Spring Lake on May 28, 2015

Aquatic Plant Surveys and Curlyleaf Pondweed Evaluation for Spring Lake, Scott County, Minnesota in 2015

No Open Lake Herbicide Application from 2007- 2015

Curlyleaf Pondweed Survey and Spring Plant Survey: May 28, 2015
Summer Point-Intercept Plant Survey: July 30, 2015

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Summary

Curlyleaf pondweed distribution and abundance were delineated in Spring Lake on May 28, 2015 to determine if curlyleaf control was needed. Curlyleaf growth was observed at 15 out of 59 samples sites (Figure S1). Growth was relatively light and no curlyleaf treatment was conducted. A follow-up late season survey was conducted on July 30, 2015 to check the status of curlyleaf pondweed and native plant community in Spring Lake.

The late season plant survey found curlyleaf was still growing but growth was still light. (Figure S2). There has been no open water curlyleaf treatment in Spring Lake from 2007 through 2015.

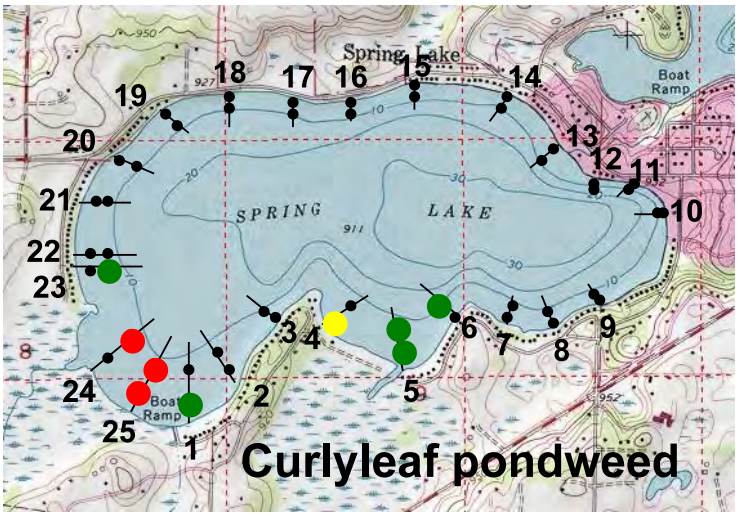


Figure S1. Map of curlyleaf pondweed for May 28 2015. Colored sample areas indicate the growth in May of 2014 for curlyleaf pondweed. Green = light growth and yellow = moderate growth and red = heavy growth.

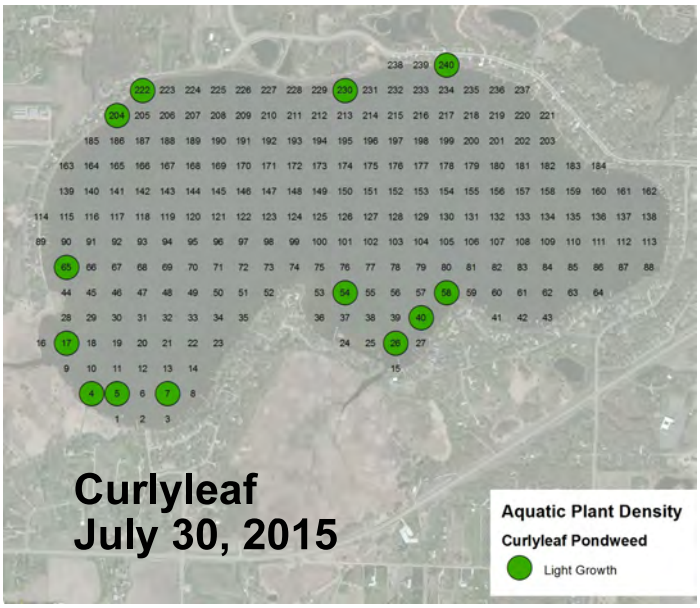


Figure S2. Map of curlyleaf pondweed sample points from a July 30, 2015 point-intercept survey. Colored sample points indicate the growth in late July, 2015 for curlyleaf pondweed. Green = light growth of curlyleaf pondweed and Yellow = moderate growth of curlyleaf pondweed.

What's Next? Treating heavy growth of curlyleaf pondweed based on early season curlyleaf distribution was conducted in Spring Lake from 2002 through 2006. However, there has been no treatment necessary due to light growth from 2007-2015. Stem density assessments have supported the treatment or no treatment decisions (Figure S3).

In 2015 there were 2 areas measuring a total area of less than10 acres that potentially could have been treated based on the early season survey. Determining what areas to treat to control excessive growth of curlyleaf pondweed has been an ongoing challenge. Curlyleaf growth in April and May is just starting to go into a rapid growth phase. However, not all early season curlyleaf growth will result in heavy curlyleaf growth in June. It appears there are factors that limit curlyleaf growth and significant variables are associated with sediment conditions. The question is how to best delineate areas to treat what could be heavy growth in June but not overtreat areas where growth wouldn't be a nuisance for the season. Currently, for Spring Lake, the method has been to use past treatment history combined with early season scouting and then a recheck to evaluate any treatment effects and see if curlyleaf areas were missed. Using this approach, 2 areas from the May survey were predicted to produce heavy CLP growth in June. The subsequent summer plant survey found curlyleaf pondweed had reached low to heavy densities with some heavy growth.

In 2016, curlyleaf delineation and assessment surveys are recommended to keep track and monitor the curlyleaf growth. Previous sediment survey results indicate where light, moderate, and heavy curlyleaf growth are likely to occur based on sediment characteristics. These results combined with data from 2015 and then early season curlyleaf scouting in May will give confidence in areas to treat, if needed in the future. Areas to be treated with herbicides can be limited to areas of heavy growth. Areas where light growth is expected based on lake sediment characteristics could be left untreated.

