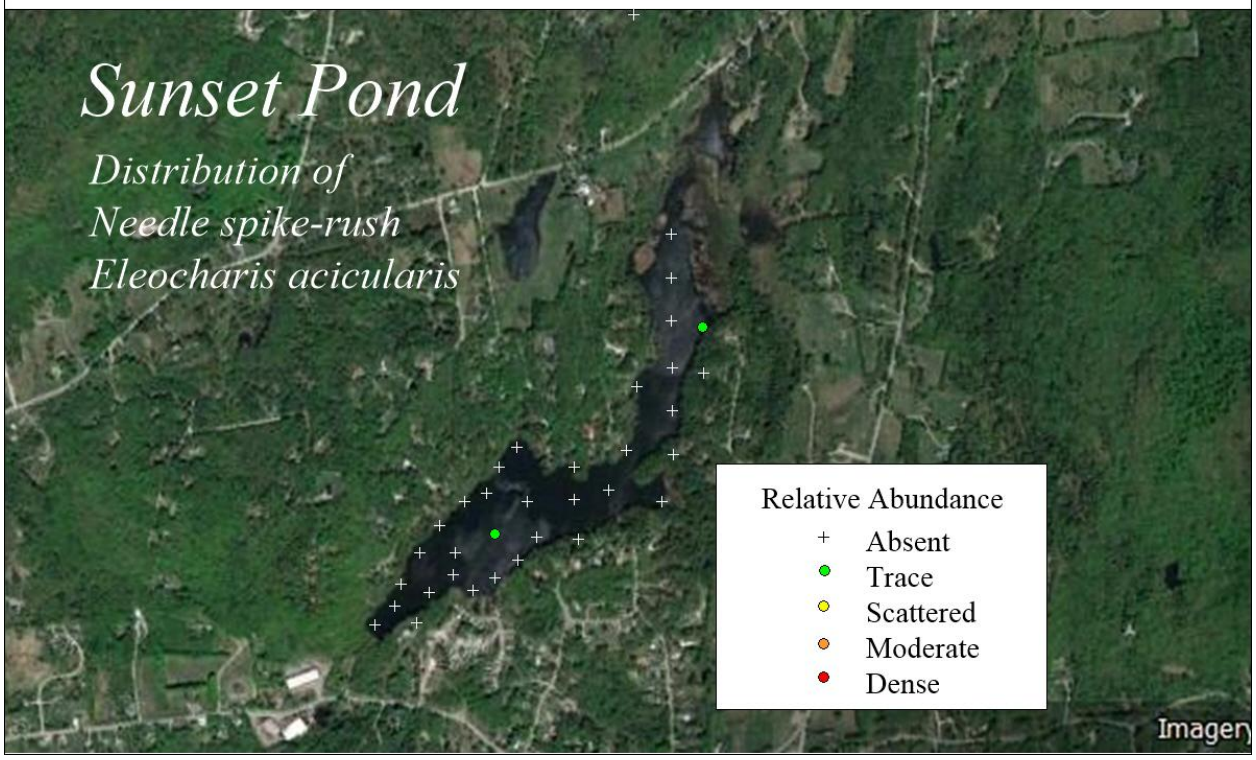

Lake Iroquois
Distribution of
Wild celery
Vallisneria americana
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense

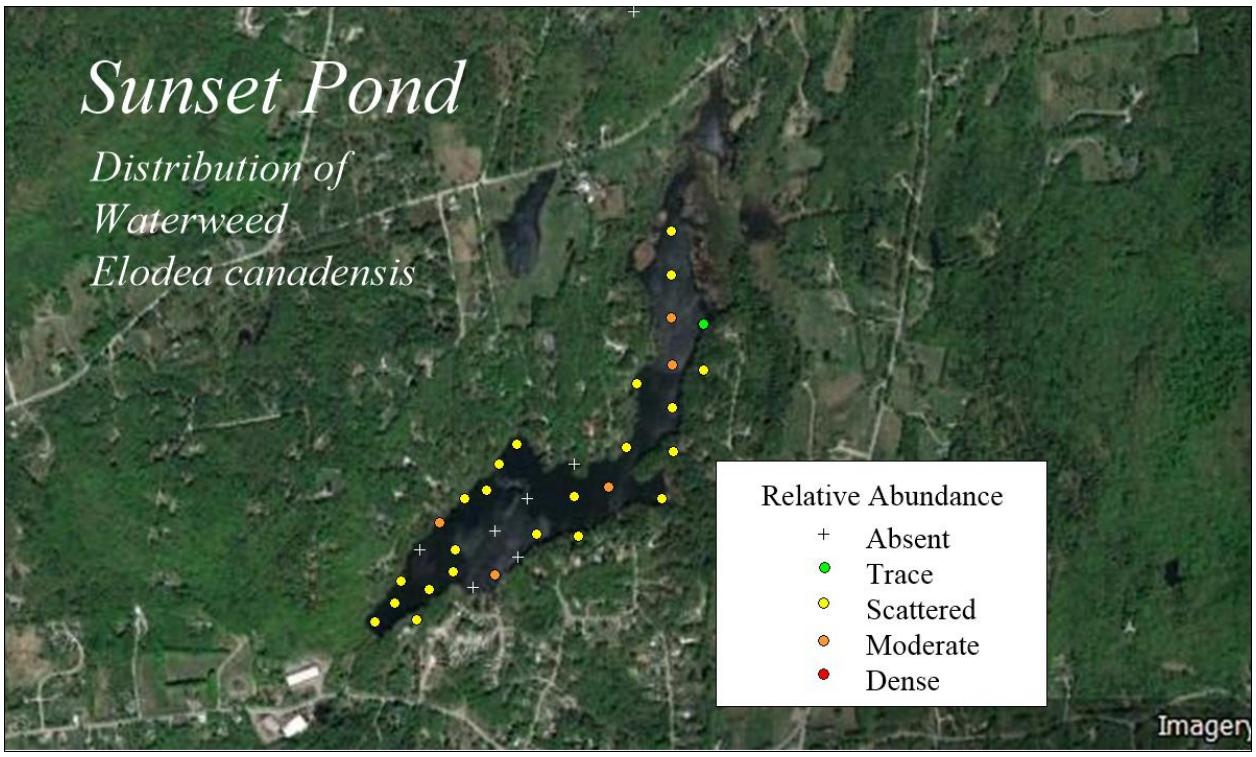

Lake Iroquois
Distribution of
Water stargrass
Zosterella dubia
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense

