Silver Lake
Vilas County, Wisconsin

Management Plan

April 2013

Sponsored by:

Eagle River Silver Lake Association

WDNR Grant Program

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Onterra, LLC
Lake Management Planning

Silver Lake

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This management planning effort was truly a team-based project and could not have been completed without the input of the following individuals:

Silver Lake Planning Committee

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Wisconsin Dept. of Natural Resources

Kevin Gauthier
Tim Plude

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1.0 INTRODUCTION

Silver Lake, Vilas County, is a seepage lake with a maximum depth of 18 feet and a surface area of 59 acres (Map 1). Silver Lake contains 26 native plant species, of which common waterweed is the most common plant. Two exotic plant species are known to exist in Silver Lake.

The conclusion of this project allows the Eagle River Silver Lake Association (ERSLA) to meet two primary goals: 1) monitor Eurasian water milfoil occurrences within the lake and continue management actions that were started in 2007 as applicable; and 2) create an update to the ERSLA's Lake Management Plan which includes a long-term control strategy to control EWM within the lake.

Field Survey Notes

(2010) – Abundant purple loosestrife on shoreline, particularly on western / north-western shoreline. Very good water clarity during surveys. Conducted a meander survey of the entire lake, paying close attention to previous treatment areas. Only several EWM plants located during late summer survey.

Photograph 1.0 Silver Lake, Vilas County

Lake at a Glance - Silver Lake

Morphology	
Acreage	59
Maximum Depth (ft)	18
Mean Depth (ft)	8
Vegetation	
Comprehensive Survey Date	July 26, 2010 (WDNR)
Number of Native Species	26
Threatened/Special Concern Species	None
Exotic Plant Species	Eurasian water milfoil, Purple loosestrife
Simpson's Diversity	0.88
Average Conservatism	6.1

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa. The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it.

The highlights of this component are described below in chronological order. Materials used during the planning process can be found in Appendix A.

Planning Committee Meeting I
On July 7th, 2011, Tim Hoyman of Onterra met with several members of the Silver Lake Planning Committee for nearly 3.5 hours. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including Eurasian water milfoil treatment results, aquatic plant inventories, water quality analysis, and shoreland assessment were presented and discussed.

Project Wrap-up Meeting
To follow plan approval.

Management Plan Review and Adoption Process
A draft report of the Silver Lake Comprehensive Management Plan was sent to ERSLA planning committee members in March of 2012 for review. Following their review of the report, an official first draft was delivered to the WDNR as well as the ERSLA in May 2012 for further review and comments. WDNR commentary was received in March of 2013, and addressed by Onterra staff. The report was finalized in April of 2013, with final drafts sent to the WDNR and ERSLA. The ERSLA would approve of the report at their next Board of Directors meeting.

3.0 RESULTS & DISCUSSION

3.1 Watershed Assessment

Watershed Modeling

(Note: Watershed modeling was not conducted as a part of this project. Therefore, the watershed background presented here is strictly for the information of the reader. Please see the Shoreland Assessment area below for specific information relating to Silver Lake.)

A lake's **flushing rate** is simply a determination of the time required for the lake's water volume to be completely exchanged. **Residence time** describes how long a volume of water remains in the lake and is expressed in days, months, or years. The parameters are related and both determined by the volume of the lake and the amount of water entering the lake from its watershed. Greater flushing rates equal shorter residence times.

Two aspects of a lake's watershed are the key factors in determining the amount of phosphorus the watershed exports to the lake; 1) the size of the watershed, and 2) the land cover (land use) within the watershed. The impact of the watershed size is dependent on how large it is relative to the size of the lake. The watershed to lake area ratio (WS:LA) defines how many acres of watershed drains to each surface-acre of the lake. Larger ratios result in the watershed having a greater role in the lake's annual water budget and phosphorus load.

The type of land cover that exists in the watershed determines the amount of phosphorus (and sediment) that runs off the land and eventually makes its way to the lake. The actual amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to permeate the ground and do not produce much surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas, minimize infiltration and increase surface runoff. The increased surface runoff associated with these land cover types leads to increased phosphorus and pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations.

In systems with lower WS:LA ratios, land cover type plays a very important role in how much phosphorus is loaded to the lake from the watershed. In these systems the occurrence of agriculture or urban development in even a small percentage of the watershed (less than 10%) can unnaturally elevate phosphorus inputs to the lake. If these land cover types are converted to a cover that does not export as much phosphorus, such as converting row crop areas to grass or forested areas, the phosphorus load and its impacts to the lake may be decreased. In fact, if the phosphorus load is reduced greatly, changes in lake water quality may be noticeable, (e.g. reduced algal abundance and better water clarity) and may even be enough to cause a shift in the lake's trophic state.

In systems with high WS:LA ratios, like those exceeding 10-15:1, the impact of land cover may be tempered by the sheer amount of land draining to the lake. Situations actually occur where lakes with completely forested watersheds have sufficient phosphorus loads to support high rates of plant production. In other systems with high ratios, the conversion of vast areas of row crops to vegetated areas (grasslands, meadows, forests, etc.) may not reduce phosphorus loads sufficiently to see a change in plant production. Both of these situations occur frequently in impoundments.

Regardless of the size of the watershed or the makeup of its land cover, it must be remembered that every lake is different and other factors, such as flushing rate, lake volume, sediment type, and many others, also influence how the lake will react to what is flowing into it. For instance, a deeper lake with a greater volume can dilute more phosphorus within its waters than a less voluminous lake and as a result, the production of a lake is kept low. However, in that same lake, because of its low flushing rate (high residence time, i.e., years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time that internal nutrient loading may become a problem. On the contrary, a lake with a higher flushing rate (low residence time, i.e., days or weeks) may be more productive early on, but the constant flushing of its waters may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

3.2 Shoreland Condition Assessment

The Importance of a Lake's Shoreland Zone

One of the most vulnerable areas of a lake's watershed is the immediate shoreland zone (approximately from the water's edge to at least 35 feet shoreland). When a lake's shoreland is developed, the increased impervious surface, removal of natural vegetation, and other human practices can severely increase pollutant loads to the lake while degrading important habitat. Limiting these anthropogenic (man-made) affects on the lake is important in maintaining the quality of the lake's water and habitat. Along with this, the immediate shoreland area is often one of the easiest areas to restore.

The intrinsic value of natural shorelands is found in numerous forms. Vegetated shorelands prevent polluted runoff from entering lakes by filtering this water or allowing it to slow to the point where particulates settle. The roots of shoreland plants stabilize the soil, thereby preventing shoreland erosion. Shorelands also provide habitat for both aquatic and terrestrial animal species. Many species rely on natural shorelands for all or part of their life cycle as a source of food, cover from predators, and as a place to raise their young. Shorelands and the nearby shallow waters serve as spawning grounds for fish and nesting sites for birds. Thus, both the removal of vegetation and the inclusion of development reduces many forms of habitat for wildlife.

Some forms of development may provide habitat for less than desirable species. Disturbed areas are often overtaken by invasive species, which are sometimes termed "pioneer species" for this reason. Some waterfowl, such as geese, prefer to linger upon open lawns near waterbodies because of the lack of cover for potential predators. The presence of geese on a lake resident's beach may not be an issue; however the feces the geese leave are unsightly and pose a health risk. Geese feces may become a source of fecal coliforms as well as flatworms that can lead to swimmers itch. Development such as rip rap or masonary, steel or wooden seawalls completely remove natural habitat for most animals, but may also create some habitat for snails; this is not desirable for lakes that experience problems with swimmers itch, as the flatworms that cause this skin reaction utilize snails as a secondary host after waterfowl.

In the end, natural shorelines provide many ecological and other benefits. Between the abundant wildlife, the lush vegetation, and the presence of native flowers, shorelands also provide natural scenic beauty and a sense of tranquility for humans.

Shoreland Zone Regulations

Wisconsin has numerous regulations in place at the state level which aim to enhance and protect shorelands. Additionally, counties, townships and other municipalities have developed their own (often more comprehensive or stronger) policies. At the state level, the following shoreland regulations exist:

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had recognized inadequacies within the 1968 ordinance and had actually adopted more strict shoreland ordinances. Passed in February of 2010, the final NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances of their own. County ordinances may be more restrictive than NR 115, but not less so. These policy regulations require each county to amend ordinances for vegetation removal on shorelands, impervious surface standards, nonconforming structures and establishing mitigation requirements for development. Minimum requirements for each of these categories are as follows (Note: counties must adopt these standards by February 2014, counties may not have these standards in place at this time):

- Vegetation Removal: For the first 35 feet of property (shoreland zone), no vegetation removal is permitted except for: sound forestry practices on larger pieces of land, access and viewing corridors (may not exceed the lesser of 30 percent of the shoreline frontage), invasive species removal, or damaged, diseased, or dying vegetation. Vegetation removed must be replaced by replanting in the same area (native species only).

- Impervious surface standards: The amount of impervious surface is restricted to 15% of the total lot size, on lots that are within 300 feet of the ordinary high-water mark of the waterbody. A county may allow more than 15% impervious surface (but not more than 30%) on a lot provided that the county issues a permit and that an approved mitigation plan is implemented by the property owner.

- Nonconforming structures: Nonconforming structures are structures that were lawfully placed when constructed but do not comply with distance of water setback. Originally, structures within 75 ft of the shoreline had limitations on structural repair and expansion. New language in NR-115 allows construction projects on structures within 75 feet with the following caveats:
    - No expansion or complete reconstruction within 0-35 feet of shoreline
    - Re-construction may occur if no other build-able location exists within 35-75 feet, dependent on the county.
    - Construction may occur if mitigation measures are included either within the footprint or beyond 75 feet.
    - Vertical expansion cannot exceed 35 feet

- Mitigation requirements: New language in NR-115 specifies mitigation techniques that may be incorporated on a property to offset the impacts of impervious surface, replacement of nonconforming structure, or other development projects. Practices such as buffer restorations along the shoreland zone, rain gardens, removal of fire pits, and beaches all may be acceptable mitigation methods, dependent on the county.

- Contact the county's regulations/zoning department for all minimum requirements.

Wisconsin Act 31

While not directly aimed at regulating shoreland practices, the State of Wisconsin passed Wisconsin Act 31 in 2009 in an effort to minimize watercraft impacts upon shorelines. This act prohibits a person from operating a watercraft (other than personal watercraft) at a speed in excess of slow-no-wake speed within 100 feet of a pier, raft, buoyed area or the shoreline of a lake. Additionally, personal watercraft must abide by slow-no-wake speeds while within 200 feet of these same areas. Act 31 was put into place to reduce wave action upon the sensitive shoreland zone of a lake. The legislation does state that pickup and drop off areas marked with regulatory markers and that are open to personal watercraft operators and motorboats engaged in waterskiing/a similar activity may be exempt from this distance restriction. Additionally, a city, village, town, public inland lake protection and rehabilitation district or town sanitary district may provide an exemption from the 100 foot requirement or may substitute a lesser number of feet.

