Spider Chain of Lakes Aquatic Plant Management Plan

AIS Education, Prevention and Planning

Sawyer County, Wisconsin

DNR No. AEPP-354-12
SEH No. SPIDC 121119

June 13, 2013

Spider Chain of Lakes Aquatic Plant Management Plan

AIS Education, Prevention and Planning
Sawyer County, Wisconsin

Prepared for:
Spider Chain of Lakes Association

Hayward, Wisconsin

Prepared by:

Dave Blumer	Project Manager/Lakes Scientist
Jacob A. Macholl	Lakes Scientist

Short Elliott Hendrickson Inc.
1701 West Knapp Street, Suite B
Rice Lake, WI 54868-1350
715.236.4000

With:

Sara M. Hatleli
Aquatic Plant and Habitat Services LLC
N4235 State Hwy 54
Black River Falls, WI 54615
715.299.4604

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
Northern Region Headquarters
810 W. Maple Street
Spooner WI 54801

Scott Walker, Governor
Cathy Stepp, Secretary
John Gozdzialski, Regional Director
Telephone 715-635-2101
FAX 715-635-4105
TTY Access via relay - 711

June 6, 2013

John Kuntz, President
Spider Chain of Lakes Association
12585 N Town Hall Road
Hayward, WI 54843

Subject: Spider Chain of Lakes Aquatic Plant Management Plan (Plan) Approval Request

Dear Mr. Kuntz,

Thank you for your efforts to understand, protect, and improve the Spider Chain of Lakes! This letter is to notify you that the DNR has approved the Plan dated May 10th, 2013. Approved management recommendations specified below are eligible for funding under Lake Management Planning, Lake Protection and Classification, and Aquatic Invasive Species grants subject to the application requirements of those programs.

Approved management recommendations include the following:

1. AIS prevention activities including watercraft inspection and volunteer monitoring.
2. Species-specific AIS monitoring and management, provided it meets DNR guidelines and approval specifications.
3. Educational activities including AIS workshops, signage, etc.
4. Lake monitoring and management planning

Please note: Aquatic plant or algae control for the purposes of nuisance relief or navigation are *not* eligible grant activities, and the Department reserves the right to inspect nuisance or navigation conditions prior to permitting the treatment of aquatic plants or algae. All wild rice consultation work with Voigt Task Force must be completed before implementation may occur.

Thanks to you and the lake community for continuing to work hard to protect the Spider Chain of Lakes.

Sincerely yours,

Alex Smith
Lakes Biologist

CC: Dave Blumer – SEH
Mark Sundeen, Jane Malischke, Max Wolter – WDNR

Distribution List

No. of Copies	Sent to
6	John Kuntz, President Spider Chain of Lakes Association 12585 N Town Hall Road Hayward, WI 54843

Executive Summary

Spider Lake, Clear Lake, North Lake, and Fawn Lake make up the Spider Chain of Lakes in north-central Sawyer County, Wisconsin. The basin north of the central narrows on Spider Lake is referred to as Big Spider Lake with Little Spider Lake to the south. The Chain of Lakes covers approximately 1,600 acres and lake levels are maintained by a low-head dam at the outlet of Little Spider Lake. The shoreline is moderately developed with residences, vacation homes, resorts, and a golf course.

Spider Lake is listed as an Outstanding Resource Water by the WDNR. Both the health and quality of the native plant community is well above average on a state-wide and regional basis. The exceptional native aquatic plant community and good water quality offers a variety of activities for lake residents and visitors. The lake supports a high quality fishery that includes walleye, northern pike, and muskellunge. The fishery and lake ecosystem is further enhanced by a rich underwater structure of reefs, points, and drop-offs which provide a multitude of habitats. Because of its rural location and diversity of aquatic plants, the Spider Chain of Lakes also supports a wide variety of wildlife. Loons are present from spring through fall with some success of loon reproduction documented by volunteer monitors.

The Spider Chain of Lakes are a moderately nutrient rich system, or mesotrophic, with relatively stable water quality since continuous monitoring began in the early 1990s. The water clarity in Clear Lake has decreased about 3 feet from historic averages with the largest change occurring between 2000 and 2005. This may be a sign that Clear Lake is moving from a macrophyte (aquatic plant) dominated state to an algae dominated state. Chlorophyll-a measured in Spider Lake over the last 20 years averaged 3.3 µg/L (micrograms per liter, or parts per billion) during the summer months. Secchi depths throughout the system are typically around 10 to 15 feet deep and total phosphorus, also measured in Spider Lake, averages about 12 µg/L in the summer months. Spider Lake is dimictic meaning the lake stratifies into layers during the summer with cooler, low-oxygen water at lower depths and oxygen rich, warmer water near the surface.

Included in the diverse aquatic plant community of the Spider Chain of Lakes are three Wisconsin Species of Special Concern were found in Spider Lake System during the 2012 plant survey: Littorella (*Littorella uniflora*), Robbins spikerush (*Eleocharis robbinsii)*, and small purple bladderwort (*Utricularia resupinata*). Management efforts will consider and limit any impacts to these species. Another high value plant, wild rice, was found in northwestern part of North Lake. Wild rice is afforded numerous protections due to its ecological and cultural significance.

Curly-leaf pondweed (*Potamogeton crispus*) has been in Big Spider Lake for at least 12 years, perhaps longer. Isolated plants and small patches of curly-leaf have also been found in Little Spider Lake. According to the Sawyer County Aquatic Invasive Species Coordinator, curly-leaf began to dominate in some areas in 2008. Curly-leaf pondweed appears to be established in all suitable habitat throughout Big Spider Lake but does not grow as a large, robust plant as observed on other lakes where it is highly invasive. In Little Spider Lake, no habitat that appeared suitable for curly-leaf was identified and only one small bed was found during the extensive aquatic plant survey done in 2012.

Purple loosestrife (*Lythrum salicaria*), another non-native aquatic invasive species, is found in wetlands bordering Clear Lake and is currently biologically controlled using *Galerucella* beetles. Eurasian watermilfoil (*Myriophyllum spicatum*), which has been monitored for extensively by volunteers and resource professionals, was not found in the Spider Chain of Lakes in 2012 or during any previous surveys. A primary concern of the Spider Chain of Lakes Association is the introduction of Eurasian watermilfoil and other aquatic invasive species.

The overall goal of aquatic plant management in the Spider Chain of Lakes is to **protect the Spider Chain of Lakes from degradation by maximizing the prevention of new invasions and through the containment and control of existing aquatic invasive species**. The primary objectives of this aquatic plant management plan are monitor for the introduction of new aquatic invasive species (early detection and rapid response) and to contain and, where and when appropriate, control curly-leaf pondweed in the Spider Chain of Lakes.

When selecting appropriate management alternatives, the Sensitive Area surveys, the WDNR Northern Region management strategy, public acceptance, and the following were considered: although a non-native species, curly-leaf pondweed appears to be minimally invasive (due to limited suitable habitat) and provides early season fish habitat; the exceptional native plant community in the lakes makes it more resistant to invasion and incidental damage to the native plant community during curly-leaf control activities could clear substrate leading to the further spread of curly-leaf or the establishment of a new aquatic invasive species such as Eurasian watermilfoil.

The objectives for this plan and the actions to be undertaken by the Association are to:

- **Objective 1: Preservation and Restoration**. Protect and restore the native plant species community in and around the lakes to decrease susceptibility to the introduction of new aquatic invasive species.
  Action: Provide shoreland restoration materials (online, newsletter).
  Action: Conduct a baseline shoreland evaluation (by boat).
  Action: Host shoreland restoration training event.
  Action: Monitor (survey in August) and protect wild rice populations.
  Action: Promote limited disruptions to native plant community on shore and in water.
- **Objective 2: Prevention**. Prevent the introduction and establishment of new aquatic invasive species through early detection and rapid response
  Action: In-lake and shoreline aquatic invasive species monitoring.
  Action: Promote riparian property owner monitoring of shoreline, open water; training as necessary.
  Action: Watercraft inspection at the 2 public access points; participate in 4th of July Landing Blitz.
  Action: Update contact information on Eurasian watermilfoil Rapid Response Plan annually and as needed.
- **Objective 3: Management**. Reduce existing aquatic invasive species populations (curly-leaf pondweed and purple loosestrife) through containment and control.
  Action: <u>Native Plant Management.</u> Limited manual removal around docks; normal boat use to maintain access lanes.
  Action: <u>Curly-leaf Pondweed Control.</u>
    Physical (hand, rake, and diver) removal primary control method. Annual coordinated effort.
    Chemical (the herbicide endothall) control if verified nuisance or spread.
    Annual bed mapping and density monitoring in Big Spider and Little Spider Lakes.
    Purchase GPS to assist with survey efforts.
  Action: <u>Purple Loosestrife Control.</u> Continue physical, biological, and chemical (glyphosate) control.
- **Objective 4: Education and Awareness**. Continue public outreach and education programs on aquatic invasive species.
  Action: Summarize Aquatic Plant Management Plan for wider distribution.
  Action: Host the Spider Lake Environmental Education for Kids (SLEEK) program.
  Action: Distribute aquatic invasive species educational materials.
  Action: Facilitate aquatic invasive species public education opportunity.
  Action: Maintain webpage/newsletter.

Executive Summary (Continued)

Action: Maintain, update, and improve aquatic invasive species signage a public access points.
Action: Present summary of water quality information during public event(s).
Action: Continue LoonWatch monitoring program on the lakes.
Action: Provide education opportunities and information on wildlife and wildlife monitoring programs.

- **Objective 5: Research and Monitoring**. Develop a better understanding of the lakes and the factors affecting lake water quality through continued and expanded monitoring efforts.
  Action: Evaluate ability to conduct CLMN Expanded water quality monitoring on all 4 lakes.
  Action: Conduct dissolved oxygen monitoring in all four lakes.
  Action: Conduct water quantity monitoring (lake stage and precipitation).
  Action: Develop a comprehensive lake management plan.
- **Objective 6: Adaptive Management**. Follow an adaptive management approach that measures and analyzes the effectiveness of control activities and modify the management plan as necessary to meet goals and objectives
  Action: Draft annual reports summarizing events and activities, and presenting strategy revisions and future management activities.
  Action: Draft end of project report reviewing success and failures after 5-year implementation of this plan.
  Action: Complete whole-lake point intercept aquatic plant survey every 5 years.

A five-year implementation plan can be found on the following page. Primary activities in this plan are related to the early detection and rapid response of new aquatic invasive species introductions, community outreach and education, purple loosestrife control, and monitoring and control of curly-leaf pondweed. Physical removal (hand-pulling, raking, and diver removal) are the preferred methods of curly-leaf pondweed control. Herbicide (endothall) can be used to control curly-leaf pondweed if nuisance conditions are documented in the area to be treated the year prior. Implementation of this plan will follow an adaptive management approach; the plan may be modified by evaluating results and adjusting actions on the basis of what has been learned.

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Spider Chain of Lakes Aquatic Plant Management Plan

AIS Education, Prevention and Planning

Prepared for the Spider Chain of Lakes Association

1.0 Introduction

The Spider Chain of Lakes is located in north-central Sawyer County about 14 miles northeast of Hayward, Wisconsin. The lakes are in the Lake Chippewa Watershed of the Upper Chippewa River Basin (Figure 1). The chain of lakes covers approximately 1,600 acres and is comprised of Spider Lake (WBIC 2435700), Clear Lake (WBIC 2435800), North Lake (WBIC 2436000), and Fawn Lake (WBIC 2435900). Locals refer to the Spider Lake basin north of the central narrow channel as Big Spider with Little Spider to the south. The lakes form the headwaters of Spider Creek, which flows south into the Tiger Cat Flowage, the outflow of which forms the North Fork of the Chief River, a tributary to Lake Chippewa. A small outlet dam is located on the southern shore of Spider Lake and is maintained by the Spider Chain of Lakes Association.

The Spider Chain of Lakes is a mesotrophic system treasured by riparian owners, area residents, Sawyer County, and the Wisconsin Department of Natural Resources (WDNR) for its fishery, aesthetics and recreational value. Curly-leaf pondweed (*Potamogeton crispus*), a non-native aquatic invasive species, has been present in Big Spider Lake since at least 2000 and a small stand (about 15 feet x 15 feet) was found in Little Spider Lake in 2012. Purple loosestrife (*Lythrum salicaria*), another non-native aquatic invasive species, is located on Clear Lake and is currently biologically controlled using *Gallerucella* beetles.

Spider Lake is listed as an Outstanding Resource Water by the WDNR. Outstanding Resource Waters receive the state’s highest protection standards because they typically do not have any point sources discharging pollutants directly to the water (for example, no industrial sources or municipal sewage treatment plants), though they may receive runoff from nonpoint sources. New discharges may be permitted only if their effluent quality is equal to or better than the background water quality of that waterway at all times.

The mission of the Spider Chain of Lakes Association (Association) is to preserve and protect the Spider Chain of Lakes for future generations. The Association actively sponsors educations programs, performs volunteer lake monitoring, and encourages the responsible use of the lakes by all. A courtesy patrol has been active for many years and provides assistance to stranded boaters, clarification of boating laws, and fishing tips. Volunteers have monitored the curly-leaf pondweed beds in Big Spider twice each summer over the last four years.

This plan is intended to establish long-term and realistic objectives for managing non-native aquatic invasive species while protecting valuable native species and their important habitat functions. Detailed aquatic plants surveys were conducted, possible management alternatives were evaluated to determine preferred management options, and an implementation plan was developed which includes a mechanism to monitor and modify this management plan as needed.

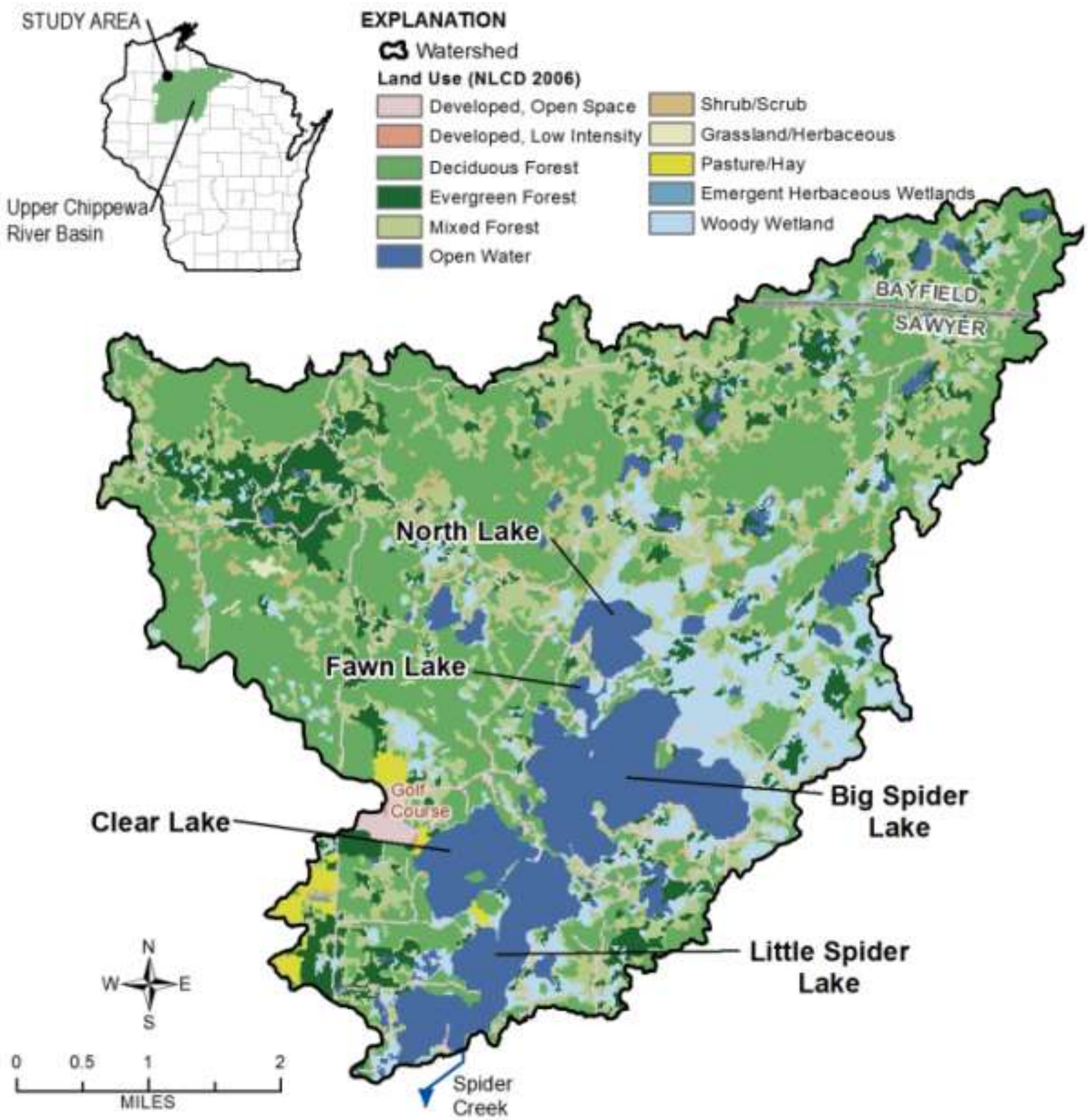


Figure 1 – Location of the Spider Chain of Lakes, Sawyer County, Wis.

Protecting the Spider Chain of Lakes requires a number of current activities to continue, including monitoring and management of invasive species and native plant restoration. This plan supports sustainable practices to protect, maintain and improve the native aquatic plant community, the fishery, and the recreational and aesthetic values of the lakes. This plan also lays out a strategy to prevent the introduction of new aquatic invasive species like Eurasian watermilfoil not currently found in the lakes, and lays out a monitoring program to aid in early detection of any new invasive species. Although considered a five-year plan for management, it is not intended to be a static document; rather, it is a living document which will be evaluated on an annual basis and can be revised to ensure goals and community expectations are being met

The Spider Chain of Lakes Association sponsored the development of this Aquatic Plant Management Plan, funded through a WDNR Aquatic Invasive Species Education, Prevention, and Planning Grant and in-kind donations by volunteers.

2.0 Aquatic Plant Management Strategy

All existing and new Aquatic Plant Management Plans and the associated management permits (chemical or harvesting) are reviewed by the WDNR. Additional review may be completed by the Voigt Intertribal Task Force in cooperation with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC). Plans developed for northern Wisconsin lakes are evaluated according to the goals of the Northern Region Aquatic Plant Management Strategy which went into effect in 2007. The WDNR guidelines, the Northern Region Aquatic Plant Management Strategy (Appendix A), and Sensitive Area investigations for the lakes formed the framework and guidance for the development of this plan.

Four stands of the non-native aquatic invasive species purple loosestrife exist on Clear Lake. Biological control efforts are underway using the *Gallerucella* beetle. Beetles are raised and released by Association volunteers in a partnership with Hayward High School students who dig and pot plants and the WDNR and the Sawyer County Land and Water Conservation Department who supply the beetles. This control effort has led to the reduction in the size of three purple loosestrife stands and will continue into the foreseeable future.

Curly-leaf pondweed was first noted in Big Spider Lake in early July, 2000 during a baseline aquatic plant survey (1). Only one plant stem was found, located just north of the channel between Big Spider Lake and Little Spider Lake, and removed. Because of the single sighting, curly-leaf was not considered problematic at that time. It is possible that curly-leaf was present in other parts of the lake but had senesced by the time of the survey. Several curly-leaf pondweed plants were observed at three sites during the Sensitive Area Survey in August 2003.

The first *official* documentation of curly-leaf in Spider Lake was in 2005 following a survey by the Great Lakes Indian Fish and Wildlife Commission. Official documentation requires that a voucher specimen be submitted to a herbarium for verification. Again, curly-leaf was found only in Big Spider, but at a slightly larger distribution. Plants were found scattered in sheltered bays and approximately 50 plants were found growing on the east side of the lake in water depths of 3 to 5 feet amongst the native Robbins' pondweed (*Potamogeton robbinsii*). Focused distribution and bed mapping of the lakes in 2012 found curly-leaf widely scattered as single plants in Big Spider Lake with denser patches in the northern bay and in the southwest corner of the east bay. It appeared that curly-leaf was established throughout all habitat suitable for its growth (areas soft muck). A small bed covering less than 250 square feet was found near the center of Little Spider Lake in 2012.

Because the lakes provide a high ecological value to the area and the curly-leaf pondweed has been present for many years without presenting significant problems, the intent of curly-leaf management at this time is not eradication, rather continued close monitoring and focused control where curly-leaf poses a nuisance. Eradication of established curly-leaf populations is generally not possible without severely disrupting the native plant population.

The focus of this plan is containment, that is, to prevent curly-leaf from spreading to other parts of the Chain of Lakes. It's important for Aquatic Plant Management Plans to include yearly monitoring and assessment programs to document not only the results of control efforts on the targeted species, but also the impacts on native plants, water quality, and fish and wildlife. It is equally important for plans to evaluate the need and potential for actively restoring the native plant community within a lake following the removal of targeted aquatic invasive species. This can prevent plant management from becoming endless, routine maintenance and buffer against the introduction of new aquatic invasive species.

3.0 Public Participation and Input

The Spider Chain of Lakes Association (Association) is very active in the stewardship of the Spider Chain of Lakes. The Association has been sharing information and providing education to its members and to the local community for many years. The website (www.spiderchainoflakes.net) provides information about the lakes, including the local history, local ordinances and lake regulations, on-going projects, newsletters, and a calendar of events. The *Spider Lines* newsletter has been produced in the spring and fall of each year.

Residents and property owners around the Spider Chain of Lakes were surveyed in the fall of 2000 (1). At that time, the majority of respondents did not feel the lakes had excessive aquatic plant problems and highly valued the clear water found in the lakes. Respondents also felt that a more aggressive strategy to protect against Eurasian watermilfoil was needed. The Association responded to this by establishing an outreach and monitoring program. Volunteers travel by boat, canoe, or kayak close to shore looking for Eurasian watermilfoil around the entire shoreline of the Spider Chain.

In 2011, the Association recognized a need to develop a plan of action for aquatic plant management, particularly to address the steps necessary to engage any future aquatic invasive species found in the lakes and to identify appropriate management alternatives for curly-leaf pondweed in Big Spider Lake. The Association then applied for and received a grant to complete this Aquatic Plant Management Plan in February 2012. Prior to the development of this plan, the distribution of curly-leaf was not well defined in the lakes.

The Association provided input, support, and review of draft and final documents during the development of this plan. The Board of Directors provided the majority of input for the development of this plan. Members included the following:

- John Kuntz (President)
- Judy Pilling (Vice President and Secretary)
- Mickie McGuiness (Treasurer)
- Barb Farrell (Chairwoman Membership Committee)
- Shirley Hill
- Bill Liebich
- Tom Jorndt
- Chris Janeczko
- Marnie Mamminga
- Pat Delaney

The Association communicated many times through email and attended aquatic plant management planning meetings. Copies of planning meeting presentations are included in Appendix E. The first presentation was held on August 20, 2011 during the annual meeting during which the aquatic plant management planning process, control methods, funding sources, and resident concerns were discussed. The concerns expressed at this meeting provided the foundations for the goal, objectives, and actions for aquatic plant management in this plan.

Prior to the extensive plant survey work completed in 2012, curly-leaf was thought to be a fairly recent arrival and have a limited distribution in Big Lake. With the survey findings of the exceptional native plant community and that curly-leaf was well distributed in Big Spider lake, was not overly invasive, and was present in nearly all suitable habitat, plant management discussions changed from eradication to monitoring and containment. This required additional education and outreach efforts to address the eradication mindset that had established in the lake community. In October 2012 a summary of aquatic plant management planning activities completed during the 2012 field season was presented to the Association. This document is also included in Appendix E.

In December 2012 a draft copy of this Aquatic Plant Management Plan was posted on the Association's website and emailed to members and Mr. Alex Smith of the WDNR for public comment and review. The Association expressed a variety of concerns regarding the use of technical language and the proposed water quality monitoring program which were addressed in a subsequent draft. Further comment was solicited for the second draft that was distributed in the same manner as the first draft. Public comment and responses can be found in Appendix E.

