Lake Riley, Carver County, Minnesota (Google Earth)

Lake Soil Fertility Evaluation for Lake Riley, Cities of Eden Prairie and Chanhassen, MN

Lake Sediment Samples Collected:
October 23, 2012 (28 samples)

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Summary

A total of 28 Lake Riley sediment samples were collected on October 23, 2012 throughout the 296 acre lake to characterize lake sediment fertility (Figure 1). The lake "soils" were analyzed for 15 parameters including phosphorus, nitrogen, potassium, iron, and pH.

One objective of the lake sediment survey was to estimate the phosphorus release potential of the lake sediments. Results indicated that deep lake sediments have a low potential for phosphorus release and shallow sediments have a somewhat greater potential based on iron to phosphorus ratios.

Another objective of the sediment survey was to determine where curlyleaf and milfoil would have the potential to produce heavy growth (where heavy growth is defined as plants matting at the surface) in Lake Riley. Based on lake sediment sample results, it is predicted the lake sediments have a potential to produce mostly light to moderate curlyleaf growth. Other sediment parameters indicate there is a potential for sediments to produce light to moderate milfoil growth conditions in the growing zone of Lake Riley.

Maps showing areas of predicted phosphorus release, curlyleaf, and milfoil growth are shown on the next three pages (Figures 2, 3, and 4).

Figure 1. Lake Riley sediments in the growing zone varies from a mucky sediment to a silty-sand mixture. This picture shows a silty-sand sediment in Lake Riley.

Sediment Phosphorus Release Potential

A variety of factors contribute to internal phosphorus loading in lakes. Research by Jensen et al (1992) found when a total iron to total phosphorus ratio was greater than 15 to 1, phosphorus release from lake sediments was minor. That benchmark has been used to characterize the potential of Lake Riley sediments to release phosphorus. Results show most of the sediment sites in deep water have a high Fe:P ratio and that phosphorus release from Lake Riley sediments in deep water would appear to be light. Phosphorus release potential is high in several areas in littoral zone depths (Figure 2).

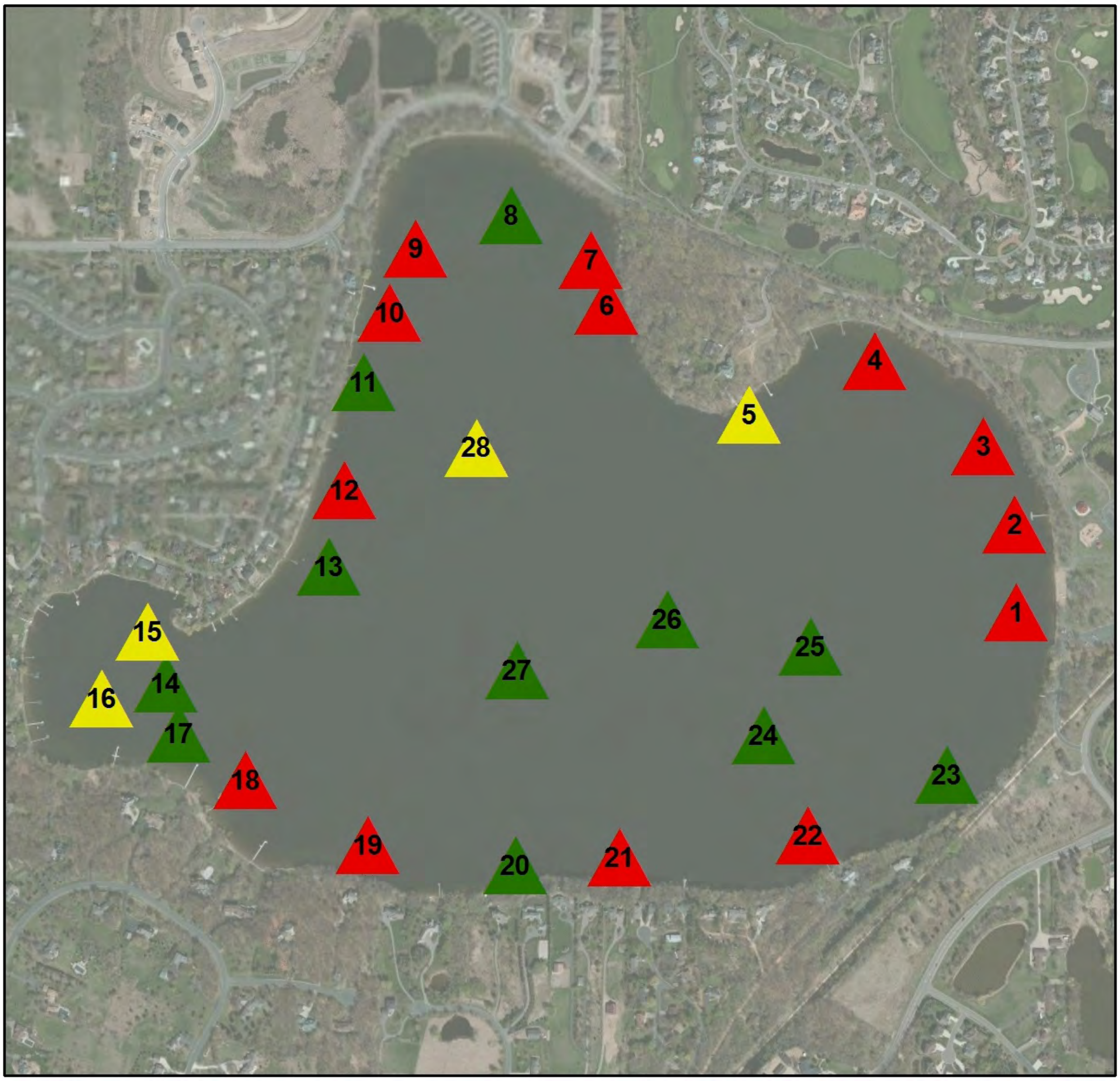


Figure 2. Lake sediment sample locations are shown with color triangles. Colored triangles represent phosphorus release potential at that site. Green = low potential, yellow = moderate potential, and red = high potential.

Curlyleaf Pondweed Growth Potential Based on Lake Sediments

Lake sediment sampling results from 2012 have been used to predict lake bottom areas that have the potential to support nuisance curlyleaf pondweed plant growth. Based on the key sediment parameters of pH, sediment bulk density, organic matter, and the Fe:Mn ratio (McComas, unpublished), the predicted growth characteristics of curlyleaf pondweed are shown in Figure 3.