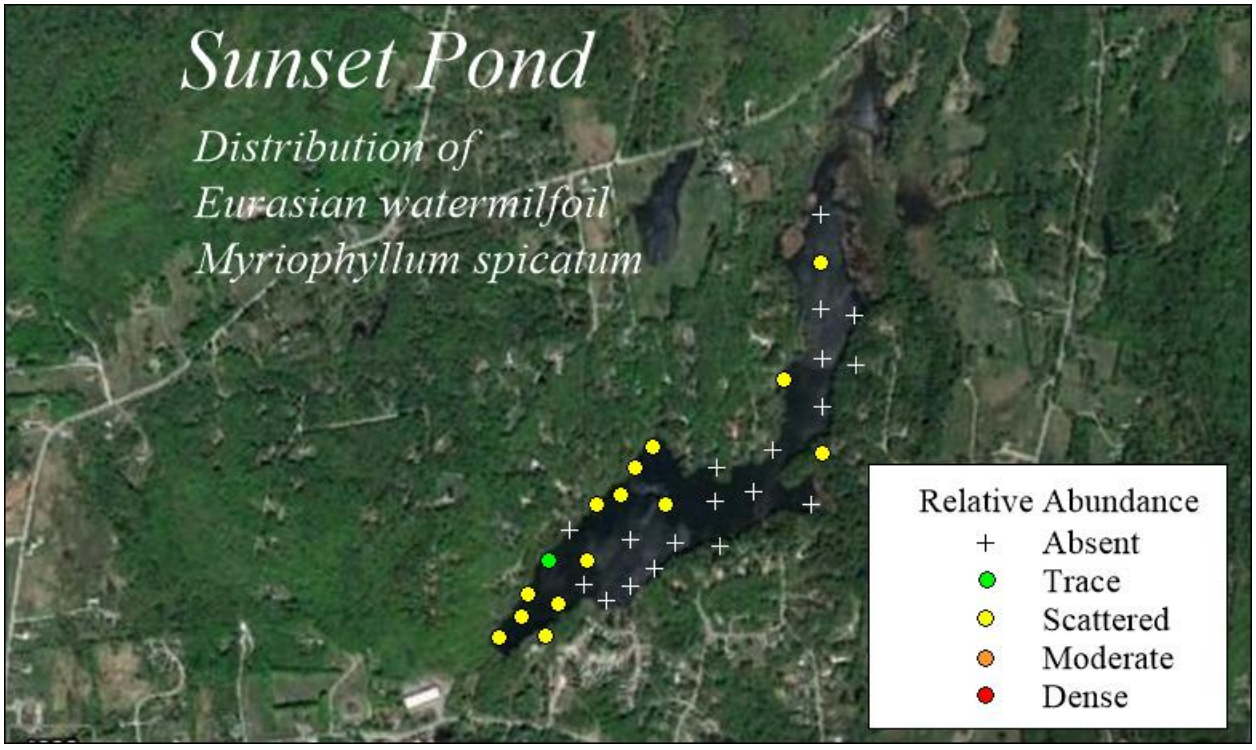
Appendix B

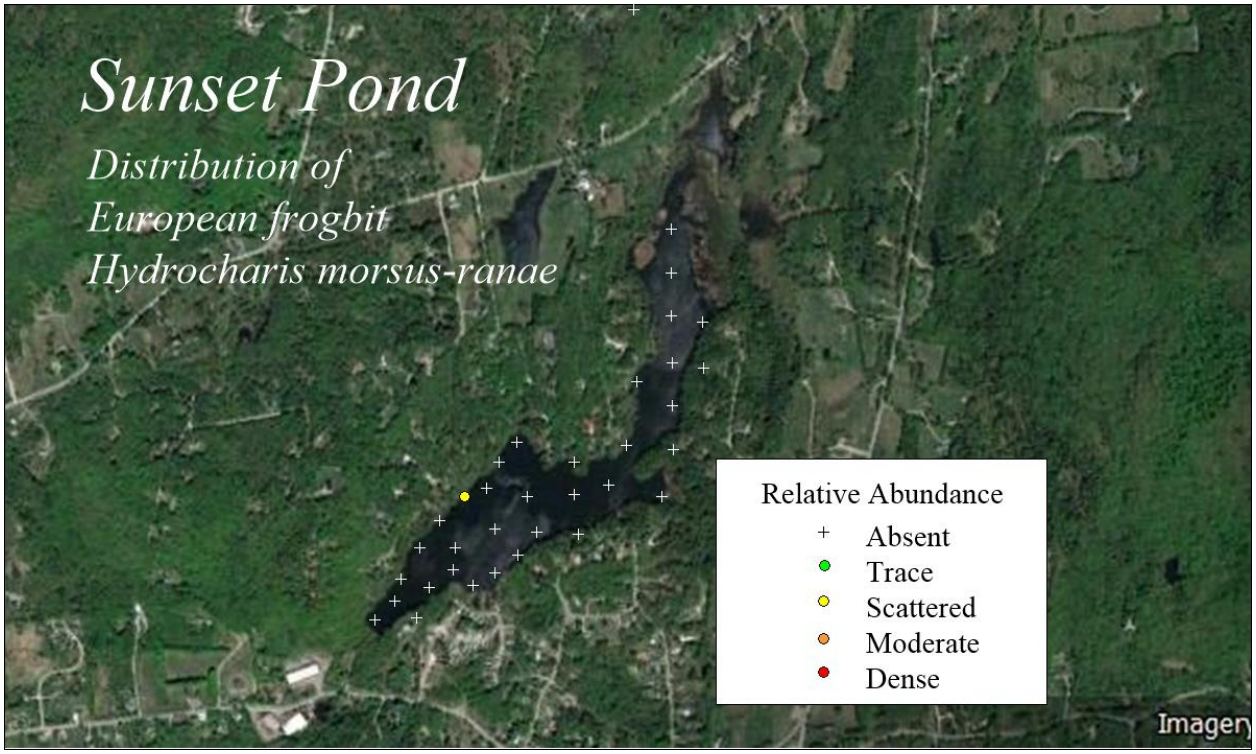
Sunset Pond Aquatic Plant Distribution Maps

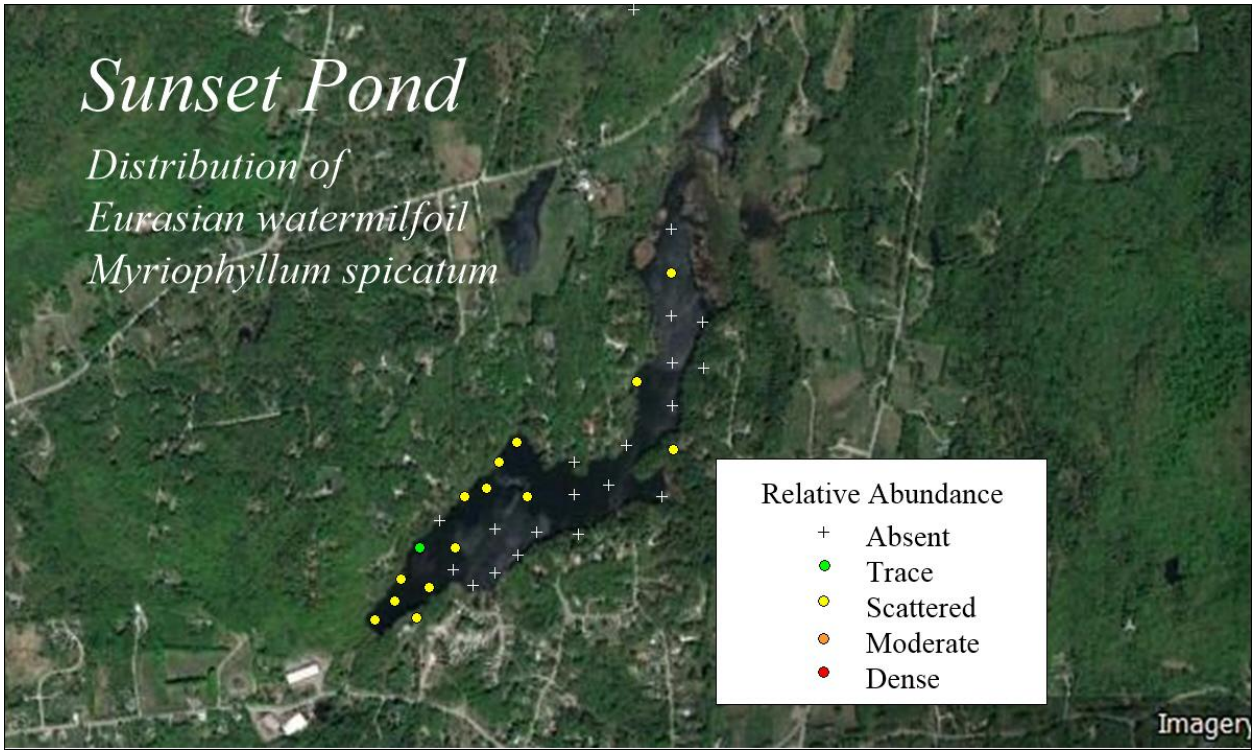

Sunset Pond
Distribution of
Coontail
Ceratophyllum demersum
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imager