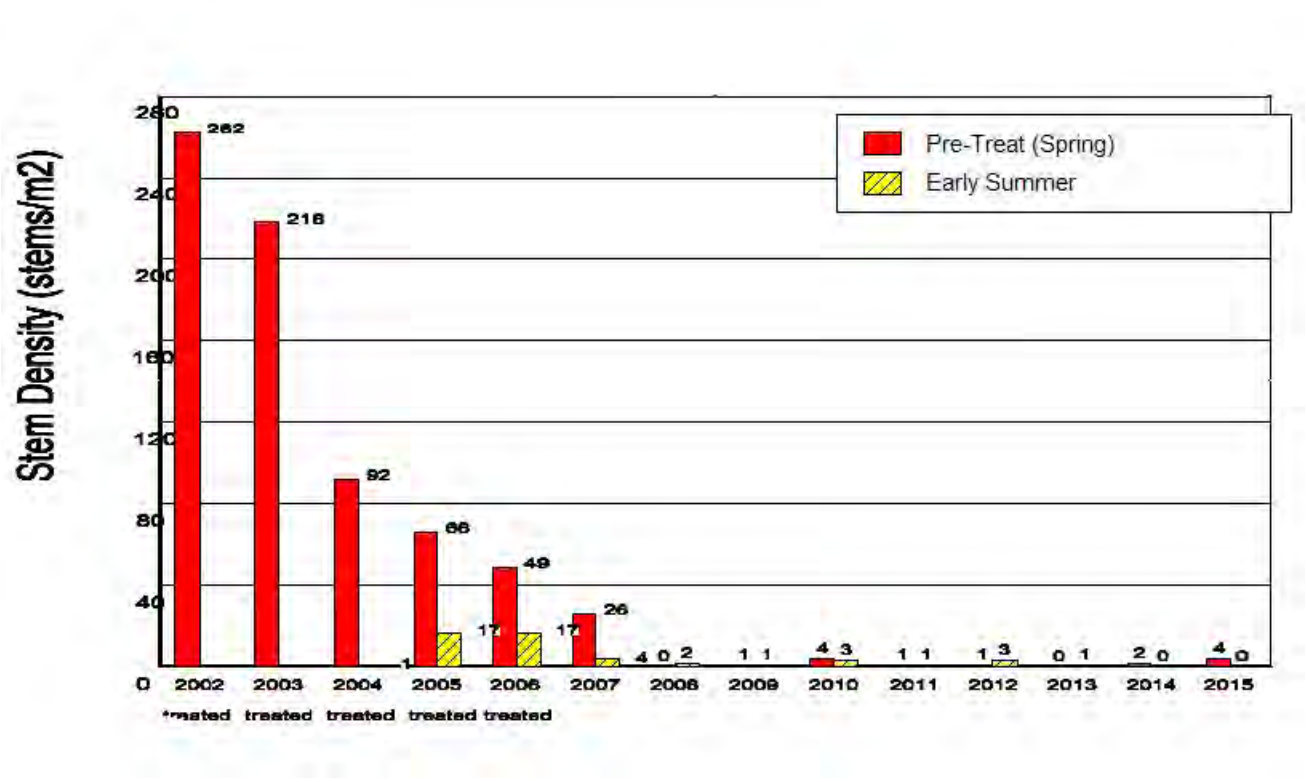


Figure S3. Curlyleaf stem densities for early season monitoring for 2002-2015 for two sites in Spring Lake. Curlyleaf stem densities have been low since 2007 and no treatment has occurred.

Aquatic Plant Surveys and Curlyleaf Pondweed Evaluation for Spring Lake, Scott County, Minnesota in 2015

Introduction

Spring Lake has an area of 592 acres with a littoral area of 290 acres (source: MnDNR). A curlyleaf pondweed delineation survey was conducted on May 28, 2015. Fifty sample locations on 25 transects are shown in Figure 1 as well as areas where curlyleaf has been found in the past.

A summer aquatic plant point-intercept survey was conducted July 30, 2015 to assess both curlyleaf growth as well as the native plant community in Spring Lake.

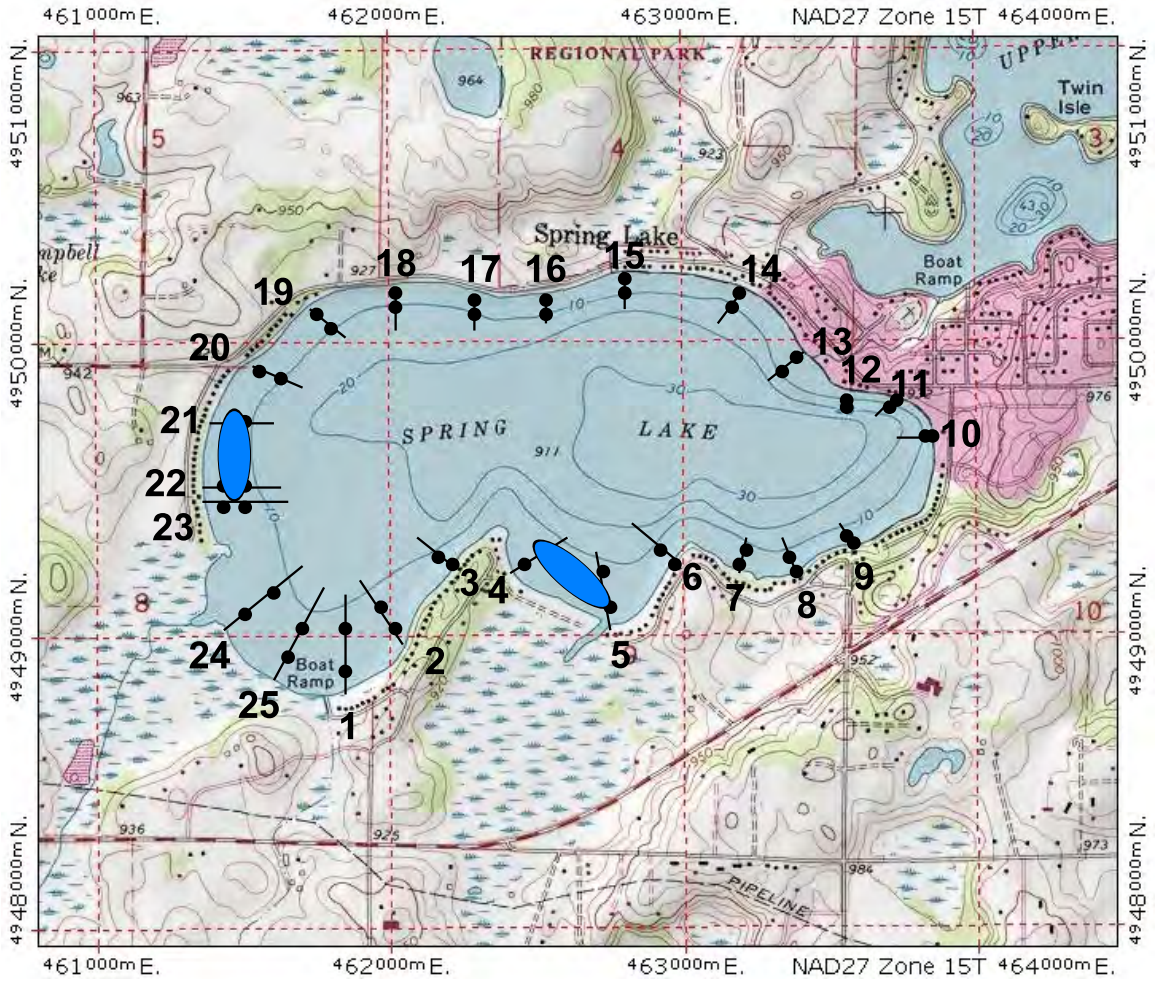


Figure 1. Transect and sample sites for whole lake plant surveys are shown with black numbers. There are 50 aquatic plant sample sites. There are two underwater evaluation sites located in the dark blue shaded areas. Map of treatment areas form 2002-2006 (5 years) are shown in dark blue shading.

Curlyleaf Pondweed Delineation Using an Early Season Aquatic Plant Survey, May 28, 2015: A curlyleaf survey using an aquatic plant line-transect survey was conducted on May 28, 2015 and curlyleaf was found at 15 out of 59 sites (Table 1 and Figure 2). Although there were 8 individual sites or points with a moderate to heavy growth potential, the individual sites were considered to be non-nuisance taken together and no broad herbicide application was recommended.

Table 1. Aquatic plant densities based on rake sampling for May 28, 2015. Densities are based on a scale from 1 to 5 with 5 being the densest. Curlyleaf stems per rake sample were also noted. Gray shading indicates additional sites that were sampled. Those points are shown in Figure 3.

