Northeast Aquatic Research

North and South Riga Ponds
2020 Monitoring Report

Prepared for the Mount Riga Association

January 2021

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<u>Clarity</u>: Water clarity in North Riga was moderate in 2020, with one measurement worse than the 6-meter threshold. At South Riga, the Secchi disk could be seen at the bottom of the deep spot during every sampling event except for September 14th, when the water clarity was 4.75 meters.

<u>Dissolved Oxygen and Temperature</u>: Oxygen remained present at the bottom of the deep spot at both ponds for the duration of the 2020 season. Oxygen was slightly reduced at the bottom 1-meter of the deep spot at North Riga in July and August. Only four profiles were collected at South Riga in 2020, but it appears that the pond remained fully mixed for the entire season.

<u>Nutrients</u>: Both Total Nitrogen and Total Phosphorus were elevated in South Riga. TP and TN in North Riga were generally good in 2020.

<u>Aquatic Plants</u>: Seventeen aquatic plant species were found in North Riga. Twenty-one aquatic plant species were found in South Riga. No invasive aquatic plant species were found in either of the ponds in 2020.

BACKGROUND

North Riga Pond (also known as Upper Riga or North Pond) and South Riga Pond (also known as Lower Riga or South Pond) are located on Mount Riga in Salisbury, Connecticut. Water quality monitoring of the two lakes has been conducted intermittently since 1986. Initially, monitoring consisted of collecting water clarity readings, as well as temperature and dissolved oxygen profiles. NEAR has monitored the two lakes roughly every year since 2007, with the exception of 2009 and 2017. In 2018, 2019, and 2020, volunteer monitors conducted the lake monitoring approximately once per month for the duration of the summer sampling season.

Between 2010 and 2020, NEAR has surveyed the two lakes once per year, except in 2017. In 2020, NEAR surveyed the two lakes on September 3rd to assess the presence and density of all aquatic plant species in the lakes. The annual aquatic plant survey also searched intensively for invasive species. No invasive species were found.

MONITORING RESULTS

In 2020, water quality monitoring at North Riga was conducted by volunteer monitors once in May, three times in July, and once per month in August, September, and November. At South Riga, volunteers monitored the pond once in May, twice in July, once in August, and once in September. In addition, NEAR conducted water quality monitoring at South Riga at the time of the aquatic plant survey on September 3rd.

The lake data is assessed using the CT DEEP categorization of lakes, which is primarily based on the amount of nutrients present in surface waters during summer conditions (**Table 1**). A trophic category is a way to classify the degree of plant and algae growth that occurs in a lake, which increases with overall water quality decline. Very clear water with no weeds or algae results from very low nitrogen and phosphorus conditions. These clear-water and low-nutrient lakes are considered oligotrophic. Lakes with excessive amounts of weeds and very green water resulting from high nutrient concentrations are eutrophic. **Table 1** shows lake Trophic Status. Target criteria are highlighted in blue: TP <10ppb, TN <200ppb, and Secchi >6m.

Table 1 - Lake trophic categories and ranges of indicator parameters.

Category	T.P.	T. Nitrogen	Secchi Depth	Chlorophyll *a*
	(ppb)	(ppb)	(m)	(ppb)
Oligotrophic	0 – 10	0 – 200	6+	0 – 2
Oligo-mesotrophic	10 – 15	200- 300	4 – 6	2 – 5
Mesotrophic	15 – 25	300 - 500	3 – 4	5 – 10
Meso-eutrophic	25 – 30	500 - 600	2 – 3	10 – 15
Eutrophic	30 – 50	600 - 1000	1 – 2	15 – 30
Highly Eutrophic	50 +	1000 +	0 – 1	30 +

**Source = CT DEP 1982*

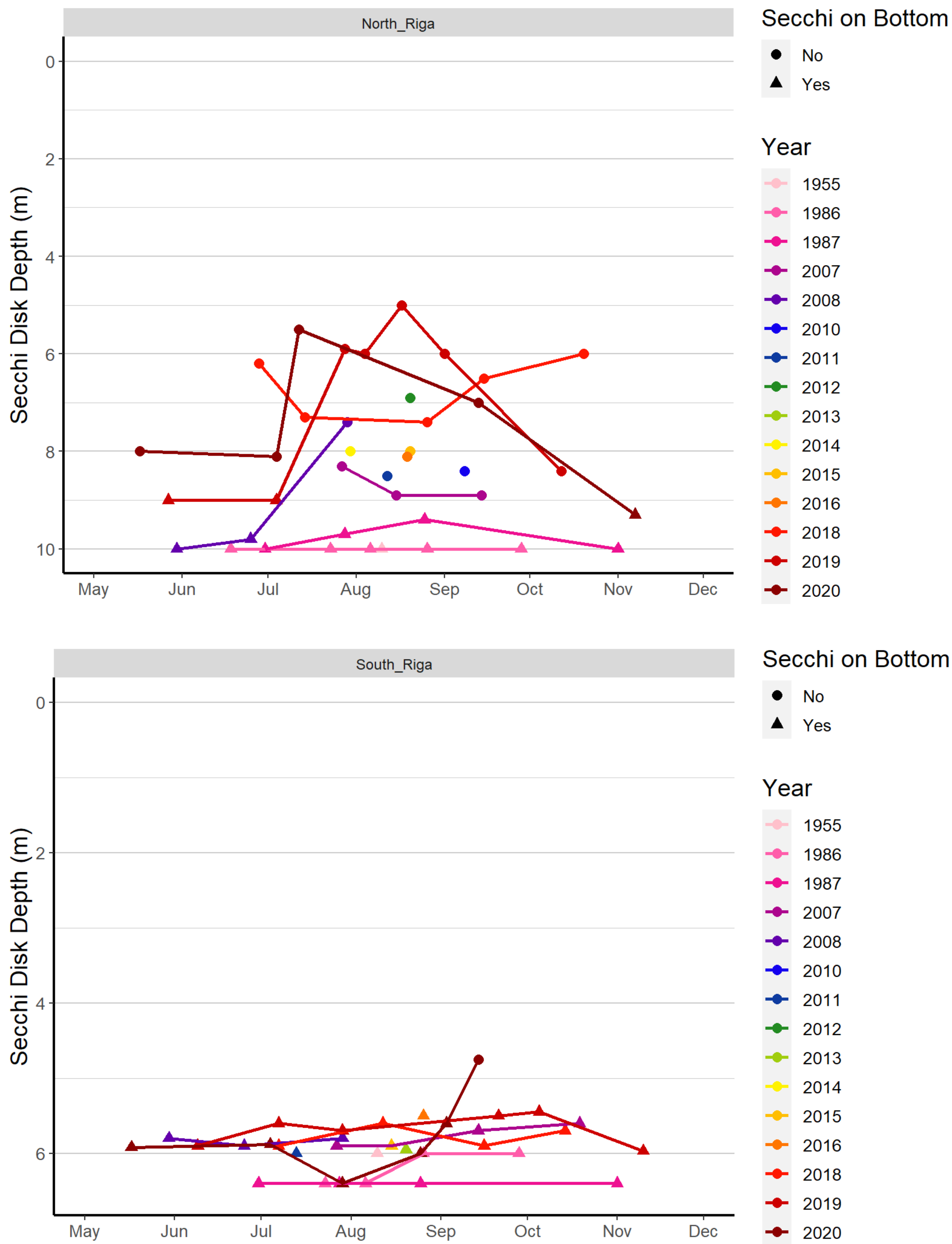
**Chlorophyll-a not included in testing because samples are very time-sensitive.*

Water Clarity / Secchi Disk Depth

North Riga Pond is approximately 10 meters deep at the deepest location. In 1986 and 1987, water clarity was measured approximately once per month in the summer season. In these years, the Secchi disk was always visible at the bottom of the deep spot (**Figure 1**). Following an extended period of no monitoring, clarity measurements were recorded three times per summer in 2007 and 2008, and then once per summer from 2009 through 2016. In these years, the water clarity was still good, but worse than in the 80s, with readings ranging from 7 meters to 9 meters. In 2018, the first year of monthly Secchi disk measurements since 1987, clarity was worse still, in the range of approximately 6 to 7.5 meters across the summer months. In 2019, clarity was worse than prior years overall, with the first known Secchi disk measurement of less than 6 meters. In 2020, clarity in North Riga remained good in May, early July and November. However, between July 4th and July 12th, the clarity went from 8.1 meters to 5.5 meters (**Table 2**). This rapid decline in clarity is indicative of increased algae in the water column, as a result of excess nutrients. A Secchi disk measurement was not collected in August, but it is likely that the clarity remained about the same as July, or perhaps worsened slightly. By mid-September, clarity had improved and by November, the Secchi disk could be seen at the bottom of the deep spot for the first time in 2020. Seasonal fluctuations in water clarity are common, as they represent precipitation changes, watershed use changes, and seasonal patterns in nutrient quantity and physical lake dynamics. However, the dramatic decrease in clarity in North Riga from early- to mid-July was unusual.

