Underwater View of Curlyleaf Pondweed in Medicine Lake, June 11, 2011

Curlyleaf Pondweed Assessment for Medicine Lake, Plymouth, Minnesota in 2011

	2004	2005	2006	2007	2008	2009	2010	2011
Herbicide Application:	May 8-11	April 19, 21	April 18	no herbicide	May 12	May 1	April 23	May 9
Pre-Herbicide Plant Evaluation:	May 6	April 22	April 24	April 17	May 4	April 22	April 20	April 28
Post Herbicide Plant Evaluation and/or Curlyleaf Assessment	June 14	June 2	May 25	April 27, May 30	June 9	June 12	June 4	June 16
Herbicide Use:	1,668 gallons, 317 ac treated	1,400 gallons, 325 ac treated	1,400 gallons 325 ac treated	0 gallons (no herbicides used)	345 gallons 80 ac treated	415 gallons 62 ac treated	194 gallons 29 ac treated	14.7 ac treated

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Curlyleaf Pondweed Assessment for Medicine Lake, Plymouth, Minnesota in 2011

Overview: In Medicine Lake in 2011, heavy curlyleaf pondweed growth was unexpectedly more widespread compared to 2010. In 2010, 29.1 acres of curlyleaf were treated and most of the heavy growth of curlyleaf was controlled (Table 1). The extent of heavy growth in 2010 was roughly 30-40 acres. In April of 2011, initial curlyleaf densities were similar to curlyleaf densities in April of 2010. However, by June of 2011, heavy curlyleaf growth dramatically expanded and was more widespread, covering about 70 acres compared to curlyleaf growth in June of 2010. Although 14.7 acres were treated in 2011, the treatment areas did not get good control, and in addition heavy growth exceeded the treated areas as well.

Table 1. Curlyleaf pondweed treatment history in Medicine Lake from 2004-2011.

	Acres Treated with an Endothall Herbicide	Curlyleaf Control Result
2004	317	Complete control.
2005	325	Complete control.
2006	325	Complete control.
2007	0	Moderate to heavy regrowth.
2008	79.8	Good control.
2009	62.0	Good control.
2010	29.1	Good control.
2011	14.7	Poor control.

In Medicine Lake, a general curlyleaf growth pattern is beginning to emerge as yearly monitoring continues. Curlyleaf pondweed in Medicine Lake appears to exhibit heavy growth in the same areas at several locations on an annual basis. The areas of heavy growth are in the north and south ends and in the eastern side of the southwest lobe of the lake. In other areas, there are years of heavy growth and then years of light growth at the same location. The boom and bust growth cycles of curlyleaf pondweed in these specific areas are not well understood. It appears lake sediment conditions indicate an average long-term growth potential but predicting annual light or heavy growth of curlyleaf pondweed based on early season scouting remains challenging.

Recommendations for 2012: Heavy curlyleaf growth can hinder navigation and the curlyleaf dieback contributes nutrients to the water column that could be used by algae. This type of growth is the kind of growth that is considered for control. In 2012, if heavy curlyleaf growth is again widespread, up to a maximum of 60 acres of heavy growth could be considered for treatment. However, because of the observation in 2011 that turion production was low on curlyleaf plants, subsequent growth in 2012 will likely be less than it was in 2011. An early season assessment will help delineate treatment areas. In the future, for delineating areas to treat, the cumulative experience in Medicine Lake would indicate if there are five or more curlyleaf stems collected on a rake sample in April there is a strong likelihood of heavy curlyleaf growth in that area in June. This approach could be used to help delineate areas to consider for treatment.

Curlyleaf Growth in 2011

Early Season Assessment: The entire nearshore area of Medicine Lake was surveyed and specific sampling and notes were taken at 17 sites on April 28, 2011. Curlyleaf pondweed stem densities were light, with the stems collected with a rake sample usually numbering less than 5 stems per rake. At several sites, curlyleaf stem densities were found at 5 stems/rake or greater with a maximum of 12 stems/rake (Table 2). A rake typically samples an area of about 0.1 m^2. Therefore stem densities were generally less than 50 stems/m^2 with a couple of areas having densities of around 100 stems/m^2. Based on the April 28, 2011 scouting results, treatment areas were delineated for herbicide applications.

Treatment: Four treatment areas with a total treatment area of 14.7 acres were treated using an endothall herbicide on May 9, 2011.

Follow-Up Assessment: On June 16, 2011, about five weeks after the herbicide treatment, the entire nearshore area of Medicine Lake was surveyed and areas of heavy curlyleaf growth were noted (Table 2). Curlyleaf growth expanded dramatically and areas of heavy growth are shown in Figure 1. Approximately 65 acres of curlyleaf pondweed were topping out at the surface on June 16, 2011. Although 14.7 acres of curlyleaf were treated, control in treated areas was marginal and heavy growth occurred outside the treated areas as well.

Representative heavy growth of curlyleaf pondweed from an underwater perspective in Medicine Lake on June 16, 2011.

Table 2. Observations of curlyleaf pondweed density for April 28, 2011 and June 16, 2011.