Shoreland Research

Studies conducted on nutrient runoff from Wisconsin lake shorelands have produced interesting results. For example, a USGS study on several Northwoods Wisconsin lakes was conducted to determine the impact of shoreland development on nutrient (phosphorus and nitrogen) export to these lakes (Graczyk et al. 2003). During the study period, water samples were collected from surface runoff and ground water and analyzed for nutrients. These studies were conducted on several developed (lawn covered) and undeveloped (undisturbed forest) areas on each lake. The study found that nutrient yields were greater from lawns than from forested catchments, but also that runoff water volumes were the most important factor in determining whether lawns or wooded catchments contributed more nutrients to the lake. Ground-water inputs to the lake were found to be significant in terms of water flow and nutrient input. Nitrate plus nitrite nitrogen and total phosphorus yields to the ground-water system from a lawn catchment were three or sometimes four times greater than those from wooded catchments.

A separate USGS study was conducted on the Lauderdale Lakes in southern Wisconsin, looking at nutrient runoff from different types of developed shorelands – regular fertilizer application lawns (fertilizer with phosphorus), non-phosphorus fertilizer application sites, and unfertilized sites (Garn 2002). One of the important findings stemming from this study was that the amount of dissolved phosphorus coming off of regular fertilizer application lawns was twice that of lawns with non-phosphorus or no fertilizer. Dissolved phosphorus is a form in which the phosphorus molecule is not bound to a particle of any kind; in this respect, it is readily available to algae. Therefore, these studies show us that it is a developed shoreland that is continuously maintained in an unnatural manner (receiving phosphorus rich fertilizer) that impacts lakes the greatest. This understanding led former Governor Jim Doyle into passing the Wisconsin Zero-Phosphorus Fertilizer Law (Wis Statue 94.643), which restricts the use, sale and display of lawn and turf fertilizer which contains phosphorus. Certain exceptions apply, but after April 1 2010, use of this type of fertilizer is prohibited on lawns and turf in Wisconsin. The goal of this action is to reduce the impact of developed lawns, and is particularly helpful to developed lawns situated near Wisconsin waterbodies.

Shorelands provide much in terms of nutrient retention and mitigation, but also play an important role in wildlife habitat. Woodford and Meyer (2003) found that green frog density was negatively correlated with development density in Wisconsin lakes. As development increased, the habitat for green frogs decreased and thus populations became significantly lower. Common loons, a bird species notorious for its haunting call that echoes across Wisconsin lakes, are often associated more so with undeveloped lakes than developed lakes (Lindsay et al. 2002). And studies on shoreland development and fish nests show that undeveloped shorelands are preferred as well. In a study conducted on three Minnesota lakes, researchers found that only 74 of 852 black crappie nests were found near shorelines that had any type of dwelling on it (Reed, 2001). The remaining nests were all located along undeveloped shoreland.

Emerging research in Wisconsin has shown that coarse woody habitat (sometimes called "coarse woody debris"), often stemming from natural or undeveloped shorelands, provides many ecosystem benefits in a lake. Coarse woody habitat describes habitat consisting of trees, limbs, branches, roots and wood fragments at least four inches in diameter that enter a lake by natural or human means. Coarse woody debris provides shoreland erosion control, a carbon source for the lake, prevents suspension of sediments and provides a surface for algal growth which important for aquatic macroinvertebrates (Sass 2009). While it impacts these aspects considerably, one of the greatest benefits coarse woody habitat provides is habitat for fish species.

Coarse woody habitat has shown to be advantageous for fisheries in terms of providing refuge, foraging area as well as spawning habitat (Hanchin et al 2003). In one study, researchers observed 16 different species occupying coarse woody habitat areas in a Wisconsin lake (Newbrey et al. 2005). Bluegill and bass species in particular are attracted to this habitat type; largemouth bass stalk bluegill in these areas while the bluegill hide amongst the debris and often feed upon in many macroinvertebrates found in these areas, who themselves are feeding upon algae and periphyton growing on the wood surface. Newbrey et al. (2005) found that some fish species prefer different complexity of branching on coarse woody habitat, though in general some degree of branching is preferred over coarse woody habitat that has no branching.

With development of a lake's shoreland zone, much of the coarse woody debris that was once found in Wisconsin lakes has disappeared. Prior to human establishment and development on lakes (mid to late 1800's), the amount of coarse woody habitat in lakes was likely greater than under completely natural conditions due to logging practices. However, with changes in the logging industry and increasing development along lake shorelands, coarse woody habitat has decreased substantially. Shoreland residents are removing woody debris to improve aesthetics or for recreational opportunities (boating, swimming, and, ironically, fishing).

Native Species Enhancement

The development of Wisconsin's shorelands has increased dramatically over the last century and with this increase in development a decrease in water quality and wildlife habitat has occurred. Many people that move to or build in shoreland areas attempt to replicate the suburban landscapes they are accustomed to by converting natural shoreland areas to the "neat and clean" appearance of manicured lawns and flowerbeds. The conversion of these areas immediately leads to destruction of habitat utilized by birds, mammals, reptiles, amphibians, and insects (Jennings et al. 2003). The maintenance of the newly created area helps to decrease water quality by considerably increasing inputs of phosphorus and sediments into the lake. The negative impact of human development does not stop at the shoreland. Removal of native plants and dead, fallen timbers from shallow, near-shore areas for boating and swimming activities destroys habitat used by fish, mammals, birds, insects, and amphibians, while leaving bottom and shoreland sediments vulnerable to wave action caused by boating and wind (Jennings et al. 2003, Radomski and Goeman 2001, and Elias & Meyer 2003). Many homeowners significantly decrease the number of trees and shrubs along the water's edge in an effort to increase their view of the lake. However, this has been shown to locally increase water temperatures, and decrease infiltration rates of potentially harmful nutrients and pollutants. Furthermore, the dumping of sand to create beach areas destroys spawning, cover and feeding areas utilized by aquatic wildlife (Scheuerell and Schindler 2004).

In recent years, many lakefront property owners have realized increased aesthetics, fisheries, property values, and water quality by restoring portions of their shoreland to mimic its unaltered state. An area of shore restored to its natural condition, both in the water and on shore, is commonly called a shoreland buffer zone. The shoreland buffer zone creates or restores the ecological habitat and benefits lost by traditional suburban landscaping. Simply not mowing within the buffer zone does wonders to restore some of the shoreland's natural function.

Enhancement activities also include additions of submergent, emergent, and floating-leaf plants within the lake itself. These additions can provide greater species diversity and may compete against exotic species.

Cost

The cost of native, aquatic, and shoreland plant restorations is highly variable and depends on the size of the restoration area, the depth of buffer zone required to be restored, the existing plant density, the planting density required, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other sites may require erosion control stabilization measures, which could be as simple as using erosion control blankets and plants and/or seeds or more extensive techniques such as geotextile bags (vegetated retaining walls), geogrids (vegetated soil lifts), or bio-logs (see above picture). Some of these erosion control techniques may reduce the need for rip-rap or seawalls which are sterile environments that do nott allow for plant growth or natural shorelines. Questions about rip-rap or seawalls should be directed to the local Wisconsin DNR Water Resources Management Specialist. Other measures possibly required include protective measures used to guard newly planted area from wildlife predation, wave-action, and erosion, such as fencing, erosion control matting, and animal deterrent sprays. One of the most important aspects of planting is maintaining moisture levels. This is done by watering regularly for the first two years until plants establish themselves, using soil amendments (i.e., peat, compost) while planting, and using mulch to help retain moisture.

Most restoration work can be completed by the landowner themselves. To decrease costs further, bare-root form of trees and shrubs should be purchased in early spring. If additional assistance is needed, the lakefront property owner could contact an experienced landscaper. For properties with erosion issues, owners should contact their local county conservation office to discuss cost-share options.

In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $1,400. The more native vegetation a site has, the lower the cost. Owner's should contact the county's regulations/zoning department for all minimum requirements. The single site used for the estimate indicated above has the following characteristics:

- Spring planting timeframe.
- 100' of shoreline.
- An upland buffer zone depth of 35'.
- An access and viewing corridor 30' x 35' free of planting (recreation area).
- Planting area of upland buffer zone 2- 35' x 35' areas
- Site is assumed to need little invasive species removal prior to restoration.
- Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
- Trees and shrubs planted at a density of 1 tree/100 sq ft and 2 shrubs/100 sq ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
- Turf grass would be removed by hand.
- A native seed mix is used in bare areas of the upland buffer zone.
- An aquatic zone with shallow-water 2 - 5' x 35' areas.
- Plant spacing for the aquatic zone would be 3 feet.
- Each site would need 70' of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
- Soil amendment (peat, compost) would be needed during planting.
- There is no hard-armor (rip-rap or seawall) that would need to be removed.
- The property owner would maintain the site for weed control and watering.

Advantages	***Disadvantages***
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreland erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Once native plants are established, they require less water, maintenance, no fertilizer; provide wildlife food and habitat, and natural aesthetics compared to ornamental (non-native) varieties. • Many educational and volunteer opportunities are available with each project.	• Property owners need to be educated on the benefits of native plant restoration before they are willing to participate. • Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in. • Monitoring and maintenance are required to assure that newly planted areas will thrive. • Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Silver Lake Shoreland Zone Condition

Shoreland Development

A lake's shoreland zone can be classified in terms of its degree of development. In general, more developed shorelines are more stressful on a lake ecosystem, while definite benefits occur from shorelines that are left in their natural state. Figure 3.1-1 displays a diagram of shoreline categories, from "Urbanized", meaning the shoreland zone is completely disturbed by human influence, to "Natural/Undeveloped", meaning the shoreline has been left in its original state.

Urbanized: This type of shoreline has essentially no natural habitat. Areas that are mowed or unnaturally landscaped to the water's edge and areas that are rip-rapped or include a seawall would be placed in this category.

Developed-Unnatural: This category includes shorelines that have been developed, but only have small remnants of natural habitat yet intact. A property with many trees, but no remaining understory or herbaceous layer would be included within this category. Also, a property that has left a small (less than 30 feet), natural buffer in place, but has urbanized the areas behind the buffer would be included in this category.

