Silver Lake Aquatic Vegetation Management Plan Prepared for the Silver Lake Association

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Executive Summary

Aquatic Weed Control was contracted by the Silver Lake Association to develop a long term lake management plan. Funding for this plan was provided by the Silver Lake Association and the Department of Natural Resources Division of Soil Conservation. This funding was part of the Lake and River Enhancement (LARE) program. Aquatic Weed Control conducted two aquatic vegetation surveys to characterize the plant community of Silver Lake. Following protocol established by the Indiana Department of Natural Resources, a qualitative survey called the Tier I reconnaissance survey was used to obtain an understanding of the vegetation present in Silver Lake. Next, a quantitative survey (Tier II) was used to document the distribution and abundances of individual plant species in Silver Lake.

Based upon the data collected in the aquatic vegetation surveys, a management plan was proposed that should help to alleviate major problems caused by invasive aquatic plants. Curly leaf pondweed was found in very low abundances, which is to be expected in a survey conducted in late summer. However, the plant has historically caused significant problems in spring and early summer.

Silver Lake has nuisance exotic vegetation in the lake that causes problems with fishing, swimming, boating and the overall use of the lake by residents and non-residents. The goal of this report is to document the need to control the exotic weed species of curly leaf pondweed and Eurasian milfoil. This report will recommend the use of Aquathal to control the curly leaf pondweed and kill its turions by spraying in late March or early April. This strategy has been proven to reduce turion production of curly leaf pondweed from year to year. Recently, Cerexagri (manufacturer of Aquathal K) has determined and evaluated on other lakes, that treating with Aquathal K in late March to early April when the water temperature reaches 50 degrees will reduce the curly leaf turion (root) production significantly. This application will also control the milfoil and thin the coontail population. Controlling the milfoil and curly leaf pondweed will allow the more beneficial native weed species to grow. In past years the curly leaf pondweed in Silver Lake has been sprayed each June, but the problem still remains.

Silver Lake Cost Summary

2005	
Pretreatment vegetation and turion survey, management plan update	$1,400.00
Herbicide and application costs	$14,000.00
2006	
Pretreatment vegetation and turion survey, management plan update	$1,400.00
Herbicide and application costs	$14,000.00
2007	
Vegetation and turion summary, management plan update	$1,400.00
Chemical treatments after the second year will be dependant upon the success of the 2005 and 2006 applications.	

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Introduction

Aquatic Weed Control was contracted by the Silver Lake Association to develop a long term lake wide management plan. Funding for this plan was provided by the Silver Lake Association and the Department of Natural Resources Division of Soil Conservation. This funding was part of the Lake and River Enhancement (LARE). When a person registers a boat within the state of Indiana a lake enhancement fee is included in the cost of registry. One third of this money is then used to provide funding for projects designed to improve the quality of Indiana lakes by controlling invasive plant species. The surveys included in this report, as well as the management plan, are required by the state to receive funding to treat the lake for exotic aquatic vegetation. Should a lake be selected for LARE funding, up to $100,000 can be given for a whole-lake treatment with a cumulative 3-year maintenance total of an additional $20,000 dollars. If the whole lake is not treated, up to $20,000 dollars can be available annually for up to three years. Requests for funding are reviewed by the Indiana Soil Conservation Board, and funds will be distributed at their discretion.

This project was initiated to take a more aggressive and long term approach to controlling the curly leaf pondweed in Silver Lake. The lake has been chemically treated periodically over many years. Although these treatments have provided temporary relief, they have not provided long term control of invasive species. This survey and management plan is a requirement to receive additional funding to treat the lake for nuisance aquatic vegetation.

Four sample sites were also taken in North Little Lake, which is joined to Silver Lake by a short channel. The management recommendations outlined in this report do not pertain to North Little Lake, and North Little Lake is not included in the action plan.

Problem Statement

Silver Lake, located in south central Kosciusko County, is in need of intervention to restore a healthy plant community and enhance recreational opportunities for residents living near the lake.

Curly leaf pondweed, an exotic aquatic plant, grows and spreads rapidly each year in early spring. Curly leaf pondweed forms large, dense weed beds that nearly ring the lake by late spring. These dense weed beds make it nearly impossible for lake residents to enjoy activities such as swimming, fishing, and boating. Eurasian milfoil also causes problems by forming dense beds as well.

In addition to suppressing the recreational value of this lake, the dense beds formed by curly leaf pondweed and Eurasian milfoil contribute to fish stunting, and the weed is undoubtedly robbing important native plants species of the light and nutrients they need to survive. This monoculture of curly leaf pondweed contributes to low plant diversity and threatens the stability of the Silver Lake ecosystem.

In the past, private lake frontages were treated with contact herbicides at the request of lake residents. These treatments provided temporary relief from curly leaf pondweed but offered little potential for long term control of this exotic species.

In summary, the presence of the curly leaf pondweed may be decreasing plant diversity and the health of the lake ecosystem while severely limiting recreational use of the lake. Unfortunately, vegetation surveys conducted in late summer will not adequately represent the abundance and distribution of curly leaf pondweed, because this plant dies off naturally as water temperatures approach 70 degrees Fahrenheit. For this reason, a spring vegetation survey is recommended to better describe the curly leaf population in Silver Lake.

Management Goals

The following management goals have been established by the IDNR for all lakes applying for LARE funding.

1. Develop or maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality and is resistant to minor habitat disturbances and invasive species.

2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.

3. Provide reasonable public recreational access while minimizing the negative impacts on plant and wildlife resources.

Specific Objectives:

1. **The first objective will be to reduce the population of exotic species in Silver Lake.** Reducing the curly leaf pondweed population in the lake will create space for native plants to grow and should increase the overall plant diversity of the lake.

2. **The second objective will be to provide more effective long term control of curly leaf pondweed as its population is reduced.** Killing turions embedded in the lake bottom should reduce the re-growth of curly leaf pondweed from year to year.

In the past, the lake was treated each June with a contact herbicide in order to provide temporary relief from exotic species. While this treatment was beneficial to those wishing to use the lake for recreation, a large portion of the spring was “lost” because exotics were already choking the lake long before the June treatments. In addition, treatments with a contact herbicide are only effective on existing weeds, offering little chance of true long-term control. This management plan should provide a more effective control of curly leaf pondweed over a longer period of time by treating the exotic weed earlier in the year to reduce turion production.

Silver Lake Fisheries

The most recent fisheries survey conducted by The Indiana Department of Natural Resources took place on August 2, 1989. Data was obtained by using electro fishing and gill nets to collect, count, measure, and then release fish. A total of 13 species of fish were collected, many of which were valuable game fish (Tyllia, 2000)

Gizzard shad dominated the survey, with 302 total shad (26.3% of the population) being collected. Gizzard shad can have harmful effects on many game fish populations, especially those who are dependent upon plankton for survival. Gizzard shad are very efficient planktivores, and compete with young of fish for food. They reproduce rapidly, even faster than other proliferate species such as crappies and bluegills. In some situations, they can quickly take over an ecosystem and rob other fish of valuable food sources. An upside to a large gizzard shad population is that they provide an excellent food source for game fish such as largemouth bass, white bass and crappies. In Silver Lake, all three of these species have above average growth rates in Silver Lake. However, bluegill growth rates have historically been high as well, indicating that they are competing well with gizzard shad in Silver Lake. A table summarizing the fisheries survey is included below.

Table 1: Silver Lake Fisheries Survey 8/2/89

Species	Total # Collected	Percentage	Size Range (in.)
Gizzard Shad	302	26.3	2.6-15.7
Bluegill	259	22.6	0.9-8.4
Largemouth Bass	195	17.0	2.2-19.5
Yellow Perch	124	10.8	6.3-11.8
Golden Shiner	84	7.3	6.6-9.5
Warmouth	38	3.3	2.6-7.8
Pumpkinseed	33	2.9	2.6-6.8
White Sucker	20	1.7	11.6-19.3
White Bass	19	1.7	11.4-41.6
Yellow Bullhead	19	1.7	6.5-11.3
Brown Bullhead	18	1.6	9.4-14.2
Black Crappie	16	1.4	6.2-10.8
Northern Pike	1	-	13.6

The healthy game fish populations indicated in this survey are assets to the Silver lake ecosystem, as well as the community surrounding the lake. According to the DNR, yellow perch and bluegills are a primary attraction for anglers at Silver Lake. Good sizes of largemouth bass were also sampled in this survey. White bass and crappie populations cycle in Silver Lake, but these two species provide excellent fishing at the high end of these cycles. (Tyllia, 2000) Good white bass populations are uncommon among most natural lakes in northern Indiana making the Silver Lake fishery even more unique and more valuable.

Unfortunately, it is difficult for anglers to take advantage of these excellent game fish populations because of the dense weed beds formed by curly leaf pondweed and coontail

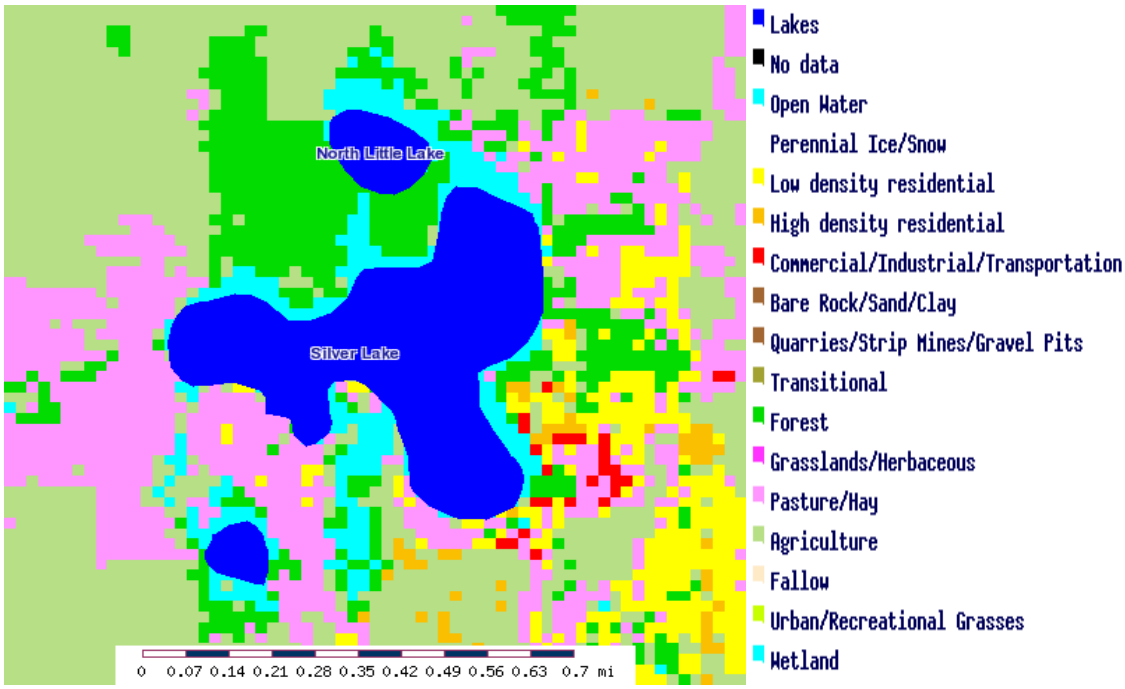
each spring. These weeds tangle in outboard motor propellers, not to mention tangling in fishing lures and fishing lines. Shore fishing is nearly impossible, as most of the shoreline is choked with these weeds. Management practices outlined in this report should provide greater access to Silver Lake so anglers can once again pursue these species.

Water Shed and Water Body Characteristics

Silver Lake, located in southern Kosciusko County, has 102 surface acres with a maximum depth of 33 feet and an average depth of 14.9 feet. This moderately eutrophic lake possesses 3,300 acres (5.2 square miles) in its watershed. As of November 2000 nearly 80% of this watershed was used for agriculture. Large amounts of agricultural activity in this watershed make Silver Lake prone to heavy sediment loading. (Giolito, 2000). Nearly 60% of the shoreline of Silver Lake is developed, which can also cause complications in the form of sewage, storm water and fertilizers entering the lake. Concrete seawalls are also prevalent along the shoreline and the lake, and may also contribute to high water turbidity and the reduction of beneficial vegetation growth around the shoreline.

Three inlet streams aid sediment loading: Funk Ditch to the north, and two unnamed inlets, the east and to the south. The following map (Figure 1) shows land use around the lake.

Figure 1: Land Use Around Silver Lake



Phosphorus levels in Silver Lake appear to be increasing from year to year. Secchi disk readings are approximately 3.0 ft and may be decreasing and the lake is considered to have poorer water quality than most lakes in Indiana (Giolito, 2000). The fact that only about 20% of the watershed's original wetlands still exist today may compound problems of sediment loading (Smith and Smith, 2001).

The characteristics of its watershed make Silver Lake very susceptible to over-abundant weed growth, and especially to aggressive, fast growing exotic plants. The watershed has a high amount of agricultural usage which adds to the phosphorus level in the lake that makes aquatic weeds grow. Phosphorous comes from cattle lot run off, septic systems, and fertilizer from lawns and crops. Residents should try to minimize the use of fertilizer on their yards or go to a lakeside fertilizer that has a reduced amount of phosphorus in the formulation. Also, residents of the lakes should attempt to get area farmers involved in the management of the lake. These plans will only work if the exotic weed treatments are coordinated with the other objectives outlined in the diagnostic report. Please follow the management recommendations given on page 67 of the Diagnostic study completed by J. F. New. in 2000. Please go to the diagnostic study to address any additional watershed information as this plan is designed to address aquatic weed management and not the watershed problems.

Present Water Body Uses

Today, Silver Lake is highly valued to many stakeholders for a number of reasons. This lake has a 10-mile per hour speed limit, which eliminates heavy use by fast moving jet skis and ski boats. This restriction calms the waters of Silver Lake and makes it an ideal place to swim, fish, or take a leisurely boat ride.