Site	April 28, 2011		June 16, 2011	
	Curlyleaf Density (scale 1 to 5) (stems/rake)	Notes	Curlyleaf Density (scale 1 to 5)	Acres of Curlyleaf Pondweed and Notes
1	1 (3-4 stems)	Potential growth area.	4.5	1 ac.
2	0		1 (1 stem)	No significant growth.
3	1 (1 stem)		1 (2 stems)	Light growth.
3.5	--	Not checked.	5	4-5 ac in 5-6 feet of water.
4	0		5	Patchy, no recreational problem.
4.1	--	Not checked.	5	3-4 ac heavy growth (8 ft depth).
4.5	--	Not checked.	5	1 ac heavy growth.
5	0		0	No CLP.
6	0		2 (6-10 stems)	Light growth.
6.5	--	Not checked.	4	0.5 ac heavy growth.
7	0		0	No significant growth.
8	1-2 (4-5 stems)	Treatment area, 4.3 ac.	5	Patchy in 6-8 feet deep. Some control in treatment area.
9	1-2 (4-5 stems)	Potential growth area. CLP is 6-8 feet deep.	4.5	Hitting the surface. No turions observed.
9.5	--	Not checked.	0	EWM at a density of 2. No CLP problem.
10	1 (1 stem)		1-4	Patchy CLP at 5-6 ft, light to moderate growth.
10.5	--	Not checked.	2-4	1-2 ac of CLP topping out.
11	1 (1 stem)		1-5	Patchy CLP. Light to moderate growth.
12	1-2 (3-4 stems) & (4-8 stems)	Treatment area, 1.9 ac.	4-5	900N, 834E to 750N, 867E. Slight control in treated area.
13	1 (1-2 stems)	Potential growth area.	1-2 (5-6 stems)	Light CLP growth.
13.5	--	Not checked.	2-5	North of site 13, CLP is topping out in patches.
14	1 (1-4 stems)	Potential growth area. Claspingleaf present also.	1-2	Light CLP growth.
14.5	--	Not checked.	2-5	North of site 14, CLP is topping out in patches. Several turions observed.
15	1-2 (5-10 stems)	Treatment area, 4.1 ac.	4-5	Significant heavy growth in some areas. Partial control in treatment area.
16	1-2 (3-5 stems) & (3-12 stems)	Treatment area, 4.4 ac. 6-8 feet deep	5	2-3 ac of CLP topping out. Slight control in treatment area.
17	1-2	Scattered stems.	4-5	4-5 ac of long narrow band of topping out CLP.

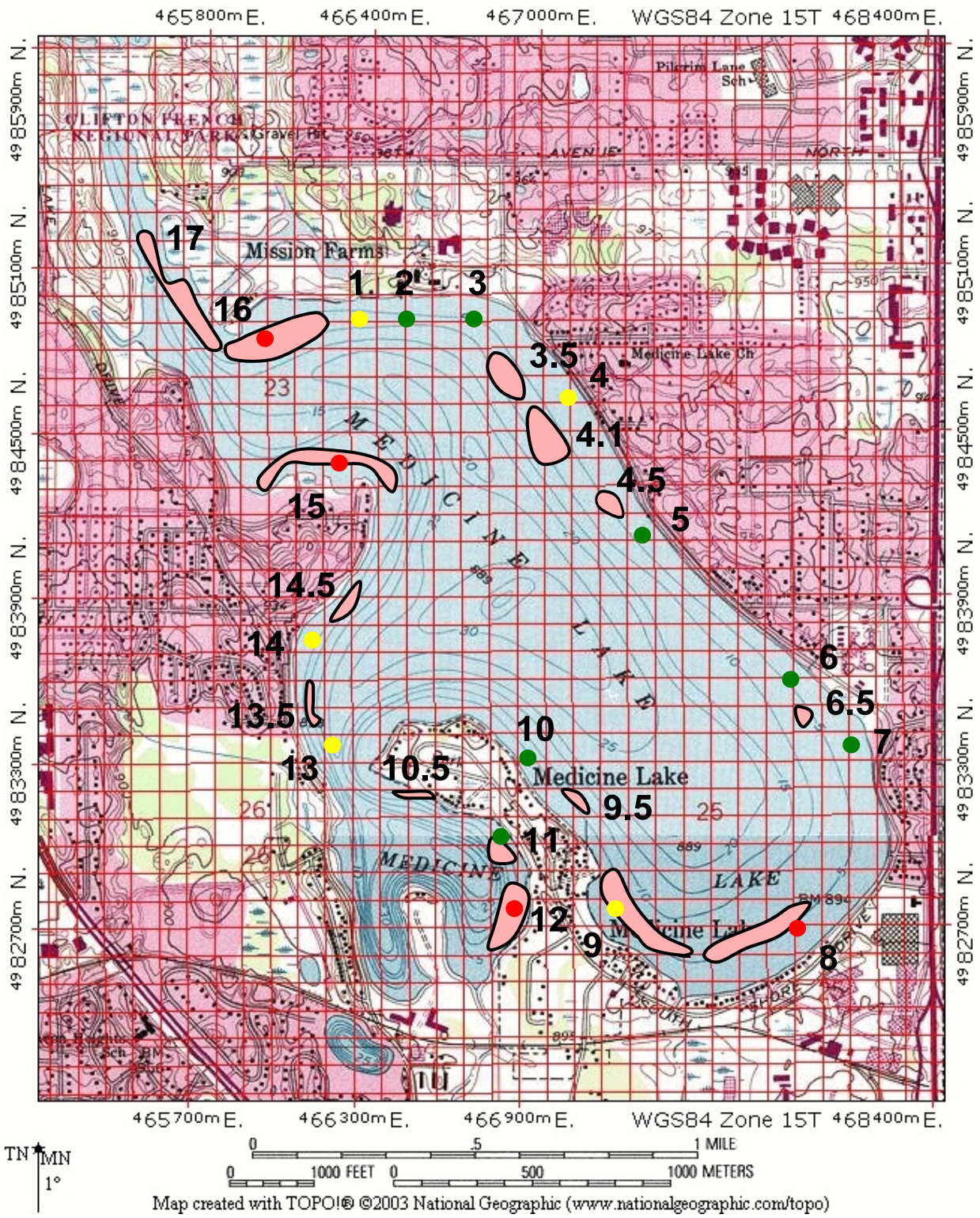


Figure 1. Curlyleaf pondweed density at various sites on April 28, 2011 is shown with dots (green = light growth, yellow = moderate growth, red = heavy growth). Curlyleaf was treated at four sites (shown with red dots) totaling 14.7 acres on May 9, 2011. Curlyleaf was checked again on June 16, 2011. Areas where curlyleaf was topping out are shown with pink shading and represent approximately 65 acres.