Sample Site	Depth (ft)	CLP	CLP stems	Elodea	Stringy	FA	No plants
1	4	2	8		1	2	
1	6						1
2	4					2	1
2	7						1
3	4					2	1
3	6						1
4	4	3	15		1		
4	6				1		
5	4	2	6		1		
5	6	2	6				
5	7	1	1				
6	4						1
6	7	1	2				
7	4					2	1
7	7						1
8	4						1
8	8						1
9	4						1
9	6						1
10	4						1
10	6						1
11	4					1	1
11	6						1
12	4					1	1
12	6						1
13	4					2	1
13	6					1	1
14	4						1
14	8						1
15	4						1
15	7						1
16	4						1
16	6						1
17	4					1	1
17	6						1
18	4						1
18	6						1
19	4					1	1
19	7						1
20	4					1	1
20	6					1	1
21	4					2	1
21	6			1			
22	4				1		
22	6					1	1
23	4			1	2		
23	6	1	5				
24	4	4		1			
24	5	4	18				
25	4	5					
25	5	5					
Average		2.7	7.6	1.0	1.2	1.4	
Occurrence (51 sites)		11	8	3	6	14	36
% occur		22	16	6	12	27	71

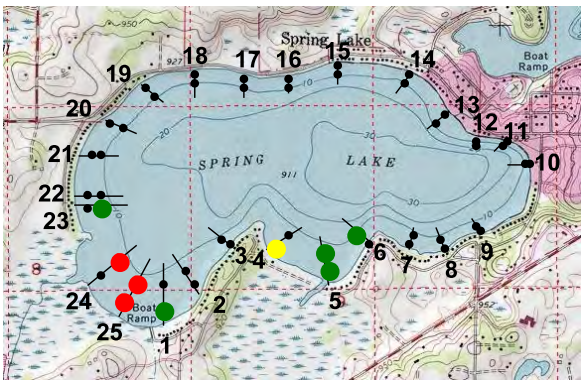


Figure 2. Map of curlyleaf pondweed for May 28 2015. Colored sample areas indicate the growth in May of 2015 for curlyleaf pondweed. Green = light growth, yellow = moderate growth and red = heavy growth.

Curlyleaf Comparison of May 21, 2014 and May 28, 2015: Full aquatic plant surveys using transects were combined with additional sampling to delineate areas of predicted heavy growth of curlyleaf in 2014 and 2015 (Figure 3). Based on the curlyleaf plant survey 4 areas of potential heavy curlyleaf growth were delineated in 2014 and are shown in Figure 3. Similar areas were found with the potential for heavy curlyleaf growth in 2015 (Figure 3).

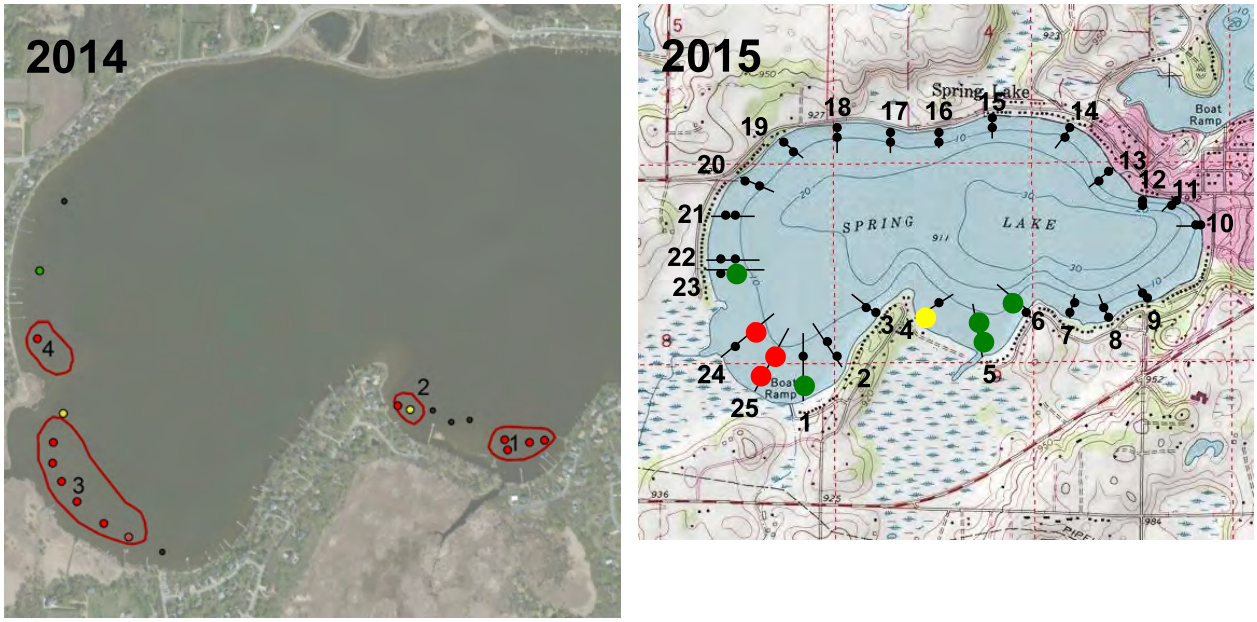


Figure 3. [left] Curlyleaf delineation in Spring Lake on May 21, 2014. Curlyleaf was growing and 4 areas had potential heavy growth that was delineated.
[right] Curlyleaf delineation in Spring Lake on May 28, 2015.
Key: Green dots = light curlyleaf growth, yellow dots = moderate growth, and red dots = heavy growth. Black dots = no curlyleaf.

Curlyleaf Stem Densities Collected at Two Treatment Locations on May 28 and July 30, 2015: Curlyleaf stem densities were determined at two depths for sample locations at Transect 4.5 and Transect 22 that were treated from 2002-2006. Ten quadrat samples were taken at two depths at each location. A total of 40 quadrat samples were taken on each date. The results for 2014 show curlyleaf was sparse and was found at low stem densities for spring and early summer (Table 2). These stem densities were similar to densities found from 2008 through 2014 and are low compared to pre-treatment stem densities from 2002 where there were over 250 stems/m^2 (Figure 7).

Table 2. Curlyleaf pondweed stem densities (stems/m^2) for 2015.

Quadrat	May 28, 2015 (stems/m^2)				July 30, 2015 (stems/m^2)			
	T4.5		T22		T4.5		T22	
	4 ft	5 - 6 ft	4 ft	5 - 6 ft	4 ft	5 - 6 ft	4 ft	5 - 6 ft
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	80	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	30	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	30	0	0	0	0
AVE	**3**	**0**	**8**	**3**	**0**	**0**	**0**	**0**

Curlyleaf Plant Density from 2002 - 2015: Rake sampling was used to collect 10 samples of curlyleaf stem densities at 4 feet and 5 feet for 10 sites at each depth at two locations in early and late season dates. Data from the two sites (n=40) for each date are shown in Figure 4. Curlyleaf stem densities have been very low since 2007.