Developed-Semi-Natural: This is a developed shoreline that is mostly in a natural state. Developed properties that have left much of the natural habitat in state, but have added gathering areas, small beaches, etc within those natural areas would likely fall into this category. An urbanized shoreline that was restored would likely be included here, also.

Developed-Natural: This category includes shorelines that are developed property, but essentially no modifications to the natural habitat have been made. Developed properties that have maintained the natural habitat and only added a path leading to a single pier would fall into this category.

Natural/Undeveloped: This category includes shorelines in a natural, undisturbed state. No signs of anthropogenic impact can be found on these shorelines. In forested areas, herbaceous, understory, and canopy layers would be intact.

Figure 3.2-1. Shoreline assessment category descriptions.

On Silver Lake, the development stage of the entire shoreline was surveyed during the fall of 2009. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreline on a property-by-property basis. During the survey, Onterra staff examined the shoreline for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.2-1.

Silver Lake has stretches of shoreland that fit all five shoreland assessment categories. In all, 0.5 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 3.2-2). These shoreland types provide the most benefit to the lake and should be left in their current state if at all possible. During the survey, 0.5 miles of urbanized and developed–unnatural shoreline were observed. If restoration of the Silver Lake shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 2 displays the location of these shoreline conditions around the entire lake.

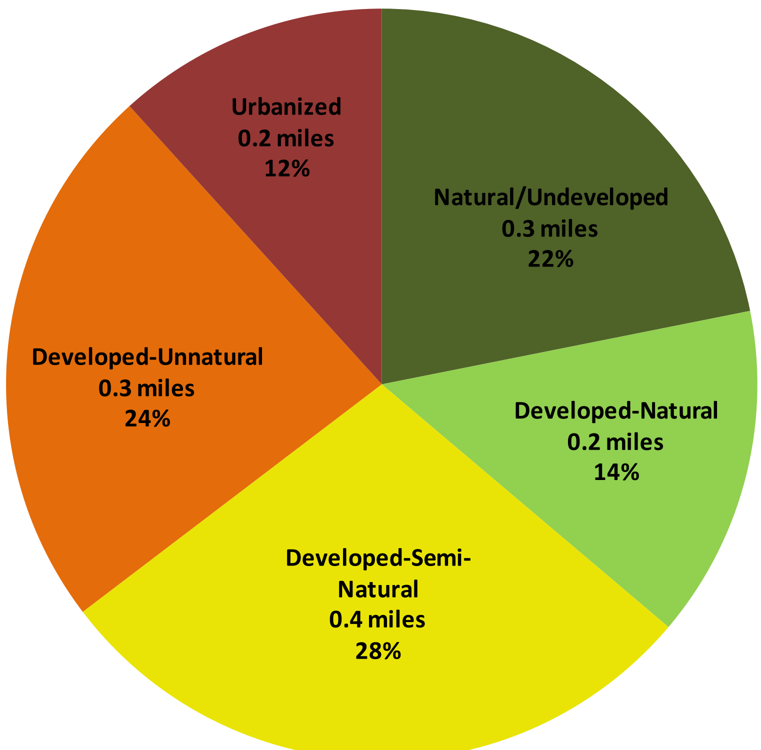

Figure 3.2-2. Silver Lake shoreland categories and total lengths. Based upon fall 2009 survey. Locations of these categorized shorelands can be found on Map 2.

3.3 Aquatic Plants

Introduction

Although the occasional lake user considers aquatic macrophytes to be "weeds" and a nuisance to the recreational use of the lake, the plants are actually an essential element in a healthy and functioning lake ecosystem. It is very important that lake stakeholders understand the importance of lake plants and the many functions they serve in maintaining and protecting a lake ecosystem. With increased understanding and awareness, most lake users will recognize the importance of the aquatic plant community and their potential negative effects on it.

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Z. palustris*) both serve as excellent food sources for ducks and geese. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*) In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the periphyton attached to them as their primary food source. The plants also provide cover for feeder fish and zooplankton, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreline erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas where plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by phytoplankton, which helps to minimize nuisance algal blooms.

Under certain conditions, a few species may become a problem and require control measures. Excessive plant growth can limit recreational use by deterring navigation, swimming, and fishing activities. It can also lead to changes in fish population structure by providing too much cover for feeder fish resulting in reduced numbers of predator fish and a stunted pan-fish population. Exotic plant species, such as Eurasian water-milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing native plants and reducing species diversity. These invasive plant species can form dense stands that are a nuisance to humans and provide low-value habitat for fish and other wildlife.

When plant abundance negatively affects the lake ecosystem and limits the use of the resource, plant management and control may be necessary. The management goals should always include the control of invasive species and restoration of native communities through environmentally sensitive and economically feasible methods. No aquatic plant management plan should only contain methods to control plants, they should also contain methods on how to protect and possibly enhance the important plant communities within the lake. Unfortunately, the latter is often neglected and the ecosystem suffers as a result.

Aquatic Plant Management and Protection

Many times an aquatic plant management plan is aimed at only controlling nuisance plant growth that has limited the recreational use of the lake, usually navigation, fishing, and swimming. It is important to remember the vital benefits that native aquatic plants provide to lake users and the lake ecosystem, as described above. Therefore, all aquatic plant management plans also need to address the enhancement and protection of the aquatic plant community. Below are general descriptions of the many techniques that can be utilized to control and enhance aquatic plants. Each alternative has benefits and limitations that are explained in its description. Please note that only legal and commonly used methods are included. For instance, the herbivorous grass carp (*Ctenopharyngodon idella*) is illegal in Wisconsin and rotovation, a process by which the lake bottom is tilled, is not a commonly accepted practice. Unfortunately, there are no "silver bullets" that can completely cure all aquatic plant problems, which makes planning a crucial step in any aquatic plant management activity. Many of the plant management and protection techniques commonly used in Wisconsin are described below.

Important Note:
Even though most of these techniques are not applicable to Silver Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake. The techniques applicable to Silver Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many aquatic plant management regulations. The rules for the regulations have been set forth by the WDNR as NR 107 and 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now, including manual and mechanical removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that 30 feet. This action can be conducted up to 150 feet from shore. Please note that a permit is needed in all instances if wild rice is to be removed. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR.

Permits are required for chemical and mechanical manipulation of native and non-native plant communities. Large-scale protocols have been established for chemical treatment projects covering >10 acres or areas greater than 10% of the lake littoral zone and more than 150 feet from shore. Different protocols are to be followed for whole-lake scale treatments (≥160 acres or ≥50% of the lake littoral area). Additionally, it is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Manual Removal

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not removed, rather the plants are cut similar to mowing a lawn; however Wisconsin law states that all plant fragments must be removed. One manual cutting technique involves throwing a specialized "V" shaped cutter into the plant bed and retrieving it with a rope. The raking method entails the use of a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the undesired plants.

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width. Please note that the use of powered cutters may require a mechanical harvesting permit to be issued by the WDNR.

When using the methods outlined above, it is very important to remove all plant fragments from the lake to prevent re-rooting and drifting onshore followed by decomposition. It is also important to preserve fish spawning habitat by timing the treatment activities after spawning. In Wisconsin, a general rule would be to not start these activities until after June 15th.

Cost

Commercially available hand-cutters and rakes range in cost from $85 to $150. Power-cutters range in cost from $1,200 to $11,000.

Advantages	***Disadvantages***
• Very cost effective for clearing areas around docks, piers, and swimming areas. • Relatively environmentally safe if treatment is conducted after June 15th. • Allows for selective removal of undesirable plant species. • Provides immediate relief in localized area. • Plant biomass is removed from waterbody.	• Labor intensive. • Impractical for larger areas or dense plant beds. • Subsequent treatments may be needed as plants recolonize and/or continue to grow. • Uprooting of plants stirs bottom sediments making it difficult to conduct action. • May disturb *benthic* organisms and fish-spawning areas. • Risk of spreading invasive species if fragments are not removed.

Bottom Screens

Bottom screens are very much like landscaping fabric used to block weed growth in flowerbeds. The gas-permeable screen is placed over the plant bed and anchored to the lake bottom by staking or weights. Only gas-permeable screen can be used or large pockets of gas will form under the mat as the result of plant decomposition. This could lead to portions of the screen becoming detached from the lake bottom, creating a navigational hazard. Normally the screens are removed and cleaned at the end of the growing season and then placed back in the lake the following spring. If they are not removed, sediments may build up on them and allow for plant colonization on top of the screen. Please note that a WDNR permit may be required for placement of a bottom screen.

Cost

Material costs range between $.20 and $1.25 per square-foot. Installation cost can vary largely, but may roughly cost $750 to have 1,000 square feet of bottom screen installed. Maintenance costs can also vary, but an estimate for a waterfront lot is about $120 each year.

Advantages	***Disadvantages***
• Immediate and sustainable control. • Long-term costs are low. • Excellent for small areas and around obstructions. • Materials are reusable. • Prevents fragmentation and subsequent spread of plants to other areas.	• Installation may be difficult over dense plant beds and in deep water. • Not species specific. • Disrupts benthic fauna. • May be navigational hazard in shallow water. • Initial costs are high. • Labor intensive due to the seasonal removal and reinstallation requirements. • Does not remove plant biomass from lake. • Not practical in large-scale situations.

Water Level Drawdown

The primary manner of plant control through water level drawdown is the exposure of sediments and plant roots/tubers to desiccation and either heating or freezing depending on the timing of the treatment. Winter drawdowns are more common in temperate climates like that of Wisconsin and usually occur in reservoirs because of the ease of water removal through the outlet structure. An important fact to remember when considering the use of this technique is that only certain species are controlled and that some species may even be enhanced. Furthermore, the process will likely need to be repeated every two or three years to keep target species in check.

Cost

The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive. If a hydro-electric facility is operating on the system, the costs associated with loss of production during the drawdown also need to be considered, as they are likely cost prohibitive to conducting the management action.

Advantages	*Disadvantages*
• Inexpensive if outlet structure exists. • May control populations of certain species, like Eurasian water-milfoil for a few years. • Allows some loose sediment to consolidate, increasing water depth. • May enhance growth of desirable emergent species. • Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.	• May be cost prohibitive if pumping is required to lower water levels. • Has the potential to upset the lake ecosystem and have significant affects on fish and other aquatic wildlife. • Adjacent wetlands may be altered due to lower water levels. • Disrupts recreational, hydroelectric, irrigation and water supply uses. • May enhance the spread of certain undesirable species, like common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*). • Permitting process may require an environmental assessment that may take months to prepare. • Unselective.