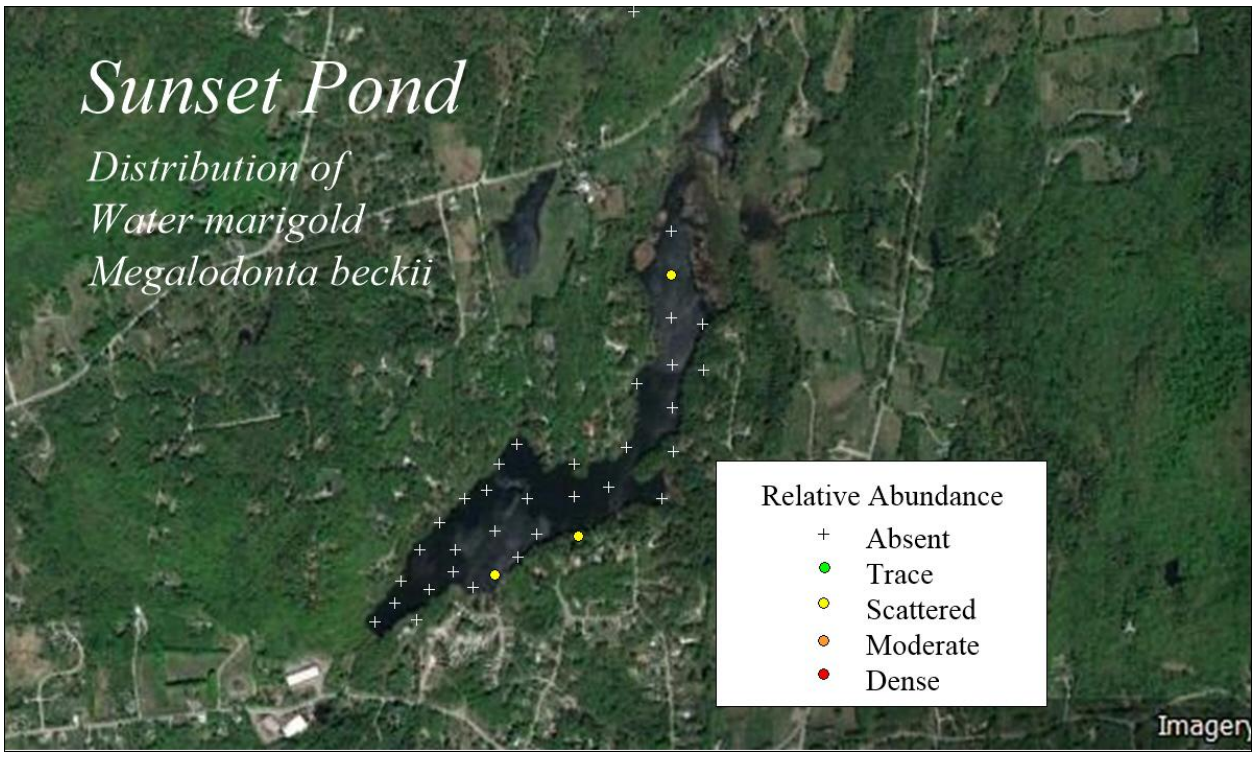

Sunset Pond
Distribution of
Needle spike-rush
Eleocharis acicularis
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imager

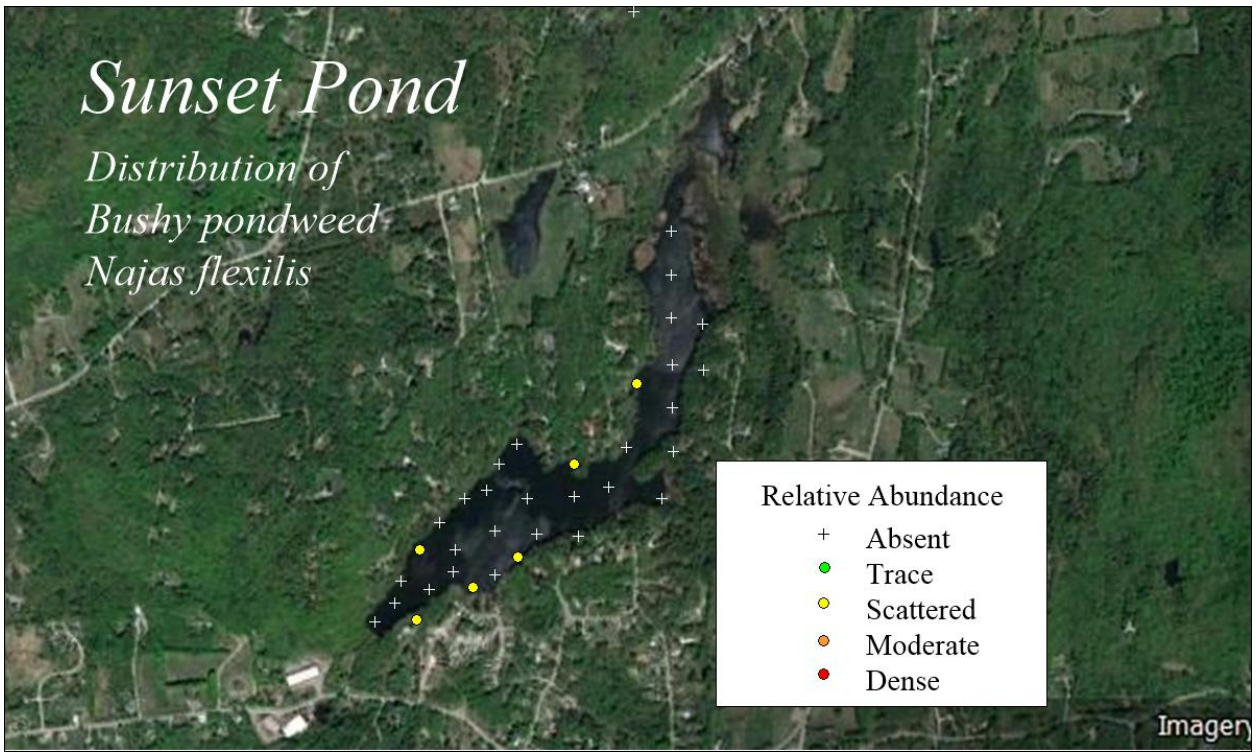

Sunset Pond
Distribution of
Waterweed
Elodea canadensis
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

