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Lake George, New York  
Adirondack Field Station at Bolton Landing

## **Aquatic Vegetation of Lake Dunmore and Fern Lake, Salisbury, Vermont**

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November 24, 2021  
DFWI Technical Report 2021-3

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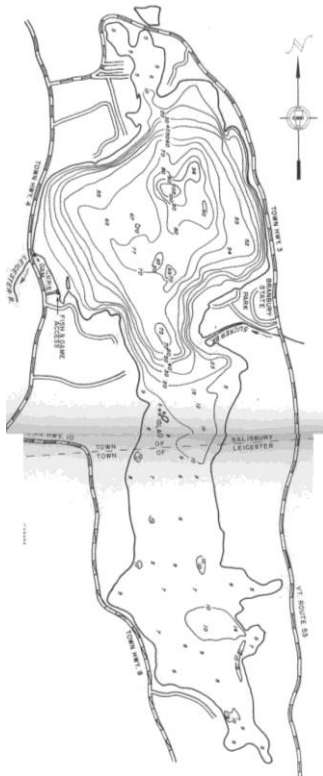
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## Background.

At the request of the Lake Dunmore Fern Lake Association, quantitative aquatic plant surveys were undertaken for Lake Dunmore and Fern Lake, Vermont. The surveys consisted of frequency of occurrence and relative abundance data for all aquatic plant species present in points distributed throughout both lakes largely duplicating surveys conducted in 2014 thru and 2020 (Eichler 2020). 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



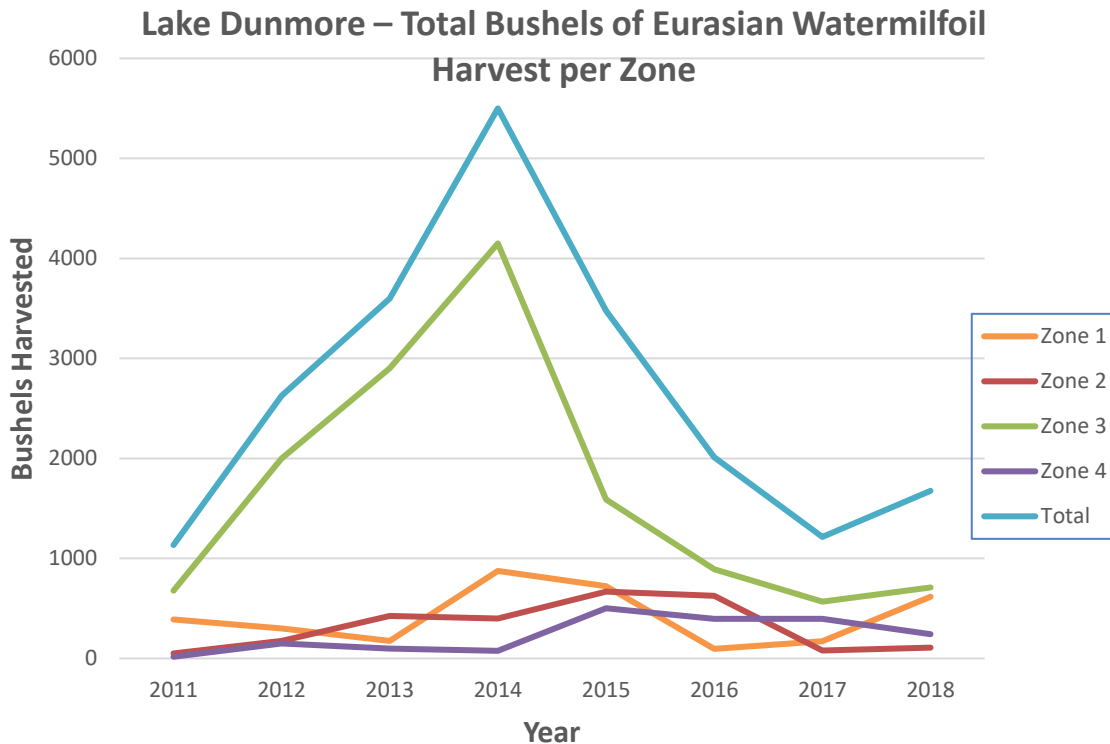
**Lake Dunmore.** Lake Dunmore is located in Addison County, in the towns of Salisbury and Leicester. The lake has a surface area of approximately 985 acres. Lake Dunmore has a single outlet with a control structure to maintain lake level. Average water depth is reported to be 28 ft, with a maximum depth of 105 ft (VTDEC 2014). Secchi disk transparency is reported to be 20 ft (6.2 m; VT DEC 2013). Eurasian watermilfoil (*Myriophyllum spicatum*) populations were first confirmed in 1988 (LDFLA 2014). A barrier was installed to contain fragments and Eurasian watermilfoil was removed by volunteers. Within a few years, a second infestation was discovered at the north end of the lake and in 1994 the current management program was initiated. Hand harvesting by skin and SCUBA divers has been the basis of the program for most years with use of diver operated suction harvesting in recent years. While there is a general sense that management efforts are controlling Eurasian watermilfoil, the level of effort to achieve control has continued to expand. By 2013, over 3600 bushels of Eurasian watermilfoil were being harvested by 2 suction harvesting teams with consideration of adding teams in the future. By 2015, harvesting had expanded to 4 teams suction harvesting during numerous person\*days. In 2016, nearly 80 acres were treated with triclopyr (Renovate®) in addition to extensive hand and suction harvesting. Hand harvested volumes in

2016 and 2017 declined sharply following the herbicide application, however harvested volumes increased in 2018, suggesting some recovery of Eurasian watermilfoil. The aquatic herbicide Procella COR was applied to 39 acres in the area of the 'spine' and 1.7 acres at the south end of the lake in 2020. Hand harvesting continued in 2021, reporting 221 bushels removed.

**Fern Lake.** Fern Lake is a 69 acre waterbody located in the town of Leicester, Vermont. Eurasian watermilfoil was first detected in Fern Lake in 1996, when a single milfoil plant was found and removed (VTDEC 2011). Eurasian watermilfoil was detected again in 2003, when 36 plants were removed. Since that time the population of Eurasian watermilfoil has expanded

substantially. Harvesting has occurred in Fern Lake every year since 2003 with diver operated suction harvesting employed since 2010. In 2013, the aquatic weevil population of Fern Lake was augmented with additional weevils as a control measure (Ritter 2013). In addition to weevil augmentation, hand and suction harvesting removed a total of 1800 bushels of Eurasian watermilfoil in 2013 (Figure 1). In 2016, the majority of Fern Lake was treated with triclopyr (Renovate®), however the northwest cove was excluded. Harvesting results for 2017 and 2018 were much lower than in previous years, 171 bushels and 66 bushels, respectively. The draft harvest log for 2021 reported 117 bushels removed from Fern Lake.

**Figure 1. Eurasian watermilfoil harvest from Lake Dunmore.**

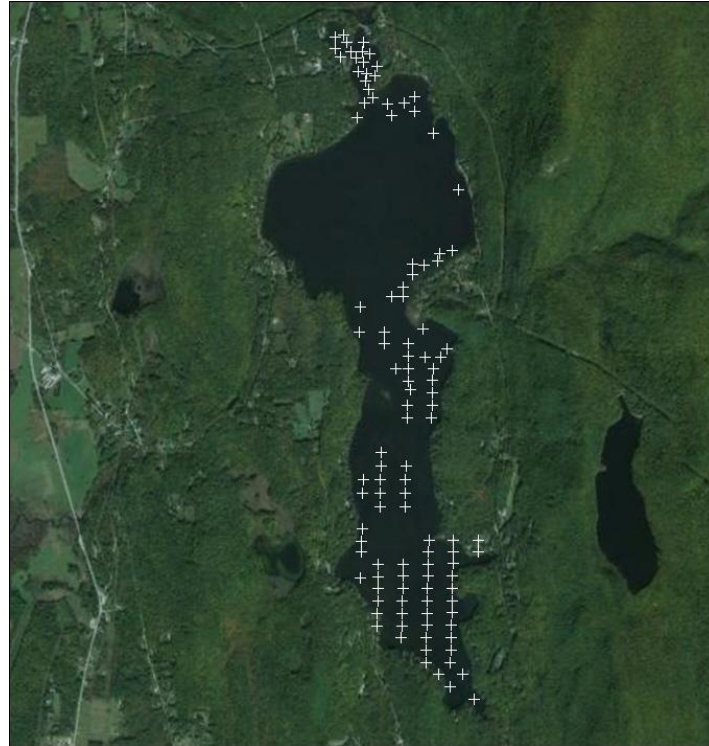


**Species List and Herbarium Specimens.** As the lakes were surveyed, the occurrence of each aquatic plant species observed in the lake was recorded and herbarium specimens of any previously unreported species were collected. The herbarium specimens were returned to the Darrin Fresh Water Institute, where they were pressed, dried, and mounted (Hellquist 1993). A number of species which were collected as reference specimens for each lake were not found in line intercept or wetland transect surveys.

**Point Intercept Surveys.** The frequency and 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 53 points were selected for Fern Lake, and 133 points were surveyed for Lake Dunmore, based on a 100 m grid. A global positioning system (GPS) was used to navigate to each point for the survey observation. Point intercept plant frequencies were surveyed on September 7, 2021 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.

**Figure 2. Map of Lake Dunmore and Fern Lakes with point intercept survey locations for 2021.**



## Results and Discussion

### Lake Dunmore Survey Results

In September of 2021, the aquatic plant community of Lake Dunmore included twenty-three submersed species, four floating-leaved species, six emergent species and two floating species (Table 1) and included some species observed but not collected in the point intercept survey. Twenty-seven species were reported for the point intercept survey in 2021. Twenty-eight species were reported for the point intercept survey in 2019, twenty-five in 2020 and twenty-three species were present in the in the 2015 and 2016 surveys, slightly less than the 27 reported in 2014 and 2018, however a greater number of survey points were included in 2014. Combining the results of all surveys, a total of 35 species of aquatic plants have been reported for Lake Dunmore. This number of species greatly exceeds the 15 species typically reported for

**Table 1. Species lists for Lake Dunmore and Fern Lake.**

<i>Species</i>	<b>Common Name</b>	<b>Lake Dunmore</b>	<b>Fern Lake</b>
<i>Brasenia schreberi</i> J.F. Gmel	watershield	fl	
<i>Ceratophyllum demersum</i> L.	coontail	s	
<i>Chara/Nitella</i> sp.	muskgrass, chara	s	s
<i>Eleocharis acicularis</i> (L.) Roemer & Schultes	needle spike-rush	e	e
<i>Elodea canadensis</i> Michx.	waterweed	s	s
<i>Fontinalis</i> sp.	moss	s	s
<i>Isoetes echinospora</i> Dur.	quillwort	s	
<i>Lemna minor</i> L.	duckweed	f	
<i>Megalodonta beckii</i> Torr.	white water crowsfoot	s	
<i>Myriophyllum tenellum</i> L.	leafless watermilfoil	s	s
<i>Myriophyllum spicatum</i> L.	Eurasian watermilfoil	s	s
<i>Najas flexilis</i> (Willd.) Rostk. & Schmidt.	bushy pondweed	s	s
<i>Najas minor</i> L.	brittle naiad		s
<i>Nuphar variegata</i> Engelm. ex Durand	yellow pondlily	fl	fl
<i>Nymphaea odorata</i> Ait.	white pondlily	fl	fl
<i>Nymphoides cordatum</i> (Ell.) Fern.	floating heart	fl	
<i>Pontederia cordata</i> L.	pickerelweed	e	e
<i>Polygonum amphibium</i> L.	water smartweed	e	e
<i>Potamogeton amplifolius</i> Tuckerm.	largeleaf pondweed	s	
<i>Potamogeton epihydrus</i> Raf.	ribbon-leaf pondweed	s	
<i>Potamogeton foliosus</i> Raf.	Leafy pondweed	s	
<i>Potamogeton gramineus</i> L.	variable-leaf pondweed	s	



<i>Species</i>	<b>Common Name</b>	<b>Lake Dunmore</b>	<b>Fern Lake</b>
<i>Potamogeton illinoensis</i> Morong	Illinois pondweed	s	s
<i>Potamogeton praelongus</i> Wulf.	White-stem pondweed	s	s
<i>Potamogeton pusillus</i> L.	narrow-leaf pondweed	s	s
<i>Potamogeton robbinsii</i> Oakes	Robbins pondweed	s	s
<i>Potamogeton spirillus</i> Tuckerm.	pondweed		s
<i>Ranunculus longirostris</i> Godron	white water crowfoot	s	s
<i>Sagittaria graminea</i> Michx.	arrowhead	s	s
<i>Scirpus</i> sp.	rush	e	
<i>Sparganium</i> sp.	burreed	e	e
<i>Spirodela polyrhiza</i> (L.) Schleid.	giant duckweed	f	
<i>Typha</i> sp.	cattail	e	e
<i>Utricularia gibba</i> Hayne	bladderwort	s	
<i>Utricularia vulgaris</i> L.	giant bladderwort	s	
<i>Vallisneria americana</i> L.	wild celery	s	s
<i>Zosterella dubia</i> (Jacq.) Small	water stargrass	s	s