Mechanical Harvesting

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes that can cut to depths ranging from 3 to 6 feet with cutting widths of 4 to 10 feet. Plant harvesting speeds vary with the size of the harvester, density and types of plants, and the distance to the off-loading area. Equipment requirements do not end with the harvester. In addition to the harvester, a shore-conveyor would be required to transfer plant material from the harvester to a dump truck for transport to a landfill or compost site. Furthermore, if off-loading sites are limited and/or the lake is large, a transport barge may be needed to move the harvested plants from the harvester to the shore in order to cut back on the time that the harvester spends traveling to the shore conveyor. Some lake organizations contract to have nuisance plants harvested, while others choose to purchase their own equipment. If the latter route is chosen, it is especially important for the lake group to be very organized and realize that there is a great deal of work and expense involved with the purchase, operation, maintenance, and storage of an aquatic plant harvester. In either case, planning is very important to minimize environmental effects and maximize benefits.

Costs

Equipment costs vary with the size and features of the harvester, but in general, standard harvesters range between $45,000 and $100,000. Larger harvesters or stainless steel models may cost as much as $200,000. Shore conveyors cost approximately $20,000 and trailers range from $7,000 to $20,000. Storage, maintenance, insurance, and operator salaries vary greatly.

Advantages	***Disadvantages***
• Immediate results. • Plant biomass and associated nutrients are removed from the lake. • Select areas can be treated, leaving sensitive areas intact. • Plants are not completely removed and can still provide some habitat benefits. • Opening of cruise lanes can increase predator pressure and reduce stunted fish populations. • Removal of plant biomass can improve the oxygen balance in the littoral zone. • Harvested plant materials produce excellent compost.	• Initial costs and maintenance are high if the lake organization intends to own and operate the equipment. • Multiple treatments are likely required. • Many small fish, amphibians and invertebrates may be harvested along with plants. • There is little or no reduction in plant density with harvesting. • Invasive and exotic species may spread because of plant fragmentation associated with harvester operation. • Bottom sediments may be re-suspended leading to increased turbidity and water column nutrient levels.

Chemical Treatment

There are many herbicides available for controlling aquatic macrophytes and each compound is sold under many brand names. Aquatic herbicides fall into two general classifications:

1. Contact herbicides act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. Systemic herbicides spread throughout the entire plant and often result in complete mortality if applied at the right time of the year.

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to both the applicator and the environment, so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

Applying herbicides in the aquatic environment requires special considerations compared with terrestrial applications. WDNR administrative code states that a permit is required if "you are standing in socks and they get wet." In these situations, the herbicide application needs to be completed by an applicator licensed with the Wisconsin Department of Agriculture, Trade and Consumer Protection. All herbicide applications conducted under the ordinary high water mark require herbicides specifically labeled by the United States Environmental Protection Agency.

Aquatic herbicides can be classified in many ways. Organization of this section follows Netherland (2009) in which mode of action (i.e. how the herbicide works) and application techniques (i.e. foliar or submersed treatment) group the aquatic herbicides. The table below provides a general list of commonly used aquatic herbicides in Wisconsin and is synthesized from Netherland (2009).

The arguably clearest division amongst aquatic herbicides is their general mode of action and fall into two basic categories:

1. Contact herbicides act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but in some plants does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. Systemic herbicides act slower than contact herbicides, being transported throughout the entire plant and disrupting biochemical pathways which often result in complete mortality.

General Mode of Action		Compound	Specific Mode of Action	Most Common Target Species in Wisconsin
Contact		Copper	plant cell toxicant	Algae, including macro-algae (i.e. muskgrasses & stoneworts)
		Endothall	Inhibits respiration & protein synthesis	Submersed species, largely for curly-leaf pondweed; Eurasian water milfoil control when mixed with auxin herbicides
		Diquat	Inhibits photosynthesis & destroys cell membranes	Nusiance natives species including duckweeds, trageted AIS control when exposure times are low
Systemic	Auxin Mimics	2,4-D	auxin mimic, plant growth regulator	Submersed species, largely for Eurasian water milfoil
		Triclopyr	auxin mimic, plant growth regulator	Submersed species, largely for Eurasian water milfoil
	In Water Use Only	Fluridone	Inhibits plant specific enzyme, new growth bleached	Submersed species, largely for Eurasian water milfoil
	Enzyme Specific (ALS)	Penoxsulam	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, potential for submergent and floating-leaf species
		Imazamox	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, potential for submergent and floating-leaf species
	Enzyme Specific (foliar use only)	Glyphosate	Inhibits plant-specific enzyme (ALS)	Emergent species, including purple loosestrife
		Imazapyr	Inhibits plant-specific enzyme (EPSP)	Hardy emergent species, including common reed

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to both the applicator and the environment, so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to reduce herbicide concentration within aquatic systems. Understanding concentration and exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Much information has been gathered in recent years, largely as a result of an ongoing cooperative research project between the Wisconsin Department of Natural Resources, US Army Corps of Engineers Research and Development Center, and private consultants (including Onterra). This research couples quantitative aquatic plant monitoring with field-collected herbicide concentration data to evaluate efficacy and selectivity of control strategies implemented on a subset of Wisconsin lakes and flowages. Based on their preliminary findings, lake managers have adopted two main treatment strategies; 1) whole-lake treatments, and 2). spot treatments.

Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. Spot treatments typically rely on a short exposure time (often hours) to cause mortality and therefore are applied at a much higher herbicide concentration than whole-lake treatments. This has been the strategy historically used on most Wisconsin systems.

Whole-lake treatments are those where the herbicide is applied to specific sites, but when the herbicide reaches equilibrium within the entire volume of water (entire lake, lake basin, or within the epilimnion of the lake or lake basin); it is at a concentration that is sufficient to cause mortality to the target plant within that entire lake or basin. The application rate of a whole-lake treatment is dictated by the volume of water in which the herbicide will reach equilibrium. Because exposure time is so much longer, target herbicide levels for whole-lake treatments are significantly less than for spot treatments.

Cost

Herbicide application charges vary greatly between $400 and $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian water-milfoil. • Some herbicides can be used effectively in spot treatments.	• Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them. • Many herbicides are nonselective. • Most herbicides have a combination of use restrictions that must be followed after their application. • Many herbicides are slow-acting and may require multiple treatments throughout the growing season. • Overuse may lead to plant resistance to herbicides

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively. Fortunately, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is no need for either biocontrol insect.

However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian water-milfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian water milfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian water milfoil.

Cost

Stocking with adult weevils costs about $1.20/weevil and they are usually stocked in lots of 1000 or more.

Advantages	***Disadvantages***
• Milfoil weevils occur naturally in Wisconsin. • Likely environmentally safe and little risk of unintended consequences.	• Stocking and monitoring costs are high. • This is an unproven and experimental treatment. • There is a chance that a large amount of money could be spent with little or no change in Eurasian water-milfoil density.

Wisconsin has approved the use of two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These beetles were imported from Europe and used as a biological control method for purple loosestrife. Many cooperators, such as county conservation departments or local UW-Extension locations, currently support large beetle rearing operations. Beetles are reared on live purple loosestrife plants growing in kiddy pools surrounded by insect netting. Beetles are collected with aspirators and then released onto the target wild population. For more information on beetle rearing, contact your local UW-Extension location.

In some instances, beetles may be collected from known locations (*cella* insectaries) or purchased through private sellers. Although no permits are required to purchase or release beetles within Wisconsin, application/authorization and release forms are required by the WDNR for tracking and monitoring purposes.

Cost

The cost of beetle release is very inexpensive, and in many cases is free.

Advantages	***Disadvantages***
• Extremely inexpensive control method. • Once released, considerably less effort than other control methods is required. • Augmenting populations many lead to long-term control.	• Although considered “safe,” reservations about introducing one non-native species to control another exist. • Long range studies have not been completed on this technique.

Analysis of Current Aquatic Plant Data

Aquatic plants are an important element in every healthy lake. Changes in lake ecosystems are often first seen in the lake's plant community. Whether these changes are positive, like variable water levels or negative, like increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways; there may be a loss of one or more species, certain life forms, such as emergents or floating-leaf communities may disappear from certain areas of the lake, or there may be a shift in plant dominance between species. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Silver Lake; concerning both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in life-forms that are present, can be an early indicator of changes in the health of the lake ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Silver Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage. Relative frequency of occurrence uses the littoral frequency for occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

In the end, this analysis indicates the species that dominate the plant community within the lake. Shifts in dominant plants over time may indicate disturbances in the ecosystem. For instance, low water levels over several years may increase the occurrence of emergent species while decreasing the occurrence of floating-leaf species. Introductions of invasive exotic species may result in major shifts as they crowd out native plants within the system.

Species Diversity

Species diversity is probably the most misused value in ecology because it is often confused with species richness. Species richness is simply the number of species found within a system or community. Although these values are related, they are far from the same because diversity also takes into account how evenly the species occur within the system. A lake with 25 species may not be more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

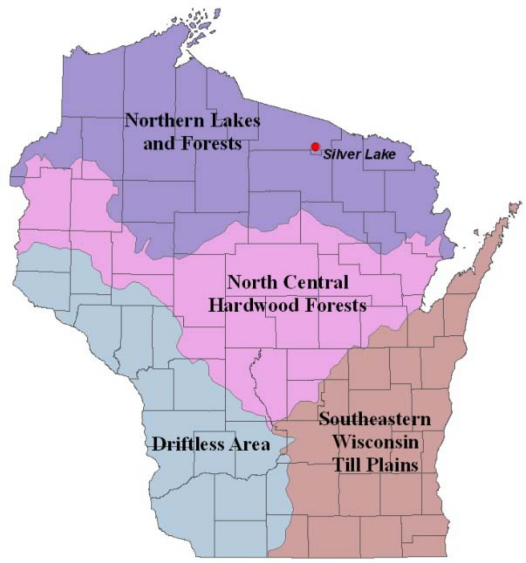

Figure 3.3-1. Location of Silver Lake within the ecoregions of Wisconsin. After Nichols 1999.

A lake with high species diversity is much more stable than a lake with a low diversity. This is analogous to a diverse financial portfolio in that a diverse lake plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. For example, a lake with a diverse plant community is much better suited to compete against exotic infestation than a lake with a lower diversity.

Box Plot or box-and-whisker diagram graphically shows data through five-number summaries: minimum, lower quartile, median, upper quartile, and maximum. Just as the median divides the data into upper and lower halves, quartiles further divide the data by calculating the median of each half of the dataset.

Between 2005 and 2009, WDNR Science Services conducted point-intercept surveys on 252 lakes within the state. In the absence of comparative data from Nichols (1999), the Simpson's Diversity Index values of the lakes within the WDNR Science Services dataset will be compared to Silver Lake. Comparisons will be displayed using boxplots that showing median values and upper/lower quartiles of lakes in the same ecoregion (Figure 3.3-1) and in the state. Please note for this parameter, the Northern Lakes and Forests Ecoregion data includes both natural and flowage lakes.