Curlyleaf Pondweed Growth Characteristics in April and June 2011

The methods for predicting the expansion and growth of curlyleaf pondweed for early season to late season is ongoing. In Medicine Lake, curlyleaf growth in 2011 was heavier than expected based on the April 28, 2011 assessment (Figure 3).

April 28, 2011 **June 16, 2011**

Figure 2. [left] Curlyleaf stem densities in April ranged from 1 to 12 stems per rake sample with the stem lengths less than 12 inches. Curlyleaf runners had already developed. Water temperature was 46°F.
[right] On June 16, 2011, a number of areas in Medicine Lake supported heavy curlyleaf growth.

Curlyleaf Pondweed Treatment and Response in 2011

In 2004, there was significant curlyleaf pondweed growth in Medicine Lake (Figure 3). This was the first year of an aggressive curlyleaf treatment program that ran from 2004-2006. There was no treatment in 2007 and curlyleaf started to grow back. Partial treatments have occurred from 2008-2011.

In 2011, 14.7 acres were treated but there was still significant growth of CLP. Several factors likely contributed to the heavy growth including climate and nutrient conditions as well as the fact that the herbicide application did not achieve good control in the treated areas.

2004 Curlyleaf Growth

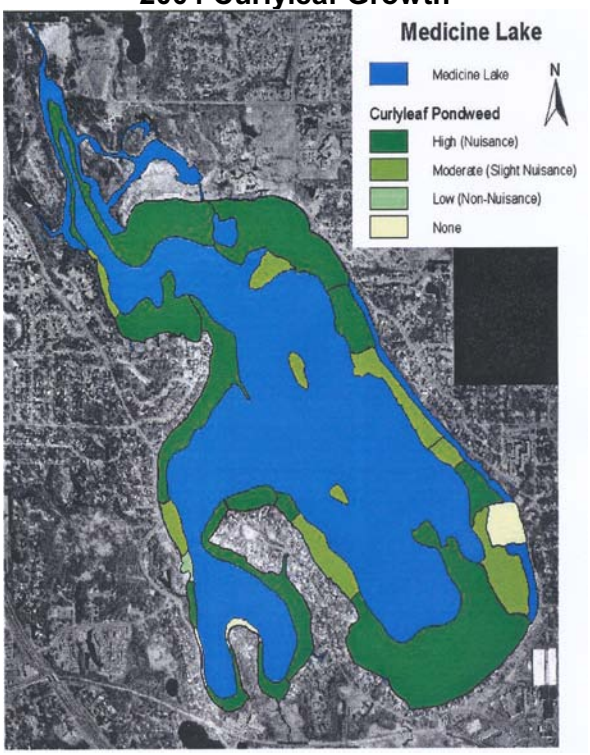


Figure 3. Curlyleaf density and distribution in 2004 (Source: Three Rivers Park District).

2011 Curlyleaf Treatment of 14.7 acres on May 9, 2011

Figure 4. Treatment areas are shown in red.

2011 Curlyleaf Heavy Growth on June 16, 2011

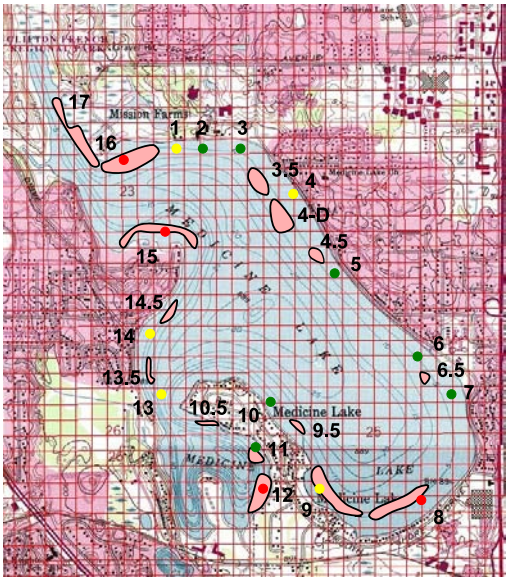


Figure 5. Curlyleaf densities on April 28, 2011 are shown with dots. Heavy curlyleaf growth on June 16, 2011 is shown with pink shading.

Comparing Curlyleaf Growth from 2010 to 2011

In 2010, curlyleaf control was fairly effective (Table 3 and Figure 6) with a small acreage of heavy growth found on June 7, 2010 (in a plant survey conducted by Three Rivers Park District)(Figure 6). In 2011, treatments did not control all the heavy growth of curlyleaf pondweed. After treatment in 2011, there were about 65 acres of heavy curlyleaf growth in June of 2011 compared to about 5 acres of heavy curlyleaf growth in June of 2010.

Table 3. Curlyleaf pondweed density on a scale from 1 to 5 with 5 the densest. NC = not checked.