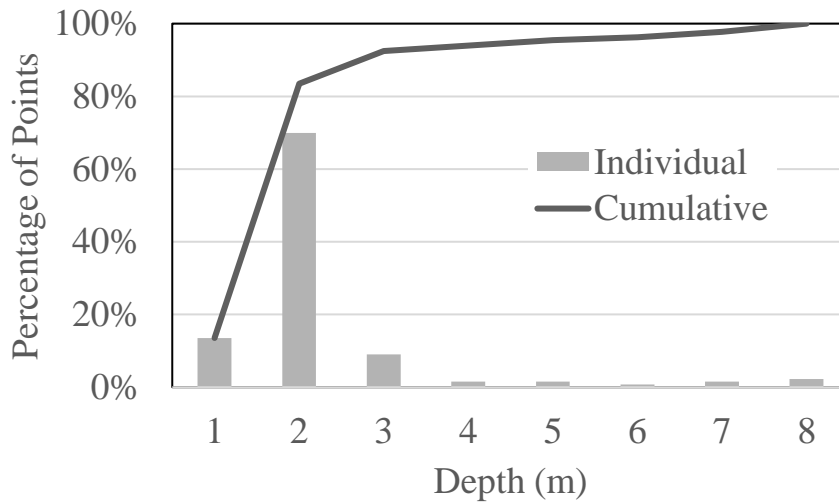
F=floating fl=floating leaved e=emergent s=submersed

moderately productive lakes in our region and indicates good water quality and a variety of habitat types. Eurasian watermilfoil (*Myriophyllum spicatum*) was the only exotic species reported in Lake Dunmore. Species richness was quite high, with a number of species occurring in more than 5% of survey points (Table 2). Robbins pondweed (*Potamogeton robbinsii*) was the most common plant. Eurasian watermilfoil (*Myriophyllum spicatum*) was present in 5% of survey points in 2021, an increase from the 1% reported in 2020, but a decrease from the 6% reported in 2019, 19% reported in 2018, 6% reported in 2017, 27% reported in 2015, and 18% reported in 2014. The increase between 2014 and 2015 may have been an artifact of a change in the survey to focus on areas known to support Eurasian watermilfoil. Comparing only the points from both 2014 and 2015, a small decline from 30% of survey points in 2014 to 27% in 2015 was reported. A number of native species were also commonly observed. One of the species present in Lake Dunmore, Humped Bladderwort (*Utricularia gibba*) is found on Vermont's rare plant list (VT DEC 2012).

### Maximum Depth of Colonization

Maximum depth of rooted aquatic plant growth was similar for the two lakes, with the littoral zone extending to a depth of approximately 5.0 meters. The extensive shallow areas at the south end of Lake Dunmore are responsible for the predominance of sample points in water depths of 2 to 3 meters. Depth distribution of sampling points is provided in Figure 3.

**Figure 3. Depth Distribution of Lake Dunmore Sampling Points in 1 meter depth classes.**



**Species Lists**

Maps of the distribution of aquatic plant species for Lake Dunmore are included in Appendix A. Frequency of occurrence results are presented in Table 2. Eurasian watermilfoil (*Myriophyllum spicatum*) was present in 5% of survey points. A number of native species were also commonly observed. Common native species for Lake Dunmore included *Potamogeton robbinsii* (54% of survey points), *Najas flexilis* (37%), *Potamogeton amplifolius* (35%), *Elodea canadensis* (28%), *Potamogeton illinoensis* (27%), *Chara/Nitella* (23%), *Vallisneria americana* (9%), and *Sagittaria graminea* (8%). Native species results are generally comparable to those reported in 2014 thru 2020.

**Table 2. Lake Dunmore percent frequency of occurrence data.**

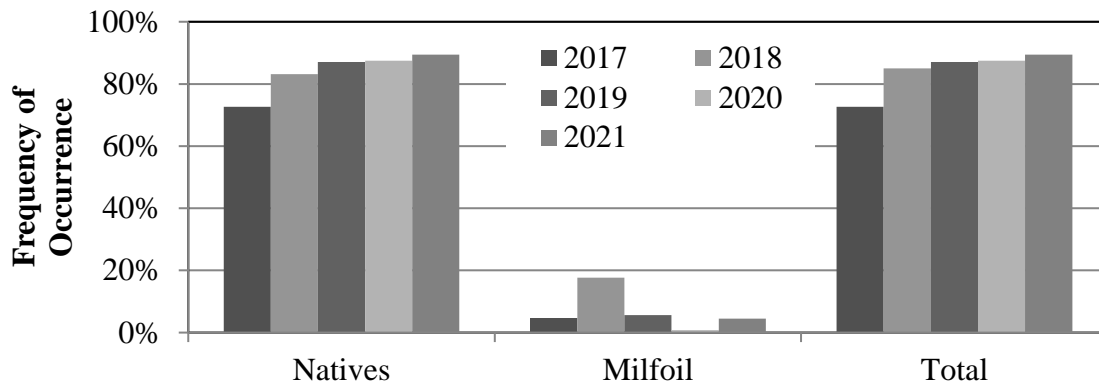
<i>Species</i>	Common Name	Lake Dunmore			
		2018	2019	2020	2021
<i>Brasenia schreberi</i> J.F. Gmel	watershield	0.9%	1.6%	0.8%	0.8%
<i>Ceratophyllum demersum</i> L.	coontail	0.9%	1.6%		3.8%
<i>Chara/Nitella</i> sp.	muskgrass, chara	32.1%	29.5%	22.7%	22.6%
<i>Eleocharis acicularis</i> (L.) Roemer & Schultes	needle spike-rush	1.8%	0.8%	1.6%	3.0%
<i>Elodea canadensis</i> Michx.	waterweed	25.0%	23.0%	21.1%	27.8%
<i>Lemna minor</i>	duckweed	0.9%			1.5%
<i>Megalodonta beckii</i> Torr.	water marigold	1.8%	4.1%	2.3%	3.8%
<i>Myriophyllum spicatum</i> L.	Eurasian watermilfoil	18.8%	5.7%	0.8%	4.5%
<i>Myriophyllum tenellum</i> L.	leafless milfoil	0.9%			
<i>Najas flexilis</i> (Willd.) Rostk. & Schmidt.	bushy pondweed	30.4%	36.9%	35.2%	36.8%
<i>Najas guadalupensis</i> L.	southern naiad	0.9%	0.8%		
<i>Nuphar variegata</i> Engelm. ex Durand	yellow pondlily	0.9%	0.8%	0.8%	0.8%
<i>Nymphaea odorata</i> Ait.	white pondlily	1.8%	0.8%	1.6%	1.5%
<i>Nymphoides cordatum</i> (Ell.) Fern.	floating heart	1.8%	0.8%	0.8%	3.0%

<i>Species</i>	Common Name	Lake Dunmore			
		2018	2019	2020	2021
<i>Pontederia cordata</i> L.	pickerelweed	0.9%			0.8%
<i>Potamogeton amplifolius</i> Tuckerm.	large-leaf pondweed	24.1%	26.2%	24.2%	34.6%
<i>Potamogeton epihydrus</i> Raf.	ribbon-leaf pondweed	3.6%	1.6%	0.8%	1.5%
<i>Potamogeton gramineus</i> L.	variable-leaf pondweed	6.3%	3.3%	4.7%	3.8%
<i>Potamogeton illinoensis</i> Morong	Illinois pondweed	27.7%	27.0%	26.6%	27.1%
<i>Potamogeton praelongus</i> Wulf.	white-stem pondweed	2.7%		1.6%	0.8%
<i>Potamogeton pusillus</i> L.	narrow-leaf pondweed	9.8%	5.7%	3.1%	6.0%
<i>Potamogeton richardsonii</i> Oakes	Richardsons' pondweed	0.9%	0.8%		
<i>Potamogeton robbinsii</i> Oakes	Robbins pondweed	48.2%	48.4%	53.9%	54.1%
<i>Potamogeton foliosus</i>	pondweed	0.9%	0.8%		
<i>Sagittaria graminea</i> Michx.	arrowhead	7.1%	4.9%	6.3%	7.5%
<i>Scirpus</i>	rush	0.9%	0.8%	0.8%	0.8%
<i>Sparganium</i> sp.	burreed	0.9%	1.6%	1.6%	3.0%
<i>Spirodela</i>	giant duckweed	0.9%	0.8%		
<i>Typha</i> sp.	cattail			0.8%	
<i>Utricularia gibba</i> Hayne	bladderwort	2.7%	0.8%	2.3%	1.5%
<i>Utricularia vulgaris</i> L.	giant bladderwort	1.8%	1.6%	2.3%	
<i>Vallisneria americana</i> L.	wild celery	17.9%	12.3%	16.4%	9.0%
<i>Zosterella dubia</i> (Jacq.) Small	water stargrass	6.3%	4.1%	3.1%	5.3%

Declines in certain native species were observed following the herbicide treatment in 2016, including *Elodea canadensis*, *Najas flexilis*, *Vallisneria americana* and *Zosterella dubia*. With the exception of *Zosterella dubia*, these species had returned to pre-treatment levels in 2017. *Zosterella dubia* returned to pre-treatment levels in 2018. Getsinger et al. (2002) reported a significant decline in the Broad-leaved Pondweeds (*Potamogeton amplifolius*, *P. illinoensis* and *P. gramineus*), as well as *Najas flexilis* and *Vallisneria americana* following herbicide treatment in both Burr Pond and Lake Hortonia, however all returned to pre-treatment levels within a year of treatment. The delay of the 2016 survey from September until October may have affected the survey results, since many species exhibit declines late in the growing season. No appreciable changes in frequency of occurrence were observed following the 2020 herbicide application.

Ninety percent of whole lake sampling points were vegetated by at least one native plant species (Figure 4), 94% of survey points with depths less than 5 m (Figure 5) and 93% of survey points with depths less than 2 meters depth yielded native aquatic plants in 2021. These results are comparable to 2020 and 2019, when 88% and 87% of whole lake sampling points and 91% and 93% of littoral zone sampling point yielded native plants and represent a slight increase from 2018, when 83% of whole lake sampling points, 84% of littoral zone points and 90% of points with depth less than 2 meters yielded native aquatic plants. In 2017, 73% of whole lake sampling points, 69% of littoral points and 81% of points less than 2 meters depth yielded native plants. Sixty-five percent of whole lake sampling points were vegetated by at least one native plant species, 78% of survey points with depths less than 5 m and 81% of survey points with

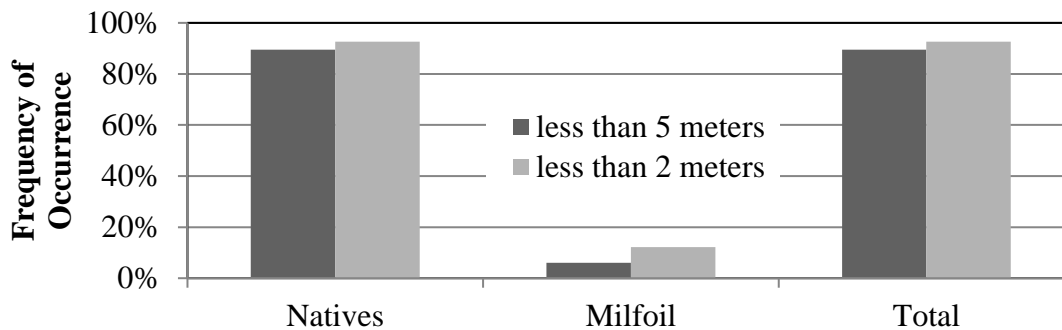
depths less than 2 meters yielded native plants in 2016. These results are quite similar to 2015, when 69% of whole lake sampling points were vegetated by at least one native plant species, 90% of survey points with depths less than 5 m and 89% of survey points with depths less than 2 meters depth yielded native plants. Results for 2014 are also similar with values reported in 2014 of 73%, 83% and 78% of survey points, respectively.



**Figure 4. Lake Dunmore frequency of occurrence summaries.**

In 2021, Eurasian watermilfoil was present in 5% of whole lake and littoral survey points. This represents an increase from 2020 when Eurasian watermilfoil was present in 1% of whole lake and littoral survey points, but a decline from 2019, when Eurasian watermilfoil was present in 6% of whole lake survey points, and 6% of survey points less than 5 m water depth. The decline continued from 2018, when Eurasian watermilfoil was present in 18% of whole lake survey points, and 12% of survey points less than 5 m water depth. Eurasian watermilfoil was present in 6% of whole lake survey points, and 7% of survey points less than 5 m water depth in 2016. Eurasian watermilfoil was present in 27% of whole lake survey points, and 51% of survey points less than 5 m water depth in 2015. For 2014 survey results, Eurasian watermilfoil was present in 18% of whole lake survey points and 30% of survey points less than 5 m water depth.