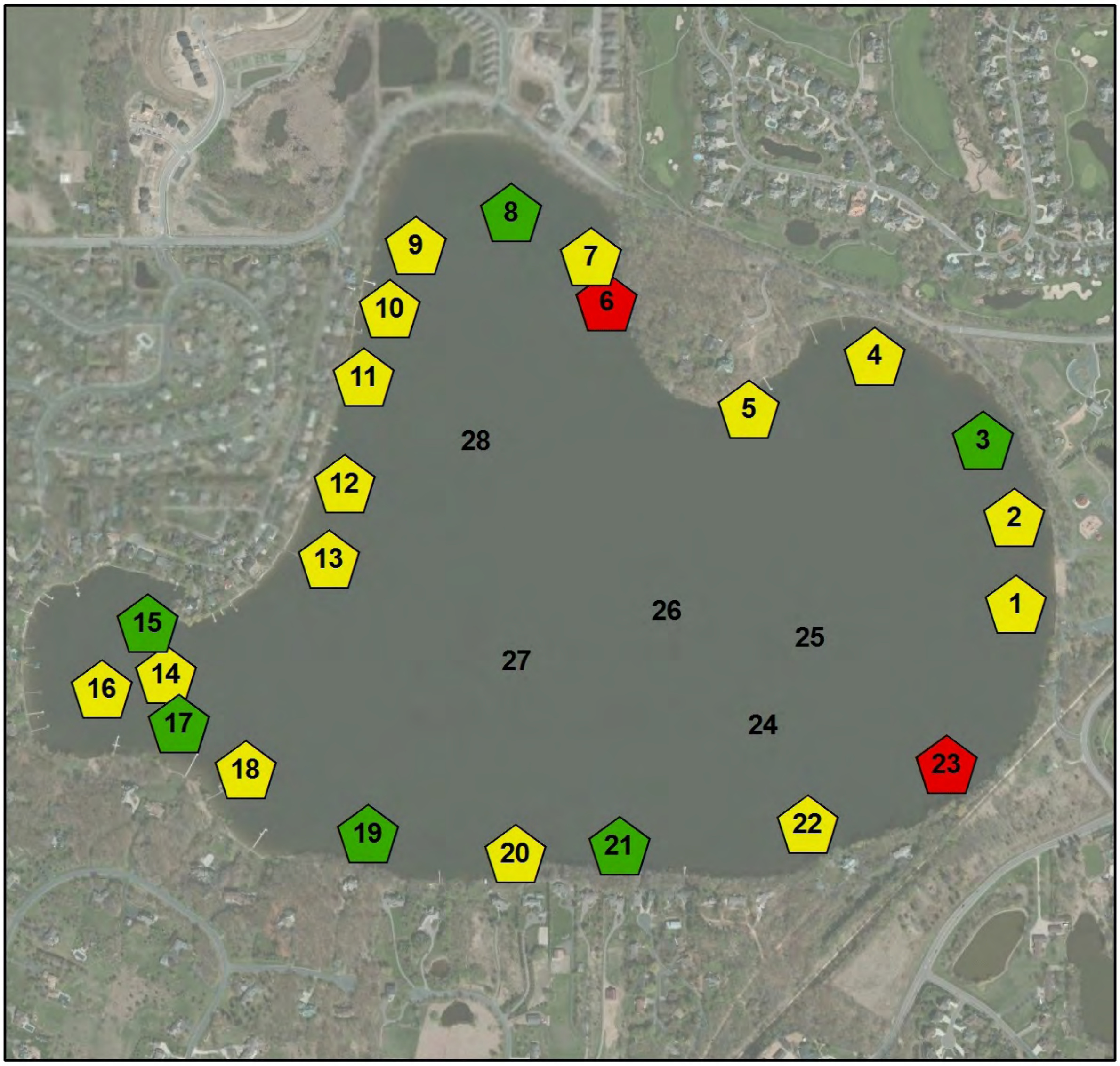


Figure 3. Curlyleaf Pondweed: Areas of predicted growth are shown with pentagons. Green = light growth, yellow = moderate growth, and red = heavy growth.

Eurasian Watermilfoil Growth Potential Based on Lake Sediments

Lake sediment sampling results from 2012 have been used to predict lake bottom areas that have the potential to support moderate EWM growth. Eurasian watermilfoil has been discovered in Lake Riley in 1990. Based on the key sediment parameters of NH_4 and organic matter (McComas, unpublished), a map was prepared that predicts what type of growth could be expected for milfoil growth in Lake Riley (Figure 4).

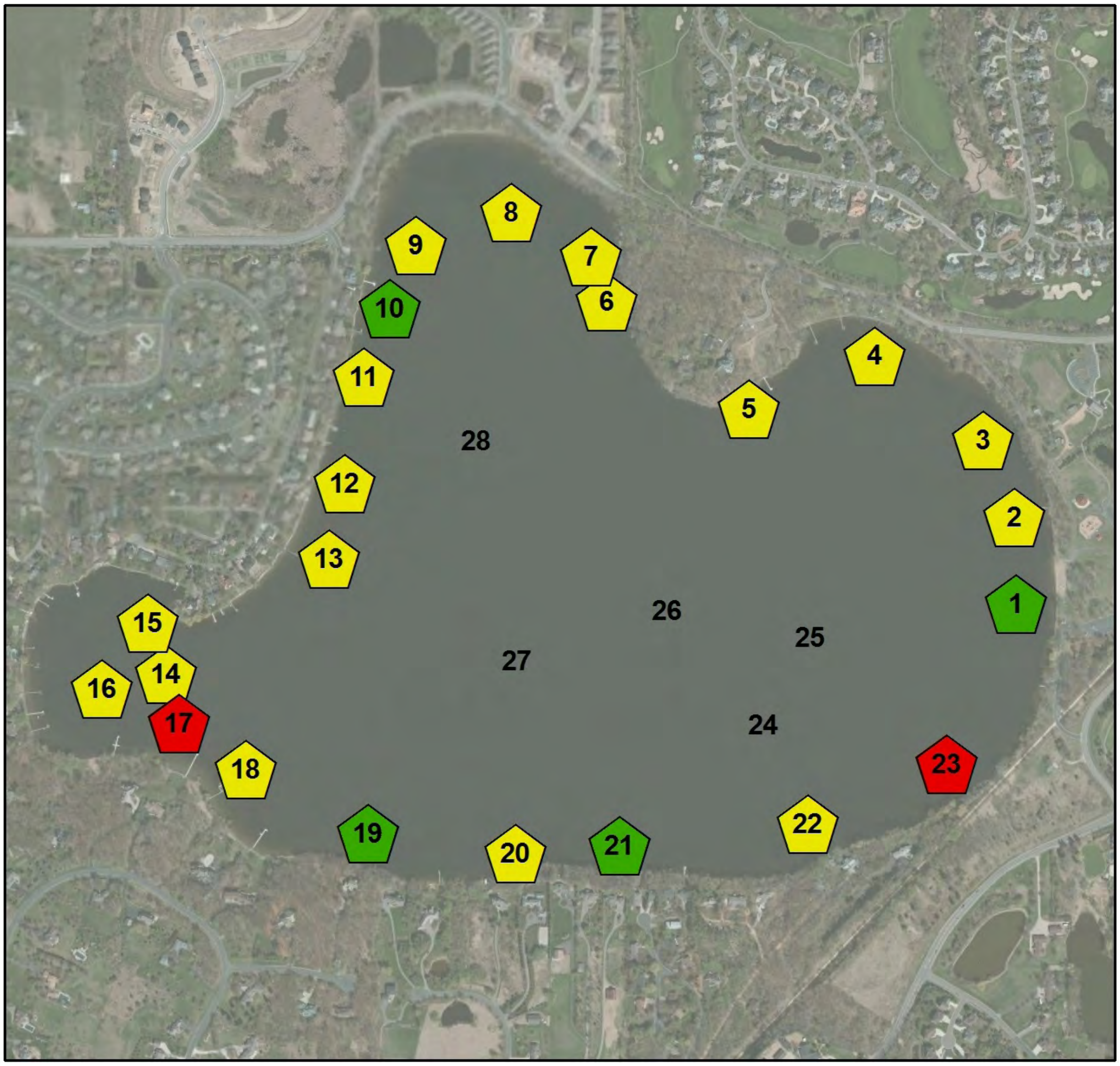


Figure 4. Eurasian Watermilfoil: Areas of predicted growth are shown with pentagons. Green = light growth, yellow = moderate growth, and red = heavy growth.

Lake Soil Fertility Evaluation for Lake Riley, Cites of Eden Prairie and Chanhassen, Minnesota

Introduction

Lake Riley is a moderately fertile, 296 acre lake located within the cities of Eden Prairie (Hennepin County) and Chanhassen (Carver County), Minnesota. The lake is a recreational lake with a public landing, a swimming beach, and has slightly eutrophic water quality.

The objectives of this lake soil fertility survey were to characterize the lake soils in the littoral and deep water areas around Lake Riley to assess potential for sediment phosphorus release and to use soil data to predict where areas of heavy growth of curlyleaf and milfoil growth could occur in the future.

Methods

Lake Soil Survey: A total of 28 samples were collected from depths ranging from 4 to 45 feet. Location of sample sites is shown in Figure 1. Samples in shallow water were collected using a modified soil auger, 5.2 inches in diameter. Samples in deep water (26 - 45 feet) were sampled using a ponar dredge. Soils were sampled to a sediment depth of 6 inches. The lake soil from the sampler was transferred to 1-gallon zip-lock bags and sent to the University of Minnesota Soil Testing and Research Analytical Laboratory.

