

Curlyleaf Pondweed in a Sampling Quadrat in Fish Lake, Scott County, MN, on April 27, 2010

Curlyleaf Pondweed Density and Abundance in Fish Lake, Scott County, 2010

First Assessment: April 27, 2010
Second Assessment: June 2, 2010

Prepared for:
Prior Lake/Spring Lake
Watershed District
Prior Lake, Minnesota



Prepared by:
Steve McComas
Blue Water Science
St. Paul, MN 55116

January 2011

Curlyleaf Pondweed Density and Abundance in Fish Lake, Scott County, 2010

Summary

Curlyleaf Pondweed Abundance in 2010: Two assessments were conducted in Fish Lake within the 15.5 acre treatment area. The first one was on April 27 and the second one was on June 10, 2010. The area shaded dark blue was treated with Aquathol from 2005 through 2008. No herbicides were used in the 15.5 acre area in 2009 and 2010. In the first assessment curlyleaf pondweed was found at only one site out of the 11 sites monitored. On the second assessment curlyleaf had increased in abundance and in distribution and was found at 5 out of 11 sites. At Site 9, curlyleaf growth was close to the surface. The coverage of this moderate to heavy growth was estimated at 3 acres.

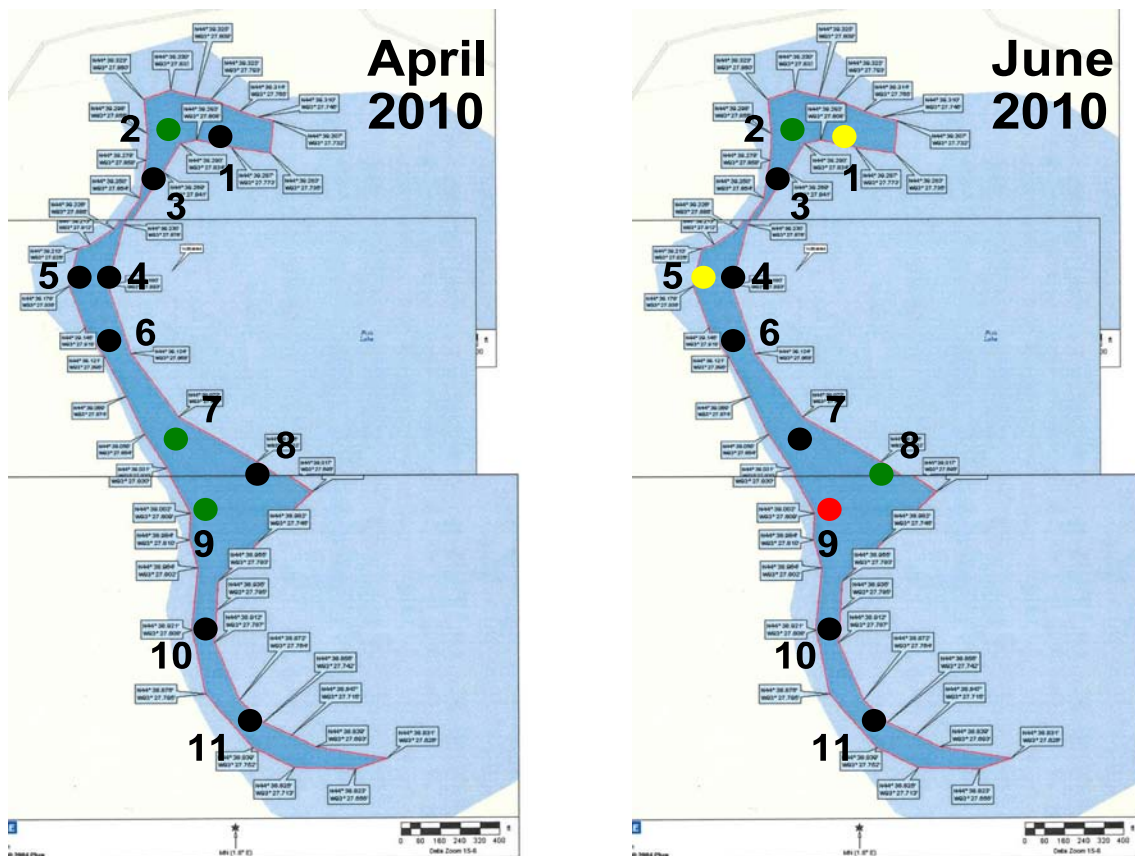
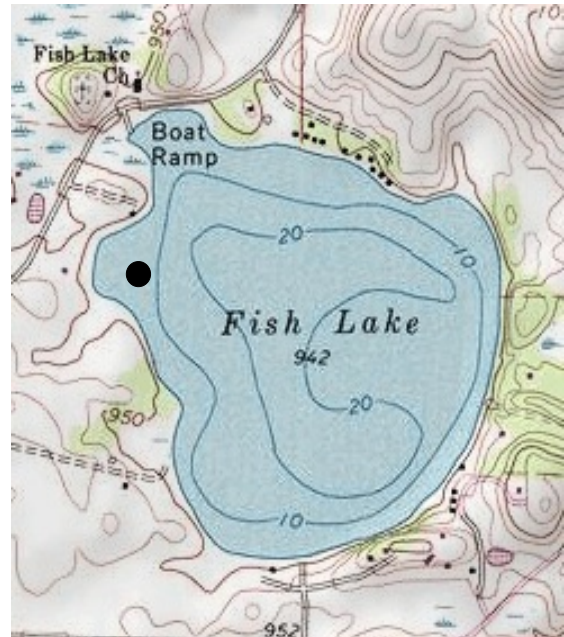


Figure 1. [left] Eleven sites within an area that was treated from 2005-2008 (dark blue shading) were monitored in April and curlyleaf was detected at three sites at low densities (green dots). [right] In June, the same sites were monitored and curlyleaf was detected at five sites. Growth was heavy at Site 9, moderate at Sites 1 and 5 and light at Sites 2 and 8.