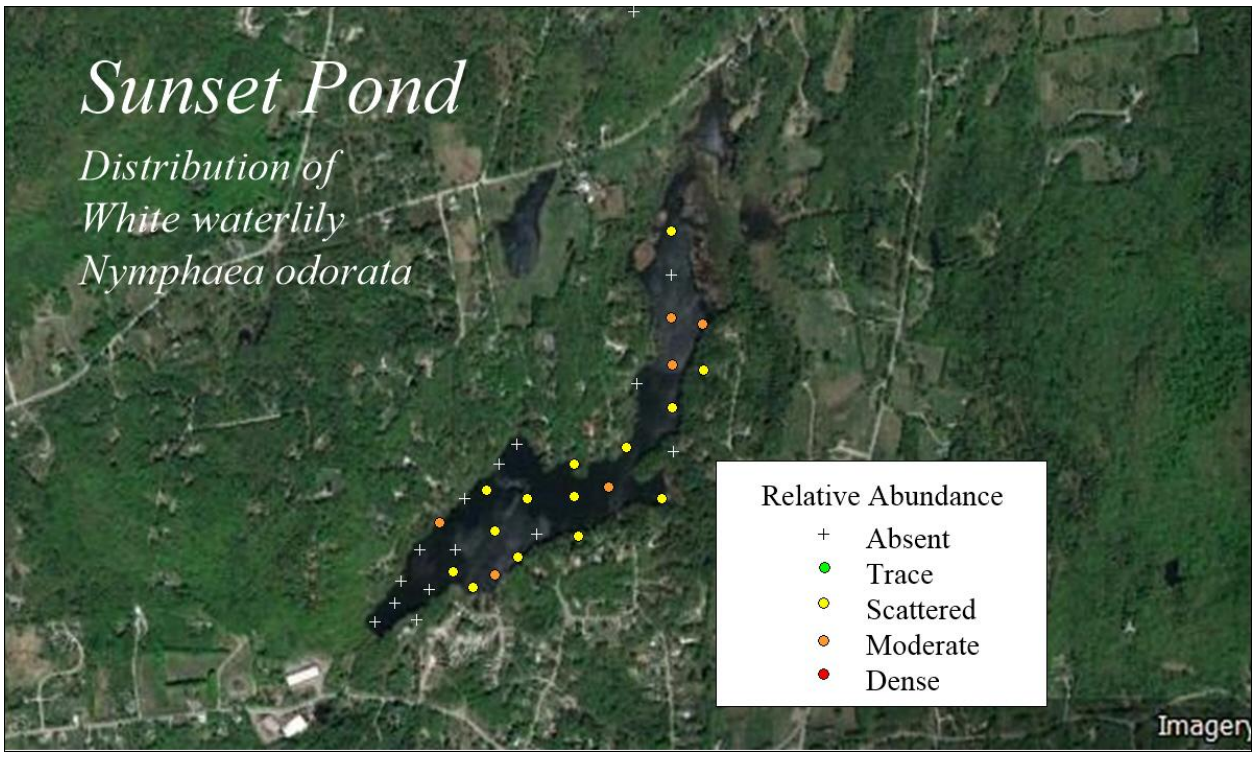

Sunset Pond
Distribution of
Eurasian watermilfoil
Myriophyllum spicatum
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense

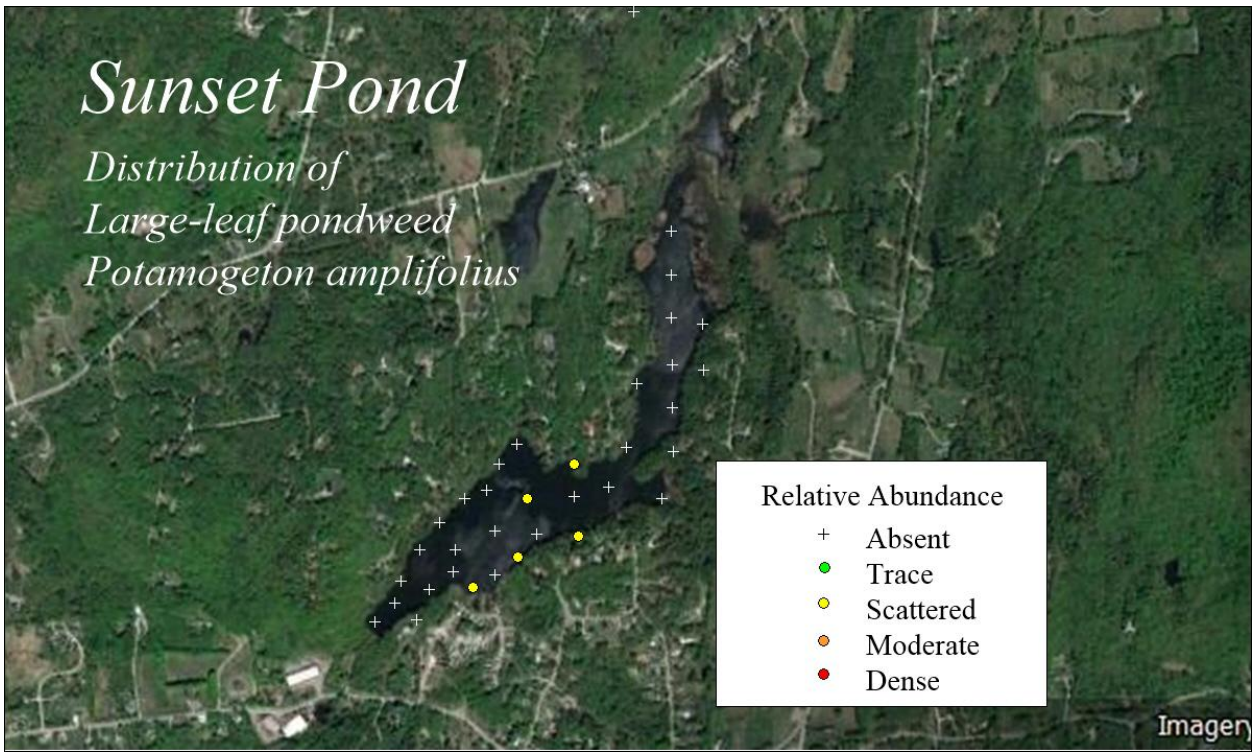

Sunset Pond
Distribution of
European frogbit
Hydrocharis morsus-ranae
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