South Riga Pond fluctuates between 5.5 meters and 6 meters at its deepest spot, based on lake water level. In the prior 14 years of water clarity measurements at South Riga, the Secchi disk has always been visible on the lake bottom. However, on September 14th, 2020, the Secchi disk depth was 4.75 meters. It is unclear exactly how far this was from the bottom because a profile was not conducted on this day. However, 10 days prior, the bottom was located at 5.6 meters, meaning clarity likely ended slightly less than a meter from the bottom. The poor clarity on this date is concerning and presumably due to excess nutrients in the water column and an associated increase in algae growth.

Figure 1. Historical Secchi disk depth measurements at North Riga and South Riga.



The above figure demonstrates the long-term worsening of summer water clarity in North Riga from 1955 to 2020. It also appears that the lake water level has changed somewhat over time in both ponds, or that the bottom has become slightly shallower.

Table 2. North Riga and South Riga Secchi disk depth measurements, 2020.

North Riga Secchi Disk Depths (m)					
17-May	4-Jul	12-Jul	23-Aug	13-Sep	7-Nov
8	8.1	5.5	NA	7	On bottom

South Riga Secchi Disk Depths (m)					
17-May	4-Jul	29-Jul	25-Aug	3-Sep	14-Sep
On bottom	On bottom	On bottom	On bottom	On bottom	4.75

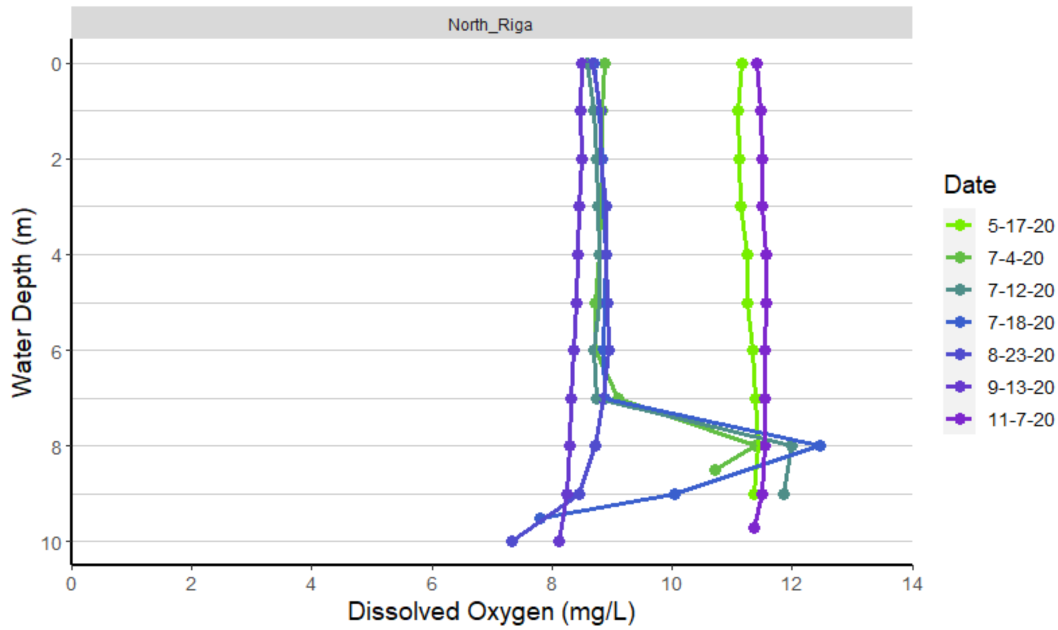
Dissolved Oxygen

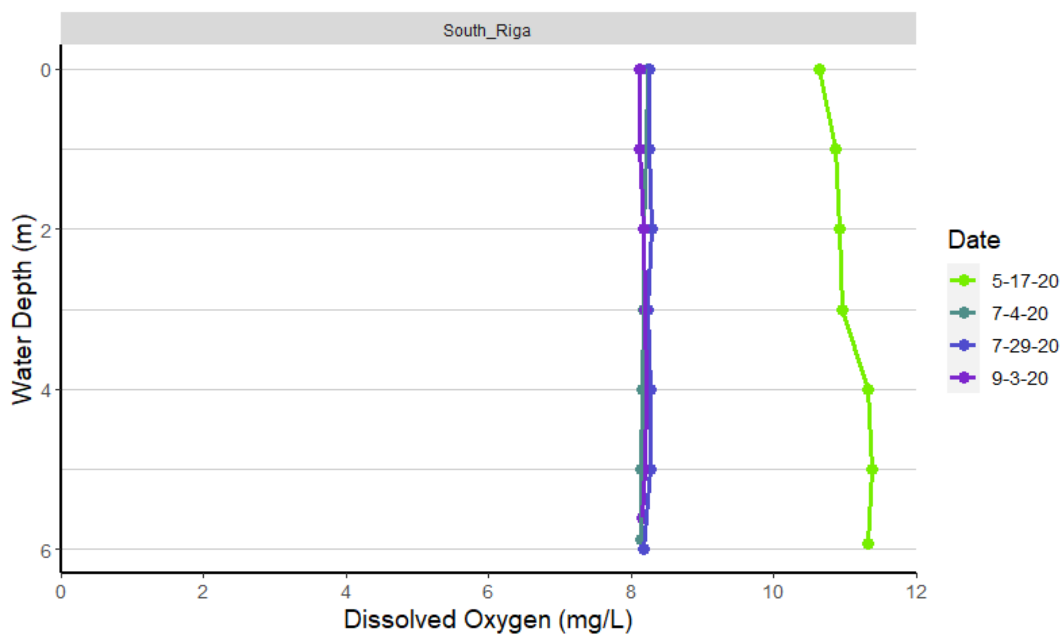
Dissolved oxygen (DO) in a lake is essential to aquatic organisms. At the surface of the lake, the water is in contact with the air, and atmospheric oxygen is dissolved into the water as a result of diffusion and wind mixing. As water mixing takes place, the dissolved oxygen is circulated throughout the water column. The decomposition of rooted aquatic plants and algae by bacteria requires dissolved oxygen (Biological Oxygen Demand) and can deplete the oxygen levels in the bottom waters below the thermocline. This phenomenon can lead to anoxic (<1 mg/l of DO) conditions in the deeper waters. Water that is anoxic (devoid of oxygen) is not suitable for fish and other aerobic aquatic organisms. When the water at the bottom of a lake is anoxic, nutrients trapped in the sediment at the lake bottom are released into the water through a process known as internal loading.

At North Riga, oxygen remained present at the bottom of the deep spot for the entire season, though oxygen was reduced in the bottom meter of water in July and August (**Figure 2**). The lake also experienced a MOMax (Metalimnetic Oxygen Maximum) in July and August. This is a phenomenon that occurs when phytoplankton are abundantly concentrated within once layer of the water column. As the phytoplankton photosynthesize, they release oxygen, thereby causing the increased dissolved oxygen concentration within this layer of water. Oxygen did not decline in the bottom waters as much in 2020 as compared to 2019, when oxygen in the bottom water declined considerably in July and came very close to becoming anoxic.