The southern portion of Silver Lake is mostly developed with many houses and lake cottages lining the shoreline. These areas would be the best places to target aquatic nuisance species so that residents can enjoy recreational activities around the shoreline, piers, and docks.

The north shore of Silver Lake is largely undeveloped, and provides an excellent sanctuary for waterfowl and other wildlife, as well as a chance for boaters to observe this wildlife and enjoy the beauty of nature.

Primary recreational areas are from points 1-22 and from points 43-60 on the map in figure 3.

Characterization of the Plant Community

Tier I and Tier II surveys were used to characterize the plant community in Silver Lake. Overall, the lake has low plant diversity, and the plant community is dominated by coontail in late summer. Low water quality may be a limiting factor for plant growth in Silver Lake. Two invasive species were found in these surveys. Curly leaf pondweed was found at seven sites throughout Silver Lake, and Eurasian milfoil was collected at one site in North Little Lake.

Silver Lake Tier I Survey Results

The Tier I reconnaissance survey is designed to identify the major plant beds present in a body of water. This is a qualitative survey designed to give an overview of the aquatic vegetation present in a lake. It identifies and documents problem areas that can be targeted when management practices are implemented. Major submersed plant beds are found visually from a boat. Each bed is given a reference number that is recorded on Tier I data sheets. The general location of these beds are recorded on a bathymetric map of the lake, and more precise locations are recorded on Tier I data sheets with the help of a WAAS enabled GPS unit.

When a major plant bed is identified, each species of plant found in that bed is recorded. Canopy ratings are given to each plant bed based on the types of plants present in that bed. The four major types of plants to be identified in this study are as follows: submersed plants, emergent plants, non-rooted floating plants, and rooted floating plants. The following scale is used to describe these four types of plants based on the percentage of the plant bed canopy they occupy:

Canopy Rating

1 = <2% of canopy
2 = 2-20%
3 = 21-60%
4 = >60% of canopy

In addition to the canopy rating, another abundance rating is given to each individual species found in a particular plant bed. This abundance rating is based on the percentage of the entire bed area that species appears to occupy. The scale for this abundance rating is the same as the canopy rating scale. The difference is that this scale identifies the abundance of *individual species* in the bed:

Species Abundance Rating

1 = < 2% of the bed
2 = 2-20%
3 = 21-60%
4 = >60% of the bed

Since this is a visual survey, results are dependant upon the surveyor's ability to locate plants below the water's surface. Tier I surveys are much less effective in lakes with low secchi disk readings. Polarized glasses were used to reduce glare from the sun and enable the surveyors to see more easily into the water. Even with the aid of polarized glasses, the Tier I survey should not be considered an exhaustive survey of aquatic vegetation. The Tier I survey is a tool that helps to provide an overall picture of an aquatic plant community when coupled with the Tier II quantitative survey.

Tier I Plant Bed Summary

During the Tier I survey of Silver Lake seven major plant beds were found. Five species of aquatic plants were identified, and their abundances at each bed were recorded. Below is a summary the results of the Silver Lake Tier I survey.

Plant Bed #1
North Little Lake
This plant bed was approximately ¼ acre in size and contained 2 plant species. Duckweed was present with an abundance rating of 2, while coontail was present with an abundance rating of 4.

Plant Bed #2
North Little Lake
This plant bed was approximately 1/10 acre is size and contained 2 plant species as well. Eurasian milfoil and coontail were both present with abundance ratings of 3.

Plant Bed #3
This plant bed was approximately 1/10 acre in size and contained only one species. Eurasian milfoil was present with an abundance rating of 4.

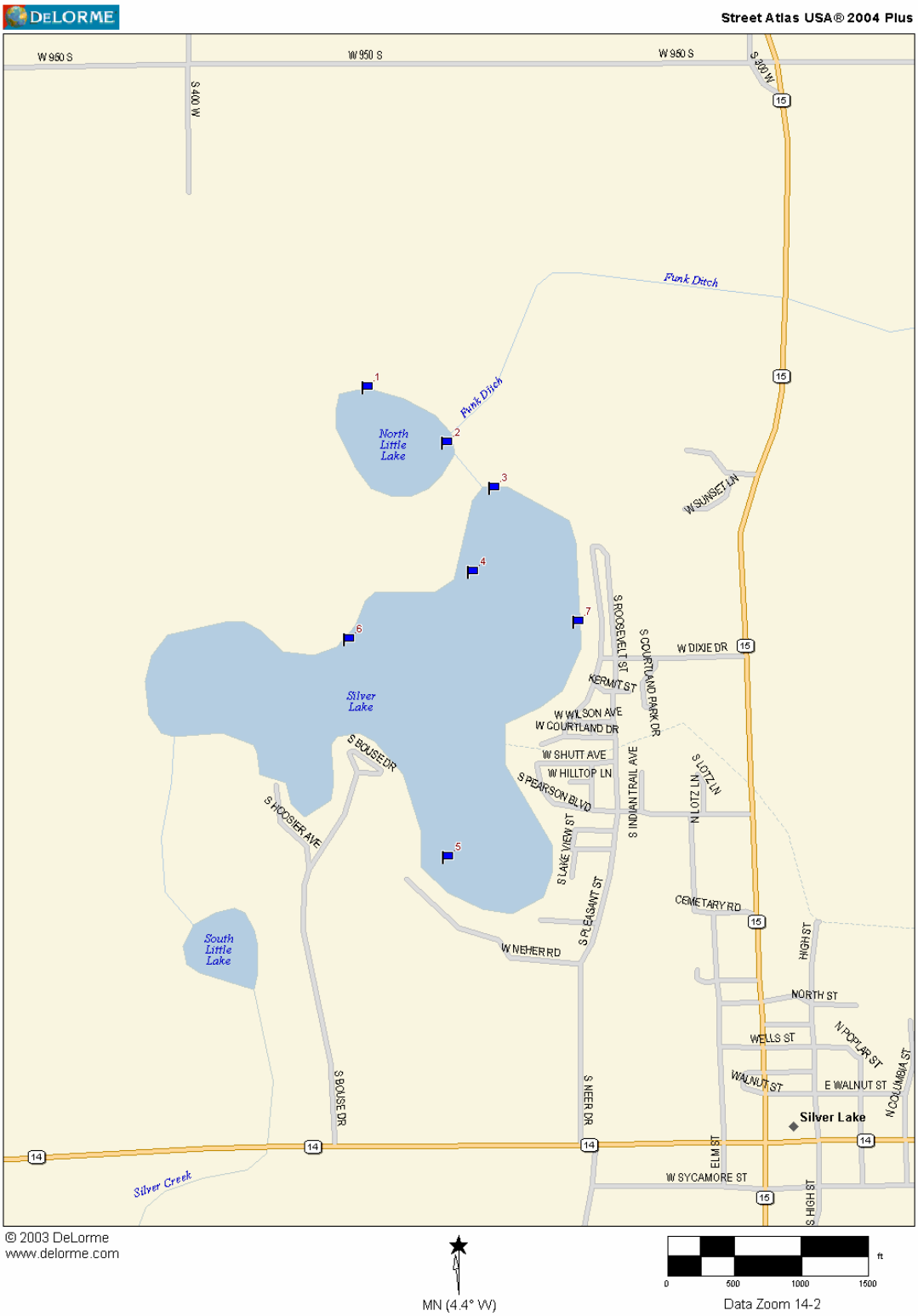
Plant Bed #4
This plant bed was approximately ¼ acre in size and contained three species. Curly leaf pondweed was present with an abundance rating of 1. Sago pondweed had an abundance rating of 2, while coontail had an abundance rating of 4.

Plant Bed #5
This plant bed was approximately ¼ acre in size and contained only one species of plant. The entire bed was composed of coontail, which had an abundance rating of 3.

Plant Bed #6
This plant bed was approximately 1 acre in size and contained 3 plant species. Curly leaf pondweed was present with an abundance rating of 1. Sago pondweed had an abundance rating of 2, while coontail had an abundance rating of 3.

Plant Bed #7
This plant bed was approximately 2 acres in size and contained 2 species. Curly leaf pondweed was present with an abundance rating of 1, while coontail had an abundance rating of 3.

Figure 2: Tier I Plant Bed Locations



Tier I Survey Summary

The seven major plant beds identified in Silver Lake and North Little Lake contained one to four plant species and covered over four acres of the lake. Coontail was the dominant plant in this survey occurring six times with an average abundance score of 3.3. Curly leaf occurred 3 times with an average abundance of 1. Sago pondweed occurred 2 times with an average abundance score of 2. Eurasian milfoil occurred 2 times with an average abundance of 3.5. Duckweed was present in one bed and had an abundance score of 2.

Chara, naiad, and eel grass were collected in the Tier II survey but were not observed in the Tier I survey. These species grow closer to the lake bottom, and poor water clarity makes them extremely difficult or impossible to see from above the water's surface. This underscores the importance of the Tier II sampling process in order to gain an accurate representation of the aquatic plant community.

Materials and Methods: Tier II Random Sampling

Tier II Survey Summary

A Tier II quantitative survey of Silver Lake was conducted on August 25, 2004. The purpose of this survey was to document the distribution and abundance of submersed and floating-leaved aquatic vegetation throughout the lake (IDNR, 2004). A specific number of sample sites were selected based on the amount of surface acreage the lake possessed. Once sample sites were determined, sampling was accomplished using an aquatic vegetation sampling rake constructed according to the guidelines of the 2004 Tier II random sampling procedure manual.

Aquatic vegetation collected at each sample site was sorted according to species, and given a value to represent its abundance at that site. These values were immediately recorded on data sheets distributed by the IDNR. These records were used for data analysis that served to characterize the aquatic vegetation community of Silver Lake.

An extremely important note is that curly leaf pondweed may occur at greater frequencies and at higher densities earlier in the year. Curly leaf pondweed begins to die out as water temperatures approach 70 degrees (Schmidt, 1998). This lake was also treated for curly leaf prior to this survey. These two factors indicate that the Tier II quantitative survey may not accurately reflect the true distribution and abundance of curly leaf pondweed in Silver Lake.

Random Sampling:

The IDNR issued the following chart to help determine the number of sample sites needed to accurately describe the aquatic plant community in a lake.

Table 2: Sample Sites by Lake Size

Number of Surface acres	Number of Sample Sites
1-100 acres	40
101-300 acres	60
Greater than 300 acres	Add 10 sites/100 acres

Based on Silver Lake's 102 surface acres, 60 sample sites were accurately needed to describe this plant community. Arial photographs and bathymetric maps were used to evenly space the sixty sample sites throughout the lake. The littoral zone of the lake was divided into four quadrants of equal length. During the vegetation collection process, an effort was made to collect plants from 15 sites in each quadrant to ensure that the entire littoral zone was surveyed adequately and that random sample sites were distributed evenly throughout the lake.

When sampling the littoral zone of the lake, a pattern was used that also helped to ensure an accurate description of the plant community. The littoral zone was divided into three sections based on depth and sample sites alternated between each of these three zones. For example, collection site 1 would be taken in shallow water very close to shore. Collection site 2 would be taken further down the shoreline, but in slightly deeper water. Collection site 3 would be taken further down the shoreline, but in even deeper water, close to the border of the littoral and pelagic (open water) zone. This sampling strategy was recommended by District 3 fisheries biologist Jed Pearson. This strategy not only helps to accurately describe the plants in the littoral zone, but it also aids in determining the maximum depth at which plant can grow in particular lake.

Aquatic Vegetation Sampling Rake:

A double-headed garden rake was used to sample aquatic vegetation. This rake design is approved and used by IDNR fisheries biologists in vegetation surveys on many Indiana lakes. It consists of two garden rake heads welded together back to back so that rake teeth are protruding from two sides. The dimensions of the rake are to be 13.5 inches wide with 2.25-inch long teeth spaced 0.75 inches apart (IDNR, 2004).

Each tooth on the rake head is divided into five equal sections and marked accordingly. These marks on the rake teeth are used to estimate the abundance of plant species when they are collected.

A nylon rope is then attached to the rake head. A black permanent marker is used to mark the rope in foot long increments. A red mark is placed every five feet along the rope. This rope is used to measure the depth at each sample site when the rake is lowered to the lake bottom.

GPS and Mapping

A WAAS enabled GPS unit was used to obtain and record the coordinates of each sample site on the lake. A WAAS enabled GPS unit is accurate to within 3 meters and was recommended by aquatic biologist Cecil Rich to obtain maximum accuracy for mapping sample sites. All GPS coordinates were then used to produce computer generated maps of the lake with each sample site labeled on the map. A spreadsheet corresponding to this map is included in this report.

Sampling Procedure

A two-person crew accomplished Tier II aquatic vegetation sampling by boat. A crew leader was responsible for driving the boat to each sample site and recording vegetation data on record sheets issued by the IDNR. An assistant was responsible for collecting the aquatic plants using the double-headed rake.

When a sample site was reached, its GPS coordinates were obtained and recorded. The boat was then brought to a complete stop and the double-headed rake was lowered to the bottom of the lake. The boat was held stationary while the water depth at the sample site was obtained by using the marked rope attached to the rake.

When water depth had been recorded, the crew leader slowly backed the boat away from the rake as the assistant simultaneously let out another ten feet of rope. During this process the rake did not move from the lake bottom.

