Spider Lake

Iron County, Wisconsin

Comprehensive Management Plan

May 2022

Sponsored by:

Spider Lake Association

WDNR Grant Program

LPL-1735-20

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Onterra, LLC
Lake Management Planning

Spider Lake

Iron County, Wisconsin

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

Spider Lake Planning Committee

James Brancel	Bob Johnson	Cathy Ortlieb
Anette Bullion	Diana Johnson	Hedda Patzke
Bob Dannenberg	Phil Lutgen	Mike Shouldice (Co-Chair)
Pat Christie	Steve Masciolek	Fred Tomko
Ryan Freckmann	Norm McKindles (Co-Chair)	Dan Tomkins
James Habanek	Bill Ortlieb	Sandy Tomkins

Iron County
Land & Water Conservation Department staff completed the shoreland assessment.

Wisconsin Dept. of Natural Resources
Madeline Mathes

TABLE OF CONTENTS

FIGURES

TABLES

PHOTOS

MAPS

APPENDICES

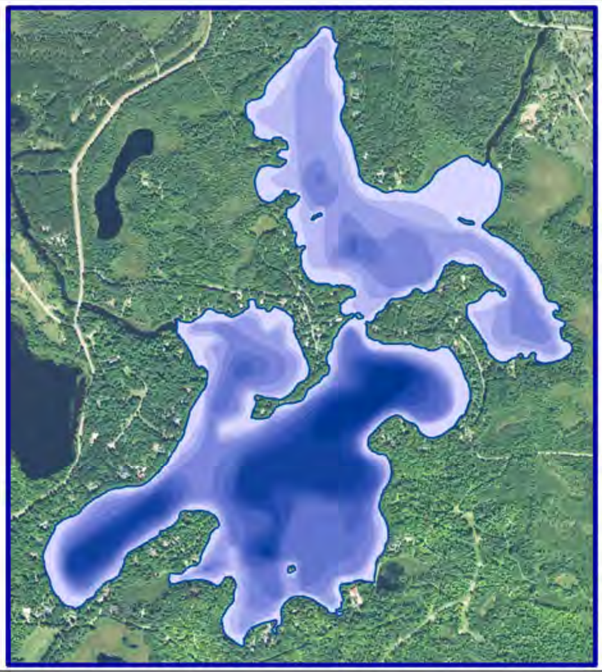
1.0 INTRODUCTION

Spider Lake is an approximate 359-acre, mesotrophic, deep lowland drainage lake in Iron County, Wisconsin (Map 1). Spider Lake is fed and drained via the Turtle River, and resides within the Flambeau River and greater Upper Chippewa River Watersheds. Spider Lake's watershed encompasses an area of approximately 53 square miles across portions of Iron, Vilas, and Gogebic (MI) counties. The lake is comprised of two main basins (north and south) and has a complex, 8.3-mile shoreline which creates a number of backwater bays. The lake has a maximum depth of 49 feet and a mean depth of 17 feet.

Assessments completed in 2020 indicate that the lake supports excellent water quality for Wisconsin's deep lowland drainage lakes. The lake supports a species-rich aquatic plant community with 59 native species recorded, of which wild celery (*Vallisneria americana*), slender naiad (*Najas flexilis*), fern-leaf pondweed (*Potamogeton robbinsii*), and common waterweed (*Elodea canadensis*) were the most frequently encountered. Two native aquatic plant species listed as special concern due to their uncommon occurrence in Wisconsin, Robbins' spikerush and Vasey's pondweed, were also located in 2020. In addition, a population of the native eastern elliptio mussel (*Elliptio complanata*), also a rare species listed as special concern, was located in Spider Lake in 2020.

Lake at a Glance - Spider Lake

Morphometry	
LakeType	Deep Lowland Drainage
Surface Area (Acres)	359 (WDNR definition); 360 (Onterra GIS Update)
Max Depth (feet)	49
Mean Depth (feet)	17
Perimeter (Miles)	8.3
Shoreline Complexity	9.7
Watershed Area (Acres)	33,696
Watershed to Lake Area Ratio	94:1
Water Quality	
Trophic State	Mesotrophic
Limiting Nutrient	Phosphorus
Avg Summer Phosphous (µg/L)	14.9 (1998-2020)
Avg Summer Chlorophyll-α (µg/L)	3.4 (1998-2020)
Avg Summer Secchi Depth (ft)	10.2 (1998-2020)
Summer pH	7.3 (2020)
Alkalinity (mg/L as $CaCO_3$)	39.3 (2020)
Vegetation (2020)	
Number of Native Species	59
NHI-Listed Species	2 (Robbins' spikerush & Vasey's pondwed)
Exotic Species	1 (Purple Loosestrife)
Average Conservatism	7.0
Floristic Quality	46.3
Simpson's Diversity (1-D)	0.95



Descriptions of these parameters can be found within each respective section of this report
NHI = WDNR Natural Heritage Inventory Program

The Spider Lake Association of Iron County, Inc. (SLA) coordinates lake stewardship and educational initiatives for Spider Lake. Volunteers as part of the Wisconsin Citizens Lake Monitoring Network have been collecting water quality data on an annual basis since 1998. In addition, SLA volunteers have been working with Iron County to monitor and control the non-native purple loosestrife in shoreland areas around Spider Lake. While the invasive aquatic plants of Eurasian watermilfoil and curly-leaf pondweed have not yet been located in Spider Lake, nearby lakes harbor populations of both of these species.

In an effort to increase aquatic invasive species monitoring and to gain a more holistic understanding of the Spider Lake ecosystem, the SLA took proactive action to initiate the development of the lake's first comprehensive management plan. The SLA successfully applied for and was awarded a Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant to aid in funding the development of the management plan. The goal of this management plan is to provide a framework for the conservation and enhancement of the Spider Lake ecosystem for current and future generations.

The management plan development included a comprehensive assessment of Spider Lake through baseline studies completed by Onterra over the course of 2020 and 2021. These baseline studies were designed to evaluate the lake's water quality, watershed, and aquatic plant community. Data regarding the health of the lake's immediate shoreland zone were collected by Iron County Land and Water Conservation Department in 2018. In addition, sociological data were collected from Spider Lake riparian property owners and stakeholders through the distribution of an anonymous stakeholder survey.

The data collected as part of this project in combination with available historical data were used to determine the current ecological state of Spider Lake and aid in the development of management goals to conserve and enhance this important natural resource. A detailed discussion of these study results can be found in sections 2.0 and 3.0 of this report. The assessments completed in 2020 indicate that Spider Lake is of exceptional quality, harboring a species-rich native aquatic plant community comprised of a number of rare and uncommon species. Approximately 35 acres of the lake was found to contain valuable emergent and floating-leaf aquatic plant communities. No occurrences of Eurasian watermilfoil or curly-leaf pondweed were located. The only non-native plant observed was isolated occurrences of purple loosestrife in shoreland areas around the lake.

The water quality parameters measured all fall within the excellent category for deep lowland drainage lakes in Wisconsin, a testament the largely undeveloped watershed mainly comprised of intact forests, wetlands, lakes and rivers. The long-term dataset collected by SLA volunteers indicates that there was a measurable decline in water clarity over the period between 1998 and 2020 despite no measured increase in agal abundance. The decline in water clarity is highly correlated with increases in precipitation over this period, and is likely the result of increased input of dissolved organic matter (DOM) which darkens (stains) the water. The shoreland assessment completed by Iron County found that the lake supports large tracts of natural shoreline with some smaller areas with a higher degree of development.

Following the completion of the studies on Spider Lake, Onterra ecologists worked with a planning committee comprised of stakeholder representatives to develop short- and long-term management goals using the information collected from the lake and its stakeholders as a guide. These management goals include the preservation of the lake's water quality and natural shorelands, restoration of developed shorelands, management of purple loosestrife, and increase awareness of lake stewardship issues among others. These management goals and associated management actions can be found in section 5.0 of this report.

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa.

The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it. All of this information is communicated through multiple meetings that involve the lake group as a whole or a focus group called a Planning Committee, the completion of a stakeholder survey, and updates within the lake group's newsletter. The highlights of this component are described below. Materials used during the planning process can be found in Appendix A.

General Public Meetings

The general public meetings were used to raise project awareness, gather comments, create the management goals and actions, and deliver the study results. Due to the Covid-19 pandemic, the Kick-off and Project Wrap-up Meeting presentations were pre-recorded and uploaded to Onterra's YouTube channel for distribution and viewing by SLAIC stakeholders. The planning meetings were held virtually using the Cisco WebEx video conferencing platform.

Kick-off Meeting

In July 2020, a pre-recorded project kick-off presentation video was provided to the SLA for their distribution to lake stakeholders. The video received over 200 views. The approximate 25-minute video presentation was given by Brenton Butterfield, an aquatic ecologist with Onterra. Mr. Butterfield's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. An email address was provided at the end of the presentation where viewers could take the opportunity to submit any questions or comments they had.

Project Wrap-up Meeting

A project wrap-up meeting will be held during the summer of 2022. This meeting will cover the results of the surveys completed in 2020, how aspects of the lake have changed over time, and the management goals that were created with the planning committee. A question-and-answer session will be held at the end of the meeting.

Committee Level Meetings

Planning Committee Meeting I

On May 14, 2021 Brenton Butterfield of Onterra met with members of the Spider Lake Planning Committee for nearly three hours. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including water quality analysis, watershed modeling, and shoreland and aquatic plant inventories were presented and discussed.

Planning Committee Meeting II

On June 16, 2021 Brenton Butterfield met with the members of the Planning Committee to discuss the stakeholder survey results and begin developing management goals and actions for the Spider Lake management plan.

Stakeholder Survey

As a part of this project, a stakeholder survey was distributed to Spider Lake riparian property owners and SLA members. The survey was designed by Onterra staff and the Spider Lake Planning Committee and reviewed by a WDNR social scientist. In September 2020, the six-page, 27-question survey was posted online through Survey Monkey for respondents to answer electronically. If requested, a hard copy was sent to the respondent with a self-addressed stamped envelope for returning the survey anonymously. The returned hardcopy surveys were entered into the online version by a Spider Lake volunteer for analysis.

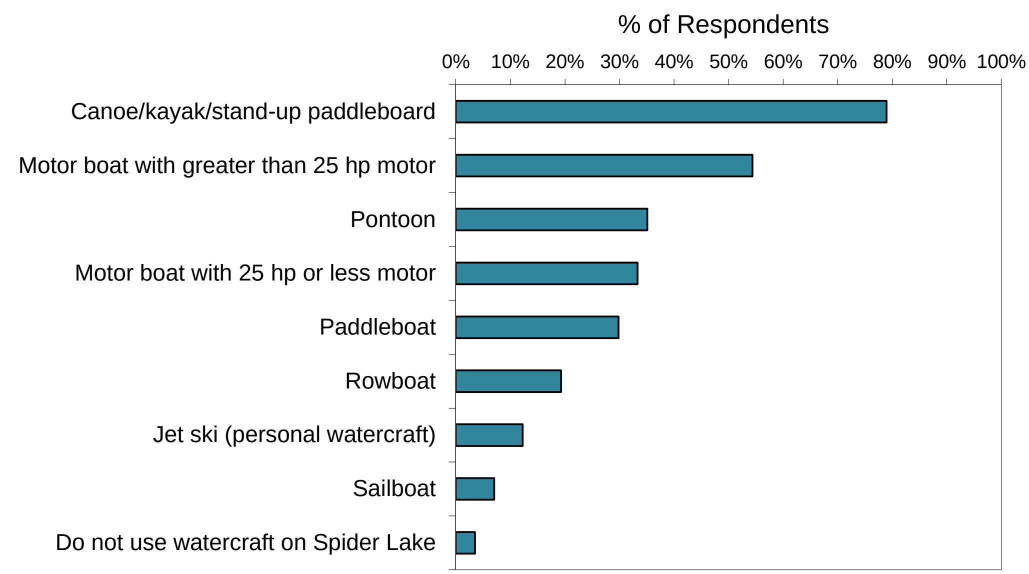
Of the 166 surveys distributed, 58 surveys (35%) were completed. Please note that typically a benchmark of a 60% response rate is required to portray population projections accurately and make conclusions with statistical validity. The data were analyzed and summarized by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan and a general summary is discussed in this section.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Spider Lake. Forty-eight percent of survey respondents indicated they own vacation property, 29% own part-time residence property, 21% own full-time residence property, and 2% own undeveloped property (Appendix B Question #3). Thirty-four percent of respondents indicated they have owned their property on Spider Lake for over 25 years, 24% for 0 to 5 years, 21% for 11 to 25 years, and 21% for 6 to 10 years (Appendix B Question #2).

The Results and Discussion Section (Section 3.0), which discusses Spider Lake's water quality, watershed, paleoecology, aquatic plant communities, and fisheries data integration, also contains information from the stakeholder survey data as they relate to these particular topics. Figures 2.0-1 and 2.0-2 highlight results from more general questions found within this survey. The survey indicated that the top three types of watercraft utilized by Spider Lake survey respondents are non-motorized watercraft such as canoes, kayaks, or standup paddleboards (79%), watercraft with a motor of greater than 25 horsepower (54%), and pontoon boats (35%) (Figure 2.0-1). Survey respondents indicated that their top three activities that are important reasons for owning their property on Spider Lake are relaxing/entertaining, fishing-open water, and nature viewing (Figure 2.0-1).

When asked to rank their top three concerns regarding Spider Lake, survey respondents indicated that aquatic invasive species introduction, water quality degradation, and excessive aquatic plant growth (excluding algae) were the top three concerns (Figure 2.0-2). Excessive watercraft traffic, shoreline development, and loss of aquatic habitat were also marked by many as top concerns on Spider Lake.

Question 12: What types of watercraft do you currently use on Spider Lake?



Question 15: Please rank up to three activities that are important reasons for owning your property on or near Spider Lake.

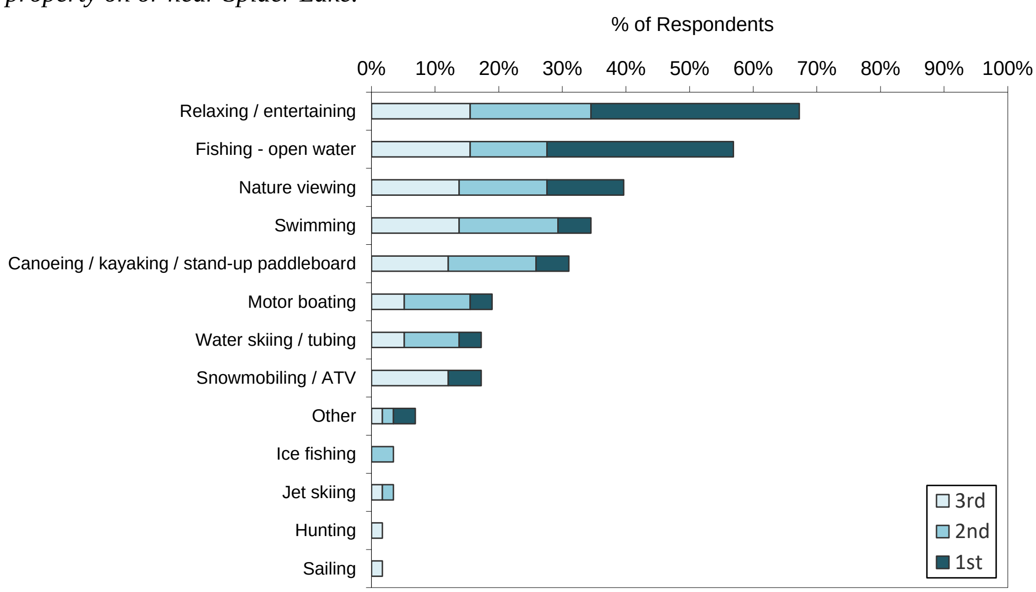


Figure 2.0-1. Select survey responses from the Spider Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question 16: Please rank your top three concerns regarding Spider Lake.

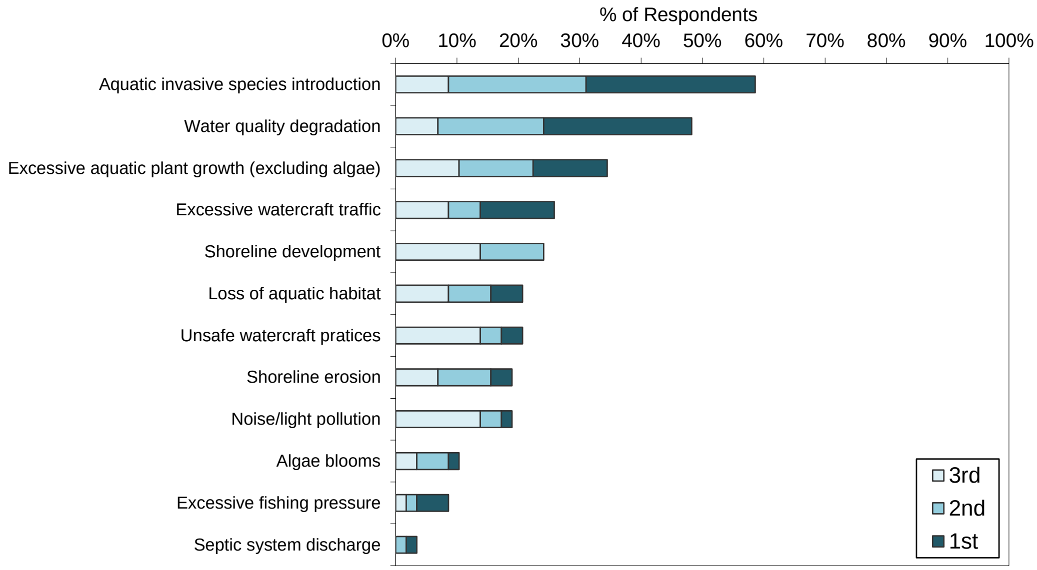


Figure 2.0-2. Select survey responses from the Spider Lake Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

Management Plan Review and Adoption Process

Prior to the first Planning Committee meeting, the results sections were sent to planning committee members for their review and preparation for the meeting. Following discussions at the planning meetings, Onterra staff drafted the Implementation Plan and sent it to the Planning Committee for review. Their comments were integrated into the plan, and the first official draft of the management plan was provided to the WDNR and SLA in November of 2021. Comments from the planning committee and WDNR were integrated into the report, and the final version was created in March of 2022.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

Many types of analyses are available for assessing the condition of a particular lake's water quality. In this document, the water quality analysis focuses upon attributes that are directly related to the productivity of the lake. In other words, the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake are related here. Specific forms of water quality analyses are used to indicate not only the health of the lake, but also to provide a general understanding of the lake's ecology and assist in management decisions. Each type of available analysis is elaborated on below.

As mentioned above, chemistry is a large part of water quality analysis. In most cases, listing the values of specific parameters really does not lead to an understanding of a lake's water quality, especially in the minds of non-professionals. A better way of relating the information is to compare it to lakes with similar physical characteristics and lakes within the same regional area. In this document, a portion of the water quality information collected on Spider Lake is compared to other lakes in the state with similar characteristics as well as to lakes within the northern region (Appendix C). In addition, Spider Lake's water quality data is also compared to upstream lakes within the Turtle River Watershed that have data available. The assessment can also be clarified by limiting the primary analysis to parameters that are important in the lake's ecology and trophic state (see below). Three primary water quality parameters are focused upon in the water quality analysis:

> **Phosphorus** is the primary nutrient that regulates the growth of planktonic algae and some larger, vascular plants (macrophytes) in the vast majority of Wisconsin lakes. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.
>
> **Chlorophyll-*a*** is the green pigment in plants used during photosynthesis. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.
>
> **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most frequently employed and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrants (a Secchi disk) into the water and recording the depth just before it disappears from sight.

These three parameters are often correlated with one another. Phosphorus controls algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority of natural Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – clear water equals clean water (Canter et al.1994; Dinius 2007; Smith et al. 1991).

Trophic State

Total phosphorus, chlorophyll-*a*, and water clarity values are directly related to the trophic state of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: oligotrophic, mesotrophic, and finally eutrophic. Oligotrophic lakes have the lowest amounts of nutrients and biological productivity, and are generally characterized by having high water clarity and a lower abundance of aquatic plants. Mesotrophic lakes have moderate levels of nutrients and biological productivity and generally support more abundant aquatic plant growth. Eutrophic lakes have higher levels of nutrients and biological productivity, and generally have a high abundance of aquatic plants.

Most lakes will naturally progress through these states under natural conditions (i.e., not influenced by the activities of humans), but this process can take tens of thousands of years. Unfortunately, human development of watersheds and the direct discharge of nutrient-rich effluent has accelerated this natural aging process in many Wisconsin lakes, and this is termed cultural eutrophication. The excessive input of nutrients through cultural eutrophication has resulted in some lakes becoming hypereutrophic. Hypereutrophic lakes have the highest levels of nutrients and biological productivity. These lakes are typically dominated by algae, have very poor water clarity, and little if any aquatic plant growth.

It is important to note that both natural factors and human activity can affect a lake's trophic state, and that some lakes can be naturally eutrophic. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the productivity of their lake over time. Yet, classifying a lake into one of three trophic states often does not give clear indication of where a lake really exists in its trophic progression because each trophic state represents a range of productivity. Therefore, two lakes classified in the same trophic state can actually have very different levels of production.

However, through the use of a trophic state index (TSI), an index number can be calculated using phosphorus, chlorophyll-*a*, and Secchi disk depth values that represent the lake's position within the eutrophication process. This allows for a clearer understanding of the lake's trophic state while facilitating clearer long-term tracking. (Carlson, 1977) presented a trophic state index that gained great acceptance among lake managers.

Limiting Nutrient

The limiting nutrient is the nutrient which is in shortest supply and controls the growth rate of algae and some larger vascular plants within the lake. This is analogous to baking a cake that requires four eggs, and four cups each of water, flour, and sugar. If the baker would like to make four cakes, they need 16 of each ingredient. If they are short two eggs, they will only be able to make three cakes even if they have sufficient amounts of the other ingredients. In this scenario, the eggs are the limiting nutrient (ingredient).

In most Wisconsin lakes, phosphorus is the limiting nutrient controlling the production of plant biomass. As a result, phosphorus is often the target for management actions aimed at controlling plants, especially algae. The limiting nutrient is determined by calculating the nitrogen to phosphorus ratio within the lake. Normally, total nitrogen and total phosphorus values from the surface samples taken during the summer months are used to determine the ratio. Results of this ratio indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 15:1, the lake is considered phosphorus limited; if it is less than 10:1, it is considered nitrogen limited. Values between these ratios indicate a transitional limitation between nitrogen and phosphorus.

Temperature and Dissolved Oxygen Profiles

Temperature and dissolved oxygen profiles are created simply by taking readings at different water depths within a lake. Although it is a simple procedure, the completion of several profiles over the course of a year or more provides a great deal of information about the lake. Much of this information relates to whether the lake thermally stratifies or not, which is determined primarily through the temperature profiles. Lakes that show strong stratification during the summer and winter months often need to be managed differently than lakes that do not. Normally, deep lakes stratify to some extent, while shallow lakes (less than 17 feet deep) do not.

> **Lake stratification** occurs when temperature and density gradients are developed with depth in a lake. During stratification, the lake can be broken into three layers: The ***epilimnion*** is the surface layer with the lowest density and has the warmest water in the summer months and the coolest water in the winter months. The ***hypolimnion*** is the bottom layer the highest density and has the coolest water in the summer months and the warmest water in the winter months. The ***metalimnion***, often called the thermocline, is the layer between the epilimnion and hypolimnion where temperature changes most rapidly with depth.

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, fish kills are often the result of insufficient amounts of dissolved oxygen. However, dissolved oxygen's role in lake management extends beyond this basic need by living organisms. In fact, its presence or absence impacts many chemical processes that occur within a lake. Internal nutrient loading is an excellent example that is described below.

Internal Nutrient Loading

In general, lakes tend to act as phosphorus sinks, meaning they tend accumulate phosphorus over time and export less phosphorus than the amount that is loaded to the lake from its watershed. In most lakes, there is a net movement of phosphorus from the water to bottom sediments where it accumulates over time. The retention of this phosphorus within bottom sediments depends on a number of physical, chemical, and biological factors (Wetzel, 2001). If this phosphorus remains bound within bottom sediments, it is largely unavailable for biological use. However, under certain conditions, this phosphorus can be released from bottom sediments into the overlying water where it may become biologically available. This release of phosphorus (and other nutrients) from bottom sediments into the overlying water is termed *internal nutrient loading*. While phosphorus can be released from bottom sediments under a few varying conditions, it occurs most often when the sediment-water interface becomes devoid of oxygen, or anoxic.

When water at the sediment-water interface contains oxygen, phosphorus largely remains bound to ferric iron within the sediment. When the water at the sediment-water interface becomes anoxic, or devoid of oxygen, ferric iron is reduced to ferrous iron and the bond between iron and phosphorus is broken. Under these conditions, iron and phosphorus are now soluble in water and are released from the sediments into the overlying water (Pettersson, 1998). Anoxia at the sediment-water interface typically first develops following thermal stratification, or the formation of distinct layers of water based on temperature and density.

As surface waters warm in late-spring/early summer, it becomes less dense and floats atop the colder, denser layer of water below. The large density gradient between the upper, warm layer of water (*epilimnion*) and lower, cold layer of water (*hypolimnion*) prevents these layers from mixing together and eliminates atmospheric diffusion of oxygen into bottom waters. If there is a high rate of biological decomposition of organic matter in the bottom sediments, anoxic conditions within the hypolimnion can develop as oxygen is consumed and is not replaced through mixing. The loss of oxygen then results in the release of phosphorus from bottom sediments into the hypolimnion.

The development of an anoxic hypolimnion and subsequent release of phosphorus from bottom sediments occurs in many lakes in Wisconsin. However, in deeper, dimictic lakes which remain stratified during the summer, internal nutrient loading is often not problematic as the majority of the phosphorus released from bottom sediments is confined within the hypolimnion where it is largely inaccessible to phytoplankton at the surface. Dimictic lakes are those which remain stratified throughout the summer (and winter) and experience only two complete mixing events (turnover) per year, one in spring and one in fall. In dimictic lakes, phosphorus released from bottom sediments into the hypolimnion during stratification only becomes available to phytoplankton in surface waters during the spring and fall mixing events. While these spring and fall mixing events can stimulate diatom and golden-brown phytoplankton blooms, these mixing events generally to not stimulate cyanobacterial (blue-green algae) blooms because water temperatures are cooler.

Internal nutrient loading can become problematic in lakes when sediment-released phosphorus becomes accessible to phytoplankton during the summer months when surface temperatures are at their warmest. Sediment-released phosphorus can be mobilized to surface waters during the summer in polymictic lakes, or lakes which have the capacity to experience multiple stratification and mixing events over the course of the growing season. Some polymictic lakes tend to straddle the boundary between deep and shallow lakes, and have the capacity to break stratification in summer when sufficient wind energy is generated. Consequently, phosphorus which has accumulated in the anoxic hypolimnion during periods of stratification is mobilized to the surface during partial or full mixing events where it then can spur nuisance phytoplankton blooms at the surface.

Phosphorus from bottom waters can also be mobilized to the surface in polymictic lakes through entrainment, or the continual deepening of the epilimnion and erosion of the metalimnion below (Wetzel, 2001). Wind-driven water generates turbulence across the thermal barrier between the epilimnion and the metalimnion and the metalimnion is eroded, mixing sediment-released nutrients into the epilimnion above. Both periodic mixing and entrainment act as "nutrient pumps" in polymictic lakes, delivering sediment-released nutrients in bottom waters to surface waters (Orihel, et al., 2015). While a continuum exists between dimictic and polymictic lakes, the Osgood Index (Osgood, 1988) is used to determine the probability that a lake will remain stratified during the summer. This probability is estimated using the ratio of the lake's mean depth to its surface area. Lakes with an Osgood Index of less than 4.0 are deemed polymictic.

Spider Lake is composed of two basins connected by a narrow channel, and each basin could be considered and treated as a distinct lake. The southern basin as a mean depth of 21 feet and a surface area of approximately 226 acres, yielding an Osgood Index value of 6.8. This value indicates the southern basin is dimictic, meaning that it remains stratified throughout the summer and completely mixes two times per year, once in spring and once in fall. The northern basin is shallower with a mean depth of 9 feet and a surface area of approximately 133 acres, yielding a lower Osgood Index value of 3.7. This indicates that the northern basin is likely polymictic, meaning it may experience periodic, whole water column mixing events in summer during high-wind storm events.

To determine if internal nutrient loading occurs and has a detectable effect on Spider Lake's water quality, the dynamics of near-surface phosphorus concentrations over the course of the growing season were examined. In dimictic lakes that experience internal nutrient loading, near-surface concentrations will often be highest in the fall following fall turnover when the phosphorus-rich bottom waters are mixed throughout the water column. In shallower lakes that experience internal loading and periodic mixing throughout the growing season, near-surface phosphorus concentrations will often increase over the course of the growing season as sediment-released phosphorus is periodically mobilized to the surface. In addition, near-bottom phosphorus concentrations are also measured during periods of stratification to determine if significant levels of phosphorus are accumulating in bottom waters.

Finally, watershed modeling was used to determine if measured phosphorus concentrations were similar to those predicted based on watershed size, land cover, and precipitation. If predicted phosphorus concentrations are significantly lower than those measured, this indicates that source(s) of phosphorus are entering the lake that were not accounted for in the model. This unaccounted source of phosphorus is often attributable to the internal loading of phosphorus.

Comparisons with Other Datasets

The WDNR document *Wisconsin 2018 Consolidated Assessment and Listing Methodology* (WDNR, Wisconsin 2018 Consolidated Assessment and Listing Methodology (WisCALM), 2018) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's land cover. For this reason, the water quality of Spider Lake is compared to lakes in the state with similar physical characteristics.

The WDNR classifies Wisconsin's lakes into ten natural communities based on size, hydrology, and depth (Figure 3.1-1). First, the lakes are classified into three main groups: (1) lakes and reservoirs less than 10 acres, (2) lakes and reservoirs greater than or equal to 10 acres, and (3) a classification that addresses special waterbody circumstances. The last two categories have several sub-categories that provide attention to lakes that may be shallow, deep, play host to cold water fish species or have unique hydrologic patterns. Overall, the divisions categorize lakes based upon their size, stratification characteristics, and hydrology. An equation developed by (Lathrop & Lillie, 1980), which incorporates the maximum depth of the lake and the lake's surface area, is used to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

Seepage Lakes have no surface water inflow or outflow in the form of rivers and/or streams.

Drainage Lakes have surface water inflow and/or outflow in the form of rivers and/or streams.

> *Headwater drainage lakes* have a watershed of less than 4 square miles.
>
> *Lowland drainage lakes* have a watershed of greater than 4 square miles.

Using these criteria, Spider Lake is classified as a deep (stratified) lowland drainage lake (category 5). The water quality from Spider Lake will be compared to water quality of other deep lowland drainage lakes in Wisconsin.

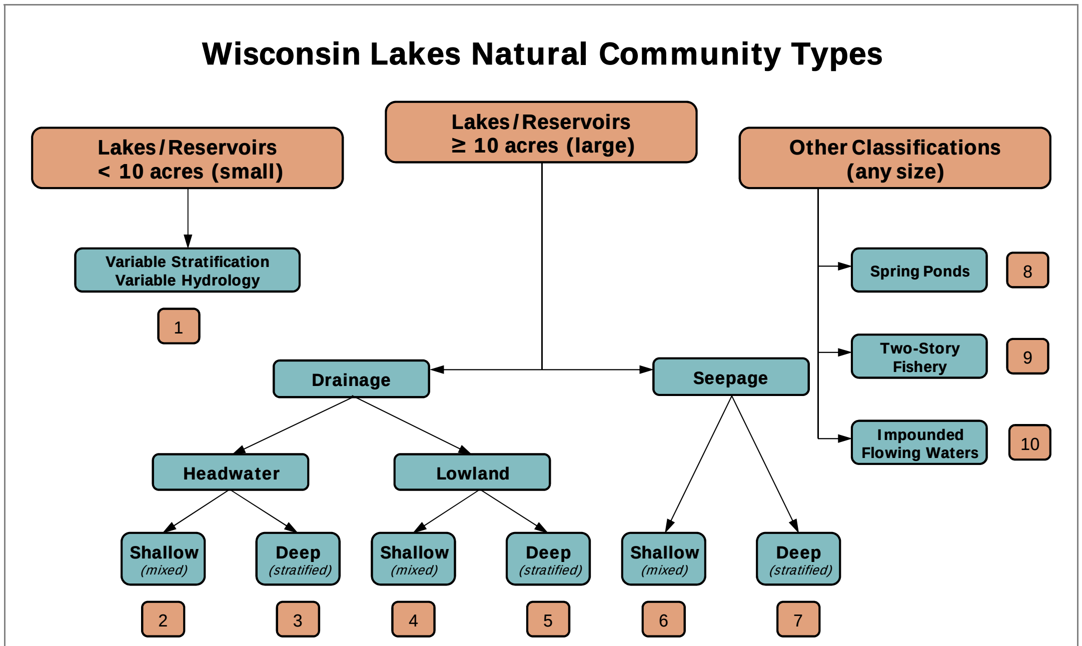


Figure 3.1-1. Wisconsin Lake Natural Communities. Spider Lake is classified as a deep (stratified) lowland drainage lake. Adapted from WDNR 2017.

Garrison et al. 2008 developed state-wide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for six of the lake classifications. Though they did not sample sufficient lakes to create median values for each classification within each of the state's ecoregions, they were able to create median values based on all of the lakes sampled within each ecoregion (Figure 3.1-2). Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Spider Lake is within the Northern Lakes and Forests (NLF) ecoregion of Wisconsin (Figure 3.1-2).

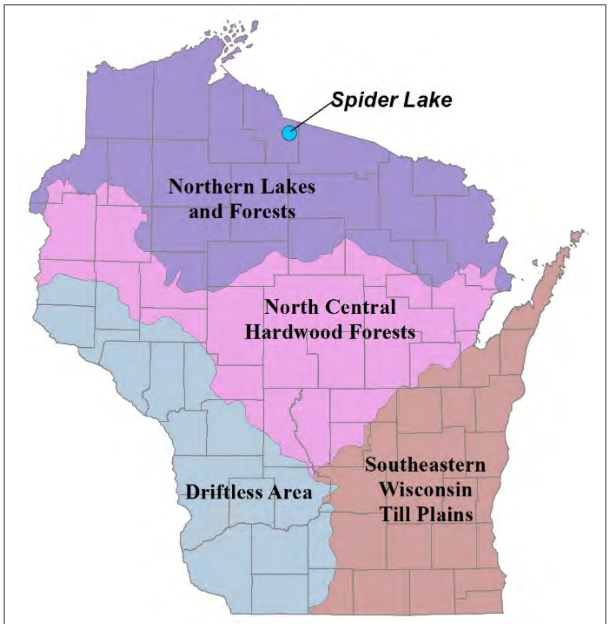


Figure 3.1-2. Location of Spider Lake within the ecoregions of Wisconsin. After Nichols 1999.

The Wisconsin Consolidated Assessment and Listing Methodology document also helps stakeholders understand the health of their lake compared to other lakes within the state. Looking at pre-settlement diatom population compositions from sediment cores collected from numerous lakes around the state, they were able to infer a reference condition for each lake's water quality prior to human development within their watersheds. Using these reference conditions and current water quality data, the assessors were able to rank phosphorus, chlorophyll-*a*, and Secchi disk transparency values for each lake class into categories ranging from excellent to poor.

These data along with data corresponding to statewide natural lake means, historical, current, and average data from Spider Lake are displayed and discussed in the subsequent section. *Growing season* refers to data collected at any time between April and October, while *summer* refers to data collected in June, July, or August. Most of the data were collected from near-surface samples as these represent the depths at which algae grow.

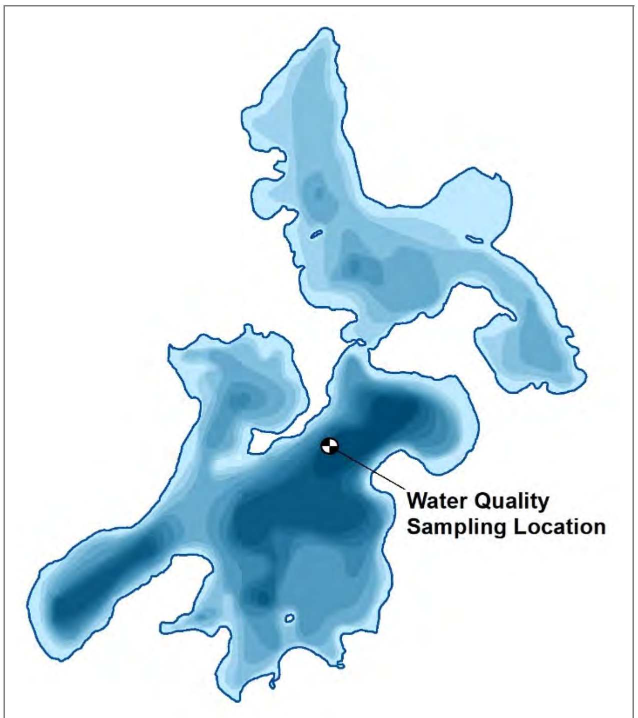


Figure 3.1-3. Spider Lake water quality sampling location.

Most of the data presented in the following section were collected by SLA volunteers through the WDNR Citizens Lake Monitoring Network. Onterra ecologists collected supplemental data in 2020/2021 as part of this lake management planning project. All data presented in this section were collected at the lake's deep hole sampling location within the southern basin (Figure 3.1-3).

Spider Lake Water Quality Analysis

Total Phosphorus

Using 2020 mid-summer nitrogen and phosphorus concentrations from Spider Lake, a nitrogen:phosphorus ratio of 31:1 was calculated. This indicates that Spider Lake is phosphorus limited, as are most of Wisconsin's lakes. In general, this means that phosphorus is the primary nutrient regulating algal growth within the lake, and increases in phosphorus will likely result in increased algal production and lower water clarity. Conservation of Spider Lake's water quality means limiting anthropogenic sources of phosphorus to the lake (i.e., shoreland development and runoff).

Near-surface total phosphorus (TP) data from Spider Lake are available from 1998 and annually from 2004-2021 (Figure 3.1-4). The weighted summer average TP concentration over this time period is 15.0 µg/L, indicating the lake's TP concentrations are *excellent* for Wisconsin's deep lowland drainage lakes. The average summer TP concentrations in 2020 and 2021 were very similar to the long-term average. Overall, Spider Lake's TP concentrations are lower than the median concentrations for Wisconsin's deep lowland drainage lakes (23.0 µg/L) and for all lakes within the NLF ecoregion (21.0 µg/L). Regression analysis indicated that there has been a statistically valid increasing trend ($\alpha \leq 0.05$) in phosphorus concentrations from 2004-2021. However, phosphorus concentrations have been relatively stable in recent years from 2017-2021. This increasing trend and likely cause are discussed in the subsequent Spider Lake Water Quality Trends subsection.

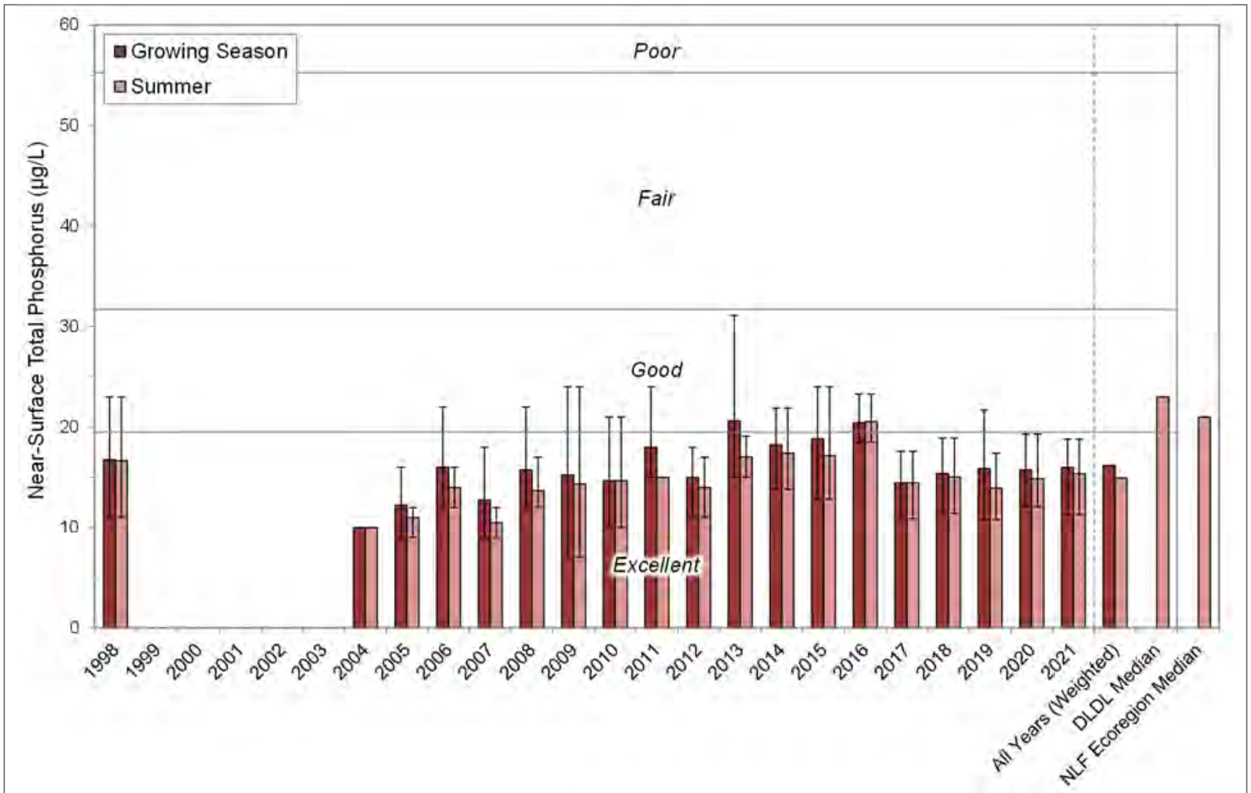


Figure 3.1-4. Spider Lake average annual near-surface total phosphorus concentrations and median near-surface total phosphorus concentrations for statewide deep lowland drainage lakes (DLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Spider Lake's average summer total phosphorus concentration was also compared against phosphorus concentrations available from upstream lakes which flow into Spider Lake (Figure 3.1-5). When compared to these nine other lakes, Spider Lake has the lowest summer phosphorus concentrations despite being the downstream-most lake. In general, lakes tend to act as phosphorus sinks, exporting less phosphorus downstream than they receive from upstream sources. Watershed modeling (discussed in the Watershed Assessment Section 3.2) indicates that Fisher Lake, immediately upstream from Spider Lake, removes approximately 25% of its incoming phosphorus. In other words, the water leaving Fisher Lake and flowing downstream into Spider Lake is lower in phosphorus than the water that flowed into it.