The Spider Chain of Lakes Association voted on and prioritized recommended management alternatives at a meeting held on Memorial Day 2013. The priority level of the various objectives and activities is included in the five-year Implementation Plan matrix at the beginning of this document.

The Association unanimously voted for approval of this plan on May 25, 2013. Approval of the APM Plan was relayed to the WDNR by John Kuntz, President of the Spider Chain of Lakes Association via email on May 27, 2013.

4.0 Documentation of Problems and Need for Management

In 2010, the Association began small-scale (less than 10 acres) herbicide treatment of curly-leaf pondweed under a WDNR Early Detection and Response grant. This grant funded treatment planning and herbicide application for 2010. A small-scale herbicide application was also completed in 2011, funded entirely by the Association. Kristine Maki, the Sawyer County Aquatic Invasive Species (AIS) Coordinator, assisted with planning and implementation both years.

This plan was developed to address several concerns the Association had regarding aquatic invasive species control and management activities. Addressed are management recommendations for existing aquatic invasive species like curly-leaf pondweed and purple loosestrife, monitoring and prevention strategies for new invasive species, preserving the lakes diverse native plant communities, and educating riparians and lake users about aquatic invasive species and the importance of native plants to the aquatic ecosystem. Continued monitoring and assessment are critical components in an effort to mitigate the problems that already exist as well as to help reduce the risk of the introduction of additional aquatic invasive species to the lakes from the surrounding area.

The possibility of the introduction of Eurasian watermilfoil into the Chain of Lakes is a primary concern of the Association. Eurasian watermilfoil is present in a number of nearby lakes and streams including Round Lake, Lake Chippewa, and the North Fork of the Chief River. This proximity makes the Spider Chain a candidate for the introduction of Eurasian watermilfoil via boat traffic. Eurasian watermilfoil would likely thrive in the Spider Chain of Lakes, but probably not to a large extent; northern watermilfoil (*Myriophyllum sibiricum*), a native macrophyte (aquatic plant) and close relative to Eurasian watermilfoil, and Illinois pondweed (*Potamogeton illinoensis*), a macrophyte commonly found growing in the same habitat as Eurasian watermilfoil, are located throughout the lakes, but their occurrences are relatively low (2),(3).

Continuing watercraft inspection and in-lake monitoring is necessary to prevent the introduction of Eurasian watermilfoil and other new aquatic invasive species. Monitoring and outreach activities at the boat landings on Little Spider Lake and Clear Lake should continue. It is also important to prevent management activities from opening up areas devoid of vegetation which can provide a place for new aquatic invasive species to gain a foothold.

Shoreland restoration is also included in this plan. Managing shorelands to maintain or improve water quality and habitat will help to preserve aquatic plant diversity and quality which in turn will also help to prevent highly competitive native plants (such as coontail and elodea) from becoming a problem.

5.0 Lake Information

Identifying appropriate aquatic plant management recommendations for the Spider Chain of Lakes requires a basic understanding of its physical characteristics, including its morphology (size, structure, and depth), critical habitat, and the fishery, as well as factors influencing water quality, such as soils and land use. All of these factors have the potential to influence aquatic plant growth. Aquatic plant management activities can impact the lakes water quality, fish and wildlife habitat, and both target and non-target aquatic plants. Plant survey data and water quality data were collected within the lakes during the development of this plan. These data along with data collected in the past and future will provide the information necessary to evaluate the effects of aquatic plant management and other management activities on the lakes and their ecosystem.

The lake inventory information that follows has been summarized from a number of resources and some of the information has been updated with more recent data. For example, lake areas were obtained from high-resolution digital orthophotos (Wisconsin Regional Orthophotography Consortium imagery). The volume of water in Clear Lake was included with the volume of Spider Lake on the WDNR lake map. The volume of Clear Lake was computed with ArcGIS software using depths measured during the 2012 plant survey and the volume and mean depth of Spider Lake were subsequently adjusted.

5.1 Physical Characteristics

The morphology of the Spider Chain of Lakes is summarized in Table 1. Spider Lake is the largest lake of the Spider Chain with a surface area of 1,232.8 acres and a volume of approximately 18,200 acre-feet (5.9 billion gallons) (Table 1). In addition to the inflow from One Shoe Lake on the northern shore, water likely enters Spider Lake from Fawn Lake and Crystal Lake. Flow between the lake basins has not been quantified and may reverse direction depending on wind direction and water levels. Outflow from Spider Lake is through the dam at the southern end of the lake into Spider Creek. Each of the lakes is therefore considered a drainage lake, or a lake that loses water via a surface outlet.

Table 1
Physical Characteristics of the Spider Chain of Lakes

Lake	Area[1] (acres)	Volume[2] (acre-feet)	Shoreline[1] (miles)	Maximum depth[3] (feet)	Average depth[4] (ft)
Spider Lake	1,232.8	18,154.1	18.07	64	14.7
Clear Lake	254.8	1,466.3	4.01	30	5.8
North Lake	139.6	1,773.6	2.62	30	12.7
Fawn Lake	30.3	339.3	1.44	35	11.2
Total	**1,657.5**	**21,733.3**	**26.14**	**64**	**13.1**

[1] Digitized from WROC (2010); [2] Clear Lake: Aquatic plant survey data, Others: WDNR Lake Maps;
[3] WDNR Lake Maps; [4] computed, volume divided by area;

5.1.1 Spider Lake

As a part of aquatic plant survey work done in 2012, depth soundings were taken at all but one of the 1,143 survey points on Spider Lake. One point was inaccessible as it was on a bog. The main basin of Little Spider Lake is a steep-sided, 20 foot deep trench running north to south with shallow bays less than 10 feet deep sloping gradually into the main body of the lake as shown in Figure 2. On the north side of the lake, a shallow bar projects north into the trench, topping out at 4 feet, and then drops off rapidly into a deep basin that reaches depths of 30 feet.

Big Spider Lake has a highly varied underwater topography consisting of numerous small islands, sunken islands, bars, humps, exposed points, and multiple basins creating a rich variety of habitats. The deepest areas occur in the main basin west of Atkins Island where the lake reached depths over 64 feet just north of the channel to Little Spider Lake (Figure 2).

Nutrient poor sandy- and marl-muck dominated the lake bottom throughout Little Spider Lake while most areas on Big Spider Lake were covered with a more nutrient rich muck. Muck was found at 82% of the 806 survey points where substrate could be reliably determined in Spider Lake. Most sand and rock areas were located along the immediate shoreline, scattered around islands, and over sunken islands, bars, and humps (Figure 2). Rock comprised 12% of the identifiable substrate and sand comprised 6%.

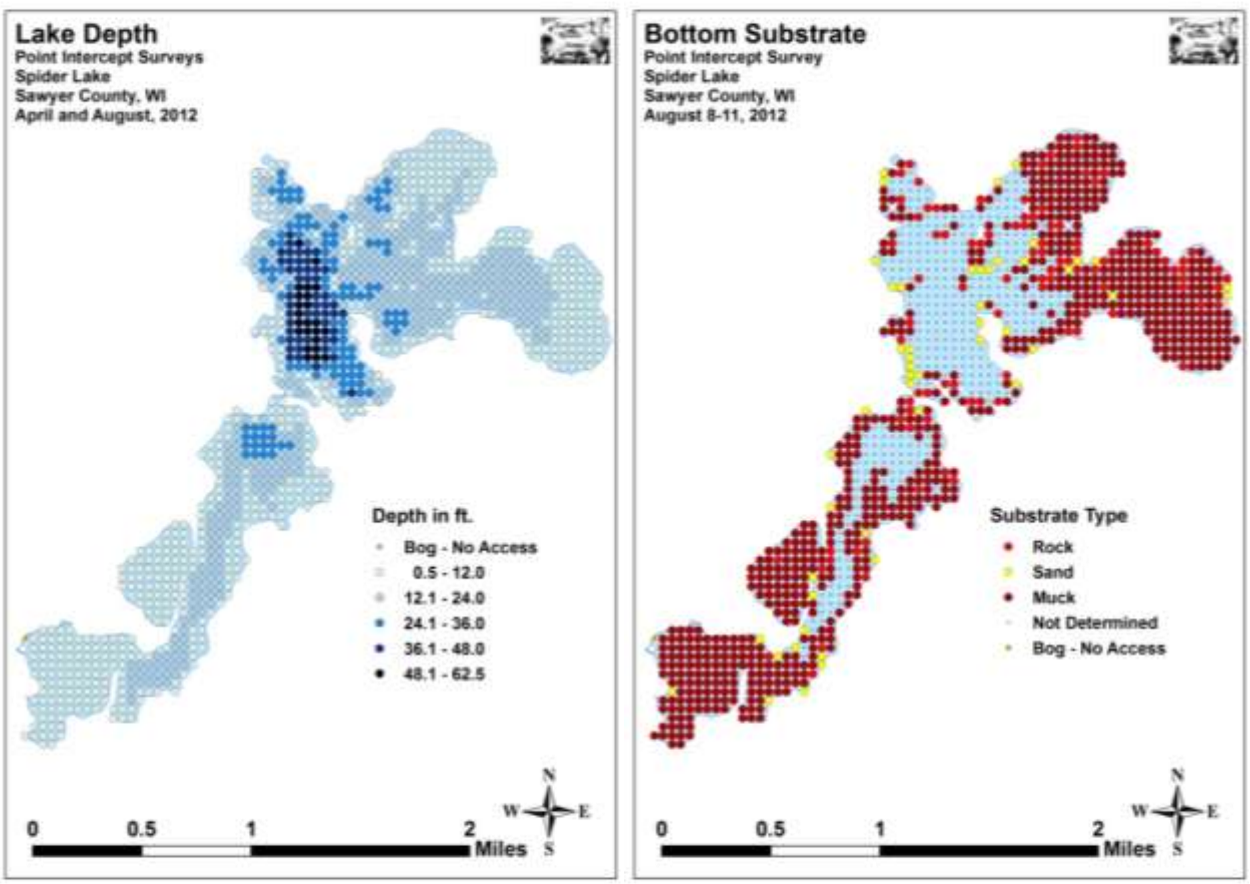


Figure 2 – Spider Lake Depth and Bottom Substrate.

5.1.2 Clear Lake

Depth soundings were taken at 453 points in Clear Lake during the 2012 aquatic plant survey. The lake's central basin is a shallow bowl that drops off gradually from shore as shown in Figure 3. This drop off is especially gradual moving from southwest to northeast. The only area on the lake that is greater than 10 feet deep is a narrow, crescent-shaped trench along the northeast shoreline that reaches depths of over 25 feet. The southern third of the lake is dominated by a broad shallow flat that spreads south, east, and west of Butternut Island (Figure 3).

Nutrient poor sandy- and marl-muck dominate the lake bottom covering 94% of survey points where substrate could be determined. Sand and rock, which covered 4% and 2% of the lake bed, respectively were primarily found along the immediate shoreline and scattered around the islands (Figure 3).

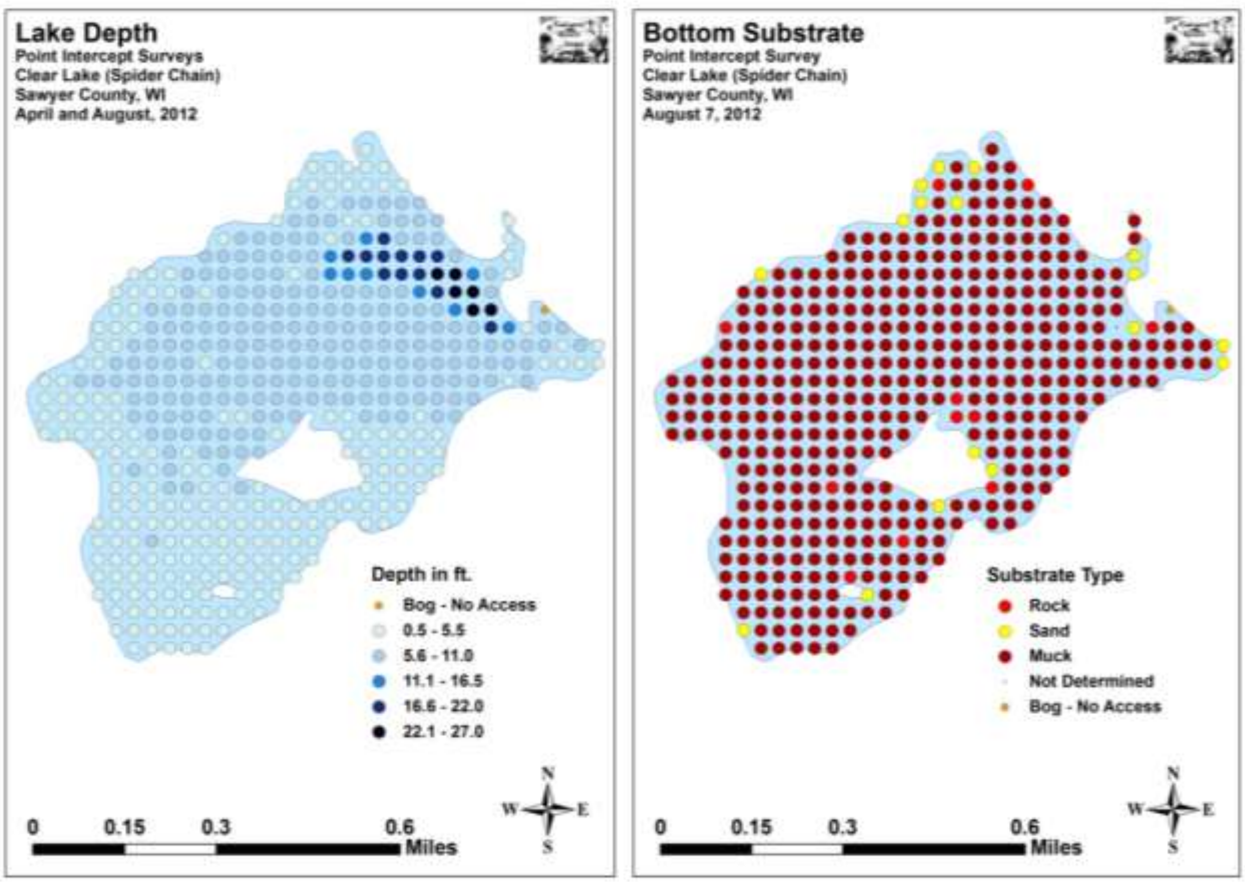
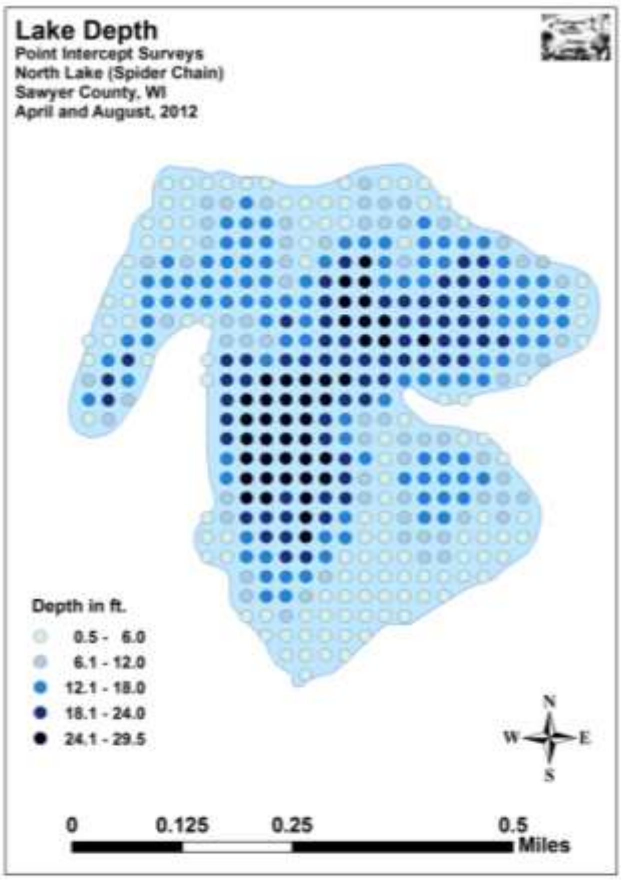


Figure 3 – Clear Lake Depth and Bottom Substrate

5.1.3 North Lake

Depth soundings were taken at 403 points in North Lake during the 2012 aquatic plant survey. The lake has a varied underwater topography with numerous small bowls reaching depths of 20 to 30 feet. There is a small sand and gravel hump in the northeast bay with depths around 6 feet and a shallow gravel bar that extends due south from the tip of the eastern peninsula for 600 feet with depths ranging from 4 to 6 feet. The shoreline south of the western peninsula and the borders of the western finger bay both drop off sharply into water deeper than 20 feet while the southeast and northwest bays slope much more gradually into deep water (Figure 4).

Nutrient rich organic muck dominates the lake bottom, covering 96% of the 260 survey points where substrate could be reliably determined. Most sand areas are located along the western shoreline, while most rock-bottomed areas are found on the gravel bar (Figure 4). Sand and rock substrate each covers 2% of the lake bed.



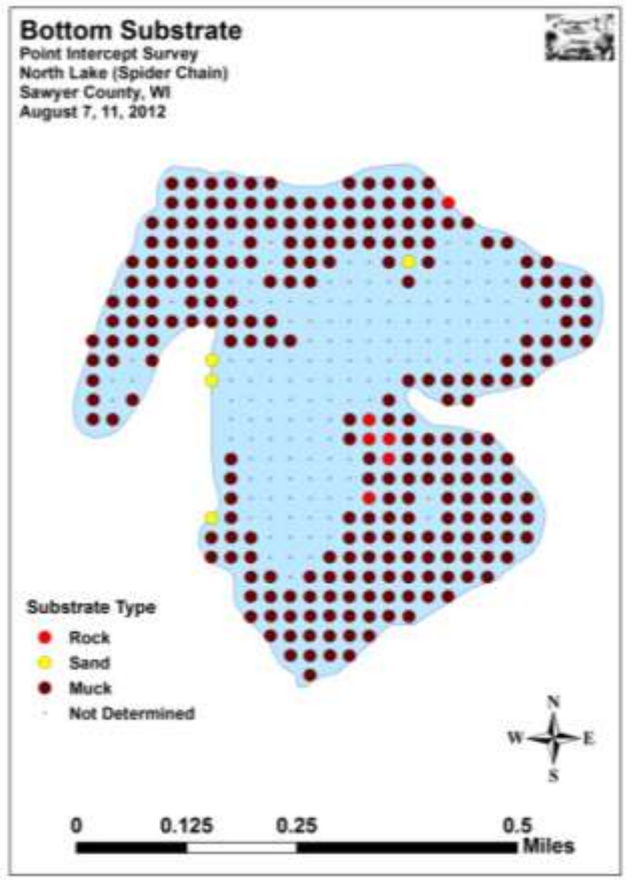


Figure 4 – North Lake Depth and Bottom Substrate

5.1.4 Fawn Lake

Depth soundings were taken at 94 points in Fawn Lake during the 2012 aquatic plant survey. Fawn lake has a crescent-shaped basin with two deep bowls—one in the northern bay that reaches depths over 25 feet, and another located southwest of the channel to North Lake that extends to 35 feet deep (Figure 5). The lake drops off rapidly to depths greater than 10 feet. The only notable exception to this was in the northwest bay where a seven-foot flat extends more than 300 feet to the northeast (Figure 5).

Nutrient rich organic muck dominated the lake bottom covering 100% of the survey points where bottom substrate could reliably be determined (Figure 5). The only sandy areas observed were located in the northern bay in front of the resort and along the eastern shoreline near the mid-lake point.

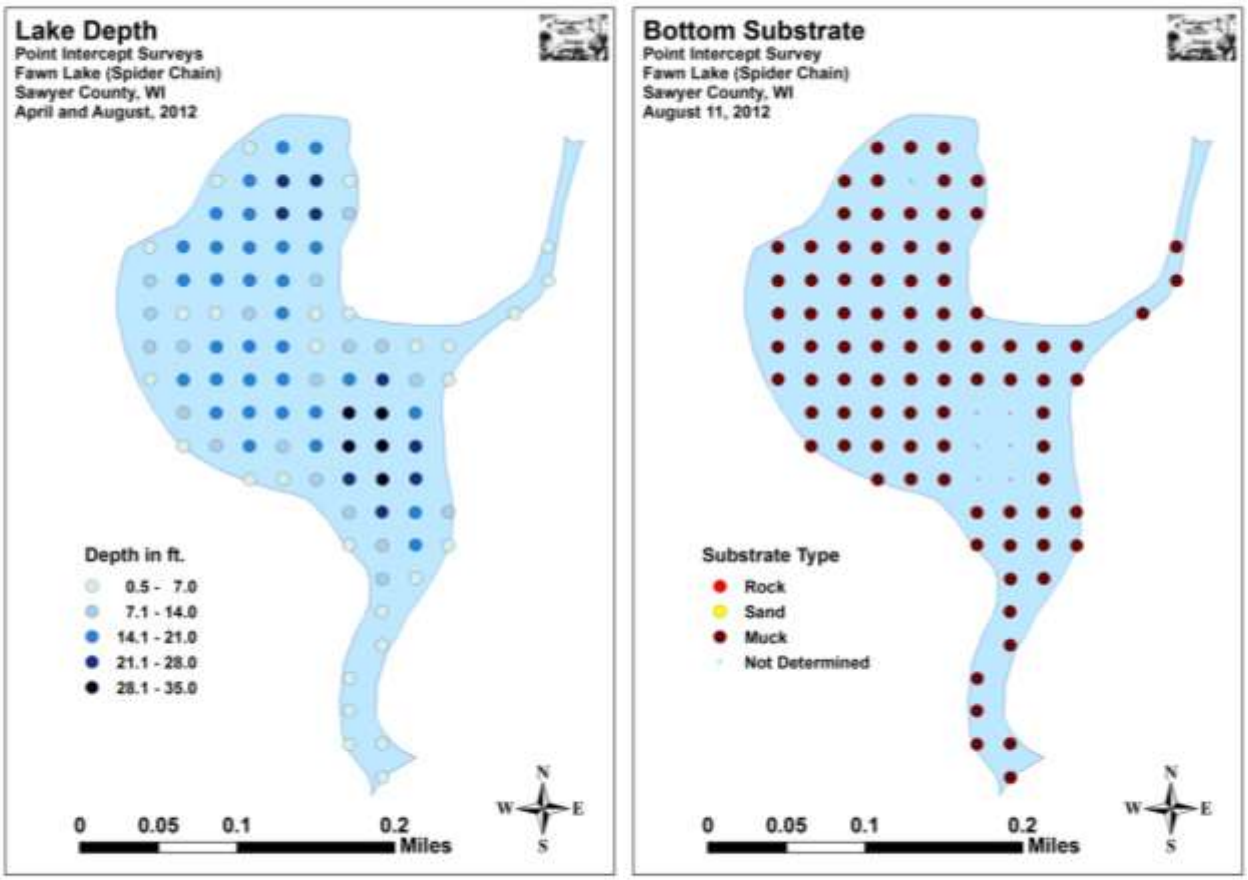


Figure 5 – Fawn Lake Depth and Bottom Substrate

5.2 Watershed

A watershed is an area of land from which water drains to a common surface water feature, such as a stream, lake, or wetland. The watershed of the Spider Chain of Lakes was delineated from the U.S. Geological Survey (USGS) National Hydrography Dataset Hydrologic Units using the 10-meter USGS digital elevation model.

The Spider Chain of Lakes watershed is about 26 mi^2 (16,668 acres) and extends northwest to just beyond the Seeley Lookout Tower and northeast into Bayfield County to include Emerson Lake. Land cover is primarily forested (68.2%) with wetlands and open water (11.6% and 13.0 percent, respectively) (Figure 1 and Table 2). Development in the watershed occurs primarily along the shoreland within the direct drainage area of the lakes. With approximately 95% of the watershed in an undeveloped state, near-shore development and land use (for example, the golf course) pose the largest threats to water quality.