In South Riga, profiles were only collected four times in 2020; once in May and twice in July by volunteer monitors, and once in September by NEAR staff. During all four sampling events, the lake was fully mixed, with no oxygen loss in the bottom waters.

Figure 2. Dissolved oxygen profiles at North Riga and South Riga, 2020.





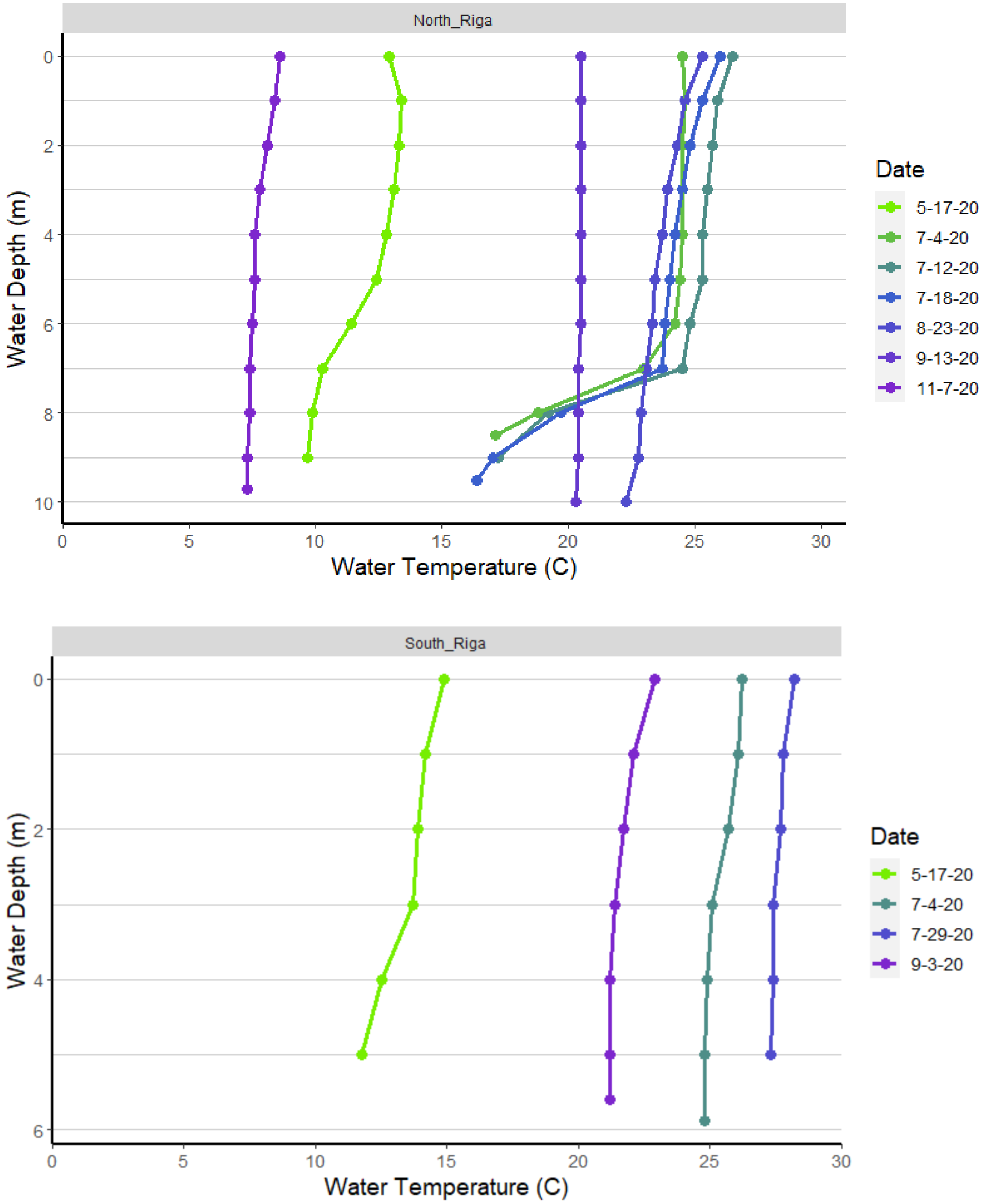
Temperature

Water temperature in lakes and ponds in the northeast follows a seasonal pattern of warming and cooling. As the sun's rays penetrate the water column during the summer, the water warms; but the depth extent of this warming is dependent on the water's clarity. Clearer water allows for more sunlight penetration and deeper water column warming.

At North Riga, the water temperature was already reduced slightly below 5 meters during the May sampling (**Figure 3**). The temperature remained reduced below 7 meters through July.

At South Riga, the temperature profiles remained relatively consistent from top to bottom during all four sampling events.

Figure 3. Temperature profiles at North Riga and South Riga, 2020.



Total Phosphorus

Phosphorus and Nitrogen are the two principal nutrients that drive aquatic plant and algae growth. Both nutrients are present in all lakes at some level. When the concentrations of these nutrients, particularly phosphorus, start to increase, algae can grow rapidly and reach nuisance conditions. Nutrients can enter the lake from the watershed in the form of natural wetland inputs, septic leachate, farm runoff, lawn fertilizers, and sedimentation from roads or streams. In freshwater systems, phosphorus tends to be the limiting factor for algae growth and is more heavily monitored for the health of inland ecosystems. Low phosphorus in a waterbody typically equates to lower phytoplankton abundance and greater overall Secchi clarity.

Due to lake temperature stratification with depth, nutrients are generally not present in the same quantities throughout the lake. Typically, the bottom of the lake accumulates more phosphorus and nitrogen as the summer progresses due to internal loading (when bottom sediments release nutrients in the presence of anoxic water). However, at North Riga and South Riga, the bottom water rarely becomes anoxic, meaning internal loading is not the primary source of nutrient input. The other major source of increased bottom-water nutrients, during summer months, is the settling of dead plant and algae material from the upper water column. Dead organic material becomes part of the bottom sediment over time.

In July 2018, the water at the bottom of the deep spot in North Riga did become anoxic, leading to elevated TP concentrations in this month (**Figure 4**). In 2019, the bottom water remained oxygenated for the entire season and, as a result, total phosphorus concentrations remained lower.

In 2020, TP concentrations were similar to those observed in 2019. TP in the bottom water was slightly elevated above the 10ppb threshold from May through August, with the highest TP concentration of 16ppb recorded on July 4th (**Table 3**). At the top and middle of the water column, TP remained near or below 10ppb for the entire season.

In South Riga in 2020, TP was elevated above 10ppb in most months. The most elevated concentrations were observed from late July through September, with multiple samples exceeding 20ppb. TP reached a maximum concentration of 31ppb at the middle of the water column on August 25th.

Figure 4. Total phosphorus concentrations at North Riga and South Riga, 2018-2020.