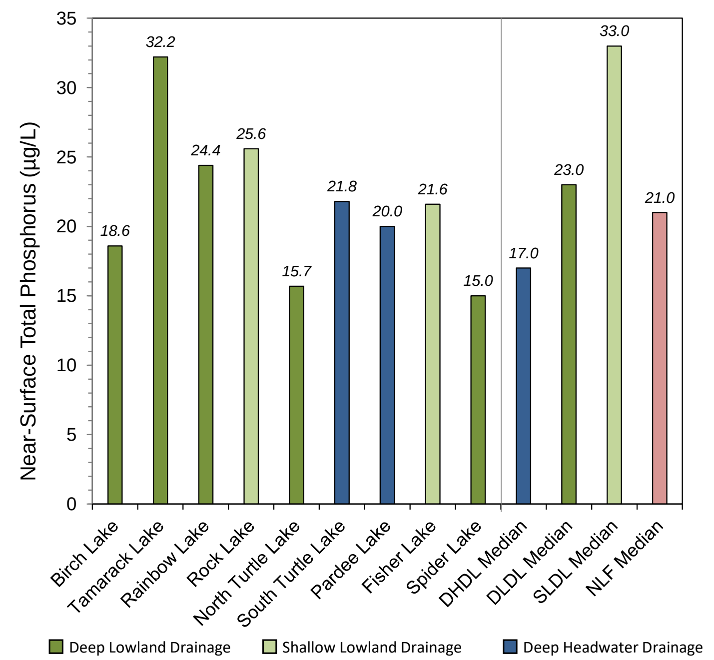


Figure 3.1-5. Spider Lake average summer total phosphorus concentrations compared to upstream lakes. Water Quality Index values adapted from WDNR PUB WT-913. DHDL = Deep Headwater Drainage Lake; SLDL = Shallow Lowland Drainage Lake; SLDL = Shallow Lowland Drainage Lake; NLF = Northern Lakes and Forests Ecoregion

Examination of Spider Lake's average near-surface TP concentrations by month shows that concentrations are on average highest in April and May, likely the result of higher precipitation and runoff from snowmelt at this time of year (Figure 3.1-6). Phosphorus concentrations tend to decline in June and July and remain relatively stable through October. As is discussed in the previous section, increasing phosphorus concentrations over the course of the growing season often indicate that internal nutrient loading is occurring and sediment-released phosphorus is being mobilized from bottom waters to the surface. This pattern is not occurring in Spider Lake, indicating that internal loading of phosphorus is not a significant contributor of phosphorus. In addition, phosphorus concentrations measured in mid-summer of 2020 in Spider Lake's hypolimnion were only 48 µg/L, indicating phosphorus loading into bottom waters during stratification is not significant.

Chlorophyll

Chlorophyll-*a* concentrations, a measure of phytoplankton abundance, are available from Spider Lake for the same time period as TP, from 1998 and annually from 2004-2021 (Figure 3.1-7). The weighted summer average chlorophyll-*a* concentration over this period is 3.3 µg/L, indicating the lake's chlorophyll-*a* concentrations are overall *excellent* for Wisconsin's deep lowland drainage lakes, and fall well below median concentrations for statewide deep lowland drainage lakes and all lake types within the NLF ecoregion. Summer 2020 chlorophyll-*a* concentrations were slightly above average at 4.8 µg/L, while summer 2021 concentrations we below average at 2.1 µg/L. While TP concentrations have exhibited an increasing trend from 2004-2021, chlorophyll-*a* concentrations have not displayed this same trend. There have been no detectable trends (positive

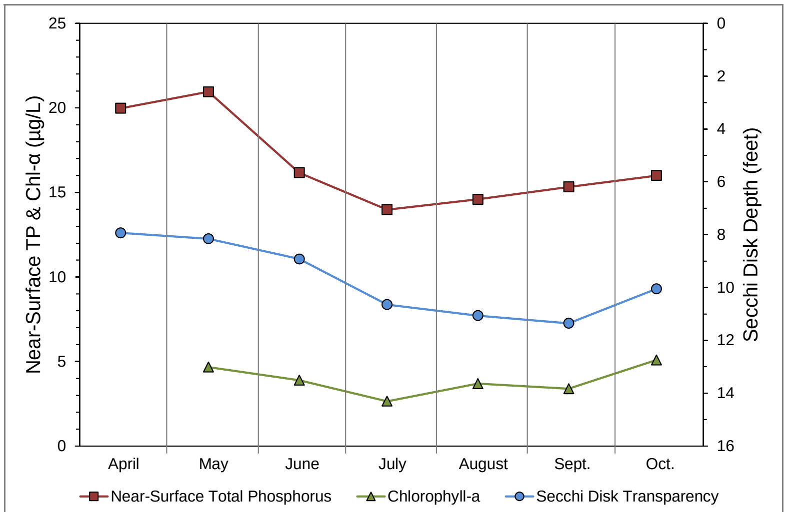


Figure 3.1-6. Spider Lake average monthly near-surface total phosphorus, chlorophyll-α, and Secchi disk depth. Monthly averages calculated using data from 1998-2020.

or negative) in chlorophyll-*a* concentrations over the period from 2004-2021. The potential explanation for why a corresponding increase in chlorophyll has not been observed with increasing phosphorus is discussed later in the Spider Lake Water Quality Trends subsection.

Average monthly chlorophyll-*a* concentrations are slightly higher in May before declining and remaining relatively stable during the summer (Figure 3.1-6). In October, concentrations increase again slightly, likely as a result of small nutrient pulse following fall mixing. Spider Lake's average summer chlorophyll-*a* concentration was also compared against concentrations available from upstream lakes (Figure 3.1-8). Like with TP, Spider Lake has the lowest average summer chlorophyll-*a* concentrations when compared to these other nine lakes.

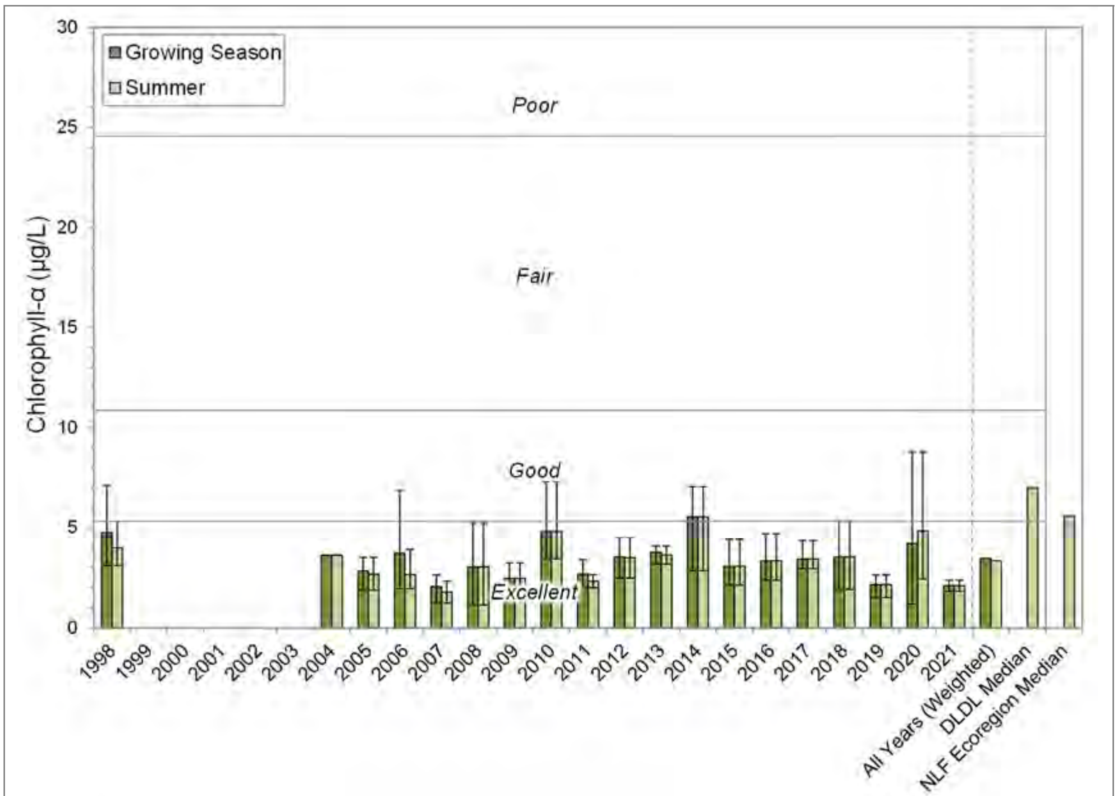


Figure 3.1-7. Spider Lake average annual chlorophyll-α concentrations and median chlorophyll-α concentrations for statewide deep lowland drainage lakes (DLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

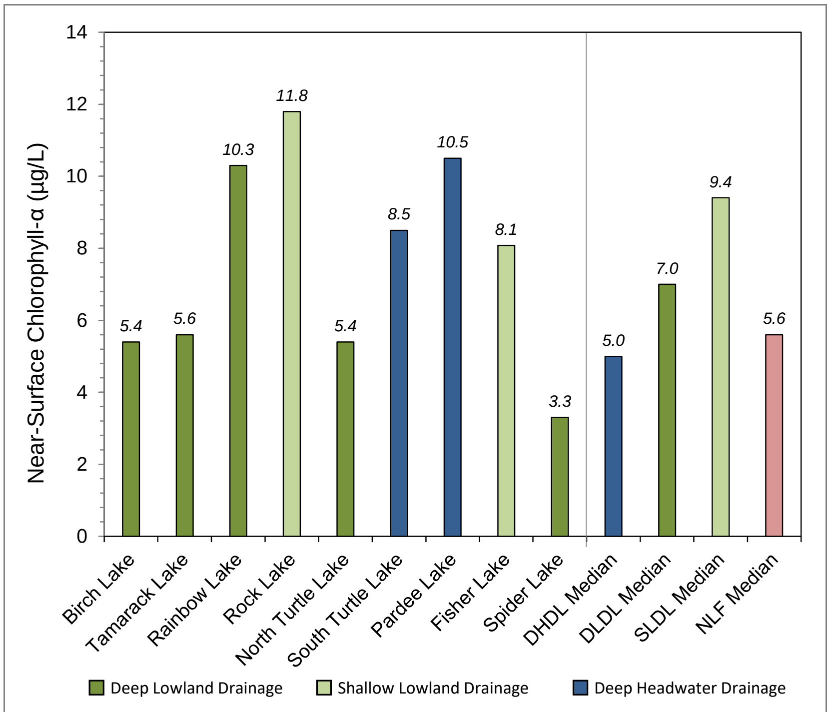


Figure 3.1-8. Spider Lake average summer chlorophyll-α concentrations compared to concentrations in upstream lakes. Water Quality Index values adapted from WDNR PUB WT-913. DHDL = Deep Headwater Drainage Lake; SLDL = Shallow Lowland Drainage Lake; SLDL = Shallow Lowland Drainage Lake; NLF = Northern Lakes and Forests Ecoregion

Water Clarity

Water clarity monitoring using Secchi disk depths has been conducted at Spider Lake's deep hole sampling location annually from 1998-2021 (Figure 3.1-9). Average summer Secchi disk depths have ranged from 14.2 feet in 2000 to 5.5 feet in 2018. The weighted summer average Secchi disk depth over this time period is 10.1 feet, indicating Spider Lake's water clarity is considered *excellent* for Wisconsin's deep lowland drainage lakes. Summer Secchi disk depths in 2020 and 2021 were slightly below the long-term average. On average, Spider Lake's Secchi disk depths are higher than median depths for other deep lowland drainage lakes in Wisconsin and all lake types within the NLF ecoregion. When compared to nine upstream lakes in the Turtle River Watershed, Spider Lake on average has the highest summer water clarity (Figure 3.1-10).

Examination of monthly average Secchi disk depths shows that water clarity in Spider Lake is lowest in April and May corresponding with the highest phosphorus and chlorophyll concentrations (Figure 3.1-6). Water clarity tends to increase over the course of the summer reaching a maximum in September before declining slightly in October. As is discussed in the subsequent Spider Lake Water Quality Trends subsection, there has been a marked decline in average water clarity beginning around 2005.

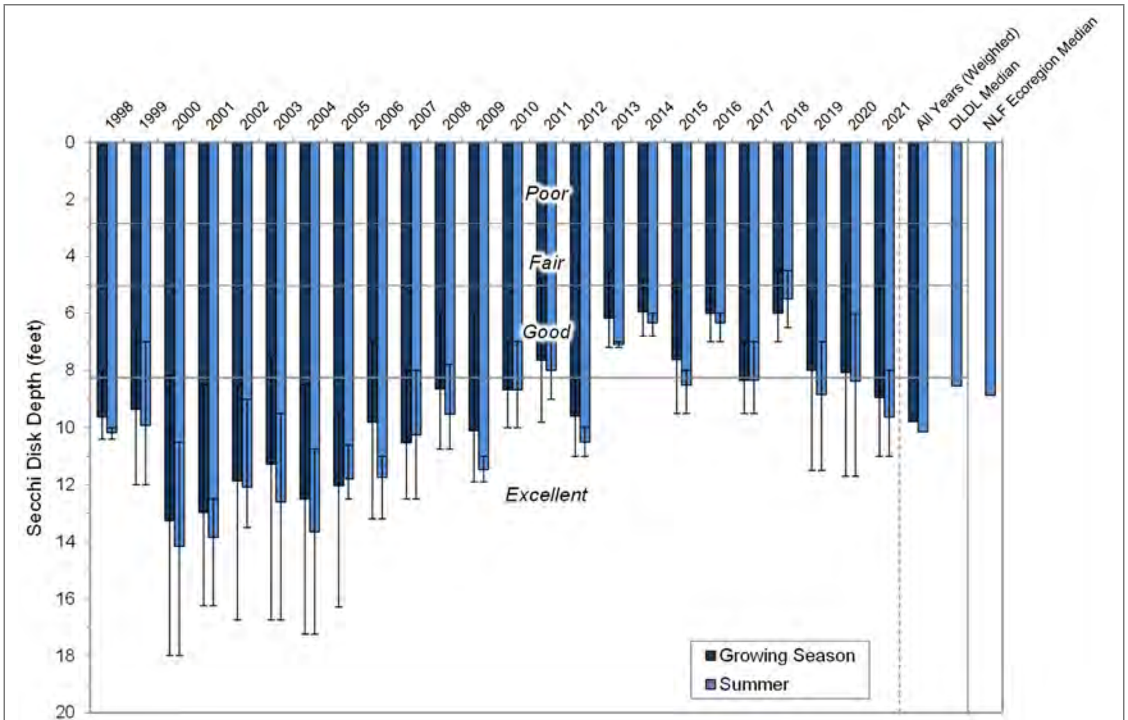


Figure 3.1-9. Spider Lake average annual Secchi disk depth measured at the deep hole sampling location and median Secchi disk depth for state-wide deep lowland drainage lakes (DLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

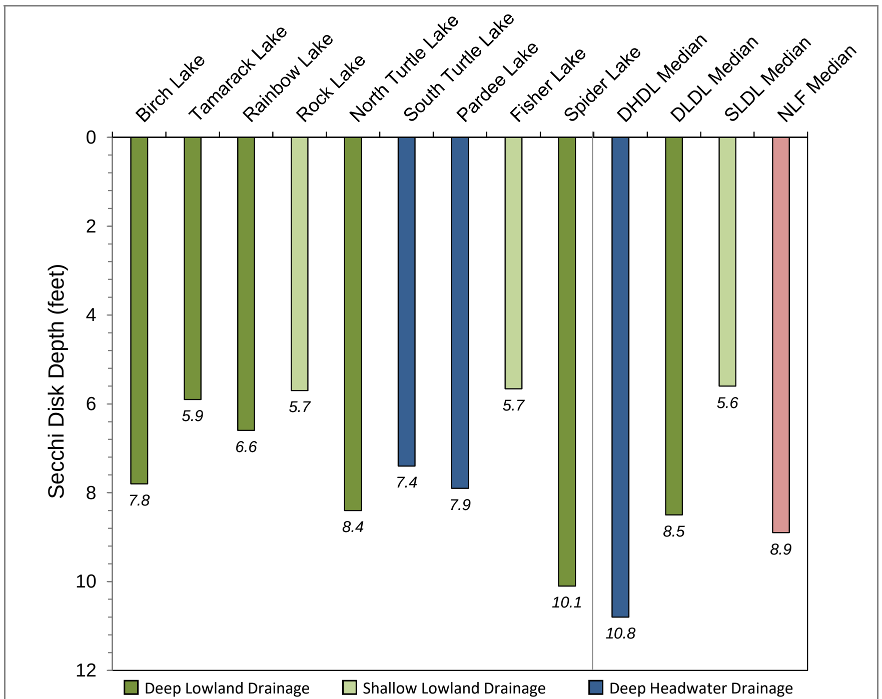


Figure 3.1-10. Spider Lake average summer Secchi disk depth compared to average Secchi disk depths in upstream lakes. Water Quality Index values adapted from WDNR PUB WT-913. DHDL = Deep Headwater Drainage Lake; SLDL = Shallow Lowland Drainage Lake; SLDL = Shallow Lowland Drainage Lake; NLF = Northern Lakes and Forests Ecoregion

Spider Lake Water Quality Trends

As mentioned previously, SLA volunteers have been collecting water quality data from Spider Lake on an annual basis since 1998. The collection of these data are invaluable as they allow for an assessment of water quality dynamics over the given period. As mentioned earlier, regression analysis revealed that there has been a statistically valid increase in phosphorus concentrations (R^2 = 0.35; p-value = 0.009) from 2004-2020 and a statistically valid decrease in water clarity (R^2 = 0.52; p-value < 0.001) over this same time period (Figure 3.1-11). Despite the increase in phosphorus over this time period, chlorophyll-*a* concentrations have not exhibited a corresponding increase (R^2 = 0.03; p-value = 0.225).

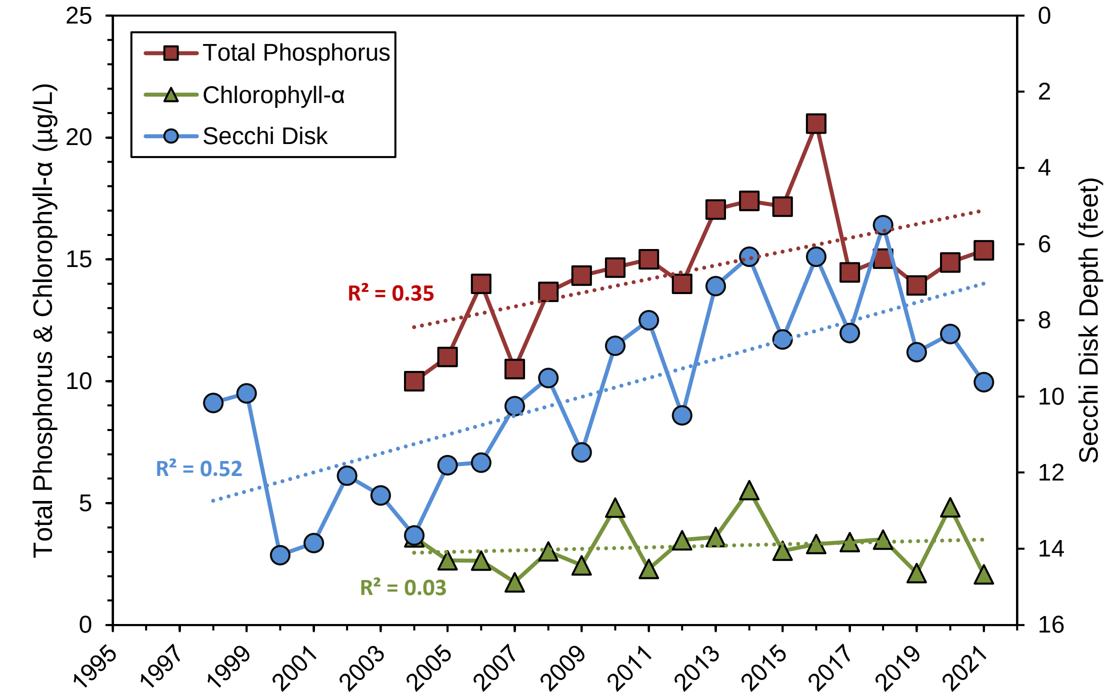


Figure 3.1-11. Spider Lake average summer Secchi disk depth compared to average Secchi disk depths in upstream lakes. Water Quality Index values adapted from WDNR PUB WT-913. DHDL = Deep Headwater Drainage Lake; SLDL = Shallow Lowland Drainage Lake; SLDL = Shallow Lowland Drainage Lake; NLF = Northern Lakes and Forests Ecoregion

When increasing trends in TP are observed, lake managers first examine the lake's watershed to determine if any significant disturbances (e.g., residential development, agriculture, clear-cutting, etc.) have occurred that may be resulting in increased nutrient runoff to the lake. Examination of Spider Lake's watershed using aerial imagery available from 1992-2018 did not reveal any significant changes in land cover, indicating the increasing trend in TP is not likely due to anthropogenic disturbances within the watershed.

Changes in TP concentrations from year to year can often be attributed to changes in precipitation and the amount of external runoff that enters the lake. To determine if changes in precipitation could account for the increasing TP trend observed in Spider Lake, annual precipitation data were obtained from a monitoring station in nearby Hurley, WI. Analysis of these data showed that there is a relatively strong positive correlation between average summer TP concentrations in Spider Lake and annual June precipitation (Figure 3.1-12). Precipitation in June has increased by approximately two inches over the period from 2004-2021. Some upstream lakes such as Rock and North Turtle lakes have also seen increasing trends in TP over this period.

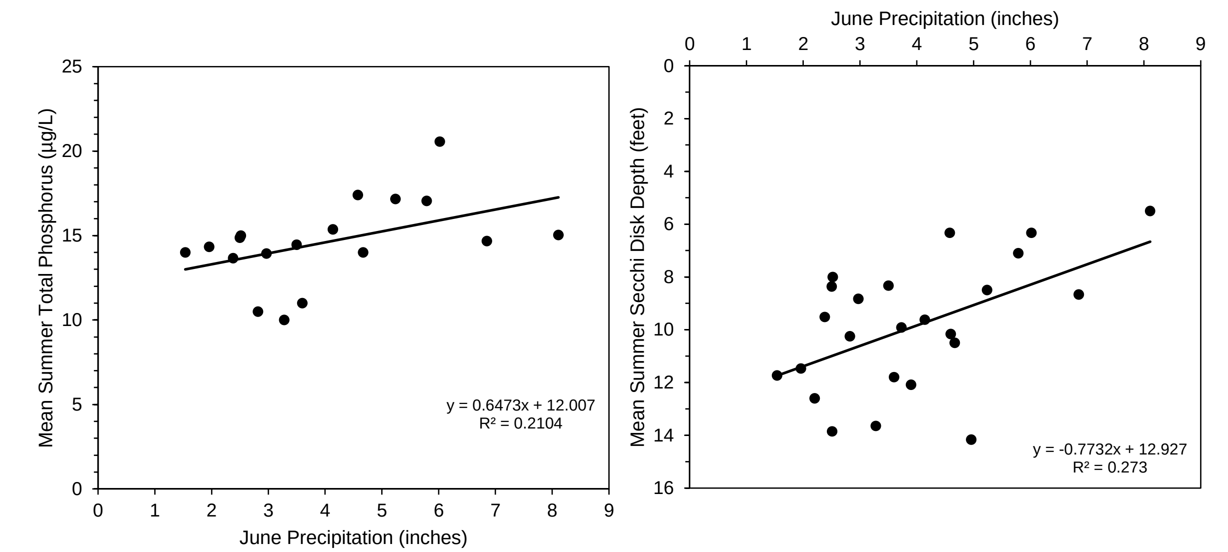


Figure 3.1-12. Spider Lake 2004-2021 mean summer total phosphorus plotted against June precipitation (left) and 1998-2021 Secchi disk depth plotted against June precipitation (right). Higher rates of precipitation over this period are the most likely explanation for increasing phosphorus and reductions in water clarity due to increases in dissolved organic matter (DOM).

Despite the increase in TP concentrations from 2004-2021, chlorophyll-*a* concentrations have not increased and have remained stable over this period. While phosphorus was identified as the primary nutrient controlling algal production in Spider Lake, this indicates that another factor is regulating algal growth and maintaining low chlorophyll-*a* concentrations despite increasing phosphorus. This other factor is believed to be the declining light availability over this period as reflected in the decreasing trend of Secchi disk depth.

The two most important factors affecting water clarity in Wisconsin's lakes are algal abundance and water color, or true color. True color is a measure of water clarity once all particulates (i.e., algae, sediments, etc.) have been filtered out and only dissolved compounds remain. Dissolved organic matter (DOM) causes the water in lakes, particularly in northern Wisconsin, to be brown in color, or stained. This DOM originates from decaying plant matter in forests and wetlands in the lake's watershed.

Studies have been showing that DOM has been increasing in lakes across North America as the result of increases in precipitation and increases in extreme precipitation events (LakeLine 2020). Higher rates of precipitation cause increases in DOM in a couple of ways: first, higher precipitation saturates soils which creates anoxic conditions which increases the production of DOM, and second, higher precipitation increases the amount of water and DOM flowing into the lake. Like with TP, there is a strong correlation between June precipitation and average summer Secchi disk depth from 2004-2020 – as precipitation increases, water clarity declines (Figure 3.1-12). There was no relationship between precipitation and chlorophyll concentrations.

The fact that Spider Lake has seen marked declines in its water clarity despite no measurable increase in algal abundance is an indicator that increases in DOM over this period have resulted in darker water and lower water clarity. Phosphorus input to the lake also tends to increase with increasing DOM input. While it would be expected that increasing phosphorus would result in higher algal production, the darker water and decreased light penetration caused by DOM suppresses algal production. In fact, the relationship between phosphorus and water clarity over this period is more highly correlated than that of phosphorus and chlorophyll.

This decline in water clarity due to increases in DOM has been observed in other regional lakes studied by Onterra. True color measurements collected from Spider Lake in 2020 indicate that the lake is *tea colored* (Figure 3.1-13), and likely contains more DOM at present than it did during the first decade of the 2000s. It is important to note that the decline in Spider Lake's water clarity and slight increase in phosphorus are driven by natural processes and are not due to human activity, and this is not an indication of degrading conditions. Water clarity would be expected to increase if precipitation lessens in the coming years.

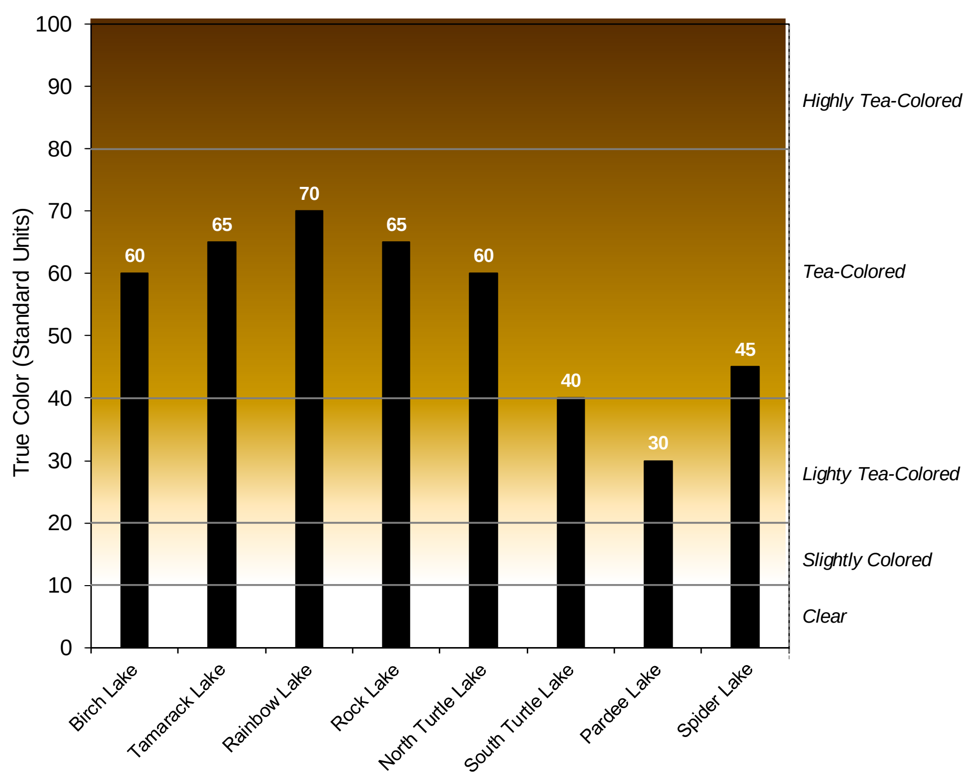


Figure 3.1-13. Spider Lake 2020 true color and true color values for seven upstream lakes in the Turtle River Watershed. These values indicate that most of these lakes have tea-colored or stained, dark water which reduces light penetration. Increases in precipitation has likely resulted in higher inputs of dissolved organic matter (DOM) and darker, less transparent water.

Spider Lake Trophic State

The Trophic State Index (TSI) values for Spider Lake were calculated using summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency data collected as part of this project along with historical data (Figure 3.1-14). In general, the best values to use in judging a lake's

trophic state are the biological parameters of total phosphorus and chlorophyll-*a* as Secchi disk transparency can be influenced by factors other than algae.
Spider Lake's TSI values for phosphorus and chlorophyll have ranged from oligo-mesotrophic to mesotrophic. The lake's productivity increased from oligo-mesotrophic to mesotrophic from 2004-2016 before declining to a lower-mesotrophic state from 2017-2021. The weighted average TSI value indicates that Spider Lake can be classified as a mesotrophic or moderately productive system. This productivity level is lower when compared to the majority of other deep lowland drainage lakes in Wisconsin which tend to me meso-eutrophic and lower than all lake types in the NLF ecoregion which tend to be upper-mesotrophic.

The weighted TSI values for phosphorus and chlorophyll are very similar, indicating that there is a high degree of correlation between phosphorus and chlorophyll concentrations. The weighted average TSI value for Secchi disk depth is slightly higher, indicating that the lake's water clarity is influenced by other factors in addition to algae. As discussed previously, this other factor is DOM, which creates the tea-like, stained water found in Spider Lake.

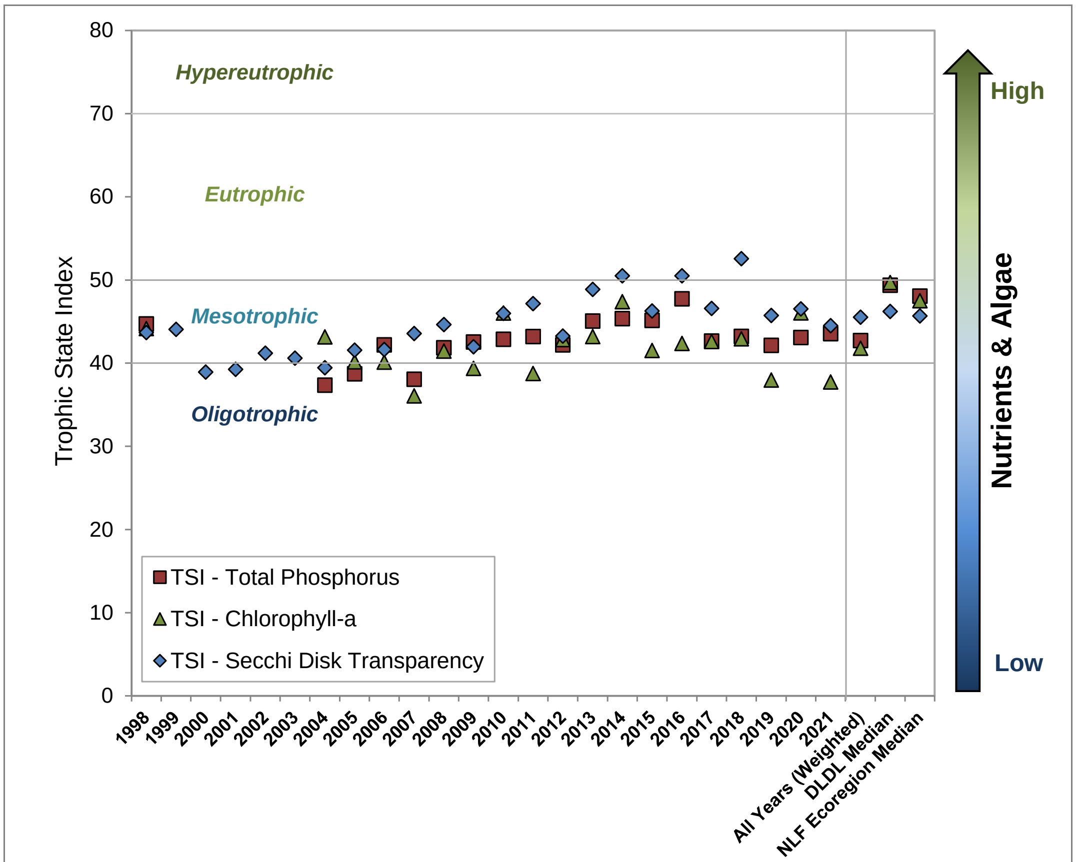


Figure 3.1-14. Spider Lake, state-wide deep lowland drainage lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Spider Lake

Dissolved oxygen and temperature were measured during the growing season of 2020 through a combination of SLA volunteers and Onterra. A profile was also collected through the ice by Onterra in February of 2021. Profiles depicting these data are displayed in Figure 3.1-15. As discussed previously, Spider Lake is dimictic, meaning that the lake remains stratified during the summer (and inversely stratified in winter) and completely mixes, or turns over, once in spring and again in fall. During the summer, the surface of the lake warms and becomes less dense than the cold layer below, and the lake thermally stratifies. Spider Lake is deep enough where wind and water movement are not sufficient during the summer to mix these layers together, only the warmer upper layer will mix. As a result, the bottom layer of water no longer receives atmospheric diffusion of oxygen and decomposition of organic matter within this layer causes oxygen levels to decline over the course of the summer.

In the fall, as surface temperatures cool, the entire water column is again able to mix, which re-oxygenates the hypolimnion. During the winter, the coldest temperatures are found just under the overlying ice as water is densest at 39 °F, while oxygen gradually declines once again towards the bottom of the lake. In February 2021, Spider Lake was found to support sufficient levels of dissolved oxygen under the ice throughout most of the water column. This indicates that winter fish kills are not a concern on Spider Lake.

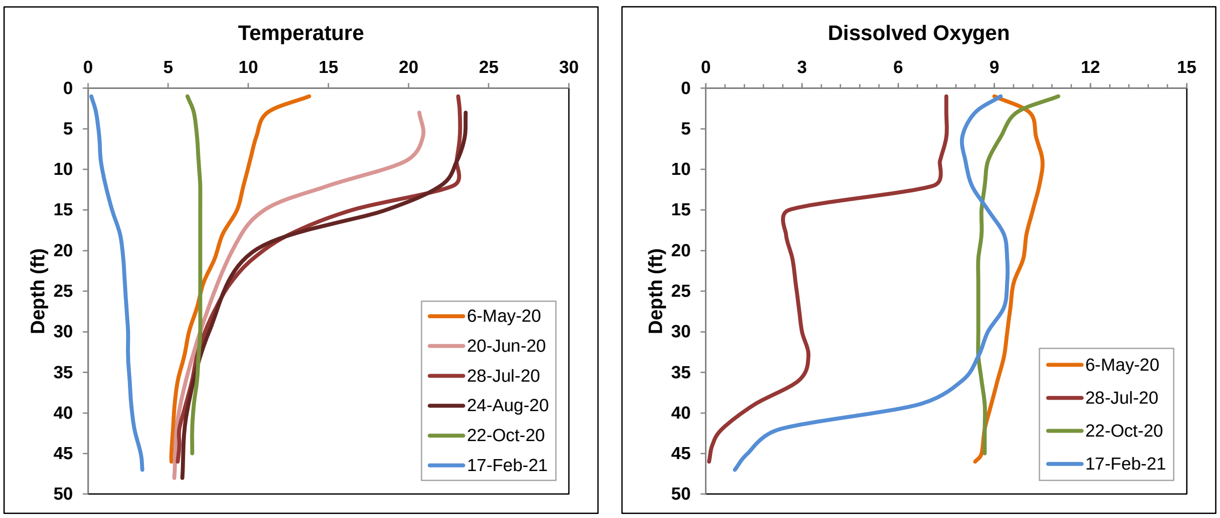


Figure 3.1-15. Spider Lake 2020 growing season and winter 2021 temperature and dissolved oxygen profiles. Collected by SLA volunteers and Onterra ecologists from the deep hole sampling location.

Additional Water Quality Data Collected at Spider Lake

The previous sections were largely centered on parameters related to lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of Spider Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity (Figure 3.1-16). Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic, meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to

8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw & Nimphius, 1985). The mid-summer pH of the water in Spider Lake was found to be just above neutral (slightly alkaline) with a value of 7.3 and falls within the normal range for Wisconsin Lakes (Figure 3.1-16).

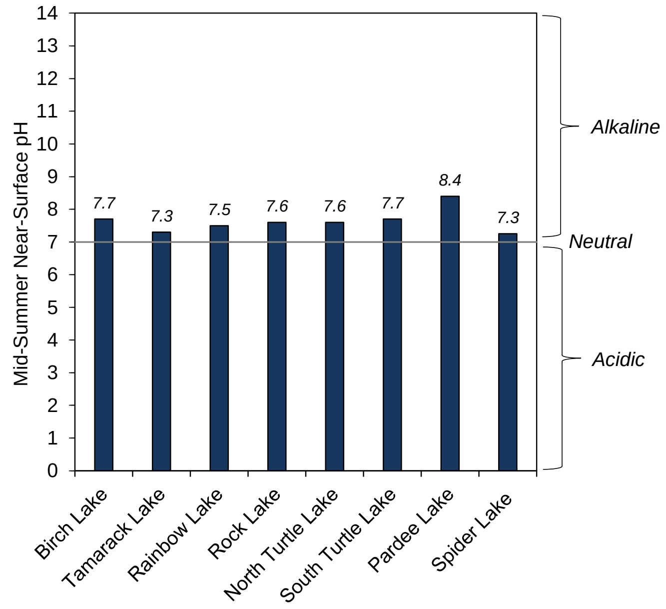


Figure 3.1-16. pH scale and Spider Lake mid-summer near-surface pH compared to pH of upstream lakes.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3)_2$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Spider Lake was measured at 35.6 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and is not sensitive to acid rain (Figure 3.1-17).

Similar to alkalinity is water hardness. While alkalinity is a measure of a lake's capacity to resist acidic changes in pH, water hardness is the combined concentration of dissolved calcium and magnesium in the water. Lakes in Wisconsin range from soft water lakes with little to no dissolved minerals to very hard water lakes with high concentrations of dissolved minerals. As is discussed in the Aquatic Plant Section (Section 3.3), alkalinity and associated water hardness are the most important factors driving aquatic plant community composition. Water hardness in Spider Lake in 2020 was 33.9 mg/L, falling below 60 mg/L and indicating that Spider

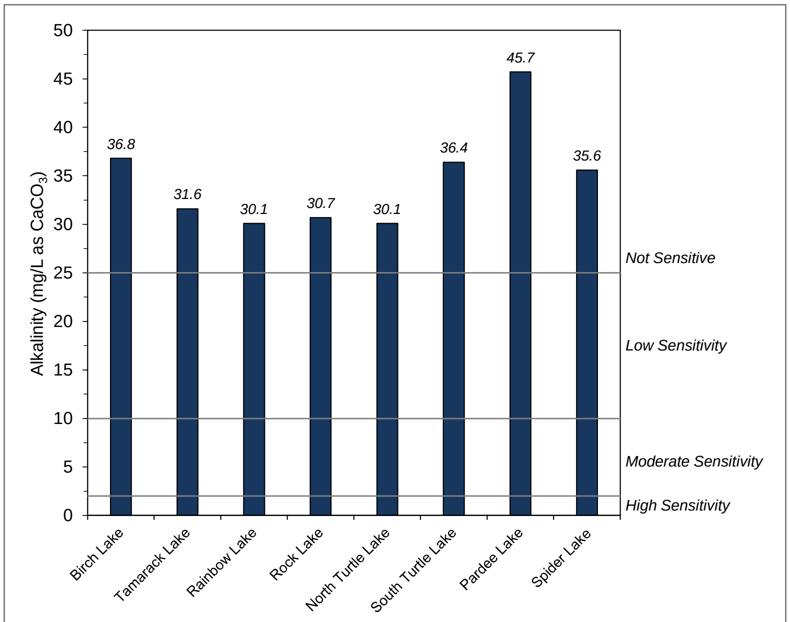


Figure 3.1-17. Spider Lake and upstream lakes' alkalinity values and sensitivity to acid rain.

Lake is considered a softwater lake.

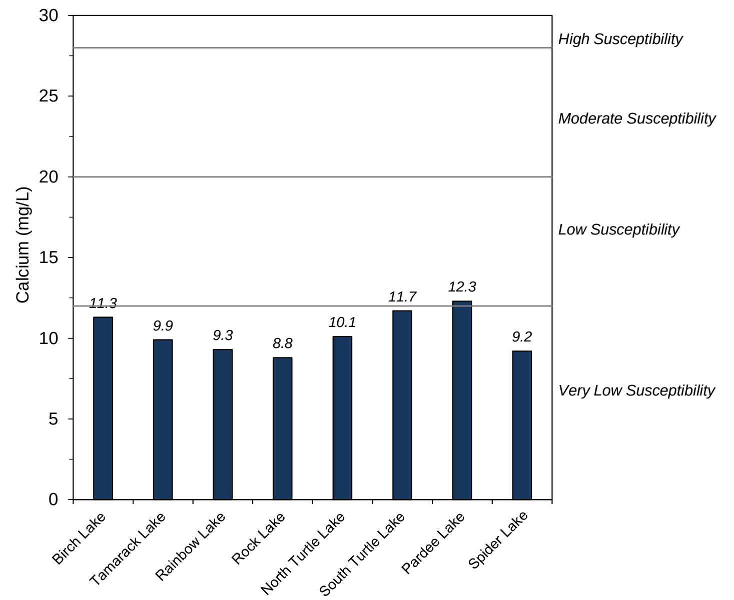


Figure 3.1-18. Spider Lake and upstream lakes' near-surface calcium concentrations and zebra mussel susceptibility.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Spider Lake's pH of 7.3 falls inside this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Spider Lake was found to be 9.2 mg/L, falling below the optimal range for zebra mussels (Figure 3.1-18).

Zebra mussels (*Dreissena polymorpha*) are a small, bottom-dwelling mussels native to Europe and Asia that found their way to the Great Lakes region in the mid-1980s. They are thought to have come into the region through ballast water of ocean-going ships entering the Great Lakes, and they have the capacity to spread rapidly. Zebra mussels can attach themselves to boats, boat lifts, and docks, and can live for up to five days after being taken out of the water. These mussels can be identified by their small size, D-shaped shell and yellow-brown striped coloring. Once zebra mussels have entered and established in a waterway, they are nearly impossible to eradicate. Best practice methods for cleaning boats that have been in zebra mussel infested waters is inspecting and removing any attached mussels, spraying your boat down with diluted bleach, power-washing, and letting the watercraft dry for at least five days.

Stakeholder Survey Responses to Spider Lake Water Quality

As discussed in section 2.0, the stakeholder survey asks many questions pertaining to perception of the lake and how it may have changed over the years. Figure 3.1-19 displays the responses of members of Spider Lake stakeholders to questions regarding water quality and how they believe it has changed over their years visiting Spider Lake. When asked what was the most important aspect regarding water quality, 45% responded that water clarity (clearness of the water) was the most important aspect, 29% indicated aquatic plant growth (not including algae blooms), and 9% indicated water levels (Figure 3.1-19). The remaining 17% of respondents selected either algae blooms, water color, smell, fish kills, or other.