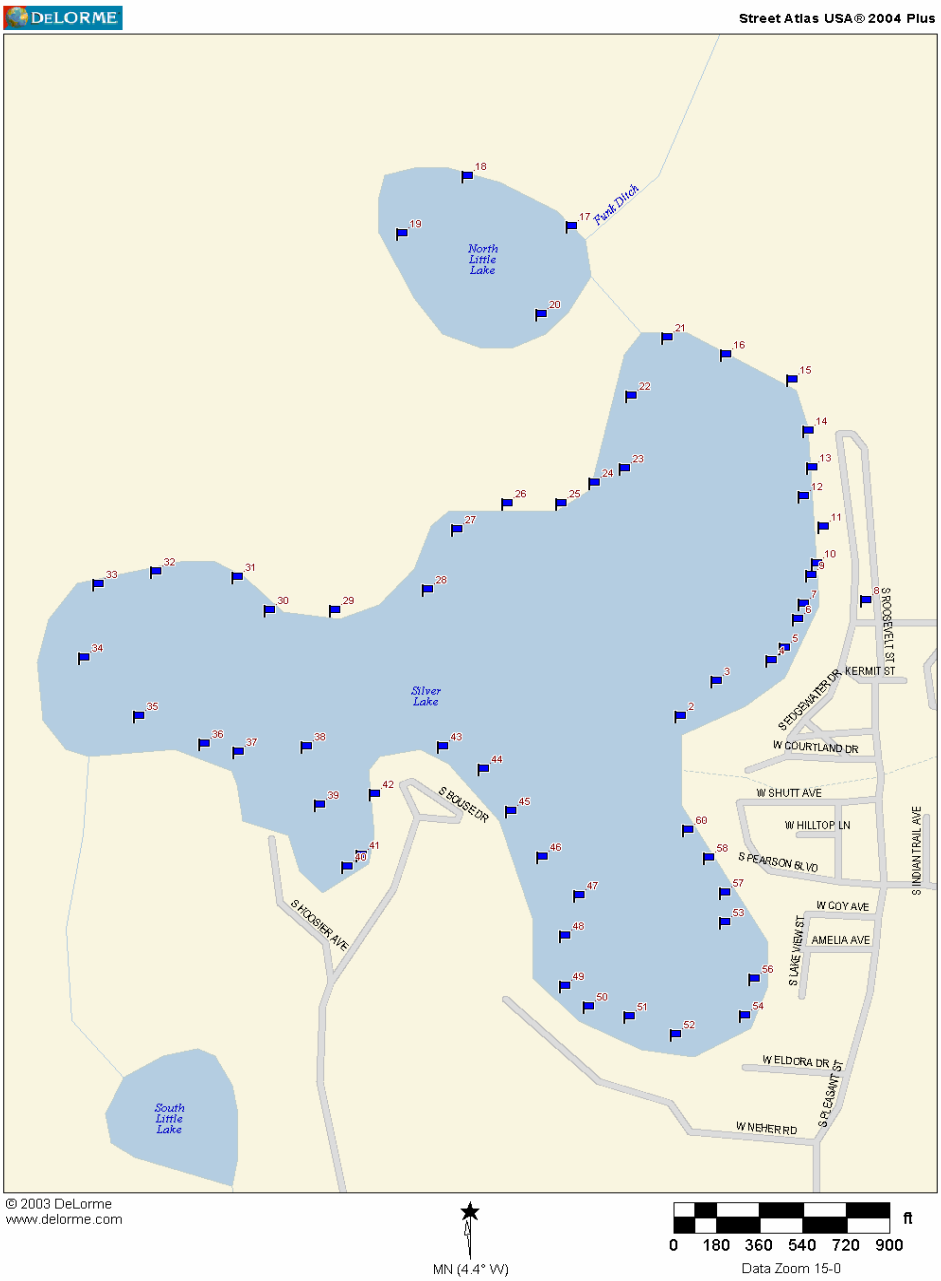
The rake was pulled from the water after the boat had reached the end of the ten extra feet of rope let out after the depth was recorded. This ensured that the rake was pulled horizontally through the water, giving it a greater chance of collecting weeds than if the rake had been lowered to the bottom and raised vertically. The vegetation caught on the teeth of the rake was then gathered into the boat.

Determining Vegetation Abundance

At each sample site, every plant species collected on the rake was scored according to its abundance. This was accomplished by removing all plants from the rake and sorting them by species. Once all plants had been sorted, they were placed back onto the rake and evenly distributed across the marks on the rake teeth. If a species filled the rake to the first mark on the teeth, that species was given a score of one on the abundance data sheet. If it filled the rake teeth to the second mark, it was given a score of two, and so on to a maximum abundance of five.

In many instances it was not necessary to place each species back onto the rake. Many species would fill the rake completely (an abundance of 5) and some species would only have one plant on the rake (an abundance of 1). In addition to abundance scores for individual species, each rake toss was given an overall abundance score, describing how much total vegetation was collected on the rake. Figure 3 below shows the sample points for the Tier II survey and Table 5 shows what was collected at each site.

Figure 3: All Tier II Sample Sites



Silver Lake Tier II Quantitative Survey Results

Survey Date: August 25, 2004

Total # of Sampling Sites: 60

Total # of Submersed Species: 7

Species list

Coontail, Curley Leaf, Sago, Chara, Naiad, Eel Grass, Eurasian Milfoil

Table 3: Tier II Survey Results

Species	# of sites present out of 60 total sites	Average abundance
Coontail	26/60	2.54
Curley Leaf	7/60	1.14
Sago	4/60	1.50
Chara	1/60	5.00
Naiad	1/60	1.00
Eel Grass	1/60	1.00
Eurasian Milfoil	1/60(North Little)	1.00

The following maps illustrate the locations of the three most frequently collected plant species in Silver Lake. Coontail was collected most often, followed by curly leaf pondweed, and sago pondweed.

Figure 4: Sites Where Coontail Was Collected

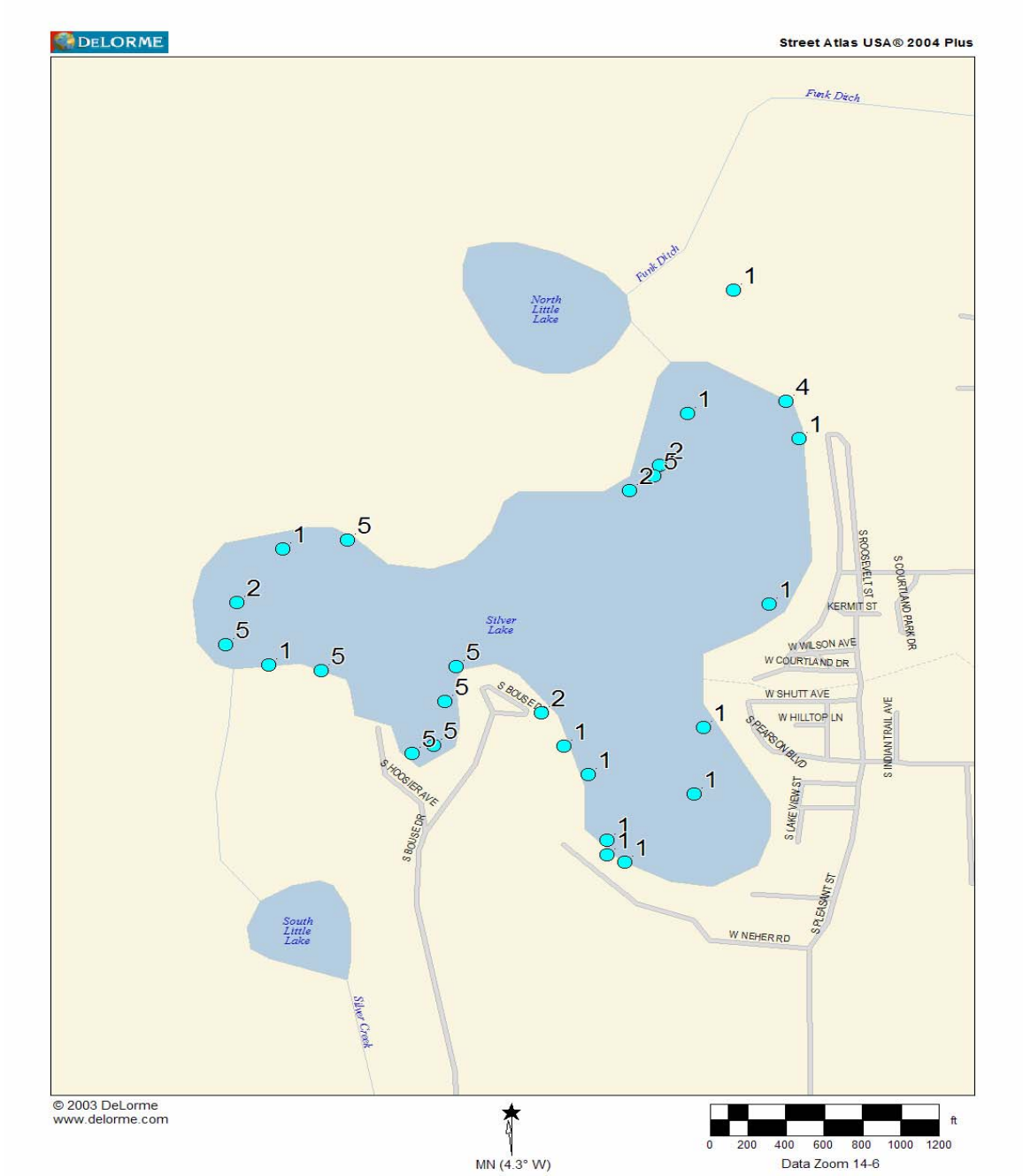
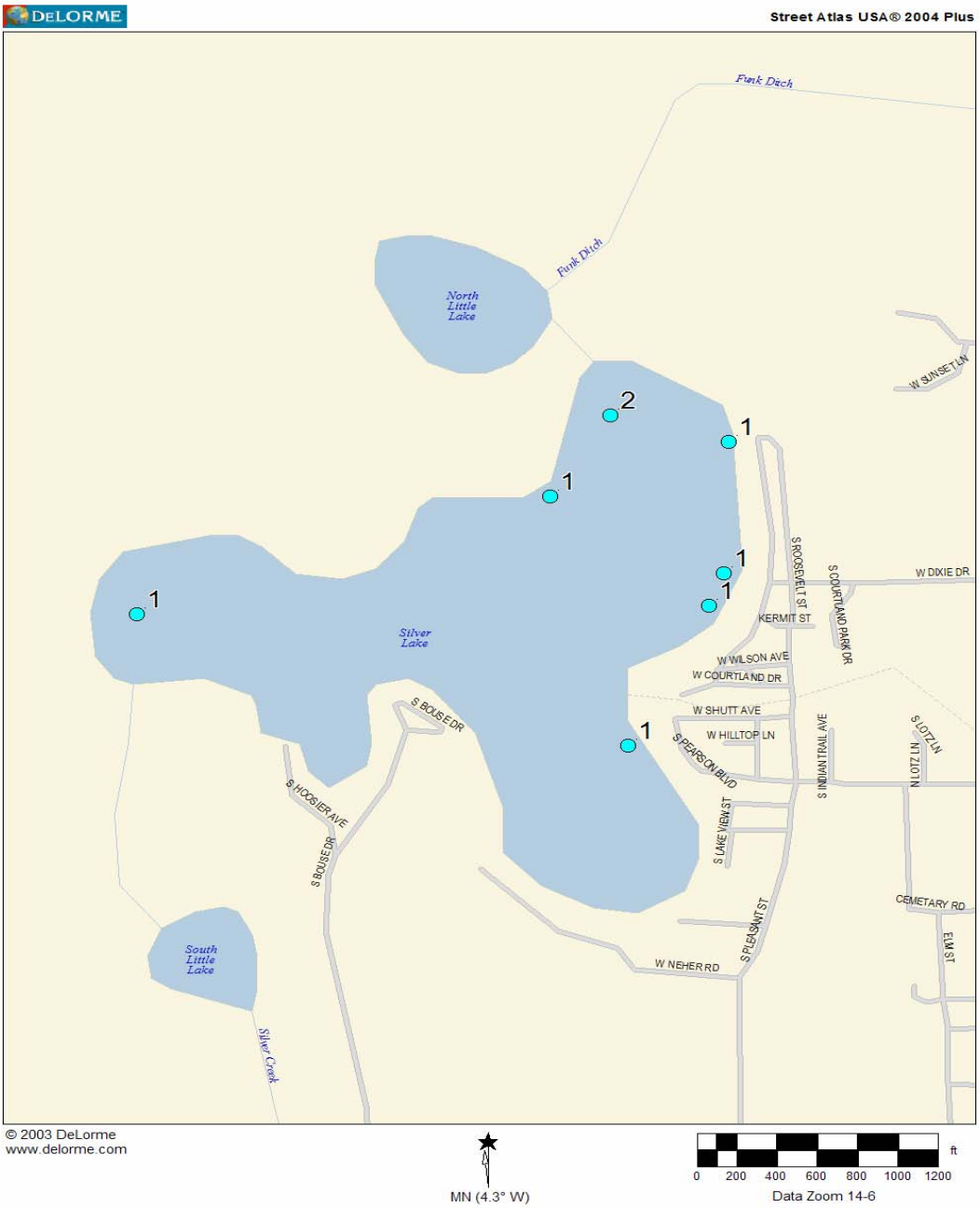