Table 2
Land Use and Land Cover in the Spider Chain of Lakes Watershed

Land Use	Square Miles	Percent of Total
Developed/Urban	1.05	4.0
Agriculture	.25	1.0
Forest	17.76	68.2
Grassland/shrubland	.60	2.3
Wetland	3.01	11.6
Water	3.38	13.0
Total	**26.04**	**100.0**
Source: 2006 National Land Cover Database		

The hummocky, glacially derived landscape of the watershed has many areas of internal drainage, which are areas where surface runoff drains to closed depressions with no outlet for overflow. Areas of internal drainage provide groundwater recharge by capturing runoff which allows for infiltration. Water eventually reaches the lakes from many of the internally drained areas via groundwater flow which takes tens to hundreds of years. Although not delineated as part of this project, a large portion of the watershed north of the lakes appears internally drained.

Land cover and land use management practices within a watershed have a strong influence on water quality and water quantity. Increases in impervious surfaces, such as roads, rooftops and compacted soils associated with residential and agricultural land uses, can reduce or prevent the infiltration of runoff. This leads to an increase in the volume and rate of stormwater runoff and pollutant loading to the lakes and their tributary streams. The removal of near-shore vegetation causes an increase in the amount of nutrient-rich soil particles transported directly to a waterbody during rain events. It is important to protect and restore the naturally occurring features of the direct drainage area (for example, the wetland fringe and native plant cover) to maintain and improve water quality.

5.3 Water Quality

The water quality of a lake influences the aquatic plant community, which in turn can influence the chemistry of a lake. Water clarity, total phosphorus, and chlorophyll *a* are measures of water quality that can be used to determine the productivity or trophic status of a lake. The Carlson trophic state index (TSI) is a frequently used biomass-related index. The trophic state of a lake is defined as the total weight of living biological material (or biomass) in a lake at a specific location and time. Eutrophication is the movement of a lake's trophic state in the direction of more plant biomass. Eutrophic lakes tend to have abundant aquatic plant growth, high nutrient concentrations, and low water clarity due to algae blooms. Oligotrophic lakes, on the other end of the spectrum, are nutrient poor and have little plant and algae growth. Mesotrophic lakes have intermediate nutrient levels and have only occasional algae blooms.

Water quality data for the Spider Chain of Lakes are available online in the WDNR Surface Water Integrated Monitoring System (SWIMS) database. Data are available for Spider Chain of Lakes beginning in 1979 with the majority of historical data from monitoring stations on Spider Lake. The lake monitoring stations are described and shown in Table 3 and in Figure 6, as are the three purple loosestrife sites on Clear Lake and the boat launches on Little Spider Lake and Clear Lake. Parameters that have been collected at the lake monitoring sites include temperature and dissolved oxygen profiles, nutrient concentrations, and Secchi depths. The purple loosestrife sites include *Galerucella* beetle release information and the boat launches have Clean Boats-Clean Waters monitoring results.

Table 3
Spider Chain of Lake Monitoring Station Names

Lake	Station ID	Station Name	Latitude	Longitude
Spider Lake	583064	Big Spider Basin - Deep Hole at South End	46.099440	-91.221115
	583171	Little Spider Basin - Big Bay Deep Hole (North End)	46.093887	-91.226400
	583048	Little Spider Basin	46.081867	-91.233536
	10018582	Access at Heinemann's Landing - SE Side Of Lake	46.074776	-91.238030
Clear Lake	10019136	Clear Lake - Spider Lake Public Access	46.096214	-91.245040
	583113	Deep Hole	46.097366	-91.231240
	10035043	Purple Loosestrife / Wetland Location - Off of N. Balsam Rd, North of N. Rich Dr., Hayward	46.100105	-91.229540
	10035042	Purple Loosestrife - Clear Lake - Off W. Elaine Dr, Hayward	46.096850	-91.243744
	10035041	Purple Loosestrife / Wetland Location - Off N. Balsam Rd, Hayward	46.101948	-91.234180
North Lake	583102	Deep Hole	46.120000	-91.216120
Fawn Lake	583101	Deep Hole	46.114130	-91.219770

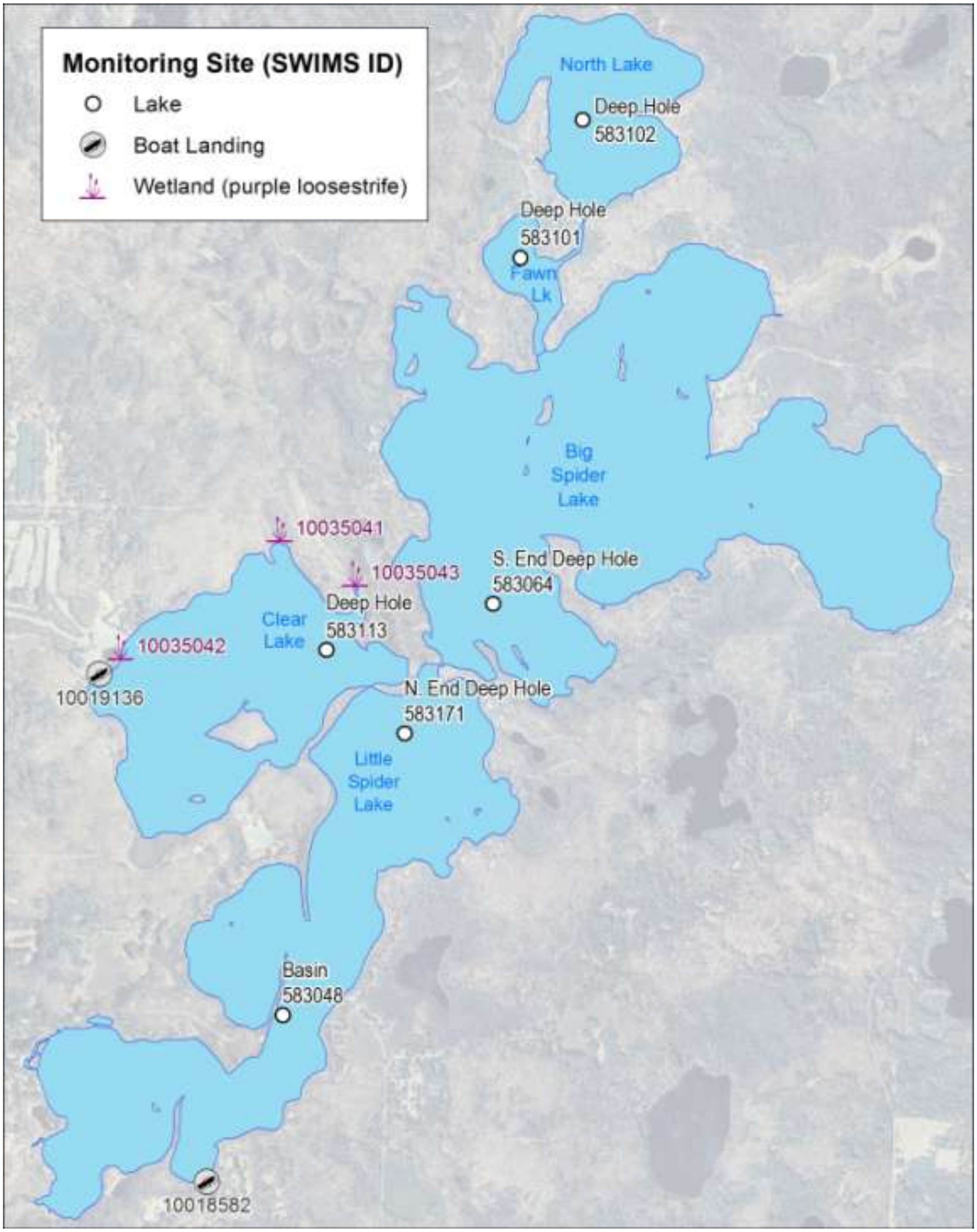


Figure 6 – Active Monitoring Stations on the Spider Chain of Lakes, Sawyer County, Wis.

5.3.1 Temperature and Dissolved Oxygen

Temperature and dissolved oxygen are important factors that influence aquatic organisms and nutrient availability in lakes. As temperature increases during the summer in deeper lakes, the colder water sinks to the bottom and the lake develops three distinct layers as shown in Figure 7. This process, called stratification, prevents mixing between the layers due to density differences which limits the transport of nutrients and dissolved oxygen between the upper and lower layers. In most lakes in Wisconsin that undergo stratification, the whole lake mixes in the spring and fall when the water temperature is about 39°F, a process called overturn. Overturn begins when the surface temperatures become colder and therefore denser and begin to sink. Below about 39°F, colder water becomes less dense and begins to rise (which is why ice floats) and inverse stratification (warmer water on bottom) occurs throughout the winter.

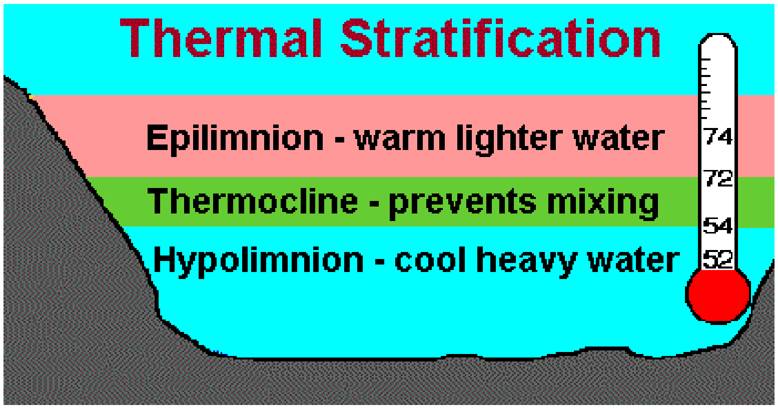


Figure 7 – Summer Thermal Stratification

During the summer months, the upper warm layer, called the epilimnion, remains well oxygenated due to wind and wave action and photosynthesis. The middle layer, called the metalimnion or thermocline, is where changes in temperature and dissolved oxygen are greatest. This middle layer acts as a barrier that prevents warmer, oxygen rich waters in the upper layer from mixing with colder, deeper waters It is common for dissolved oxygen levels to be depleted in the lower layer, called the hypolimnion, as there is no source of new oxygen and the decomposition of organic matter consumes oxygen.

Dissolved oxygen levels below 5 mg/L stresses many fish species. The dissolved oxygen level of 2 mg/L, called hypoxia, is an important criterion of sediment phosphorus release. When near-bottom dissolved oxygen is at 2 mg/L or less, the sediment-water interface is likely anoxic (no oxygen) and therefore releasing phosphorus. If the phosphorus released from sediments reaches the upper part of the lake (for example, during lake overturn in spring and fall), it can provide a significant internal source of phosphorus to fuel algae blooms.

Spider Lake is dimictic with mixing in the fall and summer (SWIMS, 2012). Hypoxia occurred intermittently at the Big Spider Lake and Little Spider Lake Deep Hole sites at depths greater than about 20 feet. No water temperature data is available for North Lake and only two dissolved oxygen readings were in the SWIMS database: one from August 1, 1979 with dissolved oxygen measures at 7.7 mg/L at 3 feet below the lake surface, and the other on August 28, 2001 with 8.4 mg/L of dissolved oxygen at 6.5 feet below the surface. Fawn Lake has no historic water temperature data available in the SWIMS database and only one dissolved oxygen reading of 8.1 mg/l taken on August 28, 2002 at a depth of 6 feet. Neither temperature nor dissolved oxygen data are available for Clear Lake.

5.3.2 Water Clarity

The depth to which light can penetrate a lake is a factor that limits aquatic plant, or macrophyte, growth. Water clarity is measured by lowering a black and white Secchi disk. The disk is lowered into the water and the depth of disappearance is recorded. The disk is then lowered further and slowly raised until it reappears. The Secchi depth is the mid-point between the depth of disappearance and the depth of reappearance. Because light penetration is usually associated with algae growth, a lake is considered eutrophic when Secchi depths are less than 6.5 feet. Secchi depths vary throughout the year, with shallower readings in summer when algae become dense and limit light penetration and deeper readings in spring and late fall.

Secchi data are available for Spider Lake from 1989 through 2012 (Figure 8). In 2012, summer (July and August) water clarity averaged just over 10 feet and ranged from 7.8 feet to 13 feet. The overall mean summer Secchi depth classifies Spider Lake as a mesotrophic system. During some years, the Secchi depth is indicative of oligotrophic conditions, notably at the Big Spider Lake Deep Hole site. Secchi depths measured at the two Little Spider Lake sites have been nearly identical.

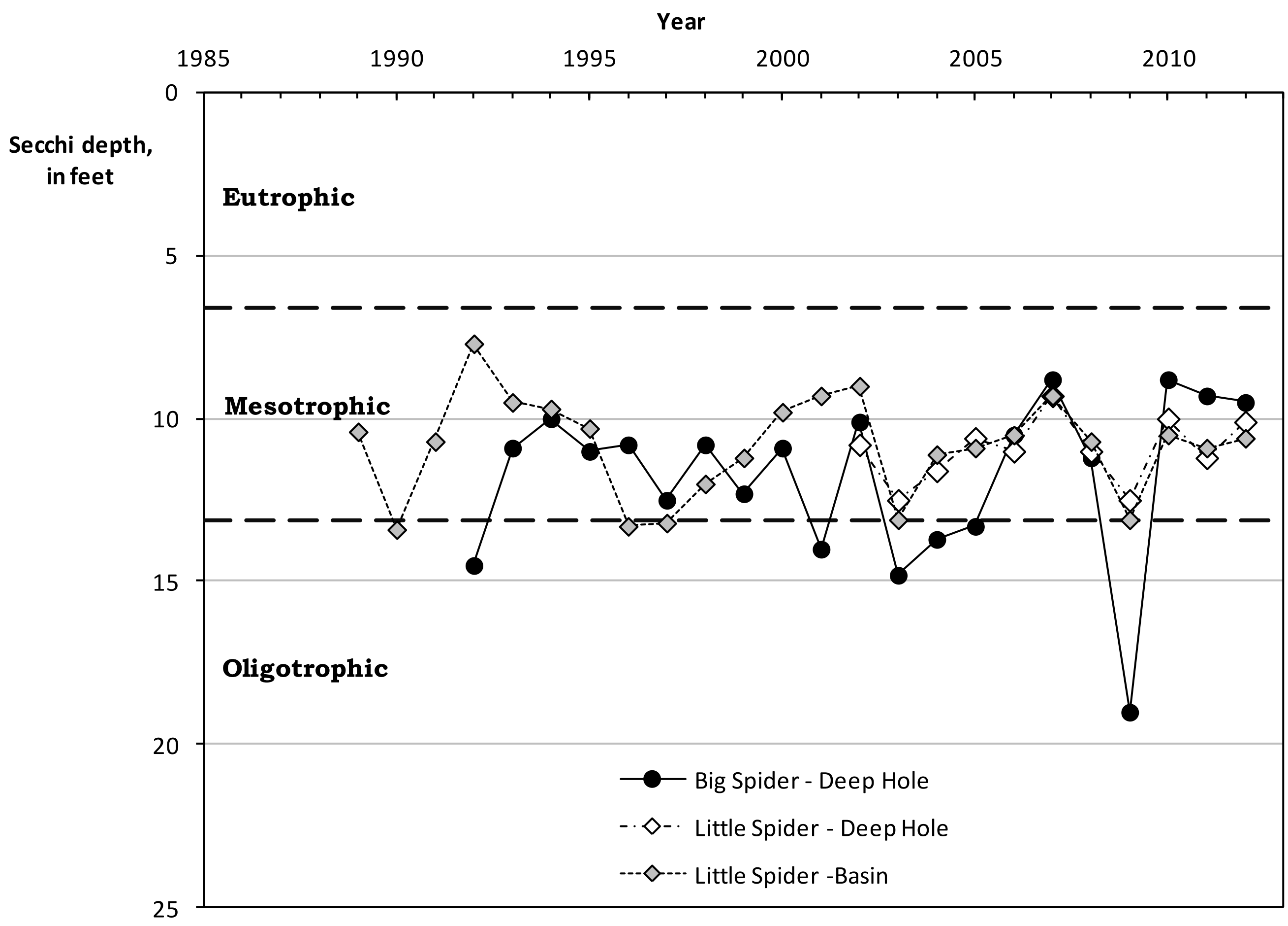


Figure 8 – Mean Summer (July and August) Water Clarity in Spider Lake

Secchi depths for Clear Lake, North Lake, and Fawn Lake are shown in Figure 9. Clear Lake lives up to its name with Secchi depths often found at depths greater than 15 feet. This is attributed to Clear Lake being a shallow, macrophyte-dominated lake. In 2012, the Secchi depth in Clear Lake ranged from 10 to 15 feet and averaged nearly 13 feet. The water clarity in North Lake and Fawn Lake was somewhat lower, averaging 6.9 and 6.5 feet in 2012, respectively, putting them on the border between eutrophic and mesotrophic. The overall mean Secchi depth for the period of record places North Lake and Fawn Lake in the mesotrophic range and Clear Lake in the oligotrophic range.

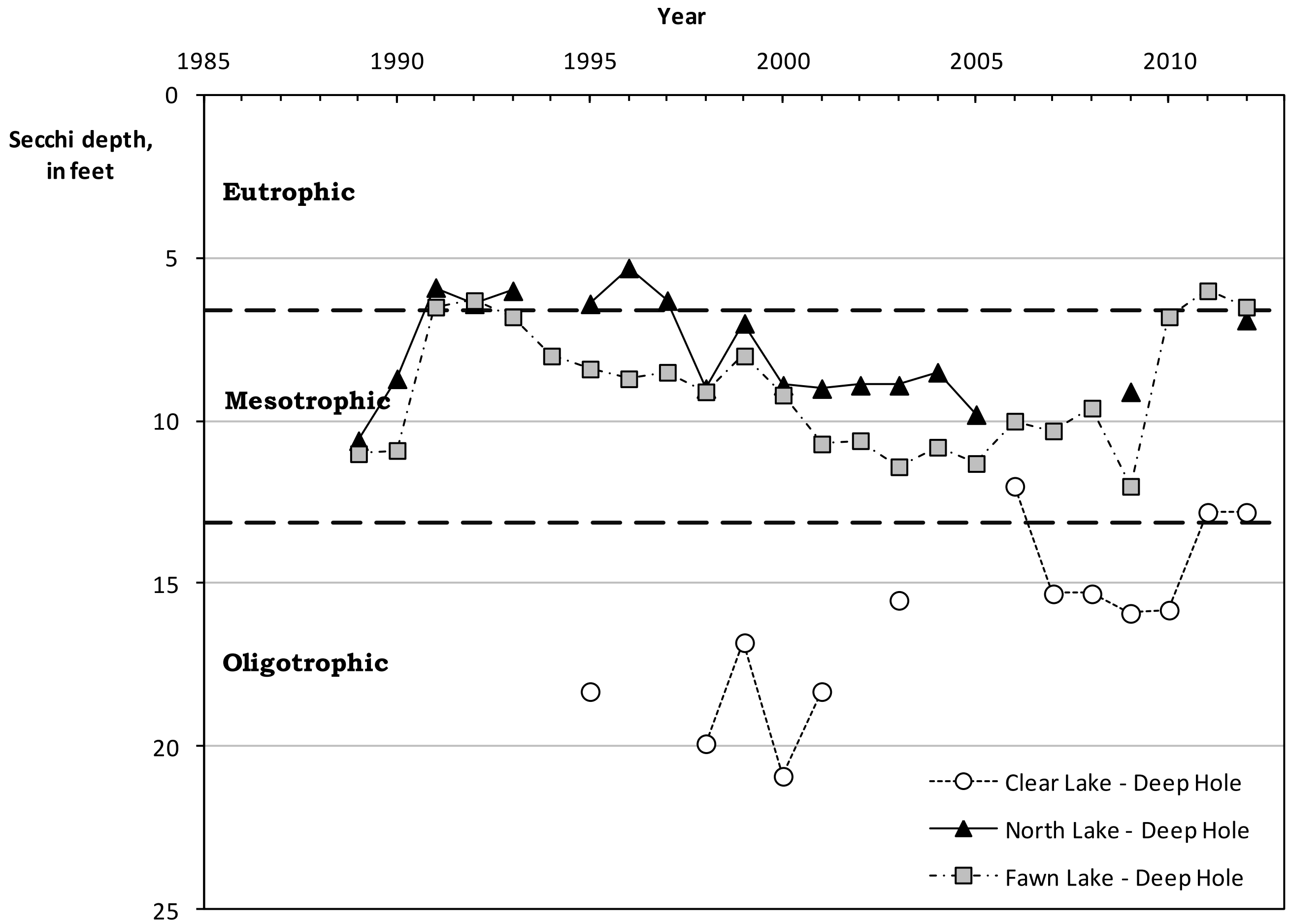


Figure 9 – Mean Summer (July and August) Water Clarity in Clear Lake, North Lake, and Fawn Lake

5.3.3 Phosphorus

Phosphorus is an important nutrient for plant growth and is commonly the nutrient limiting plant production in Wisconsin lakes. Based on measurements taken in August 2002, the total nitrogen to total phosphorus ratio is about 25:1 which suggests phosphorus is the nutrient limiting aquatic plant growth in the Spider Chain of Lakes. When phosphorus is limiting production, small additions of the nutrient to a lake can cause dramatic increases in plant and algae growth. Phosphorus should therefore be the focus of management efforts to improve water quality. A total phosphorus concentration less than 20 µg/L (micrograms per liter, or parts per billion) is necessary to prevent nuisance algal blooms in most lakes (5); the total phosphorus concentration in the Spider Chain of Lakes is generally below this threshold.

Clear Lake, North Lake, and Fawn Lake each have one total phosphorus sample taken in take in August of 2002 which measured 13, 27, and 18 µg/L, respectively.

Total phosphorus data is available for the three monitoring stations in Spider Lake from 1990 through 2012. Figure 10 shows the near-surface (sample collected at a depth of 6 feet or less, or using a 6-foot long integrated sampler) summer mean total phosphorus in Spider Lake. Total phosphorus has varied in Spider Lake, but no trends are evident. At the Big Spider Lake Deep Hole site, the overall summer average total phosphorus from 1995 through 2012 is 14.8 µg/L. The reason for the total phosphorus spikes in 1997 and 2008 are unknown; during both total phosphorus spikes, water clarity increased and chlorophyll-a decreased from the previous year suggesting less algae growth and therefore more free phosphorus in the water column.

The Little Spider Deep Hole site total phosphorus averaged 12.1 µg/L from 2002 through 2012, and historic total phosphorus at the Little Spider Basin site averaged 13.8 µg/L from 1990 through 1994. Total phosphorus was measured in the hypolimnion (near the lake bed) in the early 1990s and was generally about two times higher than the near-surface concentration.

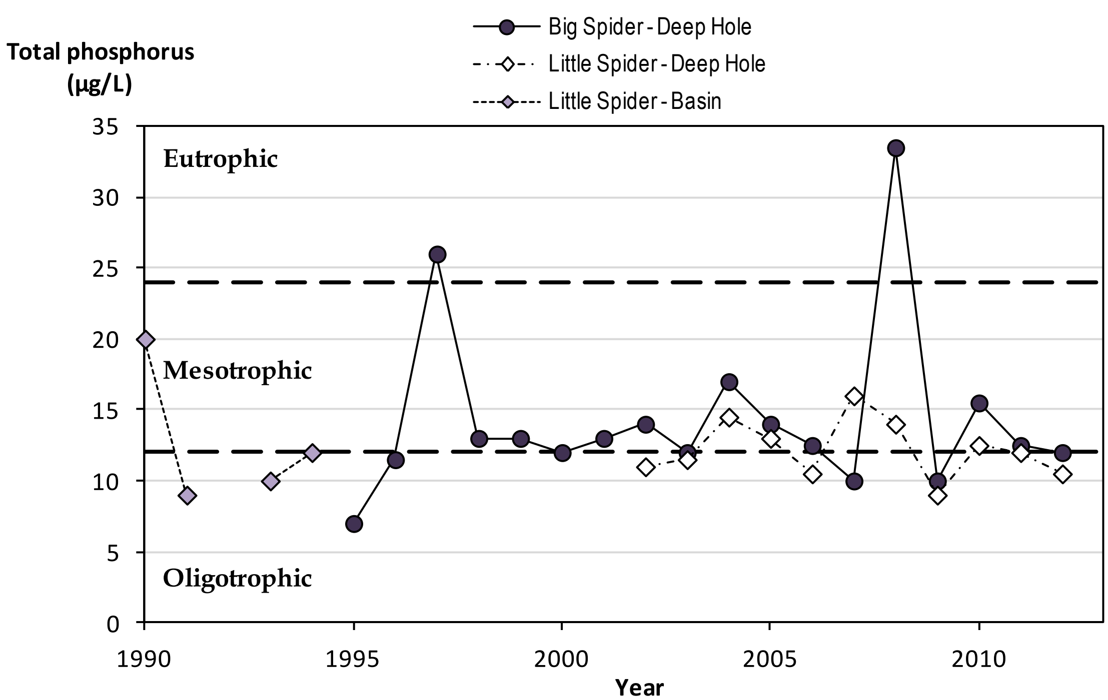


Figure 10 – Mean Summer Near-surface (0 to 6 feet deep) Total Phosphorus in Spider Lake

5.3.4 Chlorophyll *a*

Chlorophyll-a is the green pigment found in plants and algae. The chlorophyll-a concentration is used as a measure of the algal population in a lake. Values greater than about 10 µg/L (micrograms per liter or parts per billion) are considered indicative of eutrophic conditions and concentrations of 20 µg/L or higher are associated with algal blooms. Preference is given to the chlorophyll-a trophic state index for classification because it is the most accurate at predicting algal biomass.