When asked how to describe Spider Lake's current water quality, 58% of respondents indicated the current water quality was *excellent*, 28% indicated it was *good*, and 14% indicated it was *fair* (Figure 3.1-19). No respondents indicated the lake's current water quality was *poor* or *very poor*.

These responses align with the data discussed previously that indicate Spider Lake's water quality is excellent for a deep lowland drainage lake in Wisconsin.

Respondents were also asked how they believe Spider Lake's water quality has changed since they first visited the lake. The majority of respondents, 77%, indicated that the lake's water quality has remained the same, 17% indicated the water quality has somewhat degraded, 2% indicated it has severely degraded, 2% indicated it has somewhat improved, and the remaining 2% indicated it has greatly improved. The water quality data collected since 2004 indicate that Spider Lake's algal levels have remained relatively stable. However, there has been a significant decline in water clarity as the result of increasing DOM. Given most respondents indicated water clarity as their number one aspect when it comes to water quality, the 19% who indicated water quality has somewhat or severely degraded may be perceiving the darkening of the water and reduction in water clarity.

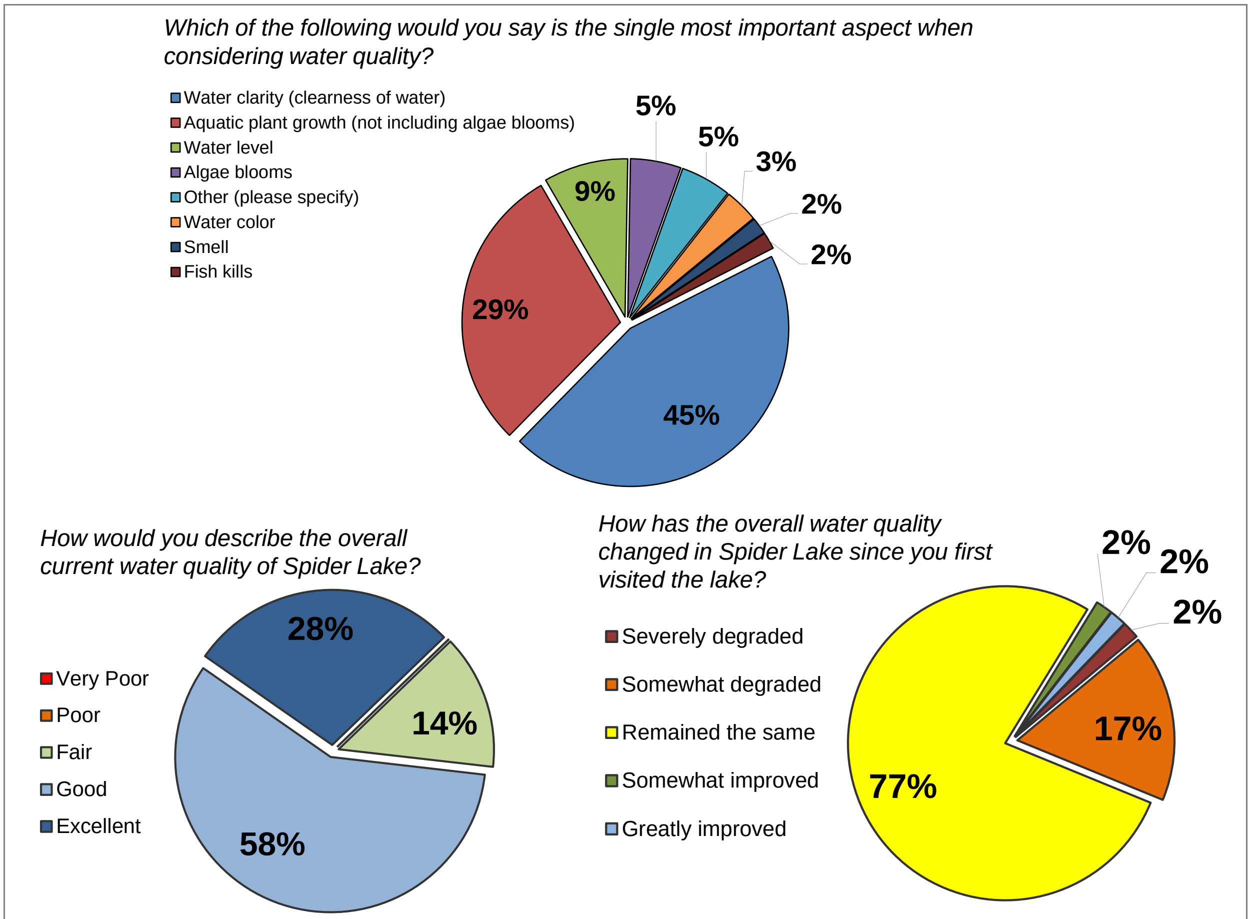


Figure 3.1-16. Stakeholder survey response Question #17. How would you describe the overall current water quality of Spider Lake?

3.2 Watershed Assessment

Two aspects of a lake's watershed are the key factors in determining the amount of phosphorus the watershed exports to the lake: 1) the land cover (land use) within the watershed and 2) the size of the watershed. The type of land cover and the amount of that land cover that exists in the watershed is largely going to determine the amount of phosphorus (and sediment) that runs off the land and eventually makes its way to the lake. The actual amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Areas within a lake's watershed that are naturally vegetated (e.g., forests, grasslands, and wetlands) strongly influence the way water behaves on the land surface after it falls as precipitation or is released by the melting of snow (Silk & Ciruna, 2005).

Runoff is slowed down in areas with denser vegetation and increases the time it takes for precipitation from a storm event to reach the lake. This allows more water to soak into the soil and reduces the potential for flooding. Intact wetlands within a lake's watershed have been likened to the "kidneys of the landscape" as they filter out nutrients, sediments, and other pollutants from water which passes through them (Silk & Ciruna, 2005). The water quality within a lake is largely a reflection of the health of its watershed, and maintaining natural land cover within a lake's watershed is essential for maintaining good water quality.

Among the largest threats to a lake's water quality is the conversion of natural areas to agriculture and urban development. Conversion of natural areas to agriculture disrupts the hydrologic regime and increases surface runoff due to increased soil compaction and reduced water infiltration. Wetlands which were drained and converted to farmland were shown to increase runoff by 200-400% (Silk & Ciruna, 2005). Agriculture accounts for 60% of the pollutants in lakes and rivers in the United States due to increased runoff in combination with the application of fertilizers, pesticides, and manure.

Similar to agriculture, urban development can significantly alter the hydrologic regime within a watershed, primarily through the installation of impervious surfaces (e.g., roads, driveways, roof-tops) which decrease water infiltration and increase runoff. As impervious surface cover increases, the time it takes water from a storm event to reach the lake decreases. With the increase in water velocity and volume entering the water body, nutrient and sediment input also increase, degrading water quality. Nutrient input can also increase from urban areas as the result of fertilizer application, wastewater treatment facilities, and other industrial activities.

As is discussed further in this section, Spider Lake's watershed is largely comprised of intact forests and wetlands with minimal amounts of agricultural or urban development. In the forested watersheds of northern Wisconsin where soils and climate are not as conducive for farming, apart from shoreland development (discussed in the next section) forestry or timber harvest likely represents the largest man-made disturbance occurring in these watersheds. While timber harvest has the potential to increase sediment erosion through the removal of vegetation and construction of access roads and bridges, the impacts of timber harvest to a lake's water quality are going to be highly dependent upon harvest rates and methods, vegetation management, and the location and size of these activities within the watershed (Silk & Ciruna, 2005).

Wisconsin is required by federal law to develop and implement a program of best management practices (BMPs) to reduce nonpoint source pollution, including from timber harvesting activities

(WDNR PUB FR-093 2010). In summary, forestry activities within Spider Lake's watershed are being implemented under this framework and should not impart significant impacts to the lake's water quality or its tributaries.

In addition to land cover within the watershed, the size of the watershed relative to the water volume within the lake also influences water quality. The watershed to lake area ratio (WS:LA) defines how many acres of watershed drain to each surface-acre of the lake. Larger ratios result in the watershed having a greater role in the lake's annual water budget and phosphorus load. In systems with lower WS:LA ratios, land cover type plays a very important role in how much phosphorus is loaded to the lake from the watershed. In these systems, the occurrence of agriculture or urban development in even a small percentage of the watershed (less than 10%) can unnaturally elevate phosphorus inputs to the lake. If these land cover types are converted to a cover that does not export as much phosphorus, such as converting row crop areas to grasslands or forested areas, the phosphorus load and its impacts to the lake may be decreased. In fact, if the phosphorus load is reduced greatly, changes in lake water quality may be noticeable, (e.g., reduced algal abundance and better water clarity) and may even be enough to cause a shift in the lake's trophic state.

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

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

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

Watershed Modeling

A reliable and cost-efficient method of creating a general picture of a watershed's effect on a lake can be obtained through modeling. The WDNR created a useful suite of modeling tools called the Wisconsin Lake Modeling Suite (WiLMS). Certain morphological attributes of a lake and its watershed are entered into WiLMS along with the acreages of different types of land cover within the watershed to produce useful information about the lake ecosystem. This information includes an estimate of annual phosphorus load and the partitioning of those loads between the watershed's different land cover types and atmospheric fallout entering through the lake's water surface.

WiLMS also calculates the lake's flushing rate and residence times using county-specific average precipitation/evaporation values or values entered by the user. Predictive models are also included within WiLMS that are valuable in validating modeled phosphorus loads to the lake in question and modeling alternate land cover scenarios within the watershed. Finally, if specific information is available, WiLMS will also estimate the significance of internal nutrient loading within a lake and the impact of shoreland septic systems.

Spider Lake Watershed Assessment

Spider Lake's watershed encompasses approximately 33,696 acres or approximately 53 square miles across portions of Iron and Vilas counties in Wisconsin and Gogebic County in Michigan (Figure 3.2-1 and Map 2). The lake's primary tributary is the Turtle River which enters on the lake's northeast side. A smaller tributary flows into the west side of Spider Lake's north basin from the nearby Viola Lake. Spider Lake is drained via the Turtle River on the northwest side of the southern basin. From there, water flows through a series of lakes until the Turtle River terminates in the Turtle Flambeau Flowage.

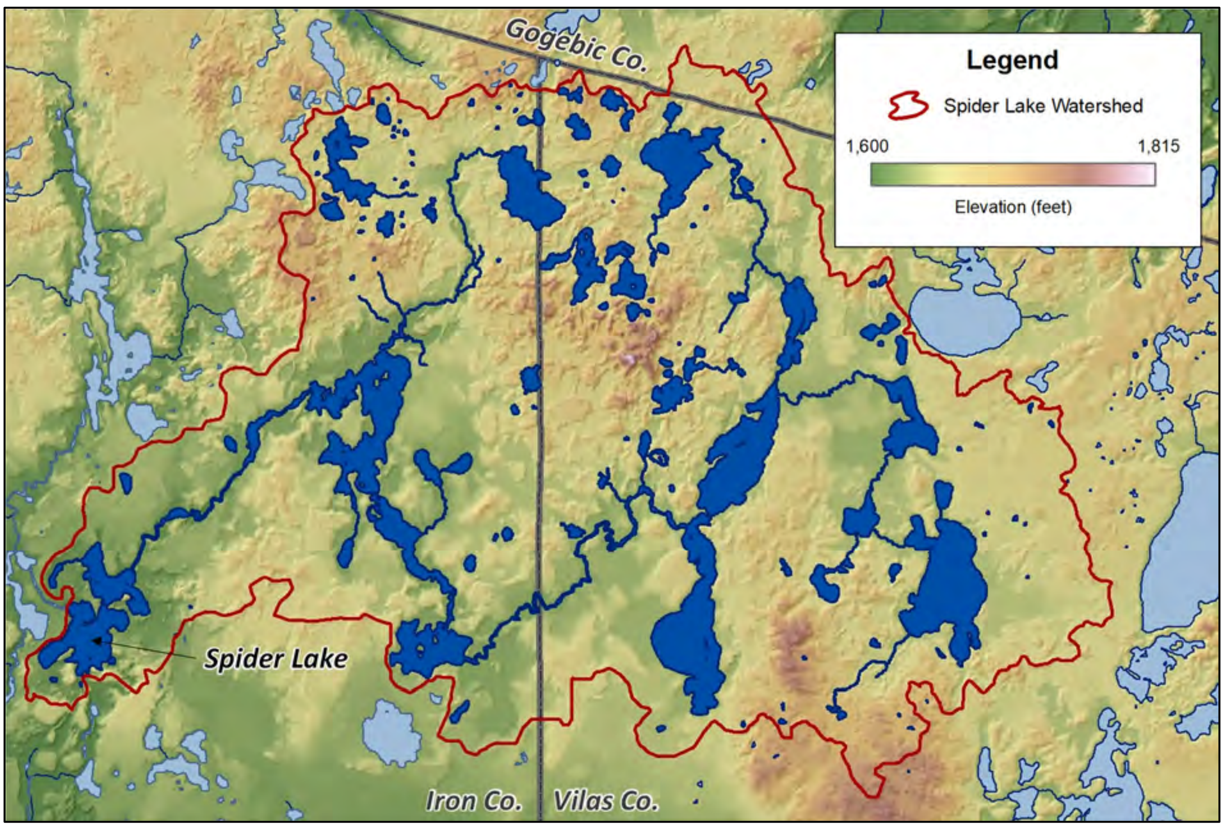


Figure 3.2-1. Spider Lake watershed and land elevation. Dark blue indicates upstream waterbodies within Spider Lake's watershed.

For modeling purposes, Spider Lake's watershed was divided into main subwatersheds: the Fisher Lake subwatershed and the Spider Lake direct watershed (Figure 3.2-2 and Map 2). Approximately 89% of Spider Lake's watershed is comprised of the Fisher Lake subwatershed while the remaining 11% is comprised of Spider Lake's direct watershed. Using total phosphorus data measured from Fisher Lake along with water outflow estimates from WiLMS, the annual phosphorus load from the Fisher Lake subwatershed was calculated. WiLMS was also utilized to estimate phosphorus inputs from land cover within Spider Lake's direct watershed and through atmospheric deposition onto the lake's surface. Phosphorus loading estimates from the Fisher Lake subwatershed and the direct watershed were combined to estimate the total amount of annual phosphorus being loaded to Spider Lake.

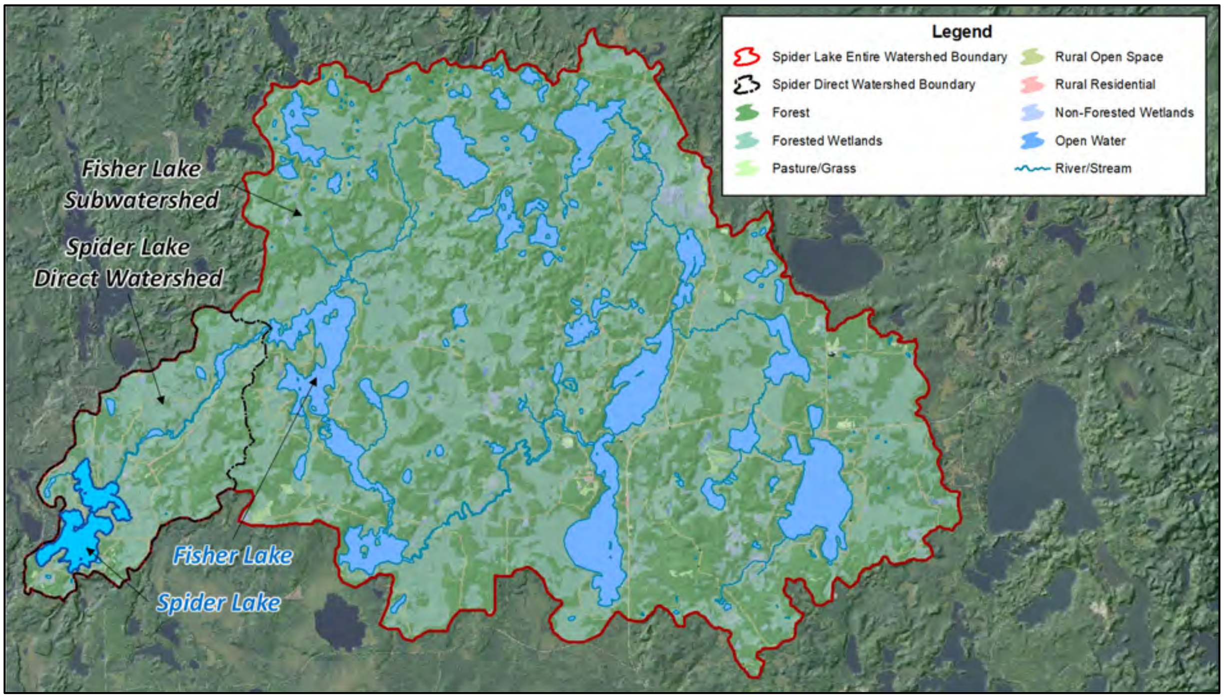


Figure 3.2-2. Spider Lake watershed and land cover types. Based upon National Land Cover Database (USGS 2019).

The 2016 land cover data indicate that Spider Lake's direct watershed is comprised of wetlands (52%), upland forests (31%), Spider Lake's surface (10%), pasture/grassland (7%), and rural residential areas (<1%) (Figure 3.2-2 and Figure 3.2-3). The vast majority of the landcover within the Fisher Lake subwatershed is also undeveloped, with 94% comprised of intact wetlands, open water, and upland forests.

Using the land cover types and their acreages within Spider Lake's direct watershed along with the estimated outflow of phosphorus from the Fisher Lake subwatershed, WiLMS was utilized to estimate the annual potential phosphorus load delivered to Spider Lake from its watershed. In addition, using data obtained from the 2020 stakeholder survey, an estimate of potential phosphorus loading to the lake from riparian septic systems was also incorporated into the model. The WiLMS model estimated that approximately 2,529 pounds of phosphorus are delivered to Spider Lake from its watershed on an annual basis (Figure 3.2-4).

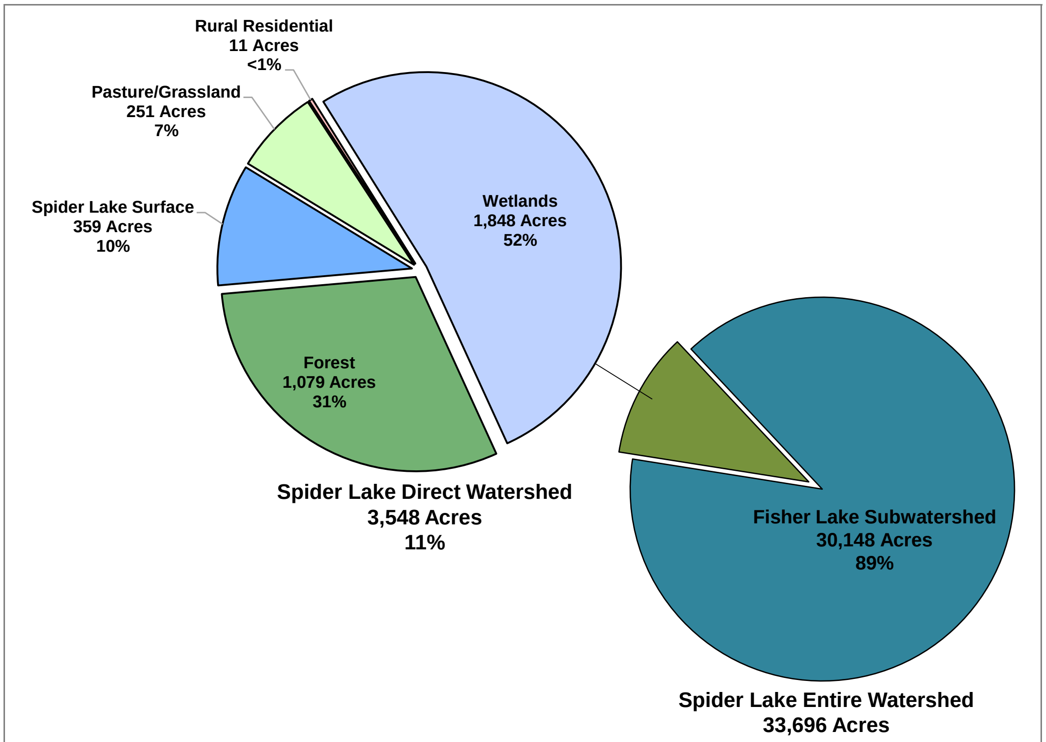


Figure 3.2-3. Spider Lake watershed and proportion of direct watershed land cover types used in WiLMS modeling. Based upon National Land Cover Database (USGS 2019).

Approximately 84% of the annual loading (2,134 lbs) originates from the Fisher Lake subwatershed while the remaining 16% (395 lbs) originates from Spider Lake's direct watershed and atmospheric deposition onto the lake's surface (Figure 3.2-4). Within Spider Lake's direct watershed, 7% (165 lbs) of the phosphorus originates from wetlands, 3% (86 lbs) from upland forests, 3% (68 lbs) from pasture/grassland, 3% (64 lbs) from atmospheric deposition, and <1% (12 lbs) is estimated to originate from riparian septic systems.

Using the estimated annual potential phosphorous load of 2,589 pounds, WiLMS predicted that the in-lake average growing season total phosphorus concentration of 19 µg/L, which is slightly higher than 2004-2020 measured average of 16.1 µg/L. This means that WiLMS is slightly overestimating the annual phosphorus load. To achieve an in-lake growing season concentration of 16.1 µg/L, the actual annual phosphorus load is likely closer to 2,100 pounds. Overall, the model indicates that there are no significant sources of unaccounted phosphorus (e.g., internal nutrient loading) being loaded to the lake at this time. Spider Lake's watershed is largely undeveloped, with the majority being comprised of intact wetlands and forests. Conservation of these natural areas is critical for maintaining the high water quality found in Spider Lake and the other waterbodies within the Turtle River Watershed.

The WiLMS model estimated that Spider Lake has a water residence time of approximately 0.16 years or nearly two months. In other words, on average, the water in Spider Lake is completely replaced once every two months, or approximately six times per year. The large amount of water gathered from its watershed results in lower water residence time, or higher flushing rate.

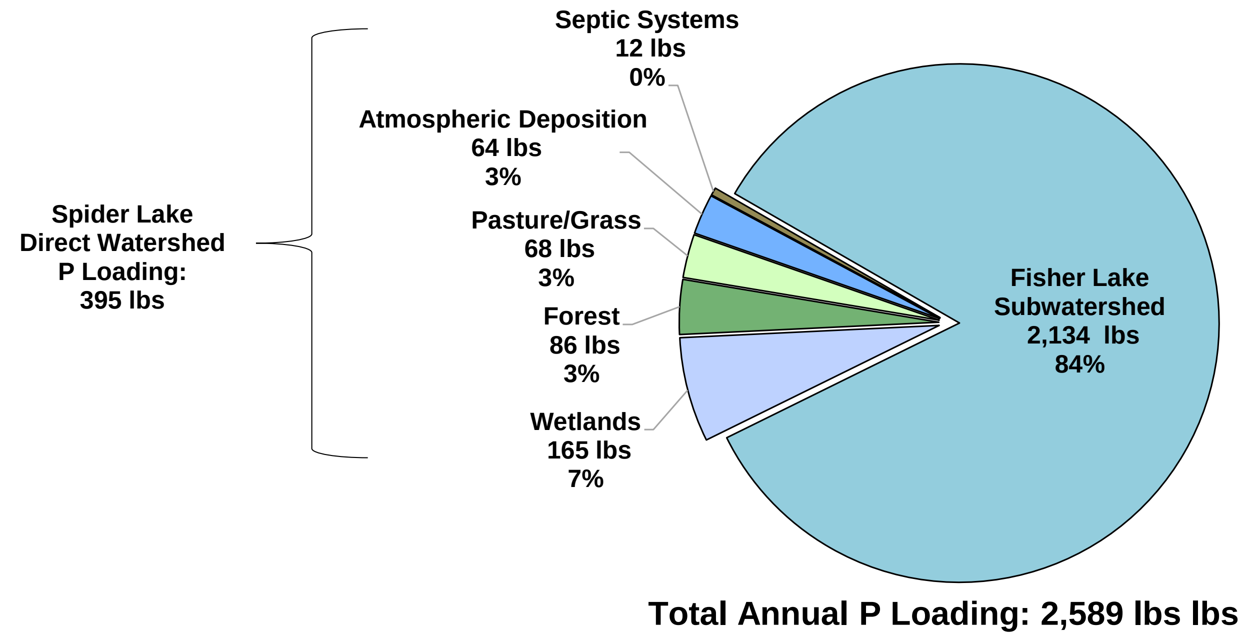


Figure 3.2-4. Spider Lake WiLMS model estimated annual watershed phosphorus loading. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates. Based on measured in-lake phosphorus, actual annual loading is likely closer to 2,100 pounds.

3.3 Paleoecology

Primer on Paleoecology and Interpretation

Questions often arise concerning how a lake's water quality has changed through time as a result of watershed disturbances. In most cases, there is little or no reliable long-term data. They also want to understand when the changes occurred and what the lake was like before the transformations began. Paleoecology offers a way to address these issues. The paleoecological approach depends upon the fact that lakes act as partial sediment traps for particles that are created within the lake or delivered from the watershed. The sediments of the lake entomb a selection of fossil remains that are more or less resistant to bacterial decay or chemical dissolution.

These remains include frustules (silica-based cell walls) of a specific algal group called diatoms, cell walls of certain algal species, and subfossils from aquatic plants. The diatom community is especially useful in reconstructing a lake's ecological history as they are highly resistant to degradation and are ecologically diverse. Diatom species have unique features as shown in Photo 3.3-1, which enable them to be readily identified. Certain taxa are usually found under nutrient poor conditions while others are more common under elevated nutrient levels. Some species float in the open water areas while others grow attached to substrates such as aquatic plants or the lake bottom.

The chemical composition of the sediments may indicate the composition of particles entering the lake as well as the past chemical environment of the lake itself. By collecting an intact sediment core, sectioning it off into layers, and utilizing all of the information described above, paleoecologists can reconstruct changes in the lake ecosystem over any period of time since the establishment of the lake.

The chemical composition of the sediments may indicate the composition of particles entering the lake as well as the past chemical environment of the lake itself. By collecting an intact sediment core, sectioning it off into layers, and utilizing all of the information described above, paleoecologists are able to reconstruct changes in the lake ecosystem over any period of time since the establishment of the lake.

An often-used paleoecological technique is collecting and analyzing top/bottom cores. The top/bottom core only analyzes the top (usually 1

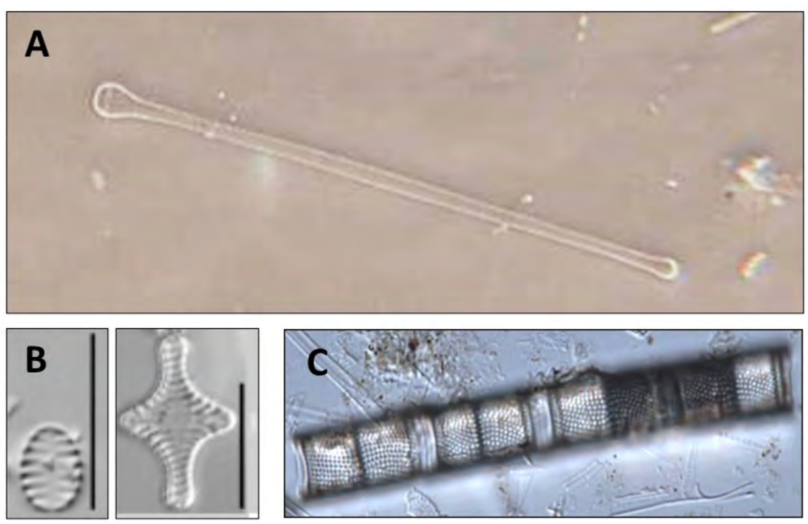


Photo 3.3-1. Photomicrographs of the diatoms commonly found in the sediment core from Spider Lake. The top diatom (A) *Asterionella formosa* is commonly found with moderate phosphorus levels but also indicates higher nitrogen concentrations. This diatom is more common in the top sample of the sediment core. *Staurosira construens* (B left) and *S. construens* var. *venter* (B right) are typically found growing on macrophytes and lake sediments. *Aulacoseira ambigua* (C) floats in the open water and is generally found in lakes with good water quality.

cm) and bottom sections. The top section represents present day conditions and the bottom section is hoped to represent pre-settlement conditions by having been deposited at least 100 years ago. While it is not possible to determine the actual date of deposition of bottom samples, a determination of the radionuclide lead-210 estimates if the sample was deposited at least 100 years ago. The primary analysis conducted on this type of core is the diatom community leading to an understanding of past nutrients, pH, and general macrophyte coverage.

Spider Lake Paleoecological Results

A sediment core was extracted from the deep area of Spider Lake on July 28, 2020 (Photo 3.3-2) to determine how the water quality and lake ecology has changed during the last century. The total length of the core was 43 cm. The top 5 cm was dark brown in color, and the rest of the core was medium brown in color. The top 1 cm was kept for diatom analysis as it is assumed to represent present day water quality conditions. The section from 40-42 cm was kept for analysis of the diatom community and radiochemical analysis. It is assumed that this section represents conditions before the arrival Euro-American settlers in the nineteenth century.

Photo 3.3-2. Photo of sediment core collected from Spider Lake.

Multivariate Statistical Analysis

In order to make a comparison of environmental conditions between the bottom and top samples of the core from Spider Lake, an exploratory detrended correspondence analysis (DCA) was performed using CANOCO 5 software (Ter Braak & Smilauer, 2012). The DCA analysis has been done on many Wisconsin lakes to examine the similarities of the diatom communities between the top and bottom samples of the same lake.

The results revealed two clear axes of variation in the diatom data, with 37% and 24% of the variance explained by axis 1 and axis 2, respectively (Figure 3.3-1). Sites with similar sample scores occur in close proximity reflecting similar diatom composition. The arrows symbolize the trend from the bottom to the top samples. In Spider Lake the top and bottom samples are very close together indicating that the diatom communities are very similar. This suggests that the water quality of Spider Lake has not changed significantly in the last 100 years.

While it is not possible to determine which were the most important environmental variables ordering the diatom communities, one trend is apparent. Axis 1 likely represents the alkalinity of the lakes. Other studies of Wisconsin and Vermont lakes indicate that the most important variable ordering the diatom communities is alkalinity. Lakes on the right side of the DCA graph tend to have the lowest alkalinity values while the highest are on the left side. A study by Eilers et al. (1989) of 149 lakes in northern Wisconsin found that as a consequence of lake shore development, alkalinity and conductivity concentrations increase. This is because of the sediment that enters the lake during cottage and road construction. Even though at the present time there is more development around these lakes than there was historically, the alkalinity has changed little in this lake. This is because Spider Lake has sufficient alkalinity such that development has not significantly changed the buffering capacity of the lakes. Very soft water lakes are much more susceptible to having their alkalinity affected by development.

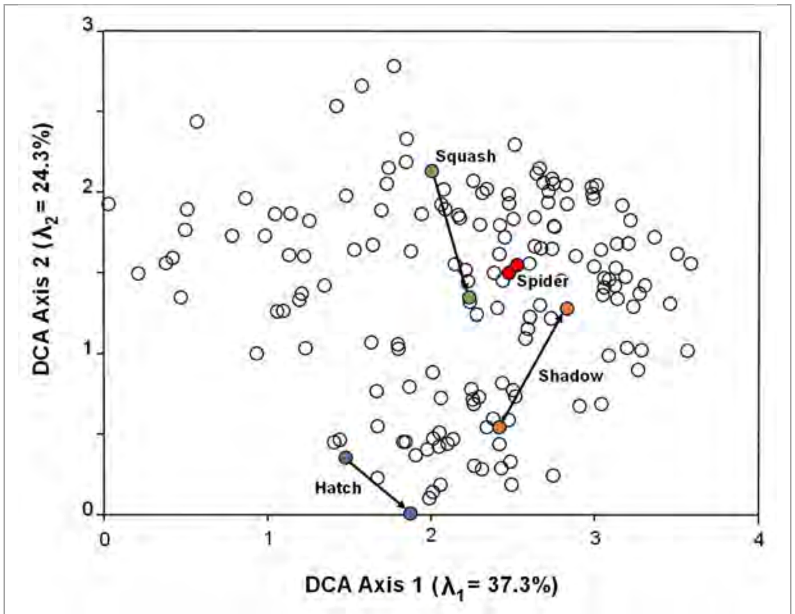


Figure 3.3-1. DCA plot of top/bottom samples highlighting lakes where Onterra staff collected sediment cores in 2020. The arrows connect bottom to top samples in the same lake. The open circles are other Wisconsin lakes where top/bottom samples have been analyzed. The diatom community in Spider Lake has changed very little suggesting that water quality at the present time is similar as it was 100 years ago.

Diatom Community Changes

Analysis showed there is very little difference between the diatom communities in the top and bottom samples in the sediment core (Figure 3.3-2). The community is very diverse and contains a large number of taxa which is indicative of good water quality. Even though the lake is relatively deep, diatoms that grow on substrates (nonplanktonic) are dominant. This probably reflects the relatively low nutrient levels as planktonic diatoms often become dominant as nutrient levels increase since reduced water clarity inhibits light penetration to the lake bottom. The only significant change between the bottom and top sample is a small increase in the diatom *Asterionella formosa* (Photo 3.1-1A). This diatom often is more common with increased nutrients, especially nitrogen. The small increase in this diatom likely signals a small increase in nitrogen levels during the last century.

Lake Diatom Condition Index

The Lake Diatom Condition Index (LDCI) was developed by Dr. Jan Stevenson, Michigan State University (Stevenson, Zalack, & Wolin, 2013). The LDCI uses diatoms to assess the ecological condition of lakes. The LDCI ranges from 0 to 100 with a higher score representing better ecological integrity. The index is weighted towards nutrients, but also incorporates ecological integrity by examining species diversity where higher diversity indicates better ecological condition. The index also incorporates taxa that are commonly found in undisturbed and disturbed conditions.

The breakpoints (poor, fair, good) were determined by the 25th and 5th percentiles for reference lakes in the Upper Midwest. The LDCI was used in the 2007 National Lakes Assessment to determine the biological integrity of the nation's lakes. The LDCI analysis indicates Spider Lake's biotic condition historically was good and remains good at the present time. This supports the earlier discussion that the diatom community has changed very little in the last 100 years (Figure 3.3-3).

Inference models

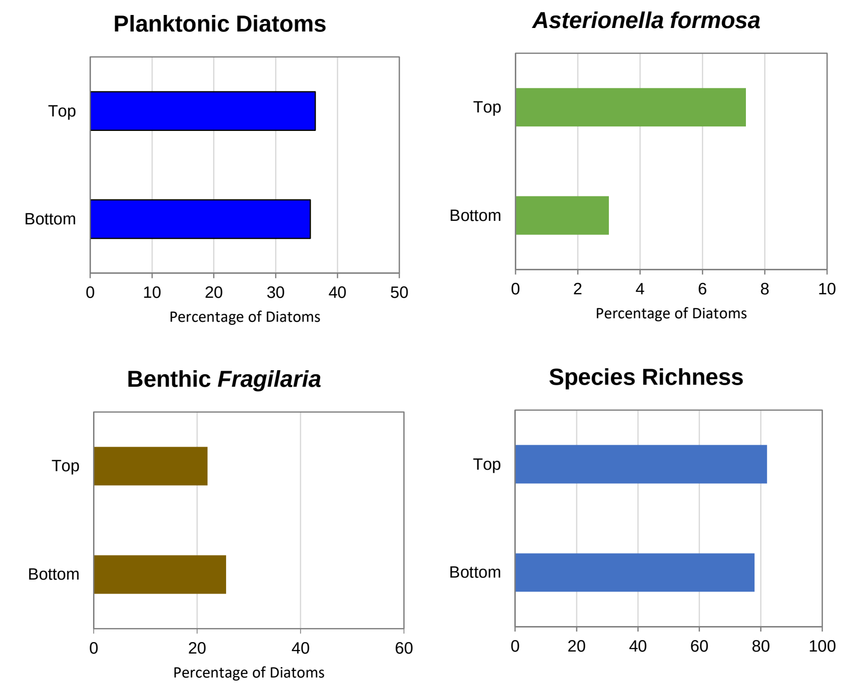


Figure 3.1-2. Changes in abundance of important diatoms found in the top and bottom of the sediment core from Spider Lake. The only change in the community in the last 100 years has been a slight increase in *A. formosa* which indicates a very slight increase in nutrients, especially nitrogen.

Diatom assemblages have been used as indicators of trophic changes in a qualitative way (Bradbury 1975, Carney 1982, Anderson et al. 1990) but quantitative analytical methods exist. Ecologically relevant statistical methods have been developed to infer environmental conditions from diatom assemblages. These methods are based on multivariate ordination and weighted averaging regression and calibration (Birks, Line, Juggins, Stevenson, & Ter Braak, 1990). Ecological preferences of diatom species are determined by relating modern limnological variables to surface sediment diatom assemblages. The species-environment relationships are then used to infer environmental conditions from fossil diatom assemblages found in the sediment core.

Weighted averaging calibration and reconstruction (Birks, Line, Juggins, Stevenson, & Ter Braak, 1990) were used to infer historical water column summer average phosphorus concentration in the sediment cores. A training set that consisted of 60 stratified lakes was used. Training set species and environmental data were analyzed using weighted average regression software (C2) (Juggins, 2014).

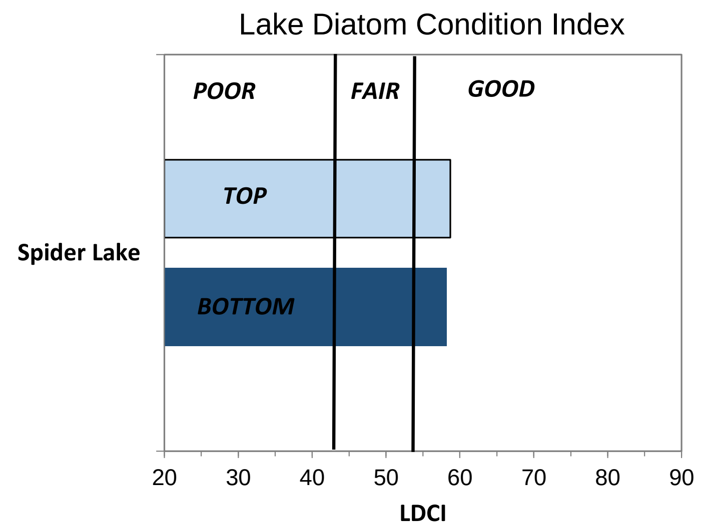


Figure 3.3-3. The Lake Diatom Condition Index (LDCI) for Spider Lake. The biotic integrity was good historically and remains so at the present time.

The diatom inferred phosphorus concentration in the top and bottom samples of Spider Lake is 20 µg/L. Although the inferred concentration is higher than the present day measured concentration (16.1 µg/L) the diatom community indicates that the phosphorus concentrations have not changed over the last 100 years.

In summary, Spider Lake historically had very good water quality and has changed very little over the last 100 plus years. There is a suggestion of a very small increase in nitrogen but phosphorus levels appear unchanged.

Table 3.1-1. Diatom inferred phosphorus concentrations in Spider lake from the sediment core samples.

Spider Lake	Diatom-Inferred Phosphorus (µg/L)
Top Core Section	20
Bottom Core Section	20

3.4 Shoreland Condition

Lake Shoreland Zone and its Importance

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

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

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

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

Shoreland Zone Regulations

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

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had recognized inadequacies within the 1968 ordinance and had actually adopted stricter shoreland ordinances. Revised in February of 2010, and again in October of 2014, the finalized NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances. Counties were previously able to set their own, stricter, regulations to NR 115 but as of 2015, all counties have to abide by state regulations. Minimum requirements for each of these categories are described below.

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

- Impervious surface standards: In general, the amount of impervious surface is restricted to 15% of the total lot size, on lots that are within 300 feet of the ordinary high-water mark of the waterbody. If a property owner treats their run off with some type of treatment system, they may be able to apply for an increase in their impervious surface limit, up to 30% for residential land use. Exceptions to this limit do exist if a county has designated highly-developed areas, so it is recommended to consult county-specific zoning regulations for this standard.

- Nonconforming structures: Nonconforming structures are structures that were lawfully placed when constructed but do not comply with distance of water setback. Originally, structures within 75 ft of the shoreline had limitations on structural repair and expansion. Language in NR-115 allows construction projects on structures within 75 feet. Other specifications must be met as well, and local zoning regulations should be referenced.

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

Wisconsin Act 31

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

Shoreland Research

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

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

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

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

Photograph 3.4-1. Example of coarse woody habitat in a lake.

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

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

National Lakes Assessment

Unfortunately, along with Wisconsin's lakes, waterbodies within the entire United States have shown to have increasing amounts of developed shorelands. The National Lakes Assessment (NLA) is an Environmental Protection Agency sponsored assessment that has successfully pooled together resource managers from all 50 U.S. states in an effort to assess waterbodies, both natural and man-made, from each state. Through this collaborative effort, over 1,000 lakes were sampled in 2007, pooling together the first statistical analysis of the nation's lakes and reservoirs.

Through the National Lakes Assessment, a number of potential stressors were examined, including nutrient impairment, algal toxins, fish tissue contaminants, physical habitat, and others. The 2007 NLA report states that "*of the stressors examined, poor lakeshore habitat is the biggest problem in the nations lakes; over one-third exhibit poor shoreline habitat condition*" (USEPA, 2009). Furthermore, the report states that "*poor biological health is three times more likely in lakes with poor lakeshore habitat.*" These results indicate that stronger management of shoreline development is absolutely necessary to preserve, protect, and restore lakes. Shoreland protection will become increasingly important as development pressure on lakes continues to grow.

Native Species Enhancement

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

Photograph 3.4-2. Example of a biolog restoration site.

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

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

Wisconsin's Healthy Lakes & Rivers Action Plan

Starting in 2014, a program was enacted by the WDNR and UW-Extension to promote riparian landowners to implement relatively straight-forward shoreland restoration activities. This program provides education, guidance, and grant funding to promote installation of best management practices aimed to protect and restore lakes and rivers in Wisconsin. The program has identified five best practices aimed at improving habitat and water quality (Figure 3.4-1).