Floristic Quality Assessment

The floristic quality of a lake is calculated using its species richness and average species conservatism. Species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species' likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1,

Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states.

while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10.

On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept survey and does not include incidental species or those encountered during other aquatic plant surveys.

In this section, the floristic quality of Silver Lake will be compared to median values from lakes in the same ecoregion and in the state as calculated by Nichols (1999). The same ecoregions used in the water quality comparison are utilized for this purpose (Figure 3.3-1). However, the comparative data within this ecoregion has been divided into two groupings: Northern Lakes and Forest Lakes (NLFL) and Northern Lakes and Forest Flowages (NLFF). Silver Lake is a natural lake and therefore will be compared to other natural lakes within the NLFL ecoregion.

Median Value This is the value that roughly half of the data are smaller and half the data are larger. A median is used when a few data are so large or so small that they skew the average value to the point that it would not represent the population as a whole.

Community Mapping

A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. A mapped community can consist of submergent, floating-leaf, or emergent plants, or a combination of these life-forms. Examples of submergent plants include wild celery and pondweeds; while emergents include cattails, bulrushes, and arrowheads, and floating-leaf species include white and yellow pond lilies. Emergents and floating-leaf communities lend themselves well to mapping because there are distinct boundaries between communities. Submergent species are often mixed throughout large areas of the lake and are seldom visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible.

Exotic Plants

Because of their tendency to upset the natural balance of an aquatic ecosystem, exotic species are paid particular attention to during the aquatic plant surveys. Two exotics, curly-leaf pondweed and Eurasian water milfoil are the primary targets of this extra attention. Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.3-2). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment.

In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

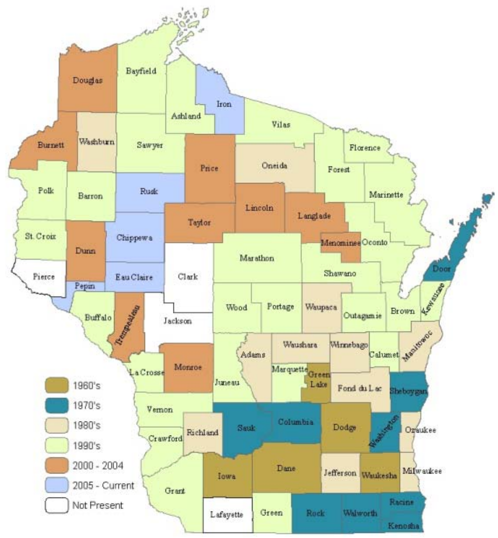

Figure 3.3-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. Curly –leaf pondweed begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like Eurasian water-milfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities within the lake. Furthermore, its mid-summer die back can cause algal blooms spurred from the nutrients released during the plant's decomposition.

Because of its odd life-cycle, a special survey is conducted early in the growing season to inventory and map curly-leaf pondweed occurrence within the lake. Although Eurasian water milfoil starts to grow earlier than our native plants, it is at peak biomass during most of the summer, so it is inventoried during the comprehensive aquatic plant survey completed in mid to late summer.

Aquatic Plant Survey Results

The 2010 point intercept survey was conducted on Silver Lake on July 26, 2010 by the WDNR. Additional surveys were completed by Onterra on Silver Lake to create the aquatic plant community map (Map 3) on September 9, 2010.

During the point-intercept and aquatic plant mapping surveys, 26 species of native plants were located in Silver Lake (Table 3.3-1). 16 of these species were sampled during the point-intercept survey and are used within the statistical analyses that follow. As mentioned previously, Eurasian water milfoil, a non-native milfoil species, also occurs within Silver Lake. This plant along with surveys and treatments aimed at controlling it within Silver Lake are discussed in more detail below.

Table 3.3-1. Aquatic plant species located on Silver Lake, July 2010. Data collected from WDNR 2010 point-intercept and Onterra 2010 community mapping surveys. Exotic species in red.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)
Emergent	*Calla palustris*	Water arum*	9
	Dulichium arundinaceum	Three-way sedge*	9
	Eleocharis palustris	Creeping spikerush*	6
	Lythrum salicaria	Purple loosestrife*	Exotic
	Schoenoplectus tabernaemontani	Softstem bulrush*	4
	Sparganium sp.	Bur-reed sp.	N/A
	Typha sp.	Cattail sp.*	1
FL	*Nuphar variegata*	Spatterdock*	6
	Nymphaea odorata	White water lily*	6
FL/E	*Sparganium angustifolium*	Narrow-leaf bur-reed*	9
Submergent	*Chara sp.*	Muskgrasses	7
	Elodea canadensis	Common waterweed	3
	Isoetes sp.	Quillwort sp.	8
	Lobelia dortmanna	Water lobelia*	10
	Myriophyllum spicatum	Eurasian water milfoil*	Exotic
	Myriophyllum tenellum	Dwarf water milfoil	10
	Najas flexilis	Slender naiad	6
	Nitella sp.	Stoneworts	7
	Potamogeton diversifolius	Water-thread pondweed	8
	Potamogeton pusillus	Small pondweed	7
	Potamogeton epihydrus	Ribbon-leaf pondweed	8
	Potamogeton amplifolius	Large-leaf pondweed	7
	Sagitaria sp. (rosette)	Arrowhead rosette	N/A
	Utricularia resupinata	Small purple bladderwort	9
	Vallisneria americana	Wild celery	6
S/E	*Eleocharis acicularis*	Needle spikerush	5
	Sagittaria graminea	Grass-leaved arrowhead*	9
	Sagittaria rigida	Stiff arrowhead*	8

FL/E = Floating Leaf and Emergent
FL = Floating Leaf
S/E = Submergent and Emergent
* = Incidental

Silver Lake supports a moderate number of aquatic plant species. On some Vilas County Lakes, as many as 40 or 50 species may be found during a point-intercept survey. However, the plant species that are present in Silver Lake are distributed fairly evenly throughout its littoral zone. As discussed earlier, how evenly the species are distributed throughout the system also influences the diversity. Simpson's diversity index (1-D) is used to determine this distribution. Simpson's diversity is calculated as:

$$D = \sum (n/N)^2$$

D is a value between 0 and 1 where:

n = the total number of instances of a particular species
N = the total number of instances of all species

For example, if a lake had a diversity index value of 0.90, it would mean that if two individual plants were randomly sampled from this lake there would be a 90% probability that the two individuals would be different species.

The aquatic plant community in Silver Lake was found to be highly diverse, with a Simpson's diversity value of 0.88 (from 2010 surveys - Figure 3.3-3). This value ranks above state and ecoregion upper quartiles. Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. A plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish and other wildlife with diverse structural habitat and various sources of food.

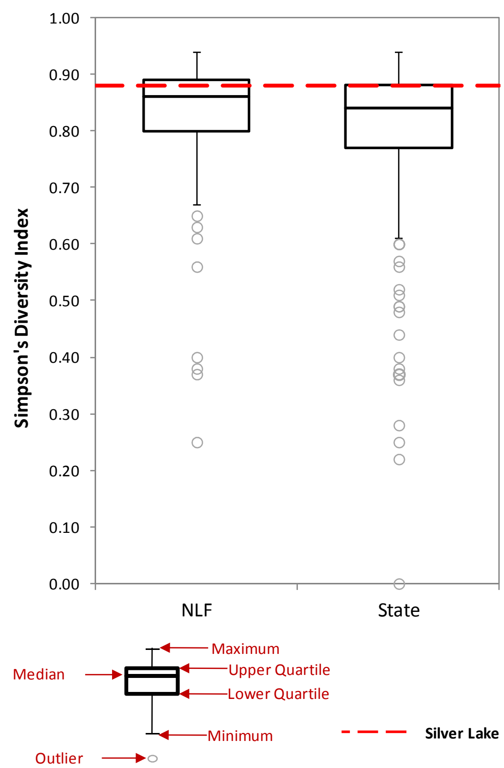

Figure 3.3-3. Silver Lake species diversity index. Created using data from WDNR 2010 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

Figures 3.3-4 and 3.3-5 show that common waterweed, wild celery, and large-leaf pondweed were the most frequently observed plants during the 2010 WDNR survey. Common waterweed can be found throughout much of the continental United States, and in some cases may grow to form nuisance conditions (especially in Europe and New Zealand, where it is non-native). It serves as habitat for fish, and food for waterfowl and other wildlife. Wild celery, the second most commonly found plant in the Silver Lake, has long, flat, ribbon-like leaves which do not distribute from a stem. Similarly to common waterweed, wild celery serves as both habitat for invertebrates and a food source for waterfowl. The third most common plant species, large leaf pondweed, has large, folded leaves that have many veins running through them. Sometimes called "musky cabbage", this plant provides excellent cover for numerous fish species. Because of Silver Lake's fairly clear water (see the Water Quality section) plants are able to grow out to the maximum depth of the lake, which is 18 feet.

Data collected from the aquatic plant surveys indicate that the average conservatism value (6.1) is slightly lower than the state median and the Northern Lakes Ecoregion median (Figure 3.3-6). This shows that the aquatic plants within Silver Lake are indicative of a somewhat disturbed system, more so than those found in most lakes in the state and the ecoregion.

Combining Silver Lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a value of 24.3 (equation shown below); which is just slightly below the median values of the ecoregion and the state (Figure 3.3-6).