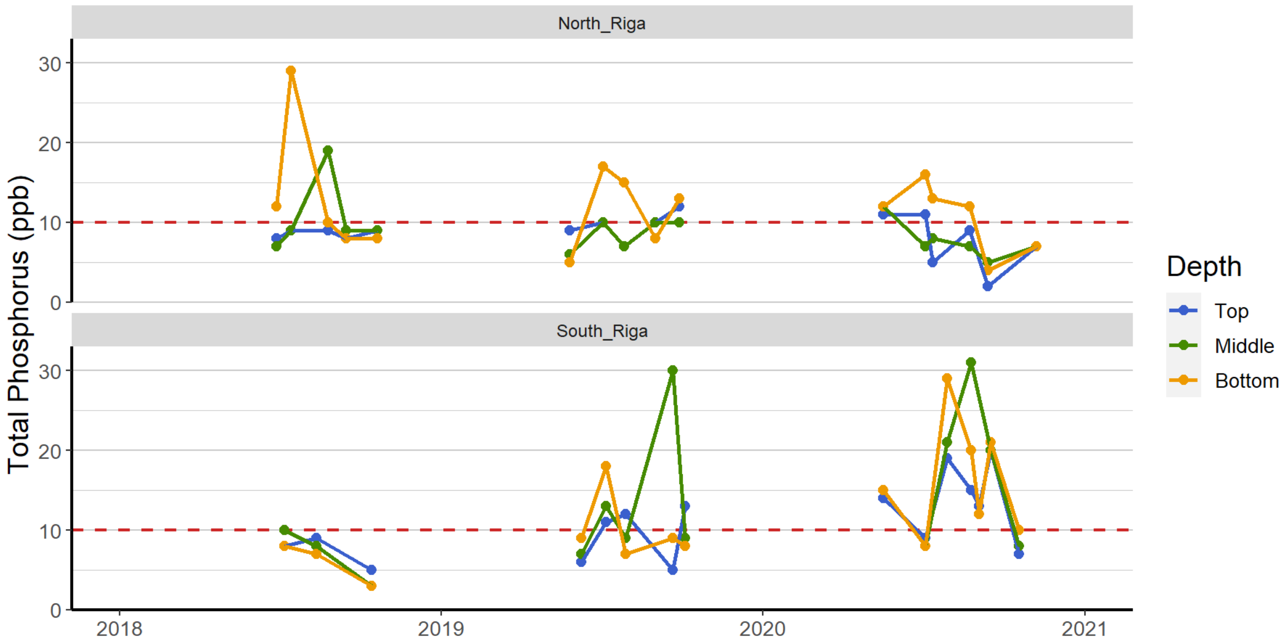


Table 3. Total phosphorus concentrations at the top, middle and bottom depths at North Riga and South Riga, 2020.

North Riga Total Phosphorus (ppb)						
	17-May	**4-Jul**	**12-Jul**	**23-Aug**	**13-Sep**	**7-Nov**
Top	11	11	5	9	2	7
Middle	12	7	8	7	5	7
Bottom	12	16	13	12	4	7

South Riga Total Phosphorus (ppb)							
	17-May	**4-Jul**	**29-Jul**	**25-Aug**	**3-Sep**	**16-Sep**	**18-Oct**
Top	14	9	19	15	13	20	7
Middle	15	8	21	31	NA	20	8
Bottom	15	8	29	20	12	21	10

Total Nitrogen

Total nitrogen (TN) includes fractions of nitrate, ammonia, and organic components. Ideally, TN should remain below 200ppb, placing the ponds in the 'oligotrophic' category. (**Table 4**, **Figure 5**).

Total Nitrogen concentrations in North Riga were good in 2020, with most concentrations near or below 100ppb. TN in the bottom water reached a maximum concentration of 137ppb in mid-July.

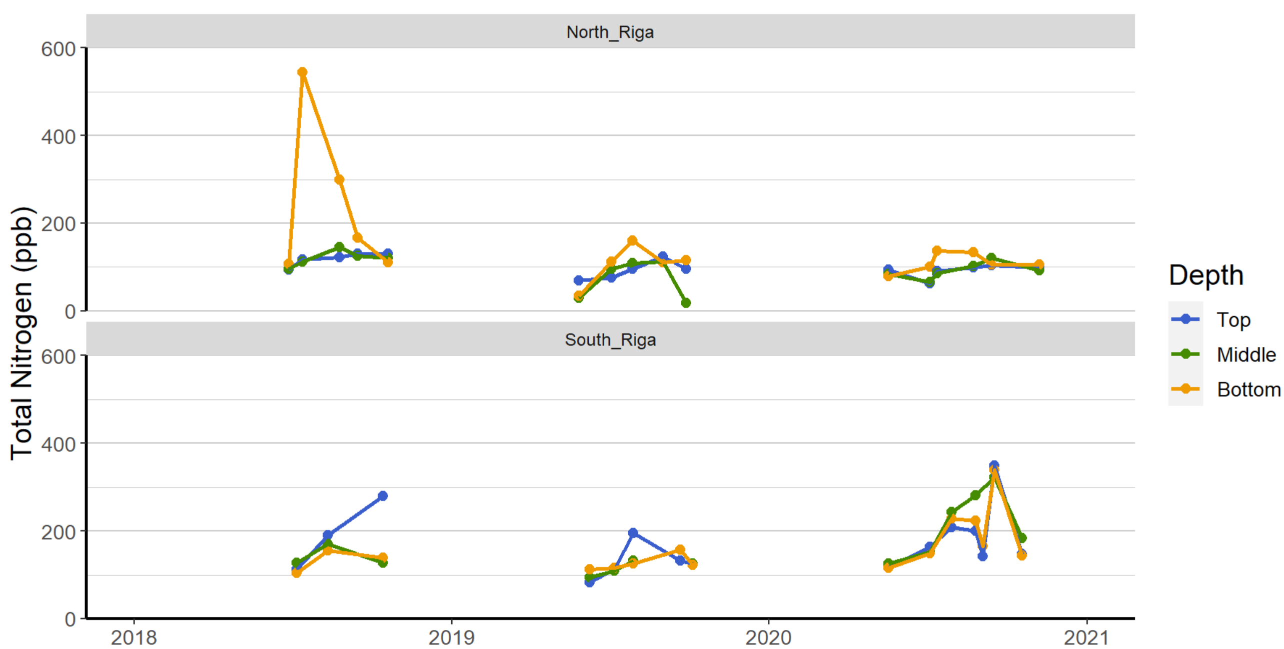
In South Riga, TN was elevated at all three sampling depths for most of the season, with much higher concentrations than were observed in the prior two years. TN was highest in mid-September, with concentrations ranging from 322ppb to 349ppb across the three sampling depths. Ideally, TN should remain below 200ppb across all sampling depths.

Table 4. Total nitrogen concentrations at the top, middle and bottom depths at North Riga and South Riga, 2020.

North Riga Total Nitrogen (ppb)						
	17-May	**4-Jul**	**12-Jul**	**23-Aug**	**13-Sep**	**7-Nov**
Top	94	62	91	99	104	99
Middle	84	66	85	103	121	93
Bottom	80	100	137	133	106	106

South Riga Total Nitrogen (ppb)							
	17-May	**4-Jul**	**29-Jul**	**25-Aug**	**3-Sep**	**16-Sep**	**18-Oct**
Top	115	164	209	201	143	349	147
Middle	125	153	244	281	NA	322	183
Bottom	115	149	228	223	165	339	144

Figure 5. Total nitrogen concentrations at North Riga and South Riga, 2018-2020.



Aquatic Plants

The aquatic plants in North Riga and South Riga were surveyed on September 3rd, 2020. No invasive aquatic plants were found in either pond.

Seventeen aquatic plant species were recorded in North Riga (**Table 5**). As in 2019, *Lobelia dortmanna* (water lobelia) was the most abundant species in the lake, present at more than half of the survey waypoints (**Figure 6**). *Utricularia purpurea* (purple bladderwort), *Eleocharis acicularis* (needle spikerush), and *Sparganium fluctuans* (floating bur-reed) were also dominant, meaning they were present at greater than 20% frequency.

Twenty-one aquatic plant species were recorded during the survey of South Riga. *Utricularia purpurea* (purple bladderwort) was abundant, present at 44% of survey waypoints (**Figure 7**). *Sparganium sp.* (emergent sparganium) and *Lobelia dortmanna* (water lobelia) were also dominant.

Potamogeton confervoides (Tuckerman's pondweed) is categorized as a Connecticut State Listed Endangered Species, pursuant to the federal Endangered Species Act. *P. confervoides* was found in one location in South Riga Pond (**Figure 8**). The species was not found in North Riga in 2020. *P. confervoides* was more abundant in both ponds in 2019, but species populations do fluctuate between years. A species is listed as endangered when there are no more than five occurrences of the species within the state. This means that the Riga Ponds are vital for the survival of *P. confervoides*.