Clear Lake, North Lake, and Fawn Lake each have one total phosphorus sample taken in take in August of 2002 which measured 3.13, 4.05, and 4.42 µg/L, respectively. Each of the measurements fall within the mesotrophic range (moderately productive) of the trophic state index.

Chlorophyll-a has been measured from 1994 through 2012 in Spider Lake (Figure 11). The chlorophyll-a levels consistently indicate Spider Lake is mesotrophic, or moderately productive. The mean summer chlorophyll-a at the Big Spider Lake Deep Hole site, which has the most comprehensive data set, ranges from 1.99 to 4.12 µg/L and averages 3.19 (trophic state index of 42) from 1996 through 2012.

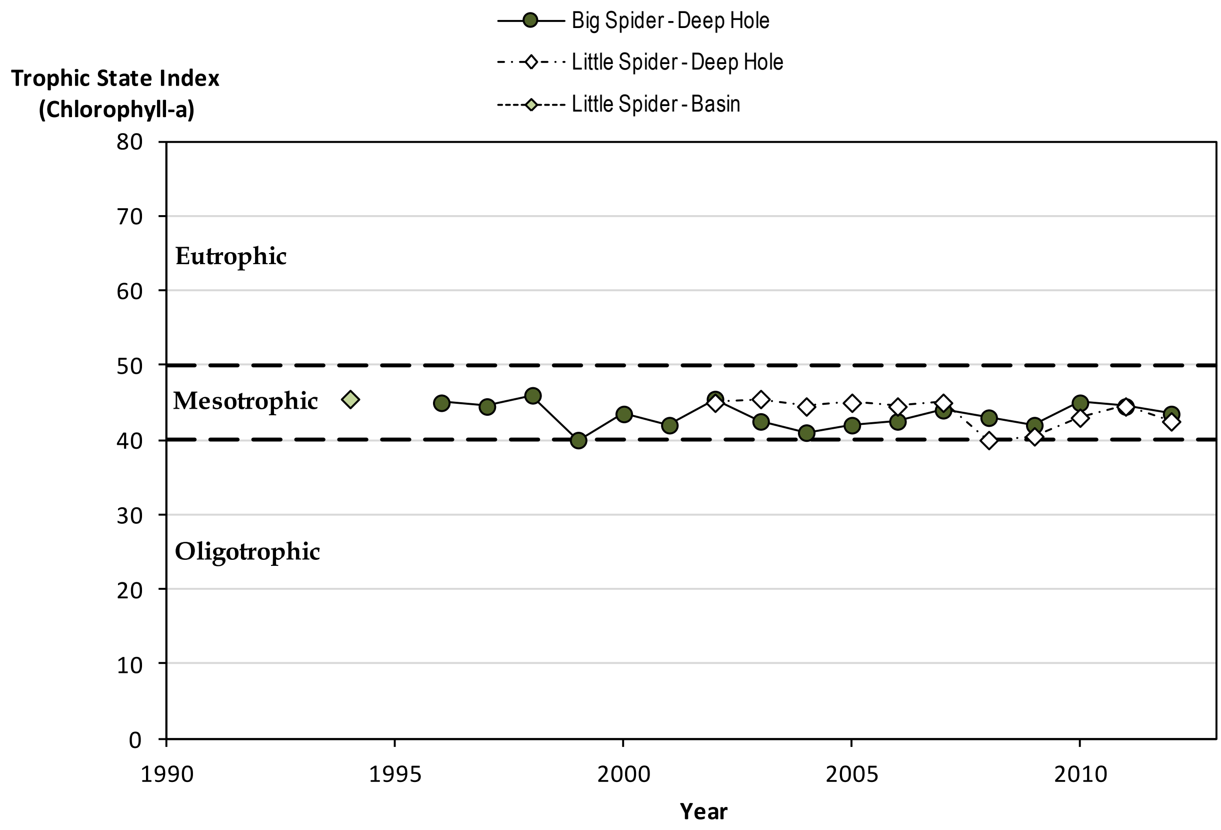


Figure 11 – Mean Summer Chlorophyll-a Trophic State Index for Spider Lake.

5.4 Water Quality Discussion

Overall there has been little apparent change in the water quality of the Spider Chain of Lakes since data collection began in the early 1990s. The lakes can be classified as mesotrophic and have clear water with diverse submerged macrophyte (aquatic plant) communities. The trophic state index and associated conditions are shown in Table 4.

Table 4
The Trophic State Index (TSI) and Associated Conditions

TSI	Trophic State	Description of Associated Conditions
<30	Oligotrophic	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
30 - 40		Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
40 - 50	Mesotrophic	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
50 - 60	Eutrophic	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
60 - 70		Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
70 - 80		Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
>80		Algal scums, summer fishkills, few plants, rough fish dominant. Very poor water quality.

Spider Chain

With phosphorus likely limiting plant and algae growth in the Spider Chain of Lakes, reductions of phosphorus inputs into the lakes would likely lead to reduced algae growth and reduced nuisance macrophyte growth. Due to the undeveloped nature of the watershed, the largest source of phosphorus to the system is likely runoff from development along the shorelines, particularly lawns and the golf course.

There has been a decrease in the summer water clarity of about 3 feet in Clear Lake, with the largest decrease occurring from 2000 to 2005, a time when the clarity in the other lakes remained stable or increased. Shallow lakes such as Clear Lake generally exist in one of two states – a clear, macrophyte-dominated state or a turbid, algae-dominated state. Fortunately, Clear Lake is in the macrophyte-dominated state. Unfortunately, a shallow lake can turn into an algae-dominated lake relatively quickly under certain, often human induced conditions called forward switches. For example, if plants are removed by pulling or harvesting, or if motor boats continually damage plants, there are fewer plants to use the nutrients which will then be used by algae for growth. In shallower waters, motor boats also churn up sediment which causes the release more nutrients. Fish such as carp can be extremely detrimental to shallow lakes as they destroy plants and re-suspend sediment during foraging activities. The cause of loss of water clarity is unknown at this time, but may be a result of one of these or another forward switch causing the lake to move from a macrophyte to algal dominated state.

5.5 Aquatic Ecosystems

Aquatic plants, also known as macrophytes, are a natural part of most lake communities and provide many benefits to fish, wildlife, and people. Native macrophytes have many important functions and values to a lake ecosystem. They are the primary producers in the aquatic food chain, converting the basic chemical nutrients in the water and soil into plant matter, which becomes food for all other life.

Aquatic plants provide valuable fish and wildlife habitat. More food for fish is produced in areas of aquatic vegetation than in areas where there are no plants. Insect larvae, snails, and freshwater shrimp thrive in plant beds. Panfish eat aquatic plants in addition to aquatic insects and crustaceans. Plants also provide shelter for young fish. Northern pike spawn in marshy and flooded areas in early spring and bass, sunfish, and yellow perch usually nest in areas where vegetation is growing.

Many submerged plants produce seeds and tubers (roots) which are eaten by waterfowl. Bulrushes, sago pondweed, wild celery, and wild rice are especially important duck foods. Submerged plants also provide habitat to a number of insect species and other invertebrates that are, in turn, important foods for brooding hens and migrating waterfowl.

The lake aesthetic valued by so many is enhanced by the aquatic plant community. The visual appeal of a lakeshore often includes aquatic plants, which are a natural, critical part of a lake community. Plants such as water lilies, arrowhead, and pickerelweed have flowers or leaves that many people enjoy.

Aquatic plants improve water clarity and water quality. Certain plants, like bulrushes, can absorb and break down polluting chemicals. Nutrients used by aquatic plants for growth are not available to algae, thus reducing algae abundance and improving water clarity. Algae, which thrive on dissolved nutrients, can become a nuisance when too many submerged water plants are destroyed. Aquatic plants also maintain water clarity by preventing the re-suspension of bottom sediments. Aquatic plants, especially rushes and cattails, dampen the force of waves and help prevent shoreline erosion. Submerged aquatic plants also weaken wave action and help stabilize bottom sediment.

Native aquatic plant communities also offer protection from non-native aquatic invasive species. Current scientific literature generally accepts the concept that invasions of exotic plants are encouraged, and in some cases induced, by the disruption of natural plant communities. Curly-leaf pondweed, which is present in the Big Spider Lake, is an opportunistic plant. Much like lawn and agricultural weeds that germinate in newly disturbed soil, curly-leaf pondweed is more likely to invade areas in which the native plant community has been disturbed or removed. Removing the natural competition from native plants may also open up the door to new invasive species and less desirable plant communities.

As a natural component of lakes, aquatic plants support the economic value of all lake activities. Wisconsin's $13 billion tourism industry is anchored by 15,081 lakes and 12,600 rivers and streams which draw residents and tourists to hunt, fish, camp, and watch wildlife on and around lakes. According to the WDNR, the world class fishery lures more than 1.4 million licensed anglers each year, supports more than 30,000 jobs, generates a $2.75 billion annual economic impact, and $200 million in tax revenues for state and local governments.

5.5.1 Wetlands

In Wisconsin, a wetland is defined as an area where water is at, near, or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation, and which has soils indicative of wet conditions (Wisconsin Statue 23.32(1)). Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes. Wetlands are protected under the Clean Water Act and state law and in some places by local regulations or ordinances. Landowners and developers are required to avoid wetlands with their projects whenever possible; if the wetlands can't be avoided, they must seek the appropriate permits to allow them to impact wetlands (for example, fill, drain or disturb soils).

According to the National Wetland Inventory, emergent, forested/shrub and aquatic bed (lake and freshwater pond) wetlands are present in the Spider Chain of Lakes watershed. The majority of the wetlands border the lakes and tributary streams and have a direct hydrologic connection to the lakes (Figure 1). Emergent wetlands are wetlands with saturated soil and are dominated by grasses such as redtop and reed canary grass, and by forbs such as giant goldenrod. Forested/shrub wetlands are wetlands dominated by mature conifers and lowland hardwood trees. Forested/shrub wetlands are the dominant form of wetlands in the watershed and are important for stormwater and floodwater retention and provide habitat for various wildlife. Aquatic bed wetlands are wetlands characterized by plants growing entirely on or within a water body that is no more than six feet deep.

Wetlands serve many functions that benefit the ecosystem surrounding the Spider Chain of Lakes. Wetlands support a great variety of native plants and are more likely to support regionally scarce plants and plant communities. Wetlands provide fish and wildlife habitat for feeding, breeding, resting, nesting, escape cover, travel corridors, spawning grounds for fish, and nurseries for mammals and waterfowl. Contrary to popular belief, healthy wetlands reduce mosquito populations; natural enemies of mosquitoes (dragonflies, damselflies, backswimmers, and predacious diving beetles) need proper habitat (that is, healthy wetlands) to survive.

Wetlands provide flood protection within the landscape by retaining stormwater from rain and melting snow and capturing floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months.

Wetland plants and soils provide water quality protection by storing and filtering pollutants ranging from pesticides to animal wastes. Wetlands also provide shoreline protection by acting as buffers between the land and water. Wetland plants protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This is important in waterways where high boat traffic, water currents, and wave action may cause substantial damage to the shore.

Although some small (two acres or less) wetlands may not appear to provide significant functional values when assessed individually, they may be very important components of a larger natural system. Not only do small wetlands provide habitat functions, they also store phosphorus and nitrogen and trap pollutants such as heavy metals and pesticides. Draining these small wetlands, which often do not appear on maps, not only requires the proper permits, but can also release the once-stored pollutants and nutrients into lakes and streams.

5.5.2 Critical Habitat

Every body of water has areas of aquatic vegetation or other features that offer critical or unique aquatic plant, fish and wildlife habitat. Such areas can be mapped by the WDNR and designated as Critical Habitat. Critical Habitat areas include important fish and wildlife habitat, natural shorelines, physical features important for water quality (for example, springs) and navigation thoroughfares. These areas, which can be located within or adjacent to the lake, are selected because they are particularly valuable to the ecosystem or would be significantly and negatively impacted by most human induced disturbances or development. Critical Habitat areas include both Sensitive Areas and Public Rights Features. Sensitive Areas offer critical or unique fish and wildlife habitat, are important for seasonal or life-stage requirements of various animals, or offer water quality or erosion control benefits.

The WDNR mapped sensitive areas on the Spider Chain of Lakes in 2002 and 2003. The full report is on file with the WDNR in Spooner, Wis. Its companion document *Guidelines for Protecting, Maintaining, and Understanding Lake Sensitive Areas* is included in Appendix B. The Sensitive Area survey identified 12 areas on Big Spider Lake, 14 areas on Little Spider Lake, 3 areas on Clear Lake, 2 areas on North Lake and 1 area on Fawn Lake that merit special protection of the aquatic habitat (Figure 12). Sensitive areas on the lakes fell into three basic categories: aquatic plant communities providing important fish and wildlife habitat, gravel and coarse rock rubble which provide important walleye spawning habitat, and areas of natural scenic beauty.

The data and recommendations from the Sensitive Area Report were reviewed and incorporated into this management plan. In addition to site-specific recommendations, the report recommends that aquatic vegetation should be protected and any removal or control should be minimized. In sensitive areas, it is important to maintain vegetated shoreland buffers. Stumps and woody habitat, which provide fish cover, should not be removed from sensitive areas.

Although restrictions are in place to protect these areas during plant management operations, in some cases, short-term disruptions to habitat during the removal of monotypic stands of aquatic invasive species may lead to positive long-term improvements to the habitat of the lake. Disruptions to the sensitive areas may be warranted when responding to the discovery of a new invasive species.

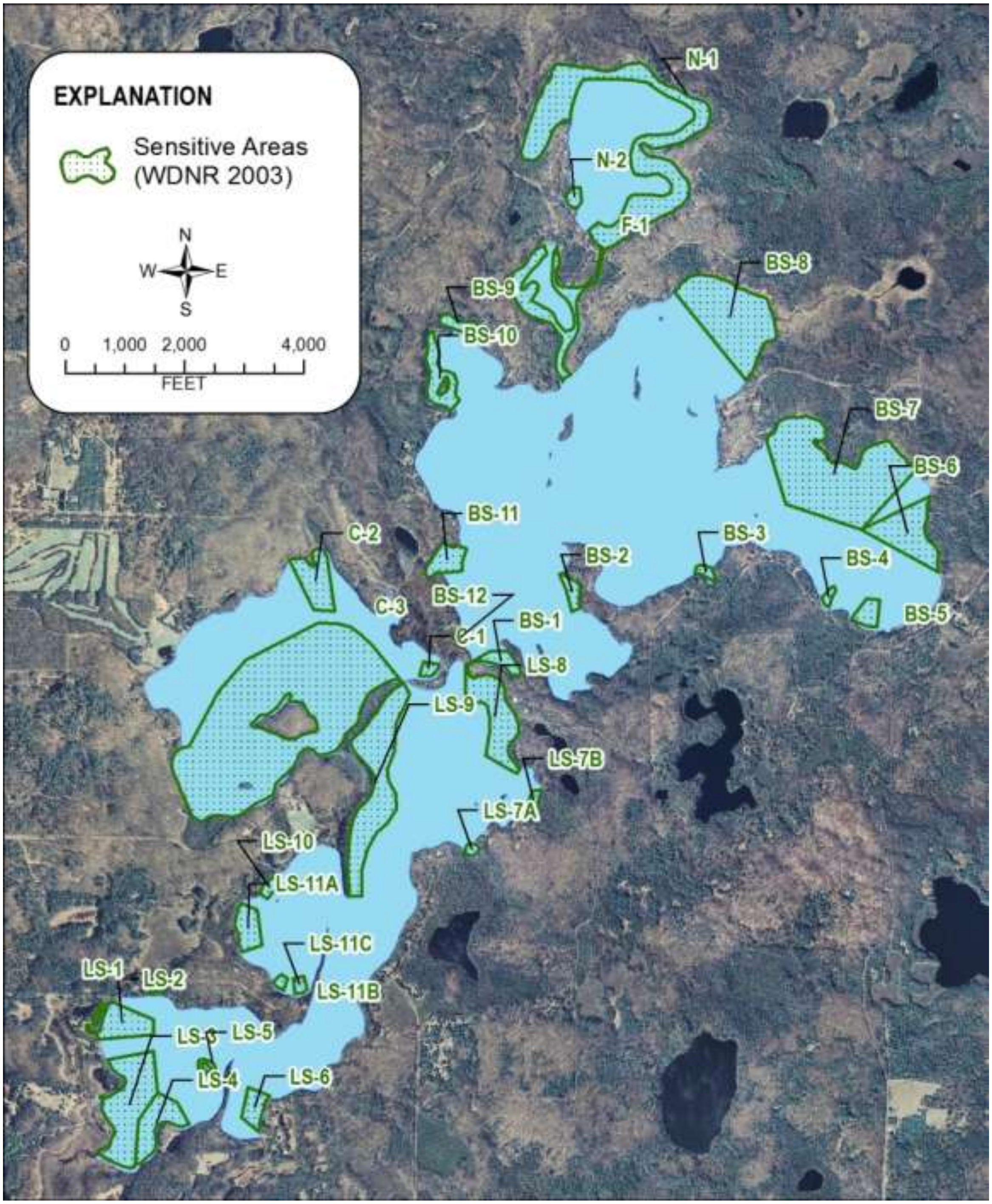


Figure 12 – Critical Habitat Areas (green) in the Spider Chain of Lakes

5.5.3 Rare and Endangered Species and Habitat

The Wisconsin Natural Heritage Inventory (NHI) program is part of an international network of programs that focus on rare plants and animals, natural communities, and other rare elements of nature. Each species has a state status including Special Concern, Threatened, or Endangered. Species are listed by township: the Spider Chain of Lakes is in the western part of the Town of Spider Lake (T42N, R7W). It is important for lake managers to consider impacts to these valuable species, nearly all of which can be directly affected by aquatic plant management. Choosing the proper management techniques and the proper timing of management activities can greatly reduce or prevent negative impacts.

One Endangered species (the moonwort grape-fern, *Botrychium lunaria*) and two Special Concern species (the gray wolf, *Canis lupus* and bald eagle, *Haliaeetus leucocephalus*) are listed for the Town of Spider Lake. Descriptions of these species can be found at http://dnr.wi.gov/topic/EndangeredResources/biodiversity.html/ (last accessed 2012-10-22). Littorella (*Littorella uniflora*), Robbins spikerush (*Eleocharis robbinsii)*, and small purple bladderwort (*Utricularia resupinata*), three Wisconsin Species of Special Concern were found in Spider Lake System during the 2012 plant survey. Littorella was found adjacent to curly-leaf beds near the south side of the islands in Big Spider Lake. Robbins spikerush was found in bog areas of the lakes, and small purple bladderwort was found in Clear Lake.

The Natural Heritage Inventory Program tracks examples of all types of Wisconsin's natural communities that are deemed significant because of their undisturbed condition, size, what occurs around them, or for other reasons. Natural communities listed for the Town of Spider Lake include: lake—deep soft seepage, northern dry-mesic forest, northern mesic forest, and northern wet forest. Full descriptions of these communities including current threats can be found on the WDNR website at:
http://dnr.wi.gov/topic/endangeredresources/communities.asp (last accessed 2012-10-22).

A number of high value aquatic plant species listed in NR 107 including *Potamogeton amplifolius, P. richardsonii, P. praelongus, P. pectinatus, P. illinoensis, P. robbinsii, Eleocharis spp., Scirpus spp., Valisneria spp., Zizania aquatic,* and *Brasenia schreberi* were found throughout the Spider Lake system. These plant species are known to offer important value to the aquatic ecosystem and any plant control activities in areas containing these high value species will be done in a manner which will not result in long-term or permanent changes to the plant community.

5.5.4 Fishery

Spider Lake is abundant in muskellunge and largemouth bass while walleye are common and panfish and smallmouth bass are present (6). No fish survey data were available in the SWIMS database but a fishery assessment was conducted in May 2008 (7) (Table 5) and stocking records were available online (Table 6). In addition to the data collected in 2008, largemouth bass, bluegill, black crappie, yellow perch, and white sucker were also observed during the survey.

Table 5
Spider Lake Fishery Assessment, May 2008

Species	Total captured	Average length (in)	Length range (in)	Percent >x inch length
Walleye	447	18.6	10-28	%>15 in. = 91%
Northern pike	1	26	26-26	%>26 in. = 100%
Muskellunge	57	27.7	21-35	%>40 in. = 0%
Source: WDNR, 2008				

Table 6
Spider Lake Fish Stocking Records

Year	Species	Age class	Number stocked	Average fish length (in)
2011	Walleye	Small Fingerling	50,890	1.5
2009	Walleye	Small Fingerling	51,017	1.7
2005	Walleye	Small Fingerling	65,422	1.5
2003	Walleye	Small Fingerling	32,640	1.6
2001	Walleye	Small Fingerling	20,018	1.6
1999	Walleye	Small Fingerling	35,000	1.3
1997	Walleye	Small Fingerling	32,715	1.6
1995	Walleye	Fingerling	32,715	2
1993	Walleye	Fingerling	45,283	2.5
1991	Walleye	Fingerling	22,464	4
1989	Walleye	Fingerling	44,154	3
1987	Walleye	Fingerling	126,420	3
1985	Walleye	Fingerling	44,100	3
1984	Muskellunge	Fingerling	200	9
1983	Walleye	Fingerling	25,674	5
1981	Walleye	Fingerling	32,050	4.6
1977	Walleye	Fingerling	33	4.33
1977	Muskellunge	Fingerling	465	3
1976	Muskellunge	Fingerling	2,000	8.33
1976	Walleye	Fingerling	39,539	3
1974	Walleye	Fingerling	25,029	3
1972	Muskellunge	Fingerling	800	15
Source: WDNR Lake Pages (online)				

Muskellunge, panfish, largemouth bass, and walleye are common in North Lake while smallmouth bass are present (6). No fish survey data were available in the SWIMS database. In 1972 there were 5,200 finglerling walleye (average length 3.00 inches) stocked in North Lake (6). Muskellunge, panfish, largemouth bass, and walleye are common in Fawn Lake while smallmouth bass are present (6). In 1972 there were 2,000 finglerling walleye (average length 3.00 inches) stocked in Fawn Lake (6).

5.5.5 Wildlife

Citizen monitoring of loons on Spider Lake was done in 2009 and 2010. Loon arrival was in mid-April of 2009 and late March of 2010 and departure in mid-November of both years. In 2009, one loon pair resided on Spider Lake and successfully hatched two loon chicks but only one survived. The cause of death for the single chick was unknown. In 2010, three loon pairs were documented on Spider Lake while only one pair successfully produced one loon chick. The other two loon pairs were presumed to produce chicks that did not survive due to eagle predation.