Site	2010		2011	
	April 20	June 4	April 28	June 16
1	0-1	1	1	4.5
2	NC	1	0	1
3	NC	1	1	1
3.5	NC	2	NC	5
4	0-1	2	0	5
4.1	NC	2	NC	5
4.5	NC	1	NC	5
5	0	1	0	0
6	1	1	0	2
6.5	NC	1	NC	4
7	0-1	1	0	0
8	1	1	1-2	5
9	0-1	2	1-2	4.5
9.5	0-1.5	1	NC	0
10	1	1	1	1-4
10.5	0-0.5	1	NC	2-4
11	1-2	2	1	1-5
12	1	2	1-2	4-5
13	0	1	1	1-2
13.5	1-2	2	NC	2-5
14	1-2	1	1	1-2
14.5	NC	1	NC	2-5
15	1-2	1	1-2	4-5
16	1-1.5	2	1-2	5
17	1-2	3.5	1-2	4-5

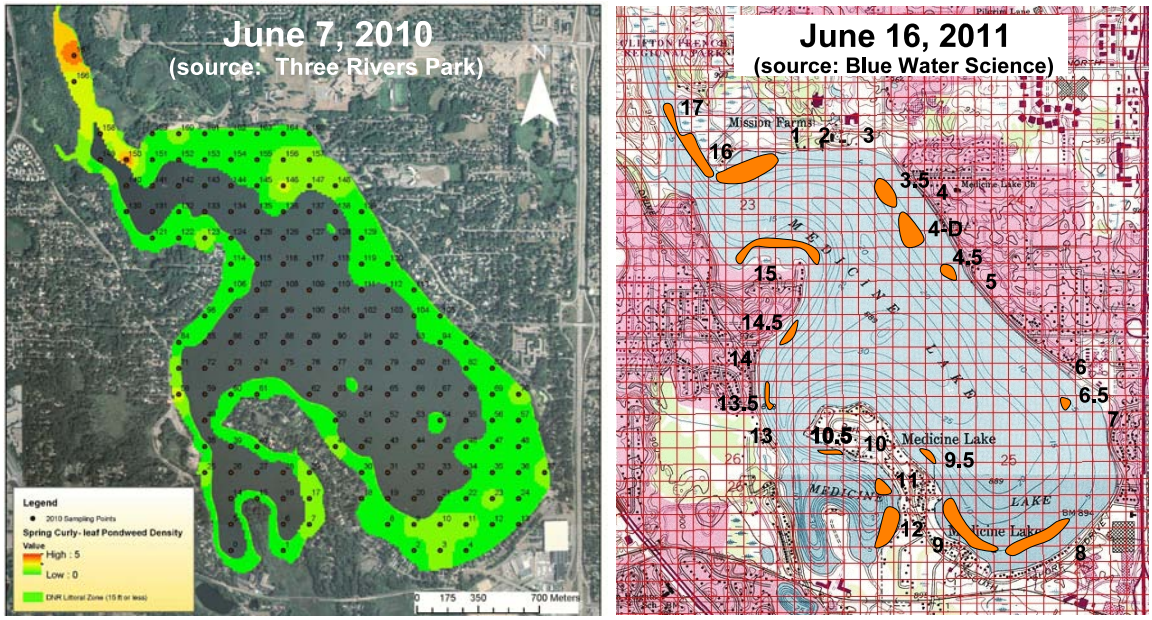
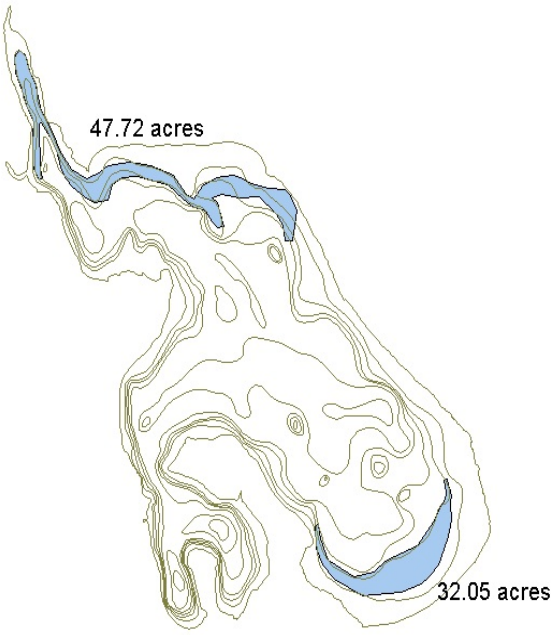


Figure 6. [left] Curlyleaf density on June 7, 2010. Orange shading represents a high density of curlyleaf growth (source: Three Rivers Park District).
[right] Curlyleaf density on June 16, 2011. Orange shading represents a high density of curlyleaf growth.