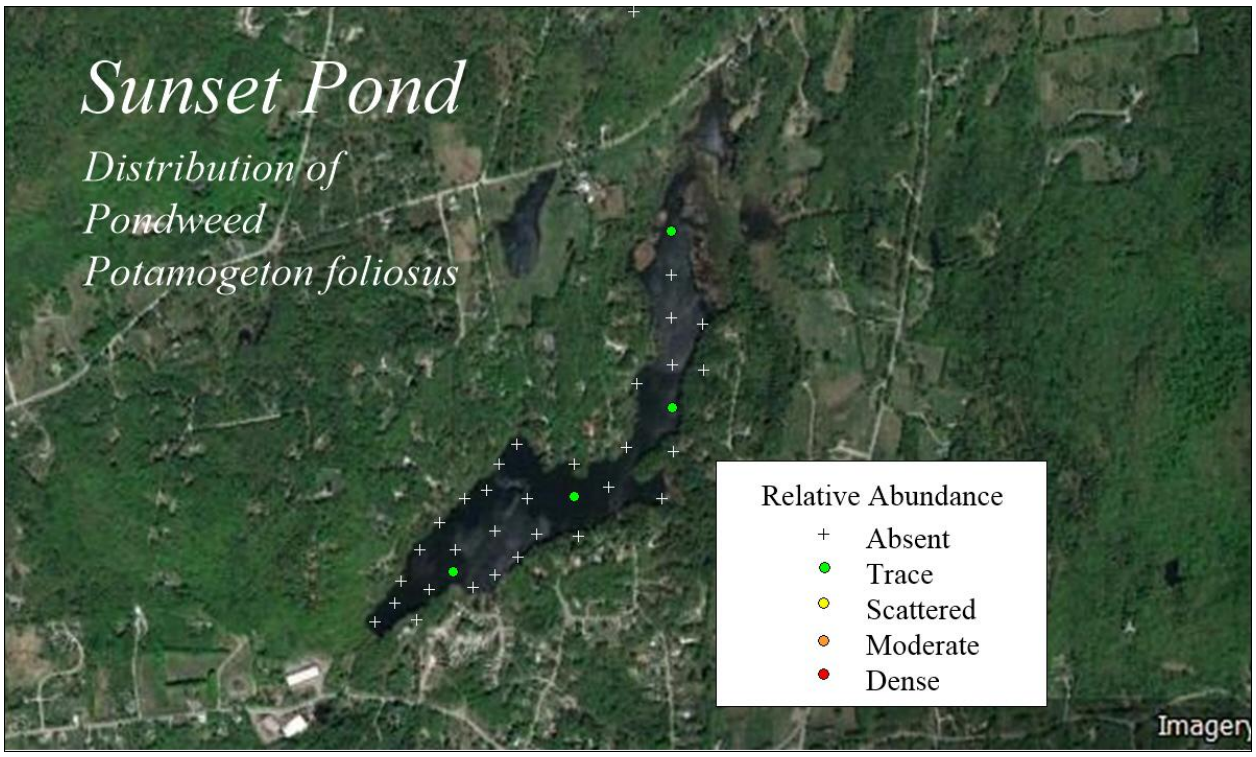

Sunset Pond
Distribution of
Eurasian watermilfoil
Myriophyllum spicatum
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

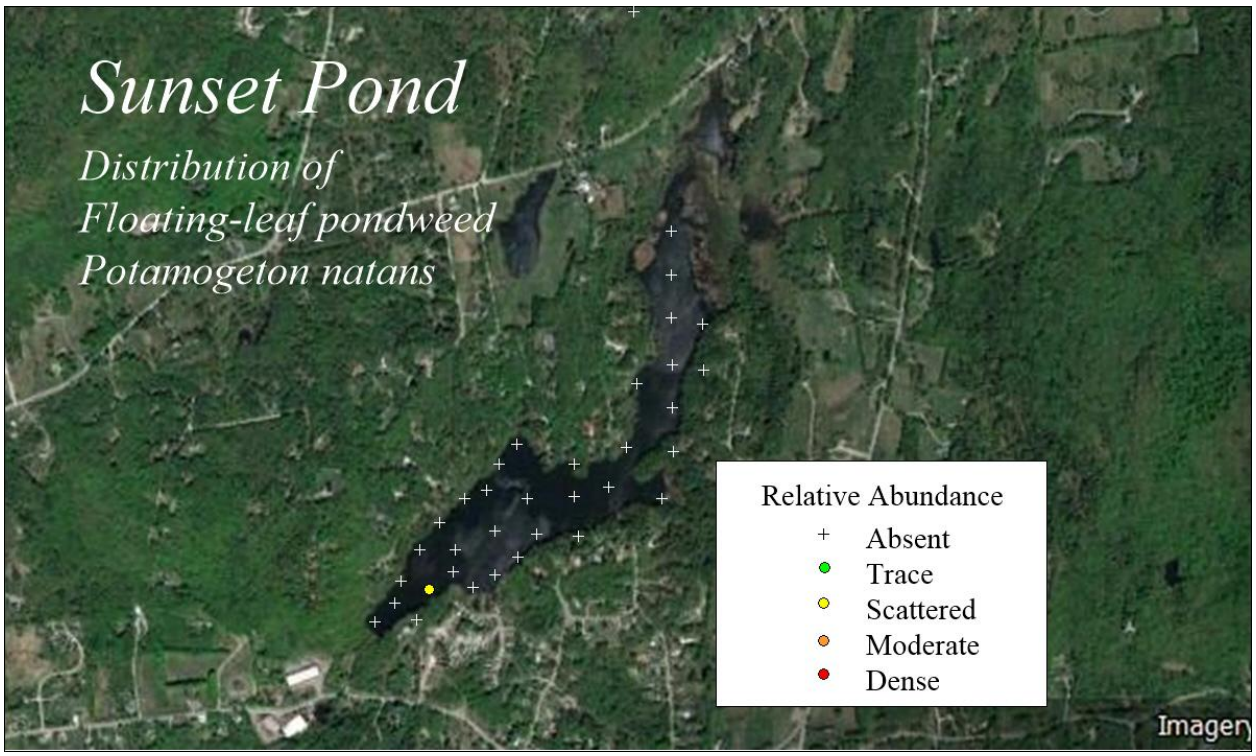

Sunset Pond
Distribution of
Water marigold
Megalodonta beckii
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

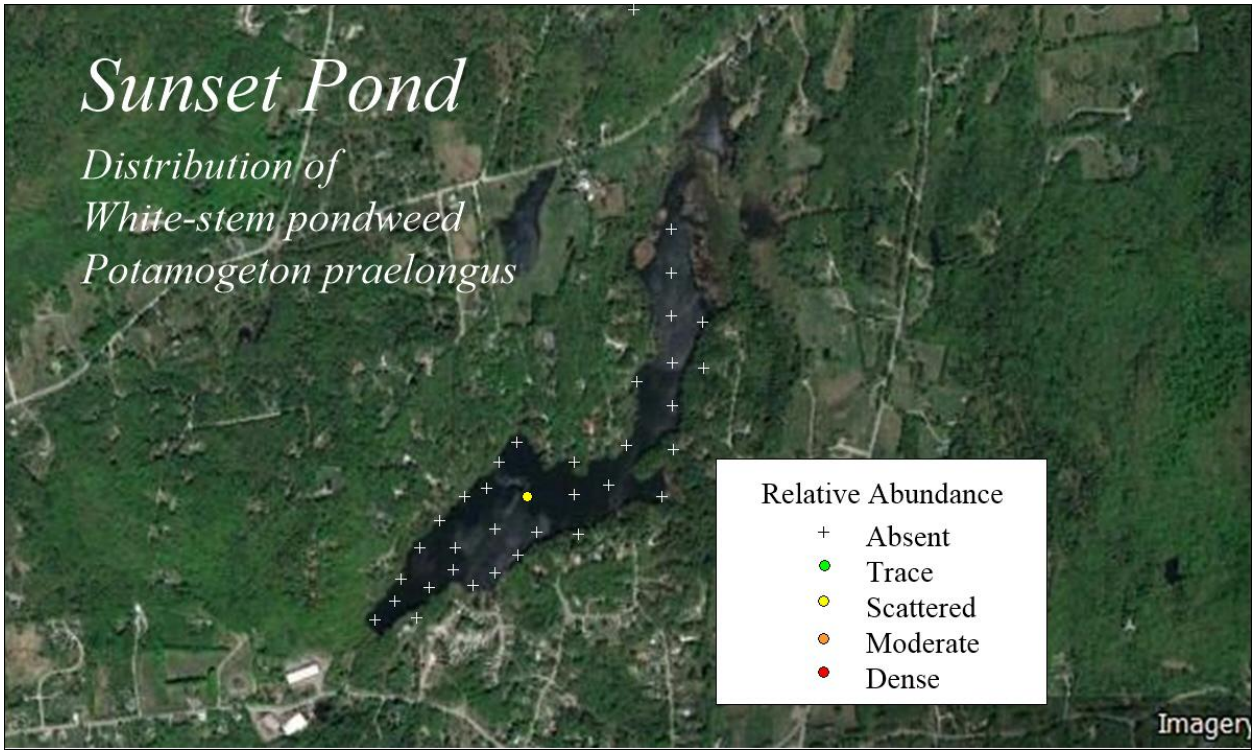

Sunset Pond
Distribution of
Bushy pondweed
Najas flexilis
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