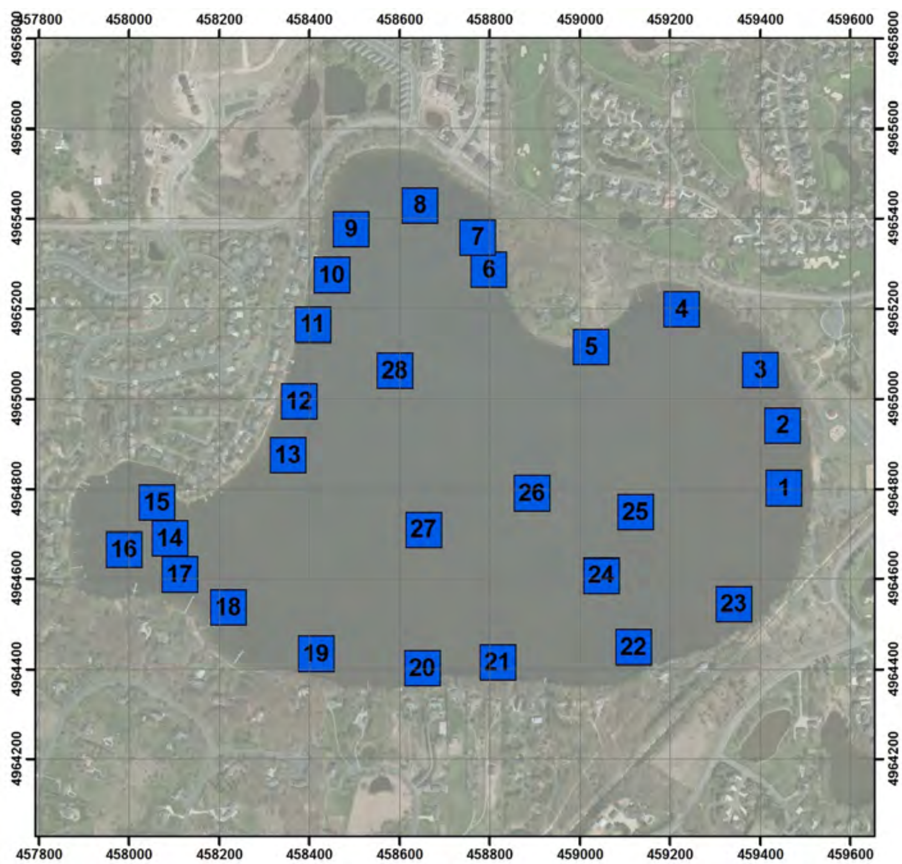


Figure 1. Location map of the lake sediment collection sites.

Lake Soil Analysis: At the lab, sediment samples were air dried at room temperature, crushed and sieved through a 2 mm mesh sieve. Sediment samples were analyzed using standard agricultural soil testing methods. Fifteen parameters were tested for each soil sample. A summary of extractants and procedures is shown in Table 1. Routine soil test results are given on a weight per volume basis.

Table 1. Soil testing extractants used by University of Minnesota Soil Testing and Research Analytical Laboratory. These are standard extractants used for routine soil tests by most Midwestern soil testing laboratories (reference: Western States Laboratory Proficiency Testing Program: Soil and Plant Analytical Methods, 1996-Version 3).

Parameter	Extractant
P-Bray	0.025M HCL in 0.03M NH_4F
P-Olsen	0.5M $NaHCO_3$
NH_4-N	2N KCL
K, Ca, Mg	1N NH_4OA_c (ammonium acetate)
Fe, Mn, Zn, Cu	DTPA (diethylenetriamine pentaacetic acid)
B	Hot water
SO_4-S	$Ca(H_2PO_4)_2$
pH	water
Organic matter	Loss on ignition at 360°C

Figure 2. Soil auger used to collect lake sediments.

Reporting Lake Soil Analysis Results: Lake soils and terrestrial soils are similar from the standpoint that both provide a medium for rooting and supply nutrients to the plant.

However, lake soils are also different from terrestrial soils. Lake soils (or sediments) are water logged, generally anaerobic and their bulk density ranges from being very light to very dense compared to terrestrial soils.

There has been discussion for a long time on how to express analytical results from soil sampling. Lake sediment research results are often expressed as grams of a substance per kilogram of lake sediment, commonly referred to as a weight basis (mg/kg). However, in the terrestrial sector, to relate plant production and potential fertilizer applications to better crop yields, soil results typically are expressed as grams of a substance per cubic foot of soil, commonly referred to as a weight per volume basis. Because plants grow in a volume of soil and not a weight of soil, farmers and producers typically work with results on a weight per volume basis.

That is the approach used here for lake sediment results: they are reported on a weight per volume basis or $\mu g/cm^3$.

A bulk density adjustment was applied to lake sediment results as well. For agricultural purposes, in order to standardize soil test results throughout the Midwest, a standard scoop volume of soil has been used. The standard scoop is approximately a 10-gram soil sample. Assuming an average bulk density for an agricultural soil, a standard volume of a scoop has been a quick way to prepare soils for analysis, which is convenient when a farmer is waiting for results to prepare for a fertilizer program. It is assumed a typical silt loam and clay texture soil has a bulk density of 1.18 grams per cm^3. Therefore a scoop size of 8.51 cm^3 has been used to generate a 10-gram sample. It is assumed a sandy soil has a bulk density of 1.25 grams per cm^3 and therefore a 8.00 cm^3 scoop has been used to generate a 10-gram sample. Using this type of standard weight-volume measurement, the lab can use standard volumes of extractants and results are reported in ppm which is close to $\mu g/cm^3$. For all sediment results reported here, a scoop volume of 8.51 cm^3 was used.

Although lake sediment bulk density has wide variations, only a single scoop volume of 8.51 cm^3 was used for all lake sediment samples. This would not necessarily produce a consistent 10-gram sample. Therefore, for our reporting, we have used corrected weight volume measurements and results have been adjusted based on the actual lake sediment bulk density. We used a standard scoop volume of 8.51 cm^3, but sediment samples were weighed. Because test results are based on the premise of a 10 gram sample, if our sediment sample was less than 10 grams, then the reported concentrations were adjusted down to account for the less dense bulk density. If a scoop volume weighed greater than 10.0 grams than the reported concentrations were adjusted up. For example, if a 10-gram scoop of lake sediment weighed 4.0 grams, then the correction factor is 4.00 g/ 10.00 g = 0.40. If the analytical result was 10 ppm based on 10 grams, then it should be 0.40 x 10 ppm = 4 ppm based on 4 grams. The results could be written as 4 ppm or 4 $\mu g/cm^3$. Likewise, if a 10-gram scoop of lake sediment weighed 12 grams, then the correction factor is 12.00 g / 10.00 g = 1.20. If the analytical result was 10 ppm based on a 10 gram scoop, then it should be 1.20 x 10 ppm = 12 ppm based on 12 grams. The result could be written as 12 ppm or 12 $\mu g/cm^3$. These are all dry weight determinations.

This correction factor is important for evaluating the ammonium-nitrogen raw data. There appears to be a threshold nitrogen concentration at 10 ppm. If nitrogen is greater than 10 ppm, heavy milfoil growth can occur. If the correction factor is not applied, light, fluffy sediments may produce a high nitrogen reading, but would not support heavy milfoil growth. When the correction factor is applied, and if the nitrogen concentration falls below 10 ppm, light or moderate growth of milfoil is predicted rather than heavy growth.

Delineating Areas of Potential Heavy Curlyleaf and Milfoil Growth: Delineating an area of potential heavy plant growth is based on conventional soil survey techniques. For this report, a zone sampling method rather than a grid sampling method was used for collecting lake sediments. For example, if sediment results show a potential for heavy growth collected in a cove, typically, the water depth in the cove from 5 to 7 feet would be designated as having a potential for heavy growth. If samples found along a stretch of shoreline had a potential for heavy growth, a designated heavy growth area would be delineated until there was a shoreline break or change in sediment texture. In other cases, if the next site down the shoreline showed a potential for light growth, then the designated heavy growth area would extend midway between a heavy and light potential growth sample sites.

Lake Soil Survey Results

A total of 28 lake sediment sites were sampled around Lake Riley in water depths from 4 to 45 feet. Lake soil sampling results are shown in Table 2. Previous research (Jensen et al) has shown that a high iron to phosphorus ratio is correlated with a low sediment phosphorus release potential. Iron and phosphorus concentrations are shown in Table 3.

Soil fertility conditions were also evaluated to determine if lake sediments could potentially support heavy growth conditions in Lake Riley for curlyleaf pondweed or for Eurasian watermilfoil.

For curlyleaf pondweed, the critical sediment parameters have been found to be sediment pH, bulk density, organic matter, and the iron to manganese ratio. Results for Lake Riley sediment concentrations are summarized in Table 4.

For Eurasian watermilfoil, we have used a sediment nitrogen concentration of over 10 parts per million (ppm) as an indicator of potential heavy growth. In other studies there is a correlation to nuisance milfoil growth when exchangeable ammonium is over 10 ppm in lake sediments. It turns out organic matter content over 20% can limit heavy milfoil growth. Results for Lake Riley sediment concentrations of exchangeable ammonium and organic matter are summarized in Table 5.

Table 2. Lake soil data with adjusted values based on standard soil testing methods. Samples were collected on October 19, 2012. Soil chemistry results are reported as ppm (μg/cm^3) except for organic matter (%), and pH (standard units).