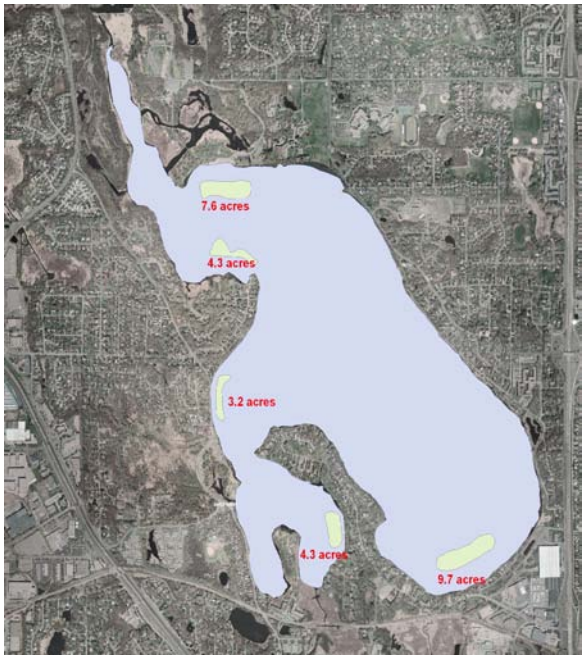
Curlyleaf Pondweed Treatment Areas from 2008-2011

2008 Curlyleaf Treatment - 80 acres

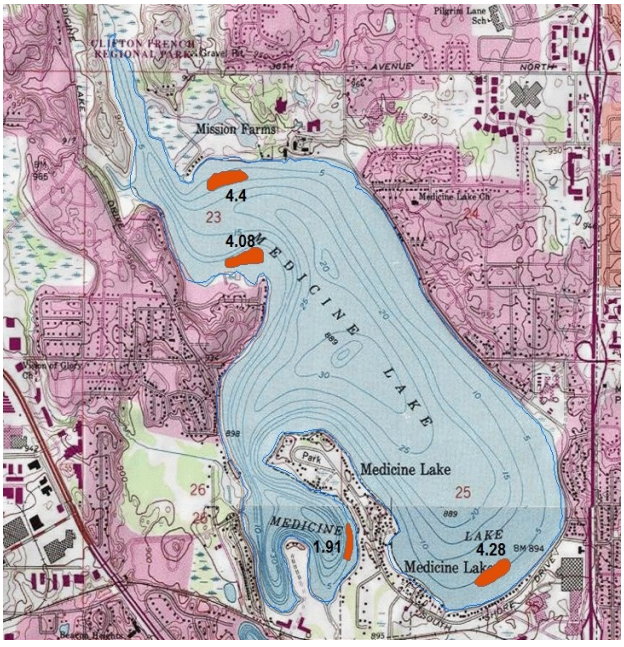


2009 Curlyleaf Treatment - 62 acres ~~62 ac~~

2010 Curlyleaf Treatment - 29.1 acres



2011 Curlyleaf Treatment - 14.7 acres



Tracking Curlyleaf Pondweed Density at Four Locations from 2004-2011

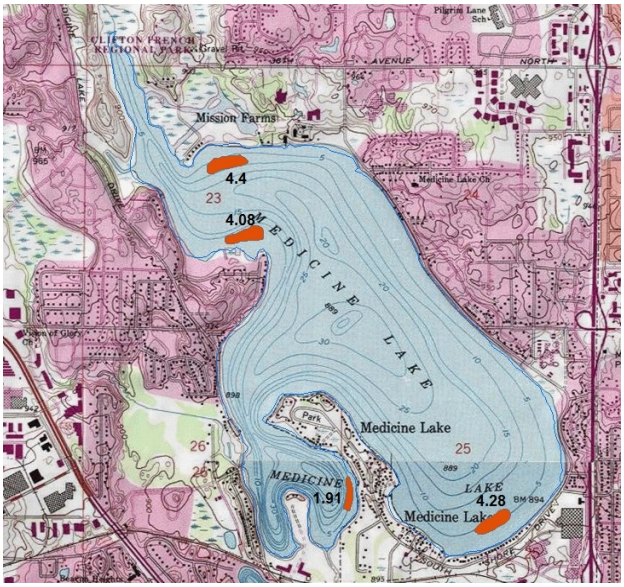
Curlyleaf stem densities at four locations were evaluated with scuba diving and quadrat sampling in 2011 (Figures 7 and 8). These same four locations have been checked since 2004. In 2011, Sites 1, 3, and 4 were treated, yet stem densities increased from May to June, indicating the herbicide application was not very effective. At Site 2, an untreated site, curlyleaf did not expand. It appears Site 2 is not conducive to heavy curlyleaf growth.

Table 4. Curlyleaf pondweed stem densities at four sites in Medicine Lake in 2011.

		May 4, 2011	June 16, 2011
		Curlyleaf Stems (stems/m^2)	Curlyleaf Stems (stems/m^2)
Site 1	6 ft	35	216
	9 ft	12	125
Site 2 (untreated)	6 ft	1	10
	9 ft	3	6
Site 3	6 ft	15	172
	9 ft	41	138
Site 4	6 ft	135	281
	9 ft	43	16
Average		35.6	120.5
6 ft average		46.5	169.8
9 ft average		24.8	71.3

Figure 7. A quadrat is a square frame laid down on the bottom. All plant stems within the 0.1 m^2 square are counted.