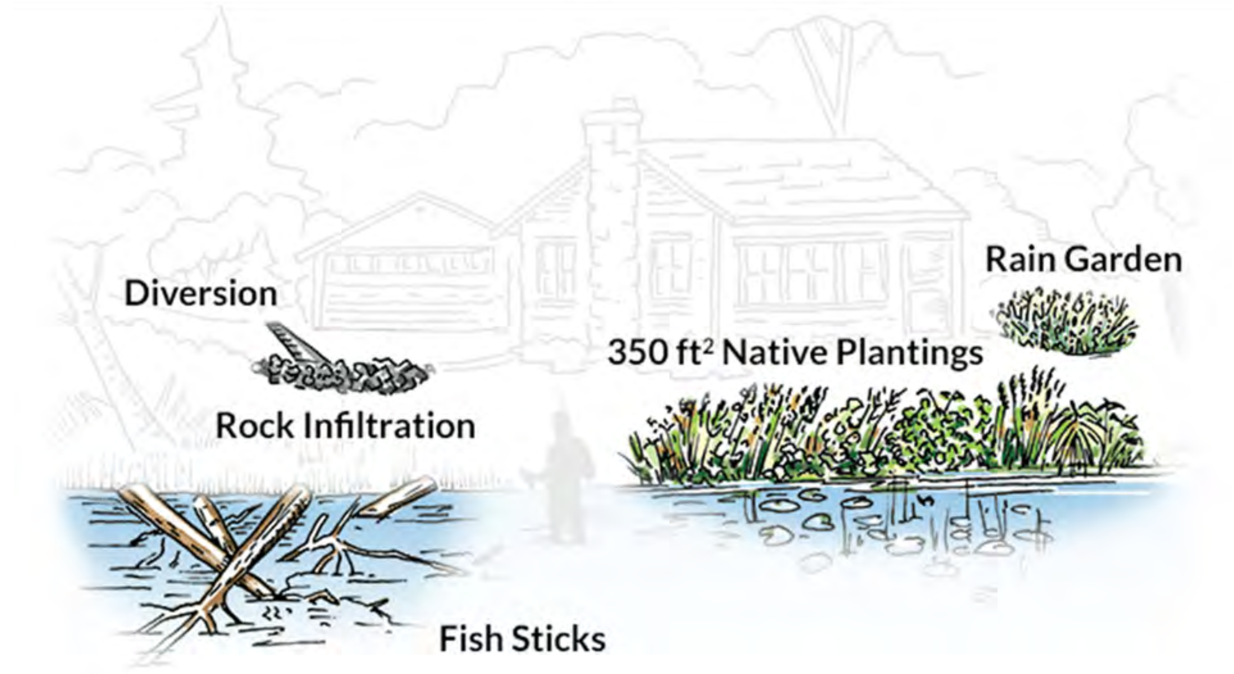


Figure 3.4-1. Healthy Lakes & Rivers 5 Best Practices. Illustration by Karen Engelbretson, extracted from healthylakeswi.com.

- Rain Gardens: This upland best practice consists of a landscaped and vegetated shallow depression aimed at capturing water runoff and allowing it to infiltrate into the soil.
- Rock Infiltration: This upland best practice is an excavated pit or trench, filled with rock, that encourages water to infiltrate into the soil. These practices are strategically placed at along a roof line or the downward sloping area of a driveway.
- Diversion: This best practice can occur in the transition or upland zone. These practices use berms, trenches, and/or treated lumber to redirect water that would otherwise move downhill into a lake. Water diversions may direct water into a Rock Infiltration or Rain Garden to provide the greatest reductions in runoff volumes.
- Native Plantings: This best practice aims to installing native plants within at least 350 square-foot shoreland transition area. This will slow runoff water and provide valuable habitat. One native planting per property per year is eligible.
- Fish Sticks: These in-lake best practices (not eligible for rivers) are woody habitat structures that provide feeding, breeding, and nesting areas for wildlife. Fish sticks consist of multiple whole trees grouped together and anchored to the shore. Trees are not felled from the shoreline, as existing trees are valuable in place, but brought from a short distance or dragged across the ice. In order for this practice to be eligible, an existing vegetated buffer or pledge to install one is required.

The Healthy Lakes and Rivers Grant Program allows partial cost coverage for implementing best practices. Competitive grants are available to eligible applicants such as lake associations and lake districts. The program allows a 75% state cost share up to $1,000 per practice. Multiple practices can be included per grant application, with a $25,000 maximum award per year. Eligible projects need to be on shoreland properties within 1,000 feet of a lake or 300 feet from a river. The landowner must sign a Conservation Commitment pledge to leave the practice in place and provide continued maintenance for 10 years. More information on this program can be found here: https://healthylakeswi.com/

It is important to note that this grant program is intentionally designed for relatively simple, low-cost, and shovel-ready projects, limiting 10% of the grant award for technical assistance. Larger and more complex projects, especially those that require engineering design components may seek alternative funding sources potentially through the County. Small-Scale Lake Planning Grants can provide up to $3,000 to help build a Healthy Lakes and Rivers project. Eligible expenses in this grant program are surveys, planning, and design.

Spider Lake Shoreland Zone Condition

Shoreland Development

Spider Lake's entire 8-mile shoreline was surveyed in 2018 by Iron County Land and Water Conservation staff, and the data presented in this section here were provided by Iron County. A draft WDNR protocol (WDNR, 2016) was utilized to evaluate the shoreland zone on a parcel-by-parcel basis beginning at the estimated high-water level mark and extending inland 35 feet. Within the shoreland zone the natural vegetation (canopy cover, shrub/herbaceous) was given an estimate of the percentage of the plot which is dominated by each category (Photo 3.4-3). Human disturbances such as impervious surface, manicured lawn, agriculture, number of buildings, boats on shore, piers, boat lifts, sea wall length, were also recorded by number of occurrence or percentage during the survey.

Photograph 3.4-3. Example of lake shoreland natural canopy, shrub, and herbaceous layers. Photo credit Onterra.

For this management plan, the percent canopy cover, percent shrub/herbaceous, percent manicured lawn, and percent impervious surfaces are primarily focused upon to assess the shoreline for development and determine a need for restoration. In general, developed shorelands impact a lake ecosystem in a negative manner, while definite benefits occur from shorelands that are left in their natural state or a near-natural state. Canopy cover was defined as an area which is shaded by trees that are at least 16 feet tall (Photograph 3.4-3). Fifty percent (4.0 miles) of the Spider Lake shoreline contains a canopy that covers between 81-100% of the parcel, 27% (2.2 miles) contains 61-80% canopy cover, 17% (1.3 miles) contains 41-60% canopy coverage, 4% (0.3 miles) contains 21-40% canopy coverage, and 2% (0.1 miles) contains 0-20% (Figure 3.4-3 and Map 3).

Shrub and herbaceous layers are small trees and plants without woody stems less than 16 feet tall (Photograph 3.4-3). Forty-eight percent (3.9 miles) of the Spider Lake shoreline contains a shrub/herbaceous layer that covers between 81-100% of the parcel, 1.7 miles (22%) contains 61-

80%, 17% (1.3 miles) contains 41-60%, 10% (0.8 miles) contains 21-40%, and 3% (0.3 miles) contains 0-20%. (Figure 3.4-3 and Map 4).

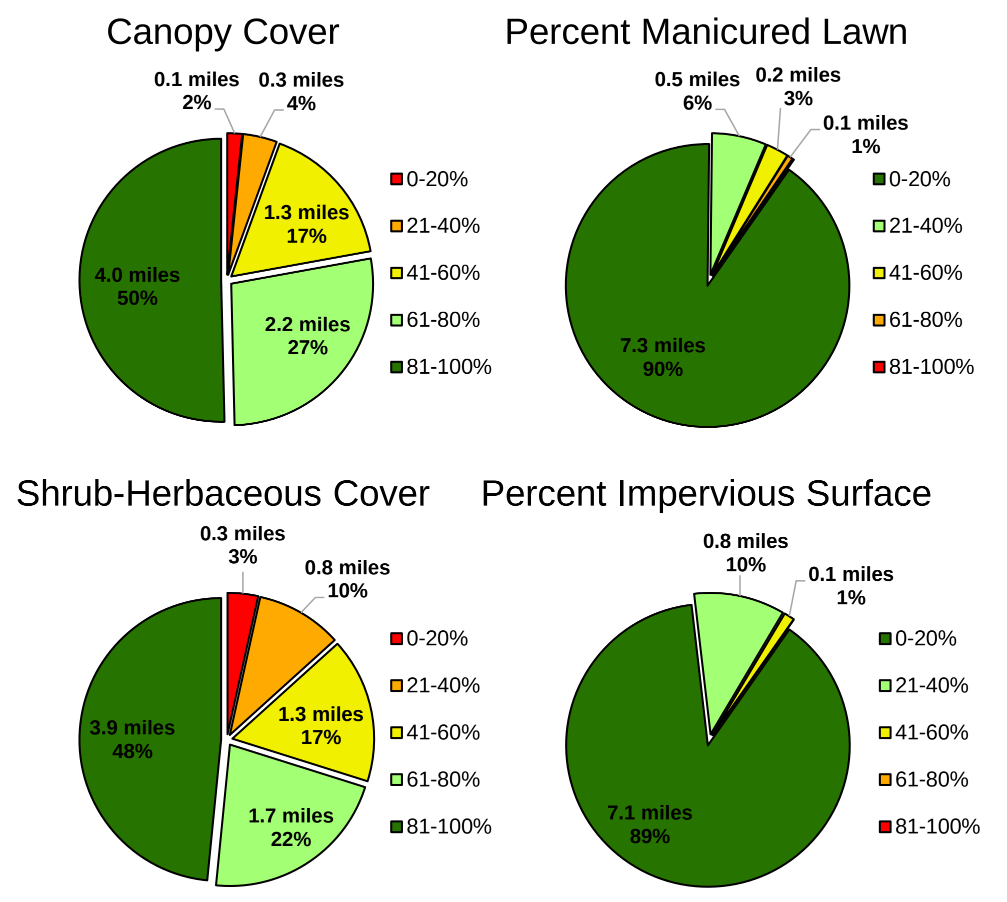


Figure 3.4-3. Spider Lake 2018 shoreland parcel canopy cover, shrub-herbaceous cover, manicured lawn, and impervious surface. Created using data provided by Iron County Land and Water Conservation Dept.

A manicured lawn is defined as grass that is mowed short and is direct evidence of urbanization. Having a manicured lawn poses a risk as runoff will carry pollutants, such as lawn fertilizers, into the lake. There were no parcels that were found to contain a coverage of manicured lawn of 81-100% (Figure 3.4-3 and Map 5). Approximately 1% (0.1 miles) was found to have lawn coverage of 61-80%, 3% (0.2 miles) 21-40%, 6% (0.5 miles), and 7.3 miles (90%) had 0-20% coverage.

Impervious surface is an area that releases all or a majority of the precipitation that falls onto it (e.g., rooftops, concrete, stairs, boulders, and boats flipped over on shore). About 7.1 miles or 89% of the Spider Lake shoreline contains between 0-20% impervious surfaces, 10% (0.8 miles) contains 21-40%, and 1% (0.1 miles) contains 41-60% coverage. (Figure 3.4-3 and Map 6).

Sections of Spider Lake's shoreline which contain a manicured lawn and a small percentage of canopy, shrub and herbaceous cover are potential candidates for shoreline restorations. A few property parcels which meet these requirements are located on the lake's western and eastern shores. Overall, natural vegetation around Spider Lake's shoreline is largely intact.

Coarse Woody Habitat

As part of Iron County's shoreland condition assessment, Spider Lake was also surveyed to determine the extent of its coarse woody habitat. All wood greater than 4 inches in diameter, at least 5 feet long and located between the high-water level (HWL) mark and 2-foot contour line was marked with a GPS waypoint. The coarse woody habitat was then given a complexity ranking (no branches, a few branches, or a full crown), noted if it touched shore, and whether or not it was mostly submerged in water. As discussed earlier, research indicates that fish species prefer some branching as opposed to no branching on coarse woody habitat, and increasing complexity is positively correlated with higher fish species richness, diversity, and abundance (Newbrey, Bozek, Jennings, & Cook, 2005).

During the survey, a total of 271 total pieces of coarse woody habitat were observed along 8.3 miles of shoreline (Figure 3.4-4 and Map 7), yielding a course woody habitat pieces per shoreline mile of 33:1. Of the 271 pieces located, 201 (74%) had no branches, 60 (22%) had a few branches, and 8 (4%) had a full crown. Onterra has completed coarse woody habitat surveys on 128 lakes throughout Wisconsin since 2012, with the majority occurring in the NLF ecoregion on lakes with public access. The number of coarse woody habitat pieces per shoreline mile in Spider Lake fell into the 64th percentile of these 128 lakes (Figure 3.5-4). Please note that based on the WDNR protocol, all Spider Lake coarse woody habitat was collected between the 2-foot contour line and the high-water level mark. The Onterra protocol, which all data from Onterra project lakes was collected from, only records data on coarse woody habitat which crosses the high-water level mark.

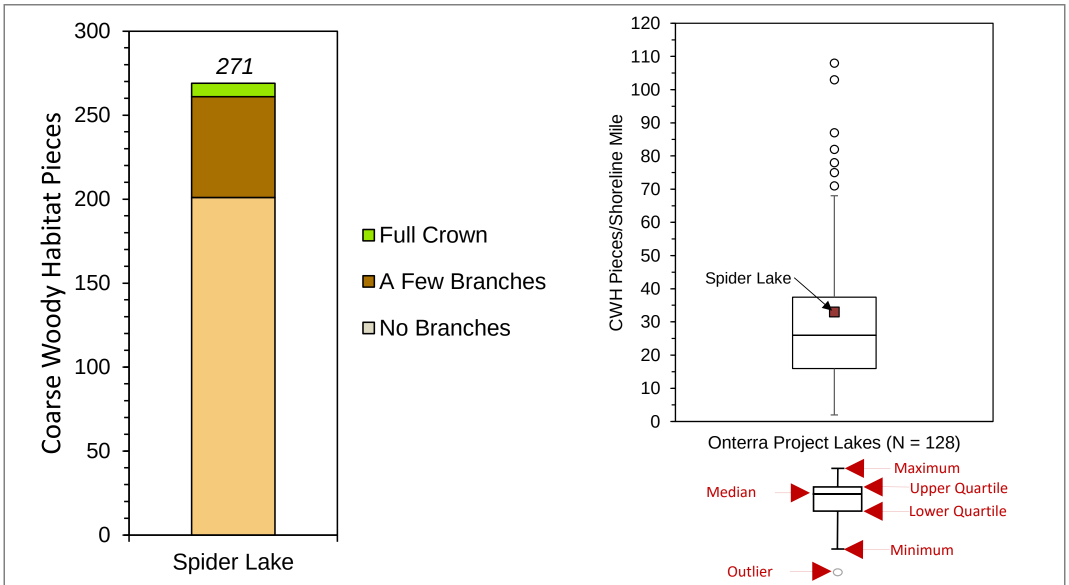


Figure 3.4-4. Spider Lake coarse woody habitat survey results. Based upon an Iron County Land and Water Conservation Dept. 2018 survey. Locations of Spider Lake coarse woody habitat can be found on Map 7.

3.5 Aquatic Plants

Introduction

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

Photograph 3.5-1. Example of emergent and floating-leaf plant community.

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

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

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

Aquatic Plant Management and Protection

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

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

Permits

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

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

Manual Removal (Hand-Harvesting & DASH)

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not removed, rather the plants are cut similar to mowing a lawn; however, Wisconsin law states that all plant fragments must be removed.

Photograph 3.5-2. Example of aquatic plants that have been removed manually.

Manual removal or hand-harvesting of aquatic invasive species has gained favor in recent years as an alternative to herbicide control programs. Professional hand-harvesting firms can be contracted for these efforts and can either use basic snorkeling or scuba divers, whereas others might employ the use of a Diver Assisted Suction Harvest (DASH) which involves divers removing plants and feeding them into a suctioned hose for delivery to the deck of the harvesting vessel. The DASH methodology is considered a form of mechanical harvesting and thus requires a WDNR approved permit. DASH is thought to be more efficient in removing target plants than divers alone and is believed to limit fragmentation during the harvesting process.

Cost

Contracting aquatic invasive species removal by third-party firm can cost approximately $1,500 per day for traditional hand-harvesting methods whereas the costs can be closer to $2,500 when DASH technology is used. Additional disposal, travel, and permitting fees may also apply.

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

Bottom Screens

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

Cost

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

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

Mechanical Harvesting


Photograph 3.5-3. Mechanical harvester.

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

Cost

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

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

Herbicide Treatment

The use of herbicides to control aquatic plants and algae is a technique that is widely used by lake managers. Traditionally, herbicides were used to control nuisance levels of aquatic plants and algae that interfere with navigation and recreation. While this practice still takes place in many parts of Wisconsin, the use of herbicides to control aquatic invasive species is becoming more prevalent. Resource managers employ strategic management techniques towards aquatic invasive species, with the objective of reducing the target plant's population over time; and an overarching goal of attaining long-term ecological restoration. For submergent vegetation, this largely consists of implementing control strategies early in the growing season; either as spatially-targeted, small-scale spot treatments or low-dose, large-scale (whole lake) treatments. Treatments occurring roughly each year before June 1 and/or when water temperatures are below 60°F can be less impactful to many native plants, which have not emerged yet at this time of year. Emergent species are targeted with foliar applications at strategic times of the year when the target plant is more likely to absorb the herbicide.

While there are approximately 300 herbicides registered for terrestrial use in the United States, only 13 active ingredients can be applied into or near aquatic systems. All aquatic herbicides must be applied in accordance with the product's US Environmental Protection Agency (EPA) approved label. There are numerous formulations and brands of aquatic herbicides and an extensive list can be found in Appendix F of Gettys et al. (2009).

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

Aquatic herbicides can be classified in many ways. Organization of this section follows Netherland (2009) in which mode of action (i.e., how the herbicide works) and application techniques (i.e., foliar or submersed treatment) group the aquatic herbicides. The table below provides a general list of commonly used aquatic herbicides in Wisconsin and is synthesized from Netherland (2009). The arguably clearest division amongst aquatic herbicides is their general mode of action and fall into two basic categories: Contact herbicides act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but in some plants does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed. Systemic herbicides act slower than contact herbicides, being transported throughout the entire plant and disrupting biochemical pathways which often result in complete mortality.

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

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to reduce herbicide concentration within aquatic systems. Understanding concentration and exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time.

Much information has been gathered in recent years, largely as a result of an ongoing cooperative research project between the Wisconsin Department of Natural Resources, US Army Corps of Engineers Research and Development Center, and private consultants (including Onterra). This research couples quantitative aquatic plant monitoring with field-collected herbicide concentration data to evaluate efficacy and selectivity of control strategies implemented on a subset of Wisconsin lakes and flowages. Based on their preliminary findings, lake managers have adopted two main treatment strategies: 1) whole-lake treatments, and 2) spot treatments.

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

Table 3.5-1. Common herbicides used for aquatic plant management.

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

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

Cost

Herbicide application charges vary greatly between $400 and $1,500 per acre depending on the chemical used, who applies it, permitting procedures, and the size/depth of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • Herbicides can target large areas all at once. • Herbicides can be economical at certain scales compared with other management options. • Herbicide type and application timing can increase selectivity towards target species. • Most herbicides are designed to target plant physiology and in general, have low toxicological effects on non-plant organisms (e.g. mammals, insects)	• All herbicide use carries some degree of human health and ecological risk due to toxicity. • Fast-acting herbicides may cause fish kills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them. • Many aquatic herbicides are nonselective. • Some herbicides have a combination of use restrictions that must be followed after their application. • Overuse of same herbicide may lead to plant resistance to that herbicide.

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as water hyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata),* respectively.

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

Cost

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

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

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

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

Cost

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

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

Analysis of Current Aquatic Plant Data

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

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Spider Lake; the first looked strictly for the exotic plant, curly-leaf pondweed, while the others that followed assessed both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the aquatic plant species, both native and non-native, that were located during the surveys completed in Spider Lake in 2016. The list also contains the growth-form of each plant found (e.g., submergent, emergent, etc.), its scientific name, common name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in growth forms that are present, can be an early indicator of changes in the ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain aquatic plant species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of the whole-lake point-intercept survey completed on Spider Lake, plant samples were collected from plots laid out on a grid that covered the lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. The occurrence of aquatic plant species is displayed as the *littoral frequency of occurrence*. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are within the maximum depth of plant growth (littoral zone), and is displayed as a percentage.

Floristic Quality Assessment

The floristic quality of a lake's aquatic plant community is calculated using its native *species richness* and their *average conservatism*. Species richness is the number of native aquatic plant species that were physically encountered on the rake during the point-intercept survey. Average conservatism is calculated by taking the sum of the coefficients of conservatism (C-values) of the native species located and dividing it by species richness. Every plant in Wisconsin has been assigned a coefficient of conservatism, ranging from 1-10, which describes the likelihood of that species being found in an undisturbed environment. Species which are more specialized and require undisturbed habitat are given higher coefficients, while species which are more tolerant of environmental disturbance have lower coefficients.

For example, algal-leaf pondweed (*Potamogeton confervoides*) is only found in nutrient-poor, acid lakes in northern Wisconsin and is prone to decline if degradation of these lakes occurs. Because of algal-leaf pondweed's special requirements and sensitivity to disturbance, it has a C-value of 10. In contrast, sago pondweed (*Stuckenia pectinata*) with a C-value of 3, is tolerant of disturbance and is often found in greater abundance in degraded lakes that have higher nutrient concentrations and low water clarity. Higher average conservatism values generally indicate a healthier lake as it is able to support a greater number of environmentally-sensitive aquatic plant species. Low average conservatism values indicate a degraded environment, one that is only able to support disturbance-tolerant species.

On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept surveys (equation shown below). This assessment allows the aquatic plant community of Spider Lake to be compared to other lakes within the region and state.

$$\text{FQI} = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

Species Diversity

Species diversity is often confused with species richness. As defined previously, species richness is simply the number of species found within a given community. While species diversity utilizes species richness, it also takes into account evenness or the variation in abundance of the individual species within the community. For example, a lake with 10 aquatic plant species that had relatively similar abundances within the community would be more diverse than another lake with 10 aquatic plant species were 50% of the community was comprised of just one or two species.

An aquatic system with high species diversity is more stable than a system with a low diversity. This is analogous to a diverse financial portfolio in that a diverse aquatic plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. A lake with a diverse plant community is also better suited to compete against exotic infestations than a lake with a lower diversity. The diversity of a lake's aquatic plant community is determined using the Simpson's Diversity Index (1-D):

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

where:
n = the total number of instances of a particular species
N = the total number of instances of all species and
D is a value between 0 and 1

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species.

The Simpson's Diversity Index value from Spider Lake is compared to data collected by Onterra and the WDNR Science Services on 212 lakes withn the Northern Lakes and Forests ecoregion and on 392 lakes throughout Wisconsin.

Community Mapping

A key component of any aquatic plant community assessment is the delineation of the emergent and floating-leaf aquatic plant communities within each lake as these plants are often underrepresented during the point-intercept survey. This survey creates a snapshot of these important communities within each lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with future surveys. Examples of emergent plants include cattails, rushes, sedges, grasses, bur-reeds, and arrowheads, while examples of floating-leaf species include the water lilies. The emergent and floating-leaf aquatic plant communities in Spider Lake were mapped using a Trimble Global Positioning System (GPS) with sub-meter accuracy.

Exotic Plants

Because of their tendency to upset the natural balance of an aquatic ecosystem, exotic species are paid particular attention to during the aquatic plant surveys. Two exotic species, curly-leaf pondweed and Eurasian watermilfoil are the primary targets of this extra attention.

Eurasian watermilfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.5-1). Eurasian watermilfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian watermilfoil has two other competitive advantages over native aquatic plants: 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants and instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian watermilfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

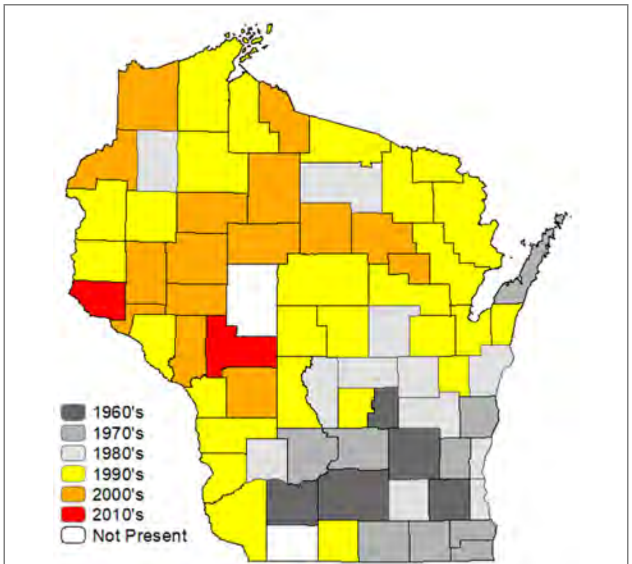


Figure 3.5-1. Spread of Eurasian watermilfoil within WI counties over time. Most recent infestations are colored in Red, Orange, and Yellow. WDNR Data 2021 mapped by Onterra.

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

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

Spider Lake Aquatic Plant Survey Results

The first survey completed on Spider Lake was the Early-Season Aquatic Invasive Species (ESAIS) Survey completed on June 24, 2020. The goal of this survey was to identify and assess any new or existing occurrences of invasive plant species in the lake, with a particular focus on species that are most likely to be observed at this time of year: curly-leaf pondweed and pale-yellow iris. During this survey, Onterra ecologists did not observed any occurrences of curly-leaf pondweed, pale-yellow iris, or Eurasian watermilfoil.

The whole-lake point-intercept survey was conducted on Spider Lake on August 11 and 13, 2020, while the emergent and floating-leaf community mapping survey was completed on August 12, 2020. During the 2020 surveys, a total of 60 aquatic plant species were located in Spider Lake, one of which is considered to be non-native, invasive species: purple loosestrife (Table 3.5-1). Purple loosestrife is discussed in the subsequent Non-Native Aquatic Plants Section.

Lakes in Wisconsin vary in their morphometry, water chemistry, water clarity, substrate composition, management, and recreational use, all factors which influence aquatic plant community composition. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in soft substrates, others only in sandy/rocky areas, and some can be found growing in either. The combination of both soft sediments and areas of harder substrates creates different habitat types for aquatic plants, and generally leads to a higher number of aquatic plant species within the lake.

During the 2020 point-intercept survey, information regarding substrate type was collected at locations sampled with a pole-mounted rake (less than 15 feet). These data indicate that 42% of the point-intercept locations contained organic sediments, 41% contained sand, and 17% contained rock (Figure 3.5-2 and Map 8). Areas of sand or rock were primarily located in near-shore areas around the lake, while the majority of sampling locations with soft organic substrate were located in the northern basin.

The combination of both soft and hard substrates in Spider Lake creates habitat types which support different aquatic plant community assemblages, resulting in higher species richness.

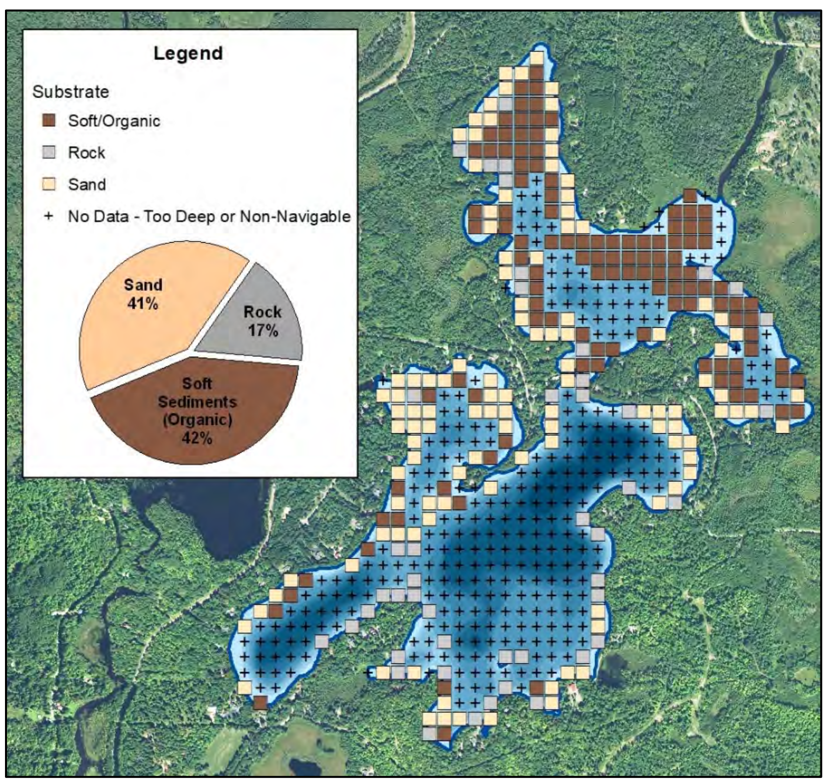


Figure 3.5-2. Spider Lake 2020 substrate types in areas ≤ 15 feet deep. Created from data collected during the 2020 whole-lake point-intercept survey.

Table 3.5-1. Aquatic plant species located in Spider Lake during Onterra 2020 aquatic plant surveys.

Scientific Name	Common Name	Growth Form	WI State Status	Coefficient of Conservatism	2020 (Onterra)
Acorus americanus	Sweetflag	E	Native	7	X
Bidens beckii	Water marigold	S	Native	8	X
Brasenia schreberi	Watershield	FL	Native	7	X
Carex comosa	Bristly sedge	E	Native	5	I
Carex lasiocarpa	Narrow-leaved woolly sedge	E	Native	9	I
Carex utriculata	Common yellow lake sedge	E	Native	7	X
Ceratophyllum demersum	Coontail	S	Native	3	X
Ceratophyllum echinatum	Spiny hornwort	S	Native	10	X
Chara spp.	Muskgrasses	S	Native	7	X
Cladium mariscoides	Smooth sawgrass	E	Native	10	X
Comarum palustre	Marsh cinquefoil	E	Native	8	X
Dulichium arundinaceum	Three-way sedge	E	Native	9	I
Eleocharis acicularis	Needle spikerush	S/E	Native	5	X
Eleocharis palustris	Creeping spikerush	E	Native	6	X
Eleocharis robbinsii	Robbins' spikerush	E	Native - Special Concern	10	I
Elodea canadensis	Common waterweed	S	Native	3	X
Equisetum fluviatile	Water horsetail	E	Native	7	X
Heteranthera dubia	Water stargrass	S	Native	6	X
Isoetes spp.	Quillwort spp.	S	Native	8	X
Lythrum salicaria	Purple loosestrife	E	Non-Native - Invasive	N/A	I
Myriophyllum heterophyllum	Various-leaved watermilfoil	S	Native	7	X
Myriophyllum sibiricum	Northern watermilfoil	S	Native	7	X
Najas flexilis	Slender naiad	S	Native	6	X
Nitella spp.	Stoneworts	S	Native	7	X
Nuphar variegata	Spatterdock	FL	Native	6	X
Nymphaea odorata	White water lily	FL	Native	6	X
Pontederia cordata	Pickerelweed	E	Native	9	X
Potamogeton amplifolius	Large-leaf pondweed	S	Native	7	X
Potamogeton berchtoldii	Slender pondweed	S	Native	7	X
Potamogeton epihydrus	Ribbon-leaf pondweed	S	Native	8	X
Potamogeton friesii	Fries' pondweed	S	Native	8	I
Potamogeton gramineus	Variable-leaf pondweed	S	Native	7	X
Potamogeton natans	Floating-leaf pondweed	S	Native	5	I
Potamogeton praelongus	White-stem pondweed	S	Native	8	X
Potamogeton pusillus	Small pondweed	S	Native	7	X
Potamogeton richardsonii	Clasping-leaf pondweed	S	Native	5	X
Potamogeton robbinsii	Fern-leaf pondweed	S	Native	8	X
Potamogeton spirillus	Spiral-fruited pondweed	S	Native	8	X
Potamogeton vaseyi	Vasey's pondweed	S	Native - Special Concern	10	X
Potamogeton x *haynesii*	Haynes' pondweed	S	Native	N/A	X
Potamogeton zosteriformis	Flat-stem pondweed	S	Native	6	X
Ranunculus aquatilis	White water crowfoot	S	Native	8	X
Sagittaria graminea	Grass-leaved arrowhead	S/E	Native	9	I
Sagittaria latifolia	Common arrowhead	E	Native	3	X
Sagittaria rigida	Stiff arrowhead	E	Native	8	I
Schoenoplectus acutus	Hardstem bulrush	E	Native	5	X
Schoenoplectus tabernaemontani	Softstem bulrush	E	Native	4	I
Scirpus cyperinus	Wool grass	E	Native	4	I
Sparganium americanum	American bur-reed	E	Native	8	I
Sparganium emersum var. *acaule*	Short-stemmed bur-reed	FL/E	Native	8	X
Sparganium eurycarpum	Common bur-reed	E	Native	5	I
Sparganium fluctuans	Floating-leaf bur-reed	FL	Native	10	X
Sparganium natans	Little bur-reed	S/E	Native	9	I
Stuckenia pectinata	Sago pondweed	S	Native	3	X
Typha latifolia	Broad-leaved cattail	E	Native	1	I
Utricularia intermedia	Flat-leaf bladderwort	S	Native	9	X
Utricularia minor	Small bladderwort	S	Native	10	X
Utricularia vulgaris	Common bladderwort	S	Native	7	X
Vallisneria americana	Wild celery	S	Native	6	X
Zizania palustris	Northern wild rice	E	Native	8	I

X = Located on rake during point-intercept survey; I = incidentally located
E = Emergent; FL = Floating-leaf; FL/E = Floating-leaf & Emergent; S = Submergent; S/E = Submergent & Emergent

The maximum depth of plant growth is largely going to be determined by water clarity. In general, aquatic plants grow to a depth of two to three times the average Secchi disk depth. Spider Lake's mean Secchi disk depth in 2020 was 8.4 feet. Despite this Secchi disk depth, aquatic plants were found growing to a maximum depth of 10.0 feet in 2020, with most vegetation occurring between 1.0 and 8.0 feet of water. Given Spider Lake's water clarity, the maximum rooting depth of aquatic plants would be expected to be around 15 feet. It is not clear why plant growth was limited to 10 feet in 2020, but it may be due to inconducive sediments in deeper areas.

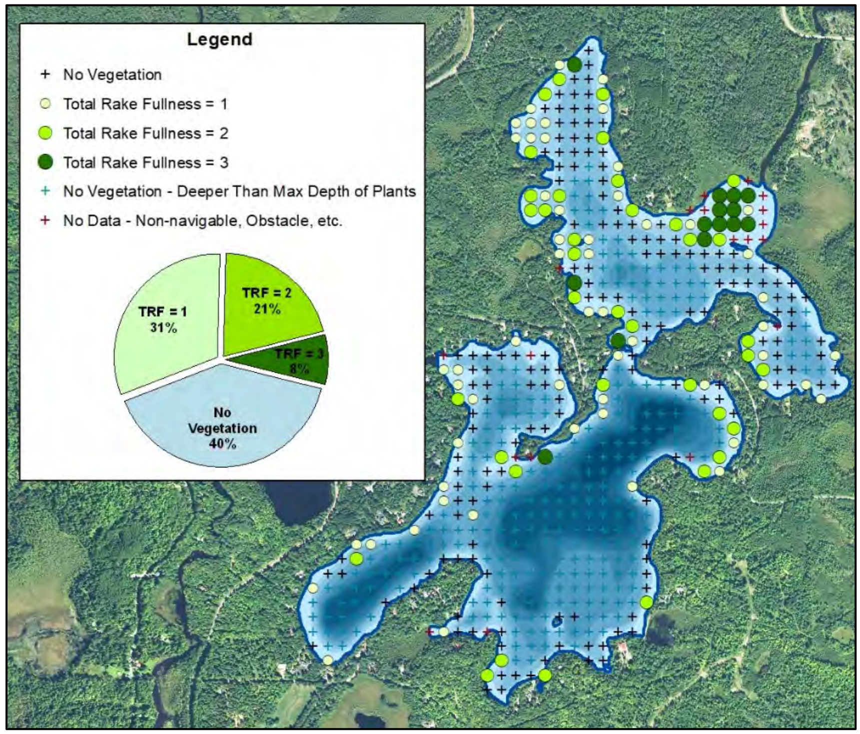


Figure 3.5-3. Spider Lake 2018 substrate types and aquatic vegetation total rake fullness ratings (TRF). Created from data collected during the 2018 whole-lake point-intercept survey (N = 335).

Of the 179 point-intercept sampling locations that fell within Spider Lake's littoral zone (≤ 10 feet) in 2020, 60% contained aquatic vegetation (Figure 3.5-3 and Map 9). Aquatic plant total rake fullness (TRF) data, a measure of plant abundance, showed that 31% of the 179 littoral sampling locations contained vegetation with a TRF rating of 1, 21% had a TRF rating of 2, and 8% had a TRF rating of 3 (Figure 3.5-3). These TRF ratings indicate that where vegetation is present in Spider Lake, its biomass is relatively low.

Of the 107 sampling locations that contained aquatic vegetation throughout the lake, 64% were located in the northern basin while 36% were located in the southern basin. The littoral frequency of occurrence of vegetation in the north basin was 67% compared to 50% in the southern basin. The data also show that 40 native aquatic plant species were recorded on the rake during the point-intercept survey in the northern basin compared to 23 in the southern basin. These differences are likely driven by differences in the morphology and substrate composition of each basin. The northern basin is shallower with more littoral area and has more areas with soft organic substrates which are conducive for plant growth. The south basin has steep contours with less littoral area and substrates largely comprised of sand or rock, substrates which are less conducive for plant growth.

The densest aquatic vegetation was found growing in the northern bay where the Turtle River enters Spider Lake (Figure 3.5-3). Here at the mouth of the river, water velocity slows and sediments and nutrients carried by the river fall out of suspension. This bay likely has nutrient-rich sediment which can support a high biomass of aquatic plants. In addition to high plant biomass, this bay also had the highest aquatic plant species richness of any other area in the lake, with 34 of 59 native aquatic plant species found throughout the whole lake occurring in this bay.

The data collected from the whole-lake point-intercept survey is also used to quantify the abundance of individual plant species within the lake. Of the 60 aquatic plant species located in Spider Lake in 2020, 44 were encountered directly on the rake during the whole-lake point-intercept survey (Figure 3.3-4). The remaining 16 species were located incidentally, meaning they were observed by Onterra ecologists while on the lake but they were not directly sampled on the rake at any of the point-intercept sampling locations. Incidental species typically include emergent and floating-leaf species that are often found growing on the fringes of the lake and submersed species that are rare within the plant community. Of the 44 species directly sampled with the rake during the point-intercept survey, wild celery, slender naiad, fern-leaf pondweed, common waterweed, and water marigold were the five most frequently encountered (Figure 3.3-4).

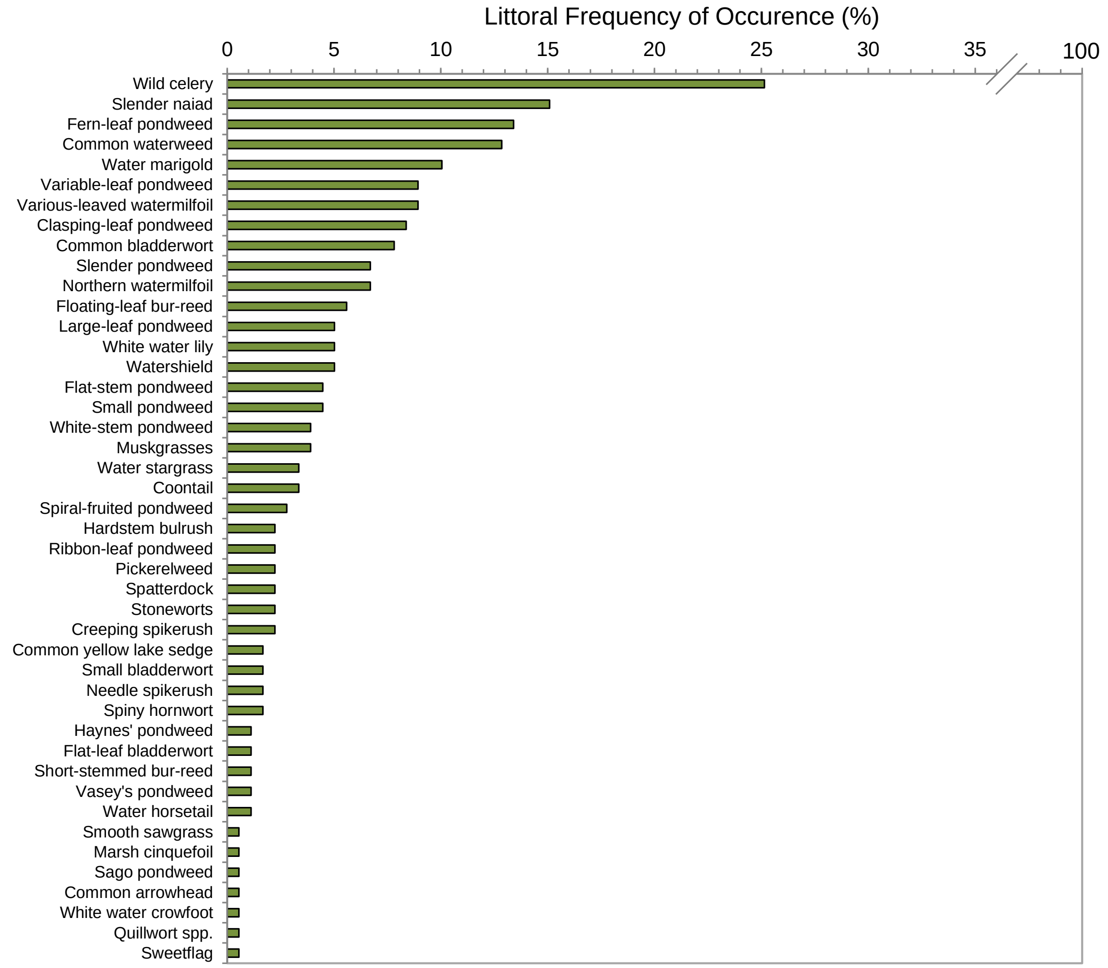


Figure 3.5-5. Spider Lake 2018 littoral frequency of occurrence of aquatic plant species. Created using data from 2018 whole-lake point-intercept survey.

Wild celery (Figure 3.5-6), also known as tape or eelgrass, was the most frequently encountered aquatic plant species in Spider Lake in 2020 with a littoral frequency of occurrence of 25%. Wild celery produces long, ribbon-like leaves which emerge from a basal rosette, and it prefers to grow over harder substrates and is tolerant of low-light conditions. Its long leaves provide valuable structural habitat for the aquatic community while its network of roots and rhizomes help to stabilize bottom sediments. In mid- to late-summer, wild celery often produces abundant fruit which are important food sources for wildlife including migratory waterfowl. In 2020, wild celery was most abundant over areas of sand in 4.0 to 7.0 feet of water.

Figure 3.5-6. Five-most frequently encountered aquatic plants in Spider Lake in 2020. Photo credit Onterra.

Slender naiad (Figure 3.5-6) was the second-most frequently encountered aquatic plant species in Spider Lake in 2020 with a littoral frequency of occurrence of approximately 15% (Figure 3.5-5). Slender naiad is one of five naiad species that can be found in Wisconsin. Being an annual, it produces numerous seeds on an annual basis and is considered to be one of the most important food sources for a number of migratory waterfowl species (Borman et al. 1997). In addition, slender naiad's small, condensed network of leaves provide excellent habitat for aquatic invertebrates. Like wild celery, slender naiad was most abundant over areas of sand in Spider Lake, and was present across most littoral depths from 1.0 to 9.0 feet.

