Birch Lake, March 2008

Predicting Curlyleaf Pondweed and Eurasian Watermilfoil Growth Based on Birch Lake Sediment Characteristics

[Sediments Collected March 11, 2008]

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Introduction

For managing non-native plants it is helpful to know where the plants have the potential to grow to nuisance conditions. A technique developed by Blue Water Science shows where nuisance growth of curlyleaf pondweed and Eurasian watermilfoil can occur in a lake based on lake sediment characteristics. This technique was applied to Birch Lake.

Birch Lake sediments were collected from eight sites around the lake on March 11, 2008. The sediments have been analyzed and results interpreted and are presented in this report.

Methods

Lake Soil Collection: A total of twenty lake sediment samples were collected from the depth of 3 to 5 feet on March 11, 2008 by Steve McComas, Blue Water Science, and Kristine Lampert, VLAWMO. Samples were collected using a modified soil auger, 5.2 inches in diameter (Figure 1). Soils were sampled to a depth of 6 inches. The lake soil from the sampler was transferred to 1-gallon zip-lock bags and delivered to the University of Minnesota soil testing laboratory.

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. Sixteen 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 Crop Research 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 1. 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 μg/cm^3. For all sediment results reported here a scoop volume of 8.51 cm^3 was used.

However lake sediment bulk density has wide variations but 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 μg/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 μg/cm^3. These are all dry weight determinations.

Delineating Areas of Potential Nuisance Curlyleaf and Milfoil Growth: Delineating an area of potential nuisance plant growth is based on conventional soil survey methods. When a sediment sample analysis has a nitrogen reading over 10 ppm and has an organic matter content of less than 20%, it has a high potential for nuisance milfoil growth. For sediment results with a high growth potential collected in a cove, typically, the water depths in the cove from 5 to 7 feet would be designated as having a potential for nuisance growth. If high potential samples are found along a stretch of shoreline, a designated high potential 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 records a low potential reading, then the designated nuisance area would extend midway between a high and low potential sample sites.

Results

Potential for Heavy Growth of Non-native Invasive Plants Based on Lake Sediment Characteristics

A total of twenty sediment sites were sampled around Birch Lake. Sediment sites and locations are shown in Table 2 and Figure 2.

Table 2. Birch Lake sediment sample locations and field observations on March 11, 2008.

Sample Number	Water Depth (ft)	UTM Coordinates (WGS 84)	
		East	North
1	4	97 200	92 190
2	5	97 052	92 151
3	5	96 985	92 200
4	5	96 904	92 050
5	5	96 746	92 098
6	5	96 648	92 158
7	5	96 448	92 054
8	4.5	96 603	91 951
9	4 (mucky)	96 757	91 908
10	3 (sandy)	96 903	91 902
11	4 (mucky-sand)	97 002	91 955
12	4 (peat)	97 149	92 052
13	3	97 151	92 348
14	5	96 901	92 356
15	5	96 809	92 356
16	5	96 751	92 302
17	4.5 (peat)	96 595	92 373
18	4.5	96 751	92 448
19	4 (peat)	96 878	92 557
20	4 (organic)	97 013	92 387

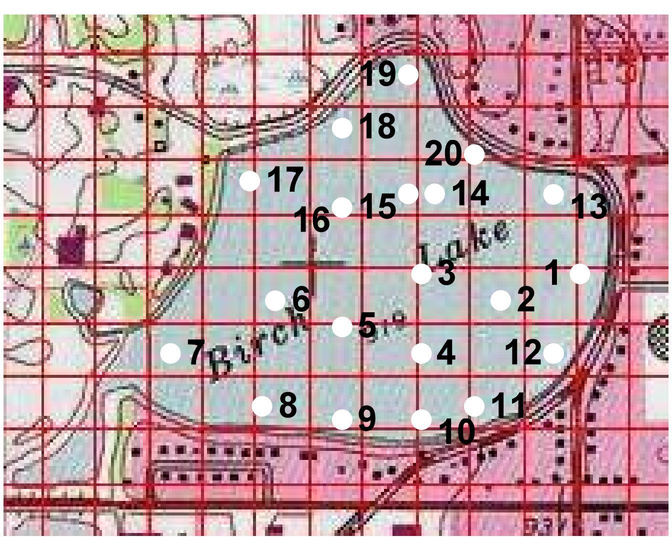


Figure 2. Lake sediment sample locations are shown with white dots.

Birch Lake sediment results are shown in Table 3 A total of 15 parameters were analyzed for each sediment sample. A low bulk density (less than 0.60 g/cm^3) indicates lake sediments are soft and mucky. Typically high organic matter content is associated with the soft mucky sediments sample sites. Lake sediment phosphorus concentrations at all sites were low.

Table 3. Birch Lake soil data. Sample were collected on March 11, 2008. Soil chemistry results are reported as µg/cm^3-dry which is equivalent to ppm except for organic matter (%) and pH (standard units).