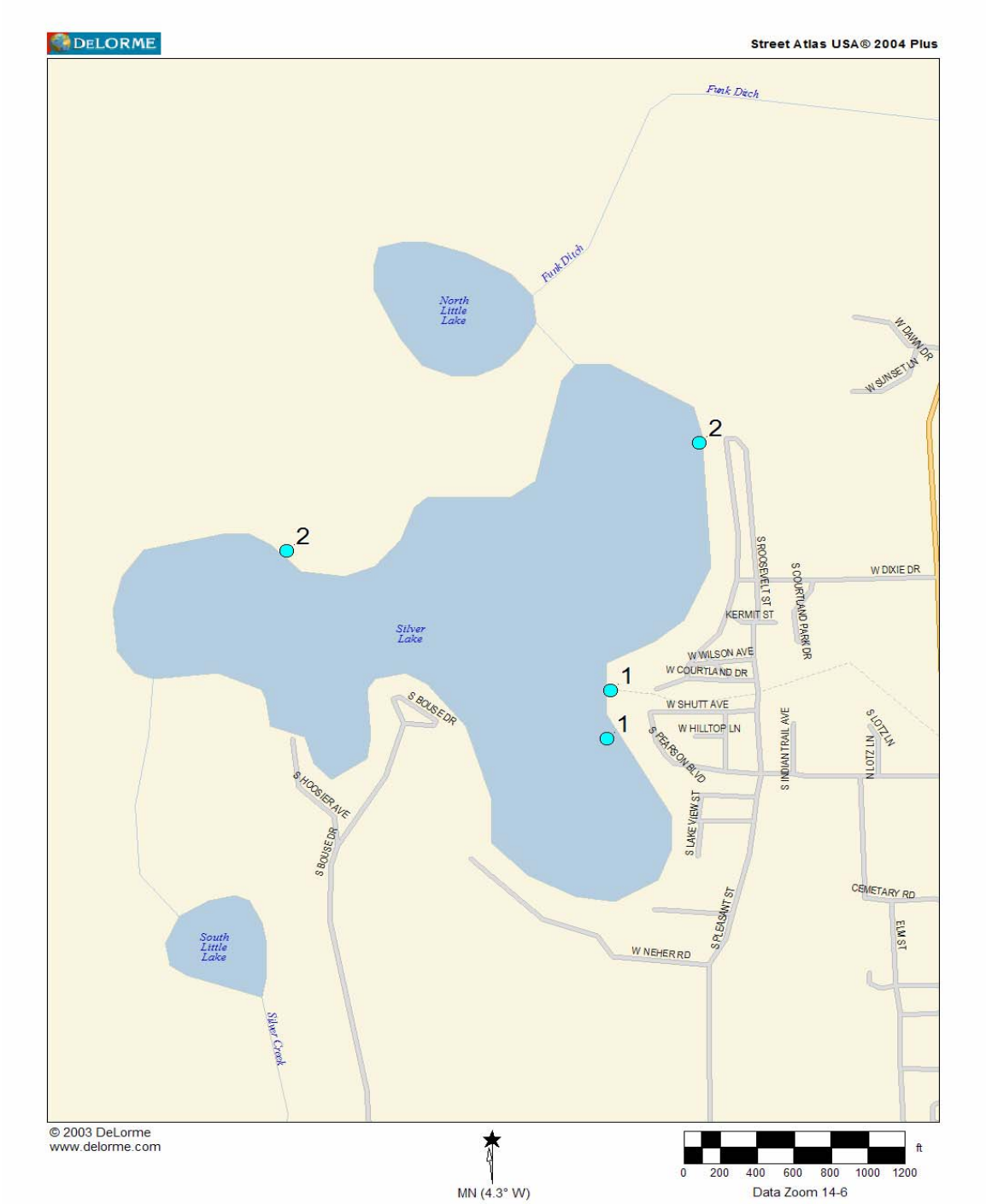
Figure 3 shows that coontail was present throughout Silver Lake. It was especially prevalent in the small bay along the southeast shoreline. In this bay, every time coontail was collected, it had an abundance rating of 5.

Figure 5: Sites Where Curly Leaf Pondweed Was Collected



Curly leaf pondweed was only collected at seven sites during this survey. However, this weed naturally dies off as water temperatures approach 70 degrees. It is known to be much more widespread and much more abundant in spring and early summer.

Figure 6: Sites Where Sago Pondweed was Collected



Although sago pondweed was the third most common species in Silver Lake, it was only collected at 4 sites. This reflects the low aquatic plant diversity in Silver Lake. Not only was it rarely found, but its abundance rating was low at each site where it was found.

Species Diversity and Species Dominance

Two of the most important values in Table 5 are the diversity indices and the species dominance. A species diversity index is actually measured as a value of uncertainty (H). If a species is chosen at random from a collection containing a certain number of species, the diversity index (H) is the probability that the chosen species will be different from the previous random selection. The diversity index (H) will always be between 0 and 1. The higher the H value, the more likely it is that the next species chosen from the collection at random will be different from the previous selection (Smith, 2001). This index is dependant upon species richness and species evenness, meaning that species diversity is a function of how many different species are present and how evenly they are spread throughout the ecosystem.

Species dominance is dependent upon how many times a species occurs, and its relative coverage area or biomass within the system. In this survey, the abundance rating given to each species at each sample site was used to determine dominance. The dominance of a particular species in this Tier II survey increases as its site frequency and relative abundance increase.

Table 4: 2004 Tier II Survey Summary

Occurrence and Abundance of Submersed Aquatic Plants

Date:	8/25/04	Littoral sites with plants:	36	Species diversity:	0.57
Littoral depth (ft):	5.0	Number of species:	5	Native diversity:	0.44
Littoral sites:	46	Maximum species/site:	3	Rake diversity:	0.42
Total sites:	60	Mean number species/site:	1.78	Native rake diversity:	0.30
Secchi:	2.0	Mean native species/site:	1.43	Mean rake score:	2.30

Common Name	Site frequency	Relative density	Mean density	Dominance
Chara	4.3	0.22	5.00	4.3
Coontail	56.5	2.83	5.00	56.5
Curly-leaf Pondweed	13.0	0.35	2.67	7.0
Eel Grass	4.3	0.04	1.00	0.9
Sago Pondweed	13.0	0.26	2.00	5.2
Sago Pondweed	8.3	0.10	1.20	2.0
Naiad sp	3.3	0.02	0.50	0.3

Secchi depth was taken prior to the survey and determined to be approximately 2.0 feet. A total of seven species of aquatic plants were collected during the Tier II survey. Of these species, two of them (Eurasian milfoil and curly leaf pondweed) were exotic species. The average number of total species collected at each sample site was 1.78 while the average number of native species collected at each site was 1.43. The species diversity index for Silver Lake was 0.57 while the native plant diversity index was 0.44. Average rake density was 2.3 while average rake diversity was 0.42. The diversity index of native plants collected on the rake was 0.30.

Chara and coontail had the highest average densities at 5.0, while coontail had the greatest relative density at 2.83. The most dominant plant in this survey was coontail with a dominance index of 56.5. The next most dominant plant had a dominance index of only 5.2.

Threatened and Endangered Species

No threatened or endangered species were found during the Tier I or the Tier II survey. Relatively poor water quality and an abundance of invasive plants are not conducive to the survival of these species. Controlling the invasive plants would promote a healthier ecosystem giving any threatened plants a chance to gain a foothold in this body of water, however, increased water quality is needed to promote the growth of these species.

Aquatic Management Plan

Silver Lake is plagued with the exotic weed species of curly leaf pondweed and Eurasian milfoil. Curly leaf pondweed was brought to North America sometime between the middle of the 19th century and 1900 and has spread throughout many parts of the United States. This species emerges very early each spring, flowers and sets seed in the late spring and early summer. When the water temperature reaches 70 degrees it dies off on its own. Curly leaf pondweed's main reproduction route is through turion production in the soil. These turions can over-winter in the soil from year to year. Early season treatment is recommended so that the plant is not allowed to produce large quantities of biomass that die naturally when the water temperature hits 70 degrees (Pullman 1992) Please remember that the higher the water temperature the less oxygen the water holds. Hence, the more biomass (weed growth) in warm water, the more potential risk of a fish kill due to low oxygen levels and stress on the fish. Research by Cerexagri has shown that early treatment with Aquathal reduces turion production from year to year.

There are many alternatives that have been use to control curly leaf pondweed in Indiana Lakes. All of them have disadvantages and advantages. The main basis for choosing which option is based on how selective the particular option is. The goal of this plan is to control the curly leaf pondweed without harming native plant species.

No Action and Other Alternatives.

If no action is taken, the curly leaf pondweed will only get worse since the curly leaf grows by turions and will remain active in the soil for years even after the curly leaf dies when the water temperature reaches 70 degrees.

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Mechanical Harvesting

Mechanical harvesting uses a machine to cut the weeds. These machines pick up the cut weeds but will still leave small fragments that will have the ability to re-grow. Mechanical harvesting is also not selective in its control. The harvesting will cut the native weed species as well as the exotics if both species are present in the same area. For the above reasons mechanical harvesting is not recommended. Harvesting can be accomplished by individual owners around their dock areas. A lake property owner can legally harvest a 625 square foot area. (25 feet by 25 feet).

Biological Control

There are no biological methods available for the control of curly leaf pondweed.

Environmental Manipulation

Draw down of the lake level is another way to control the curly leaf problem in the lake. Lower water levels expose the curly leaf to freezing and thawing. However, this plan is not selective as it will control the natives as well. Also, this will cause the curly leaf pondweed to grow in deeper water. For these above reasons draw down is not recommended for Silver Lake.

Chemical Control

Aquatic chemicals come in two types. There are contact chemicals and systemic chemicals. Systemic herbicides kill the roots of the plants. Examples of systemic herbicides are Sonar and Avast (flouridone active ingredient) and Navigate, Aqua Kleen, DMA4 (active ingredient 2, 4-D) and Renovate (Trichlophyr active ingredient). All these chemicals are effective in killing Eurasian milfoil by the roots but have no long term effect on turion control for curly leaf. Based on the author's experience and other lake managers in the Midwest, whole lake treatments of flouridone are the best at controlling Eurasian water milfoil provided the current population in a lake warrants this type of treatment. However, the best approach for curly leaf pondweed control is to use Aquathal (a contact herbicide) which reduce the turion production from year to year. Flouridone can be applied at low rates to control the Eurasian milfoil and not control the majority of the native weed species present in the lake.

2, 4-D and Trichophyr are both root control herbicides but they have the ability to be used in smaller areas where Eurasian milfoil is present whereas with flouridone the whole lake needs to be treated. The major difference between 2,4-D and Trichophyr is that trichophyr is showing that it may have the ability to control the Eurasian milfoil in select areas longer than 2,4-D. Please remember that Renovate has only been available for use for the past two seasons. The ability of Renovate to have more long term control than 2,4-D for spot root control treatments of Eurasian milfoil is still being documented. 2,4-D is less expensive to use but if trichophyr continues to show longer control in treated areas it will be a better investment in the long run. None of these above chemicals have the ability to control curly leaf pondweed.

Contact herbicides are used best to control the majority of the weeds around people's piers and in man-made channels. Contact herbicides are the not the best choice for these plans to reduce the Eurasian milfoil problem in area lakes since they are not selective and do not control the weeds by the roots. Examples of contact herbicides are Reward (active ingredient Diquat) and Aquathal (active ingredient endothal). However, where curly leaf pondweed levels are high, Aquathal can be used to reduce turion production from year to year.

The public's primary concern with the use of chemicals is safety. This should not be a concern since extensive testing is completed prior to a chemical being delivered to the market. These tests demonstrate that the chemical is safe for the environment and will not have adverse effects on humans or the animal population in a lake when used properly.

Based on IDNR revisions and suggestions it would be best to monitor the plants by conducting a spring survey to record the abundance of curly leaf pondweed. Spring curly leaf growth is a known problem in Silver Lake. Aquatic Weed Control has treated curly leaf in Silver Lake for the past two years and lake residents have expressed their concerns at informational meetings. Early spring Aquathal treatments are still recommended to reduce turion production by curly leaf pondweed.

Public Involvement and Education

A public meeting was held by the Silver Lake Association on September 18, 2004. This meeting was attended by approximately 15 lake residents. This meeting was held in order to inform residents about the problems facing Silver Lake, and to discuss possible solutions to these problems. Various ideas were discussed and Jim Donahoe of Aquatic Weed control offered potential management strategies that could be used to control the exotic plants and reclaim the lake for those who wish to enjoy it. A second public meeting will be held in January or February to discuss the management plan. There were no objections to having the lake treated at the meeting.

It is important that information about management practices on Silver Lake be made available to the public. Lake association meetings and newsletters are excellent avenues through which this information can be distributed. Informational signs could also be posted at lake access areas. Also, a summary of management practices funded by the LARE program would make an excellent addition to the annual fishing regulations guide and other IDNR publications. Additional information on aquatic management can be found at the following web sites: www.mapms.org www.aquatic.org www.apms.org www.nalms.org.

Monitoring and Evaluation of the Action Plan

When the action plan is implemented, follow-up surveys will be essential to evaluate the effectiveness of the management activities. After one year the survey should be conducted to determine the amount of curly leaf turions remaining in the benthos. This will determine if the management strategy has been effective in reducing the curly leaf pondweed population from one year to the next.

In the spring of the third year after the first chemical application, an additional survey should be conducted to determine the amount of curly leaf turions left in the soil. This survey will begin to describe how the curly leaf population is reacting to the management strategy over a longer period of time.

These surveys will provide the basis for evaluation of the management strategy and can be presented to the public should the need arise to modify the management strategy. They will also serve to keep the public interested and informed about Silver Lake so they will be motivated and equipped to help improve and conserve the quality of the Silver Lake ecosystem. These survey results should be addressed at a lake association meeting or newsletter.

Action Plan

The lake association should begin to raise funding to spray the lake in 2005 regardless as to whether the association gets a grant or not. In the past, all chemical treatments conducted on Silver Lake were requested and paid for by individuals owning lake front property. It is recommended that this money collected every year be used for the 10% match that is required for the LARE funding. It is also recommended that signs be posted at the ramp sites as to inform the residents and non residents about the two exotic weed species in the lake. These signs would help in the reduction of the exotic plants being re-introduced into the lake. These signs can be obtained from the Department of Natural Resources.

Whole Lake Sonar Treatment

Based on in-put by Ed Braun (local biologist of the lake) a whole lake treatment of Sonar herbicide will not be permitted because even at low levels the native beneficial coontail will be impacted. Even if a permit was issued to use Sonar it would not be recommended since there is not conclusive evidence that using Sonar will significantly reduce the turion production from one year to the next. Also, if Sonar is used the first year, most district biologists will not issue permits for the lake to be treated the following year to allow native plants to re-establish themselves. Curly leaf pondweed is not a native so it will also re-grow in two years.

Shoreline Treatments.

The aquatic weed problem primarily involves the shoreline of the entire lake. A whole lake treatment is not recommended for Silver Lake since coontail is a native beneficial species. In past years, there has not been a way to control the curly leaf pondweed by the roots. Curly leaf pondweed roots (turions) remain active in the soil for the entire year even though the plant dies on its own after the water temperature reaches 70 degrees.

