Tamarack Lake, March 2008

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

[Sediments Collected March 27, 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 Tamarack and Fish Lakes.

Tamarack and Fish Lakes sediments were collected from a total of nine sites around the lakes on March 27, 2008. The sediments results are presented in this report.

Methods

Lake Soil Collection: Tamarack Lake had five lake sediment samples and Fish Lake had four lake sediment samples collected from water depths of 4 to 7 feet on March 27, 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. 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 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 $\mu g/cm^3$. 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 $\mu g/cm^3$. 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.

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 5 sediment sites were sampled around Tamarack Lake and 4 sediment sites were sampled around Fish Lake on March 27, 2008. Sediment sites and locations are shown in Table 2 and Figure 2.

Table 2. Lake sediment sample locations and field observations on March 27, 2008.

TAMARACK LAKE

Sample Number	Water Depth (ft)	UTM Coordinates (WGS 84)	
		East	North
1	5	96 666	94 007
2	6.5	96 577	94 070
3	6.5	96 357	94 132
4	5	96 466	94 024
5	5	96 674	93 936

FISH LAKE

Sample Number	Water Depth (ft)	UTM Coordinates (WGS 84)	
		East	North
1	4	96 573	93 659
2	5		
3	4	96 250	93 729
4	5		

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

Tamarack and Fish 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 are low in Tamarack Lake and are moderate to high in Fish Lake.

Table 3. Lake soil data. Sample were collected on March 27, 2008. Soil chemistry results are reported as $\mu g/cm^3$-dry which is equivalent to ppm except for organic matter (%) and pH (standard units).

Sample Number	Bulk Density (g/cm3)	pH	Bray-P (ppm)	Olsen-P (ppm)	Organic Matter (%) by L.O.I.	K (ppm)	Ca (ppm)	Mg (ppm)	Boron (ppm)	NH4-N (ppm)	Fe (ppm)	Cu (ppm)	Mn (ppm)	Zn (ppm)	SO4-S (ppm)
TAMARACK LAKE															
T1	0.320	7.1	1	2	65.5		1302	90	0	11	126	0	10	0	17
T2	0.190	7.3	0	1	56.9	1	627	21	0	2	55	0	3	0	3
T3	0.379	7.5 / 7.2 / 7.4	1	5	56.1 / 54.8 / 55.5	9	1133	55	0	25	151	0	14	1	6
T4	0.322	7.5	5	2	66.3	6	866	59	0	28	110	0	12	0	7
T5	0.337	7.0	5	1	74.2	6	749	50	0	22	118	0	12	0	17
FISH LAKE															
F1	0.207	7.0	32	15	70.4	3	473	37	0	14	101	0	9	0	5
F2	1.002	7.1	13	4	5.2	45	1792	163	1	13	157	1	8	1	39
F3	0.384	7.0	10	15	59.5	12	1152	86	0	23	194	0	27	1	8
F4	0.416	6.8	17	3	75.7	11	1181	122	1	27	158	0	34	1	7

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 conditions (where plants top out in a solid canopy) in either Tamarack or Fish Lakes.

Table 4. Tamarack and Fish Lakes 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 - 50**	**<1.6**	**High (red)**
TAMARACK LAKE					
1	7.1	0.320	65.5	12.8	Medium
2	7.3	0.190	56.9	21.9	Medium
3	7.4	0.379	55.5	10.8	Medium
4	7.5	0.322	66.3	9.5	Medium
5	7.0	0.337	74.2	9.7	Medium
FISH LAKE					
1	7.0	0.207	70.4	11.4	Medium
2	7.1	1.002	5.2	19.4	Low
3	7.0	0.384	59.5	7.1	Medium
4	6.8	0.416	75.7	4.6	Medium

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 is not currently observed in either Tamarack or Fish Lakes. 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 if milfoil were to invade (Table 5 and Figure 4).

The sediment nitrogen conditions in Tamarack and Fish Lakes are relatively high, but growth is predicted to be limited because the organic matter content is also very high. Research has shown that milfoil does not grow abundantly in lake sediments with high organic matter content.

One site in Fish Lake could support heavy milfoil growth, but not on a widespread basis.

Table 5. Lake sediment data and ratings for potential nuisance Eurasian watermilfoil 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)
TAMARACK LAKE			
1	11	65.5	Low
2	2	56.9	Low
3	25	55.5	Low
4	28	66.3	Low
5	22	74.2	Low
FISH LAKE			
1	14	70.4	Low
2	13	5.2	High
3	23	59.5	Low
4	27	75.7	Low

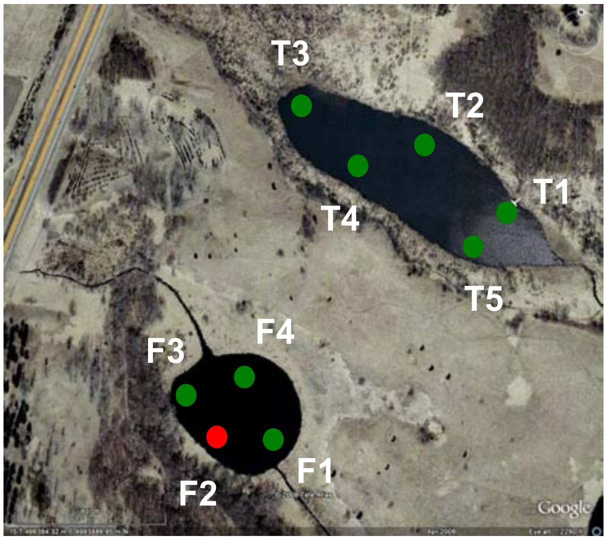
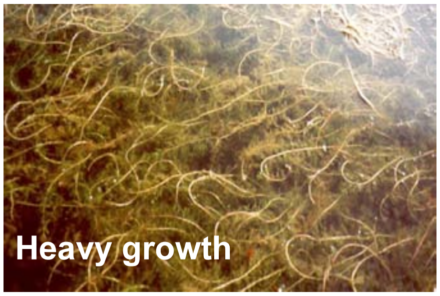


Figure 3. Sediment sample locations are shown with a circle. The circle color indicates the potential for nuisance curlyleaf pondweed to occur at that site. Key: green = low; yellow = medium; red = high potential.



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 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 µg/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.