Sample Number	Depth (ft)	Bulk Density (g/cm3)	O.M. (%) by L.O.I.	pH	Bray-P (ppm) (corr)	Olsen-P (ppm) (corr)	K (ppm) (corr)	Ca (ppm) (corr)	Mg (ppm) (corr)	Boron (ppm) (corr)	NH4-N (ppm) (corr)	Fe (ppm) (corr)	Cu (ppm) (corr)	Mn (ppm) (corr)	Zn (ppm) (corr)	SO4-S (ppm) (corr)
B1	4	0.445	42.2 / 40.5	5.8 / 6.0	2	1	22	710	86	0	8	85	1	11	5	16
B3	5	0.767	54.3	5.7	4	2	60	1401	214	1	10	153	3	13	6	49
B4	5	0.720	66.6	5.7	1	1	46	954	160	1	40	176	1	14	2	15
B5	5	0.770	52.3	5.8	3	1	74	1022	172	2	18	91	2	11	3	43
B6	5	0.794	56.9	5.8	4	1	63	1637	266	2	15	138	3	13	5	47
B7	5	0.553	48.6	5.9	3	0	46	928	143	1	13	158	1	10	1	12
B8	4.5	0.799	49.8	5.8	3	1	57	1757	207	1	15	149	2	24	3	31
B9	4	1.342	1.0	5.7	3	1	62	368	42	0	4	33	1	2	1	37
B10	3	1.071	6.4	6.1	3	1	26	813	90	0	8	76	1	6	1	16
B11	4	0.774	20.3	6.0	5	1	30	1035	118	1	8	88	1	16	3	13
B12	4	0.615	33.2	5.8	4	1	38	1068	134	1	9	126	1	12	4	21
B13	3	0.775	16.4	5.9	4	2	33	1379	107	1	10	153	3	10	10	79
B14	5	0.748	52.3	5.8	3	1	73	1765	282	1	16	208	2	10	2	19
B15	5	0.790	52.2	5.9	3	1	54	1110	183	1	19	151	2	9	5	37
B16	5	0.585	55.7	5.9	2	1	40	895	146	1	17	129	1	8	4	20
B17	4.5	0.539	40.9	6.0	4	1	30	1008	116	0	13	97	1	16	4	21
B18	4.5	0.684	36.7	6.0	3	1	61	1030	166	1	14	155	1	9	2	12
B19	4	0.638	38.4	6.0	4	1	51	1280	181	1	27	157	2	14	5	22
B20	4	0.867	12.5	6.1	4	1	41	1297	125	0	8	111	1	13	4	21

Lake Areas that Could Support Heavy Curlyleaf Growth Based on Lake Sediment Characteristics: Lake sediment sampling results from 2008 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 3.

Curlyleaf pondweed growth is not predicted to produce nuisance growth (where plants top out in a solid canopy) in Birch Lake. The sediment pH is too low and the Fe:Mn ratio is too high.

Table 4. Birch Lake sediment data and ratings for potential nuisance curlyleaf pondweed growth.

Site	pH (su)	Bulk Density (g/cm^3 dry)	Organic Matter (%)	Fe:Mn Ratio	Potential for Nuisance Curlyleaf Pondweed Growth
Light Growth	6.8	1.04	5	4.6	Low (green)
Moderate Growth	6.2	0.94	11	5.9	Medium (yellow)
Heavy Growth	>7.7	<0.51	>20	<1.6	High (red)
1	5.9	0.445	41.4	7.5	Low
3	5.7	0.767	54.3	12.4	low
4	5.7	0.720	66.6	12.6	low
5	5.8	0.770	52.3	8.1	low
6	5.8	0.794	56.9	10.7	low
7	5.9	0.553	48.6	16.0	low
8	5.8	0.799	49.8	6.1	low
9	5.7	1.342	1.0	18.3	low
10	6.1	1.071	6.4	11.8	low
11	6.0	0.774	20.3	5.4	low
12	5.8	0.615	33.2	10.6	low
13	5.9	0.775	16.4	14.8	low
14	5.8	0.748	52.3	21.5	low
15	5.9	0.790	52.2	16.5	low
16	5.9	0.585	55.7	16.4	low
17	6.0	0.539	40.9	6.0	low
18	6.0	0.684	36.7	17.2	low
19	6.0	0.638	38.4	11.1	low
20	6.1	0.867	12.5	8.5	low

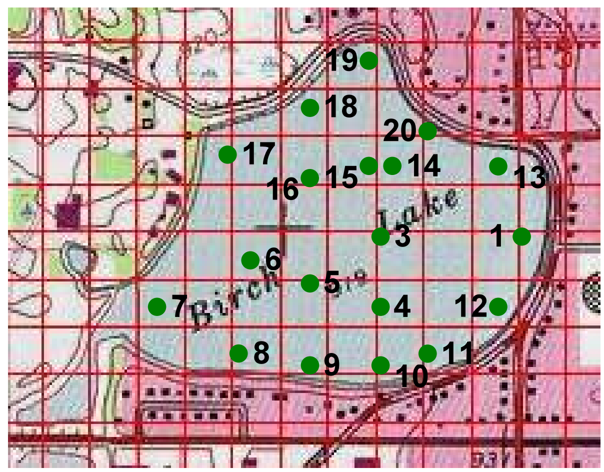


Figure 3. Sediment sample locations are shown with a circle. The circle color indicates the potential for nuisance curlyleaf pondweed to occur at that site. Key: green = low; yellow = medium; red = high potential.