Recently, Cerexagri (manufacture of Aquathal K) has determined and evaluated on other lakes that treating with Aquathal K in late March to early April when the water temperature reaches 50 degrees will reduce the curly leaf turion (root) production significantly. This application will also control the milfoil and thin the coontail

population. Controlling the milfoil and curly leaf pondweed will allow the more beneficial native weed species to grow.

The application would need to be done at least two years in a row to reduce the turion production in the soil. After two years another survey should be conducted to determine if the turion production has been reduced. Cost to complete this treatment on the developed side of the lake would be approximately $14,000 per year. Survey cost would be approximately $1,400 to collect data and update the management plan before the treatment. This pretreatment survey will be required by the IDNR. Cost to perform turion surveys in the second and third year would also be approximately $1,400.

Silver Lake Chemical Treatment Cost Summary

2005

Pretreatment vegetation and turion survey, management plan update	$1,400.00
Herbicide and application costs	$14,000.00

2006

Pretreatment vegetation and turion survey, management plan update	$1,400.00
Herbicide and application costs	$14,000.00

2007

Vegetation and turion summary, management plan update	$1,400.00

Chemical treatments after the second year will be dependant upon the success of the 2005 and 2006 applications.

A lake association meeting was held on September 18, 2004 to discuss the problem and to receive input from lake residents. This plan was also discussed with Ed Braun (IDNR biologist in charge of the lake) and this approach could be approved as presented at the meeting.

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Appendix A: Macrophytes of Silver Lake

The following appendix was compiled using information found in the 5th edition of How to Identify Water Weeds and Algae, edited by James C. Schmidt and James R. Kannenberg.

Seven major species were identified in the Tier I and Tier II aquatic vegetation surveys.

1. Coontail

Scientific name: *Ceratophyllum demersum*
Classification: Native to Indiana
Distribution: Coontail is common throughout the U.S., usually in hard water.
Presence in Silver Lake: Collected at 29 of the 60 sample sites.

Description: Coontail plants are submersed and have no roots, though they appear to be attached to the lake bottom when viewed from above the surface of the water. The free-floating nature of coontail allows it to colonize new areas of a lake quickly, and it often times forms extremely dense weed beds where sufficient light and nutrients are

available. Coontail has dark green leaves arranged in whorls around the stem and usually grows in long, bushy strands resembling evergreen trees beneath the surface of the water. Coontail's structure is very similar to Eurasian milfoil but coontail has forked leaves, which distinguishes it from the feather-like projections of milfoil leaves.

2. **Curley Leaf Pondweed**

Scientific name: *Potamogeton crispus*
Classification: Exotic to Indiana
Distribution: Found throughout the U.S. in fresh and brackish water
Presence in Silver Lake: Collected at 7 of the 60 sample sites.

Description: Curley leaf pondweed usually grows and spreads rapidly in early spring and begins to dies out by midsummer as water temperatures approach 70 degrees Fahrenheit. Curley Leaf has extremely thin, membranous leaves arranged alternately on the stem with small teeth-like projections visible along the edge of each leaf. A reproductive spike may be seen protruding from the surface of the water. Curley leaf pondweed may also leave small reproductive structures called turions in the sediment on the lake bottom that can lie dormant throughout the winter and then sprout when spring arrives.

3. **Sago Pondweed**

Scientific name: *Potemogeton pectinatus*
Classification: Native to Indiana
Distribution: Found throughout the U.S., Very common in the northern 2/3 of Indiana
Presence in Silver Lake: Collected at 4 of the 60 sample sites.

Description: Sago Pondweed has a bushy appearance with narrow, thread-like leaves that spread out to resemble a fan. Leaves are usually 1/16 of an inch wide and 1 to 6 inches long. Nutlets are formed on a string-like structure and protrude from the surface of the water. While sago pondweed can form dense beds, many times it is found in sparse, loosely distributed arrangements.

4. **Chara**

Scientific name: *Chara* sp.
Classification: Native to Indiana
Distribution: Extremely common worldwide. Found in hard water.
Presence in Silver Lake: Collected at 1 of 60 sample sites

Description: Chara is often mistaken for a vascular plant, but it is actually an advanced form of algae. It can be gray, green or yellow in color and is usually forms extremely dense beds that may cover an entire lake. It can be identified by its distinct musky odor, and calcium deposits on the algae's surface make it feel bristly to the touch. It possesses leaf-like structures that are whorled around the hollow stem, and it attaches its self to the lake bottom, although it has no actual roots. It usually grows in shallow, clear water.

5. **Naiad**

Scientific name: *Najas minor* (brittle naiad)

Classification: Native to Indiana
Distribution: Common Throughout the U.S.
Presence in Silver Lake: Collected at 1 of 60 sample sites

Description: The leaves of naiad plants are usually widest at the base and gradually become thinner near the tip of the leaf. Plants are extremely leafy and appear bush-like when viewed from above the surface of the water. Many species of naiad are very common in this area. Plant structure often resembles chara, but the absence of calcium deposits on the surface of the plant help in identification. The leaves of brittle naiad have multiple spines along the margins that are visible to the naked eye.

6. Eel Grass (Wild Celery)

Scientific name: *Vallisneria americana*
Classification: Native to Indiana
Distribution: Found from the Great Plains to the East Coast of the U.S.
Presence in Silver Lake: Collected at 1 of the 60 sample sites.

Description: Eel grass has tufts of ribbon-like leaves with a horizontal stem embedded in the sediment connecting each tuft. This native plant grows thick weed beds anchored in the mud by roots. These dense beds often shade out other forms of weeds and provide excellent escape cover for small fish. The flowers of this plant are visible in late summer at sit on the top of a coiled structure protruding to the surface. This plant is found in both lakes and rivers, but is seldom found in stagnant systems. It is considered an extremely valuable plant to aquatic ecosystems.

7. Eurasian Milfoil

Scientific Name: *Miriophyllum spicatum*
Classification: Exotic in Indiana
Distribution: Common in the Midwest and Eastern U.S. Also spreading along the Pacific coast
Presence in Silver Lake: Collected at 1 of the 60 sample sites.

Description: This extremely aggressive and extremely destructive plant has leaves in whorls of 4 around a reddish stalk. This plant grows rapidly and can reach lengths of over 10 feet. This plant has the ability to over-winter, meaning it can lie dormant during the winter months instead of dying out completely each year. This gives it a distinct advantage over many native species, as it competes for sunlight in early spring. The dormant milfoil plants reach the surface much faster than the native plants sprouting from the lake bottom. This enables the Eurasian milfoil to shade out other plants and form the dense beds that choke the littoral zone of many lakes.

A reproductive process called fragmentation aids the rapid dispersion of Eurasian milfoil. If a milfoil plant is damaged and some fragments are removed from the macrophyte, each small piece of the plant has the ability to grow roots and create a new milfoil plant. Eurasian milfoil is considered one of the most dangerous aquatic nuisance species because of its ability to rapidly disrupt and destroy lake ecosystems.

Appendix B: Tier II Data Sheets

Table 5: Tier II Sample Points by Number

Silver Lake Tier II Quantitative Survey								
25-Aug-04								
		Plants Present						
Site #		CEDE4	POPE6	MYSP2	POCR3	NAFL	CH?AR	VAAM3
		Coontail	Sago	Eur. Milfoil	Curly leaf	Naiad	Chara	Eel grass
1			1					
2								
3								
4		1						
5					1			
6								
7					1			
8								
9								
10								
11								
12								
13								
14		1	2		1			
15		4						
16		1						
17								
18				1				
19								
20								

21		1			2			
22		2						
23		5						
24		2			1			
25								
26								
27						1		
28								
29								
30			2				5	
31		5						
32		1						
33		2			1			

Site #		CEDE4	POPE6	MYSP2	POCR3	NAFL	CH?AR	VAAM3
		Coontail	Sago	Eur. Milfoil	Curly leaf	Naiad	Chara	Eel grass
34		5						
35		1						
36		5						
37								
38								
39		5						
40		5						
41		5						
42		5						
43								1
44		2						
45		1						
46		1						
47								
48		1						
49		1						
50		1						
51								
52		1						
53								
54								
55								
56								
57								
58								
59		1	1		1			
60								

Key - 5 is the highest score on the rake.
Blanks indicate zero weeds on rake
Site Number refers to flag on preceding map.

Silver Lake Aquatic Vegetation Management Plan Update

The 2005 management plan update is designed to evaluate the health of the plant community and the success of chemical treatments. It will describe the state of the plant community as it relates to the goals established by the IDNR for all public lakes in Indiana. Chemical treatments of invasive species are designed to help the lake ecosystem progress toward these goals.

1. Develop or maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality and is resistant to minor habitat disturbances and invasive species.

2. Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.

3. Provide reasonable public recreational access while minimizing the negative impacts on plant and wildlife resources.

Update Summary:

Two aquatic vegetation surveys were conducted on Silver Lake in 2005. The first survey was conducted on April 14, 2005 and the second was conducted on July 15, 2005. The purpose of these surveys was to document any changes in the plant community from the 2004 survey, and to verify the distribution and abundance of the curly leaf pondweed population before and after LARE funded chemical treatments.

The April 14, 2005 survey found high abundances of curly leaf pondweed and coontail. All other species were found in relatively low abundance. Based on the spring survey results, a whole lake chemical treatment was necessary to reduce the curly leaf pondweed population. Curly leaf pondweed must be actively growing in order for chemical treatments to be effective. Curly leaf pondweed will take the maximum amount of nutrients from the water column when actively growing, and incidentally, the maximum amount of herbicide as well. The more herbicide is absorbed by the plant, the more effective the treatment. Based on the spring survey results, curly leaf pondweed was already actively growing and becoming abundant. Based on previous studies, treating curly leaf pondweed very early in the year with low rates of Aquathol K is very effective. The LARE funded chemical treatment was conducted on the day after the spring survey, in order to achieve maximum control of the curly leaf pondweed. The entire lake was treated with Aquathol K, following the management recommendations of the Silver Lake 2005 Aquatic Vegetation Management Plan.

A late season aquatic vegetation survey was conducted on July 15, 2005. This post-treatment survey found that curly leaf pondweed abundance had decreased from a site frequency of 70 percent in the spring to just 18.3 percent in the fall. Dominance dropped from 16.7 in the spring to just 4.0 in the fall after the treatments had taken place. It is important to note that a natural die off of curly leaf pondweed is expected as water temperatures rise in the summer. It is important that early season Aquathol treatments be conducted in successive years to reduce curly leaf turion abundance in the sediment.

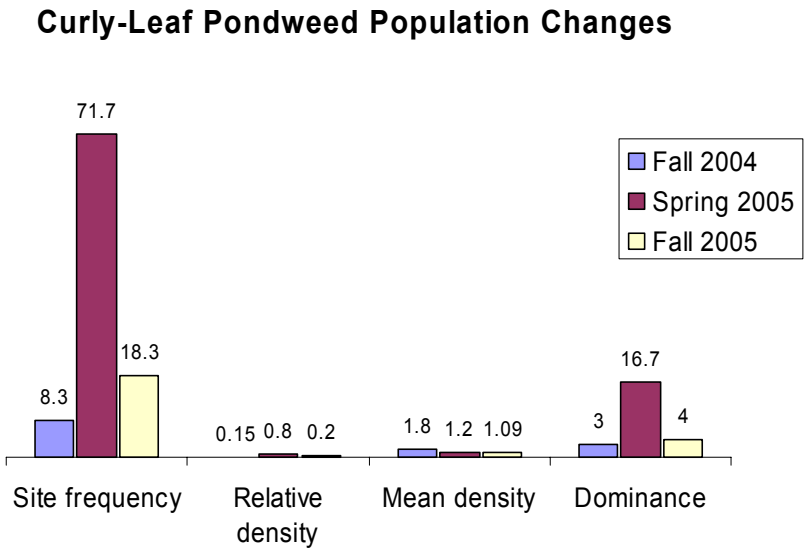

Figure 7: Curly Leaf Pondweed Population Changes

Six plant species were found in the July 2005 vegetation survey, while 7 plant species were found in the August 2004 survey. Eelgrass was found in low abundance in the August 2004 survey, but was not collected in either of the 2005 surveys. Coontail was the most dominant species in both fall surveys and was the second most dominant plant next to curly leaf pondweed in the spring 2005 survey. Sago pondweed, curly leaf pondweed, coontail, and slender naiad were all collected in all three surveys.