FQI = Average Coefficient of Conservatism (6.1) * √Number of Native Species (16)
FQI = 24.3

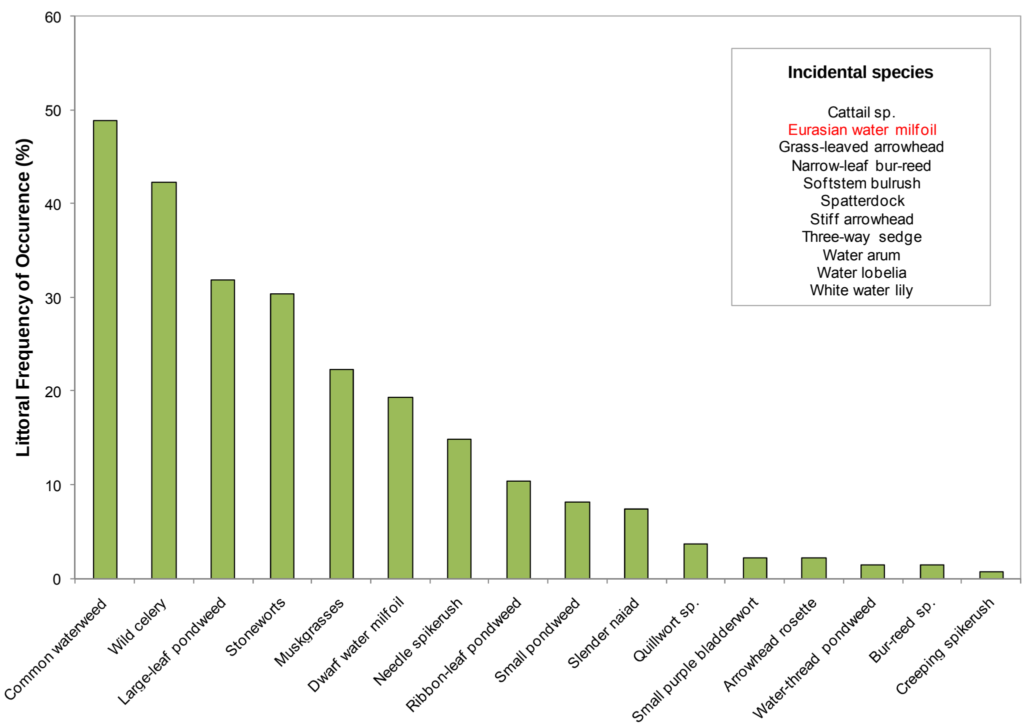

Figure 3.3-4 Silver Lake aquatic plant littoral frequency of occurrence. Created using data from WDNR July 2010 surveys. Exotic species indicated with red.

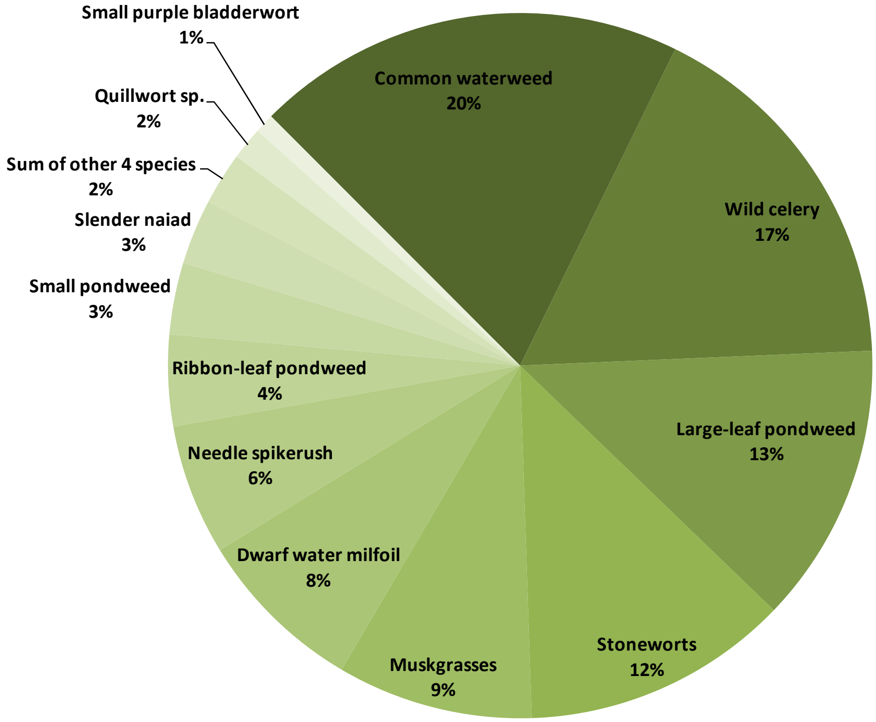

Figure 3.3-5. Silver Lake aquatic plant relative frequency of occurrence. Created using data from WDNR July 2010 surveys.

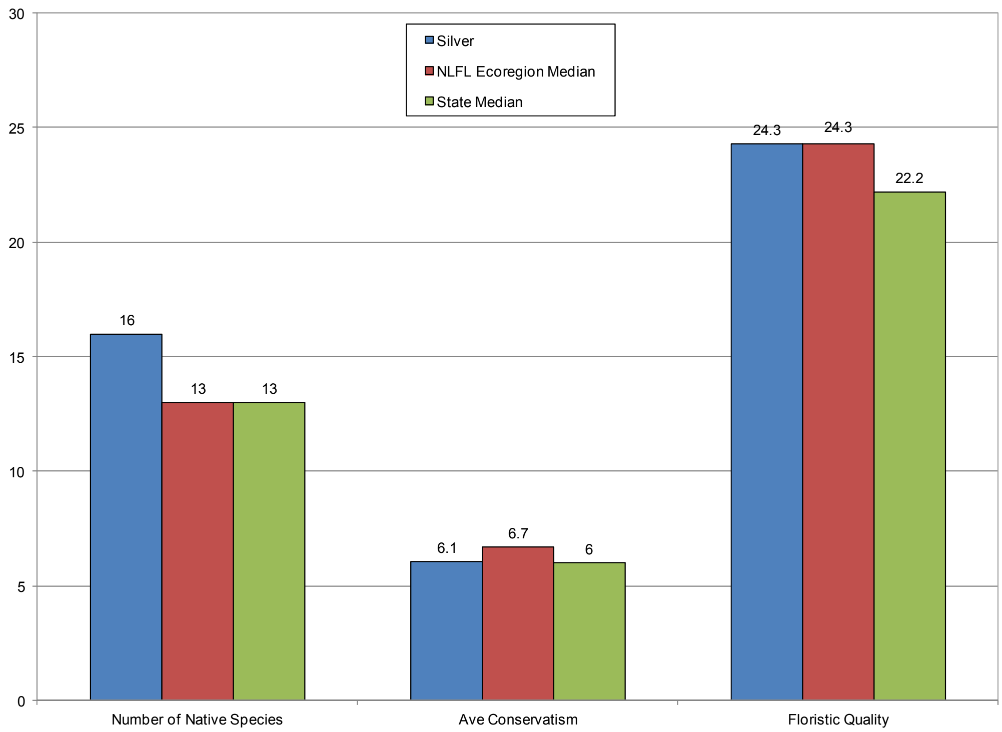

Figure 3.3-6. Silver Lake Floristic Quality Assessment. Created using data from WDNR July 2010 surveys. Analysis following Nichols (1999).

Ideally, in addition to submergent aquatic plant species a lake has emergent and floating-leaf plant communities as well, which provide a different type of habitat for aquatic and terrestrial organisms. The 2010 community map indicates that approximately 4.5 acres (4.2%) of the 225-acre lake contains these types of plant communities (Table 3.3-2, Map 3). Nine native floating-leaf and emergent species were located on Silver Lake, providing valuable fish and wildlife habitat important to the ecosystem of the lake.

Table 3.3-2. Silver Lake acres of plant community types from the 2010 community mapping survey.

Plant Community	Acres
Emergent	<0.1
Floating-leaf	1.0
Mixed Floating-leaf and Emergent	3.5
Total	4.5

The community map represents a ‘snapshot’ of the important plant communities located within the lake in 2010. A replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Silver Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Aquatic plant community trends

Silver Lake has been actively studied by WDNR Science Services as part of a research project aimed at understanding natural variation in Eurasian water milfoil populations across the state as well as how management actions affect these populations. WDNR researchers have conducted point-intercept surveys on the lake in 2005, and again each year between 2007 and 2010. In each of these years, the same methodology and sampling points were used so that data is comparable.

The aquatic plant community has changed only slightly over the time period in which monitoring has taken place. Figure 3.3-7 displays the five most common plant species in Silver Lake, and their littoral frequency of occurrence. Nitella sp. and chara sp., two very similar and easily misidentified species, are combined in this chart. Over this timeframe, these top species have fluctuated in their frequency of occurrence. This observation is likely driven by natural circumstances such as water levels, nutrient availability, or other environmental factors. The changes in these species are likely not caused by Eurasian water milfoil herbicide applications because of the infrequent occurrence of the treatments and their low acreage.

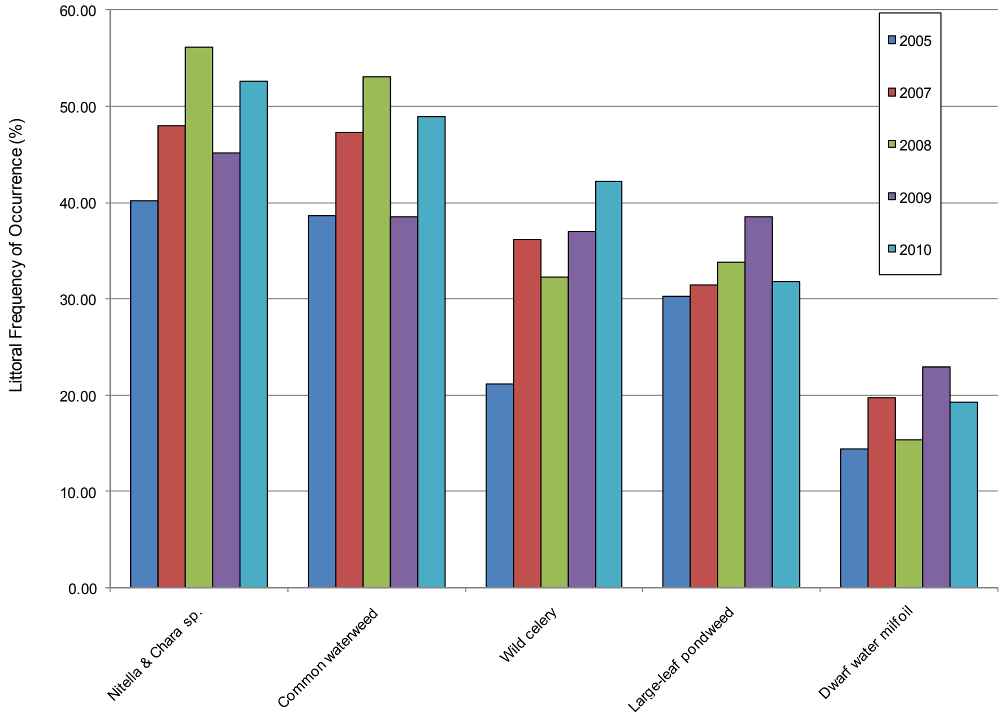

Figure 3.3-7. Littoral frequency of occurrence for several common Silver Lake aquatic plant species. Created using data from WDNR 2005 and 2007-2010 surveys.