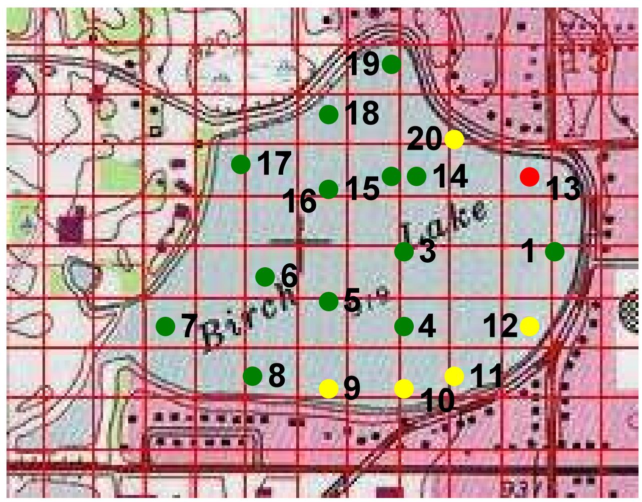
Light growth (left) refers to light nuisance growth that is mostly below the surface and is not a recreational or ecological problem. Heavy growth (right) refers to nuisance matting curlyleaf pondweed. This is the kind of nuisance growth predicted by high sediment pH and a sediment bulk density less than 0.51.

Lake Areas that Could Support Heavy Eurasian Watermilfoil Growth Based on Lake Sediment Characteristics: Lake sediment sampling results from 2008 have been used to predict lake bottom areas that have the potential to support nuisance EWM growth. Eurasian watermilfoil was first found in Birch Lake in 2005. 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 in the future after milfoil expands it's range in Birch Lake (Table 5 and Figure 4).

The sediment nitrogen conditions in Birch Lake are relatively high. However because organic matter content is very high, nuisance milfoil growth will likely be rare. Eurasian watermilfoil may grow widely through Birch Lake, but it is predicted that it not will produce extensive perennial nuisance matting conditions (which are defined as heavy growth conditions).

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

Site	NH_4 Conc (ppm)	Organic Matter (%)	Potential for Nuisance EWM Growth
Light Growth or Moderate Growth	<10	>20	Low (green) to Medium (yellow)
Heavy Growth	>10	<20	High (red)
1	8	41.4	low
3	10	54.3	low
4	40	66.6	low
5	18	52.3	low
6	15	56.9	low
7	13	48.6	low
8	15	49.8	low
9	4	1.0	medium
10	8	6.4	medium
11	8	20.3	medium
12	9	33.2	medium
13	10	16.4	high
14	16	52.3	low
15	19	52.2	low
16	17	55.7	low
17	13	40.9	low
18	14	36.7	low
19	27	38.4	low
20	8	12.5	high



Light growth (left) refers to light nuisance growth that is mostly below the surface and is not a recreational or ecological problem. Heavy growth (right) refers to nuisance matting Eurasian watermilfoil. This is the kind of nuisance growth predicted by high sediment nitrogen values and a sediment organic matter content less than 20%.

Appendix A

Management Options for Curlyleaf Pondweed and Eurasian Watermilfoil Based on Lake Sediment Characteristics

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Sampling results from over 50 lakes indicated lake sediment characteristics help delineate areas of potential nuisance verses non-nuisance growth for two invasive aquatic plant species, curlyleaf pondweed (*Potamogeton crispus*) and Eurasian watermilfoil (*Myriophyllum spicatum*) (where nuisance growth is defined as plants matting at the surface). Lake sediments were collected using a zone sampling program and standard agricultural soil test methods were used for lake sediment analysis. For curlyleaf pondweed, the primary parameter correlated with nuisance growth conditions was a sediment pH above 7.7. Other important parameters included a bulk density less than 0.50 g/cm^3-dry, organic matter greater then 30% and a Fe:Mn ratio of less than 1.6. Nuisance growth of Eurasian watermilfoil was influenced by different conditions. The two most significant sediment parameters were nitrogen, as exchangeable ammonia greater than 10 $\mu g/cm^3$-dry, and organic matter, less than 20%.

Knowing the delineation of potential nuisance and non-nuisance plant growth using lake sediment sampling assists managers in formulating aquatic plant management actions. For example, where sediment results indicate non-nuisance growth conditions would be expected, those areas can be left alone because the non-native plants present no ecological or recreational problem. In addition, knowing the primary influences that drive the nuisance growth of invasive species could produce long-term control solutions. For example, iron additions to a lake should control nuisance curlyleaf pondweed growth. Alternatively, sediment nitrogen reductions should control nuisance milfoil growth.