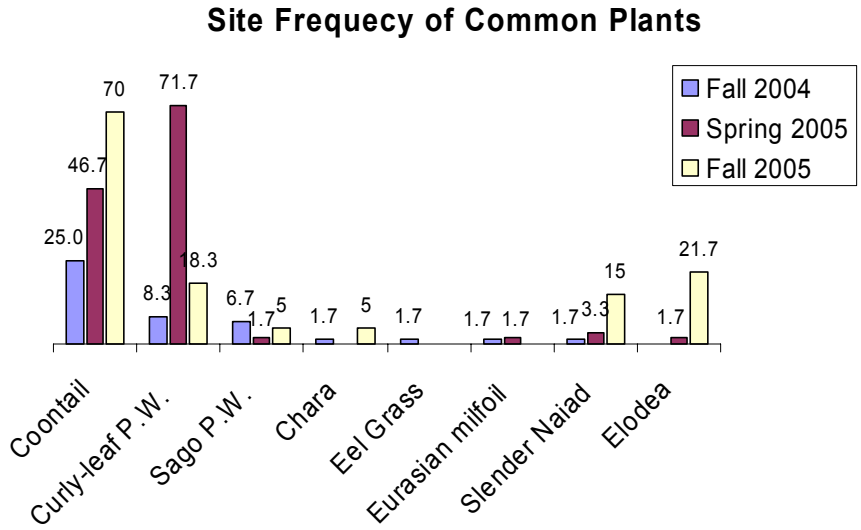

Figure 8: Site Frequency of Common Plants

Dominances of common plants followed much the same trends as site frequency. The plant community of Silver Lake has been dominated by coontail and chara. Coontail dominance increased from fall 2004 to fall 2005. American elodea also showed significant increases in dominance during this time period. Elodea was not sampled in fall 2004. Elodea had a dominance of 0.7 in spring 2005, and a dominance of 7.7 in fall

2005. Slender naiad showed much the same trend as elodea, although its dominance in fall 2005 was not as great.

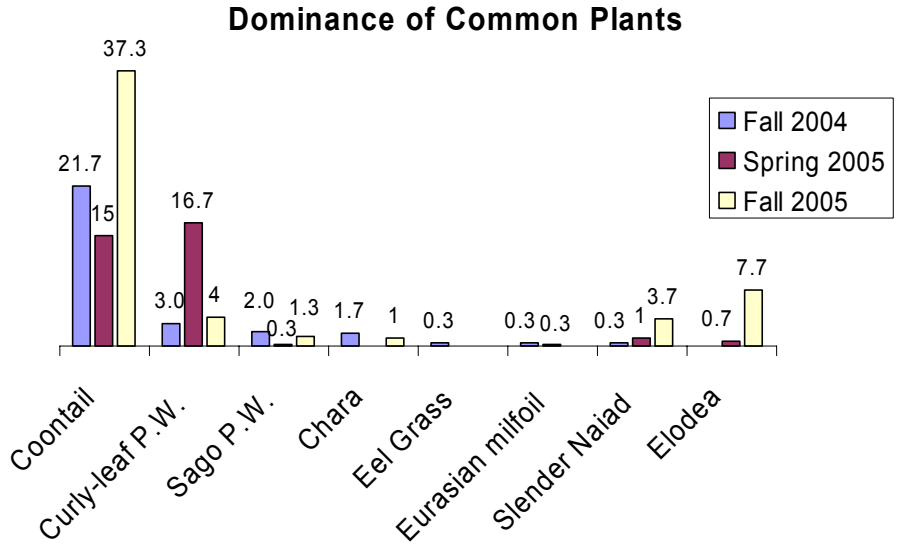

Figure 9: Dominance of Common Plants

2005 Tier I Survey Results

The following plant bed map (Figure 10) has been updated to describe the Silver Lake plant community in more detail. Plant beds are numerous throughout the littoral zone and curly leaf pondweed was present in every plant bed. Composition of the plant beds changed little from 2004, with the exception of curly leaf pondweed. This invasive species showed large changes in distribution from spring to fall (which is expected).

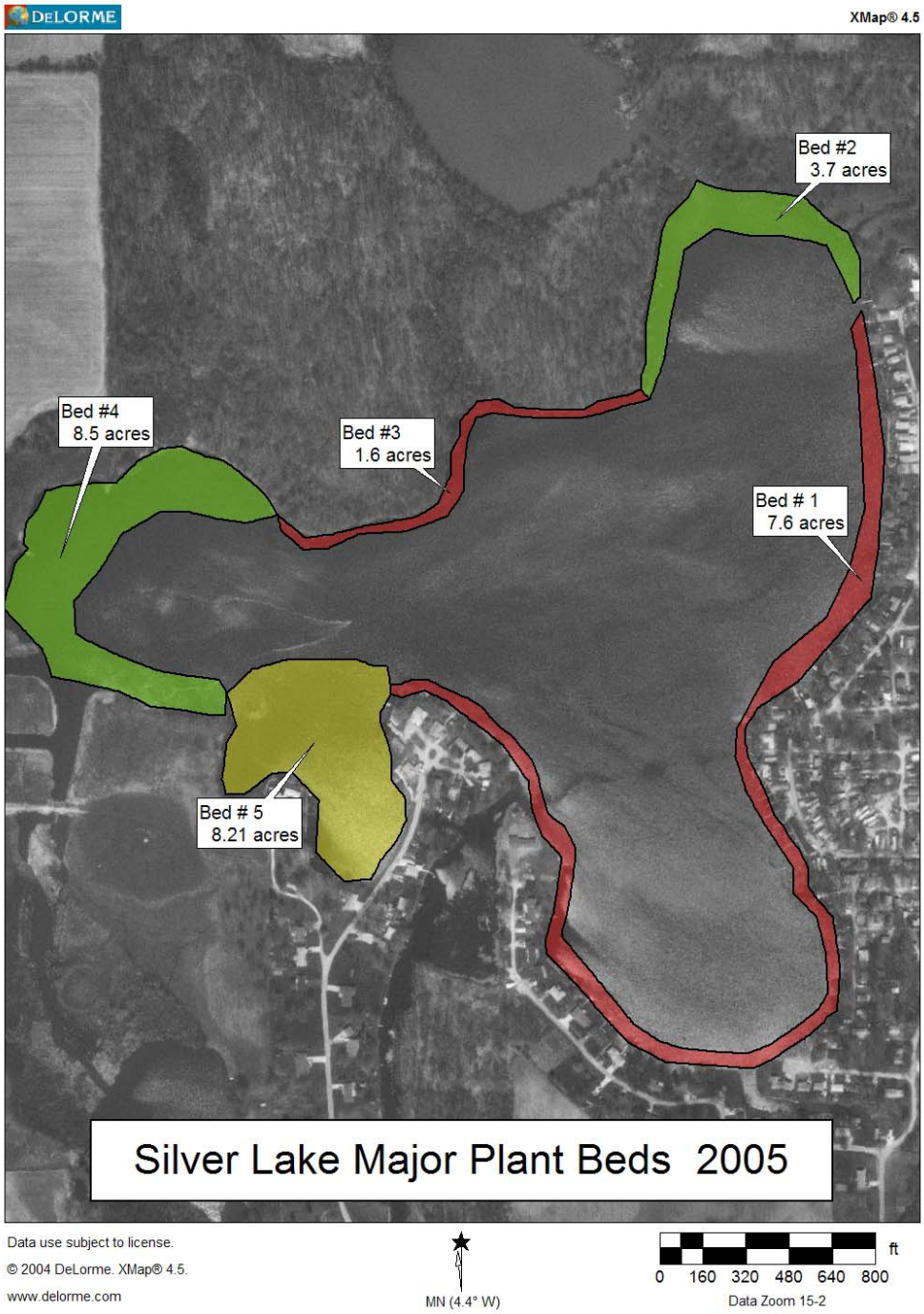

Figure 10: Silver Lake 2005 Tier I Plant Beds

2005 Tier II Survey Results

Data summaries of aquatic vegetation surveys over the past two years are included below. As more data is collected in the years to come, long term trends in the plant community can be identified. These data summaries also help to evaluate the effectiveness of chemical treatments for invasive species. Data summaries are listed in the order which the surveys were conducted.

Table 6: 2004 Tier II Survey Summary

Occurrence and Abundance of Submersed Aquatic Plants

Date:	8/14/04	Littoral sites with plants:	38	Species diversity:	0.66
Littoral depth (ft):	15.5	Number of species:	7	Native diversity:	0.50
Littoral sites:	60	Maximum species/site:	3	Rake diversity:	0.44
Total sites:	60	Mean number species/site:	0.70	Native rake diversity:	0.30
Secchi:	3.0	Mean native species/site:	0.55	*Mean rake score:	1.63

Common Name	Site frequency	Relative density	Mean density	Dominance
Coontail	25.0	1.08	4.33	21.7
Curly-leaf P.W.	8.3	0.15	1.80	3.0
Sago P.W.	6.7	0.10	1.50	2.0
Chara	1.7	0.08	5.00	1.7
Eel Grass	1.7	0.02	1.00	0.3
Eurasian milfoil	1.7	0.02	1.00	0.3
Slender Naiad	1.7	0.02	1.00	0.3

Table 7: 2005 Spring Tier II Survey Summary

Occurrence and Abundance of Submersed Aquatic Plants

Date:	4/14/05	Littoral sites with plants:	53	Species diversity:	0.54
Littoral depth (ft):	15.0	Number of species:	6	Native diversity:	0.23
Littoral sites:	60	Maximum species/site:	3	Rake diversity:	0.56
Total sites:	60	Mean number species/site:	1.28	Native rake diversity:	0.22
Secchi:	5.0	Mean native species/site:	0.55	*Mean rake score:	1.20

Common Name	Site frequency	Relative density	Mean density	Dominance
Curly-leaf P.W.	71.7	0.83	1.16	16.7
Coontail	46.7	0.75	1.61	15.0
Slender Naiad	3.3	0.05	1.50	1.0
American Elodea	1.7	0.03	2.00	0.7
Eurasian milfoil	1.7	0.02	1.00	0.3
Sago P.W.	1.7	0.02	1.00	0.3

Table 8: 2005 Fall Tier II Survey Summary

Occurrence and Abundance of Submersed Aquatic Plants

Date:	7/15/05	Littoral sites with plants:	45	Species diversity:	0.67
Littoral depth (ft):	16.0	Number of species:	6	Native diversity:	0.59
Littoral sites:	60	Maximum species/site:	5	Rake diversity:	0.51
Total sites:	60	Mean number species/site:	1.35	Native rake diversity:	0.44
Secchi:	3.5	Mean native species/site:	1.17	*Mean rake score:	2.38

Common Name	Site frequency	Relative density	Mean density	Dominance
Coontail	70.0	1.87	2.67	37.3
Elodea sp	21.7	0.38	1.77	7.7
Curly-leaf P.W.	18.3	0.20	1.09	4.0
Slender Naiad	15.0	0.18	1.22	3.7
Chara	5.0	0.05	1.00	1.0
Sago P.W.	5.0	0.07	1.33	1.3

Figure 11 shows curly leaf pondweed distribution prior to treatment in the spring of 2005. Curly leaf pondweed was widely spread throughout the entire lake, although average density was still relatively low because the survey was conducted early in the growing season.

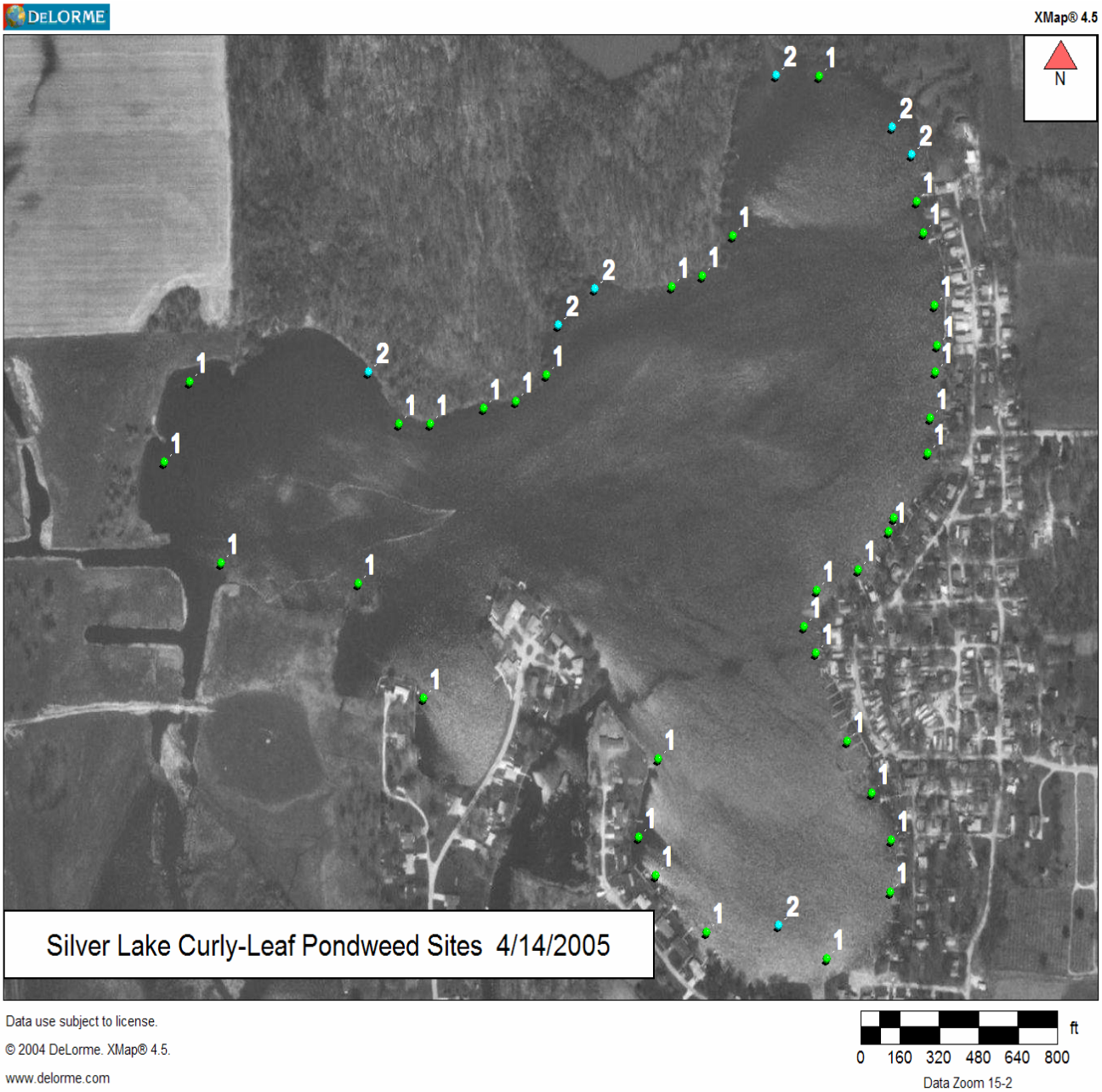

Figure 11: Spring 2005 Curly Leaf Pondweed Sites

Figure 12 shows the 2005 treatment areas for Silver Lake. The entire littoral zone of Silver Lake was treated with Aquathol K to reduce the curly leaf pondweed infestation.