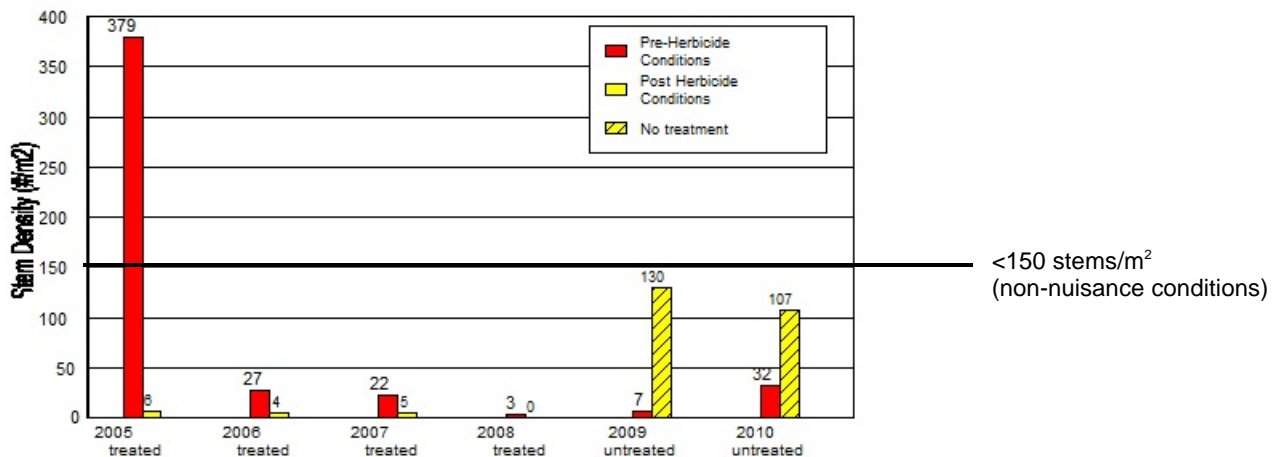
Curlyleaf Pondweed Stem Densities: Curlyleaf has been monitored at the same site on early and late season dates from 2005 through 2010. Curlyleaf stem densities were initially high on April 18, 2005. Curlyleaf was treated within this site for four years (2005-2008). No herbicide was used in 2009 and 2010. Although the early season stem density was low at 32 stems/m² on April 27, 2010, the next sample date on June 2, 2010, curlyleaf stem density averaged 107 stems/m².

Table 1. Summary of curlyleaf pondweed stem densities for both pre and post herbicide conditions in Fish Lake.

	Stem Density (#/m ²)	
	Pre-Herbicide Conditions	Late Spring Conditions
2005	379 (n=10) (April 18)	6 (n=10) (May 23)
2006	27 (n=10) (April 25)	4 (n=10) (June 2)
2007	22 (n=10) (April 16)	5 (n=10) (June 5)
2008	3 (n=10) (April 29)	0 (n=10) (June 13)
2009	7 (n=10) (April 23)	130 (n=10) (June 10)
2010	32 (n=10) (April 27)	107 (n=10) (June 2)



Monitoring site (shown in black).



Average of Fish Lake curlyleaf pondweed stem densities for early season and late season conditions in 2005, 2006, 2007, 2008, 2009, and 2010 at a 6.0-foot water depth at the monitoring site shown above.

Recommendations for 2011: Within the original 15.5 acre treatment area, it appears up to 5 acres of curlyleaf will have moderate to heavy growth in the future. The area of abundant growth in 2010 was at Site 9 (page i). This area could be treated in 2011. Early season assessments should be used to delineate potential treatment areas.

Predicted Curlyleaf Pondweed Growth Based on Lake Sediment Characteristics:

Lake sediment sampling results from 2006 have been used to predict lake bottom areas that have the potential to support nuisance curlyleaf pondweed plant growth in Fish Lake. Based on the key sediment parameters of pH, organic matter, and the Fe:Mn ratio (McComas, unpublished), the predicted growth characteristics of curlyleaf pondweed are shown in Table 2 and Figure 2.

If herbicide applications were to stop in Fish Lake, curlyleaf pondweed growth is predicted to produce mostly light to moderate growth (where plants occasionally top out) for a number of locations around Fish Lake (Figure 2).

Table 2. Fish Lake sediment data and ratings for potential curlyleaf pondweed growth. Sediment collected in 2006.

Site	Depth (ft)	pH (su)	Organic Matter (%)	Fe:Mn Ratio	Potential for Heavy Curlyleaf Pondweed Growth
Light Growth		6.8	5	4.6	Low (green)
Moderate Growth		6.2	11	5.9	Medium (yellow)
Heavy Growth		>7.7	>20	<1.6	High (red)
1	5	7.6	3.5	2.38	
2	5	7.7	2.5	4.39	
3	5	7.7	5.1	3.12	
4	5	7.6	6.4	4.13	
5	5	8.1	0.9	13.33	
6	5	7.6	3.7	2.56	
7	5	7.5	2.2	3.32	
8	5	7.5	35.7	2.74	

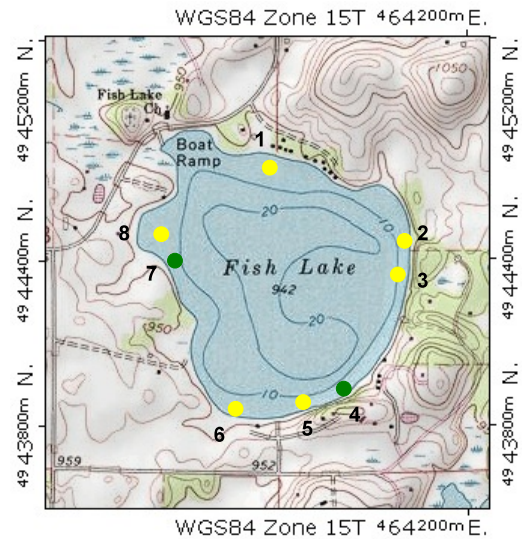


Figure 2. Sediment sample locations are shown with a circle. The circle color indicates the potential for nuisance curlyleaf pondweed to occur at that site. Key: green = low; yellow = medium; red = high potential.

Light to moderate growth typically is a non-nuisance condition. Non-nuisance growth refers to curlyleaf growth that is mostly below the surface and is not a recreational nor an ecological problem. Heavy growth refers to nuisance matting curlyleaf pondweed. This is the kind of nuisance growth predicted by high sediment pH and a low iron to manganese ratio. A chart showing the three types of growth conditions is shown on the next page.