Fern-leaf pondweed (Figure 3.5-6) was the third-most frequently encountered aquatic plant species in Spider Lake in 2020 with a littoral frequency of occurrence of 13% (Figure 3.5-5). Fern-leaf pondweed is a common plant in softwater lakes in northern Wisconsin, and is often one of the most abundant. It can be found in shallow to deep water typically over soft sediments. Large beds of fern-leaf pondweed provide excellent structural habitat for aquatic wildlife and help to prevent the suspension of the soft bottom sediments in which they grow. In Spider Lake, fern-leaf pondweed was most abundant over areas of soft sediment in the northern basin of the lake, at depths from 3.0 to 8.0 feet.

Common waterweed (Figure 3.5-6) was the fourth-most frequently encountered aquatic plant species in Spider Lake in 2020, with a littoral frequency of occurrence of 13% (Figure 3.5-5). Common waterweed can be found in waterbodies across Wisconsin and throughout North America. It often produces dense beds which provide valuable structural habitat and stabilize bottom sediments. In Spider Lake, most of the common waterweed was located in the bay where the Turtle River flows into the lake, and was most abundant between 3.0 and 6.0 feet of water. This area likely supports more nutrient-rich sediment, conducive for the growth of this species.

Water marigold (Figure 3.5-6) was the fifth-most frequently encountered aquatic plant species in Spider Lake in 2020, with a littoral frequency of occurrence of 10% (Figure 3.5-5). Water marigold is a species in the sunflower family (Asteraceae), and like our terrestrial sunflower species, produces large, showy yellow flowers above the water's surface. Water marigold is considered a highly sensitive aquatic plant species, and is often one of the first species to disappear from a waterbody with degrading water quality (Borman, Korth, & Temte, 1997). The submersed leaves of water marigold are highly dissected, and it is often mistakenly identified as a species milfoil. Like other aquatic plant species, water marigold provides excellent structural habitat for the aquatic environment and stabilizes bottom sediments. In Spider Lake, most of the water marigold was located in the bay where the Turtle River enters the lake; however, occurrences were found in other areas throughout both basins.

Other notable aquatic plants of interest located in Spider Lake include various-leaved watermilfoil, northern watermilfoil, Robbins' spikerush, Vasey's pondweed, and spiny hornwort. Various-leaved and northern watermilfoil (Figure 3.5-7) are two native milfoil species that are often mistaken for Eurasian watermilfoil. Both various-leaved and northern watermilfoil will generally have 5-11 leaf segments per side while Eurasian watermilfoil will have 14-17 or greater. In Spider Lake, various-leaved watermilfoil was observed growing in dense, surface-matted beds in the northern bay at the mouth of the Turtle River (Figure 3.5-7). Similarly, most of the northern watermilfoil was found in this same area but growing at a lower density.

Robbins' spikerush and Vasey's pondweed (Figure 3.5-7) are both native aquatic plant species listed as special concern in Wisconsin by the WDNR's Natural Heritage Inventory Program. These plants are given this special concern designation when there is uncertainty regarding their abundance and distribution within the state, and special attention is given to the monitoring of these species in an effort to prevent them from becoming listed as threatened or endangered. Robbins' spikerush is an aquatic sedge which produces long, slender hair-like stems underwater. Fertile stems emerge above the surface where flowers are wind-pollinated. Vasey's pondweed is a submersed aquatic plant which produces hair-like leaves along a very slender stem. Upon reaching the surface, small floating-leaves no larger than a fingernail are produced which subtend a small spike of flowers above the water's surface. Both of these species were located in the bay at the mouth of the Turtle River.

Spiny hornwort (Figure 3.5-7) is an uncommon to rare submersed aquatic plant found in lakes with high water quality. This species was previously listed as special concern in Wisconsin, but it has since been removed from this list as more data regarding its distribution in Wisconsin have been gathered in recent years. Regardless, this species is uncommon in Wisconsin and its presence in

Spider Lake is an indication of high-quality conditions. Like Robbins' spikerush and Vasey's pondweed, spiny hornwort was found in the bay at the mouth of the Turtle River.

Figure 3.5-7. Other native aquatic plants of interest located in Spider Lake in 2020. Photo credit Onterra.

As discussed in the Primer Section, the calculations used to create the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and do not include incidental species. The 44 native species encountered on the rake during 2020 point-intercept survey in Spider Lake and their conservatism values were used to calculate the FQI of Spider Lake's aquatic plant community (equation shown below).

$$\text{FQI} = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

Figure 3.5-8 compares the 2020 FQI components of Spider Lake to median values of lakes within the Northern Lakes and Forests (NLF) ecoregion and lakes throughout Wisconsin. The native species richness, or number of native aquatic plant species located on the rake in 2020 (44) falls well above the 75^{th} percentile value for lakes in the NLF ecoregion (28) and for lakes throughout Wisconsin (25). The average conservatism of the 44 native aquatic plant species located in Spider Lake in 2020 was 7.0, exceeding the median average conservatism values for lakes within the NLF ecoregion (6.7) and for lakes throughout Wisconsin (6.3). This analysis indicates Spider Lake contains a higher number of sensitive aquatic plant species (high C-values) when compared to most lakes in Wisconsin.

Using Spider Lake's native aquatic plant species richness and average conservatism yields an exceptionally high FQI value of 46.3 (Figure 3.5-8). Spider Lake's FQI value exceeds the 75th percentile for lakes within the NLF ecoregion (35.1) and the 75th percentile value for lakes in Wisconsin (32.6). Overall, the FQI analysis indicates that the aquatic plant community found in Spider Lake in terms of species richness and number of sensitive species ranks among the highest in Wisconsin.

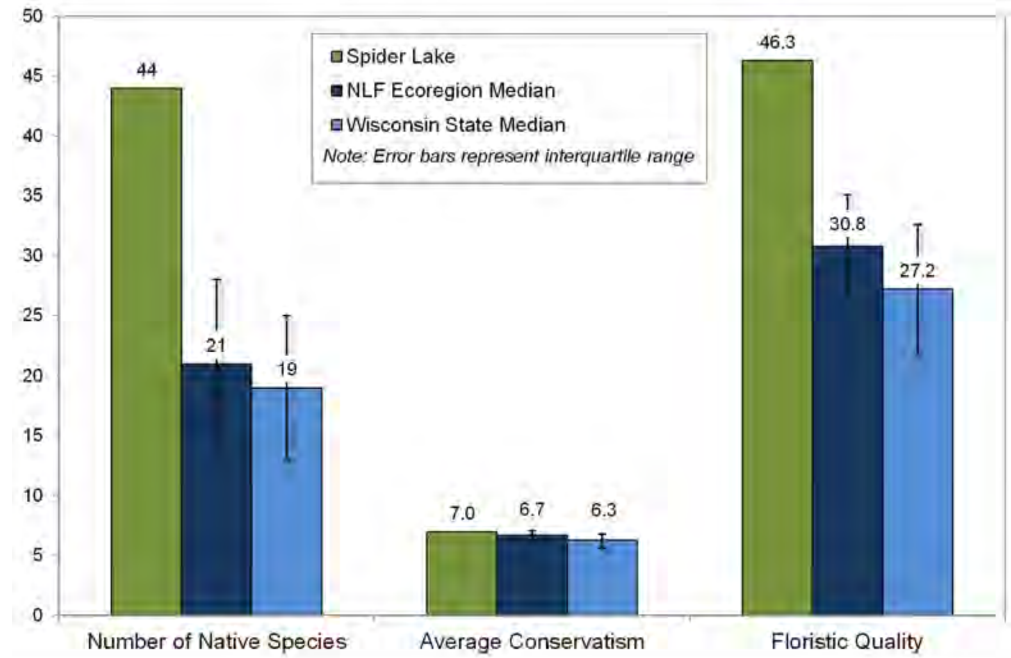


Figure 3.5-8. Spider Lake Floristic Quality Assessment. Created using data from Onterra 2020 whole-lake point-intercept survey. Analysis follows Nichols (1999).

It is believed that lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, a plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish, and other wildlife with diverse structural habitat and various sources of food. Because Spider Lake contains a higher number of aquatic plant species, one may also assume the aquatic plant community has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Spider Lake's diversity value ranks. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 212 lakes within the NLF ecoregion (Figure 3.5-9). Using the data collected from the 2020 point-intercept survey, Spider Lake's aquatic plant was found to have high species diversity with a Simpson's Diversity Index value of 0.95. In other words, there was a 95% probability that two individual aquatic plants that were randomly sampled from Spider Lake in 2020 were different species. Spider Lake's Simpson's Diversity falls at the maximum level recorded for lakes in Wisconsin, and is well above the median value for lakes in the NLF ecoregion (0.88) and the median value for lakes throughout Wisconsin (0.86).

One way to visualize Spider Lake's species diversity is to look at the relative occurrence of aquatic plant species. Figure 3.5-10 displays the relative frequency of occurrence of aquatic plant species created from the 2020 whole-lake point-intercept survey and illustrates the relatively even distribution of aquatic plant species within the community. A plant community that is dominated by just a few species yields lower species diversity. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while wild celery was found at 25% of the littoral sampling locations in Spider Lake in 2020, its relative frequency of occurrence was 13%. Explained another way, if 100 plants were randomly sampled from Spider Lake in 2020, 13 of them would have been wild celery, 8 would have been slender naiad, etc.

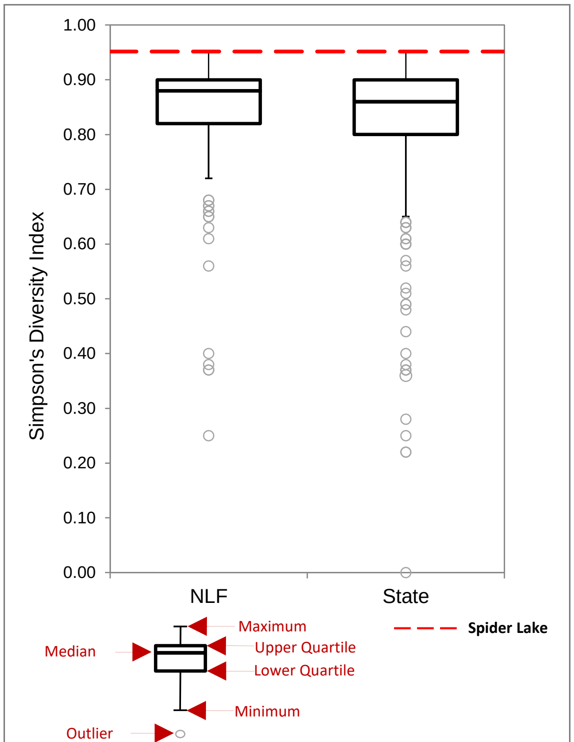


Figure 3.5-9. Spider Lake species diversity index. Created using data from Onterra 2020 point-intercept survey.

In 2020, Onterra ecologists also conducted a survey aimed at mapping emergent and floating-leaf marsh communities in Spider Lake (Photo 3.5-4 and Maps 10-11). Emergent marshes are a wetland community type dominated by species such as cattails, bulrushes, spikerushes among others, and are plants that have leaves and flowers emersed out of the water. Floating-leaved marshes are communities dominated by species that have leaves which float on the water's surface, such as white water lily and spatterdock. Emergent marshes are typically found in shallower water than floating-leaved marshes, but they do intergrade with one another. These wetland community types are important to overall lake health as they provide structural habitat for spawning and refuge and sources of food. In addition, they stabilize bottom sediments and reduce shoreland erosion. These communities are often particularly important during periods of low water levels when structural habitat provided by fallen trees become unavailable above the receding water line.

Figure 3.5-10. Spider Lake aquatic plant species relative frequency of occurrence. Created using data from Onterra 2020 point-intercept survey.

Spider Lake was found to support extensive and diverse emergent and floating-leaf marsh communities throughout shallow, near-shore areas around the lake (Figure 3.5-11). Approximately 35 acres or 10% of the lake was found to support these plant communities. The northern basin contained 26 acres or 74% of the total acreage.

A total of 26 emergent and floating-leaf plant species were documented from these communities, with floating-leaf bur-reed, watershield, white water lily, pickerelweed, and hardstem bulrush being some of the most common. One emergent species of interest, smooth sawgrass (Photo 3.5-4) was found growing in a colony surrounding the small island in the western portion of the northern basin (Map 10). Smooth sawgrass (technically a sedge) is relatively uncommon in Wisconsin and is listed as a species of special concern in Minnesota. It typically inhabits areas with coarse substrates like sand and gravel on undeveloped shorelands. Its presence in Spider Lake is an indicator of the lake's high water quality.

Photograph 3.5-4. Spider Lake mixed emergent and floating-leaf communities at the mouth of the Turtle River (left), and a colony of emergent smooth sawgrass (*Cladium mariscoides*), an uncommon and sensitive species in the lake's northern basin. Photo credit Onterra.

The community map created in 2020 represents a 'snapshot' of the important plant communities in Spider Lake, and a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within the lake. This is important because these communities are often negatively affected by recreational use and shoreland development.

The 2020 aquatic plant surveys revealed that Spider Lake supports an exceptional native aquatic plant community in terms of diversity and the high number of sensitive, uncommon, and rare species present. All assessments indicate that the lake's plant community ranks among the best in Wisconsin. Conservation of these high-quality plant communities in Spider Lake should be a priority. The plant community provides the foundation for which all other aquatic life depends upon.

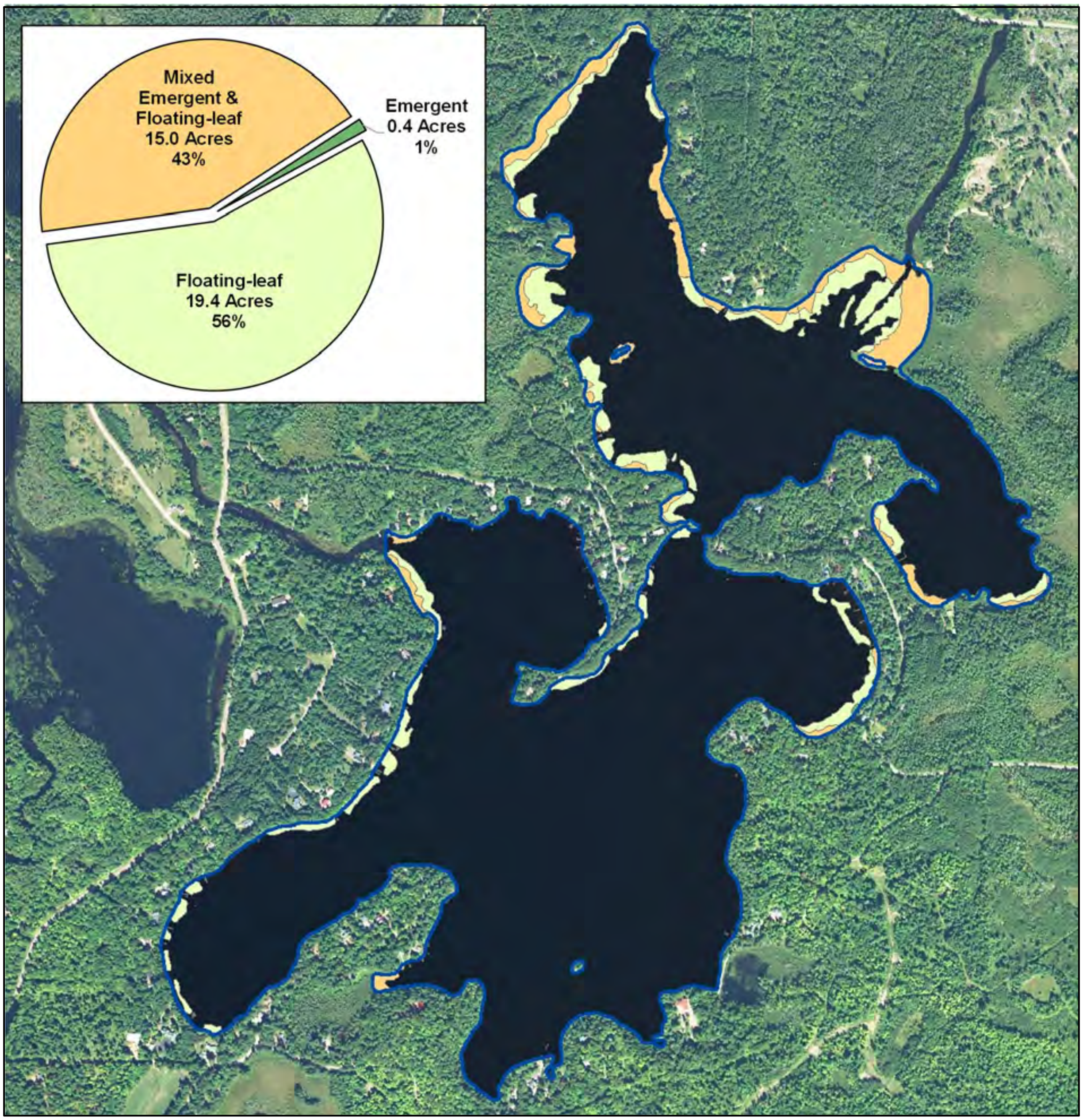


Figure 3.5-11. Spider Lake 2020 emergent and floating-leaf plant communities. Species composition of these communities can be found in the tables following Map 11.

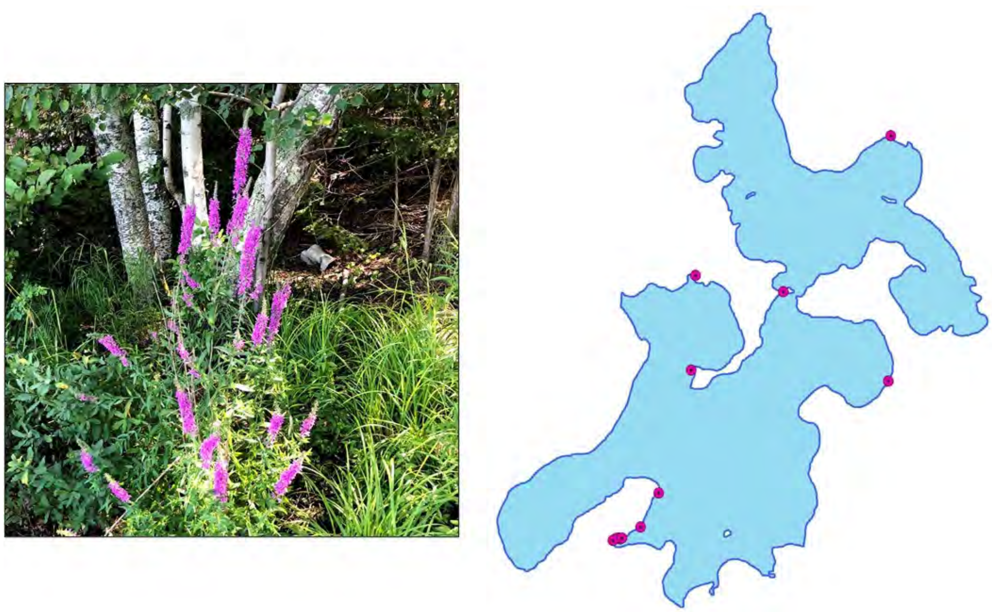
Non-Native Aquatic Plants in Spider Lake

Purple Loosestrife (*Lythrum salicaria*)

Purple loosestrife (Photo 3.5-5) is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources. First detected in Wisconsin in the 1930's, it has now spread to 70 of the state's 72 counties. Purple loosestrife largely spreads by seed, but also can vegetatively spread from root or stem fragments.

The Great Lakes Fish and Wildlife Commission located and mapped the occurrence of purple loosestrife in six locations in 2006. Eight SLA volunteers began removing purple loosestrife from those locations in 2017 and an effort each year since then has continued monitoring and removing the invasive species.

In 2020, eight purple loosestrife locations were located in isolated locations on the shores of Spider Lake (Figure 3.5-12 and Map X). The SLA has been monitoring and removing purple loosestrife on the shores of Spider Lake. The locations mapped in 2020 were provided to the SLA to aid in their efforts to remove these plants. An SLA volunteer along with a staff member from Iron County completed inspections and hand removal of plants in August of 2020. The larger population on the southern end of the lake may require more intensive hand-harvesting or possibly herbicide control. SLA is working with Iron County Land and Water Conservation Department to continue to monitor the larger population. Beatles were released in 2021 and their effectiveness will be monitored on an ongoing basis.



Photograph 3.5-5. Purple loosestrife plant (left) and summer 2020 locations of purple loosestrife on the shores of Spider Lake. Photo credit Onterra.

3.6 Aquatic Invasive Species in Spider Lake

To date, three non-native species have been documented in Spider Lake (Table 3.6-1). These include the shoreland/wetland plant purple loosestrife and two snail species, the Chinese mystery snail (documented in 2008) and the banded mystery snail (documented in 2020). In the anonymous stakeholder survey distributed in 2020, respondents were asked which invasive species they believed were present in Spider Lake. Nearly 50% of respondents indicated they believed purple loosestrife was present, while nearly 40% indicated they were unsure but believed aquatic invasive species were present (Figure 3.6-1). Nearly 30% of respondents believed that Eurasian watermilfoil was present; however, this invasive plant has not been documented in the lake and was not located in 2020. Similarly, 10% of respondents believed curly-leaf pondweed to be present, but this plant has not been documented in Spider Lake.

Table 3.6-1. Aquatic invasive species documented in Spider Lake as of March 2021.

AIS Type	Common Name	Scientific Name	Location in Report
Invertebrate	Banded Mystery Snail	*Viviparus georgianus*	Section 3.6
	Chinese Mystery Snail	*Cipangopaludina chinensis*	Section 3.6
Plant	Purple Loosestrife	*Lythrum salicaria*	Section 3.5

More information on these and other aquatic invasive species can be found at the following links:
- http://dnr.wi.gov/topic/invasives/
- https://nas.er.usgs.gov/default.aspx
- https://www.epa.gov/greatlakes/invasive-species

Aquatic Animals

Mystery snails

Photograph 3.6-1. Chinese mystery snail (left; credit Onterra) and banded mystery snail right (credit USGS).

There are two types of invasive mystery snails found within Wisconsin waters: the Chinese mystery snail (*Cipangopaludina chinensis*) and the banded mystery snail (*Viviparus georgianus*) (Photo 3.6-1). Both snails can be identified by their large size, thick hard shell and hard operculum (a trap door that covers the snail's soft body). These traits also make them less edible to native predators. These species can thrive in eutrophic waters with very little flow. They are bottom-dwellers, eating diatoms, algae and organic and inorganic bottom materials. One study conducted in northern Wisconsin lakes found that the Chinese mystery snail did not have strong negative effects on native snail populations (Solomon, Olden, P.T.J, Dillion Jr., & Vander Zander, 2010). However, researchers did detect negative impacts to native snail communities when both Chinese mystery snails and the rusty crayfish were present (Johnson, Olden, Solomon, & Vander Zanden, 2009). Rusty crayfish have to date not been documented in Spider Lake.

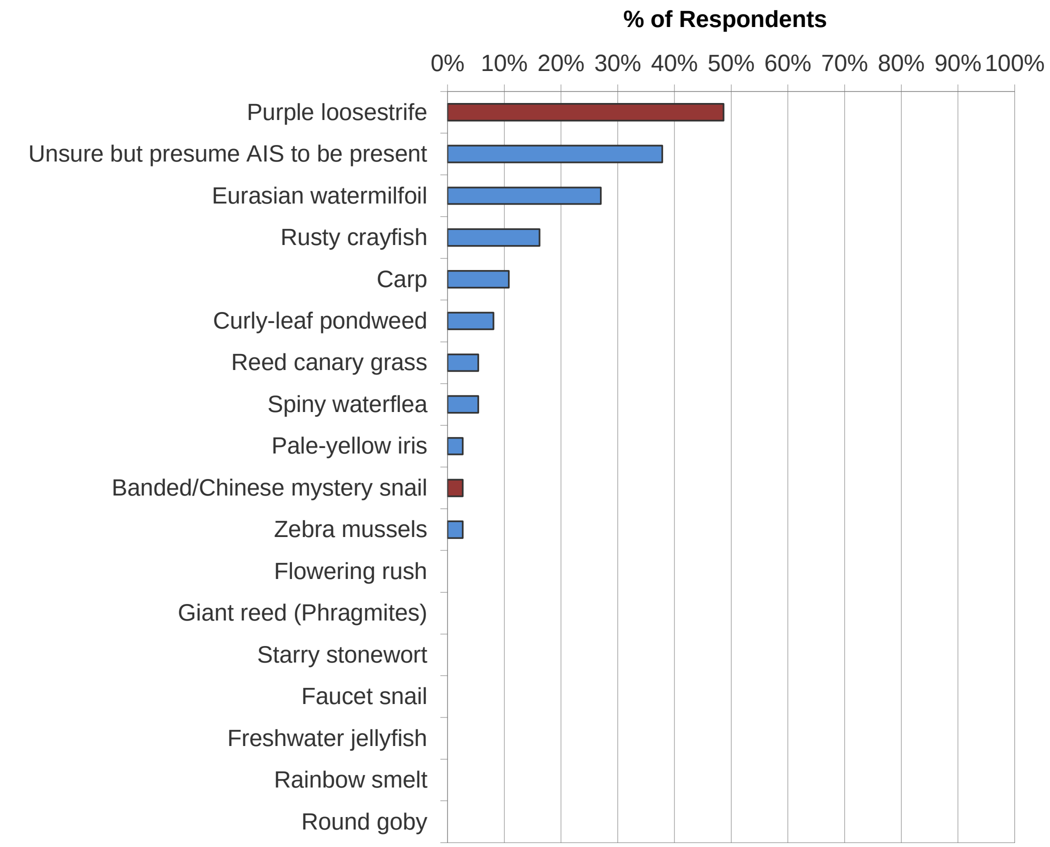


Figure 3.6-1. Spider Lake stakeholder survey response to question #22: Which aquatic invasive species do you believe are in Spider Lake? Red bars indicate species which have been documented in Spider Lake as of March 2021.

3.7 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as a reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the fisheries biologists overseeing Spider Lake. The goal of this section is to provide an overview of some of the data that exists. Although current fisheries data were not collected as a part of this project, the following information was compiled based upon data available from the Wisconsin Department of Natural Resources (WDNR), the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), and personal communications with DNR Fisheries Technician Jason Folstad.

Spider Lake Fishery

Energy Flow of a Fishery

When examining the fishery of a lake, it is important to remember what drives that fishery, or what is responsible for determining its mass and composition. The gamefish in Spider Lake are supported by an underlying food chain. At the bottom of this food chain are the elements that fuel algae and plant growth – nutrients such as phosphorus and nitrogen, and sunlight. The next tier in the food chain belongs to zooplankton, which are tiny crustaceans that feed upon plants and insects. Smaller fish called planktivores feed upon zooplankton and insects, and in turn become food for larger fish species. The species at the top of the food chain are called piscivores, and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

A concept called energy flow describes how the biomass of piscivores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscivorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 3.7-1.

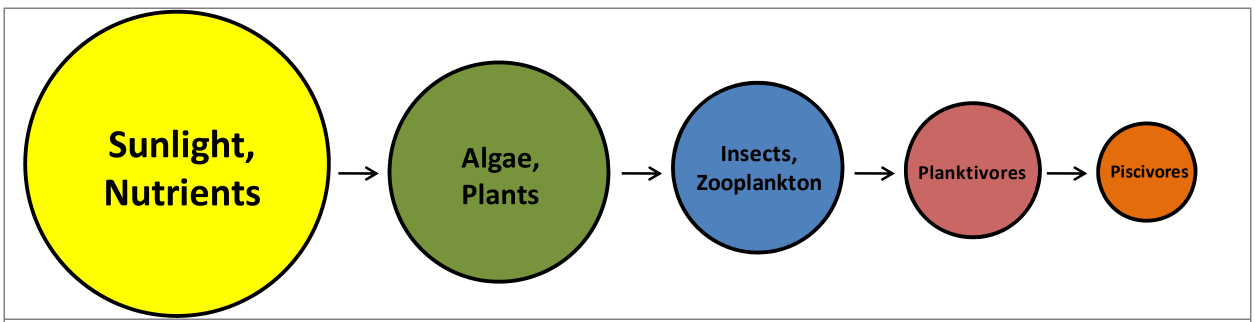


Figure 3.7-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As is discussed in the Lake Water Quality section (Section 3.1), Spider Lake is a mesotrophic system, meaning it has moderate nutrient levels, and thus a moderate level of primary productivity. In other words, Spider Lake is more productive relative to low-nutrient oligotrophic lakes, and less productive relative to high-nutrient eutrophic lakes. Simply put, this means Spider Lake should have sufficient primary productivity to support an appropriately sized population of predatory fish (piscivores) species. Table 3.7-1 shows the popular game fish species present in Spider Lake. Although not an exhaustive list of fish species in the lake, additional species documented in past WDNR surveys of Spider Lake include bluntnose minnow (*Pimephales notatus*), golden shiner (*Notemigonus crysoleucas*), johnny darter (*Etheostoma nigrum*), logperch (*Percina caprodes*), mottled sculpin (*Cottus bairdii*), shorthead redhorse (*Moxostoma macrolepidotum*), and white sucker (*Catostomus commersonii*).

Table 3.7-1. Gamefish present in Spider Lake with corresponding biological information (Becker, 1983).

Common Name (*Scientific Name*)	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements
Black Crappie (Pomoxis nigromaculat	7	May - June	Near Chara or other vegetation, over sand or fine gravel
Bluegill (Lepomis macrochirus)	11	Late May - Early August	Shallow water with sand or gravel bottom
Largemouth Bass (Micropterus salmo	13	Late April - Early July	Shallow, quiet bays with emergent vegetation
Muskellunge (Esox masquinongy)	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.
Northern Pike (Esox lucius)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves
Pumpkinseed (Lepomis gibbosus)	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom
Rock Bass (*Ambloplites rupestris*)	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep
Smallmouth Bass (Micropterus dolom	13	Mid May - June	Nests more common on north and west shorelines over gravel
Walleye (Sander vitreus)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms
Yellow Bullhead (*Ameiurus natalis*)	7	May - July	Heavy weeded banks, beneath logs or tree roots
Yellow Perch (Perca flavescens)	13	April - Early May	Sheltered areas, emergent and submergent veg

Survey Methods

In order to keep the fishery of a lake healthy and stable, fisheries biologists must assess the current fish populations and trends. To begin this process, the correct sampling technique(s) must be selected to efficiently capture the desired fish species. A commonly used passive trap is a fyke net (Photograph 3.7-1). Fish swimming towards this net along the shore or bottom will encounter the lead of the net, be diverted into the trap and through a series of funnels which direct the fish further into the net. Once reaching the end, the fisheries technicians can open the net, record biological characteristics, mark (usually with a fin clip), and then release the captured fish.

The other commonly used sampling method is electrofishing (Photograph 3.7-1). This is often done at night by using a specialized boat fit with a generator and two electrodes installed on the front touching the water. Once a fish comes in contact with the electrical current produced, the fish involuntarily swims toward the electrodes. When the fish is in the vicinity of the electrodes, they become stunned making them easier to net and place into a livewell to recover. Contrary to what some may believe, electrofishing does not kill the fish and after being placed in the livewell fish generally recover within minutes. As with a fyke net survey, biological characteristics are recorded and any fish that has a mark (considered a recapture from the earlier fyke net survey) are also documented before the fish is released. The mark-recapture data collected between these two surveys is placed into a statistical model to calculate the population estimate of a fish species. Fisheries biologists can then use this data to make recommendations and informed decisions on managing the future of the fishery.

Photograph 3.7-1. Fyke net positioned in the littoral zone of a Wisconsin Lake (left) and an electroshocking boat (right).

Fish Stocking

To assist in meeting fisheries management goals, the WDNR may permit the stocking of fingerling or adult fish in a waterbody that were raised in permitted hatcheries (Photograph 3.7-2). Stocking a lake may be done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Spider Lake was consistently stocked with muskellunge fingerlings between 1972 and 1995 (Table 3.7-2). Stocking efforts discontinued after 1995 because natural reproduction was occurring.

In 2013, Spider was selected as a control lake as part of a larger study examining northern Wisconsin's declining walleye populations. Because of Spider Lake's history of a strong, self-sustaining population, it was selected to receive no walleye stocking during this study. Population estimate surveys were conducted in both 2013 and 2019. After the 2019 estimate, it was determined that the walleye population within Spider Lake was not improving and DNR biologists have decided to implement alternate strategies in an effort to bolster populations. Stocking of walleye is tentatively scheduled to begin in 2021.

Photograph 3.7-2. Muskellunge fingerling.

Table 3.7-2. Stocking data available for muskellunge in Spider Lake (1972-1995).

Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
1995	Muskellunge	Fingerling	352	11.9
1993	Muskellunge	Fingerling	704	11.1
1992	Muskellunge	Fingerling	704	11
1991	Muskellunge	Fingerling	720	10
1990	Muskellunge	Fingerling	360	13
1989	Muskellunge	Fingerling	360	13
1988	Muskellunge	Fingerling	720	9
1987	Muskellunge	Fingerling	1080	11
1986	Muskellunge	Fingerling	720	8
1985	Muskellunge	Fingerling	720	11
1984	Muskellunge	Fingerling	468	12.3
1983	Muskellunge	Fingerling	720	7
1982	Muskellunge	Fingerling	360	11
1981	Muskellunge	Fingerling	300	11
1980	Muskellunge	Fingerling	720	9
1979	Muskellunge	Fingerling	720	9
1978	Muskellunge	Fingerling	495	11.5
1977	Muskellunge	Fingerling	722	7
1976	Muskellunge	Fingerling	700	5
1975	Muskellunge	Fingerling	450	11
1974	Muskellunge	Fingerling	700	7
1973	Muskellunge	Fingerling	300	13
1972	Muskellunge	Fingerling	350	11

Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing (open water) was the second important reason for owning property on or near Spider Lake (Question #15). Figure 3.7-2 displays the fish that Spider Lake stakeholders enjoy catching the most, with walleye, bluegill/sunfish, and smallmouth bass being the most popular. Approximately 56% of these same respondents believed that the quality of fishing on the lake was either good or fair (Figure 3.7-3). Approximately 32% of respondents who fish Spider Lake believe the quality of fishing has remained the same and 66% believe the fishing has gotten worse since they first started to fish the lake (Figure 3.7-4).

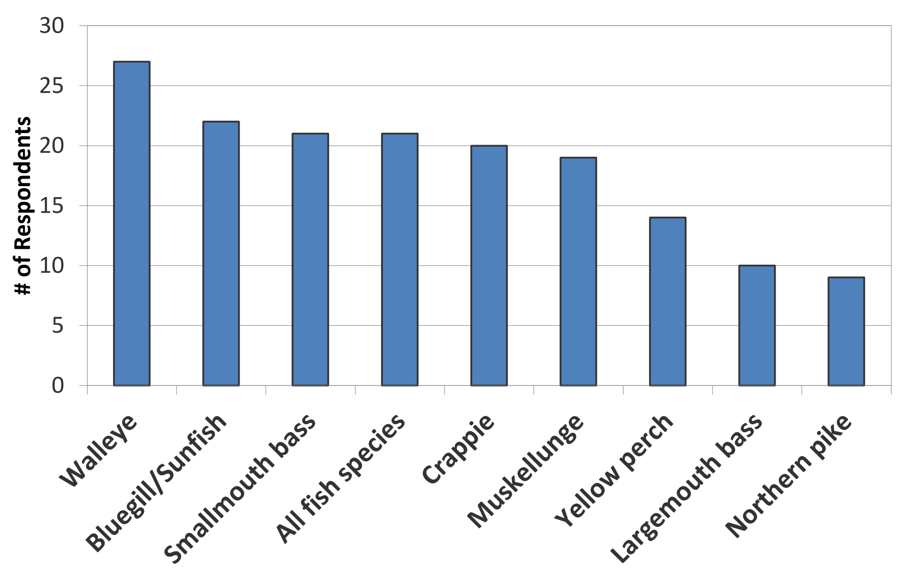


Figure 3.7-2. Stakeholder survey response Question #9. What species of fish do you like to catch on Spider Lake?

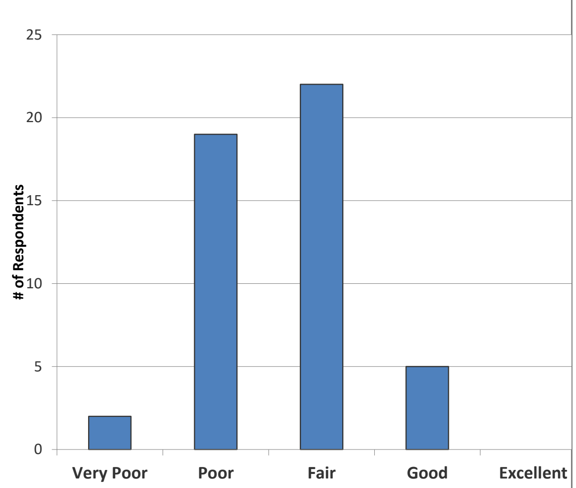


Figure 3.7-3. Stakeholder survey response Question #10. How would you describe the current quality of fishing on Spider Lake?

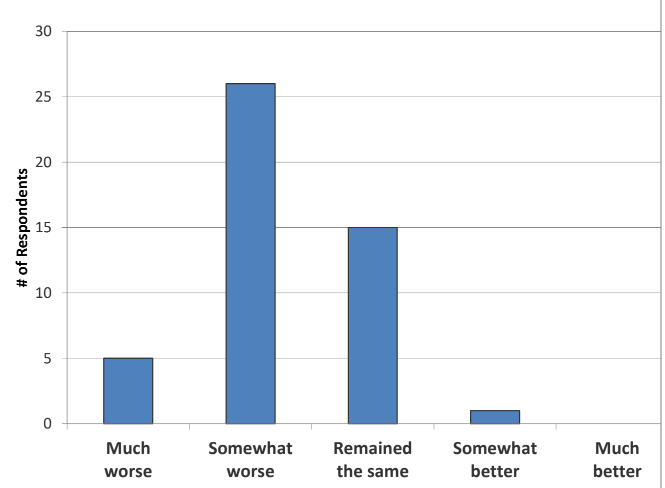


Figure 3.7-4. Stakeholder survey response Question #11. How has the quality of fishing changed on Spider Lake since you started fishing the lake?

The WDNR measures sport fishing harvest by conducting creel surveys. A Creel Survey Clerk will count the number of anglers present on a lake and interview anglers who have completed fishing for the day. Data collected from the interviews include targeted fish species, harvest, lengths of harvested fish, and hours of fishing effort. Creel clerks will work on randomly-selected days and shifts to achieve a randomized census of the fish being harvested. A creel survey was completed on Spider Lake during the 1998 and 2007 fishing seasons (Table 3.7-5). Total angler effort was slightly higher in 2007 (26.6 hours/acre) compared to the 1998 season (24.3 hours/acre). Anglers directed the largest amount of effort towards walleye and muskellunge during both the 1998 and 2007 seasons (Table 3.7-3).

Table 3.7-3. Creel Survey results 1998 & 2007.

Species	Year	Total angler effort/Acre (Hours)	Directed effort/acre (Hours)	Catch	Catch/Acre	Harvest	Harvest/Acre	Hours of Directed effort/fish caught	Hours of directed effort/fish harvested
Walleye	1998	24.3	11.4	386	1.1	220	0.6	10.6	18.6
	2007	26.6	8.8	809	2.3	269	0.8	3.8	12.5
Muskellunge	1998	24.3	7.4	88	0.3	10	0	35.7	666.7
	2007	26.6	11.3	369	1	11	0	11.1	
Northern Pike	1998	24.3	3.3	96	0.3	21	0.1	24.8	70.4
	2007	26.6	0.6	157	0.4	23	0.1	8.3	8.3
Smallmouth Bass	1998	24.3	3.9	198	0.6	26	0.1	8.3	52.9
	2007	26.6	3.6	213	0.6	10	0	16.7	
Largemouth Bass	1998	24.3	0.2	0	0	0	0		
	2007	26.6	0	12	0	0	0		

Fish Populations and Trends

Utilizing the fish sampling techniques mentioned above and specialized formulas, WDNR fisheries biologists can estimate populations and determine trends of captured fish species. One method used in calculating the numbers captured is catch per unit effort (CPUE). This number provides a standardized way to compare fish abundances between years when the amount of fishing effort (number of nights' fyke nets are set) differs. When comparing within the same year, CPUE indexes are compared to statewide data by percentiles (Niebur, 2015). For example, if a CPUE is in the 90th percentile, it is higher than 90% of the other CPUEs in the state (Niebur, 2015). Table 3.7-4 shows walleye population estimates between 1998-2019 for Spider Lake.

Table 3.7-4. Data from WDNR Walleye Population Estimates (WDNR 1998-2019).

Year	Primary Recruitment Source	Population Estimate	Lower 95 C.I.	Number / Acre	# Adults <12 Inches / Acre	# Adults 12-15 Inches / Acre	# Adults 15-20 Inches / Acre	# Adults >20 Inches / Acre
1998	NATURAL	943	794	2.7	1	1.3	0.4	0.1
2007	NATURAL	550	475	1.6	0.3	0.8	0.4	0.1
2013	NATURAL	473	332	1.3	0.2	0.4	0.4	0.2
2019	NATURAL	370	246	1.1	0	0.4	0.4	0.2

Gamefish

The gamefish present on Spider Lake represent different population dynamics depending on the species. The results for the stakeholder survey show landowners prefer to catch walleye on Spider Lake (Figure 3.7-2). Brief summaries of gamefish with fishable populations in Spider Lake are provided based off of the report submitted by WDNR fisheries biologist Zach Lawson following the fisheries surveys completed in 2013 and 2019 (Appendix E).

Walleyes are a valued sportfish in Wisconsin and are the main fishery management goal for Spider Lake. An early spring electrofishing survey was completed in 2019 to assess walleye populations. In total, 114 walleyes were captured. Sizes ranged from 11.1-23.8 inches, with an average of 15.8 inches (Appendix E). The overall size structure shows that most walleyes were relatively small.

As mentioned, Spider Lake has historically produced strong, naturally sustaining walleye populations. The most recent survey conducted in 2019 showed an estimated population of 370 walleye, or approximately 1.1 fish/acre. This is down from the 2013 estimate of 1.3 fish/acre and even more so from the 2.7 fish/acre estimate calculated in 1998 (Table 3.7-4). Walleye stocking is set to begin in 2021.

Muskellunge, like walleye, are also considered a valued sportfish of Spider Lake. Muskellunge were specifically targeted during fyke netting surveys in spring of 2019. In total, 50 muskies were sampled. Sizes ranged from 23.5-45.7 inches, with an average of 35.6 inches. The overall size structure was balanced and showed multiple fish over 40 inches (Appendix E). Spider Lake is listed as a class A2 muskellunge water, meaning anglers can expect the most consistent angling action. Lakes in this category tend to have the highest abundance of muskellunge; however, big fish make up only a small percentage of the total population. Additionally, Spider Lake is listed as a category 1 lake, where the muskellunge population is sustained 100% through natural reproduction and no stocking occurs.

Smallmouth bass are common in Spider Lake. During the spring 2019 electrofishing survey, a total of 61 smallmouth bass were sampled. Sizes ranged from 5.9-18.9 inches with an average of 11.6 inches. The overall structure was well balanced with several quality sized individuals present (Appendix E).

Northern Pike are present in Spider Lake. During the early-spring fyke netting survey, 46 northern were captured. Size structure was small as all pike sampled measured between 11.6-24.1 inches (Appendix E).