Sample Number	Depth (ft)	Bulk Density (wt/8.51)	Water pH	Bray-P (ppm)	Olsen-P (ppm)	Potass-ium (ppm)	Organic Matter (%)	Zinc (ppm)	Iron (ppm)	Copper (ppm)	Mang-anese (ppm)	Calcium (ppm)	Mag-nesium (ppm)	Boron (ppm)	Ammo-nium (ppm)	Sulfate (ppm)	Fe/Mn	Fe/P
1	7	1.19	7.5	14	4	37	0.9	2.3	35	2.2	10	1671	134	0.17	3.6	101	3.5	2.5
2	9	1.01	7.6	22	4	60	2.2	1.1	38	1.9	13	1747	251	0.17	4.2	58	2.9	1.7
3	9	1.18	7.4	20	5	54	1.4	3.0	70	4.3	27	1412	293	0.25	5.9	85	2.6	3.5
4	6	1.26	7.5	16	5	38	1.0	4.7	47	3.9	13	2109	136	0.15	4.5	112	3.6	3.0
5	11	1.16	7.9	<1	4	77	1.2	0.5	47	1.1	10	3443	237	0.12	4.3	20	4.7	11.8
6	6	1.49	7.7	29	4	34	0.4	0.9	23	1.0	15	1065	105	0.18	4.3	42	1.5	0.8
7	7	1.41	7.6	13	4	35	0.6	1.4	21	1.3	9	1346	101	0.09	4.4	107	2.3	1.6
8	8	0.80	7.5	1	3	110	12.3	1.8	78	4.0	16	3500	339	0.35	7.5	66	4.9	26.0
9	7	1.33	7.7	12	3	43	0.7	1.6	28	1.5	7	1544	127	0.11	4.0	63	4.0	2.3
10	9	1.47	7.6	15	6	43	0.4	3.2	38	4.1	32	1280	130	0.16	4.5	91	1.2	2.5
11	6	1.22	8.0	4	4	198	0.9	1.3	134	5.7	24	3649	339	0.07	7.2	28	5.6	31.9
12	9	1.33	7.7	16	5	48	0.7	1.7	25	1.8	8	1488	125	0.16	5.0	101	3.1	1.6
13	8	1.16	8.1	1	5	168	1.0	1.7	136	4.7	24	3854	309	0.02	7.7	33	5.7	27.2
14	12	0.71	7.4	6	4	97	19.0	2.3	100	3.2	22	2473	334	0.61	9.1	20	4.5	16.4
15	5	0.64	7.3	4	6	48	14.3	4.0	88	4.3	17	2372	224	0.39	5.2	66	5.2	14.7
16	7	0.67	7.4	8	5	66	16.8	5.1	102	4.5	23	2457	262	0.55	6.4	72	4.4	12.9
17	8	1.39	7.5	1	6	168	17.5	2.7	143	5.8	29	5813	542	0.41	11.5	60	4.9	23.8
18	4	1.43	7.7	16	2	54	1.3	1.8	44	2.4	21	1416	188	0.30	4.0	97	2.1	2.8
19	7	1.44	7.6	11	4	36	0.5	2.9	34	3.4	10	1225	87	0.10	4.0	109	3.4	3.1
20	6	1.29	7.8	3	4	63	0.9	1.9	75	3.0	26	2499	148	0.14	4.7	42	2.9	18.8
21	6	1.35	7.4	13	2	43	0.7	1.0	30	1.6	13	971	167	0.17	3.5	204	2.3	2.4
22	6	1.00	7.5	12	2	75	2.8	0.9	45	2.2	12	1207	249	0.20	4.7	59	3.8	3.8
23	7	1.27	7.8	5	5	187	0.8	3.8	99	9.1	52	3810	420	0.18	12.7	104	1.9	18.3
24	45	0.70	7.4	1	13	94	14.1	2.6	290	7.8	32	3743	219	0.50	12.9	375	9.1	22.3
25	45	0.69	7.4	<1	11	84	14.1	2.3	312	7.5	37	2971	173	0.68	8.5	388	8.4	28.4
26	35	0.73	7.4	<1	12	97	12.8	3.1	306	8.8	40	3256	227	0.65	10.3	318	7.7	25.5
27	36	0.70	7.4	<1	15	95	14.2	2.8	310	8.2	43	2859	205	0.70	8.3	398	7.2	20.7
28	25	0.83	7.4	<1	17	143	12.7	5.0	171	11.6	41	3491	355	0.59	11.7	285	4.2	10.1

Sediment Phosphorus Release Potential Based on Fe:P Ratios

A variety of factors contribute to internal phosphorus loading in lakes. Research by Jensen et al (1992) found when a total iron to total phosphorus ratio was greater than 15 to 1, phosphorus release from lake sediments was minor. That benchmark has been used to characterize the potential of Lake Riley sediments to release phosphorus. Results show most of the sediment sites have a high Fe:P ratio in deep water and that phosphorus release from Lake Riley sediments would appear to be light. However in shallower water, sediment phosphorus release appears to be moderate to high (Table 3 and Figure 3).

Table 3. Lake sediment data for iron and phosphorus and the calculated Fe to P ratio. Samples were collected on October 19, 2012.

Sample Number	Depth (ft)	Iron (ppm)	Bray-P (ppm)	Olsen-P (ppm)	Fe/P
1	7	35	14	4	2.5
2	9	38	22	4	1.7
3	8	70	20	5	3.5
4	6	47	16	5	3.0
5	11	47	<1	4	11.8
6	6	23	29	4	0.8
7	7	21	13	4	1.6
8	8	78	1	3	26.0
9	7	28	12	3	2.3
10	9	38	15	6	2.5
11	6	134	4	4	31.9
12	9	25	16	5	1.6
13	8	136	1	5	27.2
14	12	100	6	4	16.4
15	5	88	4	6	14.7
16	7	102	8	5	12.9
17	8	143	1	6	23.8
18	4	44	16	2	2.8
19	7	34	11	4	3.1
20	6	75	3	4	18.8
21	6	30	13	2	2.4
22	6	45	12	2	3.8
23	7	99	5	5	18.3
24	45	290	1	13	22.3
25	45	312	<1	11	28.4
26	35	306	<1	12	25.5
27	36	310	<1	15	20.7
28	25	171	<1	17	10.1

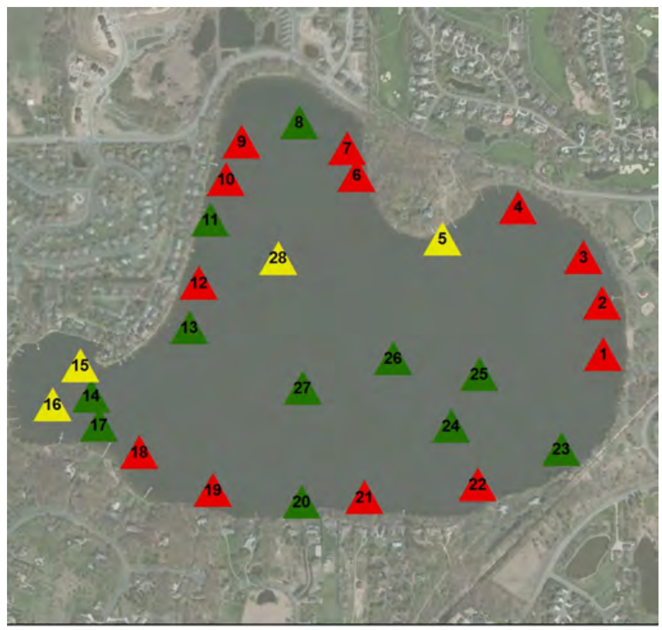


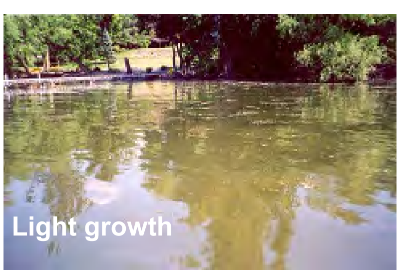
Figure 3. Lake sediment sample locations are shown with color triangles. Colored triangles represent phosphorus release potential at that site. Green = low, yellow = moderate, and red = high.

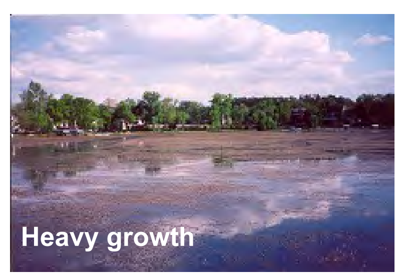
Curlyleaf Pondweed Growth Potential

Lake sediment sampling results from 2012 have been used to predict lake bottom areas that have the potential to support nuisance curlyleaf pondweed plant growth. Based on the key sediment parameters of pH, sediment bulk density, organic matter, and the Fe:Mn ratio (McComas, unpublished), the predicted growth characteristics of curlyleaf pondweed are shown in Table 4 and Figure 4.

Table 4. Lake Riley sediment data and ratings for potential heavy curlyleaf pondweed growth.