There is little information on citizen monitoring of loons on Clear Lake. Loons were monitored in 2010 and one pair of adults was documented as taking up residence. A nesting site was located; however, no chicks were hatched. Arrival and departure dates of the loon pair are not available

Citizen monitoring of loons on North Lake was done in 2008 and 2010 and found loon arrival in mid-April and departure in early to mid-October in 2008 (8). No arrival or departure data is available for 2010. In 2008, four loons were reported to use North Lake but were not documented as territorial residents. In 2010 one territorial loon pair took up residence on North Lake but no nesting site was located and no chicks were hatched.

Citizen monitoring of loons on Fawn Lake was done from 2008 through 2010 and found loon arrival in late March to mid-April and departure in early to mid-November. In 2008, the number of loon pairs on Fawn Lake is not indicated but three loon chicks were reported to have survived (8). In 2009 two loons were reported to use Fawn Lake occasionally but no chick data is available. In 2010 one loon pair was reported to take up residence and a nesting site was located, however, no eggs were laid.

5.6 Primary Human Use Areas

The Spider Chain of Lakes is used for a wide range of activities including fishing, swimming, boating, and viewing wildlife. There are two public boat landings on the chain, one on Clear Lake near the golf course and one on Little Spider Lake near the lake outlet. Access to Big Spider Lake is via a narrow channel that connects to Little Spider Lake. This narrow channel was dredged in 2007 to accommodate boat passage between the two main basins (permit ID 3013464). The entire project was financed by donations from the Spider Chain of Lakes Association members. Access to Fawn Lake is via a connecting channel with Big Spider Lake. Access between North Lake and Fawn Lake is limited to smaller boats due to the bridge crossing at West Murphy Blvd between the lakes.

6.0 Aquatic Plant Communities

Aquatic plants play an important role in lakes. They anchor sediments, buffer wave action, oxygenate water, and provide valuable habitat for aquatic animals. The amount and type of plants in a lake can greatly affect nutrient cycling, water clarity, and food web interactions. Furthermore, plants are very important for fish reproduction, survival, and growth, and can greatly impact the type and size of fish in a lake.

Unfortunately, healthy aquatic plant communities are often degraded by poor water clarity, excessive plant control activities, and the invasion on non-native nuisance plants (9). These disruptive forces alter the diversity and abundance of aquatic plants in lakes and can lead to undesirable changes in many other aspects of a lake's ecology (Figure 13). Consequently, it is very important that lake managers find a balance between controlling nuisance plant growth and maintaining a healthy, diverse plant community.

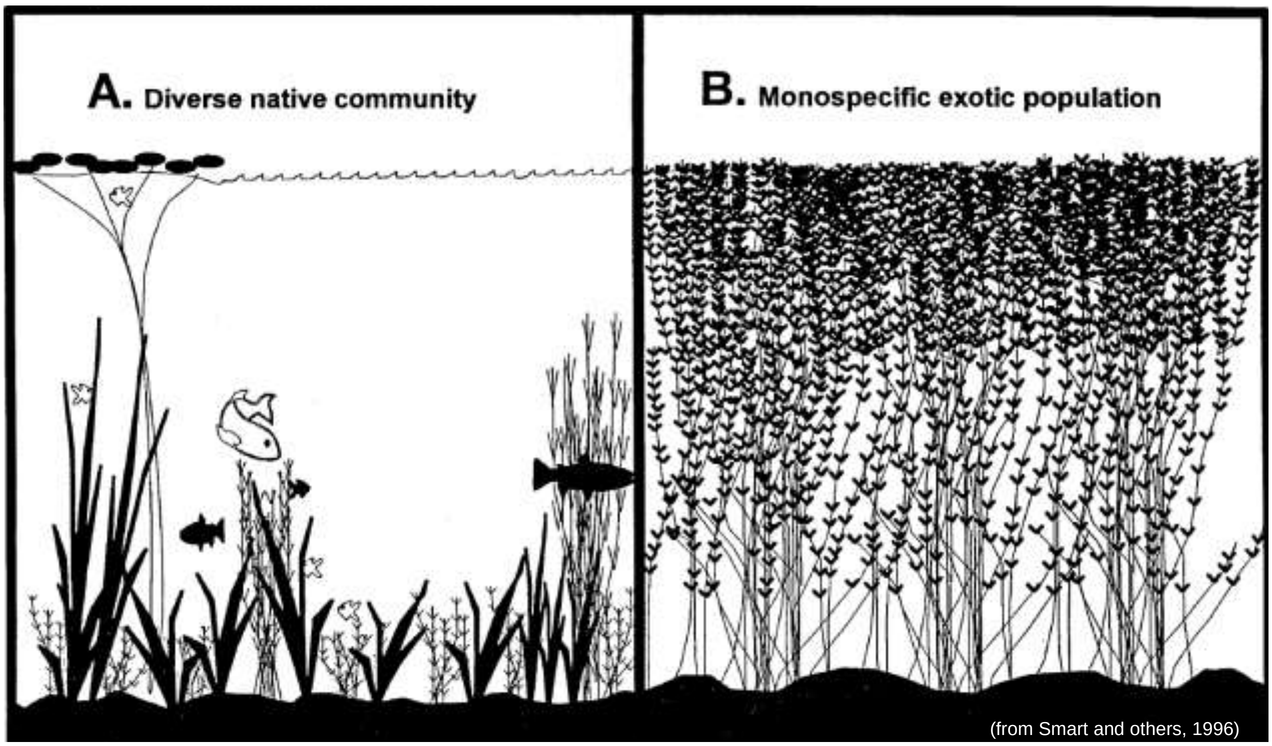


Figure 13 – Submersed Aquatic Plant Communities

6.1 Aquatic Plant Surveys in the Spider Chain of Lakes

Extensive surveys of the plant communities in the lakes were completed on three different occasions. The first survey was done in July 2000 to establish baseline information and identify any issues of concern such as the presence of non-native AIS (1). The second survey was completed by the WDNR during the summers of 2002 and 2003 for Sensitive Areas classification. The third and most recent survey was completed late spring and mid summer of 2012 by Endangered Resources Services, LLC (ERS) (St. Croix Falls, Wis.) with the same objectives. In each of the surveys, all of the lakes were found supporting diverse and healthy native aquatic plant communities occurring in light to moderate density. Each survey also identified the presence of curly-leaf pondweed in Big Spider Lake. The 2012 ERS investigations (the most recent and extensive plant surveys) were used to develop this plan and are summarized below.

ERS conducted two lake-wide plant surveys on each of the lakes in 2012. The first investigation was an early-season curly-leaf distribution and bed mapping survey completed in late April and the second a whole-lake point intercept survey in early August. The surveys provide detailed statistical assessments of the aquatic plant communities in the Spider Chain of Lakes and establish a baseline for evaluating any changes in the plant community over the coming years which will help guide responsible aquatic plant management planning. A detailed report was written for each lake by ERS and distributed to project partners in early 2013.

The **Simpson Diversity Index** was calculated for each lake using the results of the aquatic plant surveys. The Simpson Diversity Index is a value that allows the entire plant community at one location to be compared to the entire plant community at another location. It also allows the plant community at a single location to be compared over time thus allowing a measure of community degradation or restoration at that site. The index value represents the probability that two individual plants (randomly selected) will be different species. The index values range from 0 to 1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Plant communities with high diversity also tend to be more resistant to invasion by exotic species

The **Floristic Quality Index, or FQI** is a measure of the impact of human development on a lake's aquatic plants. The Floristic Quality Index, was computed for each lake using results from the plant survey. There are 124 species in the index; each assigned a **Coefficient of Conservatism, or C value**, which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species.

6.1.1 Spider Lake

The Spider Lake ecosystem is home to an exceptionally rich and diverse plant community that includes eleven high value/sensitive species. Plant distribution was somewhat patchy in nature; especially at depths over 16 feet. Collectively, plants were found growing at 612 sites or approximately 53.6% of the entire lake bottom and in 77.3% of the 18.5-foot deep August littoral zone (Figure 14).

In 2012, the lake's overall diversity was exceptionally high with a Simpson Diversity Index value of 0.94. Species richness was also very high with 53 species found in the rake during the survey. This species total increased to 57 when including visuals and plants found during the boat survey.

In 2012, the lake had an average of 3.08 native species at sites with vegetation and this dropped to 2.38 native species per site when considering the entire littoral zone. The total rake fullness was moderate averaging 2.02 at sites with vegetation (Figure 14). The mean and median depth of plant growth was 7.3 feet and 6.0 feet, respectively.

Softy muck near tamarack bogs or flowing water tended to have the highest diversity and a State Species of Special Concern, Robbins spikerush (*Eleocharis robbinsii*) was scattered in these areas throughout the lake. Littorella (*Littorella uniflora*), another species of special concern in Wisconsin, was found at one site in the Spider Lakes. Common waterweed, Slender naiad, Fern pondweed, and Wild celery were the most common macrophyte species being found at 30.23%, 28.59%, 27.94%, and 24.84% of survey points with vegetation. Together they combined for an exceptionally low 36.06% of the total relative frequency; the top four species typically account for greater than 50% of the total relative frequency. This suggests the plant community is very even with no species dominating at the expense of others. Large-leaf pondweed (7.18), Coontail (5.07), Southern naiad (4.75), and Flat-stem pondweed (4.59) were the only other species with a relative frequency over 4.0.

A total of 50 native Floristic Quality Index (FQI) plants were identified on the rake during the point intercept survey. They produced a mean Coefficient of Conservatism, or mean C, of 7.0 and a FQI of 49.6. Nichols (3) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Spider Lake above average for this part of the state. The FQI was also more than double the median FQI of 24.3 for the Northern Lakes and Forest (3). Elevn exceptionally sensitive/high value species contributed to the high FQI and mean C values. They included Pipewort (C=9), Littorella (C=9), Dwarf water milfoil (C=10), Creeping spearwort (C=9), Crested arrowhead (C=9), Water bulrush (C=9), Narrow-leaved bur-reed (C=9), Floating-leaved bur-reed (C=10), Creeping bladderwort (*Utricularia gibba*) (C=9), Flat-leaf bladderwort (*Utricularia intermedia*) (C=9), and Small bladderwort (*Utricularia minor*) (C=10).

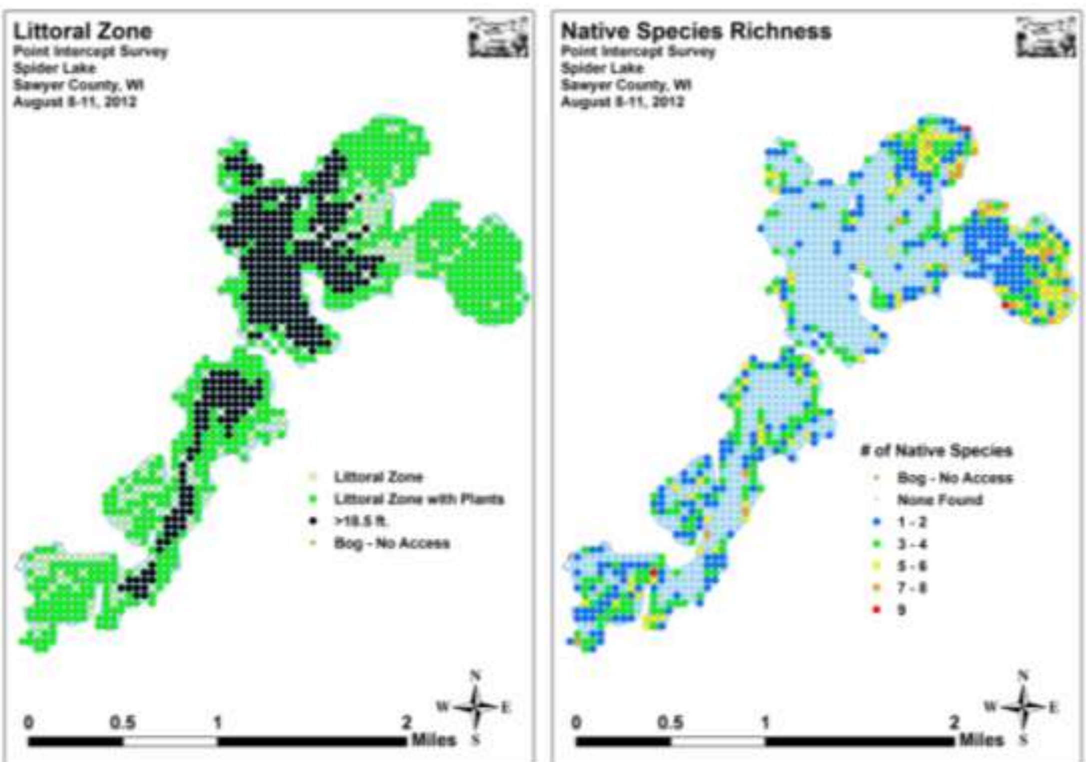


Figure 14 – Spider Lakes Littoral Zone and Native Species Richness

No wild rice, a plant of significant wildlife and cultural value, was found in any rake sampling or visually identified in the Spider Lakes.

No evidence of Eurasian watermilfoil was found in Spider Lake. Curly-leaf pondweed was present at 53 survey points in April, but had largely disappeared by August after undergoing normal summer senescence.

Areas that had curly-leaf pondweed beds in the spring, had generally filled in with coontail, common waterweed, and fern pondweed suggesting that curly-leaf pondweed is not growing in a monoculture and excluding all other species. It also reinforces the impression from the spring survey that curly-leaf pondweed is occupying a narrow habitat niche rather than being invasive and crowding out natives throughout the littoral zone.

More information about the aquatic plant community in Spider Lake can be found in the 2012 Spider Lake Aquatic Plant Survey Report completed by ERS (2).

6.1.2 Clear Lake

The Clear Lake ecosystem is home to a rich and diverse but somewhat limited plant community. Plant distribution in 2012 was somewhat patchy in nature. Collectively, plants were found growing in approximately 61.8% of the entire lake bottom and in 63.8% of the littoral zone which extended to a depth of 18 feet (Figure 15).

The lake's overall plant diversity in 2012 was high with a Simpson Diversity Index value of 0.90. Species richness was also very high for such a small lake with 31 species found in the rake during the survey. This total jumped to 46 when including visuals and plants found during the boat survey.

In 2012, the lake had a low average of 2.08 species at sites with vegetation, and this dropped to just 1.32 species per site when considering the entire littoral zone. The total rake fullness was also moderately low averaging just 1.62 at sites with vegetation. The mean and median depth of plant growth was 5.6 feet and 6.0 feet, respectively (Figure 15).

A State Species of Special Concern, small purple bladderwort (*Utricularia resupinata*), was found in the lake's shallow sugar sand areas. Slender naiad, Variable pondweed, Fern pondweed, and crested arrowhead were the most common macrophyte species in the lake being found at 49.93%, 30.00%, 20.36%, and 16.79% of survey points with vegetation. Together, they combined for 53.53% of the total relative frequency. Large-leaf pondweed (7.23), muskgrass (5.85), and white-stem pondweed (5.51) were the only other species with a relative frequency over 4.0.

A total of 30 native Floristic Quality Index (FQI) plants were identified on the rake during the 2012 point intercept survey. They produced a mean Coefficient of Conservatism, or mean C, of 7.2 and a FQI of 39.6. The mean C in Clear Lake is well above the average mean C of 6.7 for the Northern Lakes and Forest Region (3).The FQI was also well above the median FQI of 24.3 for the Northern Lakes and Forest Region (3). Contributing to these high values were seven exceptionally sensitive/high value species of note. They included threeway sedge (C=9), waterwort (C=9), dwarf water milfoil (C=10), creeping spearwort (C=9), crested arrowhead (C=9), water bulrush (C=9), and small purple bladderwort (C=9).

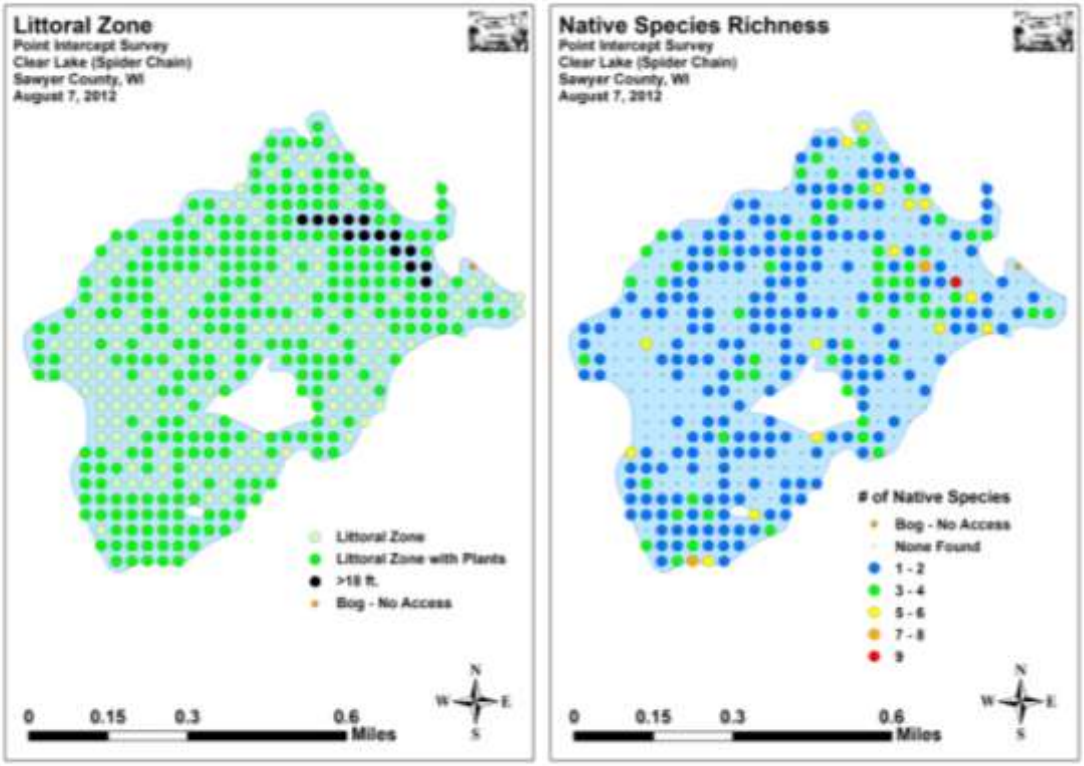


Figure 15 – Clear Lake Littoral Zone and Native Species Richness

No wild rice, a plant of significant wildlife and cultural value, was found in any rake sampling or visually identified in Clear Lake.

There was no evidence of Eurasian watermilfoil or curly-leaf pondweed in the 2012 surveys. However, Purple loosestrife was scattered on the western shoreline of the lake; especially near the public boat landing. Although this would normally be a cause for concern as loosestrife can exclude all other native plant species, at least some of the plants found showed damage due to *Galerucella* beetle herbivory. The only other exotic species found on the lake was reed canary grass (*Phalaris arundinacea*). This ubiquitous wetland species was present in limited numbers on the western shoreline near the public boat landing.

More information about the aquatic plant community in Clear Lake can be found in the 2012 Clear Lake Aquatic Plant Survey Report completed by ERS (2).

6.1.3 North Lake

The North Lake ecosystem is home to a rich and diverse plant community. In 2012, plants were found growing in approximately 42% of the entire lake bottom, and in 80% of the littoral zone which extended to waters 13.5 feet deep (Figure 16).

The lake's overall diversity in 2012 was extremely high with a Simpson Diversity Index value of 0.93. Species richness was also fairly high for such a small lake with 34 species found in the rake during the survey. The total increased to 39 when including visuals and plants found during the boat survey.

In 2012, the lake had a moderately high 4.02 species at sites with vegetation, and this dropped only slightly to 3.21 species per site when considering the entire littoral zone. The total rake fullness was moderate averaging 2.18 at sites with vegetation. Although the littoral zone extended to 13.5 feet, few sites beyond 10 feet had plants, and species richness in general declined rapidly at depths beyond 6 feet. The mean and median depth of plant growth was 5.6 feet and 4.5 feet, respectively (Figure 16).

No State Species of Special Concern were found in North Lake in 2012. Flat-stem pondweed, coontail, slender naiad, and white water lily were the most common macrophyte species being found at 51.18%, 47.06%, 37.06%, and 31.18% of survey points with vegetation, respectively. Together, they combined for a very low 41.37% of the total relative frequency (typically, the top four species account for greater than 50%). This suggests the plant community is very even with no species dominating at the expense of others. Other species with a relative frequency over 4.0 include spatterdock (6.43), large-leaf pondweed (6.29), creeping bladderwort (5.99), and northern watermilfoil (4.82).

A total of 34 native Floristic Quality Index (FQI) plants were identified on the rake during the point intercept survey. They produced a mean Coefficient of Conservatism, or mean C value, of 6.8 and a FQI of 39.6. Nichols (3) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting North Lake slightly above average for this part of the state. The FQI was, however, well above the median FQI of 24.3 for the Northern Lakes and Forest Region (3). Contributing to these high values were four exceptionally sensitive/high value species of note. They included water bulrush (C=9), creeping bladderwort (C=9), flat-leaf bladderwort (C=9), and small bladderwort (C=10).

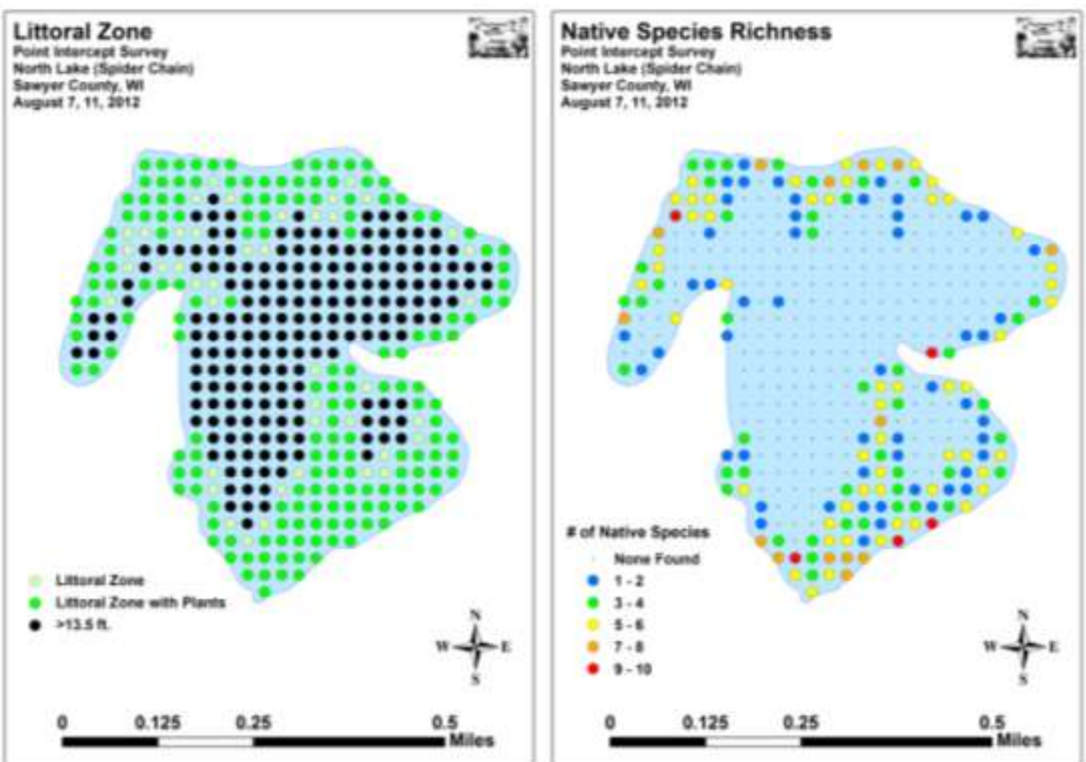


Figure 16 – North Lake Littoral Zone and Native Species Richness

Wild rice, a plant of significant wildlife and cultural value, was found in North Lake and is described in further detail in Section 7.0.

There was no evidence of Eurasian watermilfoil, curly-leaf pondweed, purple loosestrife or any other exotic species in the 2012 surveys.

More information about the aquatic plant community in North Lake can be found in the 2012 North Lake Aquatic Plant Survey Report completed by ERS (2).