Largemouth bass are present in Spider Lake. While not listed during the 2019 survey, largemouth bass were recorded in 2013. In total, seven fish were captured between 10-14 inches during this survey (Appendix E).

Panfish

The panfish present on Spider Lake represent different population dynamics depending on the species. The results for the stakeholder survey show anglers prefer to catch bluegill and sunfish on Spider Lake (Figure 3.7-2). Brief summaries of panfish with fishable populations in Spider Lake are provided based off of the WDNR fisheries survey completed in 2019.

Bluegill were targeted during the late-spring electrofishing survey. In total, 30 bluegills were captured at a rate of 30 fish/mile. Sizes ranged from 4.0-7.7 inches with an average of 6.0 inches. The size structure shows a balance distribution (Appendix E).

Black crappie were targeted during the late-spring fyke netting survey. In total, 1,331 black crappies were captured. Sizes ranged from 4.5-11.2 inches and an average size of 8.0 inches. Overall, the size structure was balanced (Appendix E).

Yellow perch were targeted during the early spring fyke-netting survey. In total, 199 perch were captured. Sizes ranged from 5.0-8.8 inches. The average size was 6.2 inches. Overall, the size structure distribution shows mostly small individuals (Appendix E).

Spider Lake Spear Harvest Records

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.7-5). Spider Lake falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on lakes located within the Ceded Territory. Determining how many fish are able to be taken from a lake by tribal harvest is a highly regimented and dictated process.

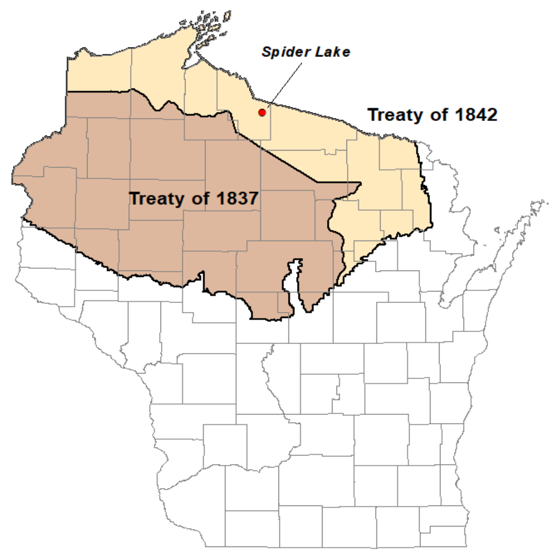


Figure 3.7-5. Location of Spider Lake within the Native American Ceded Territory (GLIFWC 2017). This map was digitized by Onterra; therefore, it is a representation and not legally binding.

This highly structured procedure begins with bi-annual meetings between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then a "total allowable catch" (TAC) is established, based upon estimates of a sustainable harvest of the fishing stock. The TAC is the number of adult walleye or muskellunge that can be harvested from a lake by tribal and recreational anglers without endangering the population.

A safe harvest value is calculated as a percentage of the TAC each year for all walleye lakes in the ceded territory. The safe harvest represents the number of fish that can be harvested by tribal members through the use of high efficiency gear such as spearing or netting without influencing the sustainability of the population. This does not apply to angling harvest which is considered a low-efficiency harvest regulated statewide by season length, size and bag limits. The safe harvest limits are set through either recent population estimates or a statistical model that ensure there is less than a 1 in 40 chance that more than 35% of the adult walleye population will be harvested in a lake through high efficiency methods.

By March 15th of each year the relevant Native American communities may declare a proportion of the total safe harvest on each lake; this declaration represents the maximum number of fish that can be harvested by tribal members annually. Prior to 2015, annual walleye bag limits for anglers were adjusted in all Ceded Territory lakes based upon the percent of the safe harvest levels determined for the Native American spearfishing season. Beginning in 2015, new regulations for walleye were created to stabilize regional walleye angler bag limits. The daily bag limits for walleye in lakes located partially or wholly within the ceded territory is three. The statewide bag limit for walleye is five. Anglers may only remove three walleye from any individual lake in the ceded territory but may fish other waters to full-fill the state bag limit (WDNR 2017).

Tribal members may harvest muskellunge, walleye, northern pike, and bass during the open water season; however, in practice walleye and muskellunge are the only species harvested in significant numbers, so conservative quotas are set for other species. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC, 2017). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing.

In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. Tribal spearers may only take two walleyes over twenty inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIFWC, 2017). This regulation limits the harvest of the larger, spawning female walleye. An updated nightly declaration is determined each morning by 9 a.m. based on the data collected from the successful spearers. Spearfishing of a particular species ends once the declared harvest is reached in a given lake. In 2011, a new reporting requirement went into effect on lakes with smaller declarations. Starting with the 2011 spear harvest season, on lakes with a harvestable declaration of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

Walleye open water spear harvest records are provided in Figure 3.7-6 from 2001-2020. During that time period, spear harvest was recorded in 2005 and 2013. In 2005, 13 walleyes were harvested. In 2013, 83 walleyes were harvested. Spear harvesters on average have taken 6.1% of the declared quota. Although the average yearly quota for muskellunge harvest is 5 fish, no muskellunge were harvested during this time period.

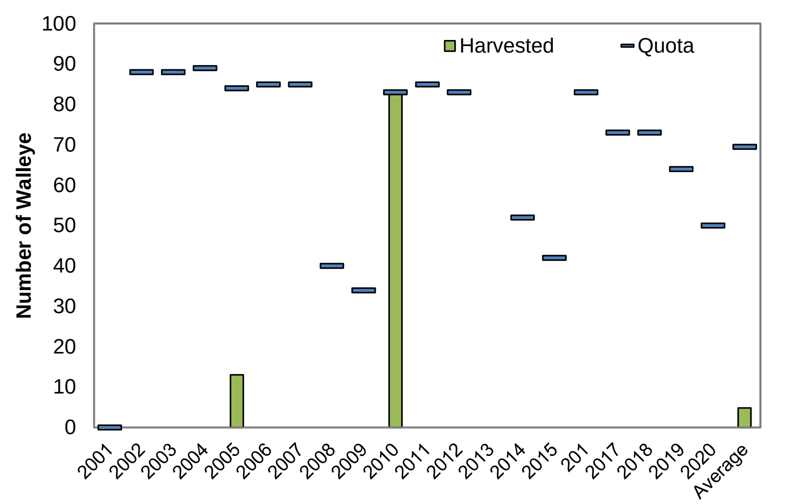


Figure 3.7-6. Spider Lake walleye spear harvest data. (GLIFWC 2001-2020).

Spider Lake Fish Habitat

Substrate Composition

Just as forest wildlife require proper trees and understory growth to flourish, fish require certain substrates and habitat types to nest, spawn, escape predators, and search for prey. Lakes with primarily a silty/soft substrate, many aquatic plants, and coarse woody debris may produce a completely different fishery than lakes that are largely sandy/rocky, and contain few aquatic plant species or coarse woody habitat.

Substrate and habitat are critical to fish species that do not provide parental care to their eggs. Northern pike is one species that does not provide parental care to its eggs (Becker, 1983). Northern pike broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result.

Walleye are another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn and care for their eggs in muck as well. According to the point-intercept survey conducted by Onterra in 2020, 42% of the substrate sampled in the littoral zone of Spider Lake were soft sediments, 41% was composed of sand, and 17% were composed of rock.

Fish Habitat Structures

Some fisheries managers may look to incorporate fish habitat structures on the lakebed or littoral areas extending to shore for the purpose of improving fish habitats and spawning areas. These projects are typically conducted on lakes lacking significant coarse woody habitat in the shoreland zone. The Fish Sticks program, outlined in the WDNR best practices manual, adds trees to the shoreland zone restoring fish habitat to critical near shore areas. Typically, every site has 3 – 5 trees which are partially or fully submerged in the water and anchored to shore (Photograph 3.7-3). The WDNR recommends placement of the fish sticks during the winter on ice when possible to prevent adverse impacts on fish spawning or egg incubation periods. The program requires a WDNR permit and can be funded through many different sources including the WDNR, County Land & Water Conservation Departments or partner contributions.

Photograph 3.7-3. Examples of fish sticks (left) and half-log habitat structures. (Photos by WDNR)

Fish cribs are a type of fish habitat structure placed on the lakebed. These structures are more commonly utilized when there is not a suitable shoreline location for fish sticks. Installing fish cribs may also be cheaper than fish sticks; however, some concern exists that fish cribs can concentrate fish, which in turn leads to increased predation and angler pressure. Having multiple locations of fish cribs can help mitigate that issue.

Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 3.7-3). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills, Bremigan, & Haynes, 2004). If the waterbody is exempt from a permit or a permit has been received, information related to the construction, placement and maintenance of half-log structures are available online.

An additional form of fish habitat structure is spawning reefs. Spawning reefs typically consist of small rubble in a shallow area near the shoreline for mainly walleye habitat. Rock reefs are sometimes utilized by fisheries managers when attempting to enhance spawning habitats for some fish species. However, a 2004 WDNR study of rock habitat projects on 20 northern Wisconsin lakes offers little hope the addition of rock substrate will improve walleye reproduction (Neuswanger & Bozek, 2004). Placement of a fish habitat structure in a lake may be exempt from needing a permit if the project meets certain conditions outlined by the WDNR's checklists available online:

(https://dnr.wi.gov/topic/waterways/Permits/Exemptions.html)

If a project does not meet all of the conditions listed on the checklist, a permit application may be sent in to the WDNR and an exemption requested. If interested, the Spider Lake Association, may work with the local WDNR fisheries biologist to determine if the installation of fish habitat structures should be considered in aiding fisheries management goals for Spider Lake.

Fishing Regulations

Regulations for Wisconsin fish species as of February 2021 are displayed in Table 3.7-4. For specific fishing regulations on all fish species, anglers should visit the WDNR website (*www.http://dnr.wi.gov/topic/fishing/regulations/hookline.html)* or visit their local bait and tackle shop to receive a free fishing pamphlet that contains this information.

Table 3.7-4. WDNR fishing regulations for Spider Lake (As of February 2021).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	10	None	Open All Year
Largemouth bass and smallmouth bass	5	14"	June 20, 2020 to March 7, 2021
Smallmouth bass	5	14"	June 20, 2020 to March 7, 2021
Largemouth bass	5	14"	May 2, 2020 to March 7, 2021
Muskellunge and hybrids	1	40"	May 23, 2020 to December 31, 2020
Northern pike	5	None	May 2, 2020 to March 7, 2021
Walleye, sauger, and hybrids	3	The minimum length is 15", but walleye, sauger, and hybrids from 20" to 24" may not be kept, and only 1 fish over 24" is allowed.	May 2, 2020 to March 7, 2021
Bullheads	Unlimited	None	Open All Year
Cisco and whitefish	10	None	Open All Year

Mercury Contamination and Fish Consumption Advisories

Freshwater fish are amongst the healthiest of choices you can make for a home-cooked meal. Unfortunately, fish in some regions of Wisconsin are known to hold levels of contaminants that are harmful to human health when consumed in great abundance. The two most common contaminants are polychlorinated biphenyls (PCBs) and mercury. These contaminants may be found in very small amounts within a single fish, but their concentration may build up in your body over time if you consume many fish. Health concerns linked to these contaminants range from poor balance and problems with memory to more serious conditions such as diabetes or cancer.

These contaminants, particularly mercury, may be found naturally to some degree. However, the majority of fish contamination has come from industrial practices such as coal-burning facilities, waste incinerators, paper industry effluent, and others. Though environmental regulations have reduced emissions over the past few decades, these contaminants are greatly resistant to breakdown and may persist in the environment for a long time. Fortunately, the human body is able to eliminate contaminants that are consumed however this can take a long time depending upon the type of contaminant, rate of consumption, and overall diet. Therefore, guidelines are set upon the consumption of fish as a means of regulating how much contaminant could be consumed over time. Spider Lake is listed as an impaired water body for elevated mercury levels. Because of this, women under 50 and children under 15 should not eat walleye over 15 inches. Women over 50 and men aged 15 or older are advised one meal of walleye over 15 inches a month.

General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 3.7-8. There is an elevated risk for children as they are in a stage of life where cognitive development is rapidly occurring. As mercury and PCB both locate to and impact the brain, there are greater restrictions on women who may have children or are nursing children, and also for children under 15.

Fish Consumption Guidelines for Most Wisconsin Inland Waterways		
	Women of childbearing age, nursing mothers and all children under 15	**Women beyond their childbearing years and men**
Unrestricted*	-	Bluegill, crappies, yellow perch, sunfish, bullhead and inland trout
1 meal per week	Bluegill, crappies, yellow perch, sunfish, bullhead and inland trout	Walleye, pike, bass, catfish and all other species
1 meal per month	Walleye, pike, bass, catfish and all other species	Muskellunge
Do not eat	Muskellunge	-

**Doctors suggest that eating 1-2 servings per week of low-contaminant fish or shellfish can benefit your health. Little additional benefit is obtained by consuming more than that amount, and you should rarely eat more than 4 servings of fish within a week.*

Figure 3.7-13. Wisconsin statewide safe fish consumption guidelines. Graphic displays consumption guidance for most Wisconsin waterways. Figure adapted from WDNR website graphic (http://dnr.wi.gov/topic/fishing/consumption/)

Fishery Management & Conclusions

Spider Lake is currently managed as a walleye and muskellunge fishery. Walleye population estimates are set to continue in 2021 and 2022 with walleye stocking scheduled to being in 2021 as well. Biologists will also be monitoring rising bass and panfish populations. The next comprehensive survey is scheduled to be completed in 2024 by the WDNR.

3.8 SPIDER LAKE AREAS OF SPECIAL CONSERVATION INTEREST

Of all the water on earth, only 2.5% is freshwater and only 0.01% is available as freshwater in lakes and rivers (Silk & Ciruna, 2005). Species richness in freshwater ecosystems is greater relative to habitat extent when compared to marine and terrestrial ecosystems, and unfortunately, biodiversity loss in freshwater ecosystems is currently estimated to be five times faster than in any other aquatic or terrestrial ecosystem (Silk & Ciruna, 2005). This loss is driven by a growing human population and its need for water. Freshwater ecosystems are being degraded or lost due to increases in nutrient and pollutant input from land use change, water diversion and extraction, and climate change.

This degradation of freshwater ecosystems results in the loss of freshwater species, communities, and ecosystems, as well as the loss of all other species dependent upon freshwater. Their degradation also inhibits their ability to provide services for humans. Given we are in a period of unprecedented biodiversity loss and in a period of uncertainty associated with the effects of global climate change, it is imperative that conservation efforts be taken to maintain freshwater biodiversity and our natural heritage.

As is discussed in the previous results subsections (Sections 3.1-3.7), Spider Lake is an exceptional freshwater resource with high biodiversity in terms of aquatic plants, fish, and freshwater mussels (see discussion on page 94). Spider Lake was also found to support three native species listed as special concern in Wisconsin (eastern elliptio mussel, Robbins' spikerush, and Vasey's pondweed). While conservation of the entire Spider Lake ecosystem and surrounding riparian zone is the ideal and ultimate goal, nine areas termed as *Areas of Special Conservation Interest*, or ASCIs, were delineated in Spider Lake based on the data collected from the 2018 Iron County Land and Water Conservation and 2020 Onterra surveys (Map 13).

These ASCIs were created with the intent to encompass and highlight the full spectrum of native species and natural community diversity present in Spider Lake. These areas were also created to include critical habitat areas where WDNR Natural Heritage Inventory listed species were documented. All nine ASCIs fall within Spider Lake's littoral zone, or the area of the lake where sunlight can sustain plant growth. The littoral zone is highly productive and contains most of the lake's biodiversity. This is the area where all aquatic plant species grow and supports spawning, rearing, refuge, and feeding habitat for diverse array of aquatic and terrestrial wildlife (Silk & Ciruna, 2005). The Spider Lake ASCIs capture the areas of highest aquatic plant species richness and diversity. While surveys aimed at macroinvertebrates (mayflies, stoneflies, caddisflies, etc.) were not completed as part of this study, other studies have shown that macroinvertebrate species richness and diversity are positively correlated with aquatic plant richness and diversity (McCreary Waters & San Giovanni, 2002).

The ASCIs were also created to capture the diversity of benthic (bottom) substrates found in Spider Lake, including rock/cobble, sand, and organic substrates. The benthic zone can be abundant with animals including macro- and microinvertebrates such as crustaceans (e.g., crayfish), insect larvae (e.g., dragonflies, true bugs, etc.), mollusks (e.g., mussels and snails), and burrowing worms (annelids). Rock/cobble substrates tend to support the highest species diversity followed by organic substrates and sand, respectively (Silk & Ciruna, 2005). Different fish species also utilize different benthic substrate types and aquatic plants on which to spawn. While there are many high-quality areas in Spider Lake, the sites of the ASCIs were also chosen based on their proximity to largely natural, minimally disturbed shorelands. In these areas, the ecotone, or natural transition zone between the aquatic and terrestrial environment is largely intact. Many of these areas also contained some of the highest concentrations of coarse woody habitat in lake mapped by Iron County in 2018.

In total, these nine ASCIs in Spider Lake encompass approximately 61 acres (Map 13). Table 3.8-1 contains information on the important natural communities these ASCIs encompass:

Table 3.8-1. Spider Lake Area of Special Conservation Interest (ASCI) descriptions. Locations of these ASCIs can be found on Map 13.

Spider Lake COA	Acres	Priority Natural Communities	Documented NHI-Listed Species	Description
A	18.0	Emergent Marsh Floating-leaved Marsh Submergent Marsh Benthic - Organic Benthic - Rock/Cobble Natural Shoreline	*Eleocharis robbinsii* *Elliptio complanata* *Potamogeton vaseyi*	Area encompasses a bay with exceptional aquatic plant diversity with over 40 native species recorded. Area is at the mouth of the Turtle River and contains areas of flownig and still water. Organic and rock/cobble substrates present. Extensive emergent, floating-leaved, and submergent marsh communities present. Contains habitat for three NHI-listed species.
B	5.3	Benthic - Rock/Cobble Coarse Woody Habitat Natural Shoreline Emergent Marsh Floating-leaved Marsh	*Elliptio complanata*	Area encompasses a continuous natural shoreline with high occurrence of coarse woody habitat and a littoral area largely comprised of rock/cobble with few aquatic plants. There is a small yet diverse emergent and floating-leaved marsh community on the COAs' southern extent. Likely an important area for fish spawning and invertebrate habitat.
C	0.6	Emergent Marsh Floating-leaved Marsh Benthic - Rock/Cobble Benthic - Sand	*Elliptio complanata*	Area encompasses an emergent/floating-leaved marsh which surrounds a small shrub-dominated island. Emergent marsh is dominated by the lake's only population of smooth sawgrass (*Cladium mariscoides*), a sensitive and relatively uncommon species in Wisconsin. Substrate is largely comprised of rock/cobble and sand, imporant substrates for spawning and invertebrate diversity. Contains habitat for one NHI-listed species.
D	16.1	Emergent Marsh Floating-leaved Marsh Submergent Marsh Natural Shoreline Coarse Woody Habitat Benthic - Rock/Cobble Benthic - Sand Benthic - Organic	*Elliptio complanata*	Like COA 1, this area encompasses an area of exceptional aquatic plant diversity with large, contigous emergent and floating-leaved marsh communities in near-shore areas. The shoreline is largely natural with a high occurrence of coarse woody habitat. Substrates of rock/cobble, sand, and organic substrates are all found here. The bays on the west side also contain a diverse submergent marsh community. Contains habitat for one NHI-listed species.
E	6.3	Benthic - Rock/Cobble Benthic - Sand Natural Shoreline Coarse Woody Habitat	*Elliptio complanata*	This area encompasses near-shore areas along the lake's southeastern shore. This area is largely comprised of rock/cobble and sandy substrates with very little aquatic plant growth. Likely an important area for fish spawning and invertebrate habitat. Shoreline is also largely natural with a high occurrence of coarse woody habitat. Contains habitat for one NHI-listed species.
F	0.9	Benthic - Rock Natural Shoreline	-	Area encompassess the shallow littoral area around the island which is largely comprised of rock/cobble substrate. Likely an important area for fish spawning and invertebrate habitat. Natural shoreline present around the island.
G	0.7	Emergent Marsh Floating-leaved Marsh Submergent Marsh Benthic - Sand Benthic - Organic Natural Shoreline	*Potamogeton vaseyi*	Area encompasses a small backwater bay which supports diverse emergent, floating-leaved, and submergent marsh plant communities. Substrates are a mix of organic and sand. Shoreline is largely natural. Contains habitat for one NHI-listed species.
H	10.4	Benthic - Sand Benthic - Rock/Cobble Natural Shoreline Coarse Woody Habitat Floating-leaved Marsh Submergent Marsh	*Elliptio complanata*	Area encompasses littoral areas around a largely undeveloped peninsula. Area is largely comprised of an extensive sand flat wth areas of rock/cobble. Submersed aquatic plants are sparse. Floating-leaved marsh communties are present immediately adjacent to shore. Coarse woody habitat is also present. Contains habitat for one NHI-listed species.
I	2.9	Emergent Marsh Floating-leaved Marsh Sumergent Marsh Benthic - Sand Benthic - Rock/Cobble Natural Shoreline Coarse Woody Habitat	*Elliptio complanata*	Area encompasses diverse emergent, floating-leaved, and submergent marsh communities adjacent to a largely natural shoreline. Substrates are largely cmprised of sand and rock/cobble. Contains habitat for one NHI-listed species.

As discussed, the purpose of these ASCIs in Spider Lake is to bring attention to the areas of the lake which encompass the majority of the species, natural communities, and habitats found in the lake and have minimal evidence of direct in-lake or shoreland impacts from human activity (Photo 3.8-1). While these areas are certainly influenced and impacted from human activity outside of these areas, the SLA can choose to take proactive action to educate lake users on the importance of these areas and how to minimize human-related disturbance (see Implementation Plan-Section 5.0).

Photograph 3.8-1. Emergent and floating-leaf marsh communities found in Spider Lake Area of Special Conservation Interest-A (Map 12). This area contained the highest number of aquatic plant species of anywhere in the lake with over 40 species documented.

Conserving the integrity of the communities within the ASCIs may include reducing watercraft speeds to slow-no-wake while in these areas to avoid impacts to plant and benthic communities through direct contact from props or indirect impacts from wave action. Other conservation actions may include efforts to protect natural shorelands in these areas and prevent or minimize impacts from future development.

Please note that these ASCIs are not legal designations, and were delineated based upon the criteria discussed earlier. The integrity of these areas is also dependent upon the conservation of the larger Spider Lake ecosystem and its watershed and does not devalue the importance of other areas around the lake. However, these ASCIs represent areas of Spider Lake which harbor the majority of the lake's biodiversity and have the least amount of human-related shoreland development.

Eastern Elliptio Mussel

During the 2020 surveys on Spider Lake, the lake was found to support a population of the eastern elliptio mussel (*Elliptio complanata*; Photo 3.8-2). The eastern elliptio is one of over 50 native freshwater mussel species that can be found in Wisconsin's lakes, rivers, and streams. Wisconsin is on the western extent of the range of this species, with the population largely found in eastern North America from Canada south to Georgia. In Wisconsin, the eastern elliptio has only been documented in the state's northernmost counties, primarily in the Lake Superior and Lake Michigan drainage basins. The eastern elliptio population in Spider Lake may represent the first population documented in the Mississippi River drainage basin; however, this has not been confirmed.

In Wisconsin, the WDNR currently lists the eastern elliptio as special concern with rank of vulnerable. The vulnerable ranking indicates that this species is at a higher risk of extirpation from the state given its fairly restricted range and relatively few population occurrences in the state. The eastern elliptio can be found in lakes and streams over a variety of habitat types (Balfour & Smock, 1995). Freshwater mussels are filter feeders, feeding on small organic particles such as algae and bacteria. They remain relatively sedentary and spend their lives fully or partially buried in the sediment.

Photograph 3.8-2. Eastern elliptio mussels found in Spider Lake during 2020 surveys. The eastern elliptio (*Elliptio complanata*) is a native freshwater mussel listed as special concern in Wisconsin. Photo credit: Onterra.

Spawning for the eastern elliptio occurs in spring, and in early summer, their larvae – called glochidia – are attached to a mucus strand and deployed from the female. The mucus strand becomes entangled on passing fish where the glochidia than become attached to the gills. The glochidia feed off the fish's blood and other nutrients for about a month before dropping off to settle on the lake bottom. The attached glochidia do not cause harm to the fish. Yellow perch, bluegill, and bass have been identified as important host fish for the eastern elliptio (Lellis, et al., 2013).

Table 3.8-1. Native freshwater mussel species recorded in Spider Lake in 2020.

Scientific Name	Common Name	Status & Distribution
Elliptio complanata	Eastern Elliptio	Special Concern - Northern WI
Eurynia dilatata	Spike	Common - Statewide
Fusconaia flava	Wabash Pigtoe	Common - Statewide
Lampsilis cardium	Plain Pocketbook	Common - Statewide
Lampsilis siliquoidea	Fatmucket	Common - Statewide
Pyganodon lacustris	Lake Floater	Common - Statewide
Utterbackia imbecillis	Paper Pondshell	Common - Statewide

In addition to the eastern elliptio, six other native freshwater mussel species were observed in Spider Lake in 2020 (Table 3.8-1). These other species are relatively common in waterbodies throughout the state. As filter feeders, native mussels are important for water quality, providing habitat for macroinvertebrates, and are sources of food for a variety of wildlife. The presence of these mussels in Spider Lake is an indicator of good environmental conditions. Maintaining good water quality and avoiding direct damage to their benthic environment through boating or shoreland development are essential for conserving the populations of these valuable animals. This is especially important given these are one of the most imperiled groups of animals in North America, with a number of species already lost to extinction. Please note that it is illegal to harvest live native mussels in Wisconsin. For more information on Wisconsin's mussels and how lakeshore property owners can assist with their conservation, please visit the WDNR's Wisconsin Mussel Monitoring Program (https://wiatri.net/inventory/mussels/).

4.0 SUMMARY AND CONCLUSIONS

The design of this project was intended to fulfill three primary objectives:

1) Collect baseline data to increase the general understanding of the Spider Lake ecosystem.
2) Collect sociological information from Spider Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.
3) Develop realistic and implementable management goals and actions to protect and enhance the Spider Lake ecosystem for future generations.

These three objectives were fulfilled during the project and have led to a greater understanding of the Spider Lake ecosystem, the distribution of non-native plant species, the concerns and perceptions of Spider Lake stakeholders, and the actions that need to be taken to conserve and enhance this important natural resource. The studies completed as part of this project indicate that Spider Lake overall is very healthy, and its water quality has remained largely unchanged for at least the past 150 years. Unlike other lakes which have seen a higher degree of development within their watersheds and along their shorelines which have resulted in degraded water quality, the majority of Spider Lake's watershed and shoreline remain undeveloped, resulting in the preservation of the lake's high water quality.

While phosphorus concentrations have increased slightly and water clarity has been lower in the recent decade, this is believed to be due to the regional increase in annual precipitation resulting in increased runoff and the flushing of wetlands within the watershed. Nutrient concentrations are generally more dynamic in drainage lakes with large watersheds like Spider Lake which receive a large portion of their water from surface runoff. The drier conditions in 2021 resulted in highest water clarity observed the lake since 2012. Continued monitoring of the lake's water quality by Spider Lake volunteers will allow for an increased understanding of nutrient dynamics in this lake and how they relate to changes in regional climate patterns. Overall, Sider Lake's water quality is considered excellent for deep lowland drainage lakes in Wisconsin.

The aquatic plant inventories found that Spider lake supports a diverse and species-rich native aquatic plant community, an indication of a healthy aquatic ecosystem. No Eurasian watermilfoil or curly-leaf pondweed were located during the 2020 surveys. However, populations of these invasive plants exist in nearby and connected waterbodies, so continued monitoring as outlined in the Implementation Plan will be important to detect any new invasions early. Isolated occurrences of purple loosestrife were mapped in shoreland areas around the lake, and the SLA has a monitoring and control program in place with Iron County.

The watershed and immediate shoreland assessment found that the vast majority of Spider Lake's watershed is comprised of intact forests and wetlands which are filters for the lake and maintain its excellent water quality. The county's shoreland assessment showed most of the shoreline supports intact natural habitat with minimal development and a high degree of course woody habitat. Like all lakes, Spider Lake faces a number of challenges and threats, SLA and other dedicated lake stakeholders are taking proactive action to meet these challenges and to ensure the conservation and enhancement of the Spider Lake ecosystem for future generations.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented in this section was created through the collaborative efforts of the Spider Lake Planning Committee, Onterra ecologists, and WDNR staff. The goals detailed within the plan are realistic and based upon findings of studies completed in conjunction with this planning project and data compiled from a comprehensive survey of Spider Lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, the needs of the stakeholders, and volunteer engagement. Please note that the listing order of these management goals is not indicative of priority.

Management Goal 1: Protect Current Water Quality Conditions

Management Action 1a:	Continue monitoring of Spider Lake's water quality through the WDNR Citizens Lake Monitoring Network (CLMN) program.
Timeframe:	Continuation of current effort.
Facilitator:	Jim Brancel (current volunteer), Mike Shouldice and Gary Patzke for Secchi disk monitoring, Fred Tomko (backup volunteer), and SLA Board of Directors.
Description:	Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. The Citizen Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. Volunteers from Spider Lake have been collecting water quality data nearly every year since 1998. Spider Lake is currently enrolled in the advanced monitoring program, where phosphorus and chlorophyll data are collected in addition to Secchi disk transparency. Continued monitoring of Spider Lake's water quality will continue to increase managers' understanding of how changes in precipitation and other environmental factors influence phosphorus concentrations in Spider Lake. In addition to monitoring phosphorus concentrations, continued monitoring will allow for the early detection of other types of water quality degradation. When a change in the collection volunteer occurs, Sandy Wickman (715.365.8951) or the appropriate WDNR/UW-Extension staff will need to be contacted to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.
Action Steps:	

1. Jim Brancel or SLA Board of Directors appoints/recruits new water quality monitoring volunteer(s) as needed.
2. New volunteer(s) contact Sandy Wickman (715.365.8951) with the WDNR as needed.
3. Volunteer(s) report annual monitoring results to WDNR SWIMS database.

Management Action 1b:	Promote the conservation of undeveloped and the restoration of highly developed shoreland areas on Spider Lake to protect and enhance habitat, reduce erosion, and protect water quality.
Timeframe:	Continuation of current effort.
Facilitator:	SLA Shoreline Committee
Potential Funding:	Healthy Lakes Grants; Lake Protection Grant
Description:	The SLA Shoreland Committee will explore project opportunities and make recommendations on best management practices along lakeshore properties of Spider Lake to the SLA Board of Directors. Projects approved by the SLA Board through recommendation by the Shoreland Committee will receive assistance from the Committee as property owners apply for grant applications. Educational materials for healthy shorelines and watercraft safety will be provided to inform and educate property owners.

The 2018 shoreland condition assessment completed by Iron County found that the majority of Spider Lake's shoreland zone is in good condition with minimal development and intact natural vegetative cover. However, the survey also found that there are some areas with a higher degree of development and lack of natural habitat that could serve as potential restoration sites.

The Shoreland Committee will provide riparian property owners information about how maintaining a more natural shoreland is important for the lake in terms of habitat, stabilizing shoreland soils, protecting water quality, and maintaining the lake's aesthetic appeal. The Shoreland Committee will also provide riparians information as to how developed shorelands lack healthy lake benefits and the possible negative affects these areas may have on the Spider Lake ecosystem.

The Shoreland Committee will encourage Spider Lake property owners to pursue projects that would qualify for Healthy Lakes grants to restore developed shorelands and implement best management practices (e.g., rain gardens and native plantings) on their property.

The WDNR's Healthy Lakes grants allow partial cost coverage for native plantings in transition areas. This reimbursable grant program is intended for relatively straightforward and simple projects. More advanced projects that require advanced engineering design may seek alternative funding opportunities, potentially through the county and the WDNR Lake Protection Grant Program. For a larger project that may include a number of properties, it may be more appropriate to seek funding through a WDNR Lake Protection Grant. While more funding can be provided through a Lake Protection Grant and there are no limits to where that funding is utilized (e.g., technical, installation, etc.). However, the grant does require that the restored shorelines remain undeveloped in perpetuity.

The Shoreland Committee should work with the WDNR's Kevin Gauthier (715.356.5211) to initiate new Healthy Lake projects and research ideas for larger-scale projects to address shoreland erosion if needed. The SLA should also work with the Iron County Land and Water Conservation Department to research other grant programs, shoreland restoration/preservation techniques, and other pertinent information that will aid the SLA.

Action Steps:

1. The Shoreland Committee gathers appropriate information from WDNR and Iron County regarding shoreland restoration and protection.
2. The Shoreland Committee and SLA provide Spider Lake property owners with informational resources on shoreland protection and restoration. Interested property owners may contact the SLA or WDNR for more information on shoreland restoration plans, financial assistance, and benefits of implementation.

Management Goal 2: Control Existing & Prevent New Invasive Species Introductions to Spider Lake

Management Action 2a: Recruit and coordinate volunteers to initiate annual monitoring for invasive species at public and private boat launches around Spider Lake.

Timeframe: Initiate in 2022

Facilitator: Bob Dannenberg

Description: Periodic monitoring for new infestations of aquatic invasive species is important as early detection may result in more cost-effective and efficient control methods and possibly even eradication. The 2020 surveys on Spider Lake did not locate any occurrences of the invasive plants Eurasian watermilfoil or curly-leaf pondweed; however, populations of these plants occur in nearby and connected waterbodies and represent an increased risk to Spider Lake.

In an effort to increase invasive species monitoring in Spider Lake, a volunteer-based monitoring effort will be initiated where public and private access points around Spider Lake (Map 14) will be inspected two to three times per year for the presence of invasive species. Bob Dannenberg of the SLA will lead this effort in recruiting and coordinating the volunteer inspections.

Once volunteers are recruited, they can attend a public or private aquatic invasive species identification workshop led by the North Lakeland Discovery Center (NLDC) in Manitowish Waters. Jamie Vandenlangenberg (jamie@discoverycenter.net), Water Program Director for the NLDC, should be contacted to determine when these workshops are held or to schedule a private training for the volunteers.

Once volunteers are trained in the identification of these invasive species and native look-a-likes present in Spider Lake, monitoring of public and private boat launches can occur annually. New volunteers should be recruited as needed. Please see the next management action (2a) regarding actions to take if a new invasive species is discovered in Spider Lake.

Action Steps:

1. Bob Dannenberg to recruit volunteers for annual invasive species monitoring.
2. Bob Dannenberg contacts Jamie Vandenlangenberg (jamie@discoverycenter.net) at the NLDC to schedule invasive species identification training for volunteer monitors.
3. Using Map 14, Bob Dannenberg coordinates volunteers to monitor areas around the public and private boat landings for invasive species two to three times per year (e.g., June, July, & August).
4. In the event a new invasive species is located, the SLA follows aquatic invasive species response protocol as outlined in management action 2b.
5. Bob Dannenberg, or current volunteer coordinator, reports monitoring efforts and findings to SLA annually.

Management Action 2b: Activate aquatic invasive species rapid response plan upon discovery of a new infestation.

Timeframe: Enact upon discovery of new invasive species

Facilitator: SLA and/or appropriate lake stakeholder(s)/volunteers

Description: In the event that a new aquatic invasive species, such as Eurasian watermilfoil, is located in Spider Lake by trained volunteers, the area(s) would be marked using GPS (e.g., smartphone). Volunteers should collect specimens and contact resource managers immediately for identification confirmation and control options. The areas marked by volunteers would serve as focus areas for professional ecologists, and these areas would be surveyed by professionals during the plant's peak growth phase. The results would be used to develop potential control strategies. The SLA will continue to educate general lake stakeholders on how to identify Eurasian watermilfoil, curly-leaf pondweed, and other invasive species so they may recognize potential occurrences while out on the lake.

Action Steps:

1. SLA Board of Directors contacts WDNR, Iron County, and NLDC upon discovery of new aquatic invasive species in Spider Lake.
2. SLA works with WDNR, Iron County, NLDC and/or qualified professionals to develop management strategy for newly discovered invasive species.
3. The SLA will communicate and advise riparian property owners and lake stakeholders immediately with new invasive species discovery and information.

Management Action 2c:	Consider utilizing professional ecologists for periodic, lake-wide invasive species monitoring.
Timeframe:	Lake-wide invasive species assessment once every five years (if no invasive species are detected by volunteers)
Facilitator:	SLA Board of Directors
Description:	As is discussed under management action 1a, the SLA will be initiating a volunteer-based monitoring program for invasive species where areas around lake access points will be inspected for invasive species on an annual basis. Given the nearby proximity of Eurasian watermilfoil and curly-leaf pondweed populations to Spider Lake, the SLA will consider utilizing professional ecologists (e.g., Onterra) to complete a lake-wide aquatic invasive species monitoring assessment once every five years (if no invasive species are detected by volunteers). This survey would likely be completed in June to coincide with the peak growth of curly-leaf pondweed and also allow for the detection of any potential Eurasian watermilfoil occurrences. Like the survey completed during the management planning development, the entire littoral zone and shoreline of Spider Lake would be searched for invasive plant species.

Action Steps:

1. Retain qualified professional to complete AIS monitoring on Spider Lake in 2025.
2. A budget of potential expenditures and revenue sources will be created and presented to the membership.
3. Create a list of qualified professionals and their expertise, and take note of engagements that have been undertaken in northern Wisconsin.

Management Action 2d:	Monitor and control purple loosestrife within the immediate shoreland zone of Spider Lake.
Timeframe:	Continuation of current effort.
Facilitator:	SLA volunteers Mike Shouldice & Pat Christie

Description: The 2020 surveys found isolated occurrences of purple loosestrife scattered around shoreland areas of Spider Lake (Map 12). The SLA in coordination with Iron County has been monitoring and removing purple loosestrife on the shores of Spider Lake since 2017. The locations mapped in 2020 were provided to the SLA to aid in their efforts to remove these plants. SLA volunteer monitors mark locations of purple loosestrife, notify riparian property owners of the occurrence, and obtain permission from the landowner to remove the plant.

The SLA will continue working with Iron County to determine a control strategy for an area in the southern part of the lake with a larger population of purple loosestrife. The SLA is working with Iron County to monitor the effectiveness of *Galerucella* beetles that were released in the southern bay in July 2021. Iron County staff plan to inspect the southern bay in the summer of 2022 to assess the effectiveness of the beetles. Volunteers dug out purple loosestrife plants in other areas around Spider Lake in 2021, and volunteers will be creating a database to document their inspection and removal efforts. The SLA also tries to educate riparian property owners about purple loosestrife on their property to increase inspection and removal efforts.

Action Steps:

1. Continue annual volunteer-based monitoring and control of purple loosestrife along the shorelines of Spider Lake.
2. Document and monitor all purple loosestrife occurrences with GPS coordinates and maintain database (e.g., Excel spreadsheet) to keep and update records.
3. Work with county partners to develop a long-term purple loosestrife monitoring and control strategy.
4. Continue to educate property owners on purple loosestrife identification and control via methods discussed above, and recruit volunteers as needed to maintain annual monitoring and control of these plants within the shoreland zone.

Management Action 2e: SLA to work with owners of private boat launches on Spider Lake regarding aquatic invasive species education and prevention.

Timeframe: Initiate in 2022

Facilitator: SLA Board of Directors

Description: In addition to the public boat launch, Spider Lake has eight boat launches under private ownership (Map 14). These boat landings represent potential points of introduction for new invasive species. In an effort to prevent the introduction of invasive species, the SLA will contact the owners of these private boat launches and provide them with information on invasive species education and prevention.

Action Steps:

1. See description above.

Management Action 2f:	SLA to investigate installing/improving aquatic invasive species signage at most frequently-used boat launches and along the Turtle River between Oxbow and Spider lakes.
Timeframe:	Initiate in 2022
Facilitator:	SLA Board of Directors
Description:	The SLA is going to investigate improving existing and/or installing new signage at Mills Point and Pine Forest Lodge, the most frequently used private boat launches. The SLA will discuss and work with the owners of these boat landings to discuss the benefits of signage and to obtain permission to install signage at these landings. The SLA will also discuss adding aquatic invasive species signage along the Turtle River between Oxbow and Spider lakes around Shay's Dam and/or the county boat landing. Invasive plant species are present in connected waterbodies downstream of Spider Lake, and this signage would be designed to alert boaters and paddlers coming upstream into Spider Lake to make sure their watercraft are free of plants and mud.
Action Steps:	

1. SLA to work with owners of Mills Point and Pine Forest Lodge boat landings to discuss installation of aquatic invasive species signage.
2. SLA explores possibility of installing invasive species signage along the Turtle River between Oxbow and Spider lakes.
2. SLA works with WDNR to obtain appropriate signage for these areas.

Management Goal 3: Increase SLA's Capacity to Communicate with Lake Stakeholders and Facilitate Partnerships with Other Management Entities

Management Action 3a:	Promote the conservation and enjoyment of Spider Lake through stakeholder education.
Timeframe:	Continuation and expansion of current efforts.
Facilitator:	SLA Board of Directors
Description:	Education represents an effective tool to address many lake challenges. The SLA currently communicates with its membership through email, a regularly published newsletter, an association Facebook page, and annual meetings. These modes of communication provide members and non-members with association-related information including current projects and updates, meeting times, and educational topics. In the 2021 stakeholder survey, approximately 98% of survey

respondents had indicated that they have heard of the SLA, while 66% and 30% indicated the SLA keeps them *highly* or *fairly well-informed* regarding issues with Spider Lake and its management, respectively.

The SLA would like to maintain and increase its capacity to reach out to and educate association and non-association members regarding Spider Lake and its conservation. In an effort to increase their outreach, the SLA will search for an SLA volunteer who may be more proficient with Facebook to increase activity on the page. Additionally, the SLA will also investigate the creation of an association website where visitors can learn about the SLA, benefits of membership, Spider Lake ecology and current projects, educational materials, meeting times, etc.

Education of lake stakeholders on all matters is important, and a list of educational topics that were discussed during the planning meetings along with others can be found below. These topics can be included within the association's newsletter, distributed as separate educational materials, or posted on the association's Facebook page and/or future website. The SLA can also invite speakers to discuss lake-related topics or hold workshops for their members at their annual meetings.

Example Educational Topics

- Aquatic invasive species identification, prevention, and management
- Information from the lake management planning project
- Noise and light pollution (encouraging *dark sky*)
- Boating regulations and responsible use
- Lake property and shoreland conservation and restoration
- Native aquatic plant conservation, importance in the aquatic community, fluctuations in abundance from year to year
- Spider Lake Areas of Special Conservation Interest (ASCIs)
- Importance of maintaining coarse woody habitat (CWH)
- Basic lake ecology (water quality, plants, fisheries, etc.)
- Effect of lawn fertilizers/pesticides on lakes
- Respect to and maintaining a safe distance from wildlife in the lake (e.g., loons and loon nests)
- Water quality updates from Spider Lake volunteer monitoring
- Fishing rules and regulations
- Catch-and-release fishing
- Septic system maintenance

Action Steps:

1. SLA continues current educational efforts and increases capacity by investigating the improvement of the association's Facebook page and creation of an association website.

2. SLA Board of Directors communicates lake-related information and educational materials to lake stakeholders through methods discussed in description.