2011 Curlyleaf Treatment - 14.7 acres



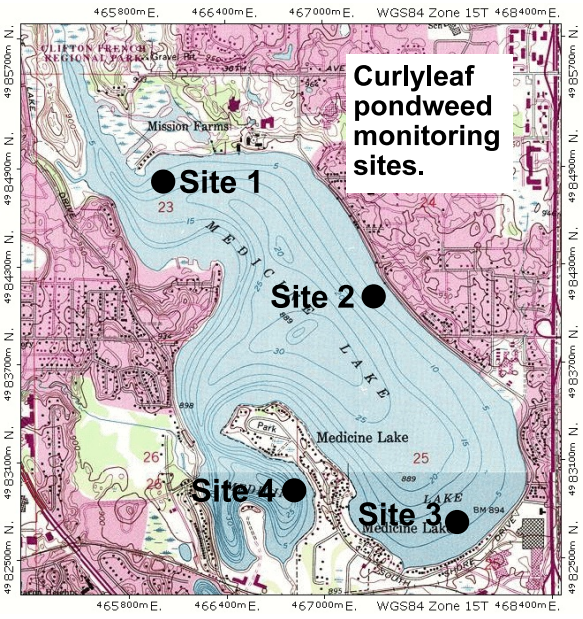
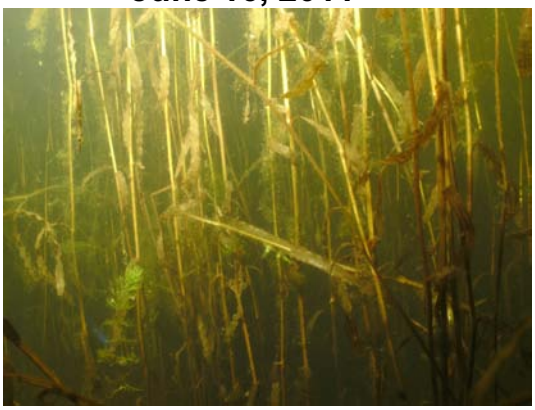
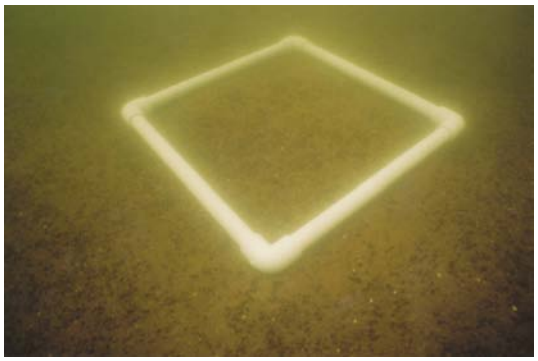
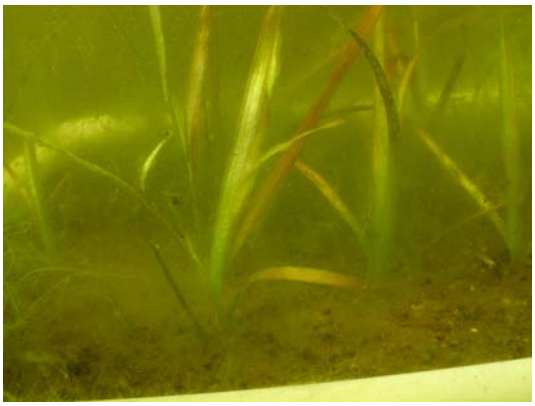
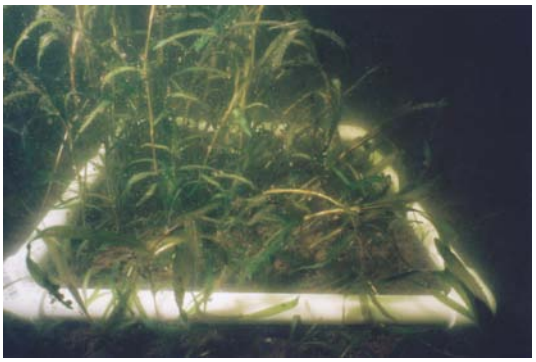
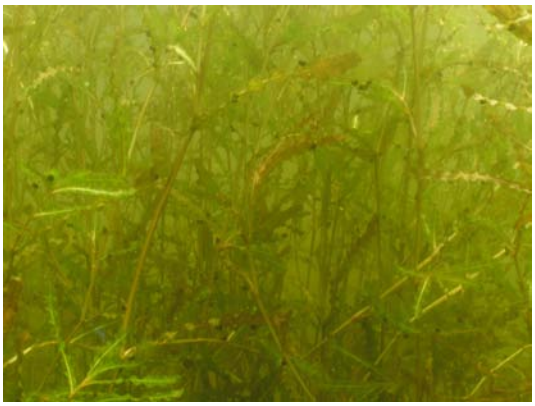
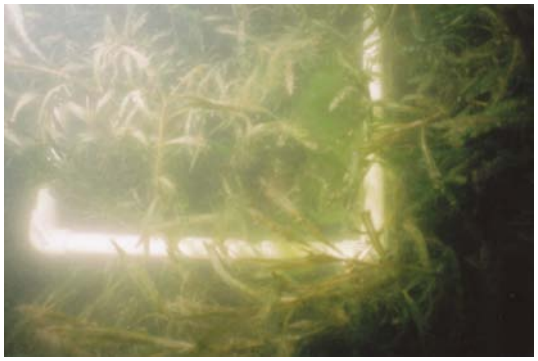
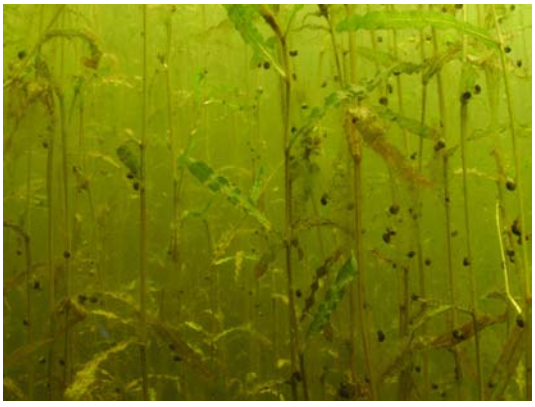


Figure 8. [left] Curlyleaf treatment areas are shown with red shading.
[right] Curlyleaf monitoring sites to collect stem densities are shown with black dots.