6.1.4 Fawn Lake

Fawn Lake ecosystem is home to a rich and diverse plant community. In 2012, plants were found growing at 38 sites or approximately 40.4% of the entire lake bottom, and in 88.4% of the littoral zone which extended to depth of 12 feet (Figure 17).

The lake's overall diversity was exceptionally high with a Simpson Diversity Index value of 0.94. Species richness was also very high for such a small lake with 31 species found in the rake during the survey. This total species encountered is 37 when including visuals and plants found during the boat survey.

In 2012, the lake had an exceptionally high 5.16 species at sites with vegetation, and this dropped only slightly to 4.56 species per site when considering the entire littoral zone. The total rake fullness was moderately high averaging 2.34 at sites with vegetation. Although the littoral zone extended to 12 feet, few sites beyond 10 feet had plants, and species richness in general declined rapidly at sites over 8 feet. The mean and median depth of plant growth was 4.9 feet and 4.0 feet, respectively (Figure 17).

Spatterdock, Watershield, Coontail, and White water lily were the most common macrophyte species being found at 52.63%, 50.00%, 47.37%, and 39.47% of survey points with vegetation. Together, they combined for an exceptionally low 36.73% of the total relative frequency (typically, the top four species account for greater than 50%). This suggests the plant community is very even with no species dominating. Creeping bladderwort (7.14), Muskgrass (6.12), Flat-stem pondweed (5.10), Common waterweed (4.59), and Northern water milfoil (4.08) were the only other species with a relative frequency over 4.0.

A total of 30 native Floristic Quality Index (FQI) plants were identified on the rake during the point intercept survey. They produced a mean Coefficient of Conservatism, or mean C, of 6.7 and a FQI of 36.7. Nichols (3) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Fawn Lake exactly average for this part of the state. The FQI was, however, well above the median FQI of 24.3 for the Northern Lakes and Forest Region (3). Contributing to these high values were four exceptionally sensitive/high value species of note. They included Water bulrush (C=9), Creeping bladderwort (C=9), Flat-leaf bladderwort (C=9), and Small bladderwort (C=10).

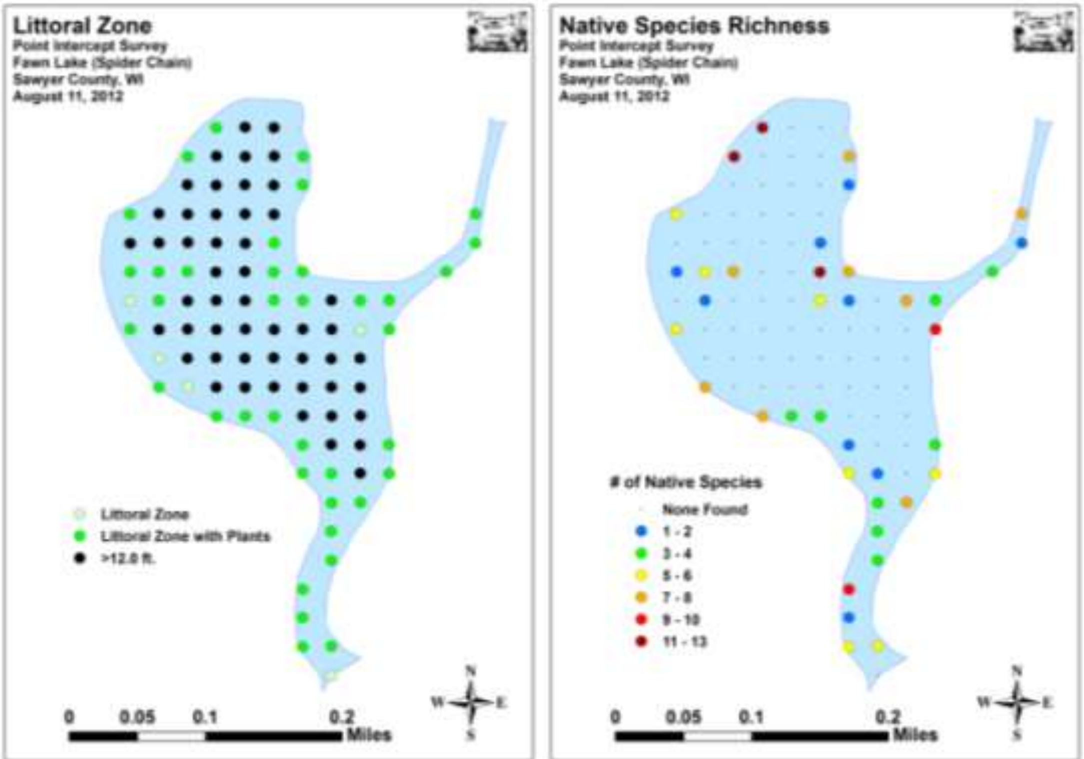


Figure 17 – Fawn Lake Littoral Zone and Native Species Richness

No wild rice, a plant of significant wildlife and cultural value, was found in any rake sampling or visually identified in Fawn Lake.

There was no evidence of Eurasian watermilfoil, curly-leaf pondweed, purple loosestrife or any other exotic species in the 2012 surveys. By all accounts, Fawn Lake appears to be in ecologically pristine condition.

More information about the aquatic plant community in Fawn Lake can be found in the 2012 Fawn Lake Aquatic Plant Survey Report completed by ERS (2).

7.0 Wild Rice

Wild rice was found only in North Lake during the 2012 aquatic plant surveys (Figure 18). When present in a lake, wild rice is afforded numerous protections due to its ecological and cultural significance. Management is therefore focused on harvest goals and protection of the resource rather than removal. According to the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), there have been no reported wild rice harvests from the Spider Chain of Lakes. Any activity included in a comprehensive lake or aquatic plant management plan that could potentially impact the growth of wild rice in any body of water that has in the past, currently has, or potentially could have wild rice in the future requires consultation with the Tribal Nations. This consultation is usually completed by the WDNR in cooperation with GLIFWC during their review of lake management documents.

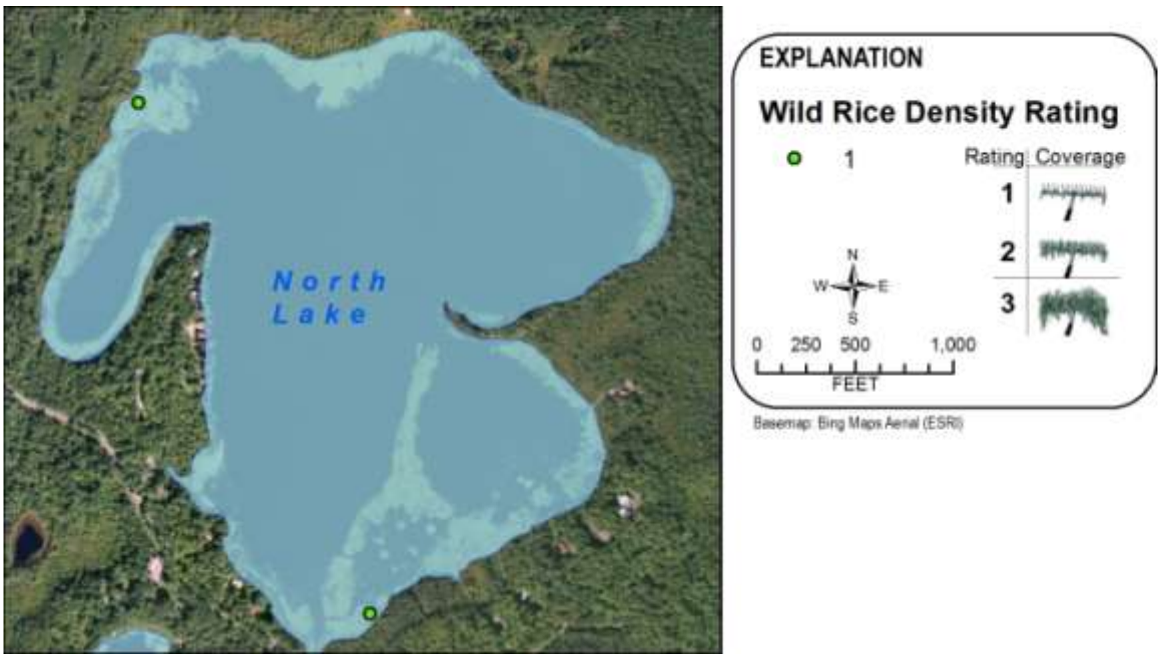


Figure 18 – Distribution of Wild Rice in North Lake, August 2012

Wild rice is an annual aquatic grass that produces seed that is a nutritious source of food for wildlife and people. As a native food crop, it has a tremendous amount of cultural significance to the Wisconsin and Minnesota Native American Nations. Wild rice pulls large amounts of nutrients from the sediment in a single year and the stalks provide a place for filamentous algae and other small macrophytes to attach and grow. These small macrophytes pull phosphorous in its dissolved state directly from the water. Wild rice can benefit water quality, provide habitat for wildlife, and help minimize substrate re-suspension and shoreland erosion.

In Wisconsin, wild rice has historically ranged throughout the state. Declines in historic wild rice beds have occurred statewide due to many factors, including dams, pollution, large boat wakes, and invasive plant and animal species. Renewed interest in the wild rice community has led to large-scale restoration efforts to reintroduce wild rice in Wisconsin's landscape. Extensive information is available on wild rice from GLIFWC and the WDNR.

8.0 Non-native Aquatic Invasive Species Present in the Lakes

Curly-leaf pondweed and purple loosestrife have been documented in the Spider Chain of Lakes. Curly-leaf pondweed is currently only found in Big Spider and four stands of purple loosestrife are located on Clear Lake. Of these, curly-leaf has the potential to be the most problematic for lake users. Purple loosestrife is being effectively managed in the lakes through the use of physical removal and biological control.

8.1 AIS Monitoring Efforts

Spider Lake was monitored for 11 aquatic invasive species between 2005 and 2011 by the WDNR (Table 7). The Spider Chain of Lakes Association is currently involved in aquatic invasive species monitoring and water craft inspection aimed at preventing the introduction of other aquatic invasive species in cooperation with WDNR and UW-Extension Lakes programs. These programs will continue into the foreseeable future. The Clear Lake boat landing is most frequently used to access the Spider Lake Chain (10). Watercraft inspections have been conducted at this boat landing consistently from 2007 through 2012 by both paid and volunteer inspectors. Since 2007, a total of 8,104 people have been contacted at the boat landing (Table 8).

Table 7
Aquatic Invasive Species Monitoring Efforts in Spider Lake

Aquatic Invasive Species	Year(s) monitored	Year AIS Found
Curly-leaf pondweed	2005, 2011	2005[a]
Purple Loosestrife	2011	—
Eurasian water-milfoil	2005, 2011	—
Freshwater jellyfish	2011	—
Zebra mussels	2005, 2011	—
Hydrilla	2011	—
Fishhook water flea	2005, 2006, 2011	—
Spiny water flea	2005, 2006, 2011	—
Banded mystery snail	2011	—
Chinese mystery snail	2011	—
Rusty Crayfish	2011	—

[a] Curly-leaf pondweed was also found during a survey in 2000 by Barr Engineering and in August 2003 by the WDNR.

Table 8
Watercraft Inspection Data for the Clear Lake Boat Landing, 2007 - 2012

Year	Paid time at landing (hr)	Volunteer time at landing (hr)	No. of people contacted
2007	330.25	9.00	635
2008	639.25	27.50	890
2009	437.50	0.00	1,123
2010	448.50	9.00	1,409
2011	440.00	0.00	1,418
2012	939.00	0.00	2,629
TOTAL	**3,234.50**	**36.50**	**8,104**

8.2 Curly-leaf Pondweed (*Potamogeton crispus*)

Curly-leaf pondweed is a submerged aquatic perennial that is native to Eurasia, Africa, and Australia. It was introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant and was planted in Michigan lakes as a food source for ducks. Curly-leaf pondweed has been documented throughout the U.S. In some lakes, curly-leaf pondweed coexists with native plants and does not cause significant problems; in other lakes, it becomes the dominant plant and causes significant problems (11). Dense growth can interfere with late spring and early summer recreation and the release of nutrients into the water column from the decaying curly-leaf during the height of the growing season can fuel algal blooms. Phosphorus release rates from the senescence of monotypic curly-leaf beds have been reported as high as nearly 10 pounds per acre and averages about 5 pounds per acre (12) (13) (14).

The leaves of curly-leaf pondweed are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed (Figure 19). The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. Curly-leaf is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures.

Figure 19 – Curly-leaf Pondweed

Curly-leaf pondweed spreads through burr-like winter buds called turions (Figure 20). These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf one of the first nuisance aquatic plants to emerge in the spring, often starting to grow late in the fall and staying green under the ice. Growth is accelerated in spring when light and temperature conditions are best suited for growth. Turions begin to grow in June and by late June and early July, the warm water conditions cause curl-leaf to senesce, dropping turions to the sediment while the rest of the plant decays (Figure 20).

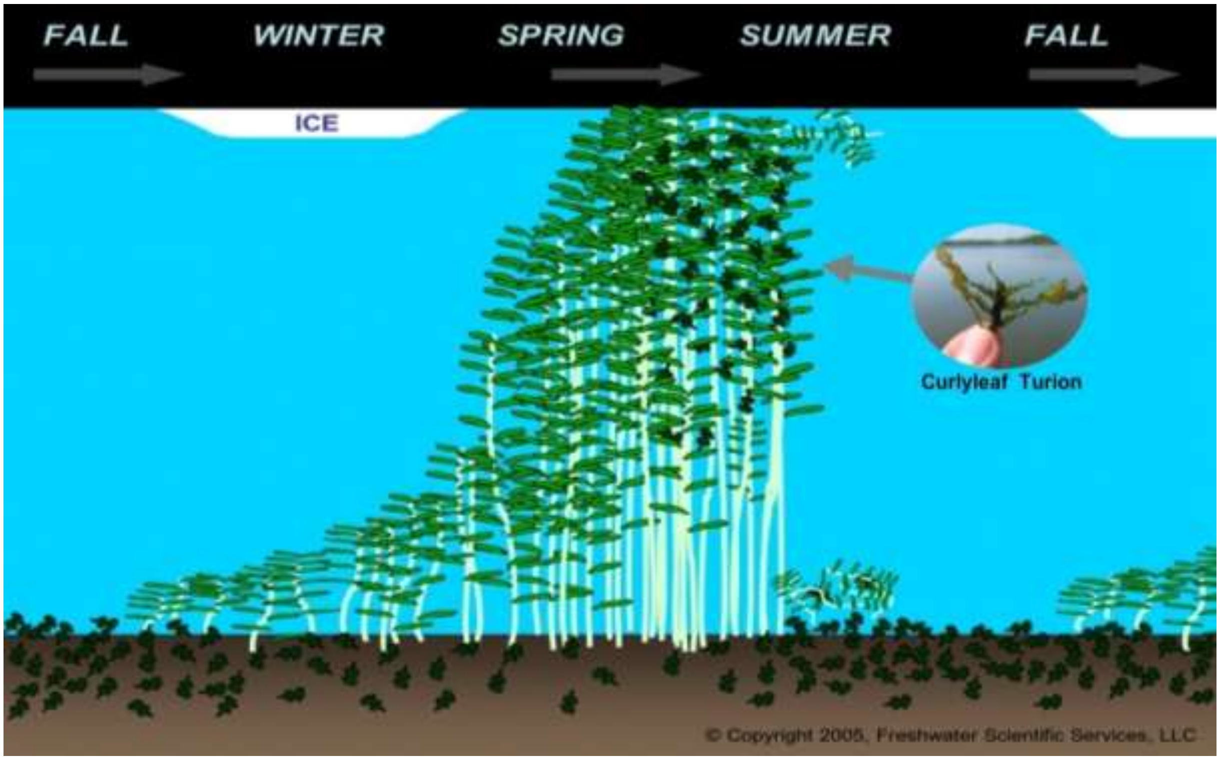


Figure 20 – Curly-leaf Life Cycle

8.2.1 Curly-leaf Pondweed in Big Spider Lake

Curly-leaf pondweed is present throughout Big Spider Lake (Figure 21). A single specimen of curly-leaf pondweed was observed during a July 2000 aquatic plant survey of the chain in the vicinity of Bed 11 (Figure 21). Several curly-leaf pondweed plants were observed in Sensitive Areas BS-7, BS-10, and BS-12 (Figure 12) during the Sensitive Area Survey in August 2003. Curly-leaf pondweed is most abundant in May and June and dies back by the beginning of July so it is likely the curly-leaf distribution was larger than found during these surveys. During the spring 2012 survey, curly-leaf was found in each of these areas except for Sensitive Area BS-12; curly-leaf was also found in all areas chemically treated in 2011.

The April and May 2012 curly-leaf pondweed surveys found that curly-leaf appears to be established throughout Big Spider in all suitable habitats. Curly-leaf pondweed was found primarily in areas where the lake substrate was composed of sticky, soft muck in depths of 10 to 12 feet. This habitat is not particularly common on Big Spider with the exception of the northern bay and the southwest corner of the northeast bay. Outside this narrow habitat range, curly-leaf was widely scattered, and most rake fullness values of 1 were samples that contained a single plant. In the east finger of Big Spider Lake, for example, curly-leaf was found as one or two plants and much of the area was dominated by nitella, a branched algae species that looks like a submerged plant.

Curly-leaf pondweed was not found to be growing as a big robust plant as observed in lakes where it is highly invasive. Plant stems were thin, and mature leaves were generally no wider than 7 to 9 millimeters across with many smaller than this (healthy plants on other lakes can top 1.5cm in width) (2). This growth pattern suggests that curly-leaf does not have ideal habitat anywhere in Big Spider Lake, and good to marginal habit in only a few places.

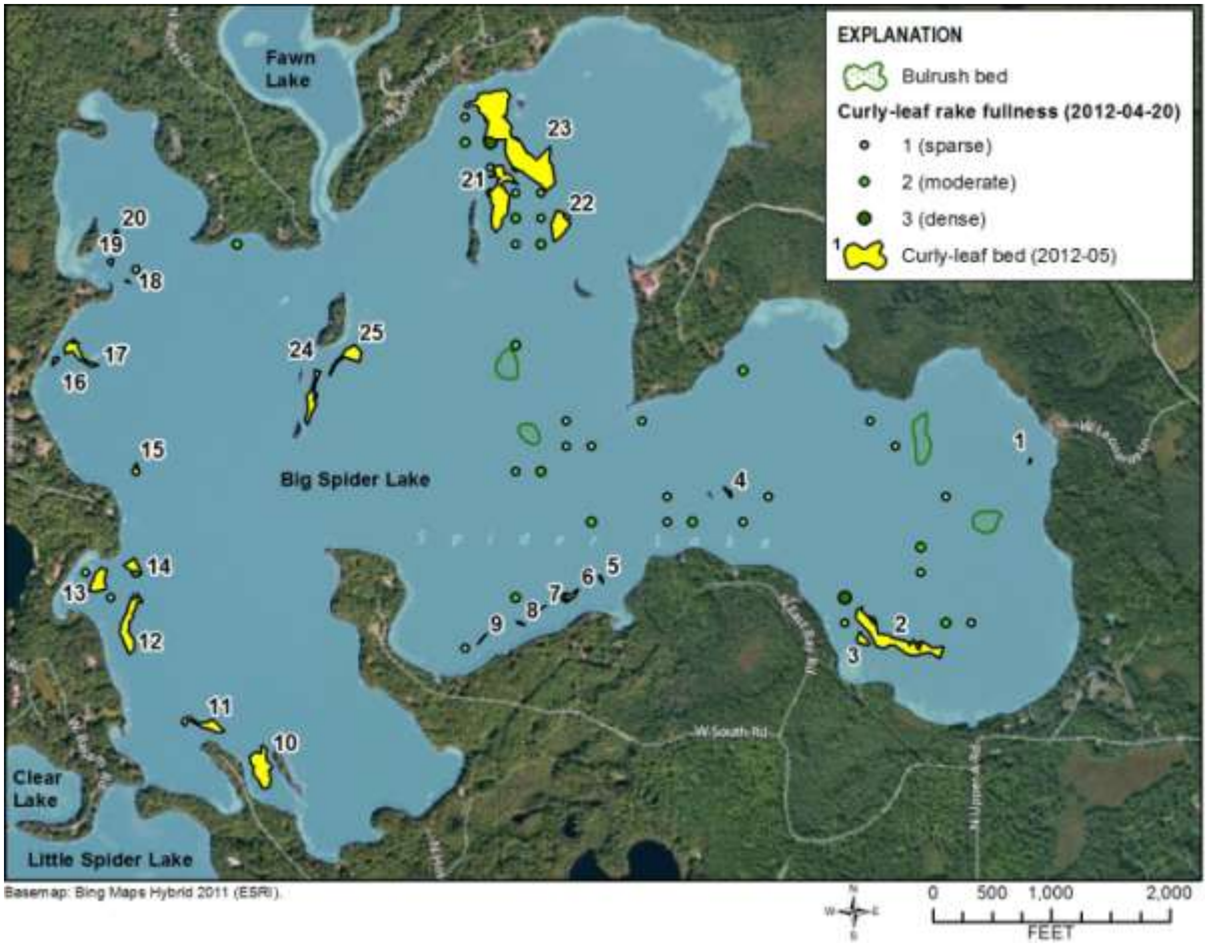


Figure 21 – Distribution of Curly-leaf Pondweed in Big Spider Lake, Spring 2012

8.2.2 Curly-leaf Pondweed in Little Spider Lake

One small (245 square-feet) bed was found in Little Spider Lake during the spring 2012 survey (Figure 22). No ideal and little suitable curly-leaf pondweed habitat was found in the lake; the majority of the substrate is a lower-nutrient, sandy marl muck that curly-leaf is not often found growing in (2). Curly-leaf was also absent in similar habitats in Big Spider Lake.

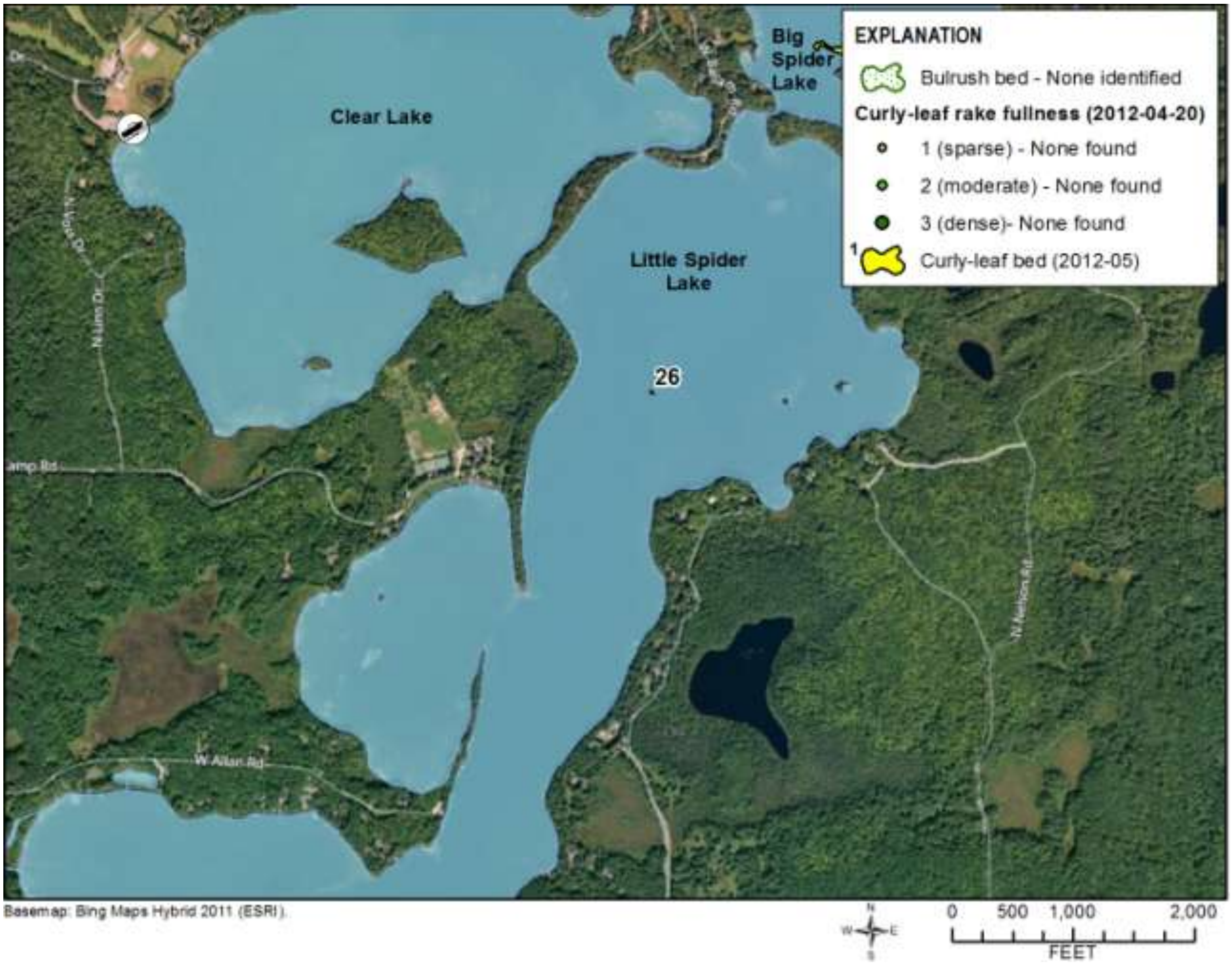


Figure 22 – Single Bed of Curly-leaf Pondweed in Little Spider Lake, Spring 2012

8.3 Purple Loosestrife (*Lythrum salicaria*)

Purple loosestrife is a perennial herb 3 to 7 feet tall with a dense bushy growth of 1 to 50 stems. The stems, which range from green to purple, die back each year. Showy flowers vary from purple to magenta; possess 5 to 6 petals aggregated into numerous long spikes, and bloom from July to September. It is easiest to distinguish in late July and August as it has a very distinctive flowering head. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat (Figure 23).