Site	Depth (ft)	pH (su)	Bulk Density (g/cm3 dry)	Organic Matter (%)	Fe:Mn Ratio	Potential for Curlyleaf Pondweed Growth
Light Growth		**<7.4**	**1.04**	**0.1-5**	**>4.5**	**Light (green)**
Moderate Growth		**7.4-7.7**	**0.52-1.03**	**6-20**	**1.6-4.5**	**Moderate (yellow)**
Heavy growth		**>7.7**	**<0.51**	**>20**	**<1.6**	**Heavy (red)**
1	7	7.5	1.19	0.9	3.5	Moderate
2	9	7.6	1.01	2.2	2.9	Moderate
3	9	7.4	1.18	1.4	2.6	Light
4	6	7.5	1.26	1.0	3.6	Moderate
5	11	7.9	1.16	1.2	4.7	Moderate
6	6	7.7	1.49	0.4	1.5	Heavy
7	7	7.6	1.41	0.6	2.3	Moderate
8	8	7.5	0.80	12.3	4.9	Light
9	7	7.7	1.33	0.7	4.0	Moderate
10	9	7.6	1.47	0.4	1.2	Moderate
11	6	8.0	1.22	0.9	5.6	Moderate
12	9	7.7	1.33	0.7	3.1	Moderate
13	8	8.1	1.16	1.0	5.7	Moderate
14	12	7.4	0.71	19.0	4.5	Moderate
15	5	7.3	0.64	14.3	5.2	Light
16	7	7.4	0.67	16.8	4.4	Moderate
17	8	7.5	1.39	17.5	4.9	Light
18	4	7.7	1.43	1.3	2.1	Moderate
19	7	7.6	1.44	0.5	3.4	Light
20	6	7.8	1.29	0.9	2.9	Moderate
21	6	7.4	1.35	0.7	2.3	Light
22	6	7.5	1.00	2.8	3.8	Moderate
23	7	7.8	1.27	0.8	1.9	Heavy
24	45	7.4	0.70	14.1	9.1	
25	45	7.4	0.69	14.1	8.4	
26	35	7.4	0.73	12.8	7.7	
27	36	7.4	0.70	14.2	7.2	
28	25	7.4	0.83	12.7	4.2	





Curlyleaf Pondweed Growth Potential Based on Lake Sediments

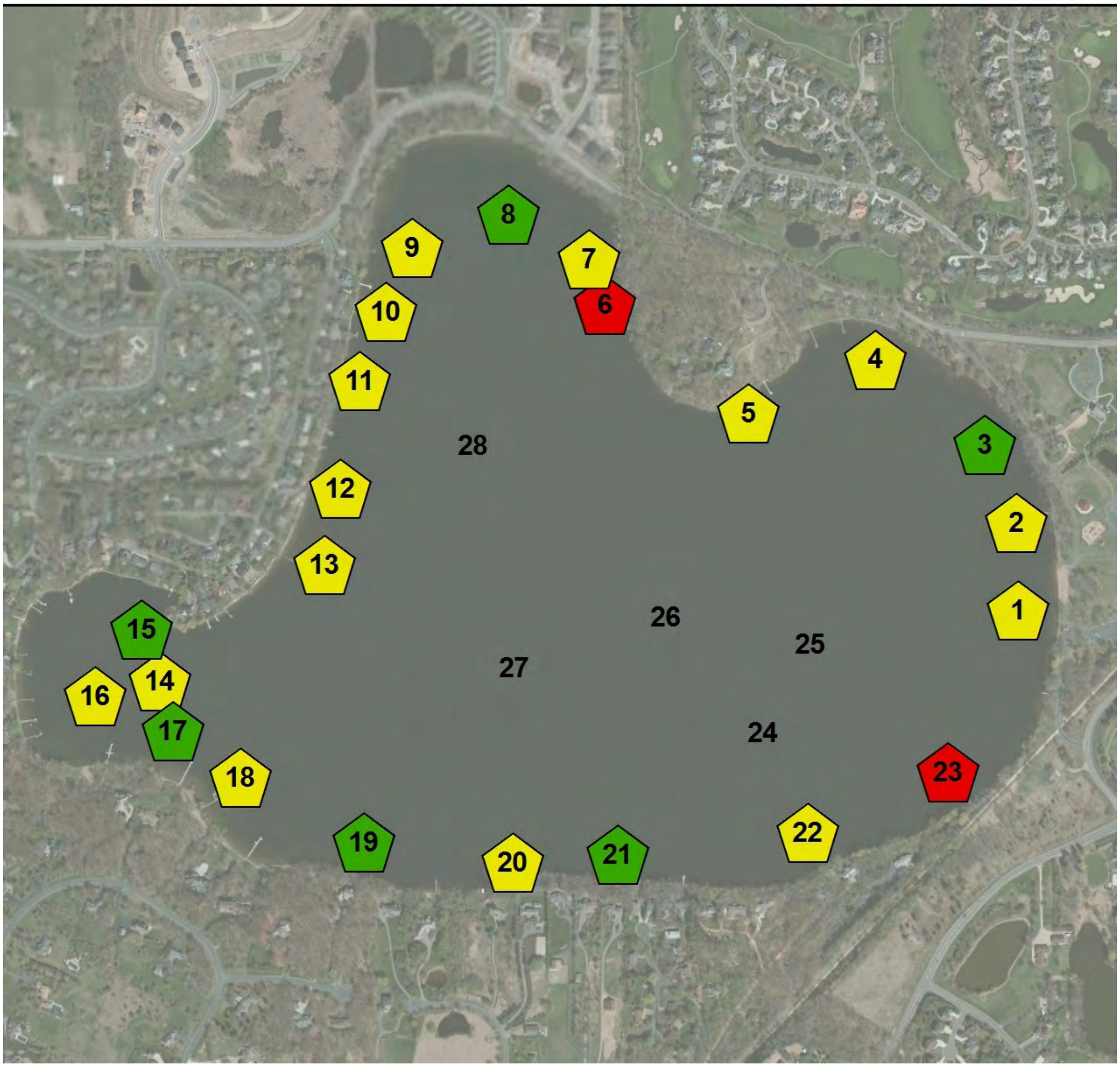


Figure 4. Curlyleaf Pondweed: Areas of predicted growth are shown with pentagons. Green = light growth, yellow = moderate growth, and red = heavy growth.

Curlyleaf Growth Predictions and 2012 Conditions

Based on lake sediment analyses, results indicate curlyleaf pondweed has the potential for mostly light to moderate growth in Lake Riley (Figure 5a). This type of growth was observed in aquatic plant surveys conducted on June 29, 2011 and May 25, 2012 by the University of Minnesota where curlyleaf growth was light to moderate with some areas of heavy growth (Figure 5b). This type of future growth pattern would be expected to occur based on lake sediment characteristics.

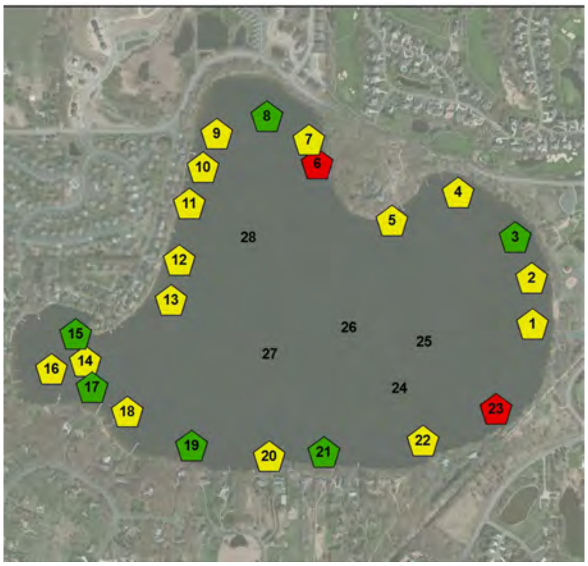


Figure 5a. Predicted curlyleaf pondweed growth characteristics based on 2012 lake sediment survey. Green shading = light growth, yellow shading = moderate growth, and red shading = heavy growth.