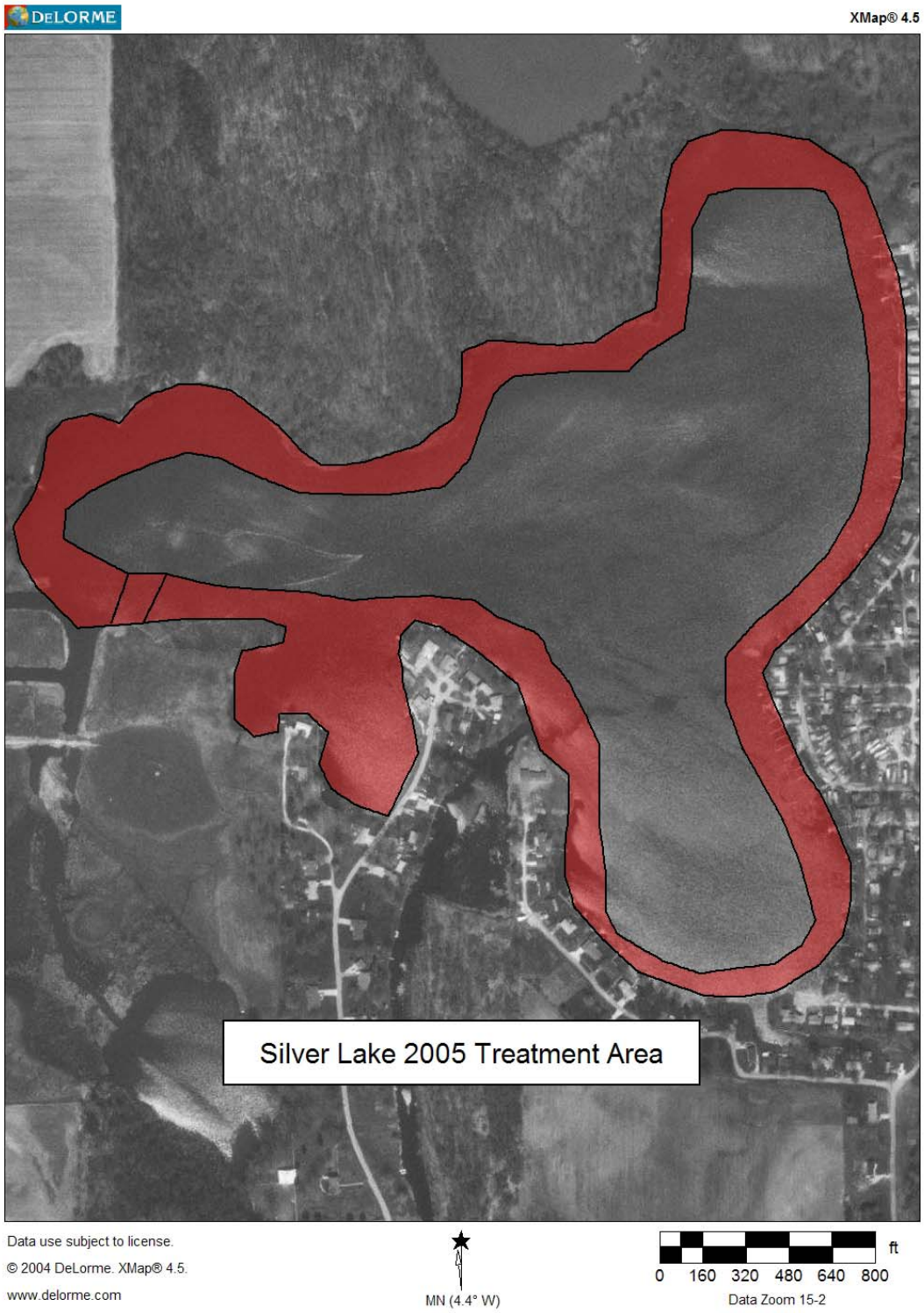

Figure 12: 2005 Treatment Area

Post treatment surveys showed that curly leaf pondweed distribution had dropped significantly from spring to fall (see Figure 13). It will take further surveys and Aquathol treatments to determine the full effect that the management plan since curly leaf pondweed is usually most abundant in the spring. Early season Aquathol treatments are designed to be conducted in successive years to reduce the turion population in the sediment.

Figure 13: 2005 Fall Curly Leaf Pondweed Sites

Secchi depth was taken prior to both surveys and determined to be approximately 5 feet in the spring and 3.5 feet in the fall. The first survey was conducted on April 14, 2005. 60 rake samples were distributed throughout the lake. A total of 6 species of submersed aquatic plants were collected during the spring (April) 2005 Tier II survey. Of these 6 species, two of them (Eurasian milfoil and curly-leaf pondweed) were exotic. The following map shows the locations of all sample sites during the spring survey.

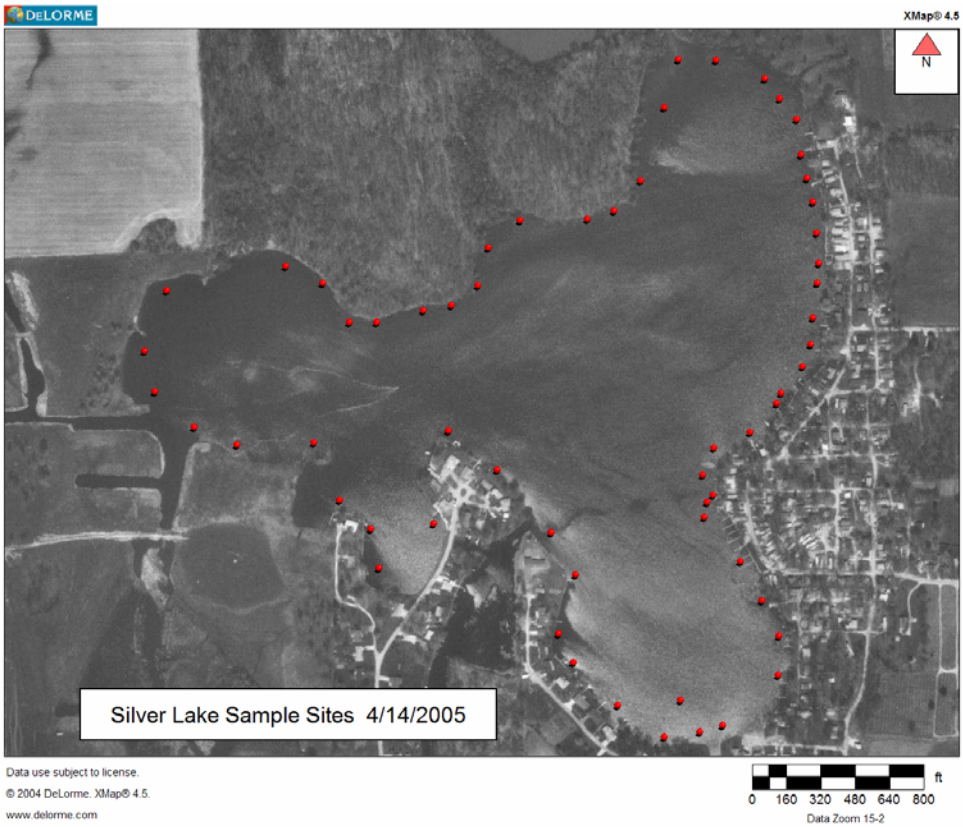

Figure 14: 2005 Spring Sample Sites

The fall survey was conducted on July 15, 2005. Sixty sample sites were distributed throughout the lake. In this Tier II survey, 6 species of submersed aquatic plants were collected. The following map shows the locations of the fall sample sites.

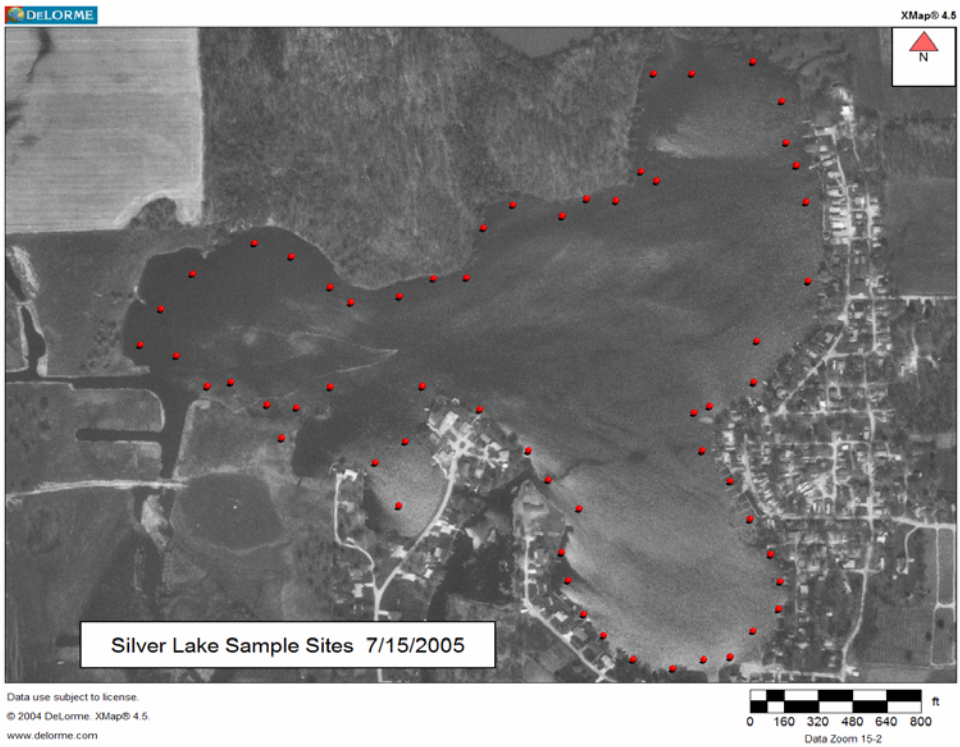

Figure 15: 2005 Fall Sample Sites

Site Frequency

Site frequency is a measure of how often a species was collected during the Tier II survey. It can be calculated by the following equation:

$$\text{Site Frequency} = \frac{\text{(\# of sites where the species was collected)}}{\text{Total \# of sample sites}} \times 100$$

Curly leaf pondweed was the most frequently collected plant in the spring survey with a site frequency of 71.7 %. Coontail was next with a site frequency of 46.7 %. Naiad had a site frequency of 3.3, while elodea, Eurasian milfoil, and sago pondweed all had site frequencies of 1.7 %.

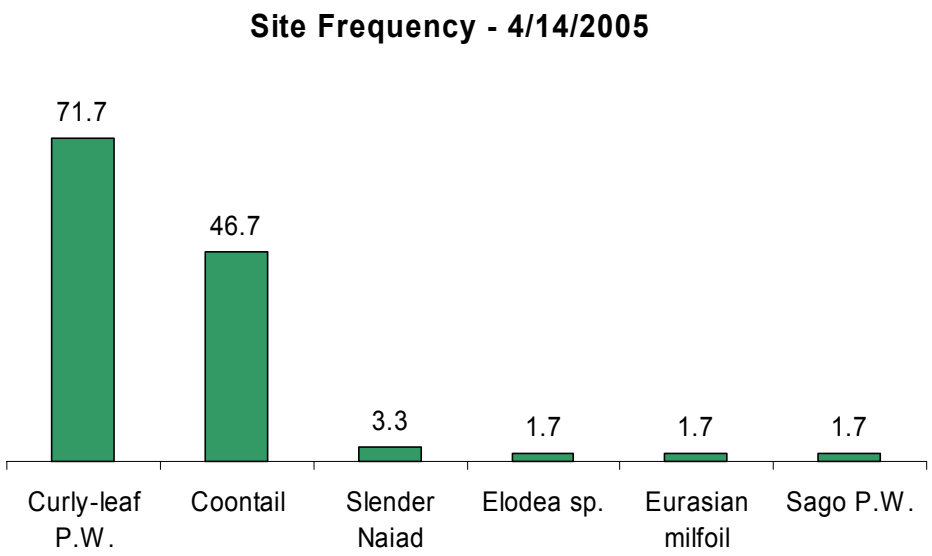

Figure 16: 2005 Spring Site Frequencies

By fall, coontail had become the most dominant plant with a site frequency of 70 %. Elodea was second with a site frequency of 21.7%. Curly leaf pondweed site frequency dropped significantly to 18.3 %. Slender naiad site frequency increased to 15.0. Chara and sago pondweed both had site frequencies of 5.0% (see Figure 17).

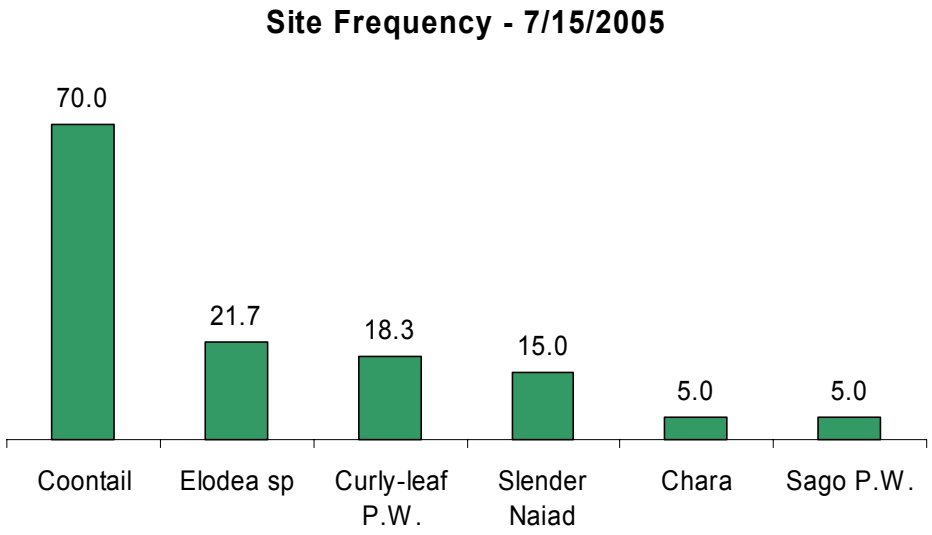

Figure 17: 2005 Fall Site Frequencies

Mean Density and Relative Density

Mean Density is a measure of the abundance of a species in areas where it is growing. For example, a species can have a high site frequency, but still have a very low mean density. This means that a species can be prevalent throughout an entire lake, but it may also be sparsely scattered. Mean density can be calculated using the following equation:

$$\text{Mean Density} = \frac{(\text{The sum of all rake scores for a species})}{(\text{Total \# of sites where the species was collected})}$$

Relative Density is calculated much like mean density, only in this case, the sum of the rake scores for a species is divided by the total number of sample sites in the survey. Unless a species was collected at every sample site, the relative density will always be smaller than the mean density.

$$\text{Relative Density} = \frac{(\text{The sum of all rake scores for a species})}{(\text{Total \# of sample sites})}$$

In spring of 2005, elodea had the greatest mean density although its relative density was very low because of its scarcity in the lake. Coontail ranked second in mean density and second in relative density, while curly leaf pondweed ranked third in mean density but first in relative density (see Figure 18).