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

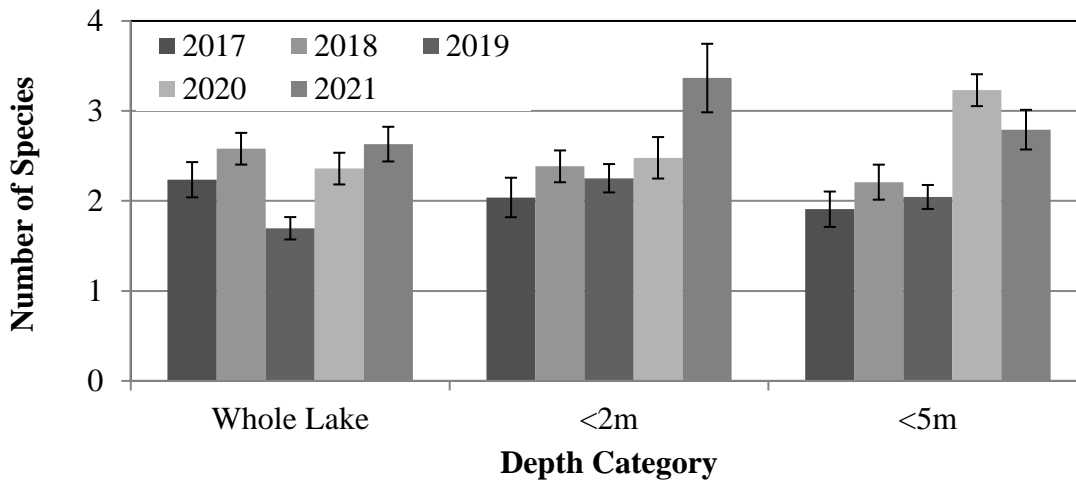


**Figure 5. Lake Dunmore frequency of occurrence summaries for sampling points less than 5 and 2 meters water depth.**

**Table 3. Lake Dunmore species richness comparison.**

Plant Grouping	Depth Class	Summary Statistic	2017	2018	2019	2020	2021
Native plant species	Whole Lake (all depths)	Mean	2.24	2.58	2.16	2.35	2.63
		N	106	113	124	128	133
		Std. Error	0.20	0.18	0.15	0.15	0.15
	Points with depths <5m	Mean	2.71	2.21	2.32	2.47	2.79
		N	80	87	116	121	125
		Std. Error	0.21	0.18	0.13	0.16	0.15
	Points with depths <2m	Mean	2.98	2.38	3.04	3.23	3.37
		N	34	52	45	39	41
		Std. Error	0.29	0.19	0.26	0.37	0.32
All plant species	Whole Lake (all depths)	Mean	2.28	2.75	2.20	2.36	2.68
		N	106	113	124	128	133
		Std. Error	0.20	0.19	0.14	0.16	0.15
	Points with depths <5m	Mean	2.77	2.31	2.37	2.48	2.84
		N	80	87	116	121	125
		Std. Error	0.21	0.18	0.15	0.17	0.15
	Points with depths <2m	Mean	3.08	2.46	3.11	3.23	3.49
		N	34	52	45	39	41
		Std. Error	0.29	0.21	0.26	0.37	0.34

Species richness results are presented in Table 3 and Figure 6. Whole lake native species richness continued to increase in 2021. In 2021, species richness was 2.63 species per sample point, slightly greater than the 2.35 species per sample point in 2020, 2.16 species per sample point in 2019, 2.58 species per sample point in 2018 and 2.24 species per sample point in 2017. Species richness in this range is comparable to other nearby lakes (Eichler et al. 2013). For survey points exclusively within the littoral zone (depths less than 5 meters), native species richness was 2.79 species per survey point, comparable to prior surveys. As expected, species richness in the littoral zone and its shallow fringe was higher than whole lake species richness.



**Figure 6. Lake Dunmore species richness for native species. Error bars are standard error of the mean.**

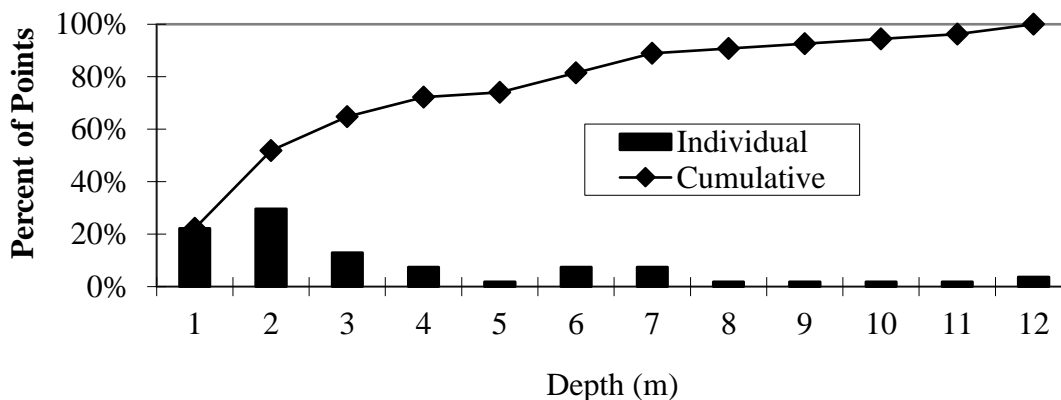
## Fern Lake Survey Results

In September of 2021, the aquatic plant community of Fern Lake included sixteen submersed species, two floating-leaved species and five emergent species. For the point intercept survey, a total of 18 species were reported in 2021 and 2020, 16 species were reported in 2019, 17 species were reported in 2018, 18 species were reported in 2017, 10 species were reported in 2016, 15 species were reported in 2015, and 14 species were reported in 2014. One new invasive species, brittle naiad (*Najas minor*) was observed in Fern Lake in 2017 (Table 1). None of the species reported for Fern Lake 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 Fern Lake, Eurasian watermilfoil (*Myriophyllum spicatum*) was present in 17% of survey points in 2021, nearly identical to 2020 results and a slight increase from the 15% in 2019, a decrease from the 24% in 2018, and comparable to the 15% of survey points in 2017 and 11% of survey points reported in 2016, but a sharp decline from the 48% of survey points in both 2014 and 2015.

## Maximum Depth of Colonization

Maximum depth of rooted aquatic plant growth for Fern Lake extended to a maximum depth of 5 m. A total of 74% of survey points were within the littoral zone (Figure 7). Viable plants were collected in depths greater than 5 m, however only for a single 6m point.

**Figure 7. Depth Distribution of Fern Lake Sampling Points in 1-meter depth classes.**



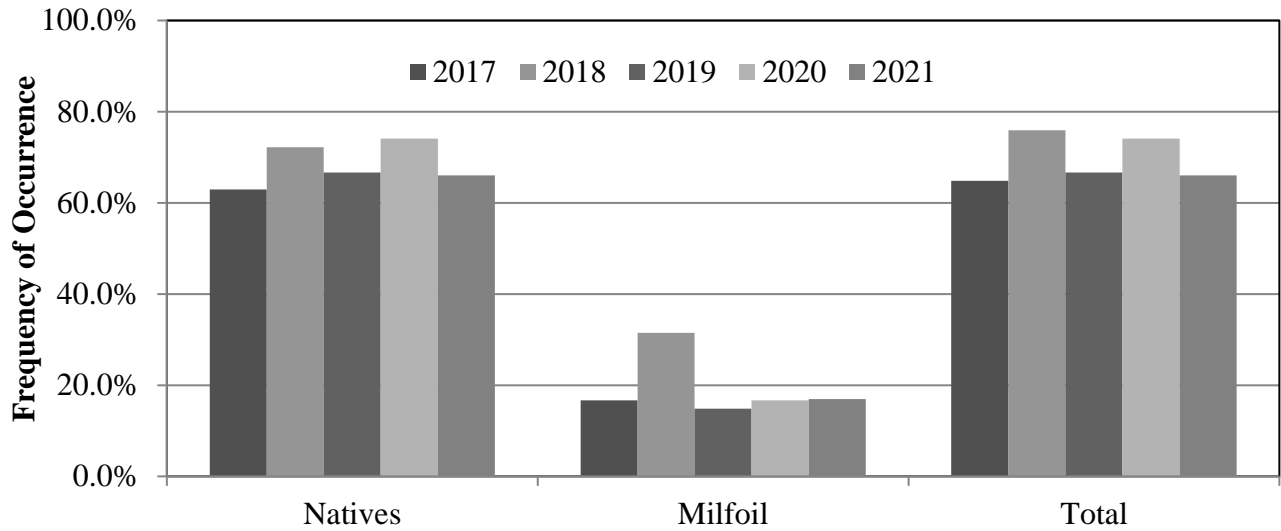
## Species Lists

Maps of the distribution of aquatic plant species for Fern Lake are included in Appendix B. Frequency of occurrence results are presented in Table 4. Illinois pondweed (*Potamogeton illinoensis*) remained the most common species, present in 36% of survey points in 2021. Eurasian watermilfoil (*Myriophyllum spicatum*) was found in 17% of survey points, comparable to the 17% of survey points in 2020, and an increase from 15% of survey points in 2019. A number of native species were commonly observed. Common native species for Fern Lake included *Potamogeton illinoensis* (36% of survey points), *Nymphaea odorata* (19%), *Potamogeton pusillus* (15%), *Potamogeton praelongus* (11%), *Chara/Nitella* (9%), *Potamogeton robbinsii* (8%), *Zosterella dubia* (7%), and *Sagittaria graminea* (6%). While dominant species present are comparable for all years (Table 4), their relative distribution is different, and less common species were absent in any given year.

**Table 4. Fern Lake percent frequency of occurrence data.**

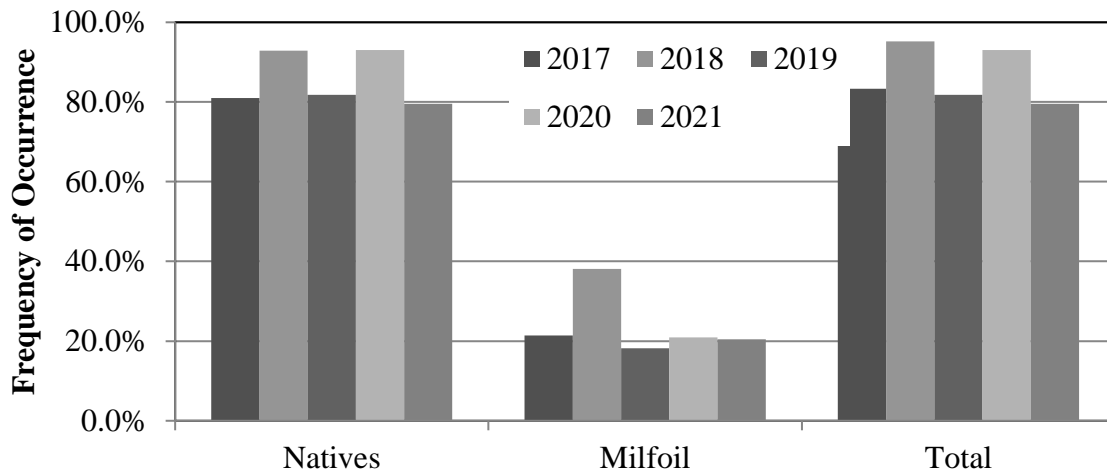
<i>Species</i>	Common Name	Fern Lake			
		2018	2019	2020	2021
<i>Chara/Nitella</i> sp.	muskgrass, chara	20.4%	9.3%	7.4%	9.4%
<i>Eleocharis acicularis</i> (L.) Roemer & Schultes	needle spike-rush		3.7%	1.9%	3.8%
<i>Elodea canadensis</i> Michx.	waterweed	3.7%	3.7%	3.7%	9.4%
<i>Fontinalis</i> sp.	moss	3.7%			
<i>Myriophyllum spicatum</i> L.	Eurasian watermilfoil	24.1%	14.8%	16.7%	17.0%
<i>Najas flexilis</i> (Willd.) Rostk. & Schmidt.	bushy pondweed		1.9%	9.3%	11.3%
<i>Najas minor</i> L.	brittle naiad	9.3%	9.3%	9.3%	11.3%
<i>Nuphar variegata</i> Engelm. ex Durand	yellow pondlily	3.7%	3.7%	3.7%	3.8%
<i>Nymphaea odorata</i> Ait.	white pondlily	18.5%	22.2%	22.2%	18.9%
<i>Polygonum amphibium</i> L.	water smartweed	1.9%		1.9%	1.9%
<i>Potamogeton gramineus</i> L.	variable-leaf pondweed		1.9%		1.9%
<i>Potamogeton illinoensis</i> Morong	Illinois pondweed	38.9%	40.7%	51.9%	35.8%
<i>Potamogeton praelongus</i> Wulf.	white-stem pondweed	11.1%	5.6%	13.0%	11.3%
<i>Potamogeton pusillis</i> L.	narrow-leaf pondweed	24.1%	25.9%	18.5%	15.1%
<i>Potamogeton robbinsii</i> Oakes	Robbins pondweed	1.9%	3.7%	1.9%	7.5%
<i>Ranunculus longirostris</i>	white water crowfoot	1.9%	3.7%	3.7%	1.9%
<i>Sagittaria graminea</i> Michx.	arrowhead	11.1%	11.1%	9.3%	5.7%
<i>Sparganium</i> sp.	burreed	1.9%		3.7%	1.9%
<i>Vallisneria americana</i> L.	wild celery	1.9%		1.9%	
<i>Zosterella dubia</i> (Jacq.) Small	water stargrass	1.9%	5.6%	7.4%	3.8%