Figure 23 – Purple Loosestrife

The reproductive success of purple loosestrife across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America. This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions.

Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many wetlands, lakes, and rivers. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

9.0 Non-Native Aquatic Invasive Species Threats

Introduction of new aquatic invasive species is a constant threat to lakes and rivers. The non-native species of most concern are Eurasian watermilfoil, zebra and quagga mussels, spiny water flea, giant reed grass, New Zealand mudsnails, and hydrilla. Aquatic invasive species monitoring recommended in this Aquatic Plant Management Plan and supported by the Spider Chain of Lakes Association will be watching for the introduction of these and other aquatic invasive species in hopes of early detection.

9.1 Eurasian Watermilfoil (*Myriophyllum spicatum*)

Eurasian watermilfoil is a submerged aquatic plant native to Europe, Asia, and northern Africa (Figure 24). Although Eurasian watermilfoil was not found in the Spider Chain of Lakes during extensive surveying in 2012, its introduction remains a concern. As a popular destination in northwestern Wisconsin, the Spider Chain of Lakes is a prime candidate for the introduction of Eurasian watermilfoil via boat traffic.

Figure 24 – Eurasian Watermilfoil

Eurasian watermilfoil first arrived in Wisconsin during the 1960s and is the only non-native milfoil in the state. During the 1980s it began to move from several counties in southern Wisconsin to lakes and waterways in the northern half of the state. Eurasian watermilfoil grows best in alkaline systems with a high concentration of dissolved inorganic carbon and fertile, fine-textured, inorganic sediments. In less productive lakes Eurasian watermilfoil is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nutrient-laden runoff, and heavy-use lakes.

Unlike many other plants, Eurasian watermilfoil is not dependant on seed for reproduction. In fact, its seeds germinate poorly under natural conditions. Eurasian watermilfoil reproduces by fragmentation, allowing it to disperse over long distances by currents and inadvertently by boats, motors, and trailers. The fragments, which are produced after the plant fruits once or twice during the summer and by destruction of the plant (for example by propellers), can stay alive for weeks if kept moist.

Once established in an aquatic community, Eurasian watermilfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). Stolons, lower stems, and roots persist over winter and store the carbohydrates that help the plant claim the water column early in spring. The rapid growth can form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block the sunlight needed for native plant growth often results in monotypic stands.

Monotypic stands of Eurasian watermilfoil provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways. For example, dense stands disrupt predator-prey relationships by fencing out larger fish and reduce the number of nutrient-rich native plants available for waterfowl. Dense stands of Eurasian watermilfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on Eurasian watermilfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". The cycling of nutrients from sediments to the water column by Eurasian watermilfoil may lead to deteriorating water quality and algae blooms in infested lakes.

Eurasian watermilfoil would likely thrive in the Spider Chain of Lakes, but probably not to a large extent; northern watermilfoil (*Myriophyllum sibiricum*), a native macrophyte and close relative to Eurasian watermilfoil, and Illinois pondweed (*Potamogeton illinoensis*), a common associate of Eurasian watermilfoil, are located throughout the lakes, but their occurrences are relatively low (2),(3). The well distributed, healthy native plant community is also protecting the lakes from the introduction and subsequent establishment of Eurasian watermilfoil. Research has shown that the abundance of Eurasian watermilfoil in a lake is inversely related to cumulative native plant cover (15). For this reason it is important to maintain healthy and diverse native stands of vegetation (16).

9.2 Rusty Crayfish and Chinese Mystery Snail

Rusty crayfish are omnivores, meaning they forage on both plant and animal material. Originally from parts of the United States south of Indiana, they are larger and more aggressive than species of crayfish native to Wisconsin (Figure 25). Rusty crayfish prefer hard bottoms and tend to avoid soft sediment or mucky areas of lakes. When introduced they tend to replace native populations of crayfish, and then multiply rapidly. As omnivores they eat many things, including plant material, fish eggs, minnows, invertebrates and other crustaceans. In some lakes, they have devastated the aquatic plant community. Often, after reaching large populations, the number of rusty crayfish in the system declines rapidly. Some research suggests that this is because of a parasite infecting the crayfish. Management of this invasive species is limited, focusing on trapping or removal by residents.

Little is known about the ecological impact of Chinese mystery snails (Figure 25) and banded mystery snails, except that large die-offs are particularly offensive to the nose and impair lake aesthetics. Management is limited and basically consists of landowner removal and disposal of snails and empty shells washed up on shore.

Figure 25 – Rusty Crayfish (left) and Chinese Mystery Snail (right)

10.0 Aquatic Plant Management Alternatives

Nuisance aquatic plants can be managed a variety of ways in Wisconsin. The best management strategy will be different for each lake and depends on which nuisance species needs to be controlled, how widespread the problem is and the other plants and wildlife in the lake. In many cases, an integrated approach to aquatic plant management that utilizes a number of control methods is necessary.

Control methods for nuisance aquatic plants can be grouped into four broad categories:

- manual and mechanical control, which include harvesting, hand-pulling, and raking plants;
- biological control, which includes the use of organisms such as herbivorous insects, parasitic organisms, and planting aquatic plants;
- physical habitat alteration, which includes dredging, drawdown, lake bottom covers, and non-point source nutrient controls; and
- chemical control, which involves the use of herbicides.

Each of the above control categories are regulated by the WDNR and most activities require a permit from the State. Most control methods are regulated under Chapter NR 109 (Appendix C) except for chemical control which is regulated under Chapter NR 107. Installing lake bottom covers, which is not a commonly accepted practice, also requires a Chapter 30 permit.

Regardless of the target plant species, native or non-native, sometimes no active management of the aquatic plant community is the best option. Plant management activities can be disruptive to native plant species their ecological functions, and may open up areas for new invasive species to colonize. Other benefits of no management include no financial cost, no system disturbance, and no unintended effects of chemicals. Not managing aquatic invasive species, however, may allow small populations of a plant to become larger and more difficult to control.

The benefits and limitations of a number of management techniques are described below. Although many of the available control methods are currently not applicable for the Spider Chain of Lakes, informed decision-making on aquatic plant management options requires an understanding of plant management alternatives and how appropriate and acceptable each alternative is for a given lake.

10.1 No Manipulation

No manipulation of the aquatic plant community is often the easiest, cheapest, and in some cases most effective aquatic plant management alternative, even for non-native invasive species like curly-leaf pondweed. Not actively managing aquatic plants in the Spider Chain of Lake is a viable alternative, particularly in areas where excess aquatic plant growth does not impact lake uses, where the benefit of management is far out-weighed by the cost of management, where water quality or other lake characteristics limit nuisance growth conditions, and where highly valued native plants or habitat would be negatively impacted (for example, within Sensitive Areas).

10.2 Manual and Mechanical Controls

Except for wild rice, manual removal of aquatic plants by means of a hand-held rake or by pulling the plants from the lake bottom by hand is allowed within a 30-foot-wide corridor along a 100-foot length of shoreline without a permit, provided the plant material is removed from the Lake (Figure 26). Plant fragments can be composted or added directly to a garden.

Although up to 30 feet of shoreland vegetation can be removed, removal should only be done to the extent necessary. Clearing large swaths of aquatic plants not only disrupts lake habits, it also creates open areas for non-native species to establish. If an aquatic invasive species such as curly-leaf pondweed is the target species, then removal by this means is unrestricted as long as native plants are not damaged or eliminated.

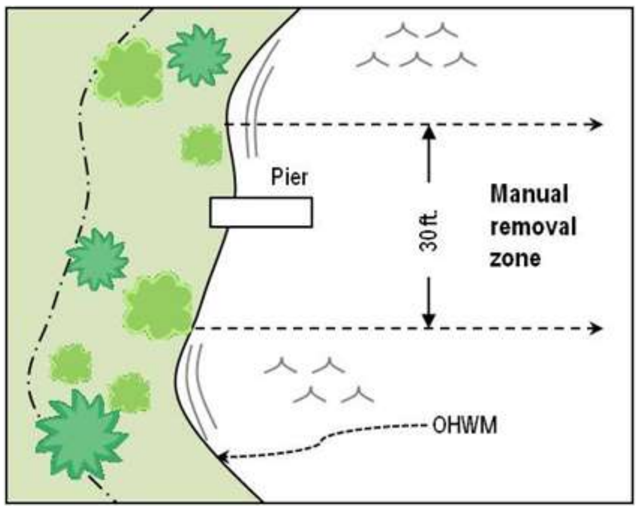


Figure 26 – Aquatic Vegetation Manual Removal Zone

Manual removal can be effective at controlling individual plants or small areas of plant growth. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. Manual removal is most effective in shallow, hard bottom areas of a lake. It is appropriate for areas important for fish spawning. Pulling aquatic invasive species while snorkeling or scuba diving in deeper water can be done without a permit and can be effective at slowing the spread of a new aquatic invasive species infestation within a lake when done properly. When harvesting curly-leaf pondweed it is important that all material is removed as free-floating curly-leaf fragments can remain viable and produce turions for up to two weeks.

10.2.1 Large-scale Manual Removal

Hand-pulling or diver removal is typically used when an aquatic invasive species exists as single plants or isolated beds, as in new infestations. Large-scale hand or diver removal projects have successfully reduced or controlled established aquatic invasive species populations (17). One such effort which involved the removal of Eurasian watermilfoil using diver hand harvesting of the entire littoral zone of the lake at least twice each summer for three years followed by three years of maintenance management successfully reduced the overall distribution of Eurasian watermilfoil in the lake from 16% of the littoral zone to 3%. Overall costs ranged from a high of $796 per hectare of Eurasian watermilfoil removed during the three years of intensive management effort, to about $300 per hectare during the three year maintenance period (17).

Several local lake groups have and continue to use large-scale manual removal to manage Eurasian watermilfoil. Horseshoe Lake in Barron County uses diver removal on small or isolated areas of Eurasian watermilfoil, and uses chemical herbicides on larger, more expansive sites. Early in the management phase, Sand Lake in Barron County participated in diver removal, but stopped using divers as the Eurasian watermilfoil expanded too rapidly for the divers to keep up with. For several years the St Croix Flowage in Douglas County attempted to control the spread of Eurasian watermilfoil by diver removal. While successful in the first couple of years, the use of small-scale herbicide application has been added to the control regime.

In 2011, the Red Cedar Lakes Association performed diver removal on a dense, isolated one acre bed of curly-leaf pondweed in Red Cedar Lake. This large-scale effort was conducted by a group of local high school students (members of the Conservation Club) and a Red Cedar Lake Association representative. Water depths and inexperience made removal difficult; however, the effort was fairly successful and the divers were able to remove a large boat load of curly-leaf pondweed. In 2012 during early summer curly-leaf bed mapping, a determination was made on whether a bed could be hand harvested based on the previous years experience. In mid-summer, volunteers re-visited sites and removed on average 83% of the curly-leaf in 14 different beds.

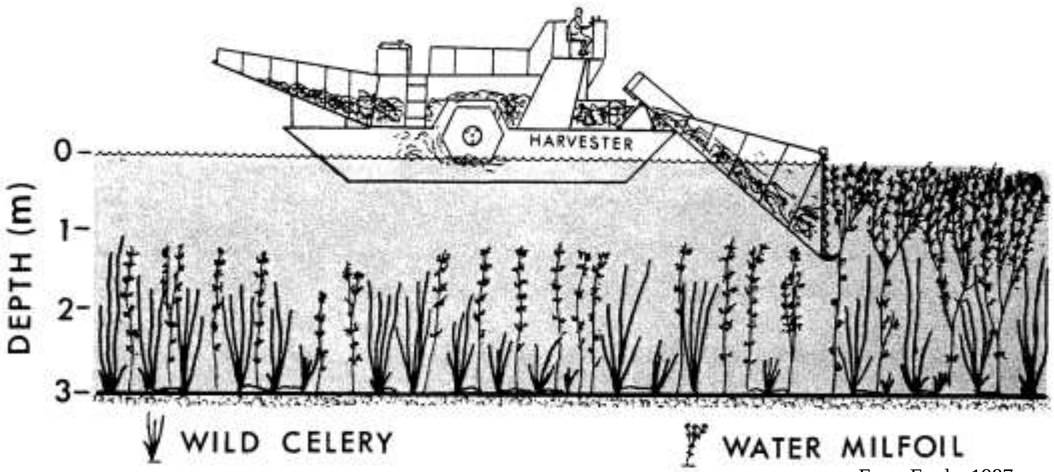
10.2.2 Mechanical Control

Mechanical control methods use motorized accessories to assist in vegetation removal. Mechanical control can be used for both small- and large-scale control efforts and require WDNR permits regardless of the size of the area to be managed. As with manual control, plant fragments must be removed from the water to the extent practical.

The most common form of mechanical control is the use of large-scale mechanical harvesters on the lake. The harvesters are generally driven by modified paddle wheels and include a cutter that can be raised and lowered to different depths, a conveyor system to capture and store the cuttings, and the ability to off-load the cuttings. Harvesters operate a depths ranging from skimming the surface to remove floating plant fragments to as much as five feet deep.

Harvesters can remove thousands of pounds of vegetation in a relatively short period of time. By removing the plant biomass, harvesting also removes nutrients form a lake. Everything in the path of the harvester will be removed including the target species, other plants, macro-invertebrates, semi-aquatic vertebrates, forage fishes, young-of-the-year fishes, and even adult game fish found in the littoral zone (18). An advantage of mechanical aquatic plant harvesting is that the harvester typically leaves enough plant material in the lake to provide shelter for fish and other aquatic organisms, and to stabilize the lake bottom sediments (19).

Large-scale plant harvesting in a lake is similar to mowing the lawn. Plants are cut at a designated depth, but the root of the plant is often not disturbed. Plant composition can be modified by cutting away dense cover which may increase sunlight penetration enough to stimulate growth of underlying species (Figure 27) (19). Cut plants will usually grow back after time, just like the lawn grass. Re-cutting during the growing season is often required to provide adequate annual control (20). Harvesting activities in shallow water can re-suspend bottom sediments into the water column releasing nutrients and other accumulated compounds (20). Some research indicates that after cutting, reduction in available plant cover causes declines in fish growth and zooplankton densities. Other research finds that creating deep lake channels by harvesting increases the growth rates of some age classes of bluegill and largemouth bass (21).



From Engle, 1987

Figure 27 – Harvesting Surface Foliage to Maintain Habitat and Stimulate Basal Plant Growth

Recent cost per acre for contracting harvesting services average $410 per acre whereas costs for purchasing, operating, and maintaining a harvester average $567 per acre (22). In general, the cost of harvesting decreased with increasing total acreage harvested, from about $500 per acre at 40 acre sites to about $250 per acre at 160 acre sites (22). The Rice Lake Protection and Rehabilitation District in Barron County, Wisconsin owns and operates three harvesters at a cost of approximately $420 per acre harvesting a total of approximately 220 acres. The costs supporting a harvesting program administered by a given lake group may be reduced by purchasing smaller or used equipment, determining a local, low cost disposal site, increasing the amount of acreage harvested, and through other cost analyses

There are a wide range of small-scale mechanical management techniques, most of which involve the use of boat mounted rakes, scythes, and electric cutters. As with large-scale mechanical harvesting, removing the cut plants is required and often accomplished with a rake. Commercial rakes and cutters range in prices from $100 for rakes and cutters that can be thrown from the shore or attached to a boat to around $3000 for electric cutters with a wide range of sizes and capacities.

One of the best ways for riparian property owners to gain navigation relief near their docks is to actively use their watercraft to create open channels. Although not truly considered mechanical management, plant disruption by normal boat traffic is a legal method of management. Most macrophytes do not grow well in an area actively used for boating and swimming. It should be noted that purposefully navigating a boat in circles to clear large areas is not only potentially illegal, but it can also re-suspend sediments, clear paths for aquatic invasive species growth and cause ecological disruptions.

10.2.3 Suction Dredging

Suction dredging is a form of mechanical harvesting where diver-operated suction tubes connected to barge- or pontoon-mounted pumps and strainer devices are used to vacuum plants uprooted by hand. This management technique is considered harvesting and not dredging because sediments are not removed from the system. Suction dredging is mostly used for control of isolated, new infestations of aquatic invasive species, and therefore not recommended for use in the Spider Chain of Lakes.

10.2.4 Other Mechanical Management

The mechanical aquatic plant control methods described below are not recommended for use on the Spider Chain of Lakes because they are often extremely disruptive to aquatic ecosystems. These methods are, however, used in other states or inappropriately employed in Wisconsin and are therefore discussed.

Cutting without plant removal, grinding and returning the vegetation to the water body, and rotovating (tilling) are also methods employed to control nuisance plant growth in some lakes. Cutting is just like harvesting except the plants are left in the lake. Grinding incorporates cutting and then grinding to minimize the biomass returned to the lake. Smaller particles disperse quicker and decay more rapidly. Rotovating works up bottom sediments dislodging and destroying plant root crowns and bottom growth.

Bottom rollers and surface sweepers are devices usually attached to the end of a dock or pier and sweep through an area adjacent to the dock. Continued disruption of the bottom area causes plants to disappear and light sediments to be swept out. The use of rollers may disturb bottom dwelling organisms and spawning fish. Plant fragmentation of nuisance weeds may also occur. In soft bottom areas, sediment disturbance can be significant. These devices are generally not permitted in Wisconsin. A permit under Section 30.12(3) is required which governs the placement of structures in navigable waters.

Another common method for removing aquatic plants from a beach or dock area is for riparian owners to hook a bed spring, sickle mower blade, or other contraption to the back of a boat, lawn mower, or ATV and drag it back and forth across the bottom. This type of management is considered mechanical and is generally not permitted by the WDNR.

10.3 Biological Controls

Biological control for aquatic plant management involves using animals, fungi, insects, or pathogens as a means to control nuisance plants. The goal of bio-control is to develop a predator-prey relationship where the growth of nuisance plants is reduced, but not eliminated. A special permit is required in Wisconsin before any biological control measure can be introduced into a new area.

Specific biological controls of curly-leaf pondweed are not known at this time. Ongoing research on naturalized and native herbivores and pathogens that impact nuisance aquatic and wetland plants is increasing the number of potential biological control agents that could be incorporated into invasive plant management programs (23).

The grass carp (*Ctenopharyngodon idella*), which feeds on aquatic plants and has been used as a biological tool to control nuisance aquatic plant growth in other states, is not permitted in Wisconsin. These fish can severely disrupt the aquatic ecosystem and have been known to nearly wipe out all aquatic vegetation in the lakes they inhabit.

There are several insects that have been studied and approved for biological control purposes of purple loosestrife. One species of insect has been proven to be extremely effective for control of purple loosestrife, the *Galerucella* beetles (*G. calmariensis* and *G. pusilla*). These beetles have been used extensively across North America to manage purple loosestrife, including in and around the Spider Chain of Lakes. Use of *Galerucella* beetles for purple loosestrife management should be continued.

The milfoil weevil (*Euhrychiopsis lecontei*) is a native aquatic weevil that feeds on aquatic milfoils. Their host plant is typically northern watermilfoil, but they prefer Eurasian watermilfoil when it is available. Studies of utilizing the milfoil weevil for Eurasian watermilfoil control have resulted in variable levels of control, with little control being achieved on lakes with extensive motorized boat traffic.

EnviroScience, Inc has taken a patent on rearing and distributing the milfoil weevil. Recent information indicates they have successfully introduced weevils to more than 100 lakes in the United States and Canada in the last ten years. Costs for using the EnviroScience program run about $1.50 per weevil purchased, but includes the costs of mapping, stocking, and monitoring of effects. Researchers in Wisconsin have been developing a protocol for layperson rearing of the milfoil weevil. This process involves setting up large tanks with Eurasian watermilfoil and purchasing starter weevils from EnviroScience. With proper care and management, it is anticipated that this rearing method may be able to produce a 10 to 100 fold increase in weevils to be released into an affected area.

Plant fungi and pathogens are currently still in the research phase. Certain species for control of hydrilla and Eurasian watermilfoil have shown promise, but only laboratory tests in aquariums and small ponds have been conducted. Methods are not available for widespread application. Whether these agents will be successful in flowing waters or large-scale applications remains to be tested (24).

Selectively planting native aquatic plants to encourage or stimulate growth of desired plant species is another form of biological control. Introducing native plants is uncommon as it is often difficult and costly and requires a fairly large source of new plants and substantial short-term labor for collecting, planting, and maintaining the stock. Maintenance of plantings may require protection from fish and birds and temporary stabilization and protection of sediment in the planting area from wind and waves. Allowing the natural re-growth of native plants in cleared areas can prevent curly-leaf and other non-native invasive plant species from establishing in those sites.

10.4 Physical Habitat Alteration

Reducing nutrient loading from the watershed (for example, reducing fertilizer use or controlling construction erosion) provides fewer nutrients available for plant growth. Runoff from development in the near-shore area and from other parts of the watershed can increase the amount of phosphorus available for plant and algae growth. The limited light penetration due to increased algae in the water will be beneficial for plants adapted to low light conditions, such as curly-leaf pondweed. Higher nutrient concentrations also favor other non-native plants such as Eurasian watermilfoil and native plants that tend to be nuisance such as coontail.

Research has shown that as shoreline development increases, the amount of aquatic plant growth near that lake shore decreases. In a Minnesota study of 44 lakes with varying amounts of developed shoreline, the average loss of aquatic plants in developed areas was 66% (25). On a lake wide basis, this loss of aquatic plant growth can lead to higher levels of phosphorus and an increase in the growth of algae, including filamentous algae that may attach to structures within the littoral zone or form surface mats. Reducing nutrient loading from the watershed (for example, reducing fertilizer use, controlling construction erosion, or shoreland restoration and buffers) is a viable option in the Spider Chain of Lakes.

Dredging is usually not performed solely for aquatic plant management but to restore lakes that have been filled in with sediments, have excess nutrients, have inadequate pelagic and hypolimnetic zones, need deepening for navigation, or require removal of toxic substances. A WDNR permit is required to perform any dredging in a waterbody or wetland. This method can be detrimental to desired plants, as all macrophytes would be prevented from growing for many years. This high level of disturbance may also create favorable conditions for the invasion of other invasive species. Dredging is not recommended for aquatic plant management in the Spider Chain of Lakes.