Examples of Curlyleaf Pondweed Growth Characteristics

Light Growth Conditions

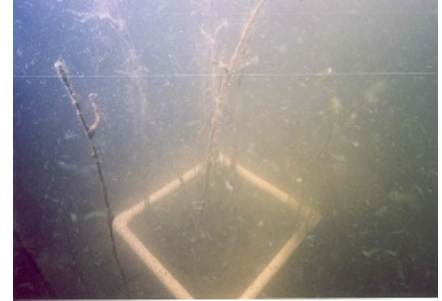
Plants rarely reach the surface.

Navigation and recreational activities are not generally hindered.

Stem density: 0 - 160 stems/m²

Biomass: 0 - 50 g-dry wt/m²

Estimated TP loading: <1.7 lbs/ac



Moderate Growth Conditions

Broken surface canopy conditions.

Navigation and recreational activities may be hindered.

Lake users may opt for control.

Stem density: 100 - 280 stems/m²

Biomass: 50 - 85 g-dry wt/m²

Estimated TP loading: 2.2 - 3.8 lbs/ac



Heavy Growth Conditions

Solid or near solid surface canopy conditions.

Navigation and recreational activities are severely limited.

Control is necessary for navigation and/or recreation.

Stem density: 400+ stems/m²



Curlyleaf Pondweed Density and Abundance in Fish Lake, Scott County, 2010

Introduction

After four years of herbicide applications (2005-2008), no herbicide treatments with Aquathol K (active ingredient is an endothal salt) were conducted in Fish Lake (171 acres) in 2009 or 2010.

The short term objective has been to reduce, to the greatest extent possible, the occurrence of the non-native plant, curlyleaf pondweed. The long-term objective is to reduce the standing crop of curlyleaf pondweed to non-nuisance conditions.

This report summarizes the curlyleaf abundance after four years of annual herbicide treatment. Curlyleaf density was sampled by scuba diving at one site on Fish Lake at a 6-foot depth and was assessed at 11 sites within a 15.5-acre treatment area.



Figure 1. Herbicides were applied to a 15-acre area from 2005 through 2008. No herbicides were applied in 2009 or 2010.

Methods

After four years of herbicide treatments on 15.5 acres (from 2005-2008), no Aquathol K was applied to Fish Lake in 2009 or 2010. Two types of surveys, curlyleaf distribution and curlyleaf stem densities were conducted on two dates in 2010. In 2010, plants were sampled on April 27, 2010 when curlyleaf was starting to grow and on June 2, 2010, when curlyleaf was at its peak biomass. Locations of the sample sites are shown in Figure 2.

Aquatic Plant Distribution Surveys: In 2010, eleven sites within a former treatment area were monitored with a rake sampler. At each sampling site, water depth, plant species, and abundance of the plant species were recorded.

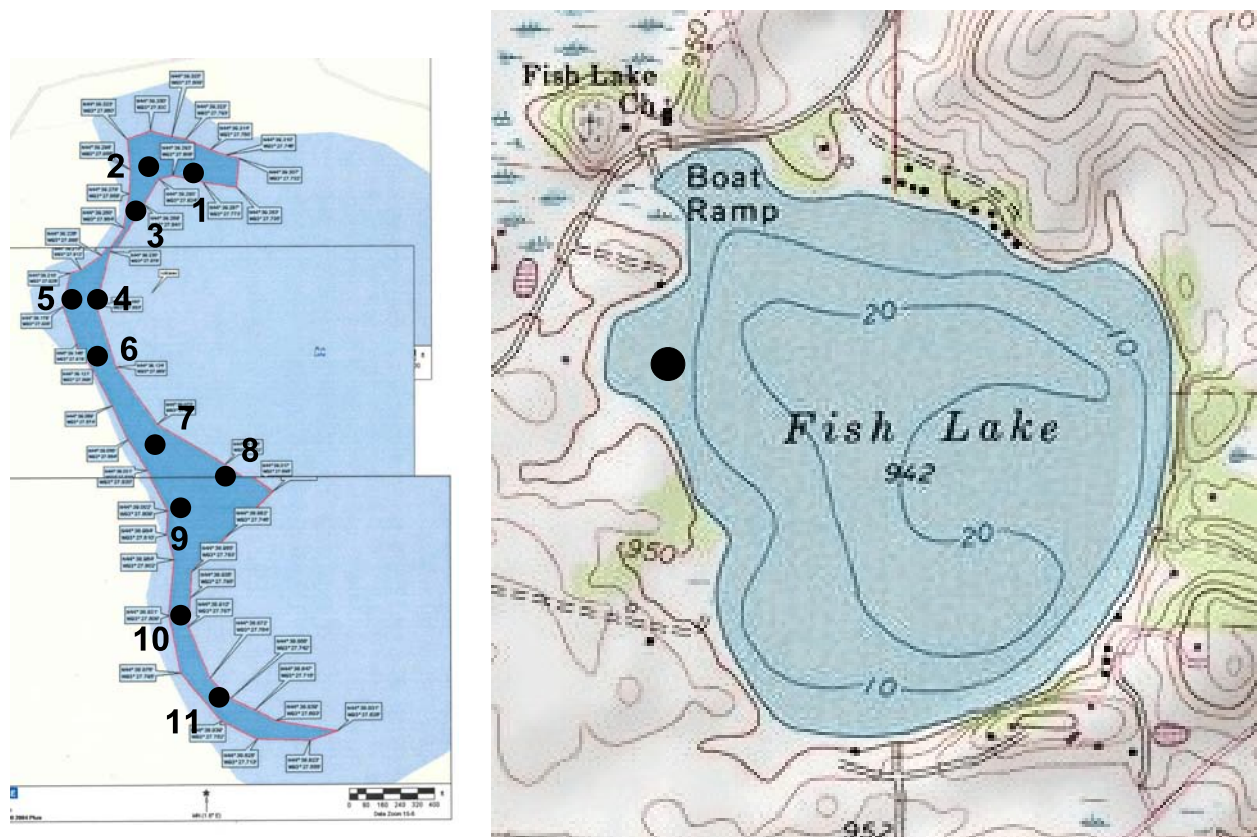


Figure 2. [left] The area treated from 2005-2008 is shown in dark blue is shown on the map to the left. The black dots shows the individual sample sites in the treatment area. Eleven sites were samples on April 27 and on June 2, 2010.