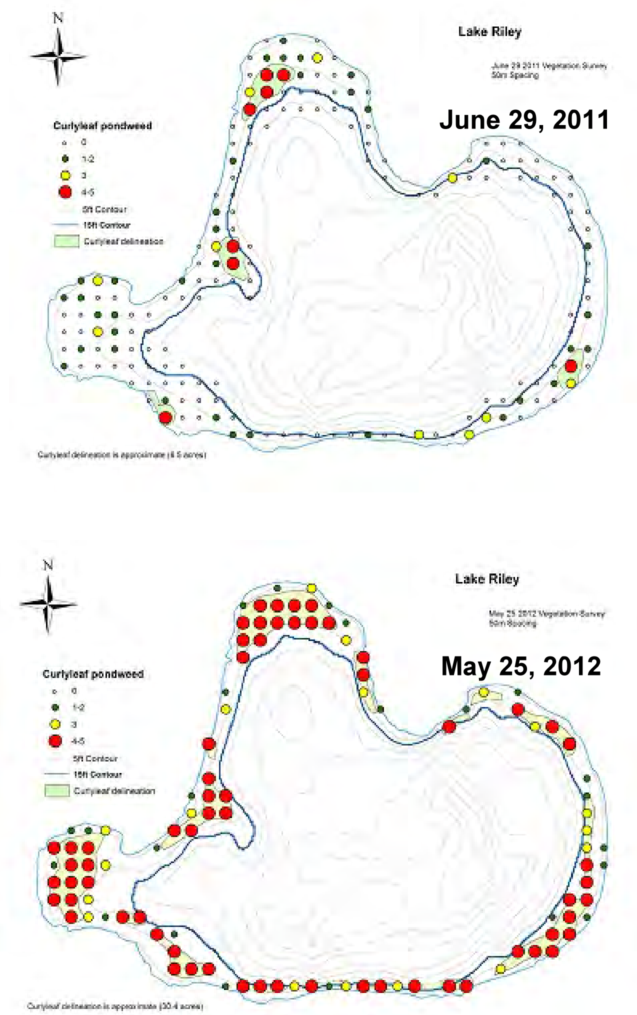


Figure 5b. Actual curlyleaf distribution in Lake Riley on June 29, 2011 (top) and May 25, 2012 (bottom). Green shading = light growth (density of 1-2), yellow shading = moderate growth (density of 3), and red shading = heavy growth (density of 4-5). Source: Dr. Ray Newman, University of Minnesota.

Eurasian Watermilfoil Growth Potential

Lake sediment sampling results from 2012 have been used to predict lake bottom areas that have the potential to support moderate EWM growth. Eurasian watermilfoil has been discovered in Lake Riley in 1990. Based on the key sediment parameters of NH_4 and organic matter (McComas, unpublished), a table and map were prepared that predict what type of growth could be expected for milfoil growth in Lake Riley (Table 5 and Figure 6).

Table 5. Lake Riley sediment data and ratings for potential EWM growth.

Site	Depth (ft)	NH_4 Conc (ppm)	Organic Matter (%)	Potential for Eurasian Watermilfoil Growth
Light Growth		**<4**	**<0.5 or>20**	**Light (green)**
Moderate Growth		**4-10**	**0.6-2 and 18-20**	**Moderate (yellow)**
Heavy Growth		**>10**	**3-17**	**Heavy (red)**
1	7	3.6	0.9	Light
2	9	4.2	2.2	Moderate
3	9	5.9	1.4	Moderate
4	6	4.5	1.0	Moderate
5	11	4.3	1.2	Moderate
6	6	4.3	0.4	Moderate
7	7	4.4	0.6	Moderate
8	8	7.5	12.3	Moderate
9	7	4.0	0.7	Moderate
10	9	4.5	0.4	Light
11	6	7.2	0.9	Moderate
12	9	5.0	0.7	Moderate
13	8	7.7	1.0	Moderate
14	12	9.1	19.0	Moderate
15	5	5.2	14.3	Moderate
16	7	6.4	16.8	Moderate
17	8	11.5	17.5	Heavy
18	4	4.0	1.3	Moderate
19	7	4.0	0.5	Light
20	6	4.7	0.9	Moderate
21	6	3.5	0.7	Light
22	6	4.7	2.8	Moderate
23	7	12.7	0.8	Heavy
24	45	12.9	14.1	
25	45	8.5	14.1	
26	35	10.3	12.8	
27	36	8.3	14.2	
28	25	11.7	12.7	

Eurasian Watermilfoil Growth Potential Based on Lake Sediments

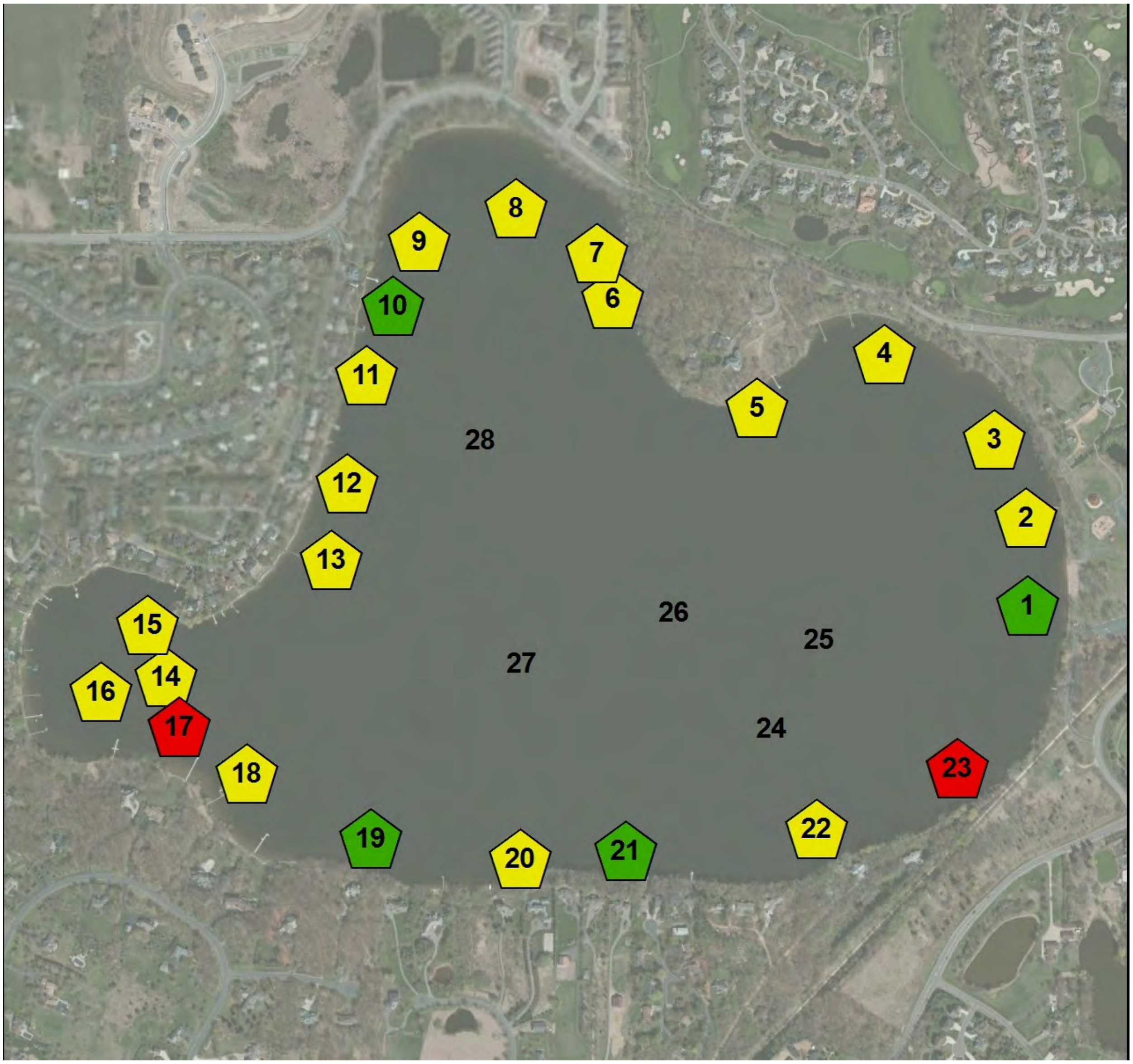


Figure 6. Eurasian Watermilfoil: Areas of predicted growth is shown with pentagons. Green = light growth, yellow = moderate growth, and red = heavy growth.

Eurasian Watermilfoil Growth Predictions

The sediment nitrogen conditions in Lake Riley are mostly moderate with some sites having low nitrogen and two sites having high nitrogen (Figure 7a). Eurasian watermilfoil may grow in a number of locations in Lake Riley and is predicted to produce perennial matting conditions (which are defined as heavy nuisance condition) in several areas primarily in the southwestern and southeastern parts of Lake Riley (Figure 7a). However, sediment parameters do not indicate that heavy milfoil growth should be sustained in the north end of Lake Riley. Lighter growth would be predicted for most years in this area in the future. Actual growth of Eurasian watermilfoil (EWM) was surveyed in 2011 and 2012 by the University of Minnesota and is shown in Figure 7b. EWM shows variability from year to year with a range of growth patterns that fall within predicted growth ranges based on lake sediment conditions.