Management Action 3b:	Continue and enhance SLA's involvement with other entities that manage aspects of Spider Lake and other conservation groups.
Timeframe:	Continuation of current effort
Facilitator:	SLA Board of Directors
Description:	The SLA is dedicated to enhancing, preserving, and protecting the quality of Spider Lake for future generations through effective environmental and education policies. The SLA promotes policies and practices that protect the interests of Spider Lake stakeholders and enhance their ability to maximize enjoyment of their shared resource. The waters of Wisconsin belong to everyone and therefore this goal of protecting and enhancing these shared resources is also held by other entities. Some of these entities are tribal and governmental while other organizations rely on voluntary participation. It is important that the SLA actively engage with all management entities to enhance the association's understanding of common management goals and to participate in the development of those goals. This also helps all management entities understand the actions that others are taking to reduce the duplication of efforts. Each entity will be specifically addressed in the table on the next pages:
Action Steps:	

1. See table guidelines on the next pages.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Town of Mercer	John Sendra, Chairman (715.476.0219)	Spider Lake falls within the Town of Mercer	Once a year, or more as needed. May check website (https://www.townofmertow.com/) for updates.	Town staff may be contacted regarding ordinance reviews or questions, and for information on community events.
Iron County Land and Water Conservation	Heather Palmquist, Department Head (715.561.2234)	Oversees conservation efforts for land and water projects.	As needed	Can provide assistance with shoreland restorations, habitat improvements, and AIS.
Wisconsin Department of Natural Resources	Kevin Gauthier, Vilas County Lakes Coordinator (715.356.5211)	Oversees management plans, grants, all lake activities.	Every 5 years, or more as necessary.	Information on updating a lake management plan (every 5 years) or to seek advice on other lake issues.
	Nick Miofsky, Conservation Warden (920.579.2751)	Oversees regulations handed down by the state.	As needed. May call the WDNR violation tip hotline for anonymous reporting (1-800-847-9367)	Contact regarding suspected violations pertaining to recreational activity on Spider Lake, include fishing, boating safety, ordinance violations, etc.
	Citizens Lake Monitoring Network contact (Sandy Wickman – Sandy.Wickman@wisconsin.gov)	Provides training and assistance on CLMN monitoring, methods, and data entry.	Twice a year or more as needed.	Late winter: arrange for training as needed, in addition to planning out monitoring for the open water season. Late fall: report monitoring activities.
	Jeanne Sherer (Purple Loosestrife Coordinator) jeanne.sherer@wisconsin.gov	Provides assistance on purple loosestrife control and monitoring.	As needed.	
Wisconsin Lakes	General staff (800.542.5253)	Facilitates education, networking and assistance on all matters involving WI lakes.	As needed. May check website (www.wisconsinlakes.org) often for updates.	SLA members may attend WL's annual conference to keep up-to-date on lake issues, AIS training, etc.

North Lakeland Discovery Center	Emily Heald, Water Program Coordinator (water@discoverycenter.net)	Educates and inspires connection to the natural state of the Northwoods	As needed	Direct resource for AIS education and monitoring needs, operates aquatic education programs and assists with volunteer recruitment.

Management Goal 4: Conserve and Enhance Spider Lake as a Fishery Resource

Management Action 4a:	Work with WDNR fisheries managers, other Turtle River Chain of Lakes Associations, and the Iron County Lakes and Rivers Alliance to conserve and enhance the fishery of Spider Lake.
Timeframe:	Continuation of current effort.
Facilitator:	SLA Board of Directors
Description:	Respondents to the 2020 stakeholder survey listed fishing as one of the top reasons for owning property on Spider Lake. Spider Lake stakeholders must realize the complexities and capabilities of this ecosystem with respect to the fishery it can produce. The SLA currently collaborates with WDNR staff to enhance the fishery of Spider Lake through stocking and habitat improvements. While Spider Lake historically had strong natural reproduction of walleye, recent surveys have shown a decline in their population. Stocking of walleye was set to occur in 2021. Ongoing research is indicating that increasing water temperatures may be the primary factor limiting natural walleye reproduction. While the SLA will continue to work with WDNR biologists to determine if habitat improvements have the capacity to increase natural reproduction. The SLA will also work with WDNR fisheries biologists to enhance fisheries habitat in Spider Lake. The 2018 WDNR shoreland survey found that Spider Lake supports a high amount of course woody habitat. The SLA will work with local fisheries biologists to determine if course woody habitat enhancements would be beneficial to the fishery in the future.
Action Steps:	
1.	SLA contact current WDNR Fisheries Biologists at least once per year to inquire about ongoing fisheries management in Spider Lake.
2.	SLA works with WDNR fisheries biologists to continue walleye stocking if necessary in the absence of natural reproduction and will continue to work to improve fisheries spawning and foraging habitat.
3.	SLA continues to educate and communicate with stakeholders about the lake's fishery, shocking and creel surveys, regulations, catch-and-release fishing, habitat, and other fisheries-related topics.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Spider Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in the lake that would most accurately depict the conditions of the lake (Map 1). Samples were collected with a 3-liter Van Dorn bottle at the subsurface (S) and near bottom (B). Sampling occurred once in spring, fall, and winter and three times during summer. Samples were kept cool and preserved with acid following standard protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included the following:

	Spring		June		July		August		Fall		Winter	
Parameter	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
Total Phosphorus	●	●	●	●	●	●	●	●	●	●	●	●
Dissolved Phosphorus	●	●			●	●					●	●
Chlorophyll - *a*	●		●		●		●		●			
Total Nitrogen	●	●			●	●					●	●
True Color	●				●							
Laboratory Conductivity	●	●			●	●						
Laboratory pH	●	●			●	●						
Total Alkalinity	●	●			●	●						
Hardness	●				●							
Total Suspended Solids	●	●			●	●			●	●		
Calcium	●				●							

In addition, during each sampling event Secchi disk transparency was recorded and a temperature and dissolved oxygen profile was completed using a HQ30d with a LDO probe.

Watershed Analysis

The watershed analysis began with an accurate delineation of Spider Lake's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the National Land Cover Database (NLCD) (USGS, 2019) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska & Kreider, 2003).

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Spider Lake during a June 8, 2020 field visit, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Spider Lake to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in the Wisconsin Department of Natural Resource document, Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry, and Analysis, and Applications (WDNR PUB-SS-1068 2010) was used to complete this study on August 6, 2020. A point spacing of 37 meters was used resulting in approximately 334 points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Spider Lake (emergent and floating-leaved vegetation) were mapped using a Trimble Pro6T Global Positioning System (GPS) with sub-meter accuracy. Furthermore, all species found during the point-intercept surveys and the community mapping surveys were recorded to provide a complete species list for the lake.

Representatives of all plant species located during the point-intercept and community mapping survey were collected, vouchered, and sent to the University of Wisconsin – Steven's Point Herbarium.

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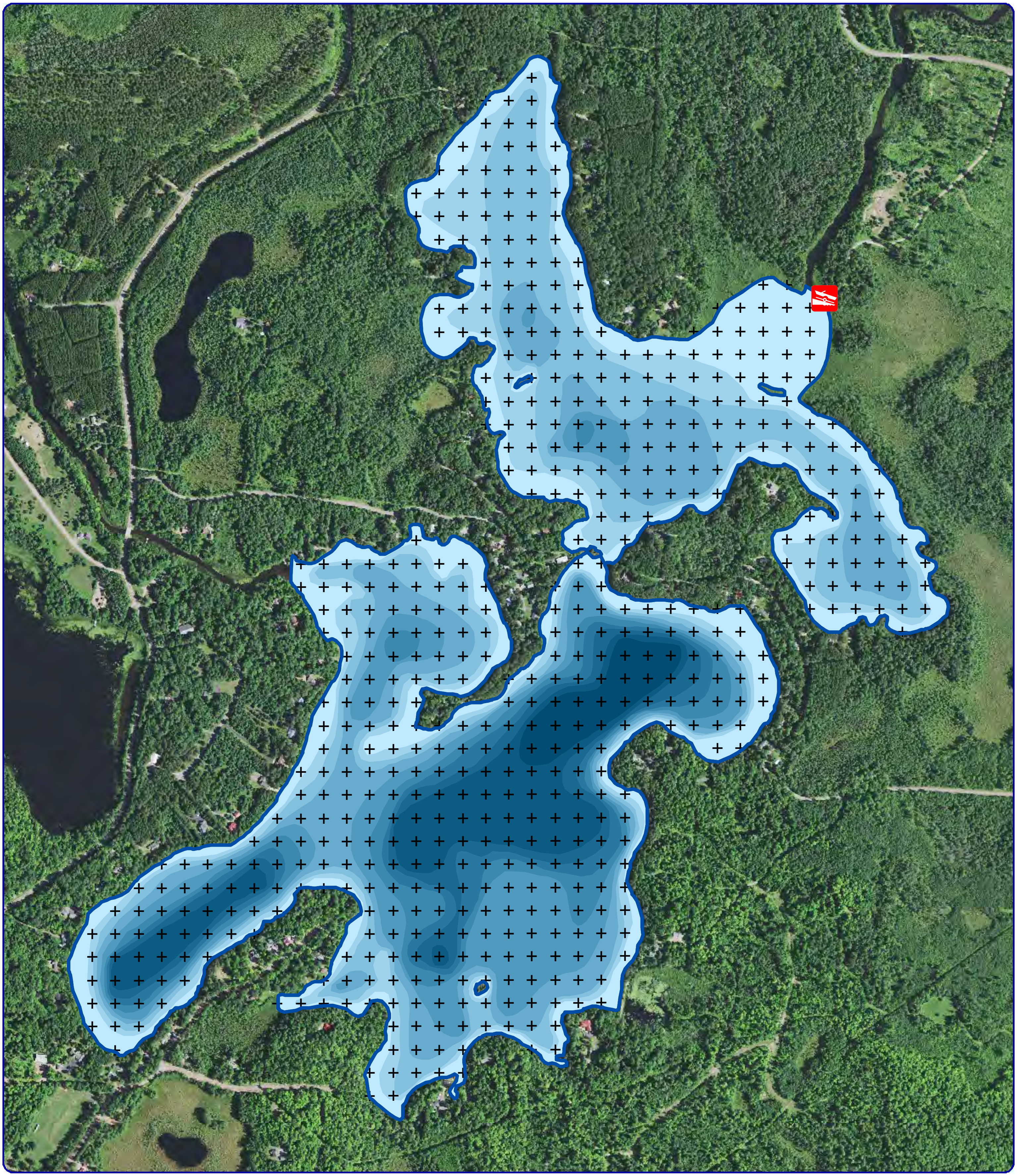

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www.onterra-eco.com

Sources:
Orthophotography: NAIP 2018
Bathymetry: WDNR, digitized by Onterra
Map Date: December 15, 2020
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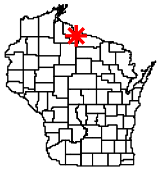


Project Location in Wisconsin

Legend

Spider Lake
(359 Acres)

Public Boat Launch

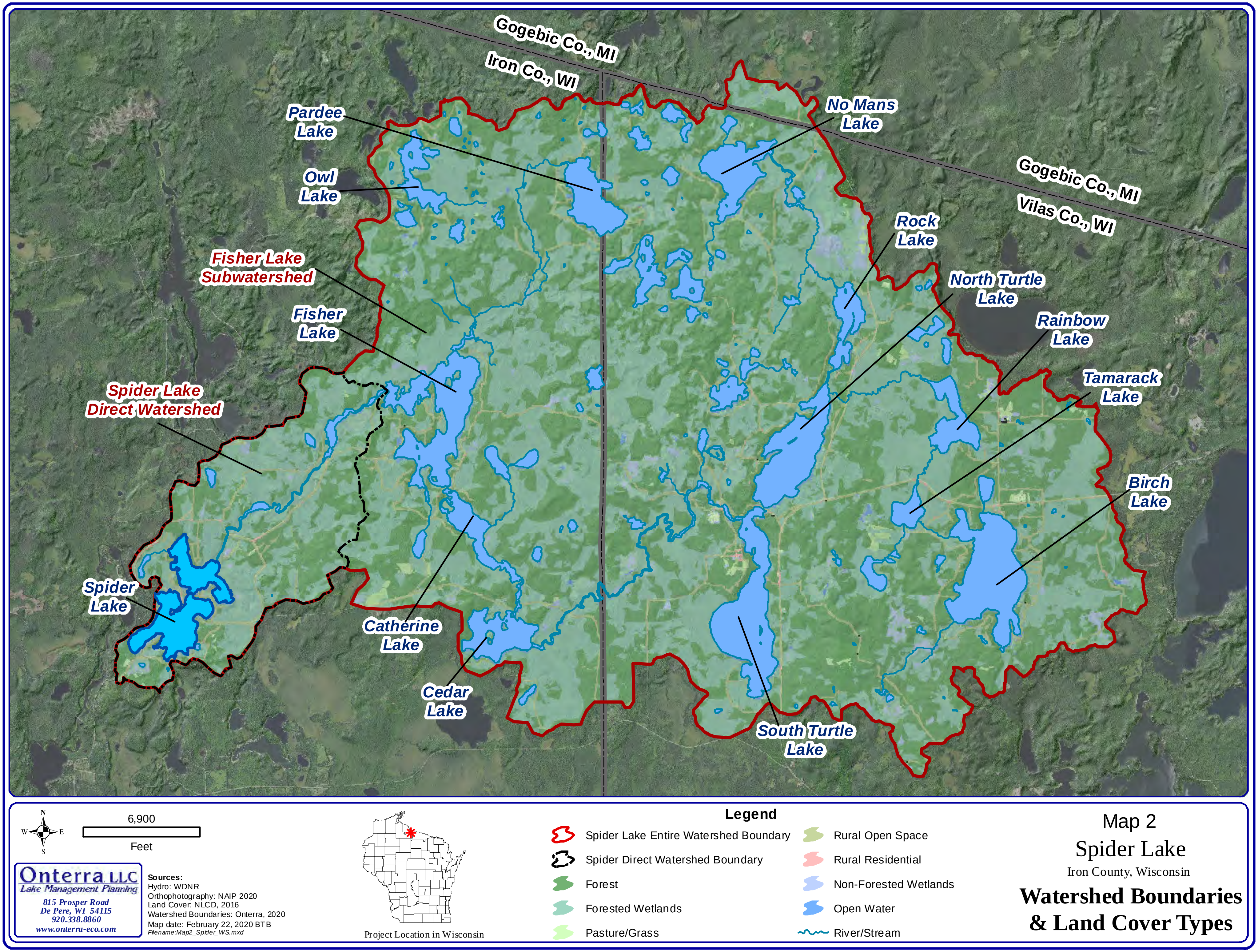
Point-Intercept Survey Sampling Location
(582 total points; 50-meter resolution)

Map 1

Spider Lake

Iron County, Wisconsin

Project Location & Lake Boundaries



Gogebic Co., MI
Iron Co., WI
Gogebic Co., MI
Vilas Co., WI
Pardee Lake
Owl Lake
No Mans Lake
Rock Lake
Fisher Lake Subwatershed
Fisher Lake
North Turtle Lake
Rainbow Lake
Tamarack Lake
Spider Lake Direct Watershed
Birch Lake
Spider Lake
Catherine Lake
Cedar Lake
South Turtle Lake
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Feet
Onterra LLC
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815 Prosper Road
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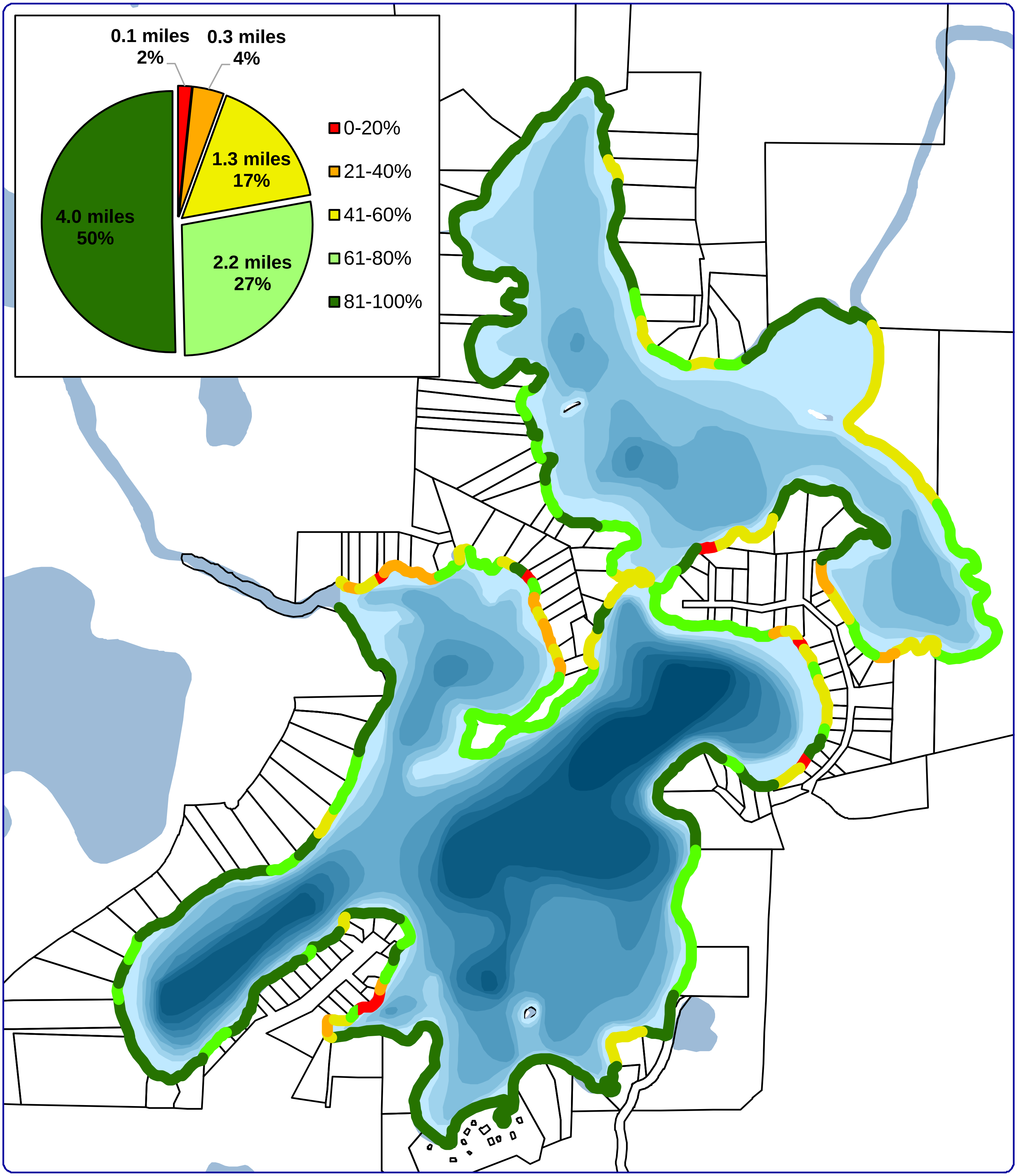
Sources:
Hydro: WDNR
Orthophotography: NAIP 2020
Land Cover: NLCD, 2016
Watershed Boundaries: Onterra, 2020
Map date: February 22, 2020 BTB
Filename:Map2_Spider_WS.mxd
Project Location in Wisconsin
Legend
Spider Lake Entire Watershed Boundary
Spider Direct Watershed Boundary
Forest
Forested Wetlands
Pasture/Grass
Rural Open Space
Rural Residential
Non-Forested Wetlands
Open Water
River/Stream
Map 2
Spider Lake
Iron County, Wisconsin
Watershed Boundaries & Land Cover Types



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Legend

- 81 - 100%
- 61 - 80%
- 41 - 60%
- 21 - 40%
- 0 - 20%
- Shoreland Parcels

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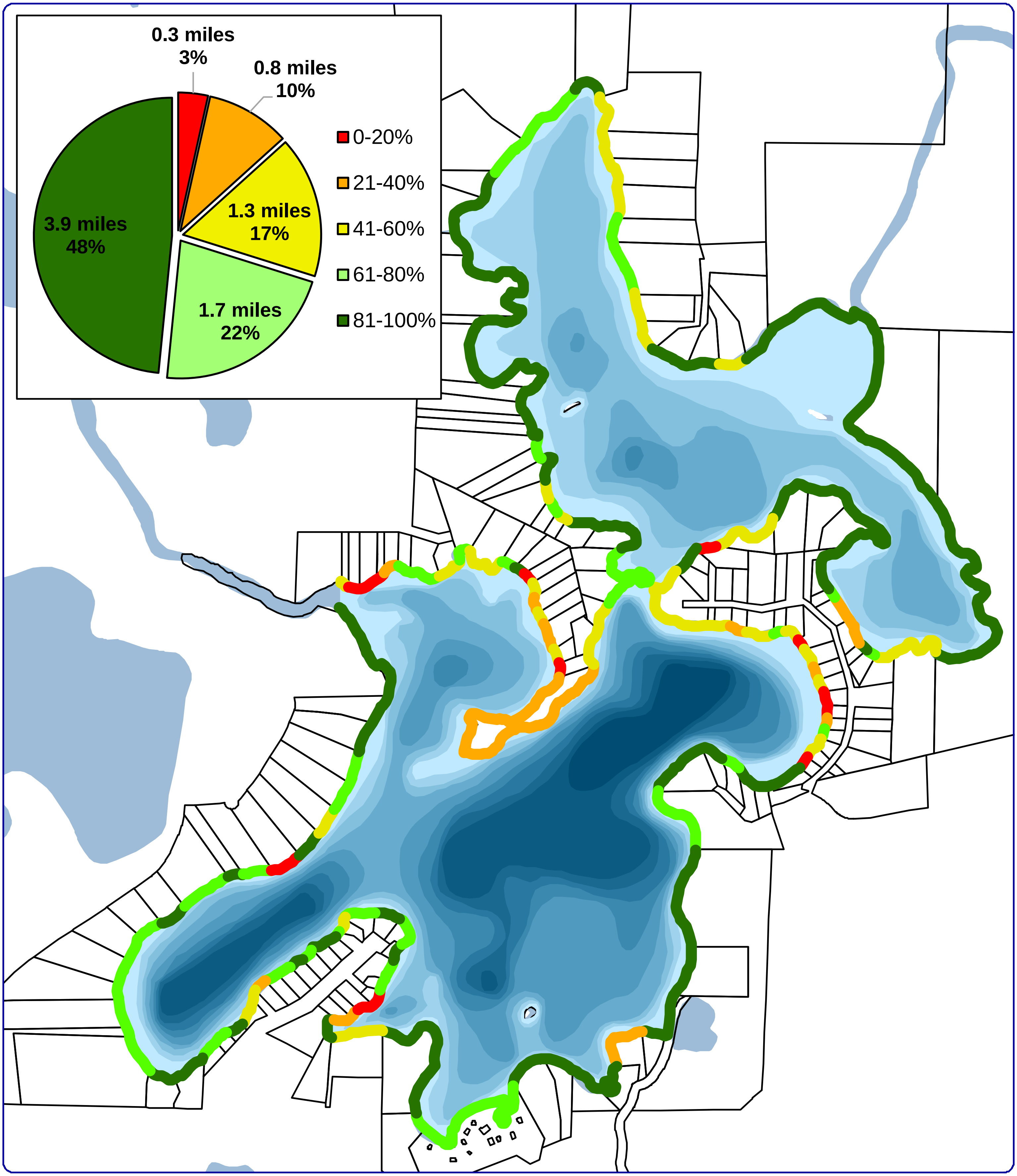
Sources:
Orthophotography: NAIP 2020
Bathymetry: WDNR, digitized by Onterra
Parcel Info: Iron Co. LWC Dept. 2018
Map Date: March 22, 2021 BTB
Filename: Map3_Spider_Canopy_2018.mxd

Map 3
Spider Lake
Iron County, Wisconsin

Iron County LWC:
2018 Parcel Canopy Cover



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Sources:
Orthophotography: NAIP 2020
Bathymetry: WDNR, digitized by Onterra
Parcel Info: Iron Co. LWC Dept. 2018
Map Date: March 22, 2021 BTB
Filename: Map4_Spider_ShrubHerb_2018.mxd

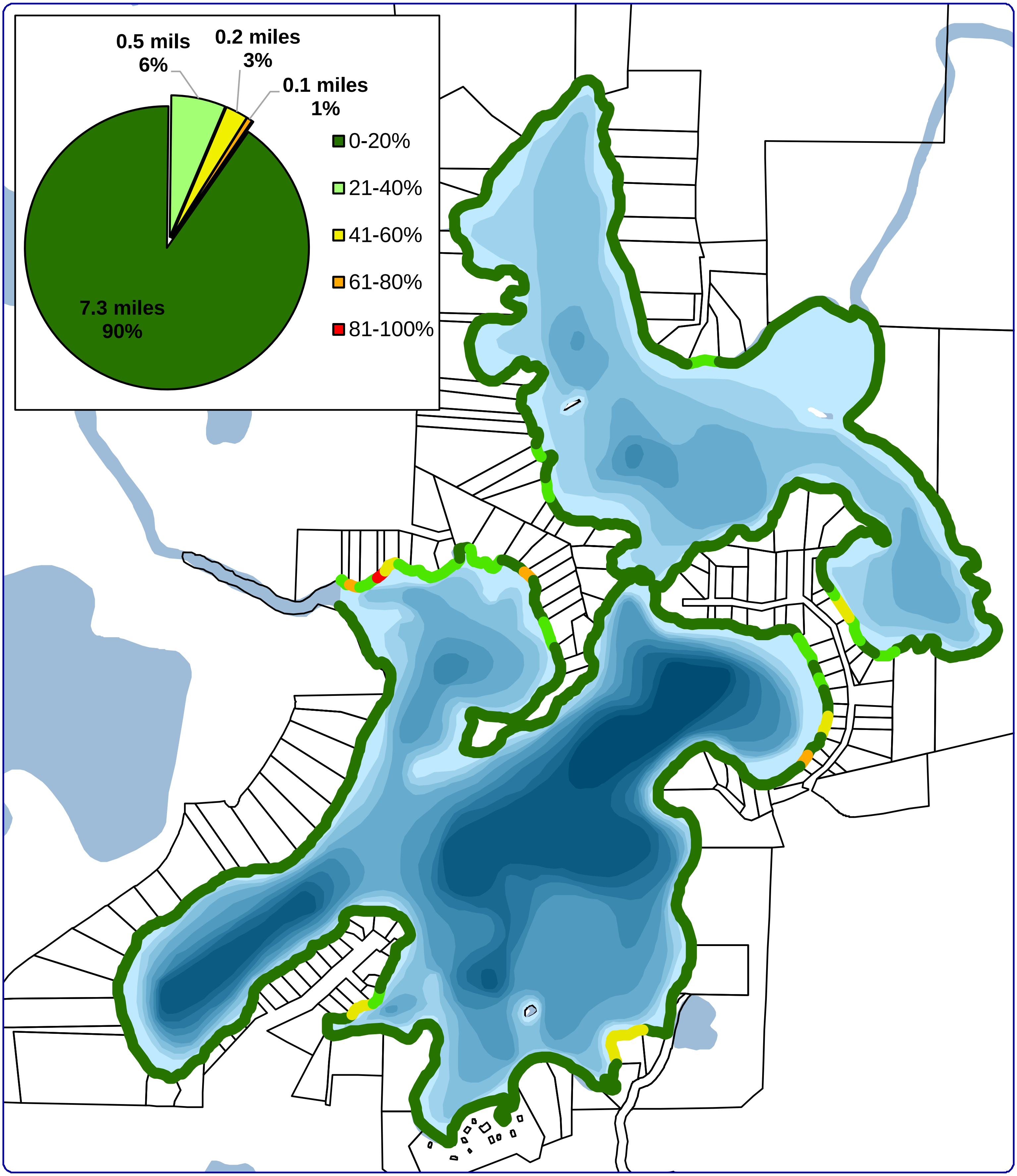
Legend

81 - 100%
61 - 80%
41 - 60%
21 - 40%
0 - 20%

Shoreland Parcels

Map 4
Spider Lake
Iron County, Wisconsin

Iron County LWC:
2018 Parcel Shrub-Herbaceous Cover



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Sources:
Orthophotography: NAIP 2020
Bathymetry: WDNR, digitized by Onterra
Parcel Info: Iron Co. LWC Dept. 2018
Map Date: March 22, 2021 BTB
Filename: Map5_Spider_Lawn_2018.mxd

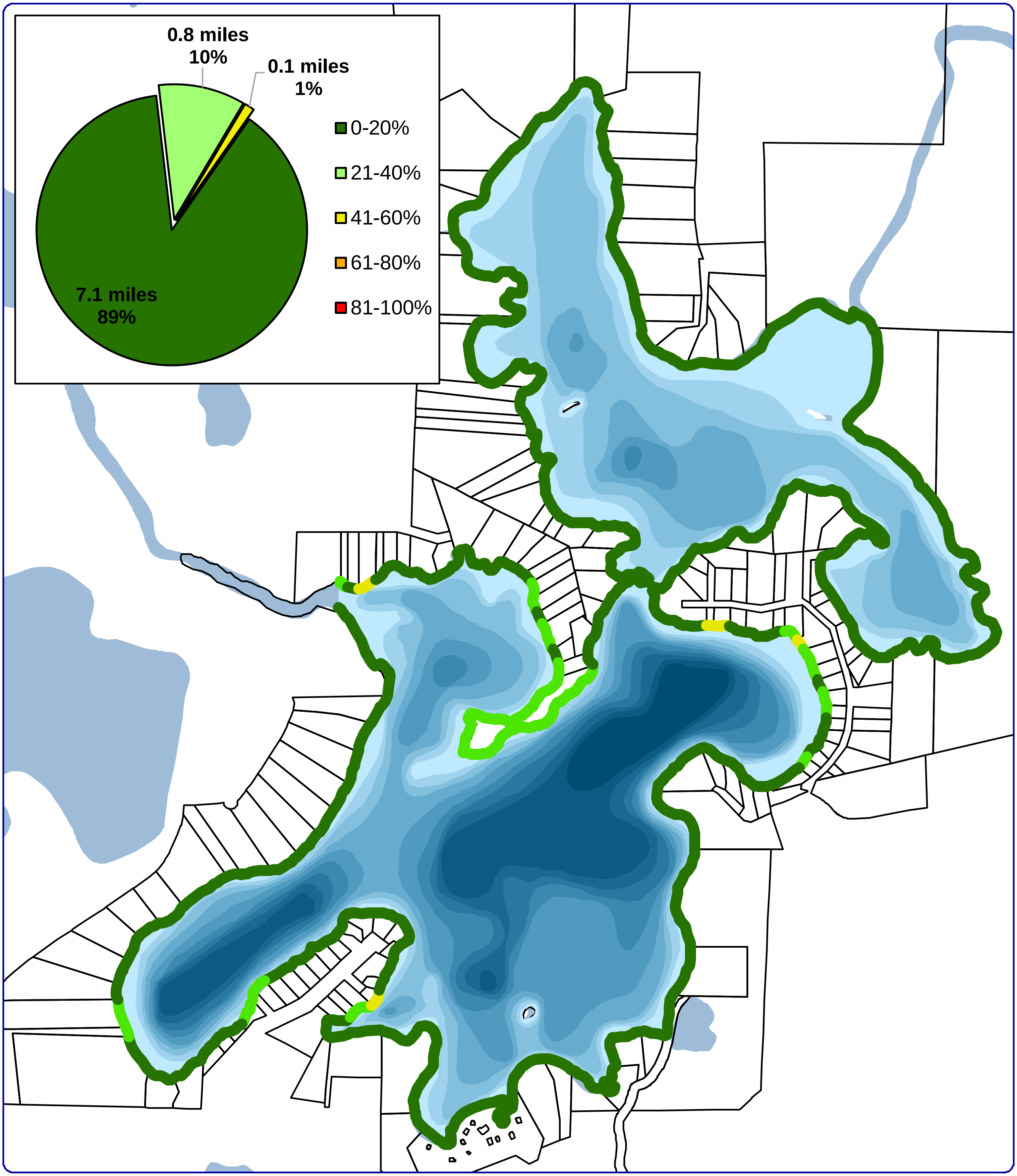
Legend

81 - 100%
61 - 80%
41 - 60%
21 - 40%
0 - 20%

Shoreland Parcels

Map 5
Spider Lake
Iron County, Wisconsin

Iron County LWC:
2018 Parcel Percent Manicured Lawn



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Legend

81 - 100%
61 - 80%
41 - 60%
21 - 40%
0 - 20%

Shoreland Parcels

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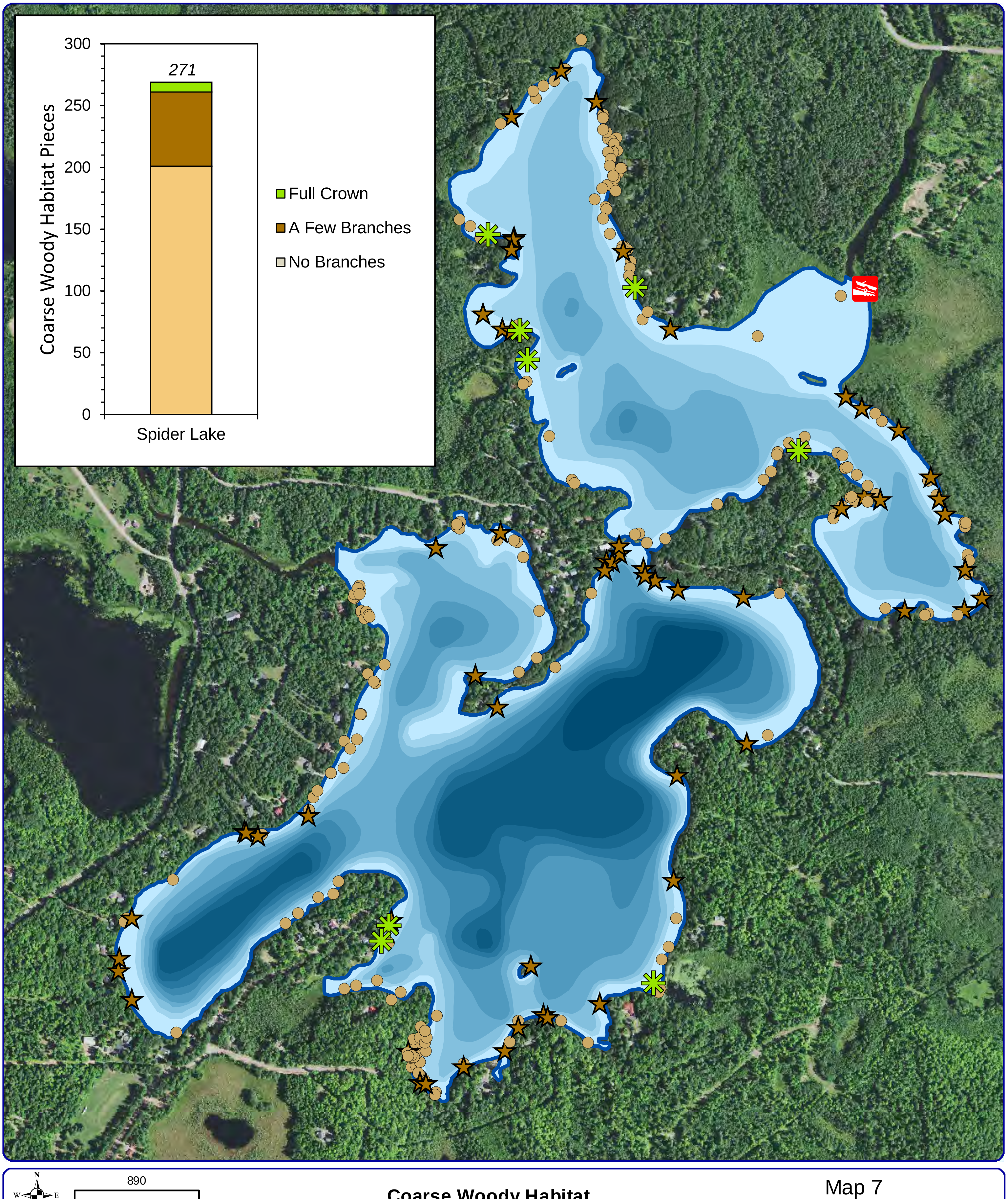
Sources:
Orthophotography: NAIP 2020
Bathymetry: WDNR, digitized by Onterra
Parcel Info: Iron Co. LWC Dept. 2018
Map Date: March 22, 2021 BTB
Filename: Map5_Spider_ImpSurface_2018.mxd

Map 6
Spider Lake
Iron County, Wisconsin

Iron County LWC:
2018 Parcel Percent Impervious Surface



Coarse Woody Habitat

No Branches
A Few Branches
Full Crown

Map 7

Spider Lake

Iron County, Wisconsin

Iron County LWC:
2018 Coarse Woody Habitat

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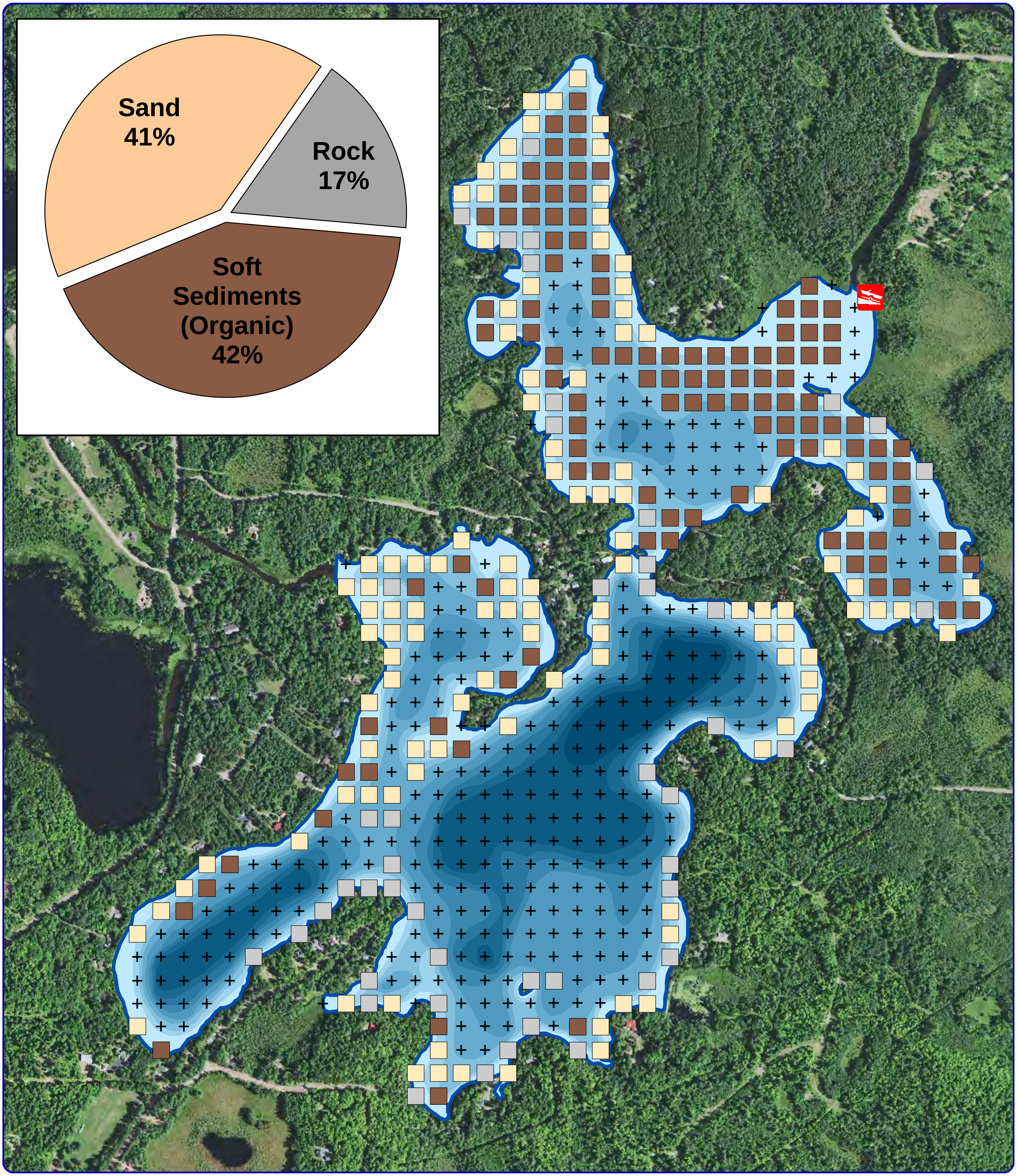
Sources:
Orthophotography: NAIP 2020
Bathymetry: WDNR, digitized by Onterra
CWH: Iron Co. LWC Dept. 2018
Map Date: March 22, 2021 BTB
Filename: Map7_Spider_CWH_2018.mxd



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Legend

Substrate

- Soft/Organic
- Rock
- Sand
- + No Data - Too Deep or Non-Navigable

Map 8

Spider Lake

Iron County, Wisconsin

2020 Point-Intercept Survey: Substrate Types

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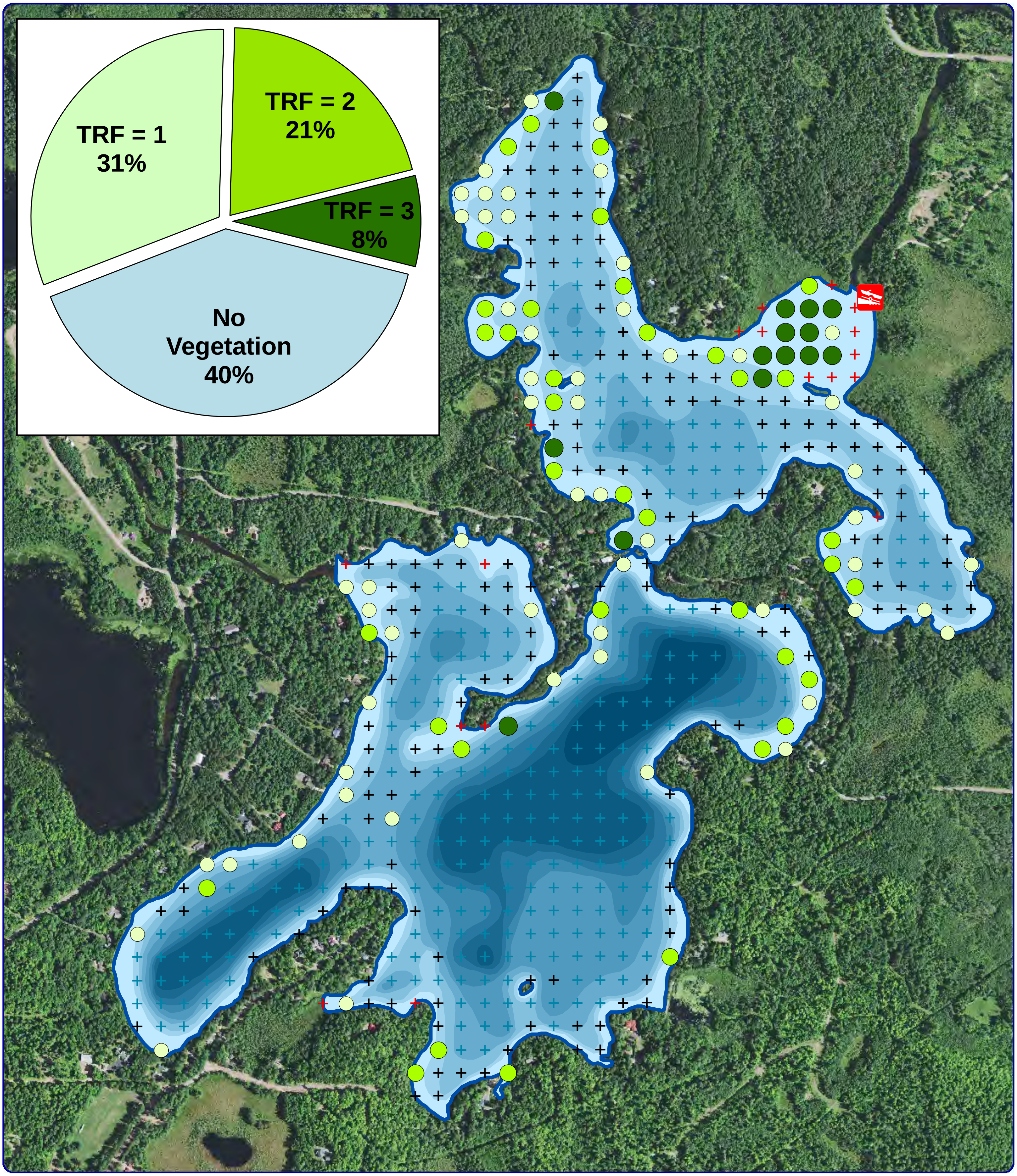
Sources:
Orthophotography: NAIP 2018
Bathymetry: WDNR, digitized by Onterra
Substrate: Onterra 2020
Map Date: December 15, 2020
Filename: Map8_Spider_Substrate_2020.mxd