[right] Stem density determinations (10 samples) were collected from one site within an area treated from 2005-2008. Stem densities were determined using scuba diving and a 0.1 m² quadrat.

Curlyleaf Stem Density Methods: In 2010, one depth (5-6 feet) was sampled at one site on two sample dates. At the site, a total of ten curlyleaf stem density samples were taken using a 0.10 m² quadrat (Figure 3). The stem density samples were randomly collected along a 50 meter transect line that ran parallel to the shoreline at each station. Other plant species were also counted if present. The counts were made by scuba diving.



Figure 3. A 0.10 m² quadrat was used to quantify curlyleaf stem densities.

Early Spring Curlyleaf Pondweed Assessment in Fish Lake

A total of 11 sites were monitored with rake sampling on April 27, 2010 in areas that previously had been treated for four consecutive years with an endothal herbicide (Figure 4). Curlyleaf was found at three sample sites out of the 11 that were monitored (Table 1). In April curlyleaf was present in the treated area but was sparse in density and in distribution. Coontail was the dominant plant.

Table 1. Aquatic plant abundance was based on rake sampling for April 27, 2010. Densities are based on a scale from 1 to 5 with 5 being the densest.

Aquatic Plant Assessment (sampling with a rake)					
April 27, 2010					
Site	Depth (ft)	Curlyleaf	Coontail	Northern Water-milfoil	FA (filamentous algae)
1	4	0	1	0	2
2	5	1 (3 stems)	2	0	2
3	6	0	2	1	0
4	8	0	2	0	2
5	5	0	3	0	2
6	6	0	3	1	2
7	6	1 (1 stem)	2	2	3
8	9	0	1	0	0
9	5	1 (2 stems)	2	1	2
10	8	0	3	2	3
11a	8	0	2	0	3
11b	7	0	1	0	3

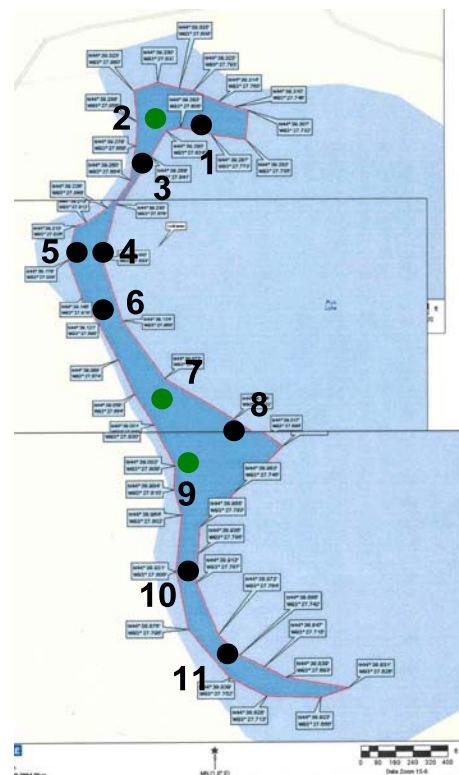


Figure 4. Map of sample locations for the April 27, 2010 curlyleaf assessment. Dark blue shading indicates area of treatment from 2005-2008.

Curlyleaf Stem Densities at One Location, April 27, 2010

Curlyleaf stem densities were determined by scuba diving at a location between sample Sites 4 and 5 (Figure 1). Ten quadrat samples were taken at this location. The results for 2010 show curlyleaf was sparse and was found at low stem densities of 32 stems/m² (Table 2). These stem densities were similar to densities found from 2006-2009 and are very low compared to pre-treatment stem densities from 2005 where 379 stems/m² were recorded (Figure 5).

Table 2. Curlyleaf pondweed stem densities for April 27, 2010. Water temperature was 58°F.

Scuba Diving	
Quadrat	April 27, 2010 (stems/m ²)
1	20
2	60
3	60
4	80
5	0
6	40
7	40
8	20
9	0
10	0
Ave	32

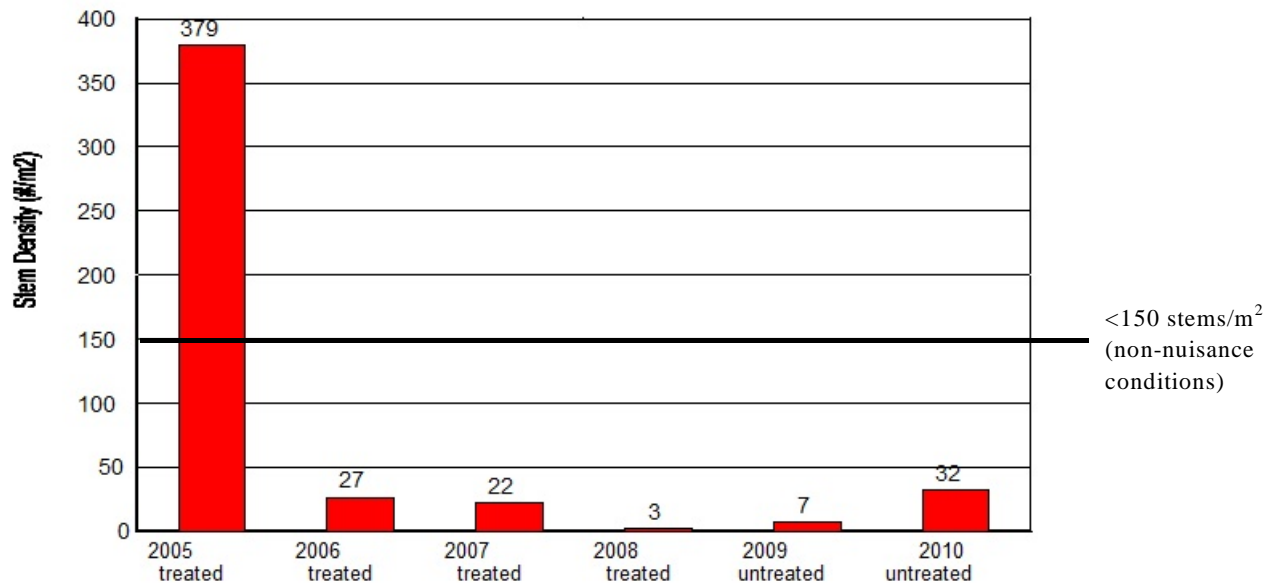


Figure 5. Curlyleaf stem densities for early season monitoring (using scuba diving) for 2005-2010.