Benthic barriers or other bottom-covering approaches are another physical management technique that has been in use for many years. The basic idea is that the plants are covered over with a layer of a growth-inhibiting substance. Many materials have been used, including sheets or screens of organic, inorganic and synthetic materials, sediments such as dredge sediment, sand, silt or clay, fly ash, and combinations of the above. WDNR approval is required and screens must be removed each fall and reinstalled in the spring to be effective over the long term.

Dropping the lake level to allow for the desiccation, aeration, and freezing of lake sediments has been shown to be an effective aquatic plant management technique. For control of certain aquatic plants, such as Eurasian watermilfoil, repeated winter drawdown lasting 4 to 6 months that include a freezing period are the most effective. Control of aquatic plants in these cases can last a number of years. The low lake levels may negatively affect native plants, provides an opportunity for adventitious species such as annuals, often reduces the recreational value of a waterbody, and can impact the fishery if spawning areas are affected. The cost of a drawdown is dependent on the outlet of the lake; if no control structure is present, pumping of the lake can be cost prohibitive whereas costs can be minimal if the lake can be lowered by opening a gate. Raising water levels to flood out aquatic plants is uncommon and has a number of negative effects including the potential for shoreland flooding, shoreland erosion, and nutrient loading.

10.5 Chemical Control

Aquatic herbicides are granules or liquid chemicals specifically formulated for use in water to kill plants or cease plant growth. Herbicides approved for aquatic use by the U.S. Environmental Protection Agency are considered compatible with the aquatic environment when used according to label directions. Some individual states, including Wisconsin, also impose additional constraints on herbicide use. There are a number of aquatic herbicides registered for use in Wisconsin. Factsheets for each can be found on the WDNR website at http://dnr.wi.gov/lakes/plants/factsheets/ (last accessed October 2012).

A WDNR permit is required to use chemical herbicides in aquatic environments and a certified pesticide applicator is required for application on most lakes. The WDNR requires aquatic plant surveys before and after chemical application when introducing new treatments to lakes where the treatment size is greater than 10 acres or greater than 10% of the lake littoral area and more than 150 feet from shore. The pre- and post-treatment survey protocol can be found at: http://www4.uwsp.edu/cnr/uwexlakes/ecology/APM/Appendix-D.pdf (last accessed October 2012).

The advantages of using chemical herbicides for control of aquatic plant growth are the speed, ease and convenience of application, the relatively low cost, and the ability to somewhat selectively control particular plant types with certain herbicides. Disadvantages of using chemical herbicides include possible toxicity to aquatic animals or humans, oxygen depletion after plants die and decompose which can cause fishkills, a risk of increased algal blooms as nutrients in released into the water by the decaying plants, adverse effects on desirable aquatic plants, loss of fish habitat and food sources, water use restrictions, and a need to repeat treatments due to existing seed/turion banks and plant fragments. Chemical herbicide use can also create conditions favorable for non-native aquatic invasive species to outcompete native plants (for example, areas of stressed native plants or devoid of plants).

When properly applied, the possible negative impacts of chemical herbicide use can be minimized. Early spring to early summer applications are preferred because exotic species are actively growing and many native plants are dormant, thus limiting the loss of desirable plant species; plant biomass is relatively low minimizing the impacts of deoxygenation and contribution of organic matter to the sediments; fish spawning has ceased; and recreational use is generally low limiting human contact. The concentration and amount of herbicides can be reduced because colder water temperatures enhance the herbicidal effects. Selectivity of herbicides can be increased with careful selection of application rates and seasonal timing (26). Lake hydrodynamics must also be considered; steep drop-offs, inflowing waters, lake currents and wind can dilute chemical herbicides or increase herbicide drift and off-target injury. This is an especially important consideration when using herbicides near environmentally sensitive areas or where there may be conflicts with various water users in the treatment vicinity.

Chemical herbicides are not recommended for control of curly-leaf pondweed in the Spider Chain of Lakes at this time for a number of reasons: curly-leaf pondweed has been present for over a decade and appears to have found its niche in the lakes; although a non-native species, curly-leaf spears to be minimally invasive in the Spider Chain of Lakes and is often found growing as thin, small plants; unlike many lakes with serious curly-leaf infestations, the Spider Chain of Lakes has an impressive native plant community which also likely makes it more resistant to invasion. The use of chemical herbicides in the Spider Chain of Lakes is only recommended as part of an integrated management approach for control of purple loosestrife and any new infestations of aquatic invasive species such as Eurasian watermilfoil. Because there are no significant, recurring algal blooms in the Spider Chain of Lakes, the use of chemical algicides is not warranted.

11.0 Aquatic Plant Management Goal, Objectives, and Actions

The Spider Chain of Lakes contains an exceptional aquatic plant community that supports a high-quality fishery. The overall goal of aquatic plant management in the Spider Chain of Lakes is to protect this outstanding resource from degradation by maximizing prevention of new invasions and through the containment and control of existing aquatic invasive species.

The objectives for this plan are to:

1. **Preservation and Restoration**. Protect and restore the native plant species community in and around the lakes to decrease susceptibility to the introduction of new aquatic invasive species.
2. **Prevention**. Prevent the introduction and establishment of new aquatic invasive species through early detection and rapid response.
3. **Management**. Reduce existing aquatic invasive species populations (curly-leaf pondweed and purple loosestrife) through containment and control.
4. **Education and Awareness**. Continue public outreach and education programs on aquatic invasive species.
5. **Research and Monitoring**. Develop a better understanding of the lakes and the factors affecting lake water quality through continued and expanded monitoring efforts.
6. **Adaptive Management**. Follow an adaptive management approach that measures and analyzes the effectiveness of control activities and modify the management plan as necessary to meet goals and objectives.

11.1 Preservation and Restoration

Eighty percent of the plants and animals on the Wisconsin endangered and threatened species list spend all or part of their life cycle within the near shore zone and as many as ninety percent of the living things in lakes and rivers are found along the shallow margins and shores. Activities along a lakeshore and in the immediate shoreland area can have major impacts on overall lake quality.

Preserving and restoring native shoreland plant communities is undertaken on many lakes to reduce erosion, increase and improve native habitat, reduce shoreland runoff, improve water quality, and compliment the lake aesthetic. The restoration or re-establishment of aquatic plants in the shallow waters adjacent to the shore, which focuses on emergent plant species like rushes, sedges, pickerel weed, wild rice, and other plants that make up the wetland fringe, is less frequently completed. These species hold sediments in place, fend off the invasion of non-native species, buffer against shoreland erosion, and improve fish and wildlife habitat. Allowing the re-growth of native plants in cleared areas can prevent curly-leaf pondweed and other non-native invasive plant species from establishing in those sites.

Shoreland buffers also provide non-point source nutrient control by slowing runoff and utilizing nutrients (and contaminants) before they reach the lake. Curly-leaf pondweed can grow in more turbid waters than many native plants, so protecting or improving the water clarity of the Spider Chain of Lakes helps native plants compete more effectively with curly-leaf.

To maintain the exceptional quality and diversity of the lake ecosystem, the Spider Chain of Lakes Association (Association) will provide riparian owners with educational materials on shoreland improvement and sponsor shoreland restoration training events. Not knowing where to begin with a shoreland restoration is often the main hurdle preventing implementation. General information on shoreland restoration will be provided to all members in a newsletter, on the webpage, and during public events.

Recent research has revealed that riparian property owners evaluate their own shorelines significantly more natural than biologists' evaluations (27). It is recommended that a shoreline evaluation be performed by resource professionals or trained volunteers. The information collected will provide baseline data on the status of the shoreline around the Spider Chain of Lakes and will allow for focused education and outreach efforts.

The Association should further encourage riparian property owners to diversify the shoreland environment by recognizing riparian owners who implement shoreland restoration and habitat improvement projects. Recognition can be in a number of ways, for example, by displaying a special sign on the shoreline or posting a notice on the webpage.

11.2 Prevention

Early detection and rapid response efforts increase the likelihood that a new aquatic invasive species will be addressed successfully while the population is still localized and levels are not beyond that which can be contained and eradicated. Once an aquatic invasive species becomes widely established in a lake, all that might be possible is the partial control of negative impacts. The costs of early detection and rapid response efforts are typically far less than those of long-term invasive species management programs.

The Association will continue to implement and further develop a proactive and consistent aquatic invasive species monitoring program that includes both casual observers and trained monitors. At least three times during the open water season, trained volunteers will patrol the shoreline and littoral zone looking for curly-leaf pondweed, Eurasian watermilfoil, purple loosestrife, Japanese knotweed, giant reed grass, zebra mussels, and other invasive species. Table 9 shows the life stage of some invasive plant and animal species and the best times of the open water season to monitor for them (28).

Monitoring will be completed as a part of the UW-Extension Lakes/WDNR Citizen Lake Monitoring Network Aquatic Invasive Species Monitoring Program. Training is available through the Wisconsin Citizen Lake Monitoring Network (different from Clean Boat Clean Waters monitoring) and the WDNR provides an excellent guide for monitoring called *Aquatic Invasive Species, A Guide for Proactive & Reactive Management* which can be found online at http://dnr.wi.gov/Aid/documents/AIS/AISguide06.pdf (last accessed April 15, 2013). Volunteers can select the species they monitor for; learn when, how and where to monitor; and the shown how to report a new find. Many new Eurasian watermilfoil and other invasive species finds have been from volunteers who know their lake. All monitoring data will be recorded annually and submitted to the WDNR SWIMS database.

Property owners will be encouraged to monitor their shoreline and open water areas for new growths of aquatic invasive species. These casual observers can undergo more simplified training than the trained monitors via meeting presentations or from more technically trained monitors. If a suspect aquatic invasive species is found, it will be reported to the Association, County, and the WDNR. Note: the contacts found in the Rapid Response Plan (Appendix D) pertain to all aquatic invasive species.

Table 9
Aquatic Invasive Species Monitoring Timetable.

	April	May	June	July	August	September
Eurasian watermilfoil						
Sprout						
Growth						
Bloom						
Die Back						
Curly-leaf pondweed						
Sprout	→					
Growth	→					
Bloom						
Die Back						
Purple Loosestrife						
Sprout						
Growth						
Bloom						
Die Back						
Zebra mussel						
Rusty crayfish						
Spiny water flea						

Aquatic invasive species can be transported via a number of vectors, but most invasions are associated with human activity. Monitoring of the boat launches on Little Spider Lake and Clear Lake by paid and volunteer inspectors will continue following WDNR/UW-Extension Clean Boats, Clean Waters guidelines. All watercraft inspection data collected should be submitted to the WDNR SWIMS database. The Association will participate in the Fourth of July Landing Blitz, an outreach effort to warn boaters of the dangers of transporting invasive species that takes place on the Fourth of July, a high-boat traffic day. The Association will also continue to maintain and update signage at the boat launches as necessary.

Preventing the introduction of invasive species is the first line of defense against invasions, but even the best prevention efforts will not stop all invasive species introductions. A Eurasian Watermilfoil Rapid Response Plan has been created for the Spider Chain of Lakes and in included as Appendix D of this plan. The Rapid Response Plan contains information on what to do if a potential aquatic invasive species is found including contacts for authoritative verification and what should be done if a positive identification is made. The herbicide 2,4-D is recommended for Eurasian watermilfoil control and appropriate selective herbicides should be used for other new aquatic invasive species.

11.3 Management

Aquatic plant management in the Spider Chain of Lakes will follow an integrated management approach that relies on a combination of methods and techniques. Manual, biological, and chemical control methods are included. Chemical herbicides may only be used for the eradication of new aquatic invasive species infestations, for purple loosestrife control, and for curly-leaf pondweed control under any of the following conditions:

- statistically significant increases in distribution and density (at a 90% probability);
- biologically significant impairment to a sensitive area;
- the discovery of new beds in the lakes currently without curly-leaf pondweed;
- documented nuisance conditions (navigation or swimming) covering area in excess of 0.25 acres (10,890 square feet);

The target level of curly-leaf pondweed growth in the Spider Lakes is distribution and density levels equal to or less than the growth found during the 2012 April and May curly-leaf surveys. Changes in sensitive areas will be based off comparisons with plant communities documented during the summer 2012 aquatic plant survey. Because early season herbicide treatments are preferred (discussed below), chemical control of problematic curly-leaf pondweed will occur the year following its documentation unless it is agreed upon by the Association and the WDNR that immediate control is warranted. Herbicides will not be used for native plant control.

Manual harvesting will be done to control both native and non-native and nuisance plant growth around docks and small populations of curly-leaf pondweed. Manual removal of aquatic plants may be completed at any time following the guidelines and regulations set forth in NR 109, which can be found in Appendix C. Native plant removal should be limited to the amount needed to access open water areas. Coarse woody habitat (tree falls, logs, etc.) should be left in the water. Coarse woody habitat is a critical feature of lakes influencing fish behavior, spawning, predator-prey interactions, growth, and species diversity. Research has shown that the growth of largemouth bass and bluegill are positively correlated with coarse woody habitat in lakes and a whole lake removal of coarse woody habitat led to the collapse of a yellow perch population (29).

11.3.1 Curly-leaf Pondweed

Curly-leaf pondweed control will be undertaken to contain the plant in Big Spider Lake. Success will be measured by keeping curly-leaf pondweed contained to Big Spider Lake and at levels (nuisance and density) equal to or below those found in 2012. Curly-leaf pondweed has been in Big Spider Lake for at least 12 years. It appears to have found its niche in the Spider Chain of Lakes and is not behaving invasively. Curly-leaf pondweed is providing early season habitat, is not causing nuisance conditions beyond those created by native plants, and is at such a low density that its contribution to the phosphorus budget during senescence is likely insignificant. Only a very small population of curly-leaf has been found in Little Spider Lake and none have been found in Clear Lake, Fawn Lake, and North Lake.

Chemical control is not recommended at this time because curly-leaf is established throughout Big Spider Lake at moderate to low densities and intermingled with native macrophytes. Manual harvesting (rake and diver removal) is recommended for any pioneer populations found in other lakes and for control of smaller (<0.25 acre), dense (rake fullness rating of 3) beds in Big Spider Lake. Manual harvesting is recommended for curly-leaf Bed 26 in Little Spider Lake (Figure 22). The efficacy of herbicides will be reduced if used in that area due to the sharp drop off to deeper waters. Volunteers should rake this small bed before turions form (late spring to early summer) to contain the plant.

The Spider Chain of Lakes Association will coordinate physical removal education and larger scale removal efforts, either by assigning these responsibilities to a committee or by forming a new committee. Members of the Association and property owners around the lakes will be taught to remove individual plants and small clusters of curly-leaf in shallow, easily accessible areas of the lakes. Instructional materials and training will be provided to aid riparian owners in the identification and removal of curly-leaf. The Association will also sponsor an annual Curly-leaf Removal Day in early to mid summer. Volunteers will be assembled and a more vigorous physical removal program undertaken which will include diver removal.

Annual bed mapping and density monitoring will be completed throughout the Spider Chain of Lakes each year to determine the distribution of curly-leaf and identify areas that are candidates for control activities. The Association will hire a resource professional to complete bed mapping and density monitoring to ensure that precise and accurate year-to-year comparisons can be made. Monitoring should be completed in early May to identify new colonies and in mid June when curly-leaf is near its peak growth before senescence. Density will be measured using rake sampling following current WDNR aquatic plant monitoring guidelines (e.g., the 0 to 3 rake fullness density measurement). New growth areas and beds with a rake density rating of 3 will be priority control areas. A bed is defined as an area where curly-leaf pondweed forms generally continuous beds with clearly defined borders and curly-leaf comprises greater than 50% of the plant biomass in the area.

If employed, the use of herbicides for curly-leaf pondweed control will be evaluated annually and used only on an as-needed basis in areas where at least one of the conditions described in Section 11.3 above are met. Consideration will be given to site-specific characteristics (steep drop-offs, presence of native plants sensitive to herbicides or high-value native plants, Sensitive Areas) to determine if chemical herbicides are appropriate for use. Nuisance conditions must be verified by the Association the year prior to herbicide. Herbicide applications will follow all permit requirements and be done in the early season (water temperature 50 to less than 60°F) to minimize negative impacts to native plant species and the fishery. Currently, endothall is the preferred chemical for curly-leaf pondweed control. Plant surveys before and after herbicide will be completed to evaluate the impact of the application to both native species and curly-leaf pondweed

11.3.2 Purple Loosestrife

Purple loosestrife control will be continued to prevent it from becoming monotypic stands along the shoreline and in adjacent wetlands. Success will be measured by keeping this plant at levels equal to or below current levels. Appropriate management alternatives for purple loosestrife control include hand-pulling and digging, biological control (*Galerucella* beetles), and application of chemical herbicide (for example, glyphosate) to individual plants (wick application). When using chemical herbicides, care should be taken to prevent clearing of the entire vegetative cover in an area of control; this will promote purple loosestrife seed germination, which can result in an increase in plant density rather than control. Since glyphosate does not provide residual control, treated areas will need to be monitored for re-growth from the roots or seedlings for several years.

Monitoring of the entire Spider Chain of Lakes for new purple loosestrife plants will be completed by volunteers in July and August. The Association will identify and offer training and support materials to the volunteers. Physical removal and occasional use of herbicides applied by hand will be used to control individual plants or isolated pioneering sites.

11.4 Education and Awareness

Providing education and outreach opportunities and materials to the lake community will improve the general knowledge base and likely increase participation in lake protection and restoration activities. To allow for greater and easier distribution, the Association will condense the Executive Summary, Implementation Plan, Aquatic Plant Management Goal, Objectives and Actions, and the Rapid Response Plan (Appendix D) and any other portions of this report deemed necessary into a summary report available to the membership.

The Spider Chain of Lakes Association will continue to cultivate a lake community that is aware of the problems associated with aquatic invasive species and that has enough knowledge about certain species to aid in detection, planning, and implementation of management alternatives. The Association should also foster a greater understanding and appreciation of the entire aquatic ecosystem and the important role plants, animals and people play in that system.

It is important for the lake community and lake users to know how their activities impact the aquatic plants and water quality of the lakes. The Spider Lake Environmental Education for Kids (SLEEK) program provides a great avenue for outreach to youth and will remain a priority program for the Spider Chain of Lakes Association. The Association will distribute or re-distribute informational materials and provide educational opportunities on aquatic invasive species and other factors that affect the Spider Chain of Lakes. At least one annual activity (Lake Fair, public workshop, guest speakers, etc.) will be sponsored and promoted by the Association that focuses on aquatic invasive species. Maintaining signs and continuing active inspections of watercraft at public launches will educate boaters about what they can do to prevent the spread of aquatic invasive species. Results of water quality monitoring should be shared with the lake community at the annual meeting or another event to promote a greater understanding of the lake ecosystem which may increase participation in planning and management.

The Spider Chain of Lakes Association will also provide education and informational materials related to wildlife and wildlife monitoring programs during public events, in newsletters, on the webpage, and during public meetings. Volunteers are currently participating in the Loon Watch program sponsored by the Sigurd Olson Institute. Other programs sponsored by the Citizen-based Monitoring Network of Wisconsin (http://wiatri.net/cbm/) will be promoted by the Association and member participation encouraged. The Association will help make arrangements for training opportunities for these and other wildlife monitoring and appreciation events.

11.5 Research and Monitoring

The purpose of this management recommendation is to develop a better understanding of the lakes and the factors affecting lake water quality through continued and expanded monitoring efforts.

11.5.1 Water Quality

Volunteers will continue to participate in the Citizen Lake Monitoring Network (CLMN) Water Quality Monitoring Program. The current level of monitoring entails Secchi disk measurements at all six lake monitoring sites shown in Figure 6: two sites in Little Spider Lake, and one each in Big Spider, Clear, Fawn, and North lakes. Expanded CLMN monitoring, which includes temperature, total phosphorus, and chlorophyll-a, are also completed at the Little Spider Deep Hole (Big Bay) and Big Spider Deep Hole (South End) sites. This current effort of volunteer monitoring will continue so long as no major aquatic plant management activities or changes to the watershed (for example, large scale development) occur. If large-scale management (10 acres or more) of curly-leaf pondweed or any other aquatic plant species is completed in one or more of the lakes, the level of water quality monitoring efforts will be re-evaluated and expanded CLMN monitoring considered for all sites.

11.5.1.1 Dissolved Oxygen

The Association will evaluate the purchase a digital dissolved oxygen meter to support their water quality monitoring efforts. Grant funding is available from the WDNR to offset the cost of a water quality meter. Monthly temperature and dissolved oxygen profiles (readings taken at intervals of 3 feet or less from the lake surface to very near the bottom) should be taken at the Deep Hole sites in each lake for at least one year. Determining if stratification occurs in each lake, at what depths, and at what levels will provide valuable information for determining internal nutrient loading and identifying fishery habitat conditions.

11.5.2 Continuing to collect temperature and dissolved oxygen profiles can be used to identify the factors leading to changes to water quality such as aquatic plant management activities, changes in the watershed land use, and the response of the lakes to environmental changes. The background information and trends provided by these data can prove invaluable for comprehensive lake management planning.Water Quantity

Water quantity monitoring will also be completed. This information can be used for comprehensive planning when determining hydrologic and nutrient budgets. Long-term lake level monitoring can provide information on how much water levels vary in a normal year (or longer time period) which can in turn be used to identify processes that drive lake hydrology and identify processes behind anomalies so management or adaptation can begin. Lake levels can be recorded by reading a staff gauge that is installed on a permanent structure in the lake or placed in reference to a permanent and unchanging structure on the shore. To facilitate daily readings, the staff gauge should be installed at the property of a volunteer who is a permanent resident on the lake.

11.5.3 Comprehensive Lake Management Planning

To further understand those factors affecting the Spider Chain of Lakes and where to focus lake protection and management efforts, the Association will develop a Comprehensive Lake Management Plan within the next five years. Comprehensive Lake Management Plans typically address five key components: water quality, aquatic plants, fisheries, the watershed, and public involvement. A Comprehensive Plan will help the Association work towards long-term lake goals such as sustained water quality, a better understanding of the complex lake ecosystem, and increased lake protection.

11.6 Adaptive Management

This Aquatic Plant Management Plan is a working document guiding management actions on the Spider Chain of Lakes over the next five years. This plan will follow an adaptive management approach by evaluating results and adjusting actions on the basis of what has been learned. This plan is therefore a living document, successively evolving and improving to meet environmental, social, and economic goals, to increase scientific knowledge, and to reduce tensions among stakeholders. Annual and end of project assessment reports are necessary to monitor progress and justify changes to the management strategy. Project reporting will meet the requirements of all stakeholders, gain proper approval, allow for timely reimbursement of expenses, and provide the appropriate data for continued management success. Success will be measured by the efficiency and ease in which these actions are completed

The Spider Chain of Lakes Association and their retainers will compile, analyze, and summarize management operations, public education efforts, and other pertinent data into an annual report each year. The information will be presented to members of the Association, Sawyer County and the WDNR and made available in hardcopy and digital format on the Association website (www.spiderchainoflakes.net). These reports will serve as a vehicle to propose future management recommendations and will therefore be completed prior to implementing following year management actions (approximately March 31st annually). At the end of this five year project, all management efforts (including successes and failures) and related activities will be summarized in a report to be used for revising the Aquatic Plant Management Plan.

Whole-lake point intercept aquatic plant surveys will be completed at three- to five-year intervals. At a minimum, a survey will be completed in 2017 and the results compared to the 2012 survey to determine the impacts of management activities on both target and non-target aquatic plants.

11.7 Funding Sources for Implementation

Funding for all eligible management activities including but not limited to shoreline restoration training, AIS monitoring and control, and education and outreach programs will be sought through the WDNR Lake Grant program. Funding for other activities such as maintaining a webpage and developing the newsletter will be generated through lake association funds, donations, and volunteer efforts. A listing of activities and eligibility for grant funding is included in the Implementation Plan matrix found at the beginning of this Aquatic Plant Management Plan.

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Appendix A

WDNR Northern Region Aquatic Plant Management Strategy

Appendix B

Guidelines for Protecting, Maintaining, and Understanding Lake Sensitive Areas

Appendix C

Wisconsin Administrative Code NR 109

Appendix D

Eurasian Watermilfoil Rapid Response Plan

Appendix E

Public Input Documentation