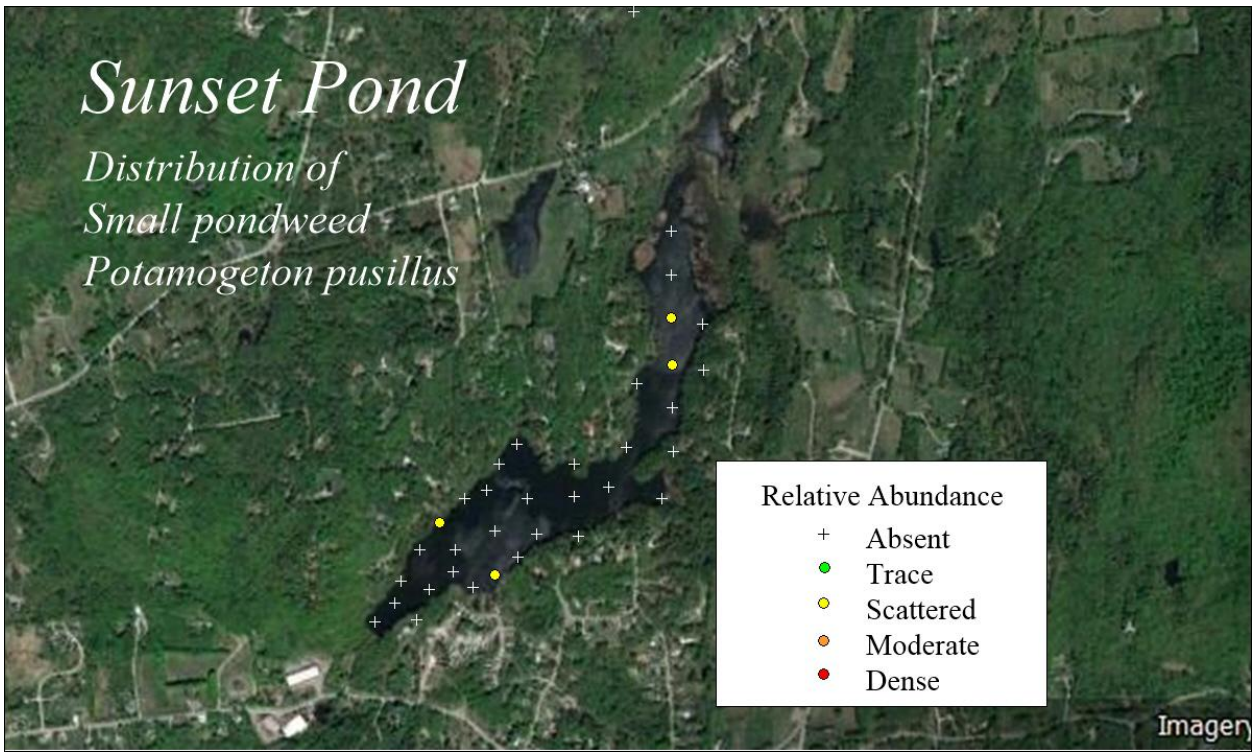

Sunset Pond
Distribution of
White waterlily
Nymphaea odorata
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

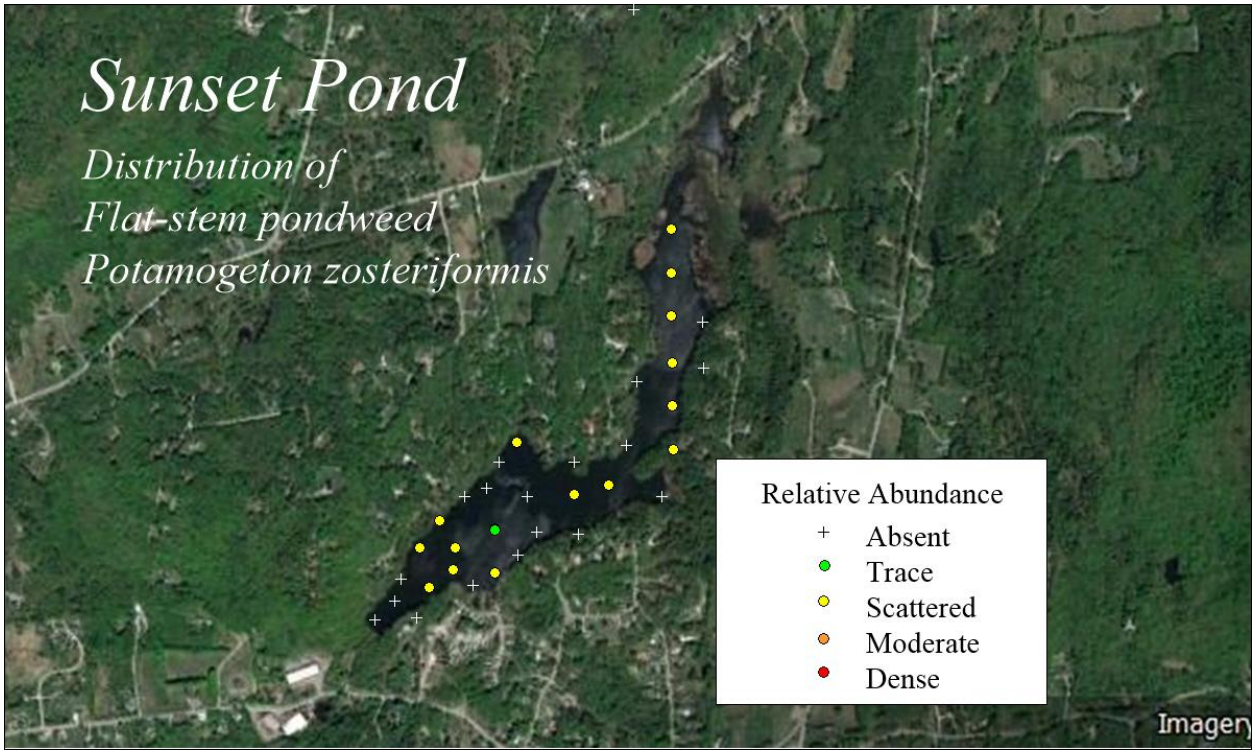

Sunset Pond
Distribution of
Large-leaf pondweed
Potamogeton amplifolius
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