Non-native Aquatic Plants

Eurasian water milfoil

In 2005, the presence of Eurasian water milfoil was verified by the WDNR in Silver Lake. During the early spring of 2007, approximately 12 acres of scattered Eurasian water milfoil were treated within the lake. The treatment was considered a success as no Eurasian water milfoil was located by professional or volunteer surveyors during the following summer. Onterra ecologists surveyed the lake from the surface and with a submersible video camera during May of 2008 and found no Eurasian water milfoil. However, in August of 2008, Onterra ecologists returned and located numerous Eurasian water milfoil plants within the lake. After discussions with the WDNR and ESLA in winter of 2008/2009, an approximately 4.8-acre treatment was proposed for May 2009. This treatment was to target scattered Eurasian water milfoil colonies located along the southeastern shoreline of the lake. Following a pretreatment survey in early May of 2009, the final treatment area was reduced to 3.4 acres (Map 4). During a post treatment survey that took place in August of 2009, no Eurasian water milfoil was observed in the lake. Table 3.3-3 displays the timing of herbicide treatments, as well as whole-lake point-intercept sampling efforts by the WDNR and 2009 treatment area sub-sampling by Onterra staff.

Table 3.3-3. Herbicide treatment and aquatic plant monitoring activities on Silver Lake, 2005-2010.

Year	Season	Herbicide Treatment	WDNR Whole Lake Point-Intercept Survey	Onterra Point-Intercept Survey (Treatment Area)
2005	Spring			
	Summer			
2006	Spring			
	Summer			
2007	Spring			
	Summer			
2008	Spring			
	Summer			
2009	Spring			
	Summer			
2010	Spring			
	Summer			

The WDNR whole-lake point-intercept surveys conducted in the summers of 2007-2009 allow for a statistical comparison to be made before (July 2008) and after (July 2009) the 2009 herbicide treatment. The data displayed in Table 3.3-4 indicates the percent change in this frequency of occurrence.

Comparing these point-intercept surveys, 4 plants showed a statistically significant change in percent frequency. It is not believed that these aquatic plant species were affected directly by the 2009 herbicide treatment. As mentioned previously, the herbicide treatment that occurred was a small scale treatment, and the observed changes in aquatic plant occurrence were on an entire lake basis. As Figure 3.3-6 demonstrates, fluctuations can and do occur in native aquatic plant frequencies on an annual basis. It should be noted, however, that recent (2010) and ongoing research on herbicide treatments in Wisconsin lakes indicates that monocots may be more susceptible to 2,4-D herbicide treatments than previously thought. Previously, it was thought that only dicot species were affected by this type of herbicide.

Table 3.3-4. Statistical analysis of Eurasian water milfoil and native aquatic plant species occurrence. Analysis includes plant species lake-wide, before and after treatment. Created using data from WDNR 2008 and 2009 whole-lake point intercept surveys.

	Scientific Name	Common Name	2008 FOO	2009 FOO	Percent Change	Direction	Chi-square Analysis	
							Significance	p-value
Dicots	Myriophyllum spicatum	Eurasian water milfoil	0.0	0.0		-		
	Utricularia resupinata	Small purple bladderw	0.7	0.7	0.0	-	No	1.0000
	Myriophyllum tenellum	Dwarf water milfoil	13.9	21.5	55.0	▲	No	0.0895
	Ceratophyllum demersum	Coontail	0.7	0.0	-100.0	▼	No	0.3165
Non-dicots	Eleocharis acicularis	Needle spikerush	2.8	12.5	350.0	▲	Yes	0.0019
	Elodea canadensis	Common waterweed	47.9	36.1	-24.6	▼	Yes	0.0424
	Najas flexilis	Slender naiad	14.6	6.9	-52.4	▼	Yes	0.0365
	Potamogeton spirillus	Spiral-fruited pondwe	2.8	0.0	-100.0	▼	Yes	0.0440
	Potamogeton epihydrus	Ribbon-leaf pondweed	5.6	9.0	62.5	▲	No	0.2571
	Isoetes sp.	Quillwort species	4.2	6.3	50.0	▲	No	0.4263
	Vallisneria americana	Wild celery	29.2	34.7	19.0	▲	No	0.3120
	Potamogeton amplifolius	Large-leaf pondweed	30.6	36.1	18.2	▲	No	0.3173
	Chara sp.	Muskgrasses	13.9	15.3	10.0	▲	No	0.7384
	Potamogeton pusillus	Small pondweed	2.8	2.8	0.0	-	No	1.0000
	Sagittaria rigida	Stiff arrowhead	1.4	1.4	0.0	-	No	1.0000
	Nitella sp.	Stoneworts	36.8	27.1	-26.4	▼	No	0.0768
	Lobelia dortmanna	Water lobelia	0.7	0.0	-100.0	▼	No	0.3165
	Elatine minima	Waterwort	0.7	0.0	-100.0	▼	No	0.3165
	Eleocharis palustris	Creeping spikerush	0.7	0.0	-100.0	▼	No	0.3165
	Sparganium angustifolium	Narrow-leaf bur-reed	0.7	0.0	-100.0	▼	No	0.3165

Following the 2009 Eurasian water milfoil treatment, the ESLA and Onterra created a conditional 2010 treatment plan in the event that a May 2010 pretreatment survey turned up treatable amounts of Eurasian water milfoil in the lake. On May 4, 2010 and again on May 18th, Onterra ecologists scoured 2009 treatment areas and conducted a meander survey of the remaining areas of the lake using a submersible video camera, and did not locate any Eurasian water milfoil. However despite not locating any plants during the month of May, during the peak-biomass survey in September of 2010, a total of seven Eurasian water milfoil plants were found, of which only one plant was located within the 2009 treatment area (Map 5). All of these plants, along with their roots, were pulled from the sediment. Because of the low occurrence of Eurasian water milfoil plants observed in 2010, a conditional treatment permit was not created for 2011; however, the lake was visited several times to survey for the exotic plant.

On September 1, 2011, Onterra ecologists located about 25 single Eurasian water milfoil plants, primarily located west of the 2009 treatment area but also located within it (Map 6). The plants were tall and easily visible within the water column. During a follow-up visit on September 9th, Two Onterra crews (four staff members) visited these locations with snorkeling gear to hand remove these plants. Conditions were ideal for snorkeling and viewing the plants; there was little to no wind and the skies were sunny and without cloud cover. The crews spent approximately 2.5 hours covering these areas and hand removed roughly 75 to 80 Eurasian water milfoil plants, concentrating greatly to remove the plants' root systems as well as the stems and leaves. While three crew members snorkeled the area, a fourth remained in the boat with a water skimmer and grabbed any fragments that may have broken off of the plants as they were removed.

While the sighting of these plants was very disheartening, Onterra staff was confident that the vast majority of the plants had been removed. However, because of the sudden resurgence of the plant it is recommended that further surveys be conducted to locate additional isolated incidences as they come about. This strategy should keep dense growth of Eurasian water milfoil down, while keeping additional spreading of the plant through the lake to a minimum as well.

Purple Loosestrife

During the 2010 community mapping survey, numerous occurrences of purple loosestrife were located along the shorelines of Silver Lake and within shallow emergent plant communities (Map 7). Purple loosestrife (*Lythrum salicaria*) is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources. First detected in Wisconsin in the 1930's, it has now spread to 70 of the state's 72 counties. Purple loosestrife largely spreads by seed, but also can vegetatively spread from root or stem fragments.

Purple loosestrife has likely been present in and around Silver Lake for some time. There are a number of effective control strategies for combating this aggressive plant, including herbicide application, biological control by native beetles, and manual hand removal. Volunteers within the ERSLA have been aggressively cutting off seed heads and treating/removing plants where possible. According to these volunteers, purple loosestrife locations have diminished substantially since the time the community mapping survey was conducted by Onterra. The ERSLA will continue to monitor and aggressively deal with new infestations as they arrive.

4.0 SUMMARY AND CONCLUSIONS

The purpose of this project was to fulfill two objectives;

1) Create an update to Silver Lake's 2007 Aquatic Plant Management Plan.
2) Monitor Eurasian water milfoil occurrences within the lake and continue management actions that were started in 2007 as applicable.

In 2007, Northern Environmental (now Stantec) created an Aquatic Plant Management Plan for Silver Lake. The report covered the limited water quality data that was available, an overview of the watershed, and an analysis of the 2005 WDNR aquatic plant survey. With regards to the water quality of Silver Lake, additional data has not been collected since this time. Volunteers from Silver Lake had been unsuccessful in enrolling into the WDNR's Citizen Lake Monitoring Network (CLMN) when budgetary issues prevented additions to the program. This is not a tremendous concern, as there are no apparent water quality issues on Silver Lake at this time. However, adding knowledge regarding the lake's ecosystem is useful, and will be helpful in future planning; therefore, if the association is able to register volunteer's in the CLMN program to collect water quality samples, they should do so.

The watershed around Silver Lake was determined by Northern Environmental to be approximately 149 acres, and largely (88.5%) consists of forested lands and wetlands (9.9%). This aspect of the lake was not "updated" in this management plan because it is highly unlikely that the watershed has changed significantly in this short time span. Although the component was not included within the grant budget, an assessment of the immediate shoreland zone was conducted in fall of 2009. This survey identified nearly 0.5 miles of shoreline that was either urbanized or unnatural-developed. Because Silver Lake is a seepage lake with a very small, forested watershed, these unnatural shoreline areas are the only potentially concerning areas located around the lake and thus should be prioritized if any remediation efforts are to occur.

Whereas in 2005, 17 macrophyte species were located in Silver Lake, 26 native species were observed in 2010, including both those sampled during the point-intercept survey (16) and those observed incidentally. Including the exotic species, Eurasian water milfoil and purple loosestrife, the total count increases to 28 species. As mentioned within the Aquatic Plant Section, this is not a large number of species to find in a lake; however, the species are evenly distributed throughout the lake which is a positive attribute of the plant community. A well mixed plant community provides better habitat for aquatic organisms. Additionally, the presence of several types of submergent, emergent, and floating leaf species is helpful in providing food, shelter, and spawning territory for both aquatic and terrestrial organisms alike. An added benefit to a diverse and well-distributed aquatic plant community is that the plants help to prevent exotic plant species, such as Eurasian water milfoil, from taking hold within the lake.

The 2007 Silver Lake Aquatic Plant Management Plan did not outline the specific steps required to address Eurasian water milfoil in Silver Lake, but instead offered a general plan for the exotic's management as was presented for other lakes within the Town of Washington Project. This project was initiated because it was believed the association would need to apply for AIS Established Population Control Grant funds to continue managing Eurasian water milfoil within Silver Lake. To be eligible for that type of grant, there must be an approved lake management plan on file with the WDNR that specifically outlines the strategy that would be used to monitor and control Eurasian water milfoil within the lake. As eluded to above, the original Silver Lake Aquatic Plant Management Plan would not have been acceptable because it was too general in its strategy.