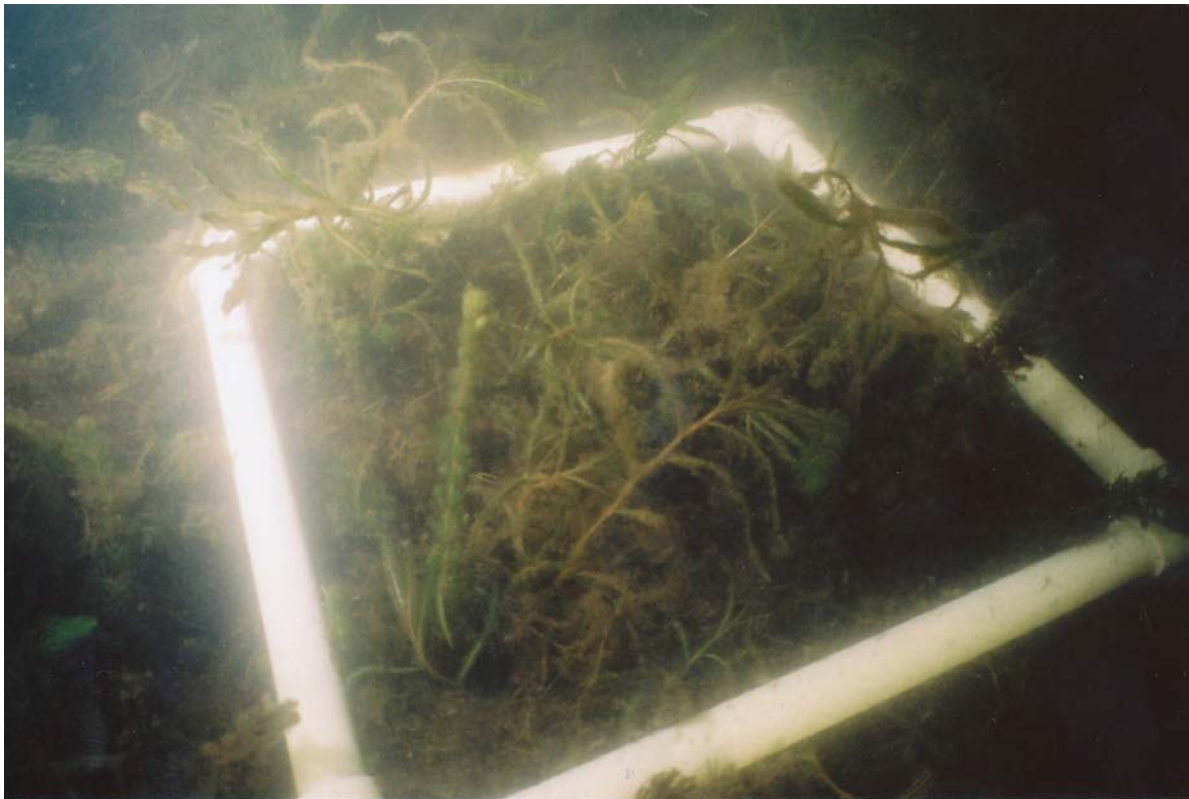
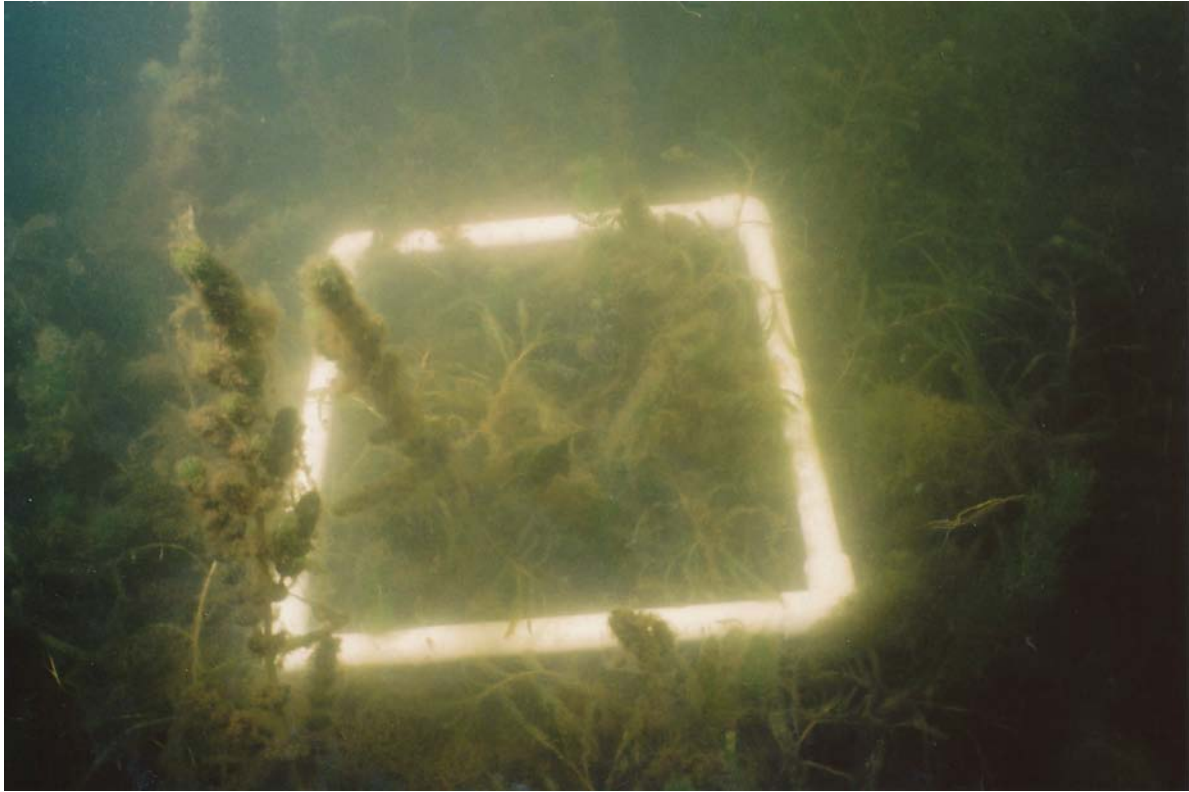


Figure 6. [top] The white frame is a quadrat sampler. All stems within the quadrat are counted. Curlyleaf was sparse at the sample sites monitored by scuba diving. [bottom] Curlyleaf pondweed and coontail were found together at 7 out of 10 quadrat samples at Site 4.