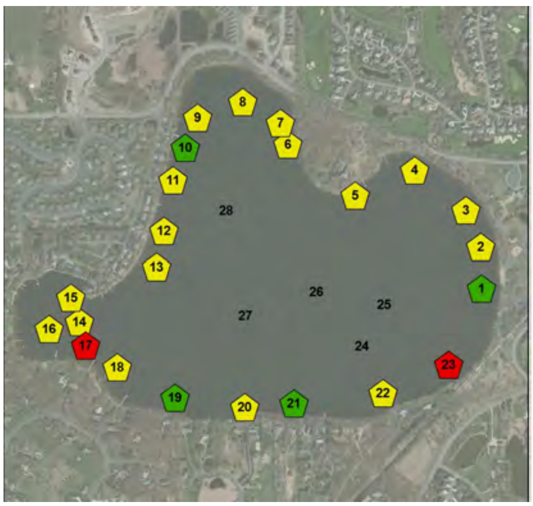


Figure 7a. Predicted Eurasian watermilfoil growth characteristics based on 2012 lake sediment survey. Green = light growth, yellow = moderate growth, and red = heavy growth.

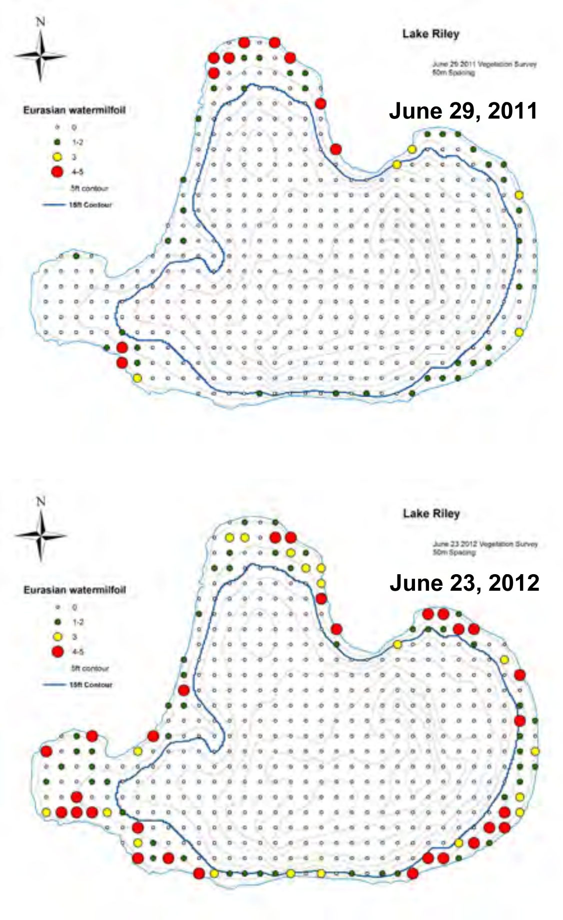


Figure 7b. Actual Eurasian watermilfoil distribution in Lake Riley on June 29, 2011 (top) and June 23, 2012 (bottom). Green shading = light growth (density of 1-2), yellow shading = moderate growth (density of 3), and red shading = heavy growth (density of 4-5). Source: Dr. Ray Newman, University of Minnesota.

Lake Soil Fertility Discussion

Phosphorus Release Potential: Phosphorus release from lake sediments has been well documented and there are a variety of ways to measure it. The approach used in this report uses limnological results but follows the interpretation that has been used in the agriculture area, where results are semi-quantitative and are indexed to empirical studies. That means, we are not sure of the exact mechanism of the mass of phosphorus released in a single season, but we can make correlations with our data to previous studies. Because of the sediment iron to phosphorus ratios, phosphorus release from lake sediments would be considered to be light in deeper water and higher in littoral zone depths.

Non-Native Plant Growth: The use of lake soil fertility sampling to predict growth of curlyleaf pondweed and Eurasian watermilfoil is an evolving area. Lake sediment sampling results from 2012 have been used to predict areas where light, moderate, or heavy growth of curlyleaf and milfoil could occur in Lake Riley.

Based on results of Lake Riley sediment sampling, it appears because of a low sediment pH and a high iron concentration in a number of areas much of the littoral zone in Lake Riley is expected to produce light to moderate growth.

Based on results of Lake Riley sediment sampling, the southern half of the lake has high enough nitrogen (as exchangeable ammonium) to generate heavy milfoil growth on a long term basis. Other areas around the lake appear to have sediment conditions conducive to light to moderate growth.

Overview of Role of Soil Nutrients for Plant Growth

The fertility of lake sediments may influence the type of aquatic plant growth in lakes. The role of sediment nutrients in mineral nutrition of land plants is shown in the box below. Aquatic plants have the same basic requirements as land plants .

Role of Soil Nutrients for the Mineral Nutrition in Plants **(from** Gardner, F.P., R.B. Pearce, and R.L. Mitchell. 1985. Physiology of Crop Plants and Foth, H.D. and B.G. Ellis. 1997. Soil Fertility 2nd Edition.)

N: Nitrogen is a constituent in amino acids, amides, proteins and nucleoprotein. It is essential to cell division, expansion and growth. Nitrogen is generally the most limiting nutrient in crop production (except for legumes).

P: Phosphorus is essential as a component of the energy transfer compound - ATP, for genetic information system (DNR & RNA), for cell membranes and phosphoprotein. Phosphorus is generally second to nitrogen as the most limiting nutrient for plant growth. Some phosphorus deficiency symptoms include dark green to blue-green leaves, and stunted plants. Phosphorus in soil solutions is usually present in low concentrations.

K: Potassium is essential to plants because it acts as enzyme activators for certain enzymes is aids in the maintenance of osmotic potential and water uptake. Most soils are buffered for potassium so yearly fluctuations are minor

Ca: Calcium is a component of the cell wall and is essential for cell division and elongation.

Mg: Magnesium is the center of the chlorophyll molecule. Magnesium also binds with ADP, ATP, and organic acids and therefore is essential for hundreds of enzymatic reactions. Magnesium is a cofactor for many enzymes. Nitrogen metabolism and protein synthesis are also dependent on the presence of Mg.

Fe: Iron is a constituent of the electron transport enzymes. Although Fe is not a part of the chlorophyll molecule, it affects chlorophyll levels because it must be present for chloroplast ultrastructure formation. Iron deficiencies can reduce the number and size of chloroplast.

Mn: Manganese is an activator of several enzymes, especially those involved in fatty acid and nucleotide synthesis and is essential in respiration and photosynthesis.

S: Sulfur is a constituent of the amino acids eystine, cysteine, and methionine. It also activities certain proteolytic enzymes and is a constituent of coenzyme A, glutathione, and certain vitamins. Sulfur deficiency can cause stunting and general plant yellowing: stems are thin. Sulfur is primarily absorbed as the SO_4 ion.

Zn: Zinc is essential for the enzymes in the synthesis of tryptophan. Zinc levels are positively correlated with increasing organic matter and negatively correlated with increasing pH.

B: Boron may influence cell development by controlling sugar transport and polysaccharide formation. Requirements for B and Ca often go hand in hand in hand; this has suggested that B, may be needed for cell wall formation and for metabolism of pectic compounds.

Cu: Copper is part of the chloroplast enzyme plastocyanin in the electron transport system between photoslystmes I and II. It is present as an exchange ion on soil particles and minutely in the soil solution. Copper may become toxic in soils with a use of copper sprays.

Na: Sodium is the most soluble of the salts. It may be a micronutrient, but generally is so abundant, is rarely limiting. It is leachable and its concentration gradually decreases over time.

CEC: Cation exchange capacity is the sum of exchangeable cations that a soil or other material can adsorb at a specific pH. CEC is determined at a pH of 7.0.

pH: pH has little or no direct effect on plant growth, however indirect effects are numerous and potent. In optimum pH is somewhere between 6.0 and 7.5.

Organic matter: Organic matter exerts a profound influence on almost every facet of the nature of soil. Most A horizons contain about 1 to 6 percent organic matter. A soil with greater than 20% organic matter is an organic soil and is classified as either peat or muck.

References

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Iron:phosphorus ratio in surface sediment as an indicator of phosphate release from aerobic sediments in shallow lakes

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Key words: Lakes, sediments, iron, phosphorus, phosphate release

Abstract

Analysis of Danish lakes showed that both mean winter and mean summer concentrations of lake water total phosphorus in the trophogenic zone correlated negatively with the total iron to total phosphorus ratio (Fe:P) in surface sediments. No correlation was found between the water total phosphorus concentration and either the sediment phosphorus concentration alone or with sediment calcium concentration. The increase in total phosphorus from winter to summer, which is partly a function of net internal P-loading, was lowest in lakes with high Fe:P ratios in the surface sediment.