Over the course of the past three years, Eurasian water milfoil has been largely controlled within Silver Lake through a series of herbicide treatments and manual removal of scattered plants. Because of aggressive Eurasian water milfoil management on Silver Lake, the need for a large-scale control strategy is no longer necessary or applicable. Instead, Eurasian water milfoil occurrences are such that continued monitoring by volunteers and careful hand-removal is likely all that is required to maintain the minimal presence of the plant. With continued monitoring, an occasional treatment may be required if Eurasian water milfoil populations reach a frequency where volunteers cannot reasonably control the plant. This type of control action would once again need to be monitored in the same manner as previous treatments to determine treatment efficacy and native plant impact.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the ERSLA Planning Committee and ecologist/planners from Onterra. It represents the path the ERSLA will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Silver Lake stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Assess and Enhance Water Quality Conditions

Management Action: Monitor water quality through WDNR Citizens Lake Monitoring Network.

Timeframe: Begin as soon as possible.

Facilitator: Planning Committee

Description: Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason as of why the trend is developing.

The Citizens Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. At this time, there are no ERSLA members currently collecting data as a part of the CLMN. Volunteers trained by the WDNR as a part of the CLMN program begin by collecting Secchi disk transparency data for at least one year, then if the WDNR has availability in the program, the volunteer may enter into the *advanced program* and collect water chemistry data including chlorophyll-a, and total phosphorus. The Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring. Note: as a part of this program, these data are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS).

At a minimum, CLMN volunteers collecting Secchi disk data should be in place on Silver Lake. Currently, the advanced CLMN program accepts five lakes each year from a prioritized list. It is important to get volunteers on board with the base Secchi disk data CLMN program so that when additional spots open in the advanced monitoring program, volunteers from the Silver Lake will be ready to make the transition into more advanced monitoring.

It is the responsibility of the Planning Committee to coordinate new volunteers as needed. When a change in the collection volunteer occurs, it will be the responsibility of the Planning Committee to contact Sandra Wickman (715.365.8951) or the appropriate WDNR/UW Extension staff to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer.

Action Steps:

Please see description above.

Management Action: Investigate impacts of storm sewer inputs to Silver Lake
Timeframe: 2012
Facilitator: Joe Laux and Jon Cook
Description: There is reason to believe that storm sewers from the Eagle River Commerce Loop Business Park may outfall into Silver Lake. However, the City of Eagle River currently does not have accurate and up-to-date information regarding the fate of storm sewer water from this area. If a storm water utility were created, the proper information would be collected to determine how much water flows into Silver Lake. Additionally, modeling could be completed to determine potential pollutant loads as well. At the ERSLA 2011 annual meeting (July 19th) a resolution was passed regarding watershed control. Within this resolution, an item was included to, "…identify the total watershed of surface drainage to Silver Lake within the City of Eagle River through a storm water management plan…" and to "…assist the Eagle River with developing a storm water management plan and storm water utility…" At this time, the ERSLA is prepared to assist the City of Eagle River in development of the storm water management plan and storm water utility. In doing so, potential concerns with water drainage to Silver Lake will be identified, and remedies evaluated.

Action Steps:

1. See above steps.

Management Action: Initiate restoration of a portion of the city-owned property on Silver Lake's north shore.
Timeframe: Begin as soon as possible
Facilitator: Joe Laux and Jon Cook
Description: The City of Eagle River owns property along the north shoreline of Silver Lake. This property is currently maintained as a park. As shown on Map 2, this area of shoreline is categorized as Urbanized and Developed-Unnatural because of the amount of development that has taken place here. The City of Eagle River and ERSLA, acting in the best interest of Silver Lake, is interested in restoring natural shoreline habitat to an area west of the city-owned beach. In order for this to happen, both the city and lake association should work with the Vilas County Land and Water Conservation Department (VCLWCD) to develop and implement a restoration project on this area. This area may then be utilized as a demonstration site to facilitate further restoration of Silver Lake shoreline on private properties. It may also be used as an educational tool for those who visit Silver Lake on the benefits of shoreline enhancement.

At the 2011 ERSLA annual meeting, the passed resolution also held an action item for "…develop(ing) a shoreline restoration project on Eagle River owned shoreline near Silver Lake Beach…" The ERSLA is now prepared to assist the city and VCLWCD in completing this project.

Action Steps:

1. See above steps.

Management Goal 2: Control Aquatic Invasive Species within Silver Lake

Management Action: Monitor Eurasian water milfoil within Silver Lake.
Timeframe: In progress
Facilitator: Board of Directors
Description: The battle between Silver Lake stakeholders and Eurasian water milfoil has, after some time, finally tilted in favor of the stakeholders. Eurasian water milfoil populations, as of 2011, were at the stage where herbicide treatments are not necessary. However, while efforts to control this invasive plant have been successful, it is much too soon to declare the battle a complete success.

This plant's resilient nature and strong competitive edge was witnessed first-hand in Silver Lake by Onterra ecologists and Silver Lake stakeholders. In May of 2010, not one plant was spotted by Onterra staff as they scoured the lake during a pre-treatment survey. Later that summer, seven plants were encountered. In 2011, between 75 and 80 plants were removed from the lake. The biology of the plant is impressive, and proves that Silver Lake stakeholders must not let their guard down and consider the struggle against Eurasian water milfoil over.

Because of the small scale of the infestation, the best course of action is for Silver Lake stakeholders to continue scouring the lake for Eurasian water milfoil, and hand-remove these plants when they are encountered. As described below in the Action Steps, volunteers should seek training from AIS (aquatic invasive species) professionals, such as the Vilas County AIS Coordinator Ted Ritter (715.479.3738). Mr. Ritter will be able to keep volunteers up-to-date on aquatic plant identification, hand-removal methodology, and monitoring techniques.

Even with diligent effort, the Eurasian water milfoil abundance may slowly increase, and eventually reach the point in which professional ecologists may need to be called upon to map the plant's occurrence in the lake and potentially develop a new control strategy. This is recommended to occur when the abundance of Eurasian water milfoil becomes more than what Silver Lake volunteers can handle.

The "trigger" for a more intensive control strategy (i.e. herbicide treatments) is somewhat difficult to decide upon. Many factors go into the planning of a herbicide treatment; water depth, water flow, treatment area size, and plant density work to dilute herbicide concentration within aquatic systems. Understanding concentration-exposure times is an important consideration for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. A newly adopted term, 'micro-treatments' is being used to describe small spot treatments (working definition is less than 5 acres). Because of their small size, it is extremely difficult to predict treatment effectiveness due to rapid dilution of the herbicide. Larger treatment areas tend to be able to hold effective concentrations for a longer time. Of course, each scenario is different and in some cases small treatment areas may be treated with success, particularly in isolated or controlled areas (bays, close to shore, etc.) where water exchange is minimized.

The problem in this scenario is two-fold: small treatment areas (<5 acres) are not always effective at holding an herbicide concentration at a desired level for a desired time period. However, a Eurasian water milfoil infestation of greater than a tenth of an acre can be incredibly difficult to control by hand-removal efforts, depending on plant density. So, managing a 2-acre Eurasian water milfoil infestation can become more confounding than managing a 20-acre infestation.

Because great strides have been made in controlling Eurasian water milfoil on Silver Lake, an aggressive approach should be continued in order to keep the invasive plant under control. Due to the fact that previous treatments have been largely successful on the lake, and seepage lakes do not have dynamic flow that can be found in drainage lakes or flowages, it is expected that a small-scale herbicide treatment on Silver Lake could be met with a higher rate of success, when treatment areas and herbicide doses are carefully calculated. Therefore, an aggressive "trigger" can be set at a point that if 100 or more plants are found at 0.3 acres (approximately 114' x 114'), volunteer hand-removal would no longer be used and professional monitoring of the colony would ensue. This is not to say that a treatment would be required; discussions between the ERSLA, WDNR, and professional consultant would determine the next appropriate action. It is important for the ERSLA to realize this "trigger" is estimated – the group needs to be confident in what they can manage as far as Eurasian water milfoil hand removal techniques. If volunteerism is low, and time spent on the lake insufficient, assistance may be required for a smaller level of Eurasian water milfoil infestation.

For now, Silver Lake volunteers should be active in monitoring their lake for Eurasian water milfoil. Surveys should consist of meandering over the littoral region, with one person driving a boat and 1-3 others standing up and peering into the water with polarized sunglasses. Eurasian water milfoil can be marked with a buoy until the survey is complete, then hand removal with rakes or snorkeling may be completed at the buoyed locations. The advantage of this approach is that by buoying plant locations, volunteers may visualize the extent of Eurasian water milfoil distribution. This can lead to a discussion of if the "trigger" for considering professional help has been met. The disadvantage is the timing of these efforts. Surveys by ERSLA volunteers will likely be conducted in July or August when the plant is at its peak growth. If the "trigger" for calling in professional assistance has been met, accurate mapping of the Eurasian water milfoil in the lake would likely not be conducted until late August or September, meaning that strategy formulation would not occur until the following fall / winter and an herbicide treatment or other management action would not occur until the next spring. The ERSLA needs to accept that Eurasian water milfoil would not be treated for an entire growing season.

Action Steps:

1. Recruit volunteers to complete surveys and hand harvesting
2. Contact Vilas County Aquatic Invasive Species Coordinator Ted Ritter (715.479.3738) to conduct a training and identification session with ERSLA volunteers.
3. Organize specific dates for visual surveys and hand harvesting to occur.
4. Log surveying and hand removal efforts, report to WDNR, Ted Ritter and ERSLA members in the form of an annual summary.

6.0 METHODS

Aquatic Vegetation

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Silver Lake by the WDNR to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in "Appendix D" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin, (April, 2007) was used to complete this study on in 2005 and 2007-2010 by the WDNR. A point spacing of 40 meters was used resulting in approximately 144 points.

Community Mapping

In 2010 Onterra mapped the aquatic vegetation community types within Silver Lake (emergent and floating-leaved vegetation) using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy. Furthermore, all species found during the point-intercept surveys and the community mapping surveys were recorded to provide a complete species list for the lake.

Representatives of all plant species located during the point-intercept and community mapping survey were collected and vouchered by the University of Wisconsin – Steven's Point Herbarium. A set of samples was also provided to the Eagle River Silver Lake Association.

Eurasian Water Milfoil Treatment Monitoring

The methodology used to monitor the Eurasian water milfoil herbicide treatments is included within the results section under the heading: *Eurasian water milfoil.*

7.0 LITERATURE CITED

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