Late Spring Curlyleaf Pondweed Assessment in Fish Lake

A total of 11 sites were monitored with rake sampling on June 2, 2010 in areas that previously had been treated for four consecutive years with an endothall herbicide. There was no herbicide use in 2010. Curlyleaf was found at 5 out of 11 sample sites where as coontail was found at all 11 sites. Northern milfoil was found at five sites.

Curlyleaf at Site 9 had moderate to heavy growth. This type of growth is sometimes controlled.

Table 3. Aquatic plant abundance was based on rake sampling for June 2, 2010. Densities are based on a scale from 1 to 5 with 5 being the densest.

Aquatic Plant Assessment (sampling with a rake)				
Site	Depth (ft)	June 2, 2010		
		Curlyleaf	Coontail	Northern watermilfoil
1	5	3	1	0
2	4	0.5	2	0
3	6	0	3	0
4	6	0	3	1
5	5	3	3	0
6	5	0	2	4
7	6	0	3	2
8	7	2	2	1
9	5	4	3	1
10	6	0	3	0
11	5	0	2	0

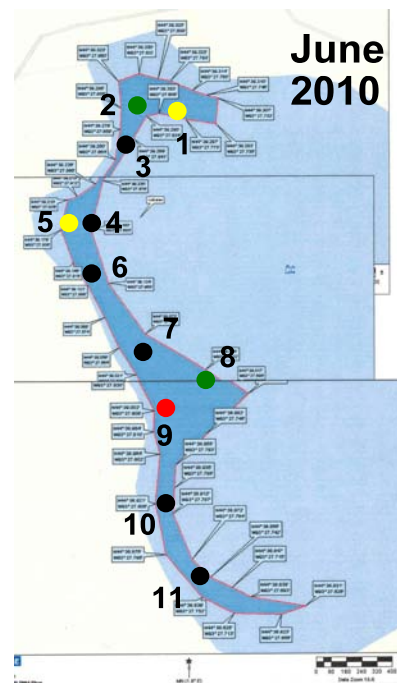


Figure 7. Map of sample locations for the June 2, 2010 curlyleaf assessment.

Curlyleaf Stem Densities at One Location, June 2, 2010

Curlyleaf stem densities were determined by scuba diving at a location between sample sites 4-5 on June 2, 2010 (Figure 1). Ten quadrat samples were taken at this location. The results for 2010 show curlyleaf was found at moderate to high stem densities but the average was a moderate density (Table 4).

The curlyleaf density on June 2, 2010 was higher than the treated years, but slightly lower compared to 2009 (Figure 8).

Table 4. Curlyleaf pondweed stem densities for June 2, 2010. Secchi disc transparency was 3.8 feet and water temperature was 73°F.

Quadrat	Scuba Diving					
	4-ft			5-ft		
	Curlyleaf (stems/m ²)	Coontail (stems/m ²)	Northern watermilfoil (stems/m ²)	Curlyleaf (stems/m ²)	Coontail (stems/m ²)	Northern watermilfoil (stems/m ²)
1	70	6	4	10	6	4
2	120	14	6	20	6	4
3	20	8	4	10	12	5
4	20	8	4	10	10	0
5	10	8	8	20	6	4
6	360	6	0	0	6	0
7	140	12	0	0	8	5
8	90	6	4	0	8	6
9	230	6	6	0	10	4
10	10	8	6	0	6	4
Ave	107	--	--	7	--	--

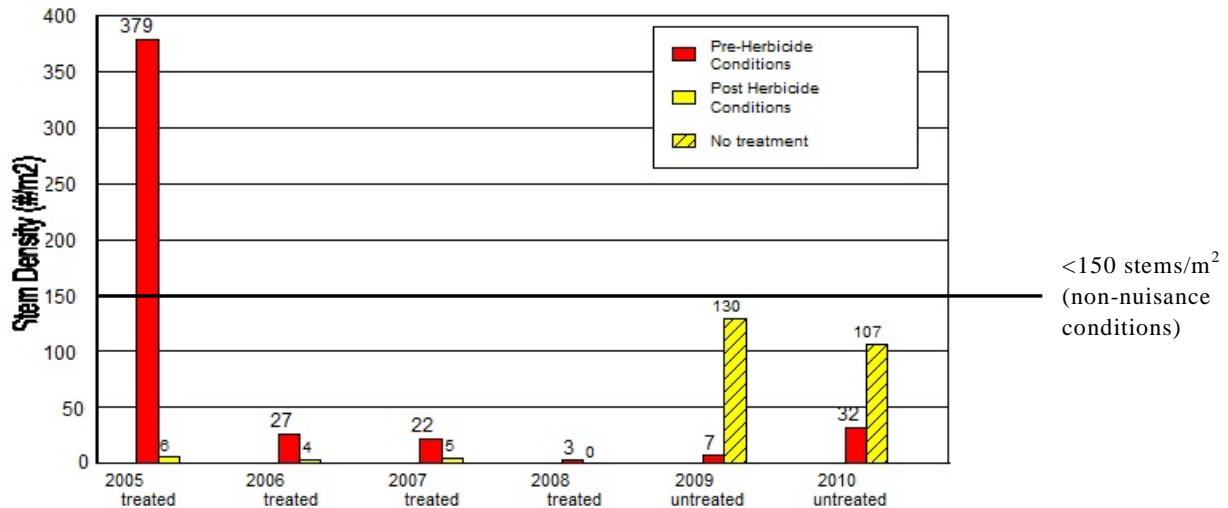


Figure 8. Curlyleaf stem densities for early and late season monitoring (using scuba diving) for 2005-2010.