In 2021, sixty-six percent of whole lake sampling points were vegetated by at least one native plant species (Figure 8), 80% of survey points with depths less than 5 meters (Figure 9) and 82% of survey points less than 2 meters depth yielded native aquatic plants. This represented a decline from 2020 results but was comparable to prior years. In 2019, sixty-seven percent of whole lake sampling points were vegetated by at least one native plant species, 82% of survey points with depths less than 5 meters and 85% of survey points less than 2 meters depth yielded native aquatic plants. In 2018, seventy-two percent of whole lake sampling points were vegetated by at least one native plant species, 93% of survey points with depths less than 5 meters and 97% of survey points less than 2 meters depth yielded native aquatic plants. In 2017, seventy-three percent of whole lake sampling points were vegetated by at least one native plant species, 69% of survey points with depths less than 5 meters and 81% of survey points less than 2 meters depth yielded native aquatic plants. In 2016, fifty-three percent of whole lake sampling points were vegetated by at least one native plant species, 60% of survey points with depths less than 5 meters and 68% of survey points less than 2 meters depth yielded native aquatic plants. In 2015, sixty-nine percent of whole lake sampling points were vegetated by at least one native plant, 86% of survey points with depths less than 5 meters and 97% of survey points less than 2



**Figure 8. Fern Lake frequency of occurrence summaries.**

meters depth yielded native plants. In 2014, seventy-six percent of whole lake sampling points were vegetated by at least one native plant species, 93% of survey points with depths less than 5 meters and 96% of survey points less than 2 meters depth yielded native aquatic plants. Eurasian watermilfoil was present in 17% of whole lake survey points, 21% of survey points less than 5 meters water depth and 27% of survey points less than 2 meters water depth, a slight increase from 2019 and 2020 levels, but still a substantial decline from both 2015 and 2014 results.



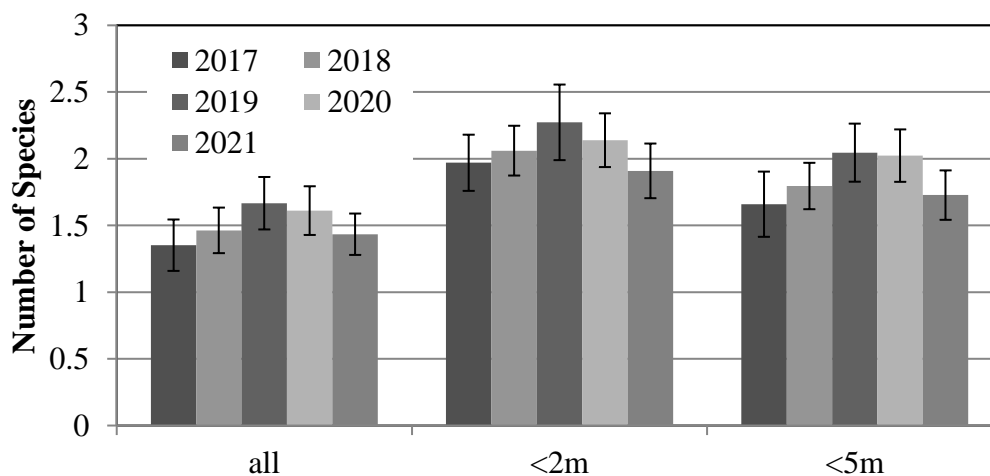
**Figure 9. Fern Lake frequency of occurrence summaries for sampling points within the littoral zone (<5 m water depth).**



**Table 5. Fern Lake species richness comparison.**

Plant Grouping	Depth Class	Summary Statistic	2017	2018	2019	2020	2021
Native Plant Species	Whole Lake (all depths)	Mean	1.35	1.46	1.43	1.61	1.43
		N	54	54	54	54	54
		Std. Error	0.19	0.17	0.18	0.18	0.20
	Points with depths <5m	Mean	1.66	1.80	1.75	2.02	1.73
		N	42	44	44	43	44
		Std. Error	0.21	0.17	0.18	0.18	0.21
	Points with depths <2m	Mean	1.97	2.06	1.94	2.14	1.91
		N	34	34	34	36	34
		Std. Error	0.24	0.19	0.22	0.21	0.24
All plant Species	Whole Lake (all depths)	Mean	1.52	1.80	1.67	1.87	1.72
		N	54	54	54	54	54
		Std. Error	0.21	0.20	0.21	0.22	0.25
	Points with depths <5m	Mean	1.86	2.21	2.05	2.35	2.07
		N	42	44	44	43	44
		Std. Error	0.22	0.21	0.22	0.22	0.27
	Points with depths <2m	Mean	2.15	2.48	2.27	2.50	2.36
		N	34	34	34	36	34
		Std. Error	0.26	0.23	0.25	0.25	0.32

Species richness results for Fern Lake are presented in Table 5. Whole lake native plant species richness in 2021 was 1.43 species per survey point, comparable to prior surveys (Figure 10), with the exception of 2016, when species richness was reduced. The decline may be attributable to the herbicide application however the 2016 survey was also conducted in October, one month later than the two previous surveys, and a time when many native species have decomposed to the point of being unrecognizable. Species richness is comparable to other regional lakes (Eichler et al. 2013), but slightly lower than Lake Dunmore, perhaps due to the smaller size and limited habitat complexity of Fern Lake..



**Figure 10. Fern Lake species richness for native species. Error bars are standard error of the mean.**

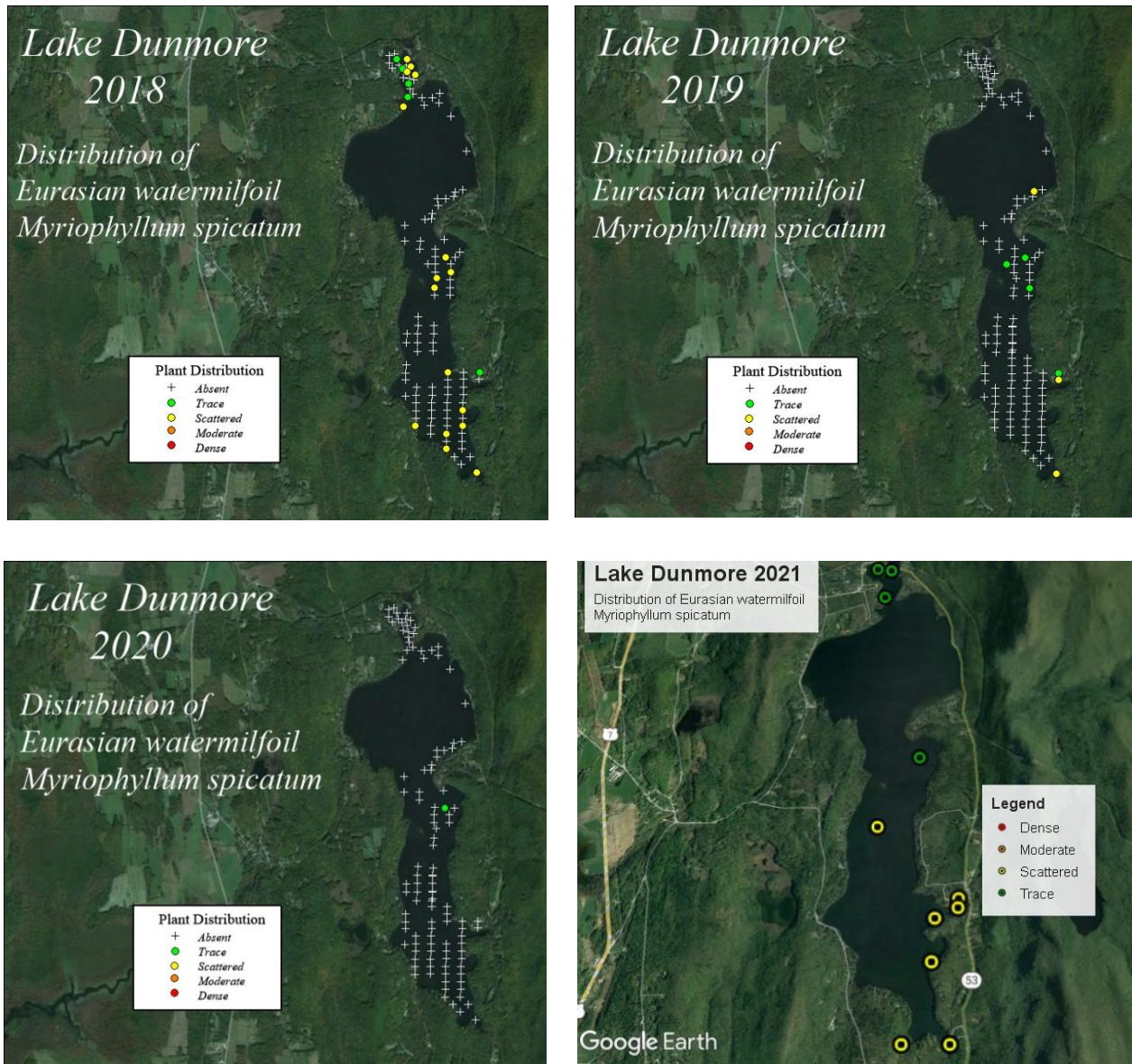
## Summary

Quantitative aquatic plant surveys were undertaken for Lake Dunmore and Fern Lake, Vermont, in September of 2021. Surveys were designed to duplicate prior surveys in 2014 thru 2020, and conducted to obtain post-treatment data for an herbicide application in 2016 and 2020 in conjunction with annual hand and suction harvesting efforts to control Eurasian watermilfoil. 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.

Eurasian watermilfoil (*Myriophyllum spicatum*) populations were first confirmed in Lake Dunmore in 1988; and in 1994 the current management program was initiated. Eurasian watermilfoil was first detected in Fern Lake in 1996, with annual management efforts since 2003. Hand harvesting by skin and SCUBA divers has been the basis of the program for most years with use of diver operated suction harvesting in recent years. While there was a general sense that management efforts were controlling Eurasian watermilfoil, the level of effort required to achieve control continued to expand. By 2013, over 3600 bushels of Eurasian watermilfoil were being harvested from Lake Dunmore by 2 suction harvesting teams. In 2015, the effort had expanded to 4 teams and a greatly increased number of harvesting days. In Fern Lake, the aquatic weevil population was augmented in 2013 as an additional control measure. In addition to weevil augmentation, hand and suction harvesting removed a total of 1800 bushels of Eurasian watermilfoil. Approximately 80 acres of Lake Dunmore and the majority of Fern Lake were treated with the aquatic labeled herbicide triclopyr (Renovate®) in 2016. The aquatic herbicide Procella COR was applied to 39 acres in the area of the ‘spine’ and 1.7 acres at the south end of the lake in 2020. Extensive hand and suction harvesting were also part of the annual management effort and continue to be employed annually.

The aquatic plant community of Lake Dunmore includes twenty-three submersed species, four floating-leaved species, six emergent species and two floating species. 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 Dunmore, Humped Bladderwort (*Utricularia gibba*) is found on Vermont’s rare plant list (VT DEC 2012). Eurasian watermilfoil (*Myriophyllum spicatum*) was present in 5% of survey points, and increase from the 1% of survey points in 2020, but a decrease from the 6% reported in 2019, 19% reported in 2018, 5% reported in 2017 and 6% of survey points in 2016, and substantially less than the 27% of survey points in 2015 (Figure 11). The increase between 2014 and 2015 may be an artifact of a change in the survey to focus on areas known to support Eurasian watermilfoil. Comparing only the points from both 2014 and 2015, a small decline from 30% of survey points in 2014 to 27% in 2015 was reported.