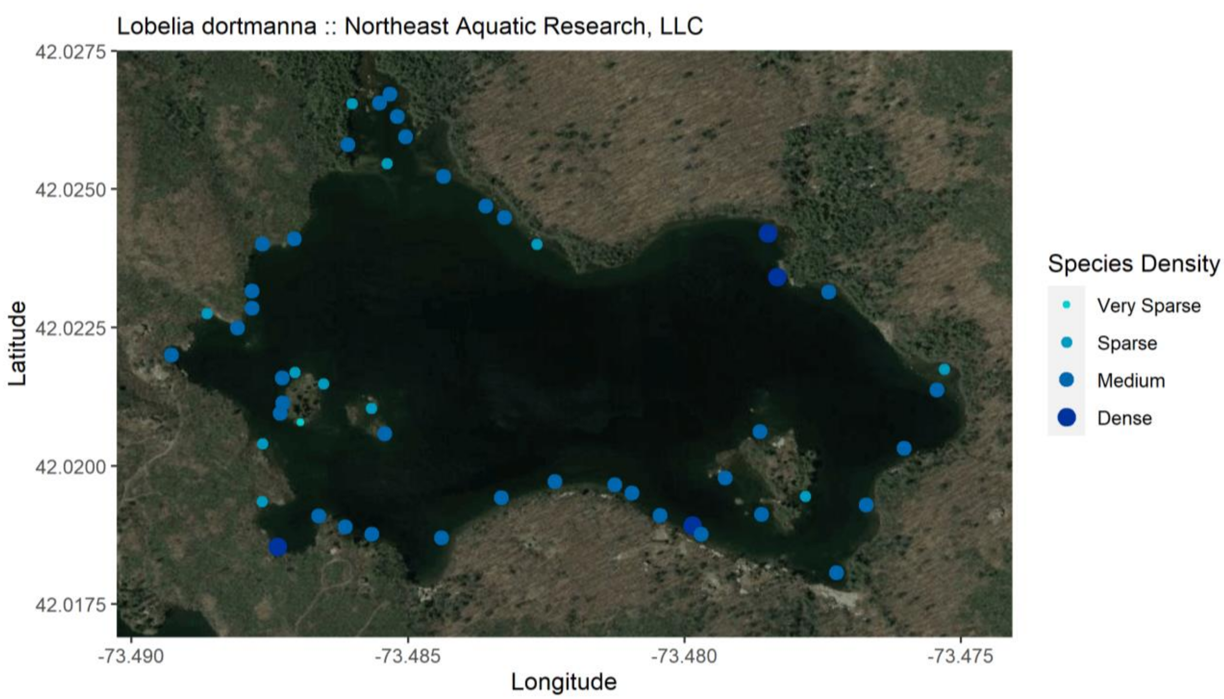
At both North Riga and South Riga, some coves contained filamentous algae and slime-covered plants and rocks (**Figure 9**). This indicates elevated nutrient levels in these areas, possibly caused by nutrients entering the lake in these areas via inlets or seeps.

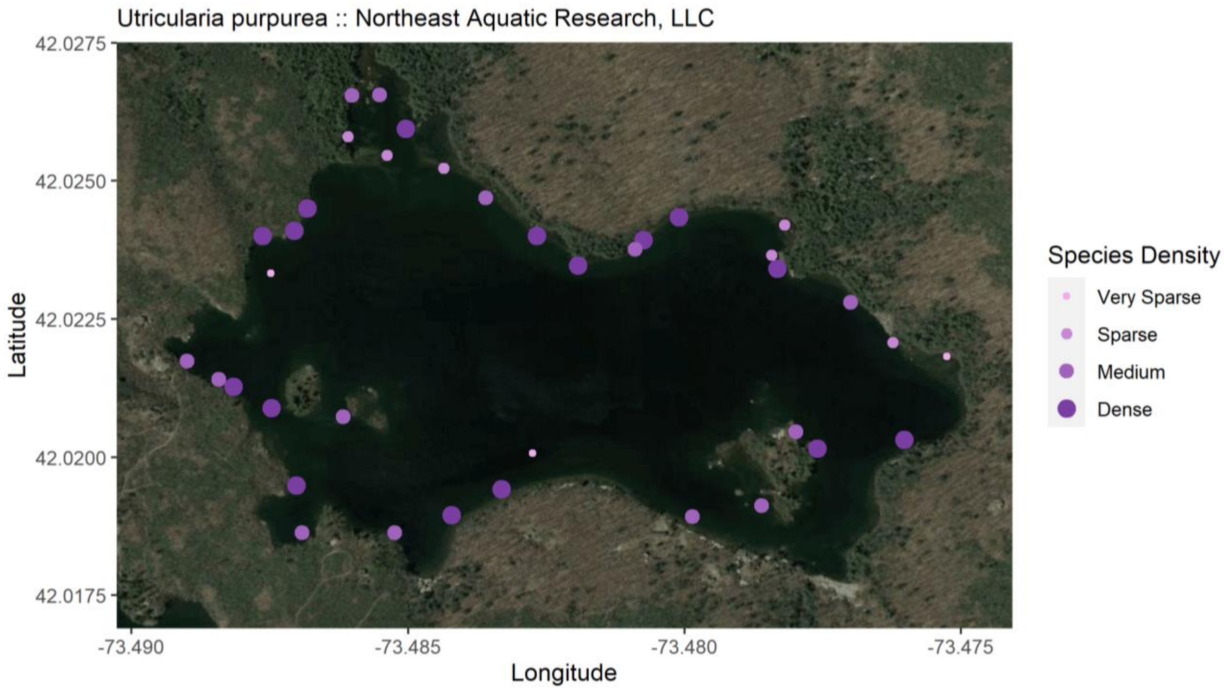
Table 5. Aquatic plants in North and South Riga lakes, September 2020.

North Riga		
Species	**Frequency**	**Density**
Lobelia dortmanna	58.1	15.7
Utricularia purpurea	41.9	15.7
Eleocharis acicularis	26.9	23.0
Sparganium fluctuens	20.4	23.1
Nuphar variegata	18.3	13.8
Eriocaulon sp	8.6	25
Myriophyllum humile	7.5	57.1
Nymphaea odorata	7.5	22.9
Filamentous algae	4.3	5
Utricularia minor	4.3	5
Sparganium sp	2.2	50
Myriophyllum alterniflorum	2.2	80
Utricularia geminiscapa	2.2	7.5
Elatine sp	1.1	5
Fontinalis sp	1.1	60
Isoetes sp	1.1	5
Potamogeton natans	1.1	10

South Riga		
Species	**Frequency**	**Density**
Utricularia purpurea	44.2	42.2
Sparganium sp.	28.6	11.0
Lobelia dortmanna	21.8	25
Eleocharis robbinsii	16.3	47.7
Nuphar variegata	15.6	8.0
Eleocharis acicularis	11.6	31.5
Eriocaulon sp	9.5	24.3
Nitella sp	8.2	14.6
Nymphaea odorata	6.1	16.7
Sparganium fluctuens	6.1	7.7
Fontinalis sp	5.4	28.8
Potamogeton natans	5.4	46.9
Potamogeton bicupulatus	4.1	5.8
Potamogeton epihydrus	2.0	11.7
Chara sp	0.7	5
Elatine sp	0.7	5
Filamentous algae	0.7	3
Isoetes sp	0.7	5
Myriophyllum humile	0.7	10
Potamogeton confervoides	0.7	5
Sagittaria sp	0.7	10

Figure 6. Dominant aquatic plants in North Riga Pond, September 3, 2020.