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Legend

- + No Vegetation
- Total Rake Fullness = 1
- Total Rake Fullness = 2
- Total Rake Fullness = 3
- + No Vegetation - Deeper Than Max Depth of Plants
- + No Data - Non-navigable

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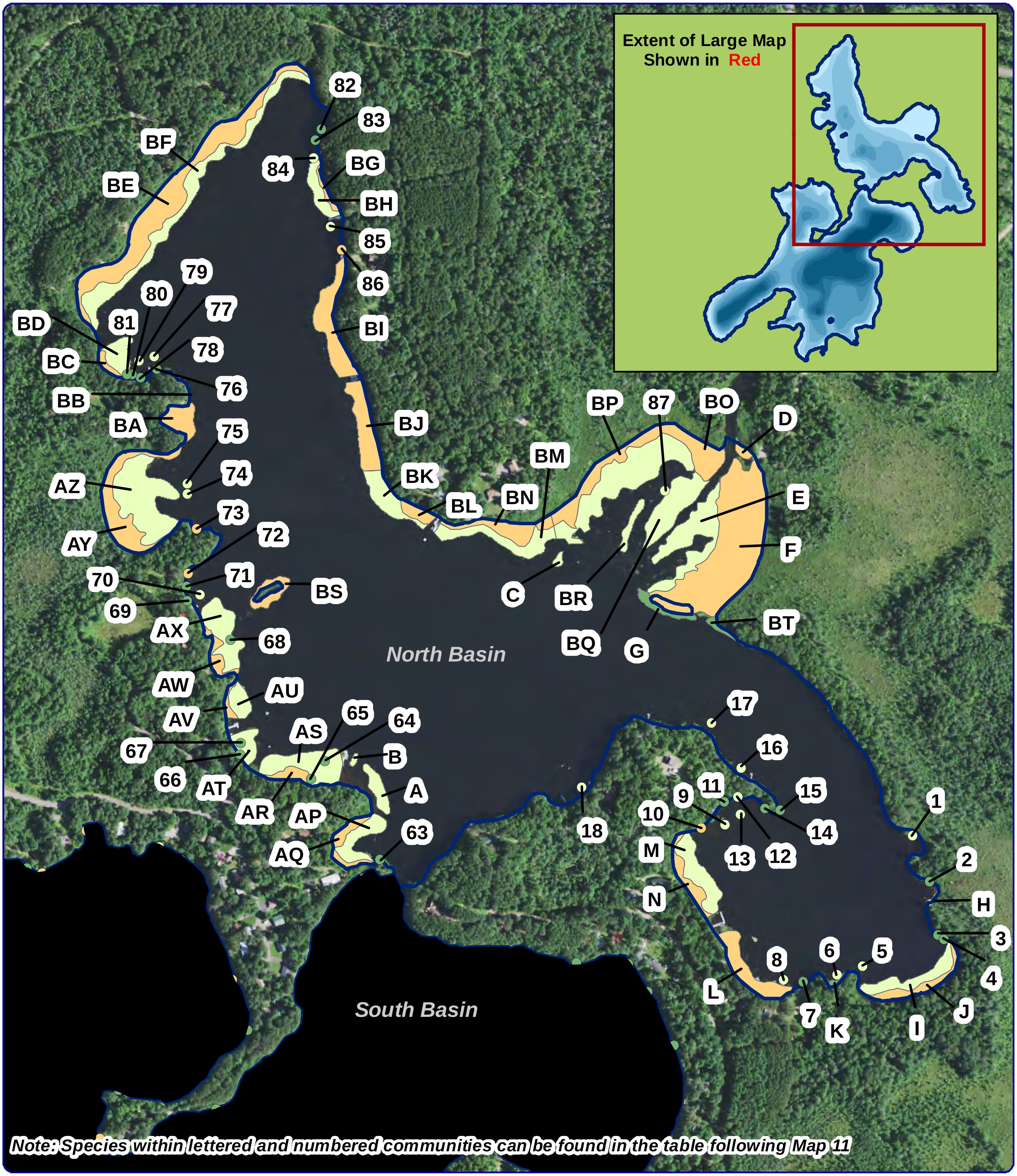
Sources:
Orthophotography: NAIP 2018
Bathymetry: WDNR, digitized by Onterra
Substrate: Onterra 2020
Map Date: December 15, 2020
Filename: Map9_Spider_TRF_2020.mxd

Map 9
Spider Lake
Iron County, Wisconsin
2020 Point-Intercept Survey: Vegetation Distribution



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Feet

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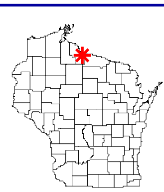
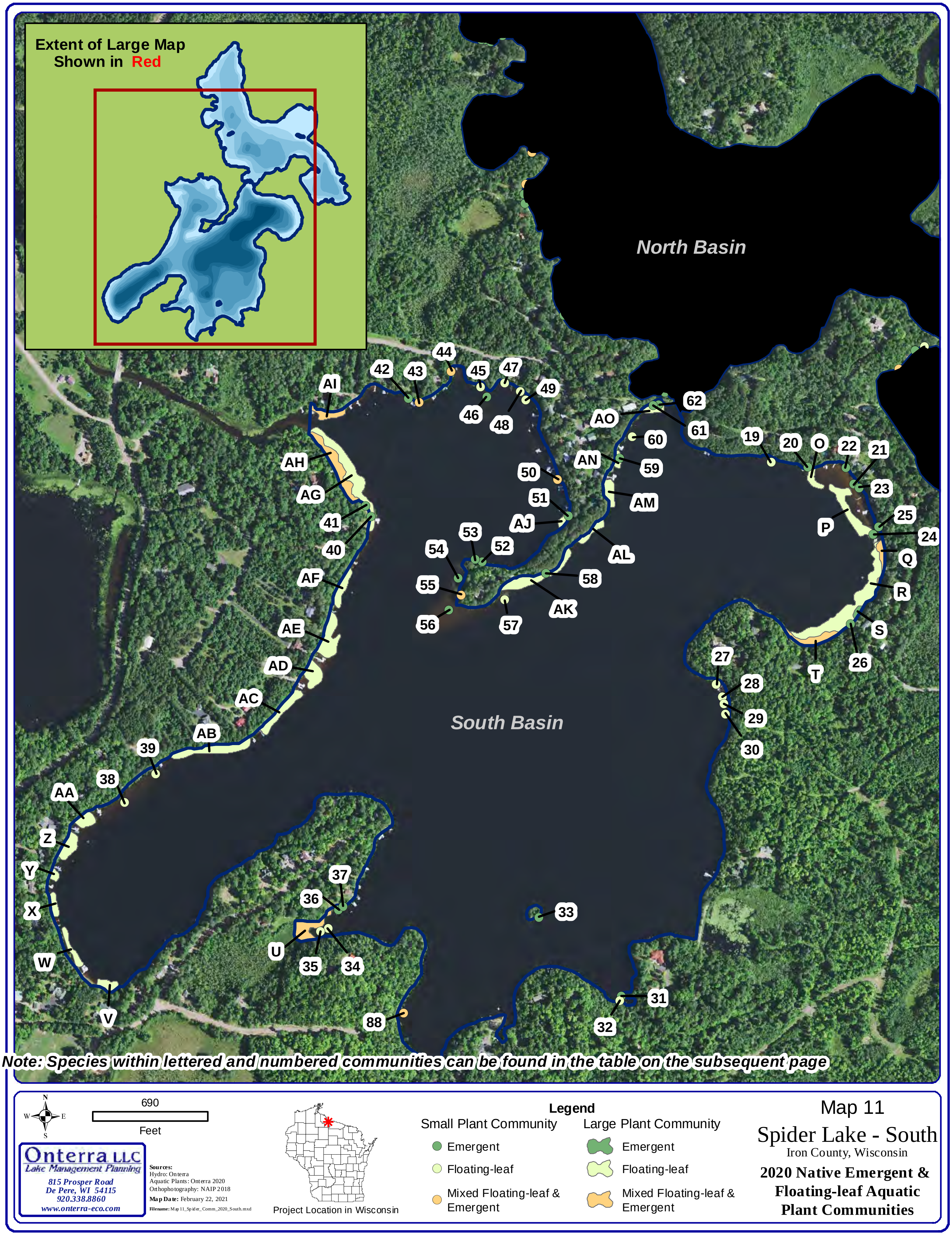
Sources:
Hydro: Onterra
Aquatic Plants: Onterra 2020
Orthophotography: NAIP 2018
Map Date: February 22, 2021
Filename: Map10_Spider_Comm_2020_North.mxd


Project Location in Wisconsin

Legend

Small Plant Community	Large Plant Community
Emergent	Emergent
Floating-leaf	Floating-leaf
Mixed Floating-leaf & Emergent	Mixed Floating-leaf & Emergent

Map 10
Spider Lake - North
Iron County, Wisconsin
2020 Native Emergent & Floating-leaf Aquatic Plant Communities


Extent of Large Map
Shown in Red
North Basin
South Basin
AI
42
43
44
45
46
47
48
49
AH
AG
41
40
AF
AE
AD
AC
AB
39
38
AA
Z
Y
X
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V
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AJ
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AM
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88
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32
Note: Species within lettered and numbered communities can be found in the table on the subsequent page
N
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690
Feet
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Sources:
Hydro: Onterra
Aquatic Plants: Onterra 2020
Orthophotography: NAIP 2018
Map Date: February 22, 2021
Filename: Map11_Spider_Comm_2020_South.mxd
Project Location in Wisconsin
Legend
Small Plant Community
Emergent
Floating-leaf
Mixed Floating-leaf & Emergent
Large Plant Community
Emergent
Floating-leaf
Mixed Floating-leaf & Emergent
Map 11
Spider Lake - South
Iron County, Wisconsin
2020 Native Emergent & Floating-leaf Aquatic Plant Communities

Spider Lake 2020 Emergent & Floating-Leaf Plant Species

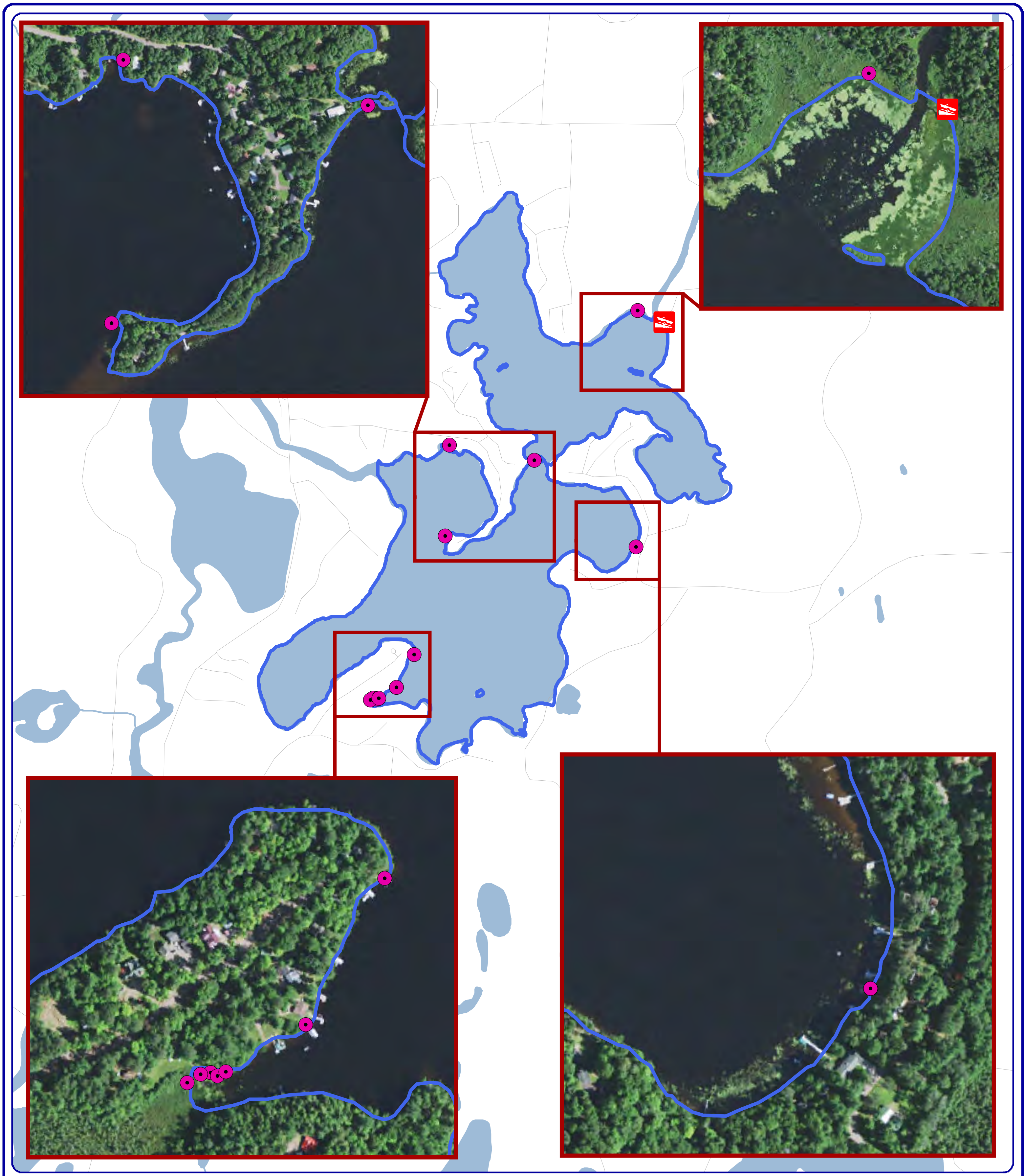
Corresponding Community Polygons and Points are displayed on Maps 10 & 11

Large Plant Community (Polygons)									
Site	Species 1	Species 2	Species 3	Species 4	Species 5	Species 6	Species 7	Species 8	Acres
A	Floating-leaf bur-reed	White water lily	Spatterdock						0.25
B	Floating-leaf bur-reed								0.03
C	Floating-leaf bur-reed								0.05
D	Pickerelweed	Short-stemmed bur-reed	Northern yellow lake sedge	Common arrowhead	Creeping spikerush	Broad-leaved cattail	Narrow-leaved woolly sedge	Common bur-reed	0.08
E	White water lily	Spatterdock	Watershield	Floating-leaf bur-reed					1.14
F	Pickerelweed	White water lily	Spatterdock	Watershield	Floating-leaf bur-reed	Three-way sedge	Softstem bulrush	Northern yellow lake sedge	3.52
G	Hardstem bulrush	Creeping spikerush							0.20
H	Northern yellow lake sedge	Spatterdock	Watershield	Creeping spikerush	Floating-leaf bur-reed				0.03
I	Floating-leaf bur-reed	Spatterdock	Watershied	White water lily					0.50
J	Creeping spikerush	Hardstem bulrush	Floating-leaf bur-reed	Spatterdock	Watershield	White water lily	Common arrowhead	Stiff arrowhead	0.34
K	Narrow-leaved woolly sedg	Northern yellow lake sedge	Creeping spikerush						0.06
L	Spatterdock	Floating-leaf bur-reed	Pickerelweed	Softstem bulrush	Watershield	Creeping spikerush	Three-way sedge	Sweetflag	0.63
M	Floating-leaf bur-reed	Spatterdock	White water lily	Watershield					0.62
N	Pickerelweed	Softstem bulrush	Three-way sedge	Northern yellow lake sedge	Creeping spikerush	Floating-leaf bur-reed	White water lily	Spatterdock	0.31
O	Watershield	Floating-leaf bur-reed							0.14
P	Watershield	White water lily	Floating-leaf bur-reed						0.50
Q	Creeping spikerush	Northern yellow lake sedge	Floating-leaf bur-reed	White water lily	Spatterdock	Watershield	Pickerelweed		0.16
R	White water lily	Floating-leaf bur-reed	Spatterdock	Watershield					1.21
S	Creeping spikerush								0.06
T	Water horsetail	Three-way sedge	Creeping spikerush	Common arrowhead	White water lily	Spatterdock	Watershield	Pickerelweed	0.28
U	Pickerelweed	Creeping spikerush	Short-stemmed bur-reed	Northern yellow lake sedge	Spatterdock	Floating-leaf bur-reed	White water lily	Three-way sedge	0.37
V	Watershield	White water lily	Floating-leaf bur-reed						0.16
W	Watershield	White water lily							0.18
X	Watershield	White water lily	Floating-leaf bur-reed						0.14
Y	Watershield	White water lily	Floating-leaf bur-reed						0.08
Z	Watershield	White water lily							0.27
AA	White water lily								0.19
AB	Watershield	White water lily							0.51
AC	Watershield	White water lily	Floating-leaf bur-reed						0.36
AD	Watershield	White water lily							0.30
AE	Watershield	White water lily							0.49
AF	Watershield	White water lily	Floating-leaf bur-reed						0.25
AG	Watershield	White water lily	Floating-leaf bur-reed						0.85
AH	Creeping spikerush	Three-way sedge	Pickerelweed	Northern yellow lake sedge	Common arrowhead	Short-stemmed bur-reed			0.54
AI	Hardstem bulrush	Creeping spikerush	Watershield	White water lily	Northern yellow lake sedge				0.20
AJ	Watershield	White water lily							0.09
AK	Watershield	White water lily	Floating-leaf bur-reed						0.50
AL	Watershield	White water lily	Floating-leaf bur-reed	Spatterdock					0.16
AM	White water lily	Watershield	Floating-leaf bur-reed						0.21
AN	Watershield	Floating-leaf bur-reed	White water lily						0.10
AO	Floating-leaf bur-reed	Spatterdock	White water lily						0.18
AP	Pickerelweed	Eastern bur-reed	Three-way sedge	Spatterdock	White water lily	Floating-leaf bur-reed	Watershield	Grass-leaved arrowhead	0.29
AQ	Floating-leaf bur-reed	White water lily	Watershield	Spatterdock					0.43
AR	Hardstem bulrush	Pickerelweed	Common bur-reed	Eastern bur-reed	Short-stemmed bur-reed				0.20
AS	Floating-leaf bur-reed	White water lily	Spatterdock	Watershield					0.82
AT	Floating-leaf bur-reed	Watershield	White water lily						0.30
AU	Floating-leaf bur-reed	White water lily	Watershield						0.25
AV	Hardstem bulrush	Eastern bur-reed	Pickerelweed	Three-square rush	Floating-leaf bur-reed	Watershield	White water lily	Northern yellow lake sedge	0.08
AW	Eastern bur-reed	Hardstem bulrush	Pickerelweed	Three-way sedge					0.22
AX	Floating-leaf bur-reed	Watershield	White water lily	Spatterdock					0.71
AY	Pickerelweed	Narrow-leaved woolly segde	Hardstem bulrush	White water lily	Spatterdock	Watershield			0.94
AZ	White water lily	Floating-leaf bur-reed	Watershield	Spatterdock					1.50
BA	Hardstem bulrush	Pickerelweed	Watershield	White water lily	Narrow-leaved woolly segde				0.37
BB	Hardstem bulrush								0.01
BC	Broad-leaved cattail	Three-way sedge	Northern yellow lake sedge	Eastern bur-reed	Pickerelweed				0.10
BD	Floating-leaf bur-reed	Spatterdock	White water lily	Watershield					0.33
BE	Hardstem bulrush								2.38
BF	Floating-leaf bur-reed	Watershield	White water lily	Spatterdock					1.39
BG	Pickerelweed	Hardstem bulrush	Floating-leaf bur-reed	White water lily	Watershield	Spatterdock			0.10
BH	Floating-leaf bur-reed	Watershield	White water lily	Spatterdock					0.29
BI	Floating-leaf bur-reed	Creeping spikerush	Pickerelweed	Northern yellow lake sedge	Spatterdock	White water lily	Northern wild rice		0.84
BJ	Creeping spikerush	Floating-leaf bur-reed	Norther wild rice						0.69
BK	Floating-leaf bur-reed	Watershield	Spatterdock	White water lily					0.48
BL	Pickerelweed	Hardstem bulrush	Creeping spikerush	Floating-leaf bur-reed	Watershield	Spatterdock	White water lily		0.19
BM	Hardstem bulrush	Pickerelweed	Northern yellow lake sedge	Eastern bur-reed	Northern wid rice				0.52
BN	Floating-leaf bur-reed	Watershield	White water lily	Spatterdock					0.63
BO	Pickerelweed	Hardstem bulrush	Creeping spikerush	Water horsetail	Northern yellow lak sedg	Narrow-leaved woolly segde	Eastern bur-reed		1.31
BP	Floating-leaf bur-reed	White water lily	Spatterdock	Watershield					1.78
BQ	White water lily	Floating-leaf bur-reed							0.16
BR	White water lily	Spatterdock	Floating-leaf bur-reed						0.84
BS	Twig rush	Hardstem bulrush	Narrow-leaved woolly segde	Pickerelweed	Three-square rush	Watershield	White water lily	Spatterdock	0.25
BT	Hardstem bulrush	Creeping spikerush	Softstem bulrush	Northern yellow lake sedge	Short-stemmed bur-reed				0.10

Spider Lake 2020 Emergent & Floating-Leaf Plant Species

Corresponding Community Polygons and Points are displayed on Maps 10 & 11

Small Plant Community (Points)					
Site	Species 1	Species 2	Species 3	Species 4	Species 5
1	Floating-leaf bur-reed	Spatterdock	Water arum		
2	Narrow-leaved woolly segde	Creeping spikerush			
3	Northern yellow lake sedge	Narrow-leaved woolly segde			
4	Creeping spikerush				
5	Spatterdock				
6	Watershield	Floating-leaf bur-reed			
7	Northern yellow lake sedge				
8	Floating-leaf bur-reed				
9	Pickerelweed	White water lily	Watershield		
10	Floating-leaf bur-reed	Spatterdock			
11	Common bur-reed				
12	White water lily				
13	Spatterdock				
14	Creeping spikerush				
15	Creeping spikerush				
16	Floating-leaf bur-reed				
17	Floating-leaf bur-reed				
18	Floating-leaf bur-reed				
19	Floating-leaf bur-reed				
20	Northern yellow lake sedge	Three-way sedge			
21	Broad-leaved cattail				
22	Creeping spikerush				
23	Broad-leaved cattail	Creeping spikerush			
24	Creeping spikerush				
25	Creeping spikerush				
26	Creeping spikerush				
27	Watershield	Floating-leaf bur-reed	White water lily		
28	Floating-leaf bur-reed				
29	Floating-leaf bur-reed	White water lily			
30	Watershield				
31	Northern yellow lake sedge				
32	White water lily				
33	Creeping spikerush				
34	Floating-leaf bur-reed				
35	Floating-leaf bur-reed	White water lily			
36	Pickerelweed	Creeping spikerush			
37	Three-way sedge	Pickerelweed	Wool-grass	Nothern yellow lake sedge	
38	White water lily				
39	Watershield	White water lily			
40	Broad-leaved cattail				
41	Broad-leaved cattail				
42	Pickerelweed	Broad-leaved cattail			
43	Creeping spikerush	Watershield			
44	Pickerelweed	Watershield	Sweetflag	Northern yellow lake sedge	
45	White water lily				
46	Creeping spikerush				
47	White water lily				
48	White water lily				
49	White water lily				
50	White water lily	Creeping spikerush	Pickerelweed		
51	Pickerelweed	Common bur-reed			
52	Creeping spikerush				
53	Creeping spikerush				
54	Creeping spikerush				
55	White water lily	Watershield	Creeping spikerush	Pickerelweed	Northern yellow lake sedge
56	Creeping spikerush				
57	Watershield	White water lily			
58	Creeping spikerush				
59	Northern wild rice				
60	Floating-leaf bur-reed				
61	Broad-leaved cattail				
62	Grass-leaved arrowhead				
63	Northern yellow lake sedge				
64	Short-stemmed bur-reed				
65	Pickerelweed	Short-stemmed bur-reed			
66	Common bur-reed				
67	Northern yellow lake sedge	Pickerelweed			
68	Eastern bur-reed				
69	Floating-leaf bur-reed	Watershield			
70	Northern yellow lake sedge				
71	Common bur-reed				
72	Hardstem bulrush	Pickerelweed	Watershield	Northern yellow lake sedge	Narrow-leaved woolly segde
73	Pickerelweed	Watershield	Spatterdock	Common bur-reed	Creeping spikerush
74	White water lily				
75	White water lily				
76	Narrow-leaved woolly segde				
77	Spatterdock	Floating-leaf bur-reed			
78	Pickerelweed				
79	Floating-leaf bur-reed	White water lily			
80	Three-way sedge				
81	Northern yellow lake sedge				
82	Northern yellow lake sedge				
83	Pickerelweed				
84	Floating-leaf bur-reed	Watershield	White water lily		
85	Floating-leaf bur-reed				
86	Creeping spikerush	Pickerelweed	Watershield		
87	White water lily				
88	Eastern bur-reed	Watershield			



N
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Feet

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Sources:
Orthophotography: NAIP 2020
Bathymetry: WDNR, digitized by Onterra
PPL Locations: Onterra 2020
Map Date: August 18, 2020 BTB
Filename: Map12_Spider_PPL_Aug20.mxd

Legend

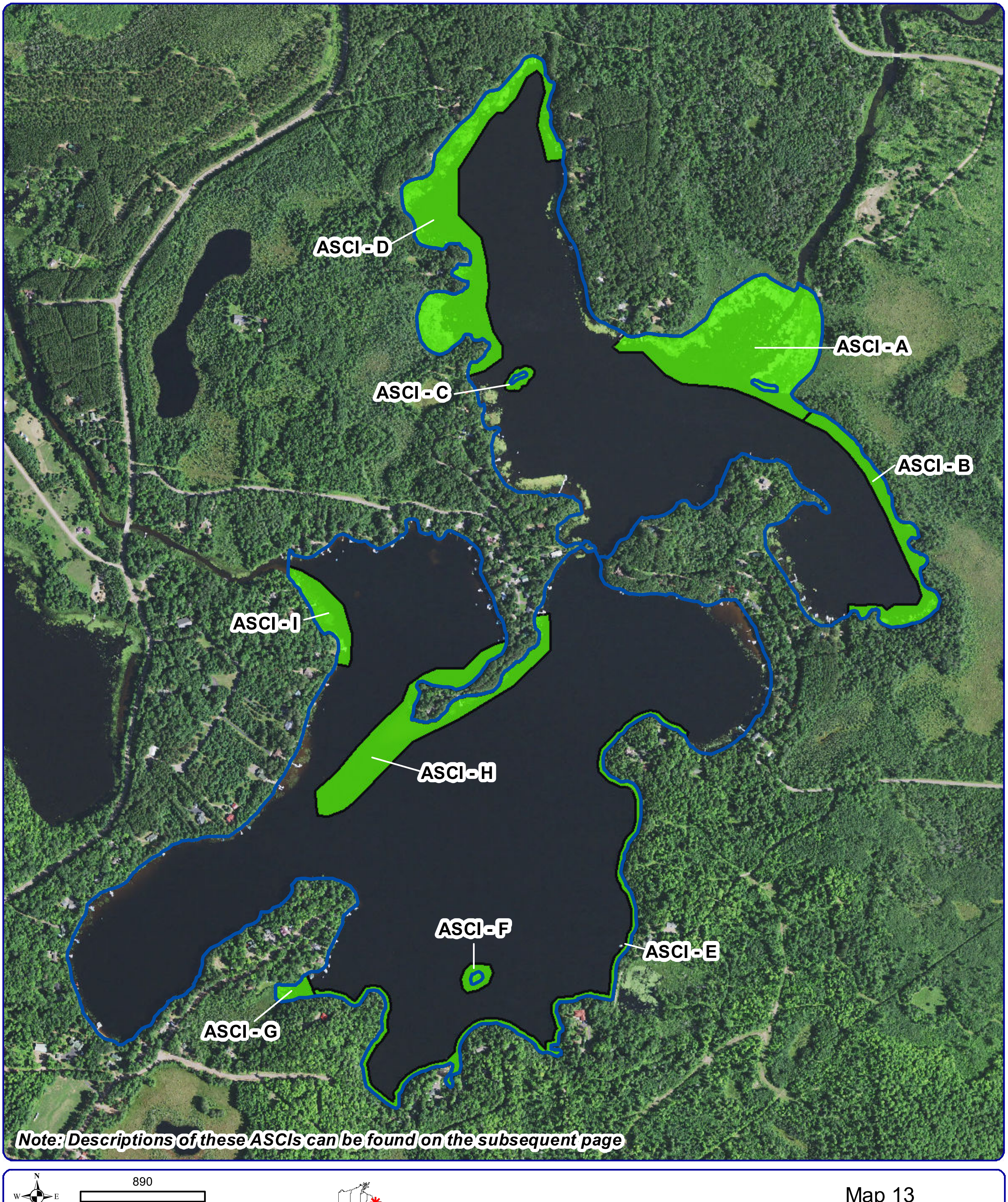
Purple Loosestrife (*Lythrum salicaria*)
Single Plant

Public Boat Launch

Map 12

Spider Lake
Iron County, Wisconsin

Purple Loosestrife
August 2020



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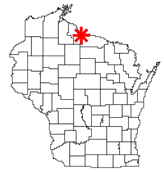
Sources:
Hydro: Onterra
Aquatic Plants: Onterra 2020
Orthophotography: NAIP 2020

Map Date: February 22, 2021

Filename: Map13_Spider_COAs.mxd



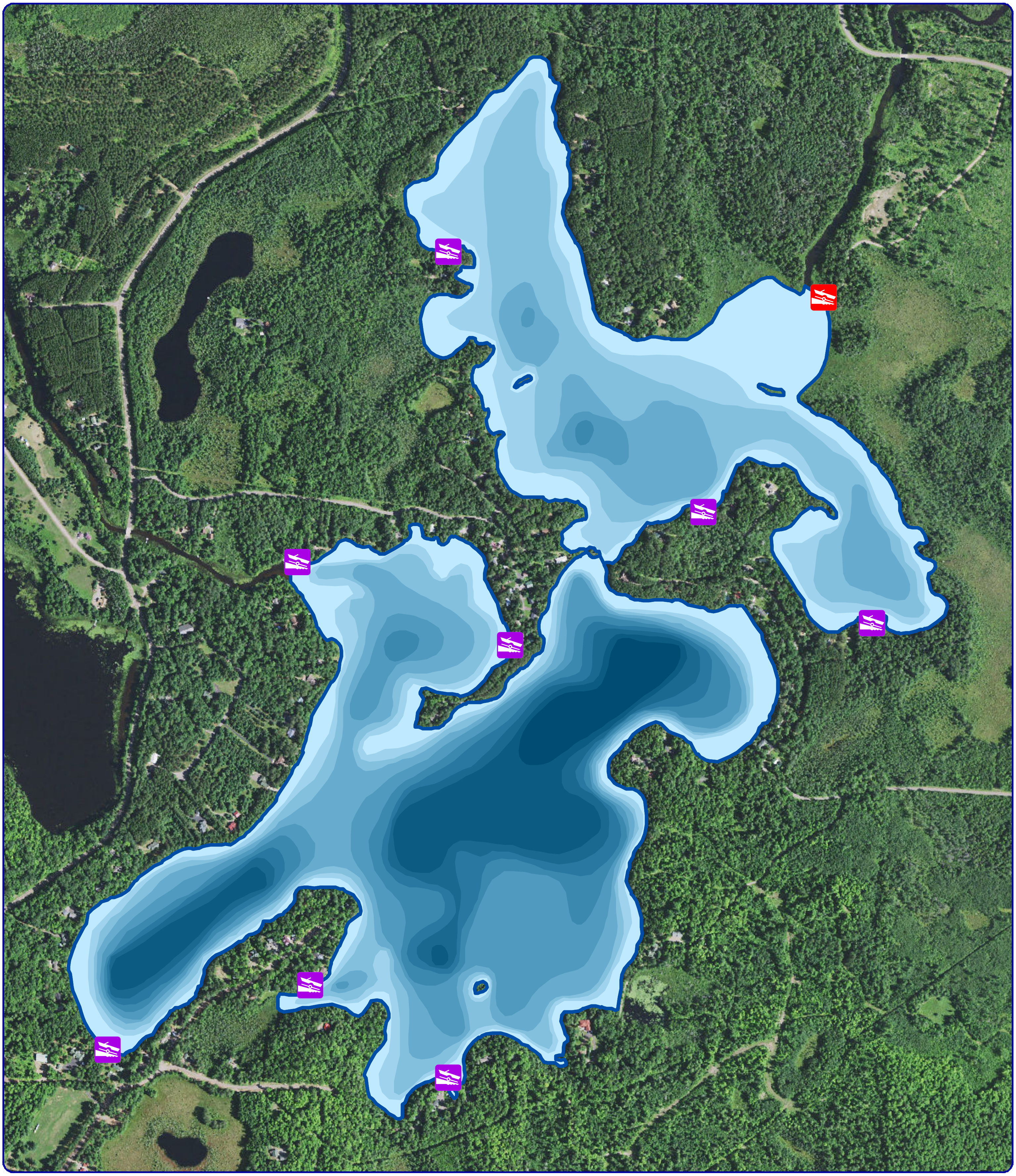
Project Location in Wisconsin

Legend

Area of Special Conservation Interest (ASCI)

Map 13
Spider Lake
Iron County, Wisconsin
Areas of Special Conservation Interest (ASCIs)

Spider Lake COA	Acres	Priority Natural Communities	Documented NHI-Listed Species	Description
A	18.0	Emergent Marsh Floating-leaved Marsh Submergent Marsh Benthic - Organic Benthic - Rock/Cobble Natural Shoreline	*Eleocharis robbinsii* *Elliptio complanata* *Potamogeton vaseyi*	Area encompasses a bay with exceptional aquatic plant diversity with over 40 native species recorded. Area is at the mouth of the Turtle River and contains areas of flownig and still water. Organic and rock/cobble substrates present. Extensive emergent, floating-leaved, and submergent marsh communities present. Contains habitat for three NHI-listed species.
B	5.3	Benthic - Rock/Cobble Coarse Woody Habitat Natural Shoreline Emergent Marsh Floating-leaved Marsh	*Elliptio complanata*	Area encompasses a continuous natural shoreline with high occurrence of coarse woody habitat and a littoral area largely comprised of rock/cobble with few aquatic plants. There is a small yet diverse emergent and floating-leaved marsh community on the COAs' southern extent. Likely an important area for fish spawning and invertebrate habitat.
C	0.6	Emergent Marsh Floating-leaved Marsh Benthic - Rock/Cobble Benthic - Sand	*Elliptio complanata*	Area encompasses an emergent/floating-leaved marsh which surrounds a small shrub-dominated island. Emergent marsh is dominated by the lake's only population of smooth sawgrass (*Cladium mariscoides*), a sensitive and relatively uncommon species in Wisconsin. Substrate is largely comprised of rock/cobble and sand, imporant substrates for spawning and invertebrate diversity. Contains habitat for one NHI-listed species.
D	16.1	Emergent Marsh Floating-leaved Marsh Submergent Marsh Natural Shoreline Coarse Woody Habitat Benthic - Rock/Cobble Benthic - Sand Benthic - Organic	*Elliptio complanata*	Like COA 1, this area encompasses an area of exceptional aquatic plant diversity with large, contigous emergent and floating-leaved marsh communities in near-shore areas. The shoreline is largely natural with a high occurrence of coarse woody habitat. Substrates of rock/cobble, sand, and organic substrates are all found here. The bays on the west side also contain a diverse submergent marsh community. Contains habitat for one NHI-listed species.
E	6.3	Benthic - Rock/Cobble Benthic - Sand Natural Shoreline Coarse Woody Habitat	*Elliptio complanata*	This area encompasses near-shore areas along the lake's southeastern shore. This area is largely comprised of rock/cobble and sandy substrates with very little aquatic plant growth. Likely an important area for fish spawning and invertebrate habitat. Shoreline is also largely natural with a high occurrence of coarse woody habitat. Contains habitat for one NHI-listed species.
F	0.9	Benthic - Rock Natural Shoreline	-	Area encompassess the shallow littoral area around the island which is largely comprised of rock/cobble substrate. Likely an important area for fish spawning and invertebrate habitat. Natural shoreline present around the island.
G	0.7	Emergent Marsh Floating-leaved Marsh Submergent Marsh Benthic - Sand Benthic - Organic Natural Shoreline	*Potamogeton vaseyi*	Area encompasses a small backwater bay which supports diverse emergent, floating-leaved, and submergent marsh plant communities. Substrates are a mix of organic and sand. Shoreline is largely natural. Contains habitat for one NHI-listed species.
H	10.4	Benthic - Sand Benthic - Rock/Cobble Natural Shoreline Coarse Woody Habitat Floating-leaved Marsh Submergent Marsh	*Elliptio complanata*	Area encompasses littoral areas around a largely undeveloped peninsula. Area is largely comprised of an extensive sand flat wth areas of rock/cobble. Submersed aquatic plants are sparse. Floating-leaved marsh communties are present immediately adjacent to shore. Coarse woody habitat is also present. Contains habitat for one NHI-listed species.
I	2.9	Emergent Marsh Floating-leaved Marsh Sumergent Marsh Benthic - Sand Benthic - Rock/Cobble Natural Shoreline Coarse Woody Habitat	*Elliptio complanata*	Area encompasses diverse emergent, floating-leaved, and submergent marsh communities adjacent to a largely natural shoreline. Substrates are largely cmprised of sand and rock/cobble. Contains habitat for one NHI-listed species.



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Sources:
Orthophotography: NAIP 2018
Bathymetry: WDNR, digitized by Onterra
Map Date: September 27, 2021
Filename: Map14_Spider_BoatLandings.mxd

Project Location in Wisconsin

Legend

Public Boat Launch

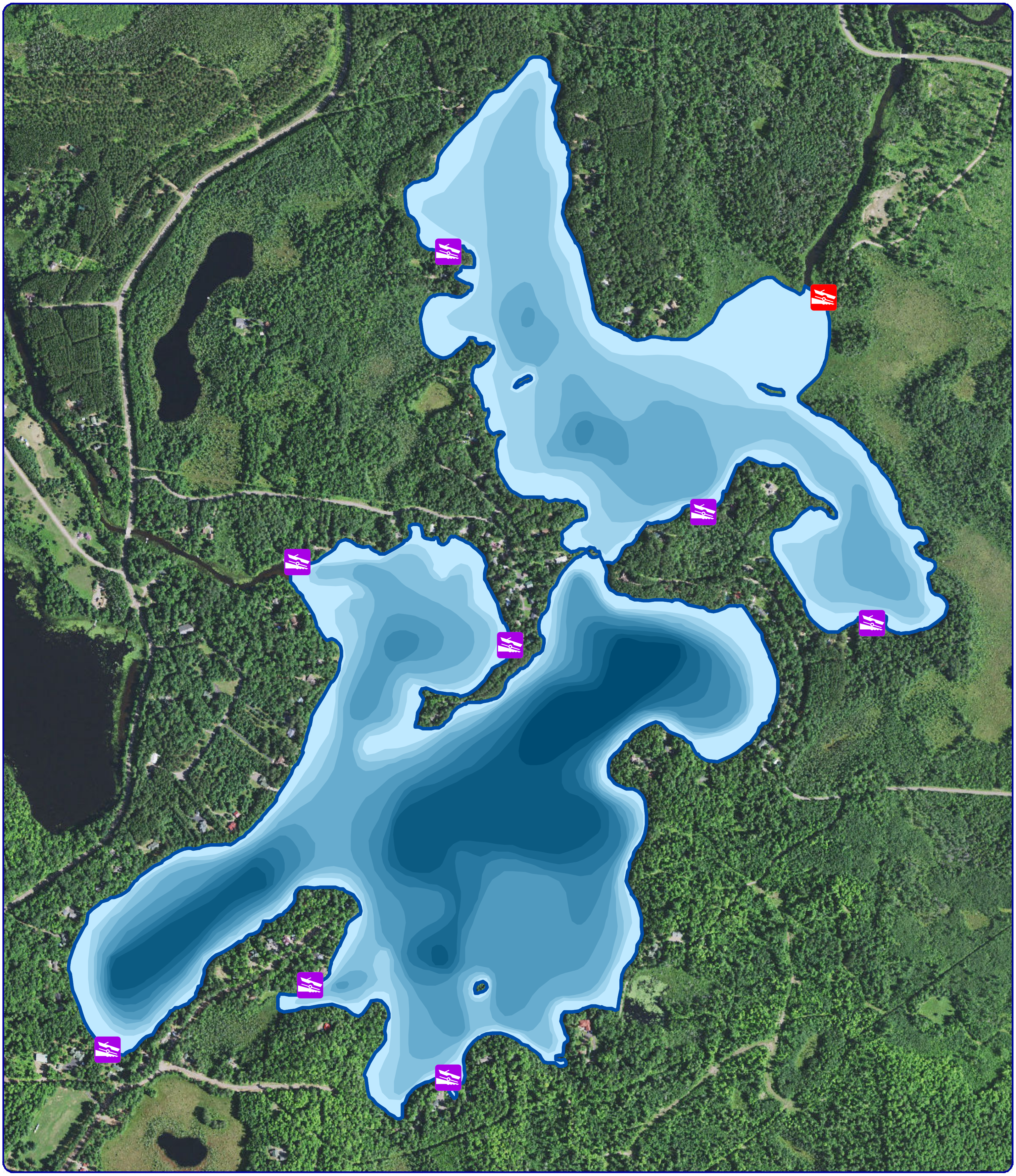
Private Boat Launch

Map 14

Spider Lake

Iron County, Wisconsin

Public & Private Boat Landings



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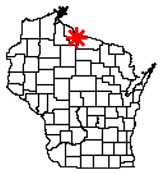

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Spider Lake

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Public & Private Boat Landings