**Figure 11. Distribution of Eurasian watermilfoil in Lake Dunmore.**



Species richness in Lake Dunmore was quite high, with a number of species occurring in more than 5% of survey points. Ninety percent of sampling points were vegetated by at least one native plant species, comparable to the 88%, 87%, 83%, 73%, 65%, 69% and 73% reported in 2020 through 2014, respectively. The large number of points supporting native plant species suggests that Lake Dunmore is a prime candidate for recovery of its native plant population following management of Eurasian watermilfoil. Native species richness in the littoral zone was 2.63 species per sample in 2021, slightly more than prior surveys, which ranged from 2.21 to 2.47 species per sample. These results are in the average range for regional lakes.

Common native species for Lake Dunmore included Robbins Pondweed (*Potamogeton robbinsii*, 54% of survey points), Bushy Pondweed (*Najas flexilis*, 37%), Illinois Pondweed (*Potamogeton*

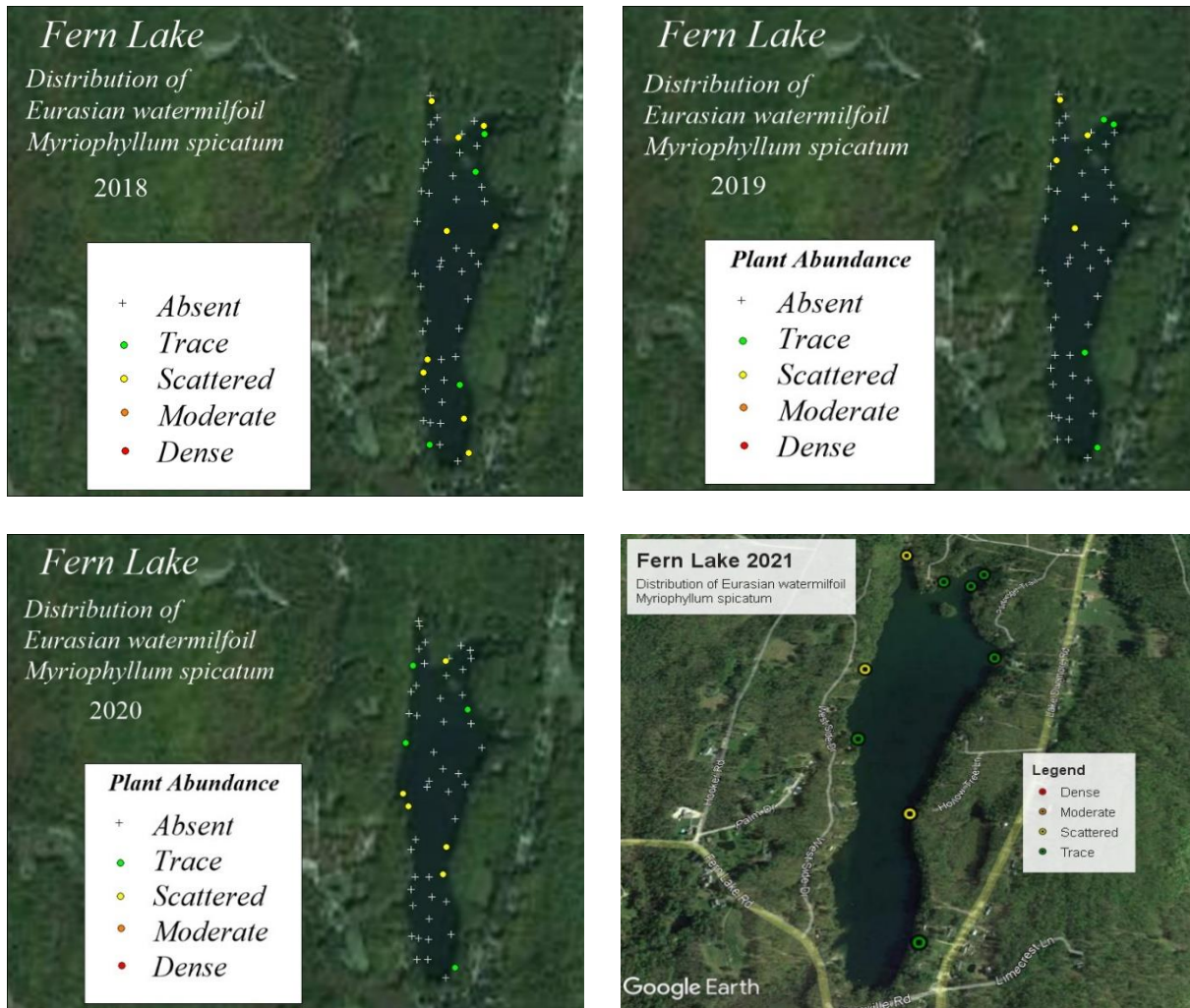
*illinoensis*, 27%), Broad-leaf Pondweed (*Potamogeton amplifolius*, 35%), Waterweed (*Elodea canadensis*, 28%), Muskgrass (*Chara/Nitella* 23%), Duck Celery (*Vallisneria americana*, 9%), Arrowhead (*Sagittaria graminea*, 8%), Narrow-leaf Pondweed (*Potamogeton pusillus*, 6%), and Water Stargrass (*Zosterella dubia*, 5%). Native species results are generally comparable to those reported in 2014 through 2020 with a few exceptions. Declines in certain native species were observed following the herbicide treatment in 2016, including *Elodea canadensis*, *Najas flexilis*, *Vallisneria americana* and *Zosterella dubia*. All had recovered by 2018. Getsinger et al. (2002) reported a significant decline in the Broad-leaved Pondweeds (*Potamogeton amplifolius*, *P. illinoensis* and *P. gramineus*), as well as *Najas flexilis* and *Vallisneria americana* following herbicide treatment in both Burr Pond and Lake Hortonia, however all returned to pre-treatment levels within a year of treatment. The delay of the 2016 survey from September until October may have affected the survey results, since many species exhibit declines late in the growing season. The 2020 herbicide treatment appears to have had little effect on native species frequency of occurrence.

For Fern Lake, the aquatic plant community included sixteen submersed species, two floating-leaved species and five emergent species. None of the species reported for Fern Lake were on Vermont's rare plant list. One new invasive species, brittle naiad (*Najas minor*) was observed in Fern Lake in 2017. This annual species has been expanding its' range northward over the last decade. For Fern Lake, Eurasian watermilfoil (*Myriophyllum spicatum*) was present in 17% of survey points, nearly identical to 2020 results and a slight increase from the 15% reported in 2019, but less than the 24% reported in 2018 and comparable to the 15% and 11% of survey points reported in 2017 and 2016, and a substantial decline from the 48% of survey points in both 2014 and 2015 (Figure 12). Common native species for Fern Lake included Illinois Pondweed (*Potamogeton illinoensis*, 36% of survey points), White Pondlily (*Nymphaea odorata*, 19%), Narrow-leaf Pondweed (*Potamogeton pusillus*, 15%), White-stem pondweed (*Potamogeton praelongus*, 11%), Muskgrass (*Chara/Nitella*, 9%), Waterweed (*Elodea canadensis*, 9%), Robbins Pondweed (*Potamogeton robbinsii*, 8%) and Arrowhead (*Sagittaria graminea*, 6%). 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 appears to be rapid following management efforts. While the dominant species present were comparable for all years, their relative distribution was different, and several of species were absent in 2016. There are two possible explanations, the effect of the herbicide treatment in 2016 or the delay in the survey until October when some of the less robust species may have already undergone Fall senescence.

Eurasian watermilfoil growth in both Lake Dunmore and Fern Lake was limited to scattered and trace levels of growth in September of 2021. In Lake Dunmore, Eurasian watermilfoil was located primarily at the south end of the lake. In Fern Lake, Eurasian watermilfoil growth was principally at the north end and native plant populations appear robust and similar to other regional lakes. Survey results in 2014 and 2015 suggested that Eurasian watermilfoil was slowly expanding its coverage in both Lake Dunmore and Fern Lakes, even with the ongoing management efforts. Management efforts were slowing the spread of Eurasian watermilfoil however the amount of plant material harvested continued to increase on an annual basis. Following an application of herbicide in 2016, Eurasian watermilfoil frequency of occurrence declined sharply and relative abundance went from moderate growth to scattered plants in both



**Figure 12. Distribution of Eurasian watermilfoil in Fern Lake.**



lakes. Eurasian watermilfoil remained at low levels in 2017 in both lakes. By 2018, Eurasian watermilfoil was showing signs of recovery and the volume of harvested plant material was starting to rise. In 2019, Eurasian watermilfoil occurrence had returned low levels, most likely as a result of management efforts. Extremely limited growth of Eurasian watermilfoil in Lake Dunmore in 2020 may be attributed to the use of an herbicide (Procella COR), in conjunction with a suction harvesting program. For Fern Lake, a recently discovered invasive species, brittle naiad (*Najas minor*), maintained its' expanded coverage from 2020 and should be monitored. This species can spread by vegetative (fragments) means and seed dispersal. It is known to grow densely at the shallow margins of Eurasian watermilfoil growth and crowd out native species.

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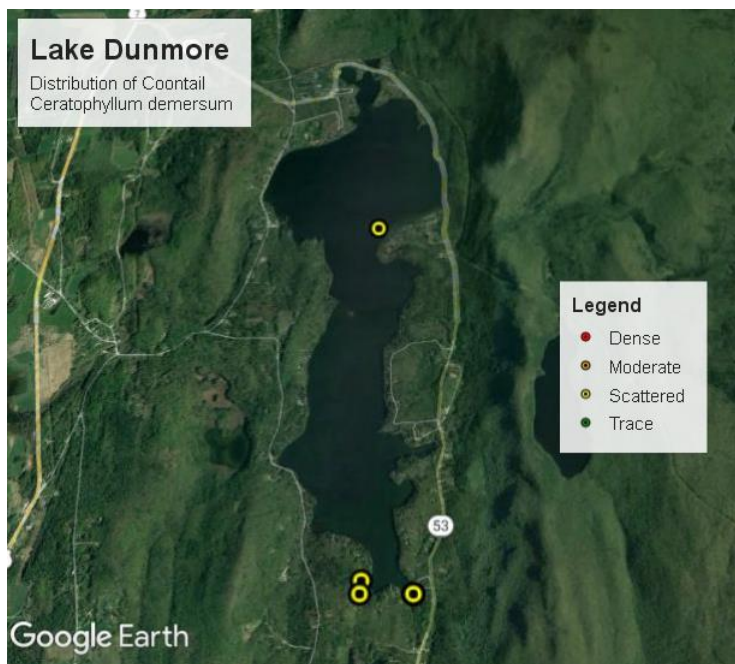
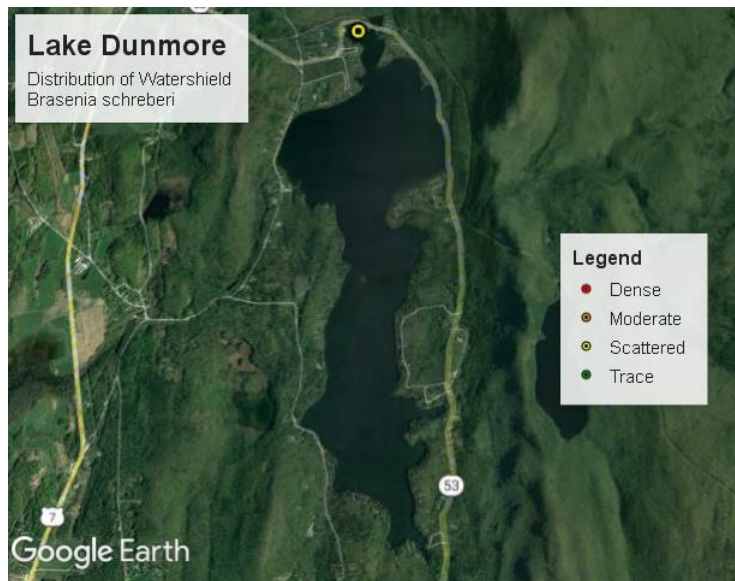
## **Acknowledgements**