Utricularia purpurea :: Northeast Aquatic Research, LLC
42.0275
42.0250
42.0225
42.0200
42.0175
Latitude
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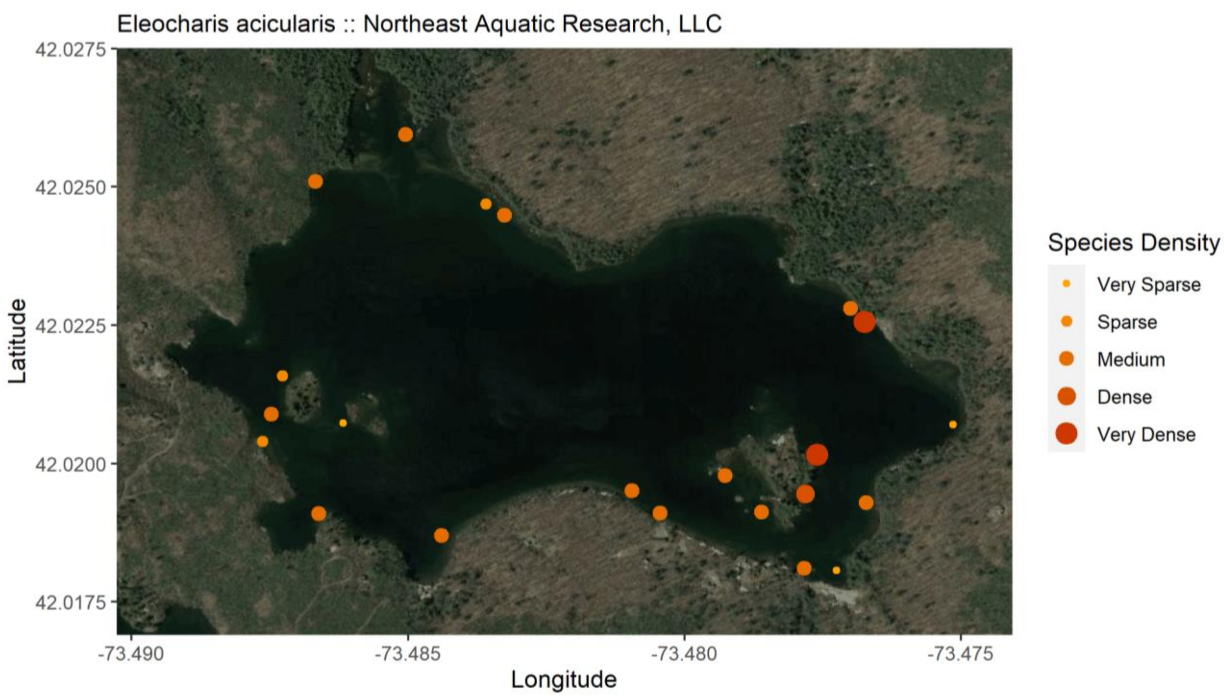
-73.485
-73.480
-73.475
Longitude
Species Density
Very Sparse
Sparse
Medium
Dense


Eleocharis acicularis :: Northeast Aquatic Research, LLC
42.0275
42.0250
42.0225
42.0200
42.0175
Latitude
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Longitude
Species Density
Very Sparse
Sparse
Medium
Dense
Very Dense

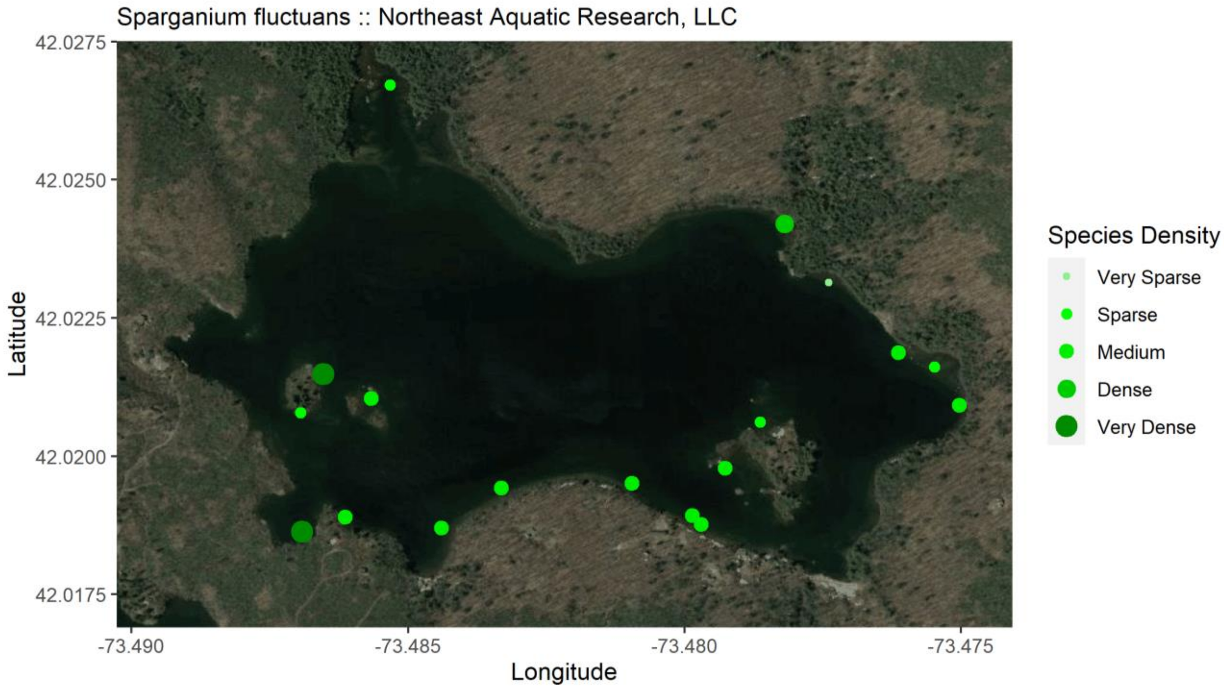
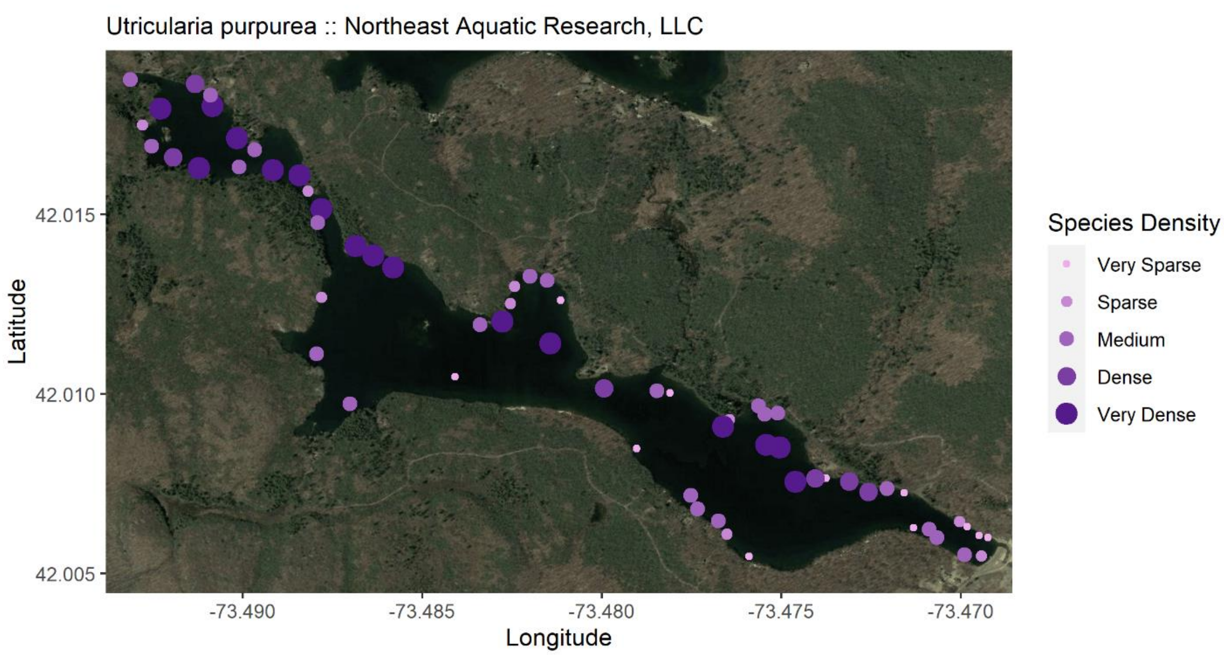
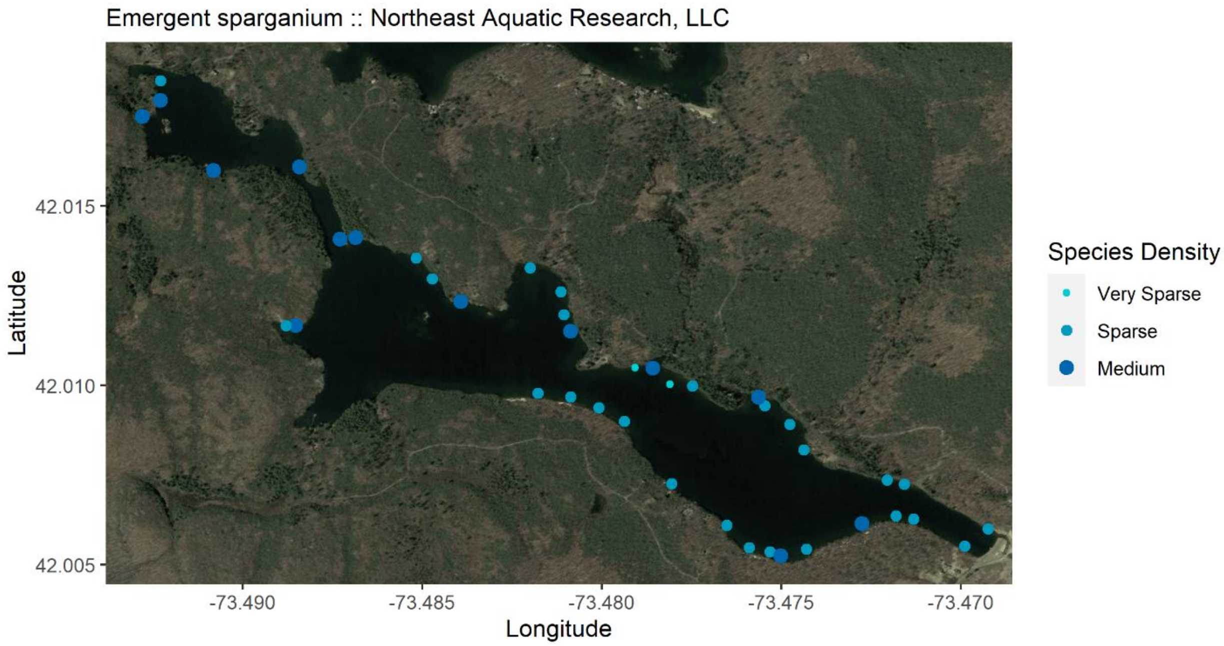