A study of aerobic sediments from fifteen lakes, selected as representative of Danish lakes with respect to the sediment Fe and phosphorus content, showed that the release of soluble reactive phosphorus was negatively correlated with the surface sediment Fe:P ratio. Analysis of phosphate adsorption properties of surface sediment from 12 lakes revealed that the capability of aerobic sediments to buffer phosphate concentration correlated with the Fe:P ratio while the maximum adsorption capacity correlated with total iron. Thus, the Fe:P ratio may provide a measure of free sorption sites for orthophosphate ions on iron hydroxyoxide surfaces.

The results indicate that provided the Fe:P ratio is above 15 (by weight) it may be possible to control internal P-loading by keeping the surface sediment oxidized. Since the Fe:P ratio is easy to measure, it may be a useful tool in the management of shallow lakes.

Sample ID	Bulk Density	Water pH	Bray-P (ppm)	Bray-P (ppm) adj	Olsen-P (ppm)	Olsen-P (ppm) adj	K (ppm)	K (ppm) adj	Org Mat (%)	Zn (ppm)	Zn (ppm) adj	Fe (ppm)	Fe (ppm) adj	Cu (ppm)	Cu (ppm) adj	Mn (ppm)	Mn (ppm) adj	Ca (ppm)	Ca (ppm) adj	Mg (ppm)	Mg (ppm) adj	Boron (ppm)	Boron (ppm) adj	NH_4-N (ppm)	NH_4-N (ppm) adj	SO_4-S (ppm)	SO_4-S (ppm) adj	Avg Scoop	Correct Factor
RI1	1.19	7.5	14	14.2	4	4	37	37	0.9	2.254	2.3	34.345	35	2.155	2.2	9.478	10	1649.4	1671	131.97	134	0.17	0.17	3.6	3.6	100	101	10.13	1.01
RI2	1.01	7.6	26	22.3	5	4	70	60	2.2	1.244	1.1	43.779	38	2.220	1.9	15.664	13	2033.1	1747	291.79	251	0.20	0.17	4.9	4.2	67	58	8.59	0.86
RI3	1.18	7.4	20	20.1	5	5	54	54	1.4	3.007	3.0	70.157	70	4.252	4.3	27.261	27	1405.0	1412	291.97	293	0.25	0.25	5.9	5.9	85	85	10.05	1.00
RI4	1.26	7.5	14.5	15.5	5	5	35	38	1.0	4.393	4.7	43.936	47	3.631	3.9	12.170	13	1966.7	2109	126.69	136	0.14	0.15	4.2	4.5	104	112	10.72	1.07
RI5	1.16	7.9	<1	<1	4	4	78	77	1.2	0.520	0.5	47.278	47	1.097	1.1	10.000	10	3486.2	3443	239.92	237	0.12	0.12	4.4	4.3	20	20	9.88	0.99
RI6	1.49	7.7	23	29.1	3	4	27	34	0.4	0.678	0.9	17.861	23	0.823	1.0	11.861	15	842.5	1065	83.078	105	0.14	0.18	3.4	4.3	33	42	12.65	1.26
RI7	1.41	7.6	11	13.2	3	4	29	35	0.6	1.126	1.4	17.594	21	1.115	1.3	7.270	9	1121.4	1346	84.031	101	0.078	0.09	3.6	4.4	89	107	12.01	1.20
RI8	0.80	7.5	1	0.7	5	3	162	110	12.3	2.615	1.8	114.89	78	5.829	4.0	23.325	16	5142.6	3500	498.75	339	0.52	0.35	11.0	7.5	97	66	6.81	0.68
RI9	1.33	7.7	11	12.4	3	3	38	43	0.7	1.460	1.6	24.41	28	1.287	1.5	6.627	7	1367.9	1544	112.09	127	0.101	0.11	3.6	4.0	56	63	11.29	1.13
RI10	1.47	7.6	12	15.0	5	6	34	43	0.4	2.564	3.2	30.035	38	3.234	4.1	25.281	32	1022.1	1280	104.11	130	0.13	0.16	3.6	4.5	73	91	12.52	1.25
RI11	1.22	8.0	4	4.2	4	4	190	198	0.9	1.203	1.3	128.50	134	5.439	5.7	23.422	24	3508.0	3649	325.99	339	0.064	0.07	6.9	7.2	27	28	10.40	1.04
RI12	1.33	7.7	14	15.9	4	5	42	48	0.7	1.483	1.7	22.120	25	1.603	1.8	7.072	8	1312.1	1488	110.03	125	0.14	0.16	4.4	5.0	89	101	11.34	1.13
RI13	1.16	8.1	1	1.0	5	5	170	168	1.0	1.766	1.7	137.29	136	4.751	4.7	24.309	24	3902.4	3854	312.67	309	0.023	0.02	7.8	7.7	33	33	9.88	0.99
RI14	0.71	7.4	10	6.1	7	4	159	97	19.0	3.735	2.3	164.03	100	5.276	3.2	35.846	22	4066.7	2473	548.93	334	1.01	0.61	15.0	9.1	33	20	6.08	0.61
RI15	0.64	7.3	8	4.4	11	6	88	48	14.3	7.382	4.0	161.26	88	7.810	4.3	30.924	17	4336.3	2372	409.48	224	0.71	0.39	9.5	5.2	120	66	5.47	0.55
RI16	0.67	7.4	14	7.9	8	5	117	66	16.8	8.953	5.1	179.70	102	8.032	4.5	41.038	23	4338.7	2457	462.75	262	0.97	0.55	11.3	6.4	128	72	5.66	0.57
RI17	1.39	7.5	1	1.2	5	6	142	168	17.5	2.319	2.7	121.32	143	4.876	5.8	24.753	29	4923.6	5813	458.89	542	0.35	0.41	9.8	11.5	51	60	11.81	1.18
RI18	1.43	7.7	13	15.8	2	2	44	54	1.3	1.443	1.8	36.457	44	1.986	2.4	17.464	21	1162.4	1416	154.19	188	0.25	0.30	3.3	4.0	80	97	12.18	1.22
RI19	1.44	7.6	9	11.1	3	4	29	36	0.5	2.391	2.9	27.848	34	2.752	3.4	8.372	10	995.81	1225	70.734	87	0.081	0.10	3.3	4.0	89	109	12.30	1.23
RI20	1.29	7.8	3	3.3	3.5	4	58	63	0.9	1.707	1.9	68.575	75	2.744	3.0	24.217	26	2284.2	2499	135.51	148	0.13	0.14	4.3	4.7	38	42	10.94	1.09
RI21	1.35	7.4	11	12.7	2	2	37	43	0.7	0.895	1.0	25.989	30	1.419	1.6	11.550	13	844.0	971	145.13	167	0.15	0.17	3.0	3.5	177	204	11.50	1.15
RI22	1.00	7.5	14	11.9	2	2	88	75	2.8	1.119	0.9	52.513	45	2.562	2.2	13.949	12	1423.0	1207	293.37	249	0.24	0.20	5.5	4.7	70	59	8.48	0.85
RI23	1.27	7.8	5	5.4	5	5	173	187	0.8	3.468	3.8	90.998	99	8.402	9.1	48.001	52	3517.7	3810	387.88	420	0.17	0.18	11.7	12.7	96	104	10.83	1.08
RI24	0.70	7.4	1	0.6	21	13	156	94	14.1	4.311	2.6	483.45	290	13.008	7.8	52.581	32	6241.6	3743	364.86	219	0.84	0.50	21.4	12.9	625	375	6.00	0.60
RI25	0.69	7.4	<1	<1	19	11	143	84	14.1	3.873	2.3	528.96	312	12.702	7.5	62.534	37	5035.5	2971	293.39	173	1.16	0.68	14.4	8.5	658	388	5.90	0.59
RI26	0.73	7.4	<1	<1	19	12	157	97	12.8	5.082	3.1	494.77	306	14.176	8.8	64.920	40	5260.4	3256	366.34	227	1.05	0.65	16.7	10.3	514	318	6.19	0.62
RI27	0.70	7.4	<1	<1	25	15	161	95	14.2	4.756	2.8	523.44	310	13.870	8.2	72.786	43	4821.2	2859	345.13	205	1.18	0.70	14.0	8.3	671	398	5.93	0.59
RI28	0.83	7.4	<1	<1	24	17	202	143	12.7	7.037	5.0	241.59	171	16.360	11.6	58.438	41	4937.1	3491	502.20	355	0.84	0.59	16.5	11.7	403	285	7.07	0.71