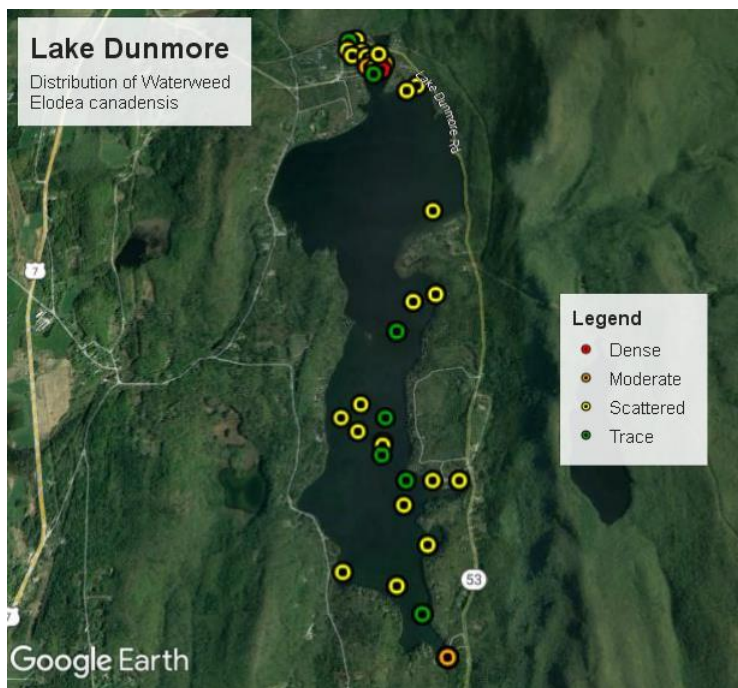
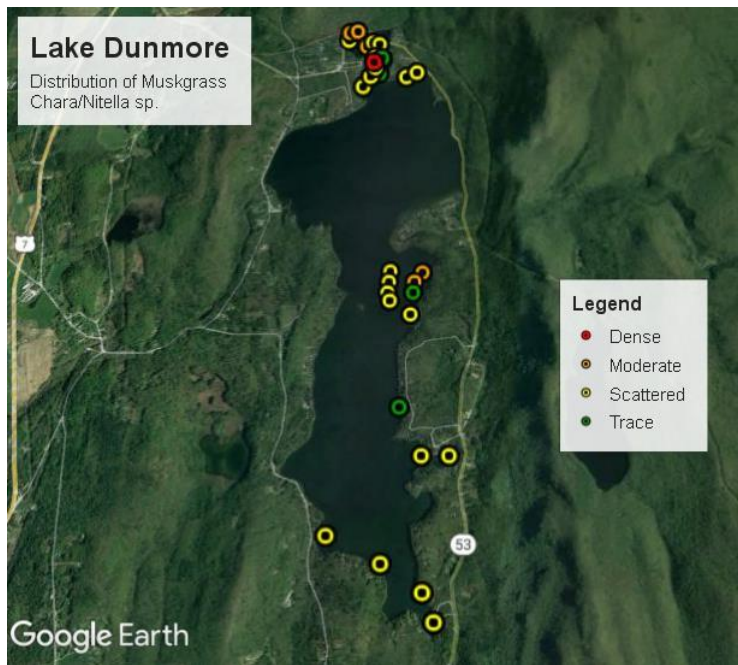
The authors would like to acknowledge Josh Quinn, Katie Gellenbeck, Brett Zimmermann, Chip Paison, Richard Dahlgren and James Foley of the Lake Dunmore Fern Lake Property Owners Association for their assistance in coordinating the current survey project.

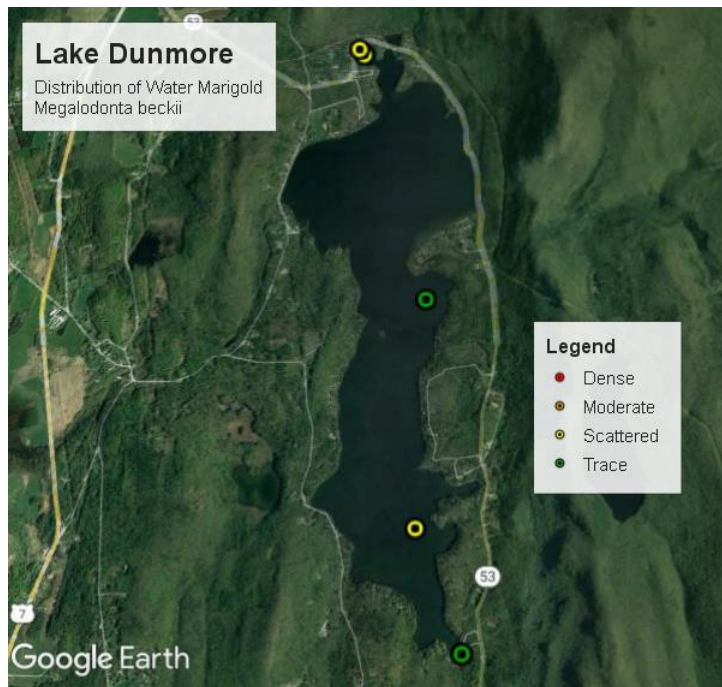
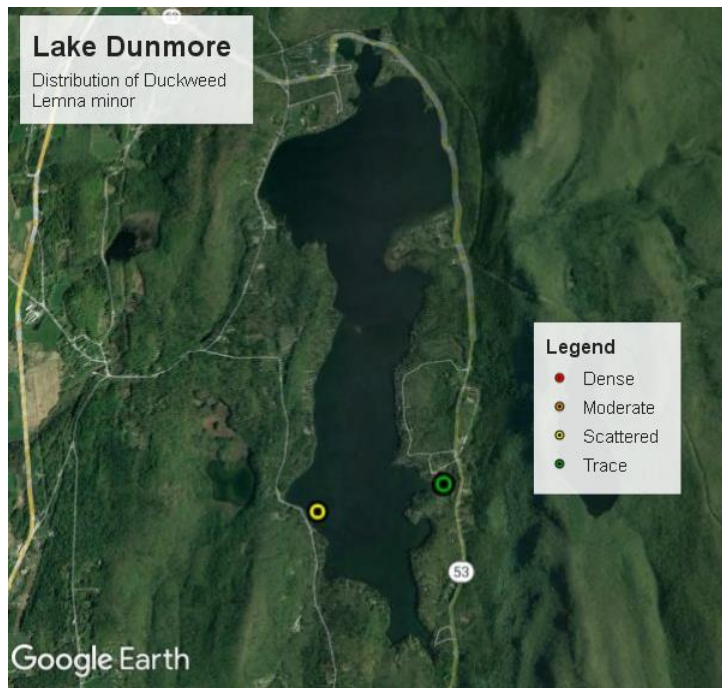
# **Appendix A**

## **Lake Dunmore Aquatic Plant Distribution Maps**

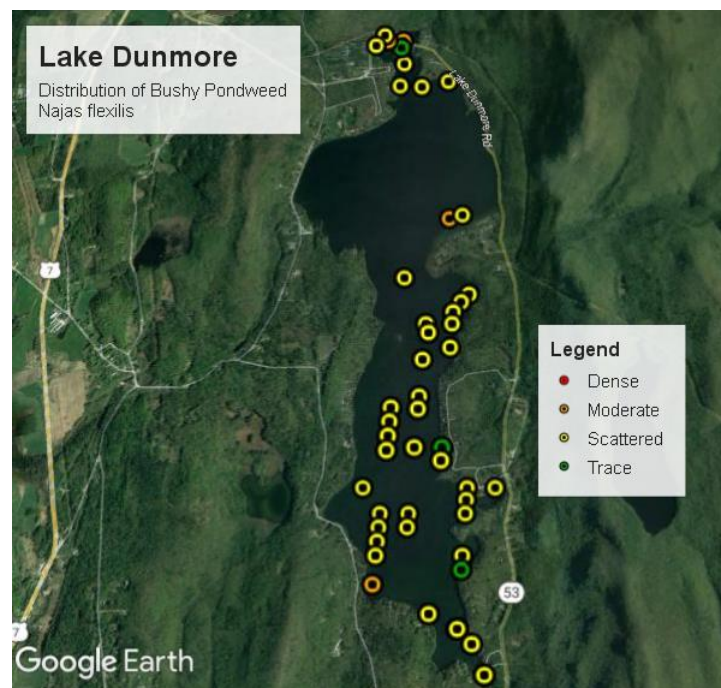
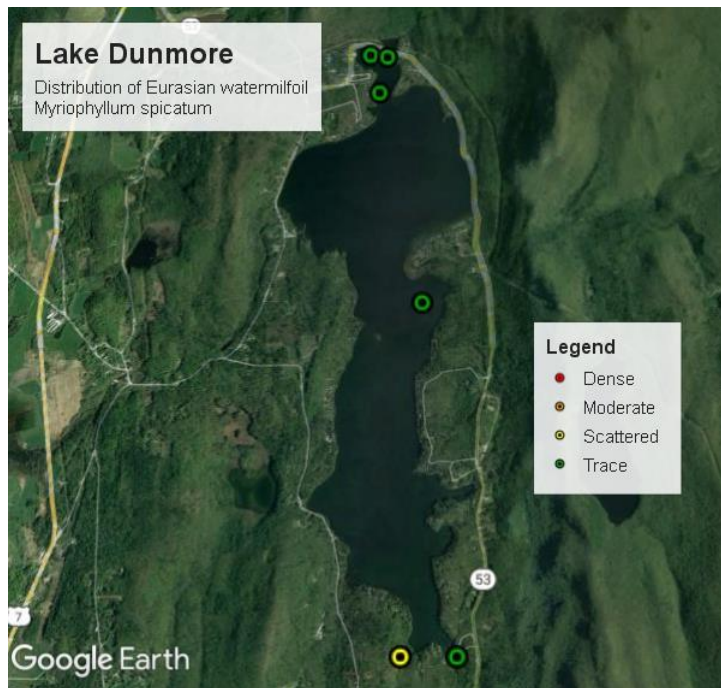


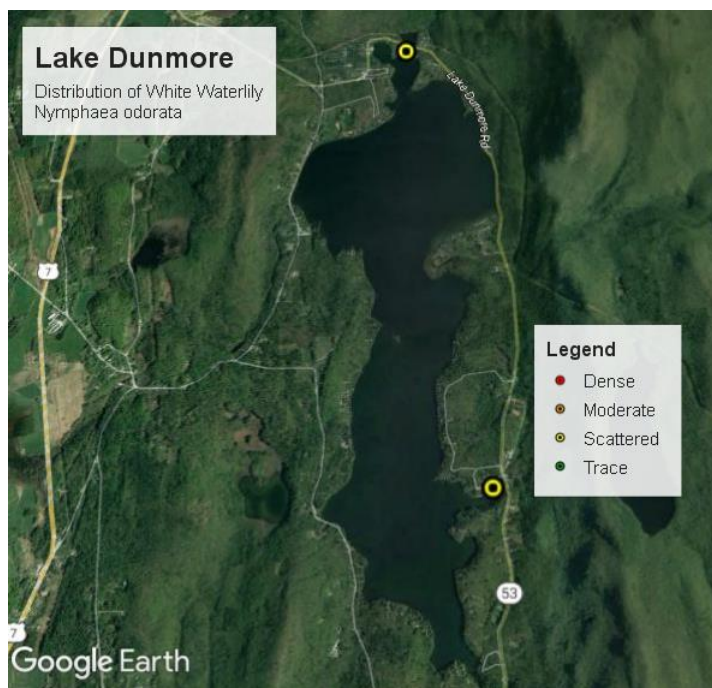
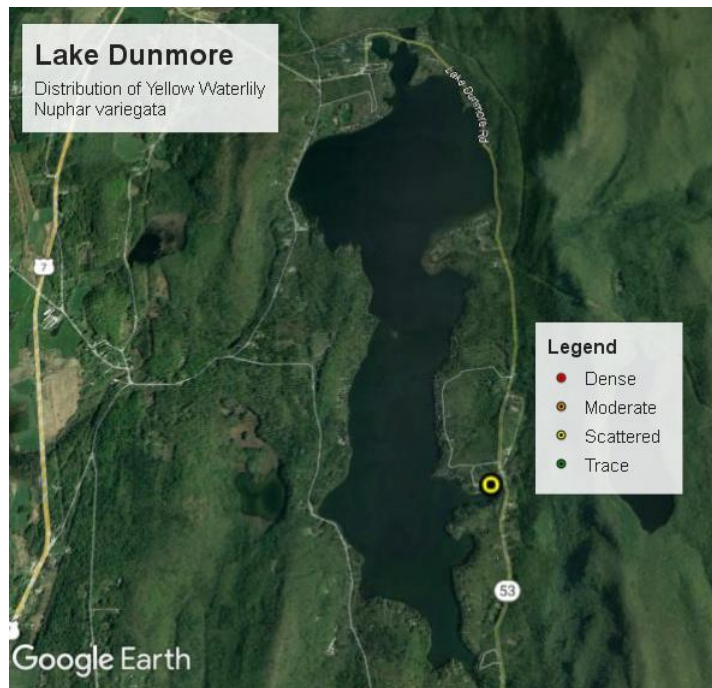