Figure 7. Dominant aquatic plants in South Riga Pond, September 3, 2020.




Emergent sparganium :: Northeast Aquatic Research, LLC
Latitude
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42.010
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-73.480
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Longitude
Species Density
Very Sparse
Sparse
Medium

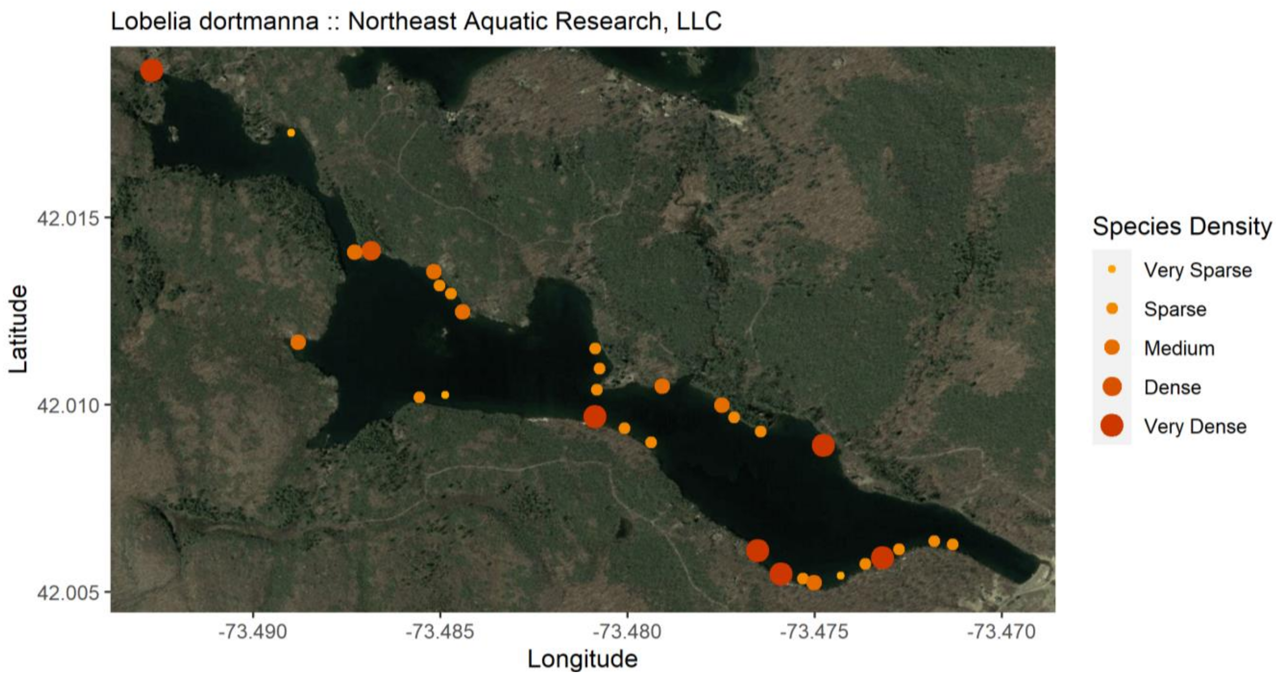

Lobelia dortmanna :: Northeast Aquatic Research, LLC
Latitude
42.015
42.010
42.005
-73.490
-73.485
-73.480
-73.475
-73.470
Longitude
Species Density
Very Sparse
Sparse
Medium
Dense
Very Dense

Figure 8. Location of *Potamogeton confervoides* in South Riga Pond.