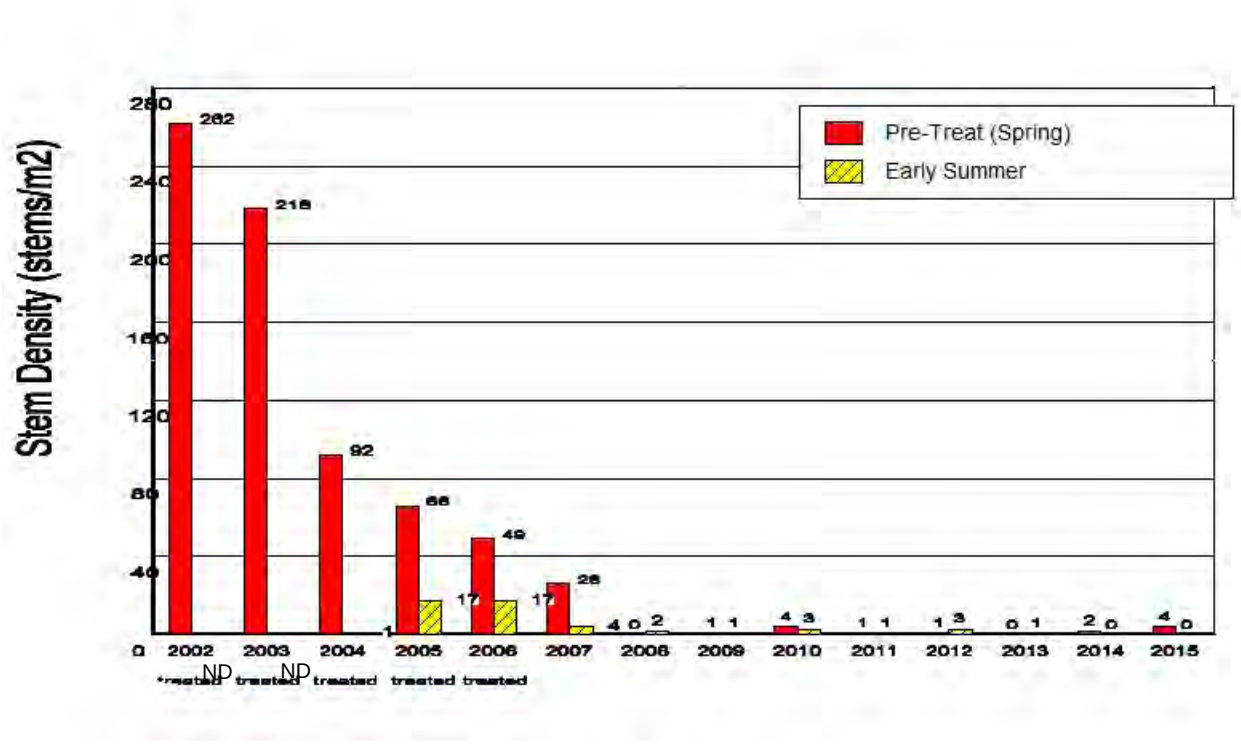


Figure 4. Curlyleaf stem densities (stems/m^2) for early season and late season monitoring (using scuba diving) for 2002-2015 (ND = no data).

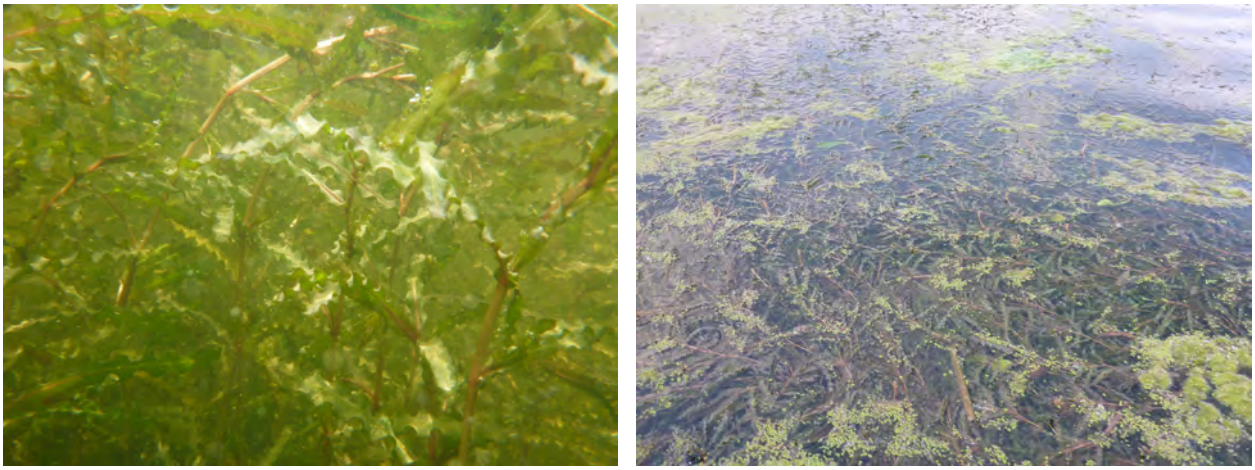


Figure 5. Curlyleaf pondweed conditions in May. [left] Underwater view of curlyleaf in May 2015. [right] Curlyleaf stems reaching and matting at the lake surface.

Review of Spring Lake Aquatic Plants Over the Years

Summary of Whole Lake Curlyleaf Pondweed Surveys for 2007-2015: Curlyleaf pondweed was found at 11 locations out of the 51 that were monitored on May 28, 2015 in the course of an aquatic plant survey that sampled two depths on 25 line transects. Curlyleaf growth was sparse in 2015 and has been sparse since 2007. From 2007 through 2015 there have been no open water herbicide applications (Table 3).

Table 3. Summary of Curlyleaf Pondweed Distribution and Abundance from 2000 - 2015.