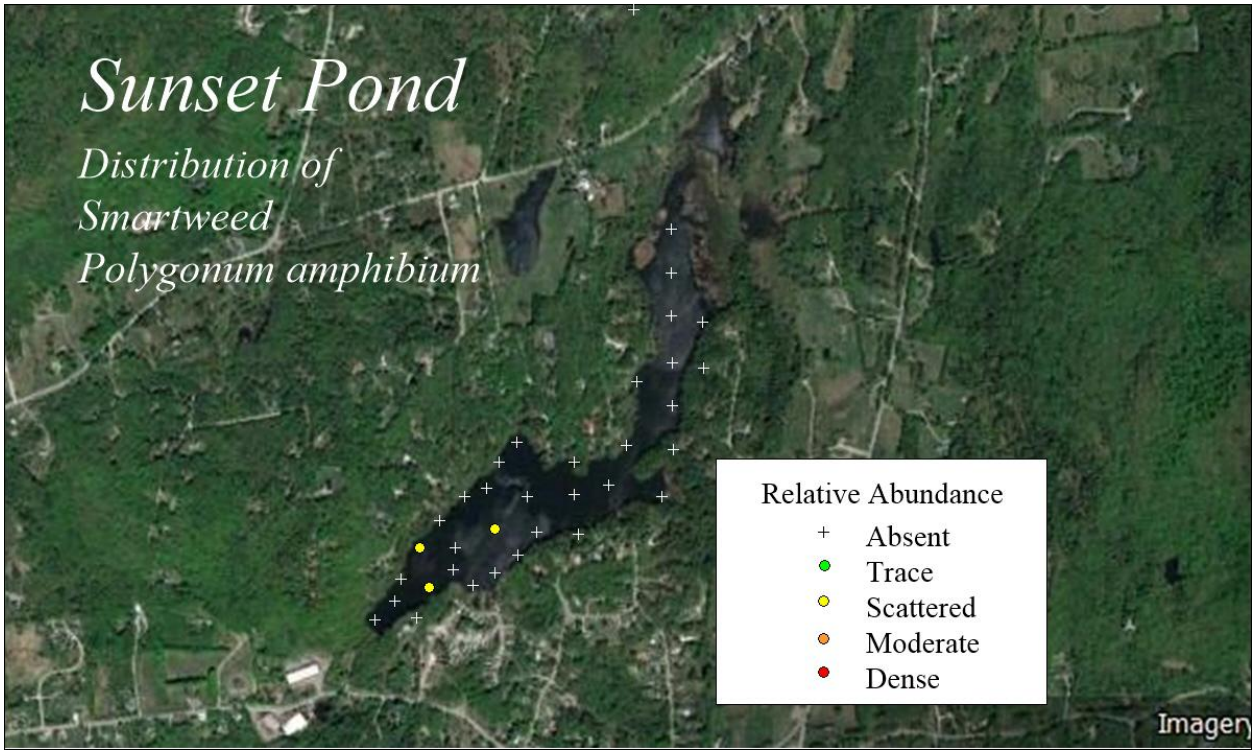

Sunset Pond
Distribution of
Pondweed
Potamogeton foliosus
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

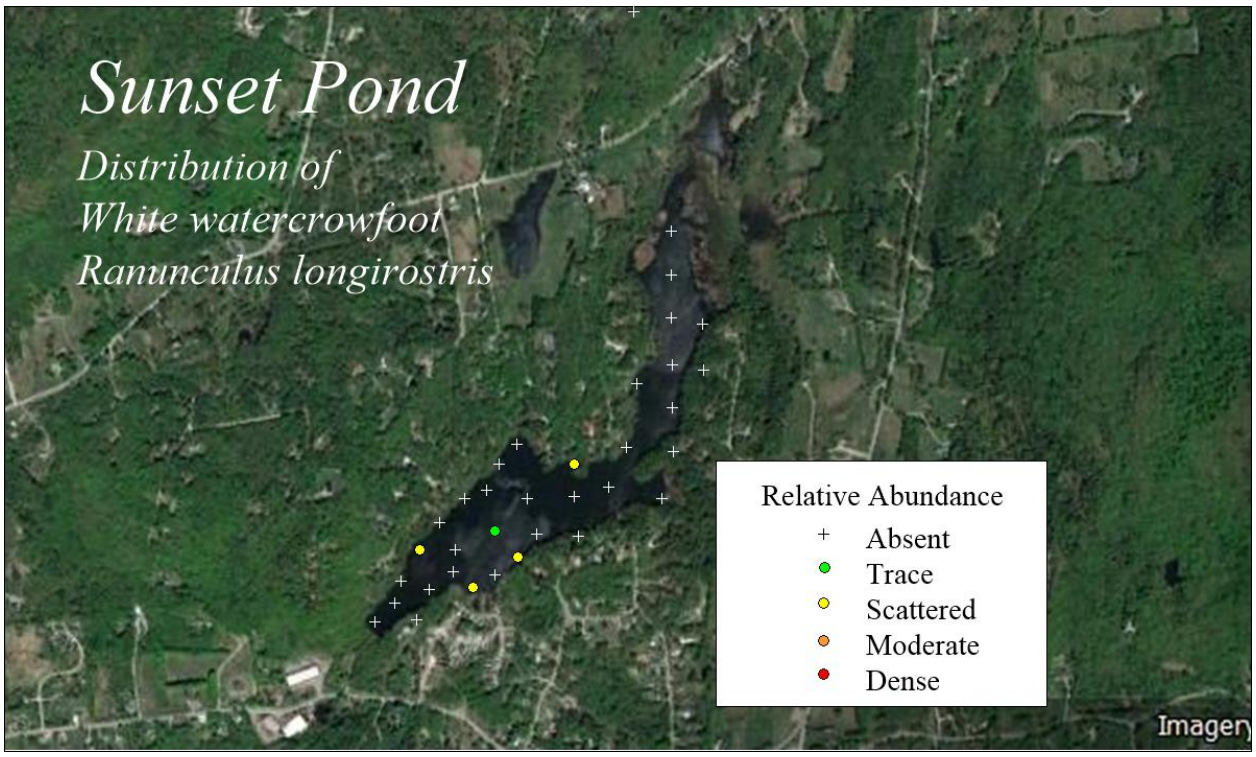

Sunset Pond
Distribution of
Floating-leaf pondweed
Potamogeton natans
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

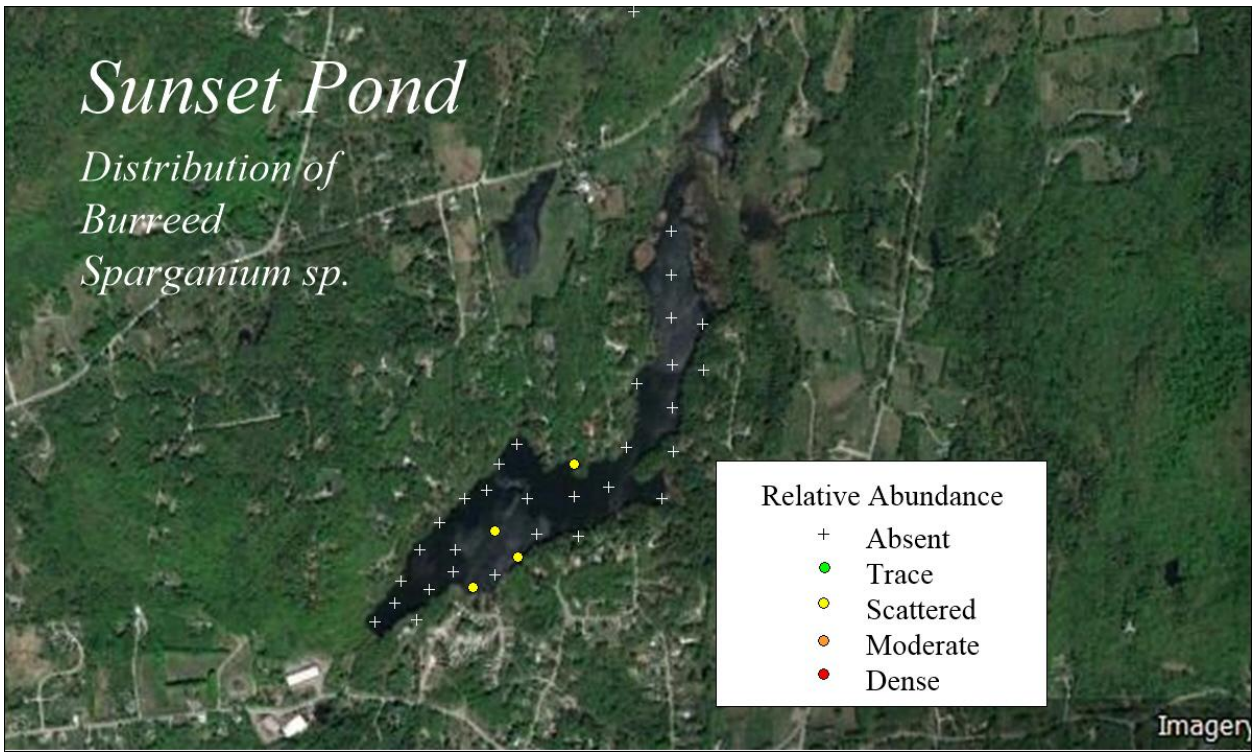

Sunset Pond
Distribution of
White-stem pondweed
Potamogeton praelongus
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