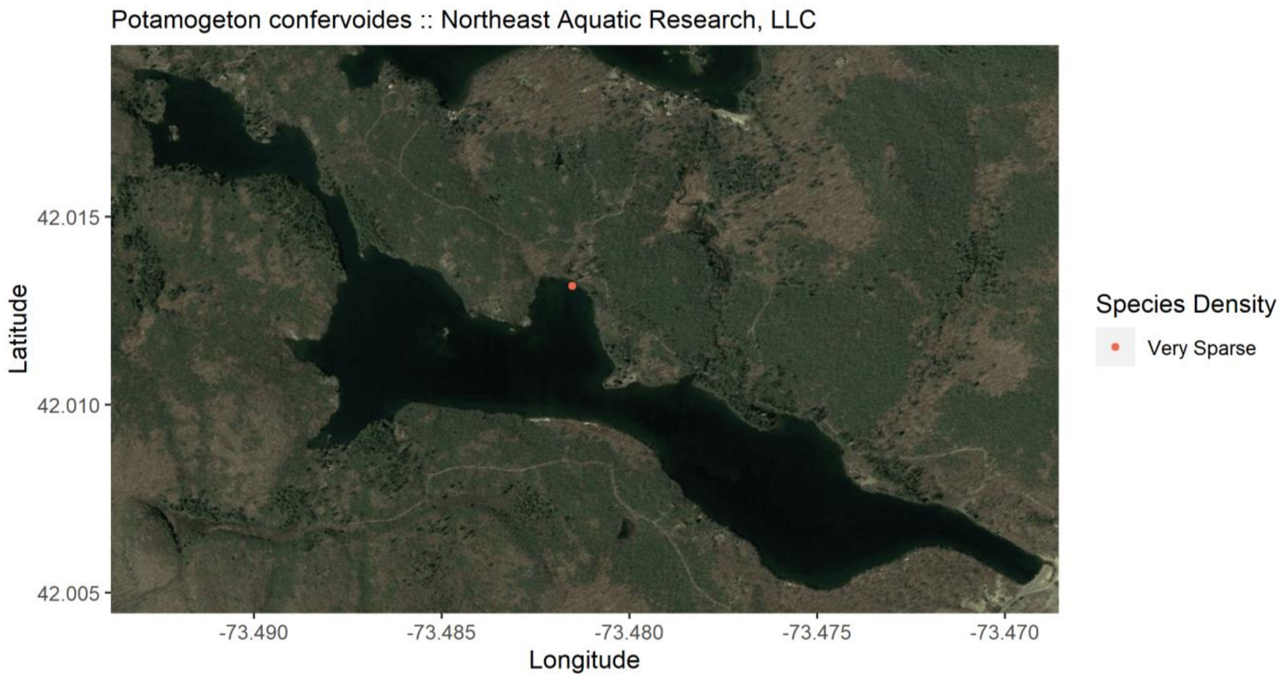
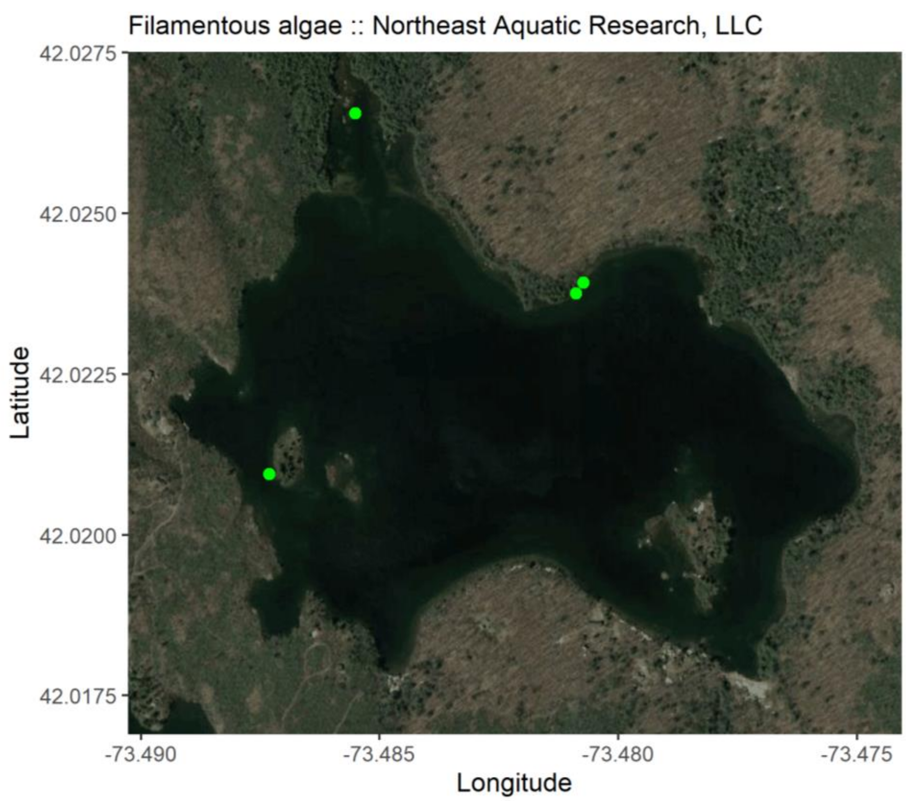
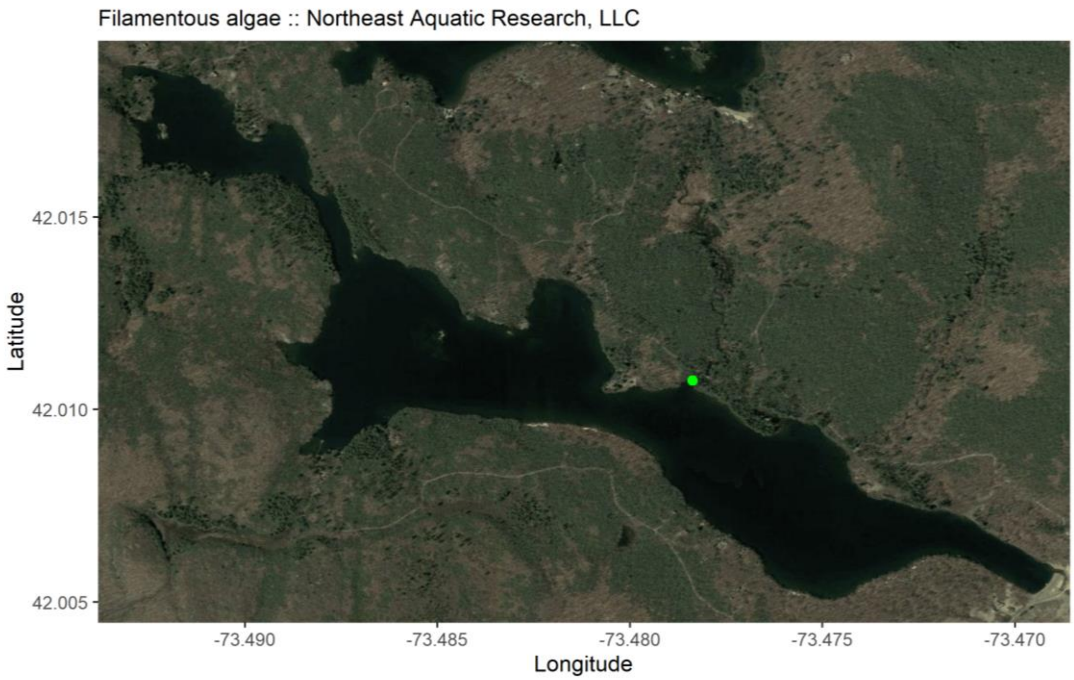


Figure 9. Locations of Filamentous Algae in North Riga and South Riga.





Suggested 2021 Actions

Both North Riga and South Riga are exhibiting declining water quality, with worsening clarity and increasing nutrient concentrations. The water quality of South Riga is more concerning than that of North Riga at this time. Actions should be taken to determine the nutrient source(s), particularly around South Riga.

1. Continue the in-lake water quality monitoring from May through October, to track the full extent of seasonal fluctuations, including peak extent of anoxic water, best and worst seasonal clarity, and peak nutrient concentrations. It is important to collect all sampling parameters (water clarity, profiles, and water samples) each month. In 2019, Secchi disk measurements were not collected during two sampling trips at North Riga, and profiles were not collected in certain months due to an issue with the equipment. Volunteers should inform NEAR of any issues with equipment and attempt to re-sample as soon as the equipment is functioning again.
2. Mouth Riga Lakes, Inc. should invest in a continuous data logger set-up in both lakes to better track the oxygen and temperature dynamics at the lake bottoms, between volunteer monitoring events. These systems can also be paired with a water level data logger to track water fluctuation throughout the season. Continuous water level data would provide a good understanding of the quantity of water reaching the lakes after particular rainfall events, which translates to greater understanding of watershed nutrient dynamics.

3. Collect inlet samples from all flowing inlets once per month from May through October to assess watershed nutrient loading. The samples should be tested for total phosphorus, total nitrogen, and nitrate nitrogen. All shoreline areas where filamentous algae is indicated in **Figure 9** should be inspected for inlets and seeps.

4. Conduct late-summer full-lake aquatic plant surveys at the two ponds to document the presence and abundance of aquatic plant species in the lake and to search for invasive species.

5. The Riga Lakes residents should discuss watershed protection efforts, including limiting development, road maintenance to prevent erosion, onsite wastewater updates for local camps, and potential in-lake management efforts.

6. Both ponds should be sampled for Giardia in 2021, near drinking water intakes. Ideally, testing should occur once per month, but at least 3 times in 2021 to provide a baseline. We recommend testing both ponds once in the spring, once in August, and once immediately following a large rain event.

7. Any water pulled from the pond for drinking purposes should be filtered. Pond water can contain parasites and bacteria that are hazardous to humans. Parasites and bacteria can concentrate in one area (i.e., if there is a dead animal in the water) and so testing at one site may not pick up issues in another area of the pond. Many lake water filters are available for purchase online.