Transect	Depth	2000	2002	2003	2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		2014		2015		Predicted growth based on lake soils
		Jun 3	Jun 7	May 15	May 2	Jun 14	Apr 20	Jun 1	Apr 26	Jun 2	Apr 15	Jun 5	Apr 29	Jun 13	Apr 23	Jun 10	Apr 27	Jun 2	May 12	Jun 10	Apr 17	Jun 5	May 29	Jun 24	May 21	June 19	May 28	Jul 30	
1	S	5	0.5	0	0	0	0	0	0	0	0	2	0	0	0.5	2	0	0	0	0	0	0	1	1	0	1	2	0	
	M	4	2	2	1	0	1	1	0.5	0	0	0	0.7	1	1	0	0	0	0	0.5	0	0	0	0	0	0	0	1	Heavy
2	S	4	0.5	0	0.5	0	0	2	1	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	
	M	5	2	4	0.5	0	0	0.3	0.7	0	0	1.8	0	1	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	Moderate
3	S	2	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0.5	1	0	0	0	0	0	0	0	0	0	0	Light
	M	4	2	0.5	0.5	0	0.5	1	0.8	0.5	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	Light
4	S	4	2	0.5	1	0	1	0	0	0	0	0	0.5	0	0	1	0	0	0	0.5	0	0	0	0	2	1	3	0	Moderate
	M	5	2.5	4	1	0	2	0.8	1.3	0.7	0	1	0	0.5	0	0	0	0	0	0.5	0	0	0	1	0	0	0	1	
5	S	2	2	0.5	1	0	2	1	1	0.5	0	0.7	0	0	0	0.5	1	1	0	2.5	0	0	0	0	2	2	2	0	
	M	5	3	2	2.5	0	0.5	0	2	1	0	0	0	0	0	0	1	1.3	0	0.3	0	1	0	3	2	0	2	1	Light
6	S	1.8	0	0	0.5	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	
	M	2	2	1	1	0	0.5	0.5	2	0.3	1	0	0	0	0	0	0.5	0	0	0	0.5	0	0	0	0	0	1	1	Moderate
7	S	1	0.5	0	0	0	0	0	1	1	1	1	0	1	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0	
	M	4.5	1.5	1	0	0.5	0.5	1	1.8	1	0.5	1.5	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	Light
8	S	1	1	0	0.5	0	0.3	1	0	0	0	0	0	0	0	0	0.5	0	0.5	0	0	1	0	0	0	0	0	0	
	M	3	1	1	0	0	0.5	1	0	0.3	0	0	0	0	0	0.5	0	0	1	0	0	0	0	0	0	0	0	0	Moderate
9	S	4	0.5	0	0	0	0	1	0	1	0	1	0	0	0	0	1	0.5	0	2	0	1	0	1	0	0	0	0	Moderate
	M	4	0.5	0.5	0.5	0	0	1	0.8	0.5	0.5	1.8	0	0	0	0.5	0	0.5	0	0	1	0	0	0	0	1	0	0	
10	S	2	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	
	M	4	0	0	0.5	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	Light
11	S	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	M	3	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Moderate
12	S	3	0.5	0	0.5	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	2	0	0	
	M	3	0.5	0	0.5	0	0	0	0	0	0	1	0	0.3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
13	S	0	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
	M	2.7	1	0.5	0.5	0	0.5	0.7	1	1.7	0.8	3.5	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	Moderate
14	S	3	0.5	0.5	0.5	0	0	1	2	0.5	1	1	0	1	0	0	0.5	1	0.5	1	0	0	0	0	0	0	0	0	
	M	4	1.5	2	1	0	2	1.5	2	3	1	2.8	0	1.5	0	0	0.5	1	0	1	0	0	0	0	0	0	0	0	Moderate
15	S	2	1	0.5	2	0	0.3	1	1	2	0	3.5	0	1	0	2	1	1	0	0	0	0	0	0	0	0	0	0	
	M	2	0.5	3	1	1	1	1.5	1	2.5	1.3	2.8	0	2	0	0.3	1	1	0.5	0.5	0	0	0	0	0	1	0	1	Moderate
16	S	2	0	0.5	0.5	0	0.5	1	1.3	0	0	1	0	0	0	0	1	1	0	0.8	0	0	0	1	0	1	0	0	
	M	4	4	1	1	1	1	1	0.5	1.5	0.5	1.8	0	0	0	0	1	1	0	0.5	0	0.5	0	0	0	0	0	1	Moderate
17	S	2	1	0.5	1	0	1.5	1	1.5	2	0.5	0	0	0	0	0	1	0	0	0.5	0	0	0	0	0	1	0	0	Light
	M	4	2	2	1	0	1	0	1.5	1.7	0.3	2	0.3	0	0	0.3	1	1	0	0	0	0	0	0	0	1	0	0	
18	S	2	0	0.5	0.5	0	1	1	0	2	0.5	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	
	M	4	3	2	1	0	2	1.8	0.8	2.5	0.5	1	0.3	0	0	0	1	0	0.5	0.5	0.3	0.5	0	0	0	0	0	0	Light
19	S	3	1	3	0.5	0	0.5	1	0	3	0	1	0	0	0	0.5	1	1	0	0	0	0	0	0	0	0	0	0	
	M	5	1.5	2	0.5	0	0.3	0.3	0	0	0	0	0	0	0	0	0	1	0	0	0.5	0	0	1	0	0	0	1	Moderate
20	S	3	1	0.5	0.5	0	0	2	1.5	3	0.5	2.8	0	0	0	0	0.5	1	0	0	0	0	0	0	0	0	0	0	Moderate
	M	5	1.5	2	0.5	0	1.5	2	0.3	3	0.5	0	0	1	0.3	0	0.5	0.5	0	0	0	0	0	1	0	0	0	1	
21	S	2.5	0.5	0.5	0.5	0	0	1	0.5	3	0	1.5	0	0	0	1	1	0.5	0.5	0	0	0	0	0	0	0	0	0	Moderate
	M	5	2.5	3.5	0.5	0	2	0.5	1.3	3	0	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
22	S	3	0.5	0	0	0	0	0	0.5	2	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	
	M	5	2	3	1	0	1	1	0.2	1	1	0	0	0	0	0	0.5	0	0	0	0	0	0	0	1	1	0	0	Moderate
23	S	2	1	0	0.5	0	0	0	0	1	1	0	0	0	0	1	0	1	0.5	0	0	0	0	0	2	1	0	0	
	M	4.7	4.5	3	0.5	0	1	1	0.8	1.3	0.5	1	0	0.5	0	0	0	0	0	0	0	0	0	1	1	0	1	1	Moderate
24	S	3	1	0.5	0.5	0	0	4	0.5	0	1	0	0	1	1	2	0	1	0	0	0	0	0	0	2	1	4	0	
	M	5	1.5	4	2	0	1.5	0.5	0.5	1.3	0.5	0	0	1	0	0	1	1	0	0	0	0	1	1	3	1	4	1	Moderate
25	S	2	1	0.5	0.5	0	1	2	1.8	2	1	0.5	0	1	1	1	0	2	0.5	1	0	0	0	2	1	1	5	1	
	M	4.7	3	4	0	0	1	1	1.7	0.5	0	0	0	1	0	0	1	0	0	0.8	0	0	1	3	1	3	5	1	Moderate
Number of Reds		23	2	4	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	

Depth Zones: S = 0 - 4 feet; M = 5 - 8 feet

Figure 6. Summary of curlyleaf pondweed density for early summer aquatic plant surveys for Spring Lake from 2000-2015. Curlyleaf density is shown on a scale from 0.5 - 5 (with 5 being most dense) for each depth zone on all 25 transects for each survey. Colors are coded for density. A sediment survey was conducted on Spring Lake in 2008. Predicted curlyleaf growth (far right column) has been close to actual curlyleaf growth conditions. Purple shading in transect column indicates transect areas that were harvested or treated with herbicides from 2002-2006 (blue shading for years of treatment). There has been no treatment from 2007-2015. Purple shading in Transect column indicates transect areas that were harvested or treated with herbicides from 2002-2006 (blue shading for years of treatment. There has been no treatment from 2007-2015.

Curlyleaf Pondweed Treatment and Coverage from 2002 - 2015: Spring Lake is a 580 acre eutrophic lake in Scott County, Minnesota with a history of nuisance curlyleaf pondweed growth going back to the 1980s. In 2000, heavy growth of curlyleaf pondweed was estimated at 180 acres. Major nuisance areas of curlyleaf were managed annually in Spring Lake from 2002 through 2006 (5-years). In 2006, there was an estimated 150 acres of curlyleaf pondweed but at mostly low to moderate abundance, prior to treatment. From 2007 through 2015, herbicides have not been applied in offshore areas. However, the coverage of curlyleaf has not increased in this time span. It is not clear why curlyleaf has been under control. In 2007, curlyleaf covered about 113 acres and in 2008 curlyleaf covered about 60 acres in June. In 2009 through 2015, curlyleaf covered about 50 to 90 acres and no heavy growth was observed (Figure 9).

Table 4. Curlyleaf treatment history for 2002 through 2015.

	Between T4 & T5	Between T19-25	Shorelines
2002	herbicides (14 ac)	harvesting (60 ac)	herbicides (individual permits)
2003	herbicides (14 ac)	harvesting (74 ac)	herbicides (individual permits)
2004	herbicides (14 ac)	herbicides (45 ac)	herbicides (individual permits)
2005	herbicides (14 ac)	herbicides (45 ac)	herbicides (individual permits)
2006	herbicides (14 ac)	herbicides (45 ac)	herbicides (individual permits)
2007	no treatment	no treatment	no treatment
2008	no treatment	no treatment	herbicides (individual permits)
2009	no treatment	no treatment	herbicides (individual permits)
2010	no treatment	no treatment	herbicides (individual permits)
2011	no treatment	no treatment	herbicides (individual permits)
2012	no treatment	no treatment	herbicides (individual permits)
2013	no treatment	no treatment	herbicides (individual permits)
2014	no treatment	no treatment	herbicides (individual permits)
2015	no treatment	no treatment	herbicides (individual permits)

Recommendations for 2016: Based on the findings for the last few years, no offshore herbicide treatments for the areas of T4-T5 (14 ac) and T19-25 (45 ac) are expected. However, early season scouting and plant surveys should be conducted to monitor potential curlyleaf problems. A late summer survey is recommended as well. It appears native plants may be increasing in Spring Lake and this survey would document the dynamics of the aquatic plant community.

Figure 7. Curlyleaf pondweed growth was very heavy in 2000.

Figure 8. Curlyleaf pondweed growth was ling in 2014 at the same location as shown in Figure 10.