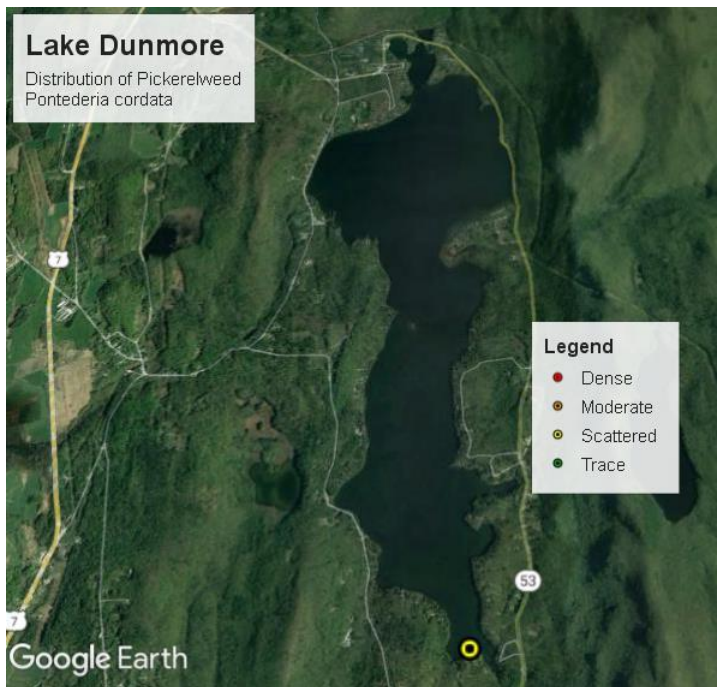
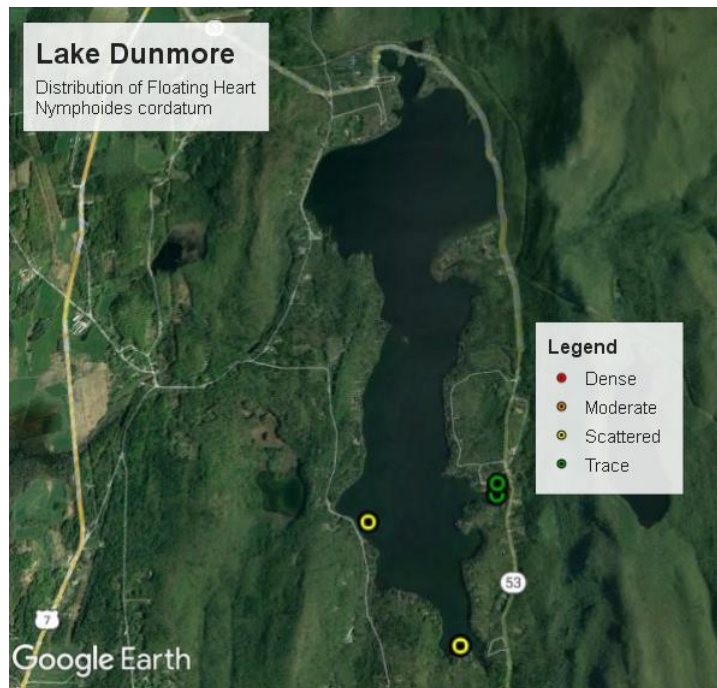




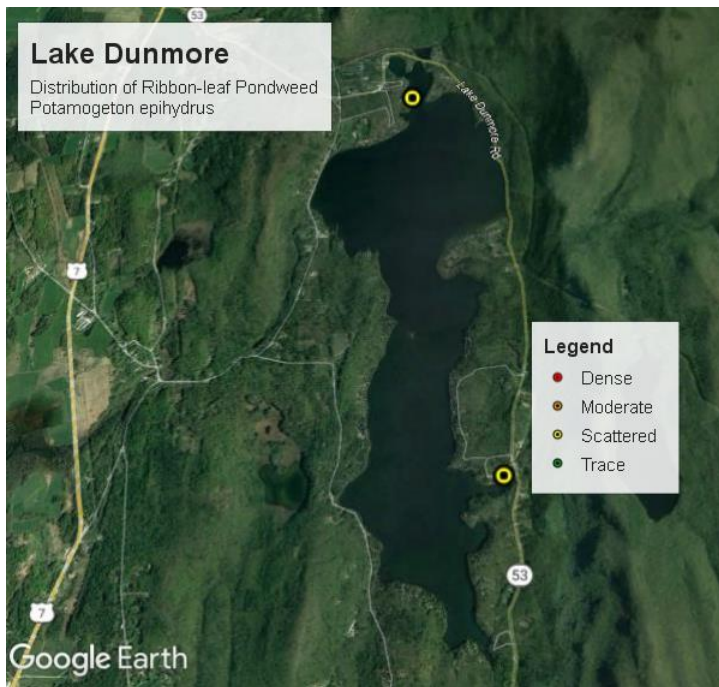
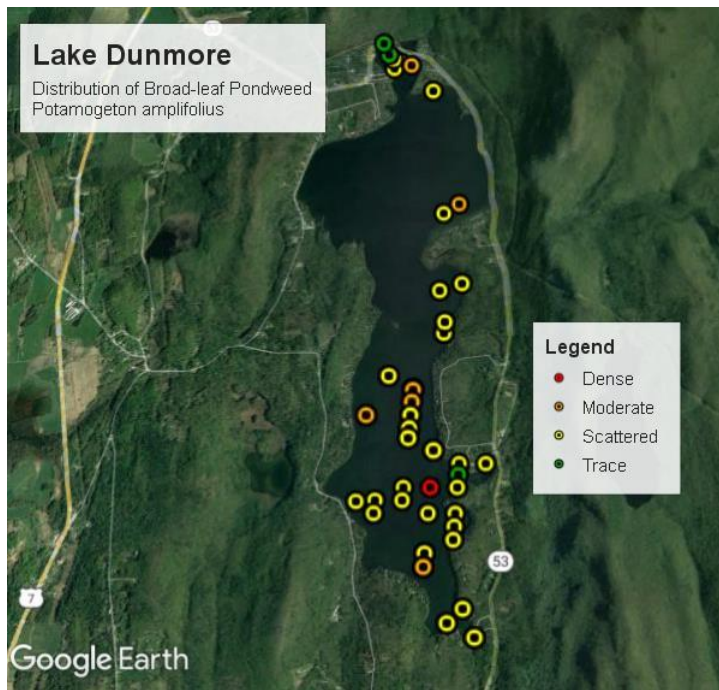


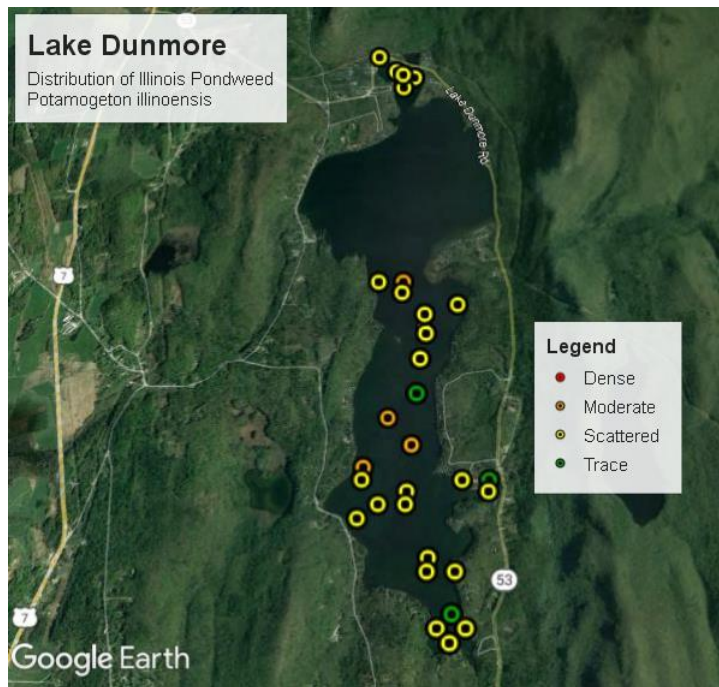
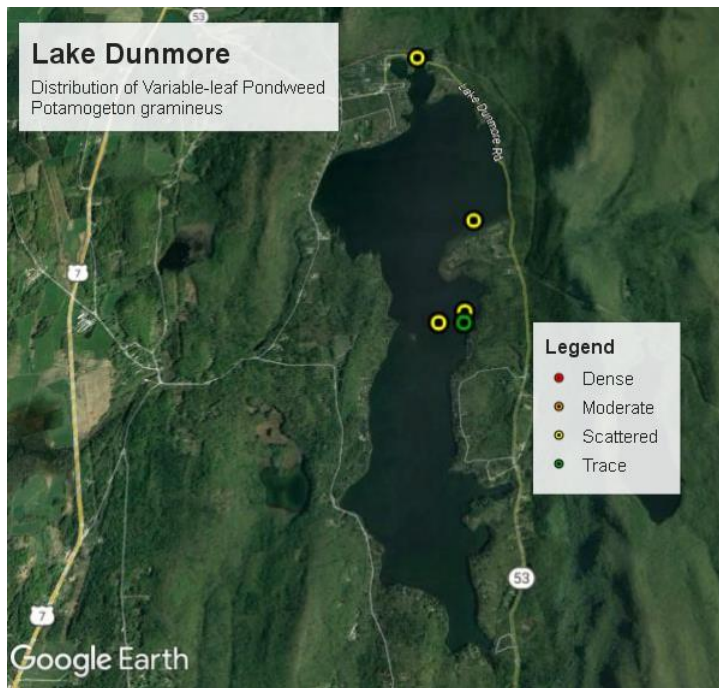




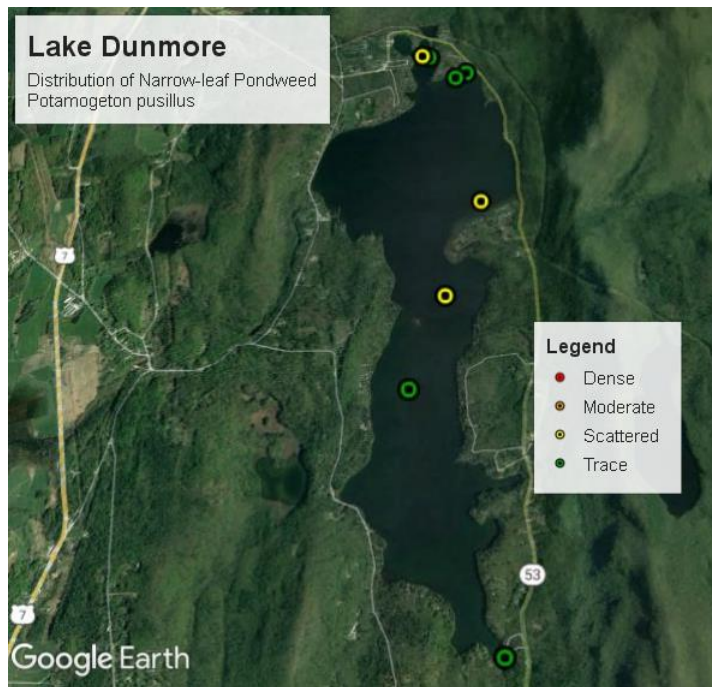
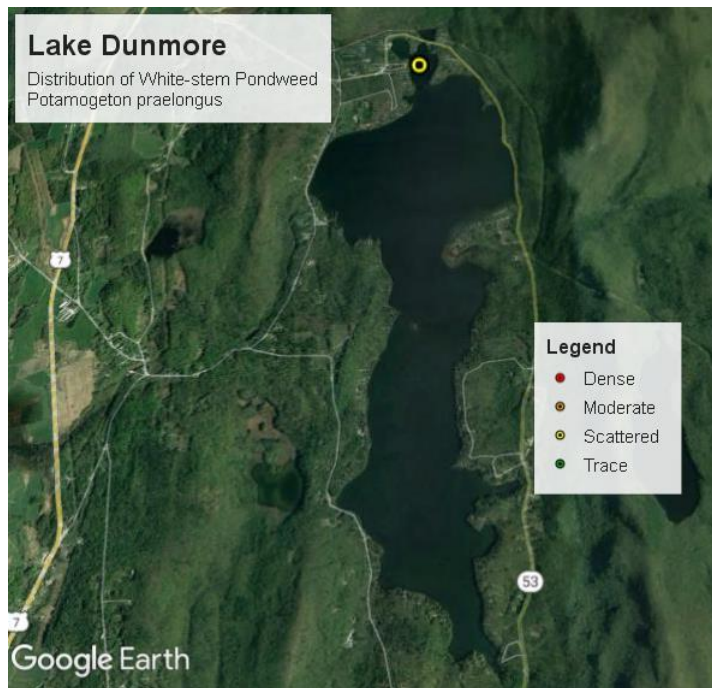