Figure 9. [top] Curlyleaf pondweed was sampled at a density of a 1 on June 2, 2010. Also present on the sample rake was coontail and northern watermilfoil. [bottom] Sampling quadrat with curlyleaf pondweed stems on June 10, 2009.

Results for 2005-2010

A summary from the sampling site for curlyleaf pondweed stem densities for pre-herbicide and post herbicide conditions is shown in Table 5.

Stem density results for April conditions were higher in 2010 than in 2006 - 2009. Curlyleaf stem densities for April conditions in 2010 averaged 32 stems/m².

In 2010, stem densities in June were higher compared to years with herbicide treatments but slightly lower compared to 2009.

Table 5. Summary of curlyleaf pondweed stem densities prior to the effects of herbicide treatment and after the herbicide treatment.

Site	Stem Density (stems/m ²)											
	April Status						May or June Status					
	5 - 6 foot Depth						5 - 6 foot Depth					
	2005 (Apr 18) (n=10)	2006 (Apr 25) (n=10)	2007 (Apr 16) (n=10)	2008 (Apr 29) (n=10)	2009 (Apr 23) (n=10)	2010 (Apr 27) (n=10)	2005 (May 23) (n=10)	2006 (Jun 2) (n=10)	2007 (Jun 5) (n=10)	2008 (Jun 13) (n=10)	2009 (Jun 10) (n=10)	2010 (Jun 2) (n=10)
							treated	treated	treated	treated		
1	290	50	0	10	10	20	10	10	0	0	50	70
2	460	0	0	20	10	60	20	10	0	0	50	120
3	270	0	0	0	20	60	30	10	0	0	220	20
4	260	10	0	0	0	80	0	10	10	0	130	20
5	480	20	30	0	30	0	0	0	30	0	90	10
6	250	80	40	0	0	40	0	0	10	0	50	360
7	540	60	30	0	0	40	0	0	0	0	100	140
8	370	20	80	0	0	20	0	0	0	0	150	90
9	270	30	20	0	0	0	0	0	0	0	110	230
10	600	30	20	0	0	0	0	0	0	0	320	10
Ave	379	27	22	3	7	32	6	4	5	0	130	107

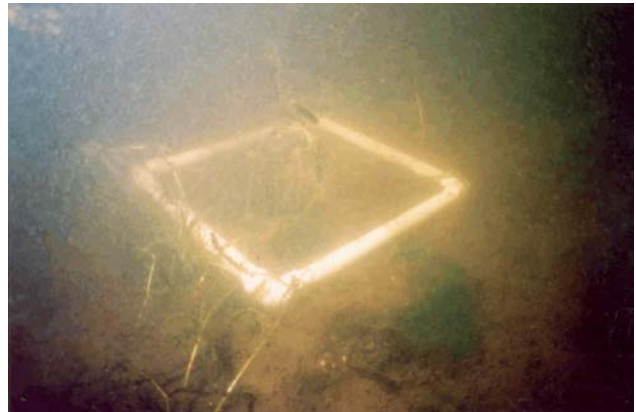
Subsurface Curlyleaf Pondweed Conditions in Fish Lake in 2005, 2006, 2007, 2008, 2009, 2010

Pre-Herbicide Conditions

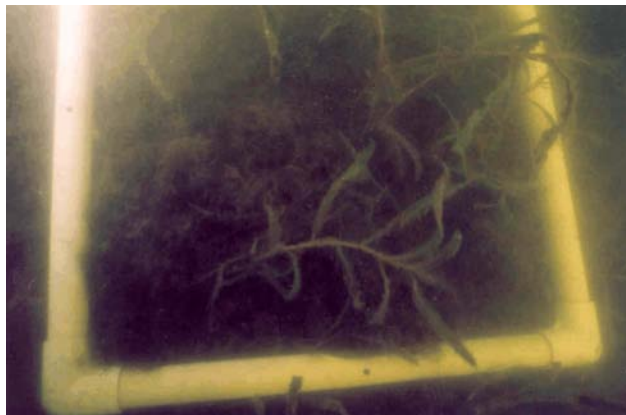
Post Herbicide Conditions



April 18, 2005



May 23, 2005



April 25, 2006



June 2, 2006



April 16, 2007



June 5, 2007

Pre-Herbicide Conditions



April 29, 2008



April 23, 2009



April 27, 2010

Post Herbicide Conditions



June 13, 2008



June 10, 2009



June 2, 2010

Curlyleaf Pondweed Conditions in early June in 2003 and 2005-2010



2003



2005



2006



2007



2008



2009

Curlyleaf Pondweed Conditions in early June in 2003 and 2005-2010



2010

Predicted Curlyleaf Pondweed Growth Based on Lake Sediment Characteristics

Lake sediment sampling results from 2006 have been used to predict lake bottom areas that have the potential to support nuisance curlyleaf pondweed plant growth in Fish Lake. Based on the key sediment parameters of pH, organic matter, and the Fe:Mn ratio (McComas, unpublished), the predicted growth characteristics of curlyleaf pondweed are shown in Table 6 and Figure 10.

If herbicide applications were to stop in Fish Lake, curlyleaf pondweed growth is predicted to produce mostly light nuisance growth (where plants occasionally top out) for a number of locations around Fish Lake (Figure 10).

Table 6. Fish Lake sediment data and ratings for potential curlyleaf pondweed growth. Sediment collected in 2006.