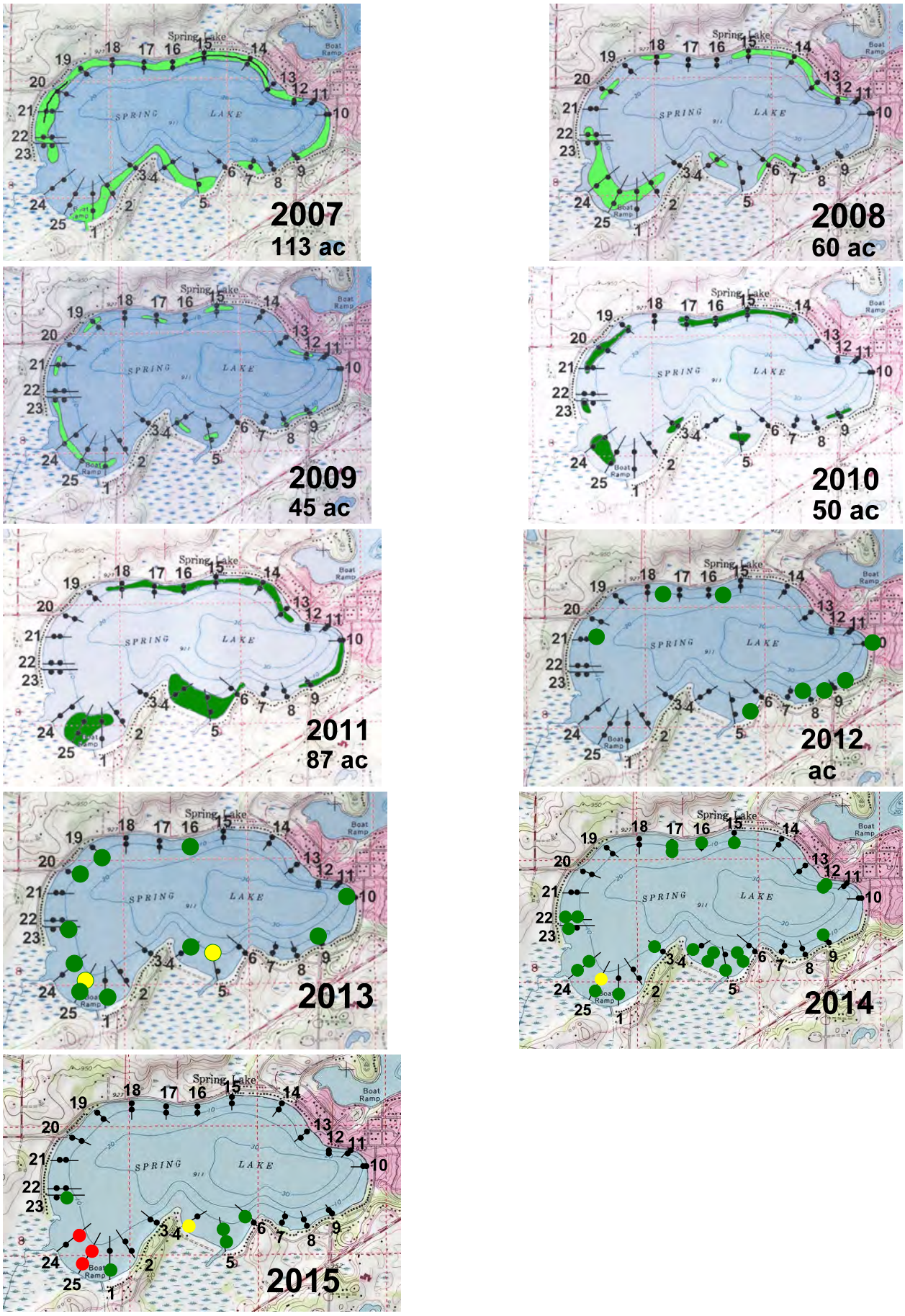


Figure 9. Curlyleaf pondweed distribution during the peak growing season from 2007 through 2015.

2015 Point Intercept Survey

Introduction: An aquatic plant point-intercept survey was conducted on 592 acre Spring Lake, located in Scott County on July 30, 2015. The objective of the survey was to characterize the aquatic plant community.

Methods: An aquatic plant point-intercept survey of Spring Lake was conducted by Blue Water Science. A total 113 points in the littoral zone were sampled. Sample points were spaced 50 meters apart on a grid that covered the lake (Figure 10). At each sample point, a sampling rake was lowered into the water and a plant sample was taken. The plant species were recorded and the density of each species was assigned. Densities were based on the coverage on the teeth of the rake. Density ratings ranged from 1 to 5 with 1 being sparse and 5 being heavy growth. Based on these sample sites, a plant distribution map was constructed.

Figure 10. Point-intercept sample sites for Spring Lake in 2015. Sample sites were spaced 50 meters apart.

Results - Point Intercept Aquatic Plant Survey on August 24, 2015:

Results of the summer aquatic plant survey conducted on July 30, 2015 found nine native submerged plant species and one non-native plant species present and restricted to water depths of 7 feet or less in Spring Lake (Table 5). Coverage of the native plants species found in the July survey are shown in Figure 11. Native plants were found around the perimeter of the basin of Spring Lake. Plant distribution and abundance are shown in Table 5.

Table 5. Spring Lake aquatic plant occurrence and density for the July 30, 2015 survey based on 74 sites. Density ratings are 1-5 with 1 being low and 5 being most dense.

Spring Lake	All Stations (n=113)		
	Occur	% Occur	Average Density
Coontail (*Ceratophyllum demersum*)	17	15	1.6
Chara (*Chara sp*)	5	4	1.0
Elodea (*Elodea canadensis*)	47	42	1.6
Naiads (*Najas flexilis*)	24	21	1.8
Curlyleaf pondweed (*Potamogeton crispus*)	13	12	1.1
Claspingleaf pondweed (*P. Richardsonii*)	4	4	1.5
Stringy pondweed (*P. sp*)	33	29	1.2
Sago pondweed (*Stuckenia pectinata*)	19	17	1.6
Water celery (*Vallisneria americana*)	10	9	2.1
Water stargrass (*Zosterella dubia)*	6	5	1.0