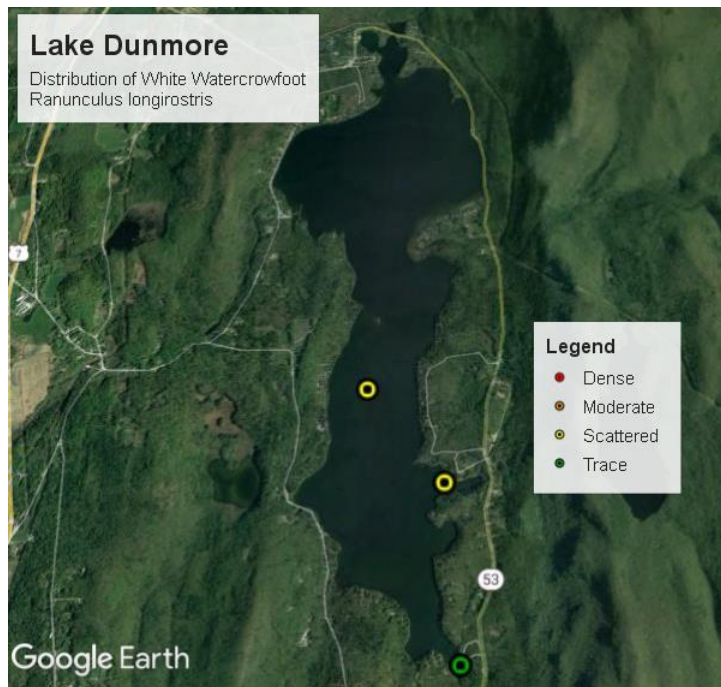
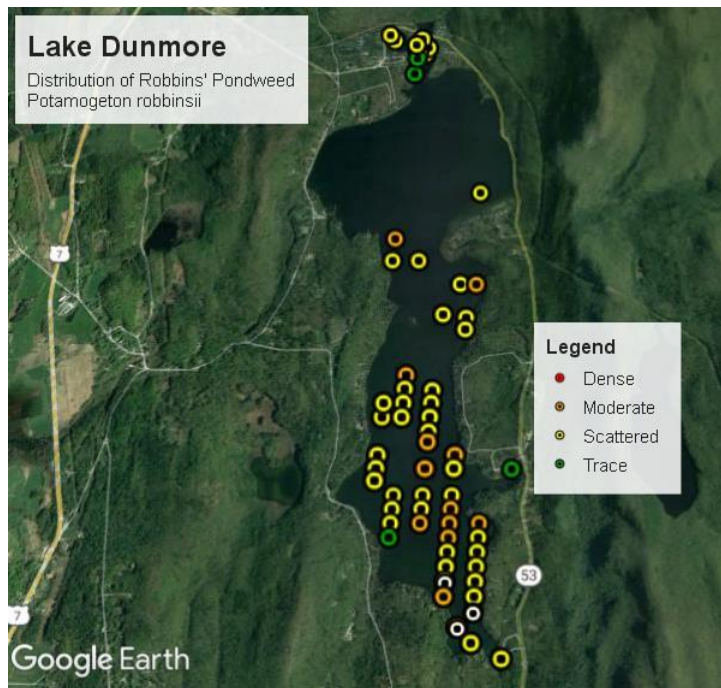


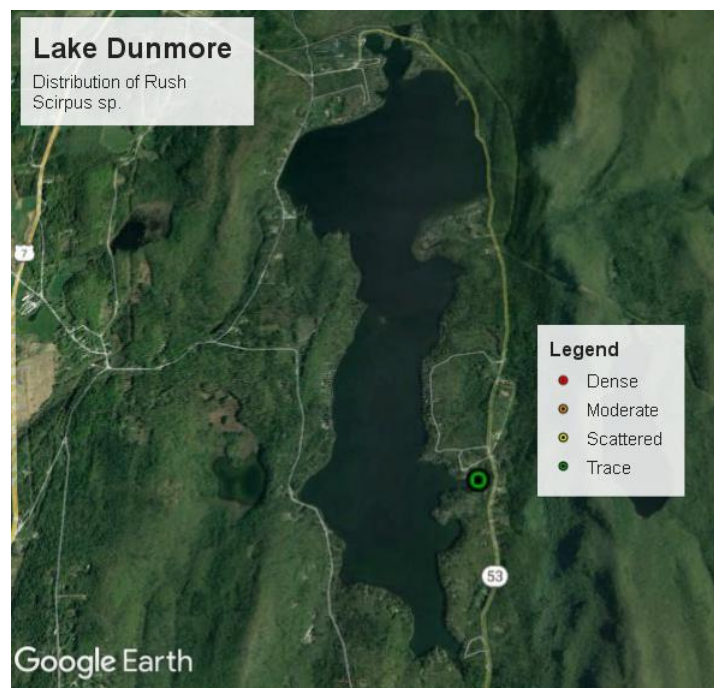
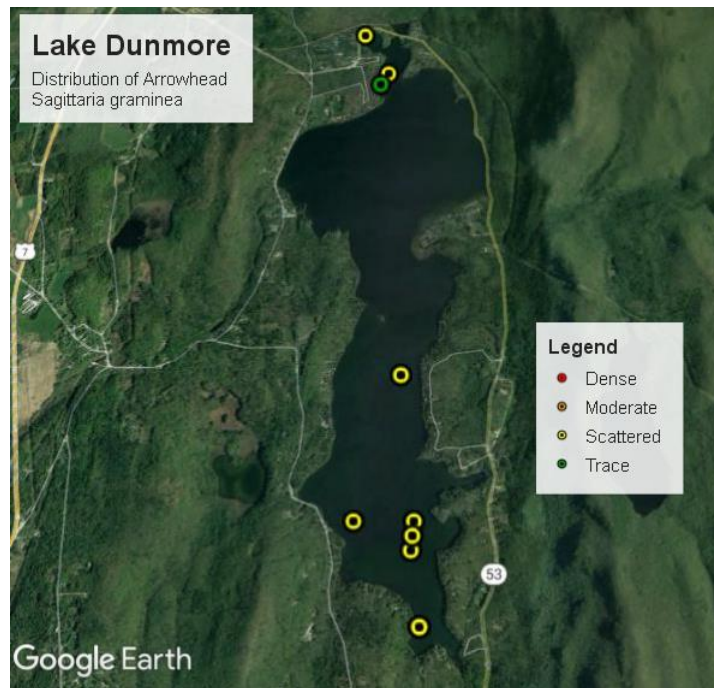




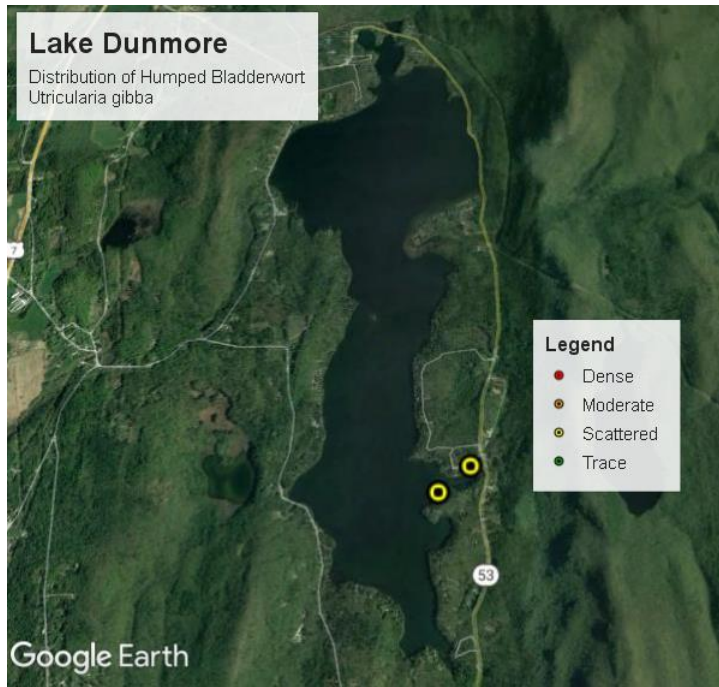
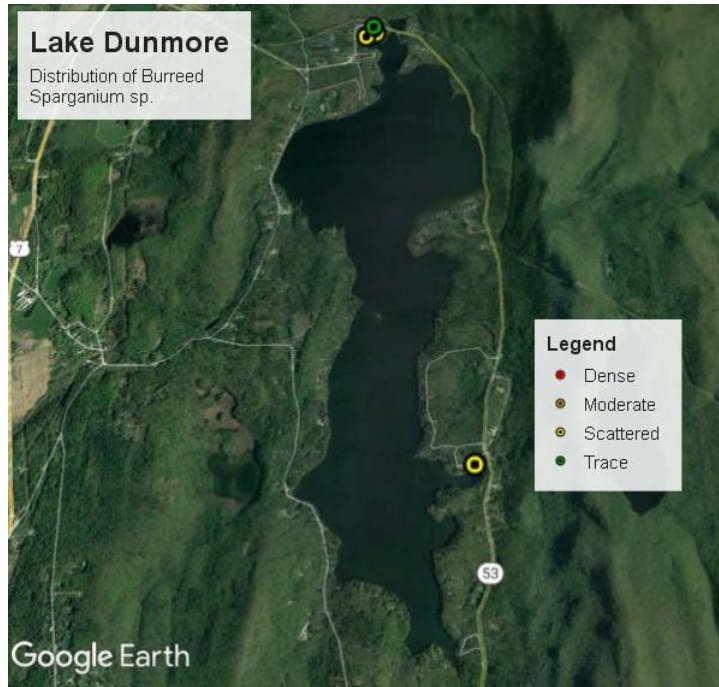


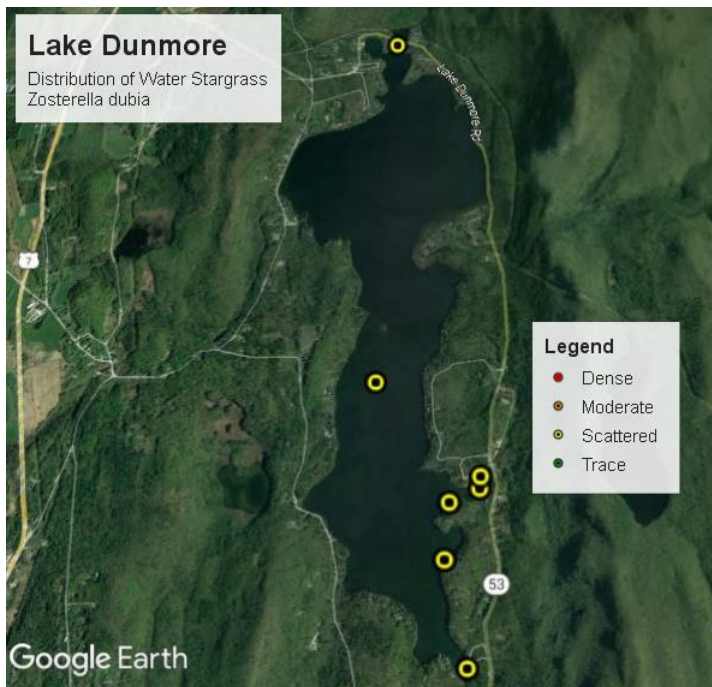
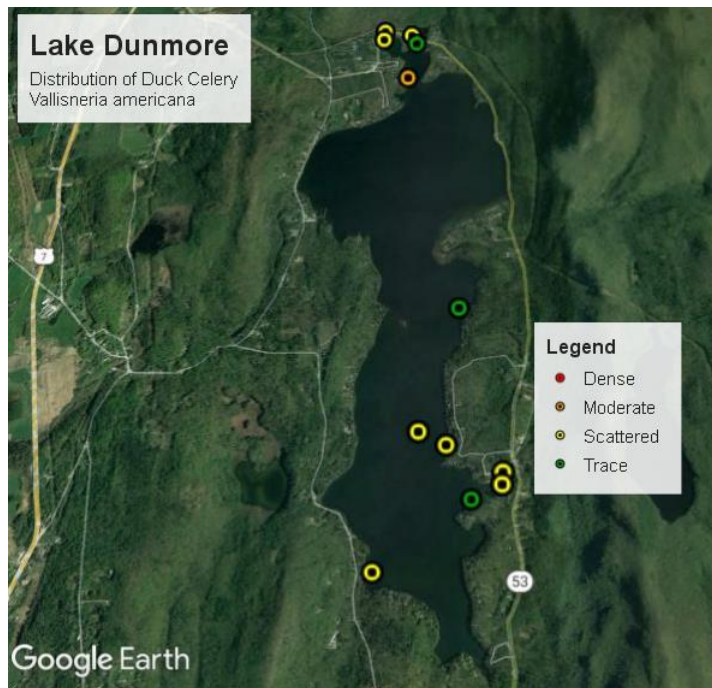












# **Appendix B**

## **Fern Lake Aquatic Plant Distribution Maps**