Underwater Curlyleaf Pondweed Growth Characteristics in 2011

May 4, 2011		June 16, 2011
	Site 1	
	Site 2	
	Site 3	
	Site 4	

Curlyleaf Pondweed Densities at Four Sites from 2004 - 2011: A summary of curlyleaf pondweed stem densities from the four permanent sample sites that have been monitored since 2004 is shown in Table 5. Stem densities at all four sites were high at the start of the curlyleaf control program in 2004 (Table 5). Stem densities were measured on May 6, 2004 and this was the reference condition. After three years of aggressive herbicide treatment with over 300 acres treated per year (in 2004, 2005, and 2006), stem densities had declined when early season stem densities from 2007 - 2011 were compared to the May 6, 2004 measurements (Table 5).

The three consecutive years of herbicide treatment (2004, 2005, 2006) reduced the early season curlyleaf stem densities in Medicine Lake. Curlyleaf was not treated in 2007 and the late season curlyleaf stem densities increased at 3 out of 4 sites. Early season stem densities increased in 2008 compared to 2007 indicating curlyleaf stem density was coming back in 3 out of 4 sites that were not treated in 2007. Two sites were treated in 2008 with good control. At the untreated Site 4, curlyleaf increased from the early to late season sampling. In 2009, three sites were treated, and late season curlyleaf growth was light at all four monitoring sites including monitoring Site 2 which was not treated. In 2010, three sites (1, 3, and 4) were treated and Site 2 was not treated. Curlyleaf pondweed stem densities were light at all four monitored sites (Table 5 and Figure 9) .

In 2011, the same three sites were treated that were treated in 2010 and 2009. However, in 2011, curlyleaf stem density control was not nearly as effective as compared to 2009 and 2010.

Table 5. Summary of curlyleaf pondweed stem densities for early (typically April) and late season (typically June) conditions for individual sites. Sites that were not treated are shown in blue shading.

		Sites (average of 6 ft and 9 ft depths)(#/m^2)				Average (all sites)
		1	2	3	4	
2004	early	667	680	611	273	558
	late	2	2	0	0	1
2005	early	304	408	27	385	281
	late	0	0	0	0	0
2006	early	31	114	130	68	86
	late	0	16	73	25	29
2007	early	8	16	9	23	14
	late	61	80	152	15	77
2008	early	131	83	18	20	63
	late	0	59	0	402	116
2009	early	43	21	3	49	29
	late	4	0	0	5	2
2010	early	13	1	9	32	14
	late	0	11	39	39	12
2011	early	24	2	28	89	36
	late	171	8	155	149	121