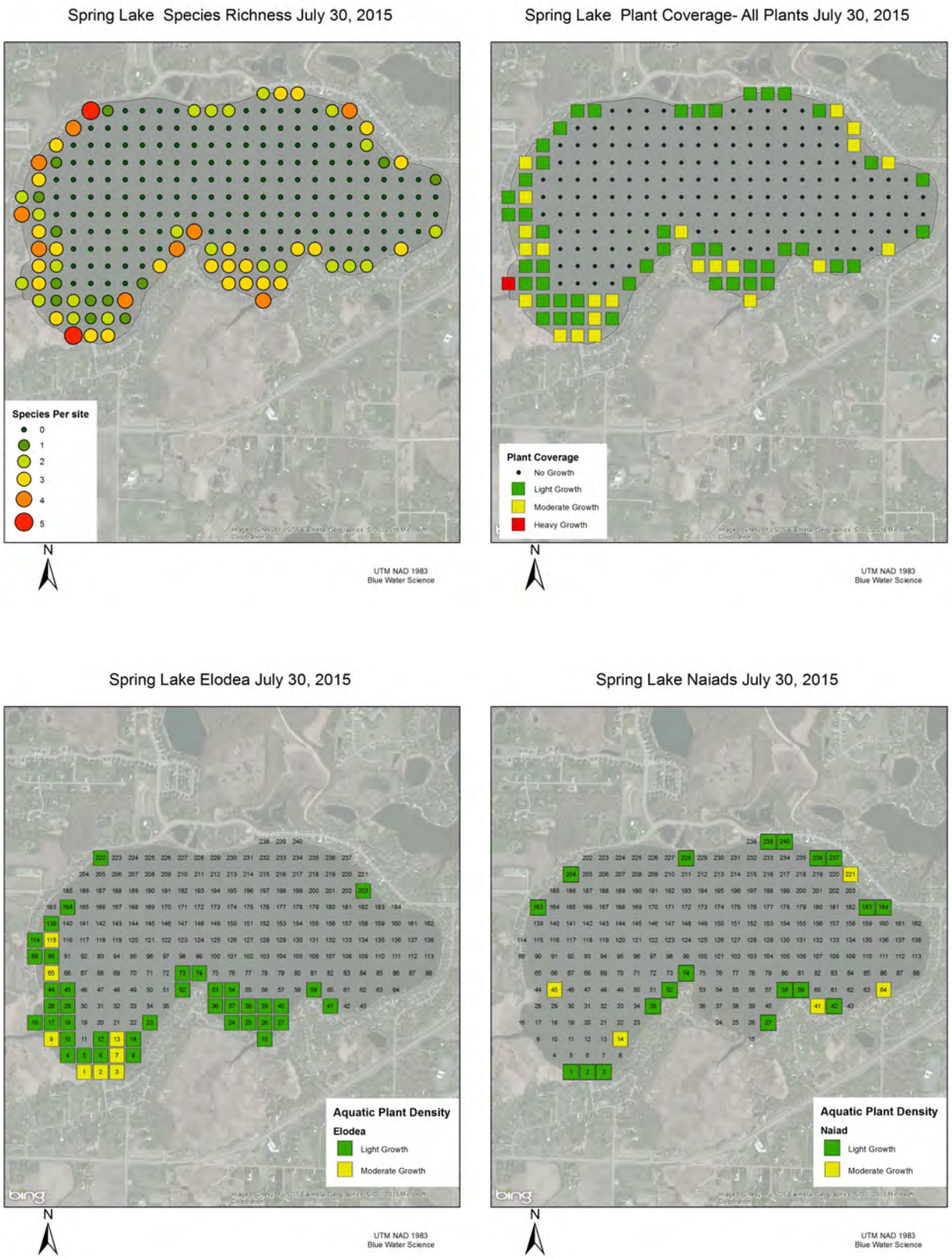


Figure 11. Distribution and abundance maps for select submerged aquatic plant species. Key: green = light growth, yellow = moderate growth, and red = heavy growth.

Summary of All Species in Aquatic Plant Surveys from 1948 - 2015

Since 1948, a number of plant species within the aquatic plant community have appeared and others have disappeared (Table 8). The percent occurrence of the native plants elodea and water stargrass have decreased since 2000. Curlyleaf distribution and curlyleaf density are lower in 2015 compared to 2000. Curlyleaf changes observed in the lake may be due to the curlyleaf management program.

Overall, the native aquatic plant community has been fairly stable for a number of years but stringy pondweed, a native plant, may be increasing which is an encouraging sign that native plants are starting to increase.

Figure 12. Aquatic plants in Spring Lake on June 19, 2014.

Table 6. List of aquatic plants found in past surveys. Surveys from 1948 to 1988 were conducted by MnDNR. Surveys in 2000 and 2002 through 2014 were conducted by Blue Water Science. Numbers for plant species in 2000 and 2002 through 2014 represent percent occurrence. Key: A = Abundant, C = Common, O = Occasional, P = Present, R = Rare, and X = Present

Year	1948	1973	1982	1986	1988
Date (month.day)	9.18	7.9	8.16	7.2	8.15
Secchi disc (ft)	2.6	3.0	3.3	--	2.5
Lesser duckweed (*Lemna minor*)				X	R
Duckweed (*Lemna sp*)			O		
White waterlilies (*Nymphaea tuberosa*)					
Greater duckweed (*Spirodela polyrhiza*)				X	
Coontail (*Ceratophyllum demersum*)	R	O	A	X	O
Chara (*Chara sp*)					
Elodea (*Elodea canadensis*)			O		O
Moss (*Drepanocladus sp*)					
Naiads (*Najas flexilis*)					
Berchtold's pondweed (*Potamogeton berchtoldi*)	R	O			
Curlyleaf pondweed (*P. crispus*)			R	X	
Variable pondweed (*P. gramineus*)	R	C	O		
Floatingleaf (*P. natans*)	R	C			P
Stringy pondweed (*P. pusillus*)					
Claspingleaf (*P. Richardsonii*)	R	C			O
Stringy pondweed (*P. strictifolius*)					
Narrowleaf pondweed (*P. sp*)			O	X	
Sago* (*Stuckenia pectinata*)	R	C			C
Star duckweed (*Lemna trisulca*)		C			
Wild celery (*Vallisneria americana*)			O		P
Mud plantain* (*Zosterella dubia*)	R	R	C		C
Number of submerged species	7	8	7	3	7

* Stuckenia pectinata = Potamogeton pectinatus Mud plantain = water stargrass Zosterella dubia = Heteranthera dubia

Table 6. Concluded.

Year	2000		2002		2003	2004			2005			2006			2007			2008			2009			2010		2011		2012		2013		2014		2015	
Date (month.day)	6.3	9.3	6.7	9.3	5.15	5.2	6.14	8.27	4.20	6.1	8.18	4.26	6.2	9.1	4.15	6.5	7.13	4.29	6.12	8.13	4.23	6.10	8.19	4.27	6.2	5.12	6.10	4.17	6.5	5.29	6.24	5.21	6.19	5.28	7.30
Secchi disc (ft)	7.0					7.1	7.2	3.5	16.7	6.9	2.0	4.7	5.0	2.0				2.3	3.9		3.5	6.2	2.9		2.2		5.6					15.5			4.5
Lesser duckweed (*Lemna minor*)																	2																		
Duckweed (*Lemna sp*)											6																								
White waterlilies (*Nymphaea tuberosa*)																																			
Greater duckweed (*Spirodela polyrhiza*)								2																											
Coontail (*Ceratophyllum demersum*)		29	4	22		13	28	40	8	14	58	16	26	50	22	28	30	8	30	16	4	8	24	18	26	16	22	4	30	3	6		16		15
Chara (*Chara sp*)		4		2			4									2				8		2		12										4
Elodea (*Elodea canadensis*)		25	8	18	6	25	48	68	22	54	76	64	68	48	20	6	2			4			4	2	2	2	4	2			2			6	42
Moss (*Drepanocladus sp*)																		1																	
Naiads (*Najas flexilis*)																							6												21
Berchtold's pondweed (*Potamogeton berchtoldi*)																																			
Curlyleaf pondweed (*P. crispus*)	98	40	86	4	72	78	6	10	58	72	12	64	64	2	44	58		5	38	8	10	28	18	50	42	20	36	14	16	5	23	20	36	22	12
Variable pondweed (*P. gramineus*)																																			
Floatingleaf (*P. natans*)																																			
Stringy pondweed (*P. pusillus*)		2	6	8	2			4		6	8		20			26																			
Claspingleaf (*P. Richardsonii*)				10				6		2	4		2	4		2	2		2	2		2	6		4		2			2				5
Stringy pondweed (*P. strictifolius*)														2	2		2			24		14	66	52	34		64	36	92	5	16		48	12	29
Narrowleaf pondweed (*P. sp*)																						2													
Sago* (*Stuckenia pectinata*)	40	15		36	2		24	6		6	14			6		8	2	1	24	8		24	20		26						16		6		17
Star duckweed (*Lemna trisulca*)																																			
Wild celery (*Vallisneria americana*)		6		16			2	22		2	32		2	18		6	12			18		2	18		4		2		6				10		9
Mud plantain* (*Zosterella dubia*)		17		22				24			30			4						8			24												5
Number of submerged species	2	8	4	9	4	3	6	9	3	7	9	3	6	8	4	8	6	4	4	9	2	8	9	5	7	3	6	4	4	4	5	1	5	3	10

* Stuckenia pectinata = Potamogeton pectinatus Mud plantain = water stargrass Zosterella dubia = Heteranthera dubia

Table 7. Individual sample site data for sites sample in Spring Lake on July 30, 2015.