Site	Depth (ft)	pH (su)	Organic Matter (%)	Fe:Mn Ratio	Potential for Heavy Curlyleaf Pondweed Growth
Light Growth		6.8	5	4.6	Low (green)
Moderate Growth		6.2	11	5.9	Medium (yellow)
Heavy Growth		>7.7	>20	<1.6	High (red)
1	5	7.6	3.5	2.38	
2	5	7.7	2.5	4.39	
3	5	7.7	5.1	3.12	
4	5	7.6	6.4	4.13	
5	5	8.1	0.9	13.33	
6	5	7.6	3.7	2.56	
7	5	7.5	2.2	3.32	
8	5	7.5	35.7	2.74	

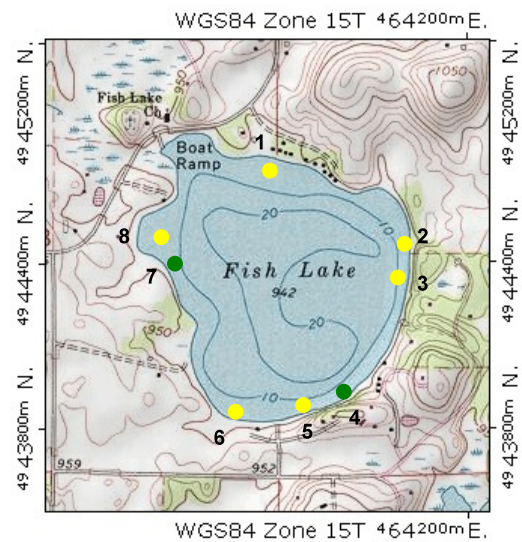


Figure 10. Sediment sample locations are shown with a circle. The circle color indicates the potential for nuisance curlyleaf pondweed to occur at that site. Key: green = low; yellow = medium; red = high potential.

Light nuisance growth has intermediate growth characteristics between non-nuisance and nuisance growth. Non-nuisance growth refers to curlyleaf growth that is mostly below the surface and is not a recreational nor an ecological problem. Heavy growth refers to nuisance matting curlyleaf pondweed. This is the kind of nuisance growth predicted by high sediment pH and a low iron to manganese ratio. A chart showing the three types of growth conditions is shown on the next page.

Examples of Curlyleaf Pondweed Growth Characteristics

Light Growth Conditions

Plants rarely reach the surface.

Navigation and recreational activities are not generally hindered.

Stem density: 0 - 160 stems/m²
Biomass: 0 - 50 g-dry wt/m²
Estimated TP loading: <1.7 lbs/ac



Moderate Growth Conditions

Broken surface canopy conditions.

Navigation and recreational activities may be hindered.

Lake users may opt for control.

Stem density: 100 - 280 stems/m²
Biomass: 50 - 85 g-dry wt/m²
Estimated TP loading: 2.2 - 3.8 lbs/ac



Heavy Growth Conditions

Solid or near solid surface canopy conditions.

Navigation and recreational activities are severely limited.

Control is necessary for navigation and/or recreation.

Stem density: 400+ stems/m²



Conclusions: At the curlyleaf monitoring site used in this study, prior to a herbicide application in 2005, curlyleaf stem densities were recorded at an average stem density of 379 stems/m². This would put curlyleaf growth into the moderate to heavy growth category. After one season of an herbicide treatment program (in 2005), curlyleaf stem densities were dramatically reduced the following season (2006) in Fish Lake. Stem densities in April of 2006 (prior to the 2006 herbicide treatment) were 27 stems/m².

Because of the low pH in the lake sediments at the 2010 sample Site 4-5 it is predicted that curlyleaf stem densities in the future could regrow to a moderate abundance condition. A low sediment pH (less than 7.7) seems to be a key variable that is correlated with light to moderate curlyleaf growth. In 2006 the sediment pH at the assessment Site 4 was 7.5.

On a lakewide basis, lake sediment results indicate a potential for light to moderate growth for curlyleaf pondweed in Fish Lake. It should be noted that moderate growth of curlyleaf pondweed can be perceived by lake users as a condition that should be managed. This type of curlyleaf

growth, which would be predicted to occur if herbicide applications are discontinued in Fish Lake, represents a slight navigational problem and a moderate phosphorus loading condition.

Within the 15.5 acre treatment area, up to 10 acres could be a candidate area for curlyleaf control with herbicides in 2011 although a treatment area of up to 3 acres is more likely.

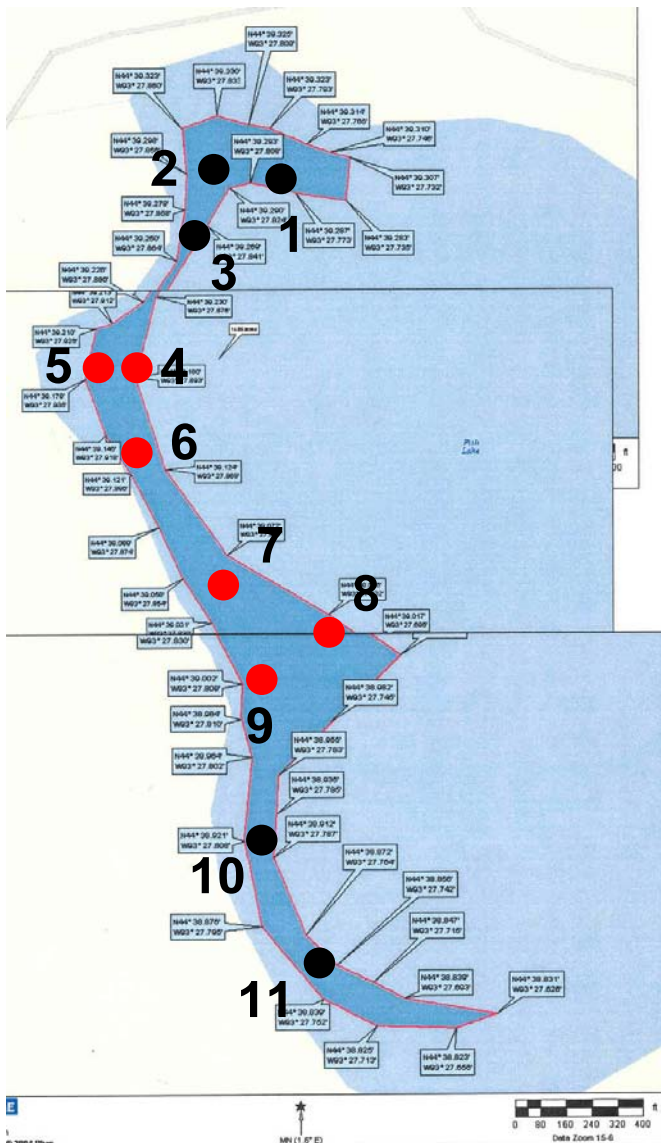


Figure 11. The red dots represent potential treatment areas totaling about 10 acres for 2010.