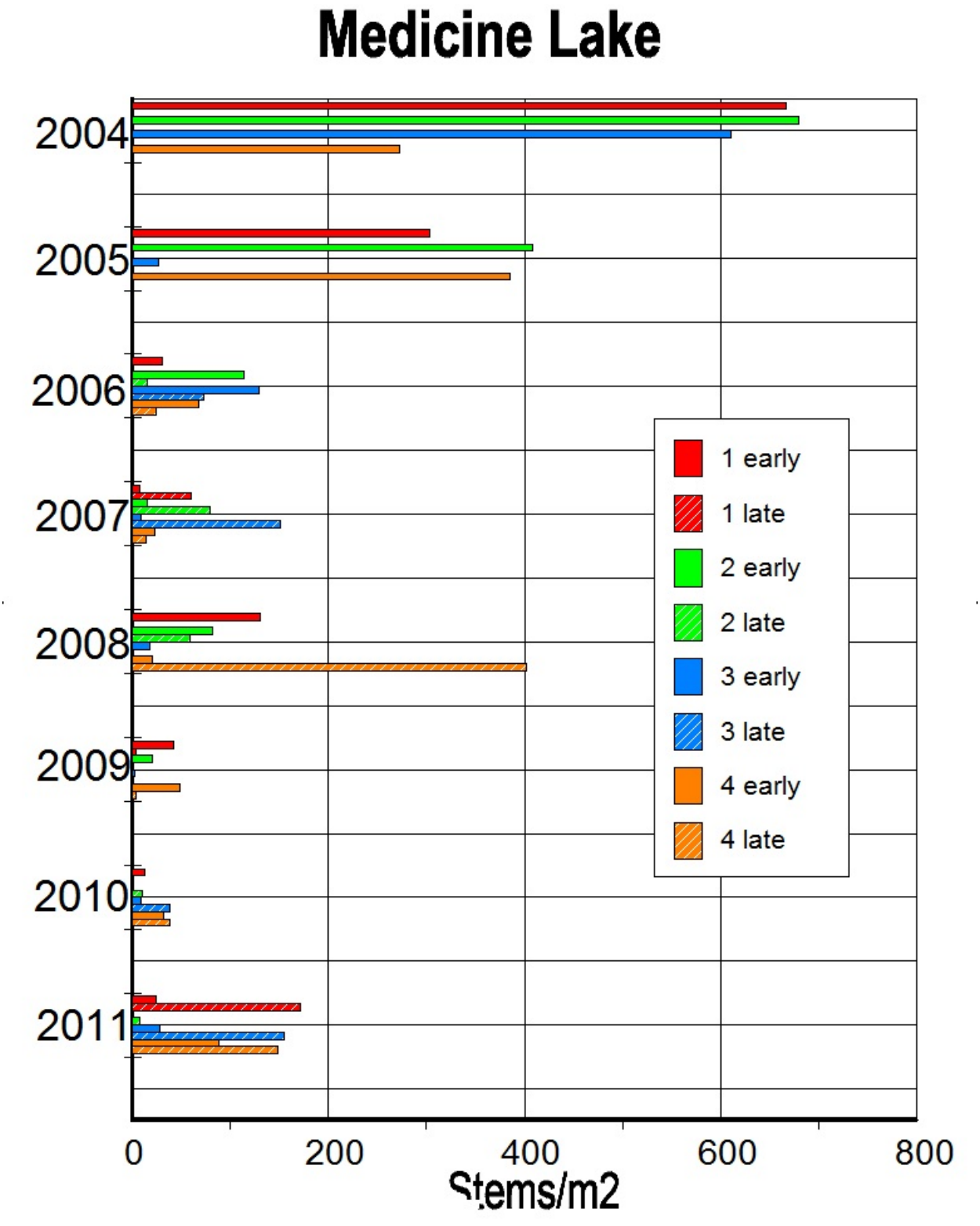


Figure 9. Medicine Lake curlyleaf pondweed stem densities from 2004-2011 for four sites for early and late spring conditions. Initial stem densities were high in 2004.

Discussion and Recommendations for 2012

Aquatic plant management in Medicine Lake keeps evolving. A 3-year lake-wide curlyleaf pondweed control program involving the treatment of between 317 to 325 acres was conducted in 2004, 2005, and 2006. This was a distribution control strategy where all curlyleaf was treated with the objective to restrict curlyleaf by diminishing or depleting all turions in the lake. Then in 2007 no curlyleaf treatment was conducted. During the 2007 growing season, curlyleaf re-growth was uneven but significant with some areas showing light growth and other areas approaching heavy growth.

Much was learned from this aggressive control program, chiefly, that a three-year lake-wide treatment would not keep curlyleaf from coming back in Medicine Lake. Starting in 2008, the distribution control strategy evolved into a biomass control strategy, where only the heavy curlyleaf growth was treated. This biomass control strategy has been employed from 2008 through 2011.

Results from June 2011 found poor curlyleaf control in treatment areas resulting in some heavy growth in treatment areas with additional heavy growth in untreated areas as well. Although the treatment of 29.1 acres controlled the majority of heavy curlyleaf growth in 2010, in 2011 it was estimated that there was 65 acres of heavy growth. The treatment of 14.7 acres in 2011 did not achieve the goal of reducing nuisance growth of curlyleaf in recreational areas.

In 2012, the likely coverage of heavy curlyleaf growth is not expected to exceed the 65 acres of heavy growth found in 2011. The 65 acres of heavy curlyleaf growth is about the maximum that has been found in Medicine Lake in years past and is not likely to be greater than that amount, although curlyleaf growth could be present in other areas, but at light to moderate levels. In addition, it was observed turion production was low on 2011 plants and this could limit curlyleaf growth in 2012 because curlyleaf growth comes from turions.. A likely curlyleaf treatment range for 2012 is between 30 to 60 acres.

Predicting the exact acres of heavy growth with subsequent early season herbicide treatments remains challenging. It is recommended that in 2012, early season scouting should be combined with previous growth history and lake sediment information to delineate areas to treat. The biomass control strategy which just treats areas of heavy growth is a more cost-effective and ecologically-sound option than the distribution management strategy which treats all curlyleaf, regardless of growth status.

There appears to be a potential for areas of heavy curlyleaf growth in Medicine Lake. Lake sediment sampling results from 2009 have been used to predict lake bottom areas that have the potential to support three types of curlyleaf pondweed plant growth: light, moderate, or heavy based on the key sediment parameters of pH, the Fe:Mn ratio, sediment bulk density, and organic matter (McComas, unpublished). Curlyleaf pondweed growth is predicted to produce a combination of moderate growth (where plants may occasionally top out in a broken canopy) and heavy growth (mostly a solid canopy) in Medicine Lake. The north and south ends of the lake appear to be conducive to heavy growth with some areas of heavy growth in the southwestern lobe.

Predicted Curlyleaf Pondweed Growth Based on Lake Sediments

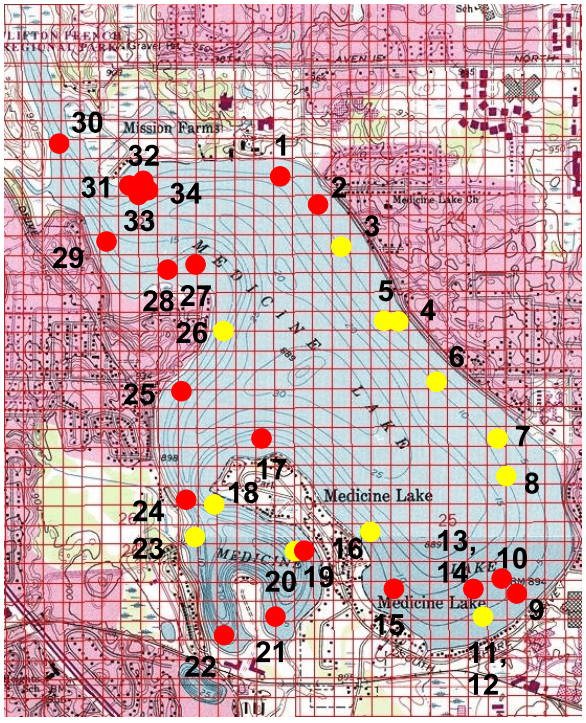


Figure 10. Sediment sample locations are shown with a circle. The circle color indicates the type of curlyleaf pondweed growth predicted to occur at that site. Key: green = light; yellow = moderate; red = heavy.