Site	Depth (ft)	Chara	Clasping-leaf	Coontail	Curlyleaf	Elodea	Naiad	Sago	Stringy	Water celery	Water stargrass	Fila algae	No plants
1	3			1		3	1	1			1		
2	4			1		3	1						
3	4			1		3	2						
4	5			1	1	1						2	
5	6				1	1						1	
6	6					1						1	
7	6				1	3							
8	5					2							
9	4			3		3							
10	6					2						1	
11	7			1					1				
12	9					2							
13	9					3							
14	8			1		2	3		2				
15	2			2		1		3	1				
16	3			4		2						4	
17	5			1	1	1						1	
18	7					2							
19													1
20													1
21													1
22													1
23	6					1							
24	2			1		1		1					
25	2	1				1		1					
26	5			2	1	1							
27	4					2	2	1					
28	2			2		1		1					
29	8					1			1				
30													1
31													1
32													1
33													1
34													1
35	5						1		1	2			
36	5			3		1		1					
37	5					1		3	1				
38	4					2		1		3			
39	4					1			1				
40	8				1	1							
41	2					1	3						
42	4						2			1		1	
43	4								1		1		
44	3		1	2		2				3			
45	5					1	3		1				
46													1
47													1
48													1
49													1
50													1
51	13												
52	4					1	1	1		2			
53	4	1				1							
54	9				1	1			1				
55	13												
57													1
58	6				1		1		2				
59	7					1	2		1				
60	11												
63	8												
64	5						3		1		1		
65	5			1	1	3							

Table 7. Individual sample site data for sites sample in Spring Lake on July 30, 2015.

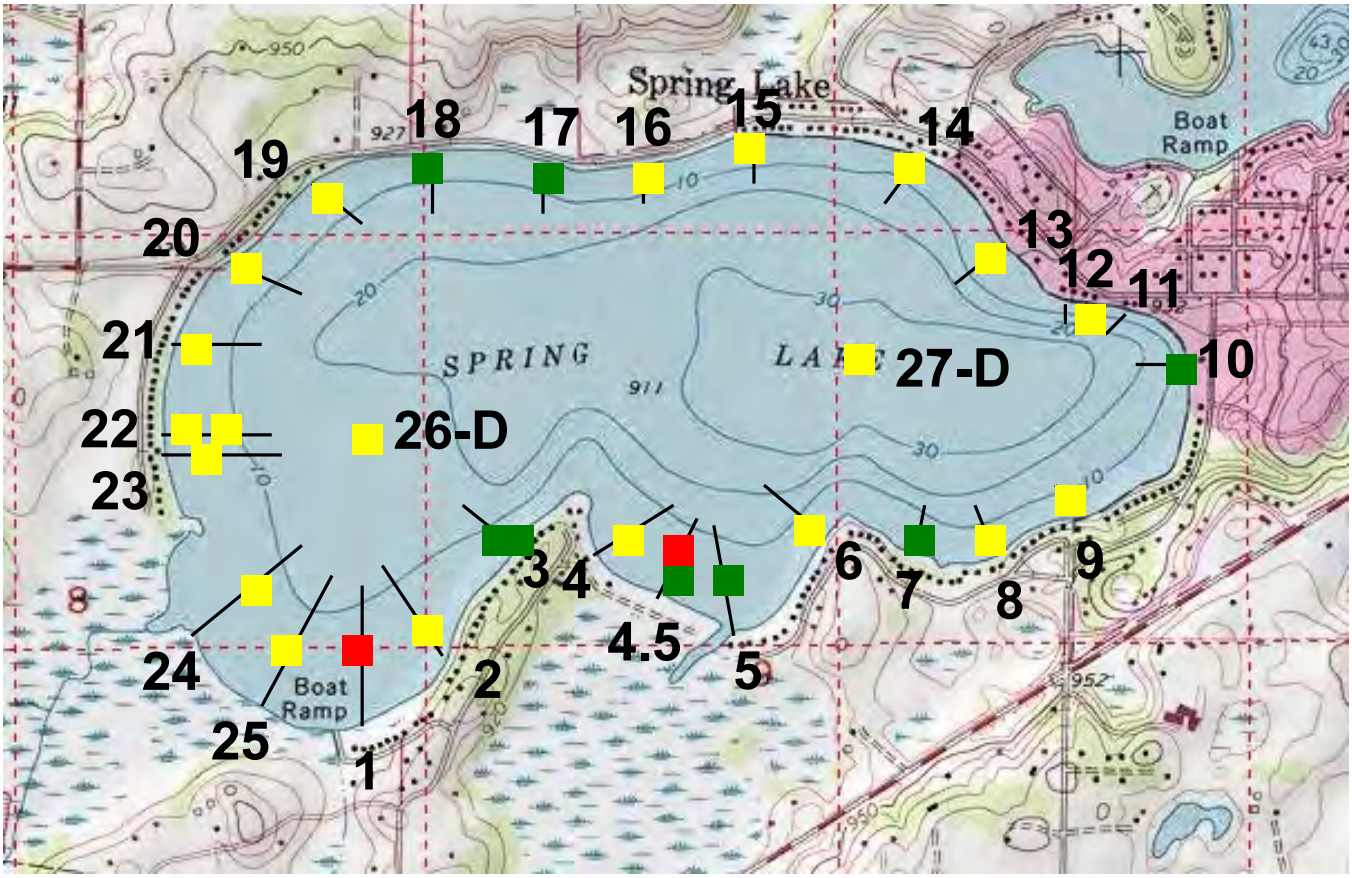
Site	Depth (ft)	Chara	Clasping-leaf	Coontail	Curlyleaf	Elodea	Naiad	Sago	Stringy	Water celery	Water stargrass	Fila algae	No plants
66	6			1								2	
67													1
68													1
69													1
72													1
73	8					2			1				
74	5					1	2		1	3			
75	10												
87	16												
88	5							2	1				
89	2		1			2			1		1	1	
90	6					1			1			1	
91													1
114	2					2		1					
115	6					3						1	
116													1
138													1
139	6					2		1	1				
140													1
162	7								1				
163	3		1				2		2	3			
164	9					1							
183	6						1						
184	3		3				1			1			
185	4							1	2	2			
186													1
202													1
203	5					1		3					
204	4	1			1		2		2				
205													1
220													1
221	3	1					3				1		
222	3				2	1		1	2		1		
223	7								2				
224													1
225													1
226													1
227	9												
228	5						2		1			2	
229	5							2	1				
230	8				1				1				
231													1
232													1
233													1
234													1
235													1
236	7						1		1				
237	4						1	3	2	1			
238	4							2	1				
239	3	1					1		1				
240	4				1		1		1				
Average		1.0	1.5	1.6	1.1	1.6	1.8	1.6	1.2	2.1	1.0	1.5	1.0
Occurrence (113 sites)		5	4	17	13	47	24	19	33	10	6	12	35
% occurrence		4	4	15	12	42	21	17	29	9	5	11	31

APPENDIX

Spring Lake Curlyleaf Growth Potential Based on Lake Sediment Characteristics

A Spring Lake sediment survey was conducted on August 13, 2008. Lake sediment sampling results from 2008 have been used to predict lake bottom areas that have the potential to support heavy 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 14.

Except for two sites, curlyleaf pondweed growth is predicted to produce mostly light to moderate growth around the lake based on lake sediment characteristics.



Sediment sample locations are shown with a square. The square color indicates the potential for curlyleaf pondweed growth to occur at that site. Key: green = light; yellow = moderate; red = heavy. A key that illustrates the three types of growth is shown on the next page.