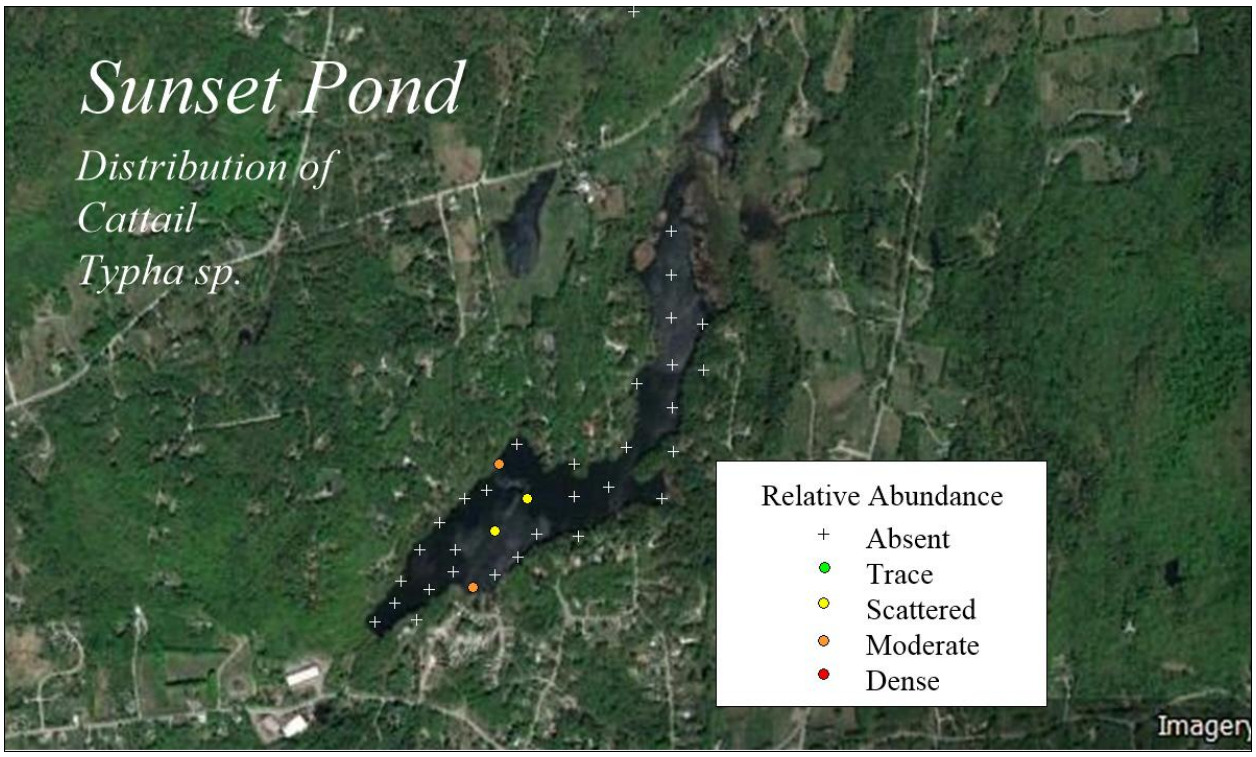

Sunset Pond
Distribution of
Small pondweed
Potamogeton pusillus
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery

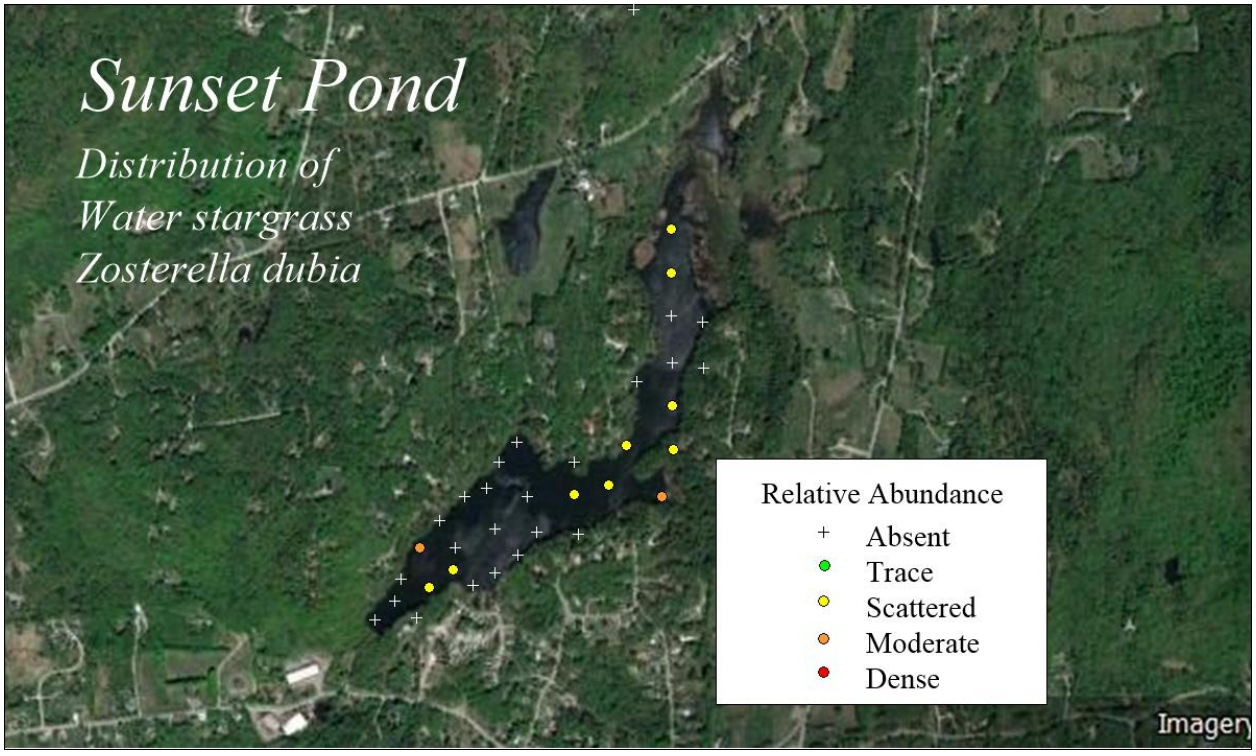

Sunset Pond
Distribution of
Flat-stem pondweed
Potamogeton zosteriformis
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery


Sunset Pond
Distribution of
Smartweed
Polygonum amphibium
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery


Sunset Pond
Distribution of
White watercrowfoot
Ranunculus longirostris
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery


Sunset Pond
Distribution of
Burreed
Sparganium sp.
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery


Sunset Pond
Distribution of
Cattail
Typha sp.
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery


Sunset Pond
Distribution of
Water stargrass
Zosterella dubia
Relative Abundance
Absent
Trace
Scattered
Moderate
Dense
Imagery