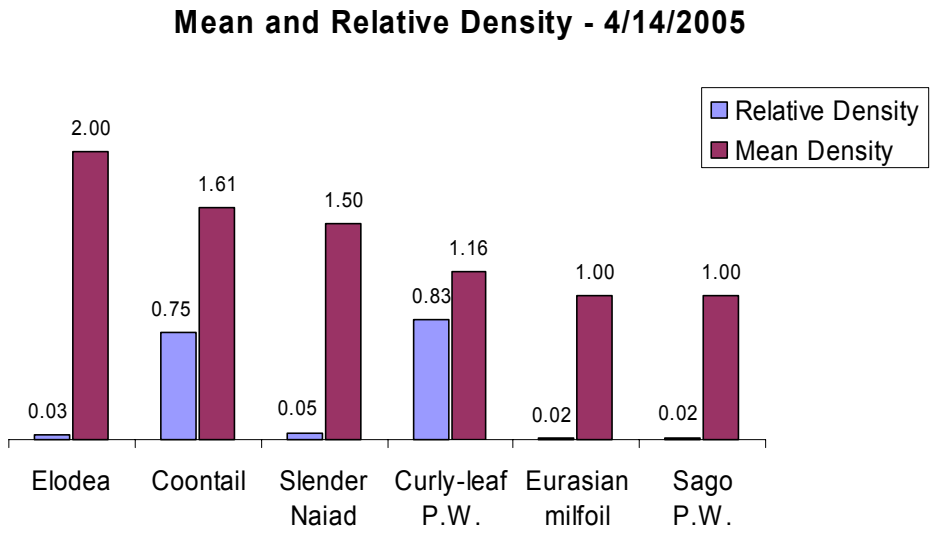

Figure 18: 2005 Spring Plant Densities

By July, coontail had the highest mean density, at 2.67, and the highest relative density at 1.87. Elodea mean density was 1.77 and relative density increased significantly to 0.38. Curly leaf pondweed mean density increased slightly, while its relative density decreased significantly to 0.20 (see Figure 19).

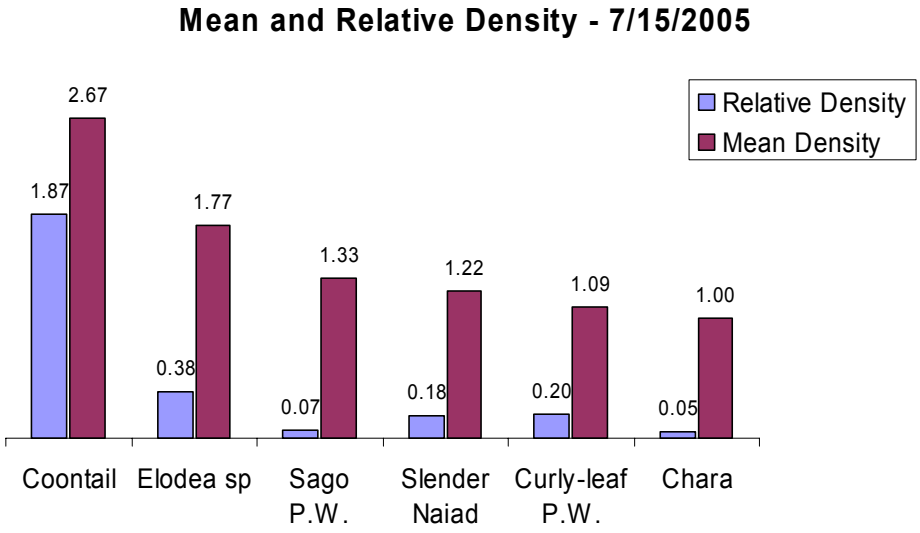

Figure 19: 2005 Fall Plant Densities

Species Diversity

The species diversity indices listed in the plant descriptors to help describe the overall plant community. A species diversity index is actually measured as a value of uncertainty (H). If a species is chosen at random from a collection containing a certain number of species, the diversity index (H) is the probability that a chosen species will be different from the previous random selection. The diversity index (H) will always be between 0 and 1. The higher the H value, the more likely it is that the next species chosen from the collection at random will be different from the previous selection (Smith, 2001). This index is dependant upon species richness and species evenness, meaning that species diversity is a function of how many different species are present and how evenly they are spread throughout the ecosystem.

The species diversity index for Silver Lake in the April survey was 0.54 and this diversity index increased to 0.67 in the July survey. Native plant diversity in the April survey was measured at 0.23. Native diversity increased in the July survey, with a value of 0.59. Rake diversity was measured at 0.56 in the April survey, and decreased in the July survey to 0.51. Native rake diversity decreased from 0.22 in April to 0.44 in July.

The average (mean) rake score for the April survey was 1.20 and the average rake score for the July survey was 2.38. This indicates an overall reduction in plant biomass in the fall survey.

Species Dominance

Species dominance is dependent upon how many times a species occurs, and its relative coverage area or biomass within the system. In this survey, the abundance rating given to each species at each sample site was used to determine dominance. The dominance of a particular species in this Tier II survey increases as its site frequency and relative abundance increase.

In the spring survey, curly leaf pondweed and coontail dominated the lake (Figure 20). Curly leaf pondweed had a score of 16.7 and coontail had a dominance score of 15.0. All other plants had extremely low dominance scores when compared to these two species.

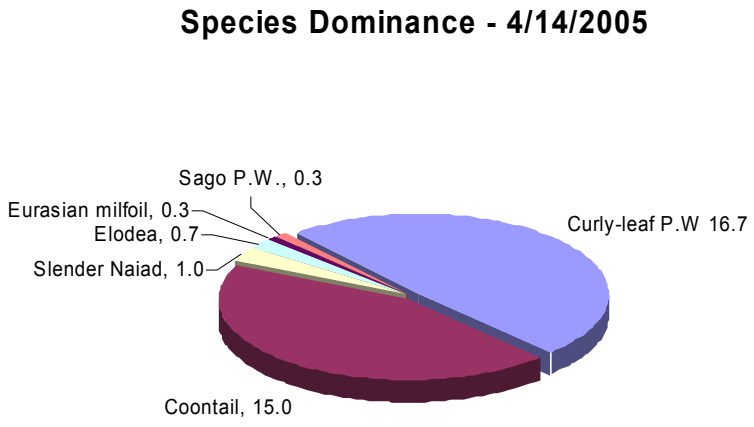

Figure 20: 2005 Spring Plant Dominance

In July, coontail was by far the most dominant species with a score of 37.3. Curly leaf pondweed dominance had dropped significantly to 4.0. Elodea had overtaken chara as the second most dominant species, with a score of 7.7. Slender naiad had a score of 3.7, sago pondweed had a score of 1.3, and chara had a score of 1.0 (see Figure 21).

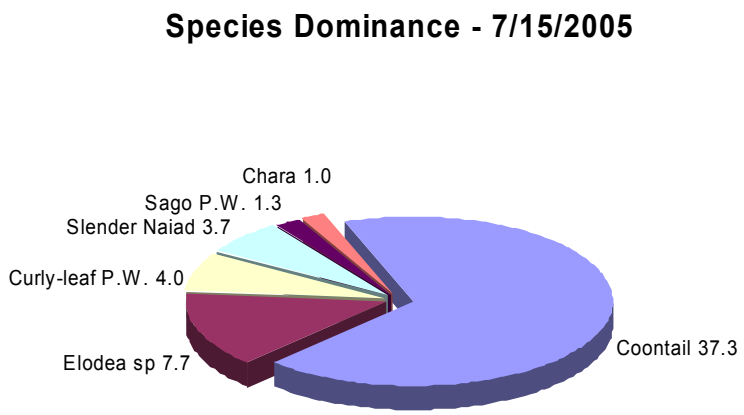

Figure 21: 2005 Fall Plant Dominance

The average number of total species collected at each sample site in the April survey was 1.28 while the July survey collected an average of 1.35 species per site. The average number of native species collected at each site in the April survey was 0.55 and increased to 1.17 in the July survey.

Public Involvement

The following figure summarizes the results of a public questionnaire handed out to all in attendance at the public meeting. This sample questionnaire shows the total number of responses for each question.

(22 participants)

Lake Use Survey — Lake name Silver

Are you a lake property owner? Yes 22 No 0

Are you currently a member of your lake association? Yes 20 No 1

How many years have you been at the lake?
- 2 or less -4
- 2 – 5 years -6
- 5-10 years - 5
- Over 10 years -7

How do you use the lake (mark all that apply)
- 11 Swimming
- 19 Boating
- 21 Fishing
- 1 Irrigation
- 0 Drinking water
- 1 Other Scenery

Do you have aquatic plants at your shoreline in nuisance quantities? Yes 20 No 0

Do you currently participate in a weed control project on the lake? Yes 19 No 1

Does aquatic vegetation interfere with your use or enjoyment of the lake? Yes 19 No 2

Does the level of vegetation in the lake affect your property values? Yes 17 No 2

Are you in favor of continuing efforts to control vegetation on the lake? Yes 22 No 0

Are you aware that the LARE funds will only apply to work controlling invasive exotic species, and more work may need to be privately funded? Yes 22 No 0

Mark any of these you think are problems on your lake:
- 1 Too many boats access the lake
- 0 Use of jet skis on the lake
- 0 Too much fishing
- 1 Fish population problem
- 18 Dredging needed
- 0 Overuse by nonresidents
- 17 Too many aquatic plants
- 2 Not enough aquatic plants
- 9 Poor water quality
- 0 Pier/funneling problem

Please add any comments:
- 2 cows in the lake
- 2 excessive speed
- Keep up the periodic treatments, problem with purple loose-strife

Figure 22: 2005 Public Involvement

Integrated Management Strategy

The early season Aquathol treatment program calls for treatments in successive years to gradually reduce the amount of turions left in the sediment. A whole lake Aquathol treatment should be conducted again in 2006 to continue this program. A drastic post treatment reduction was seen in the curly leaf pondweed, but natural die offs are expected from spring to fall, and it will take at least two more years of surveys to determine if the long term strategy is effective. Treatment area will be the same as in 2005 (see Figure 12)

Project Budget

2006

Pretreatment and post treatment vegetation survey, management plan update		$1500.00
Herbicide and application costs		$14,400.00
Post treatment and plan update costs will depend upon new IDNR requirements	Approximately	$4500.00

2007

Pretreatment Vegetation Survey		$1500.00
Herbicide and application costs		$15120.00
Post treatment and plan update costs will depend upon new IDNR requirements	Approximately	$4500.00

Application for Aquatic Vegetation Control Permit
Species Distribution Maps
Data Sheets

APPLICATION FOR AQUATIC VEGETATION CONTROL PERMIT

State Form 26727 (R / 11-03)
Approved State Board of Accounts 1987

[ ] Whole Lake [X] Multiple Treatment Areas

Check type of permit

INSTRUCTIONS: Please print or type information

FOR OFFICE USE ONLY
License No.
Date Issued
Lake County

Return to: Page 1 of ____

DEPARTMENT OF NATURAL RESOURCES
Division of Fish and Wildlife
Commercial License Clerk
402 West Washington Street, Room W273
Indianapolis, IN 46204

FEE: $5.00

Applicant's Name: Jim Walker	Lake Assoc. Name: Silver Lake Conservation Association Inc,	
Rural Route or Street: 3332 West Neher Road		Phone Number: 260-352-0806
City and State: Silver Lake IN		ZIP Code: 46982
Certified Applicator (if applicable)	Company or Inc. Name	Certification Number
Rural Route or Street		Phone Number
City and State		ZIP Code

Lake (One application per lake): Silver Lake	Nearest Town: Silver Lake	County: Kosciusko
Does water flow into a water supply	[ ] Yes	[X] No

Please complete one section for *EACH* treatment area. Attach lake map showing treatment area and denote location of any water supply intake.

Treatment Area # 1	LAT/LONG or UTM's: Entire perimeter of Lake	
Total acres to be controlled: 29.39	Proposed shoreline treatment length (ft): 10,244	Perpendicular distance from shoreline (ft): 125
Maximum Depth of Treatment (ft): 5	Expected date(s) of treatment(s): Late March early April	

Treatment method: [X] Chemical [ ] Physical [ ] Biological Control [ ] Mechanical

Based on treatment method, describe chemical used, method of physical or mechanical control and disposal area, or the species and stocking rate for biological control. Aquathal K

Plant survey method: [X] Rake [ ] Visual [ ] Other (specify) ____

Aquatic Plant Name	Check if Target Species	Relative Abundance % of Community
Eurasian Milfoil	X	20
Curley Leaf	X	70

Page ___ of _____

Treatment Area #	LAT/LONG or UTM's	
Total acres to be controlled	Proposed shoreline treatment length (ft)	Perpendicular distance from shoreline (ft)
Maximum Depth of Treatment (ft)	Expected date(s) of treatment(s)	

Treatment method: ☐ Chemical ☐ Physical ☐ Biological Control ☐ Mechanical

Based on treatment method, describe chemical used, method of physical or mechanical control and disposal area, or the species and stocking rate for biological control. _____

Plant survey method: ☐ Rake ☐ Visual ☐ Other (specify) _____

Aquatic Plant Name	Check if Target Species	Relative Abundance % of Community