Management Goal 4: Prevent New Aquatic Invasive Species Introductions to Rainbow Lake

Management Action: Continue RLA volunteer aquatic invasive species monitoring using the shoreline monitors.

Timeframe: Continuation of current effort.

Facilitator: RLA Board of Directors (suggested)

Description: As of this writing, no aquatic invasive species have been documented in Rainbow Lake. The RLA understands that it important to prevent future introductions of non-native species such as Eurasian watermilfoil and curly-leaf pondweed. Nearby waterbodies such as Harris Lake and the Manitowish Chain of Lakes contain populations of curly-leaf pondweed, while Presque Isle Lake contains a population of Eurasian watermilfoil. In lakes without Eurasian watermilfoil and curly-leaf pondweed, early detection of these can often lead to successful control, and in instances with small infestations, possible even eradication. Currently, RLA volunteers have received aquatic invasive species identification and monitoring training and perform shoreline surveys in which volunteers are responsible for periodically monitoring specific areas of the lake. This methodology allows the entire lake to be monitored for the presence of non-native species. In addition to RLA volunteer monitoring, NLDC staff completes AIS surveys on Rainbow Lake two times per year.

Action Steps:

1. RLA volunteers updated their identification and monitoring skills by attending training sessions provided by the NLDC (877.543.2085).
2. Trained volunteers recruit and train additional association members.
3. Complete monitoring surveys following protocols.

Management Action: Initiate aquatic invasive species rapid response plan upon discovery of new infestation.

Timeframe: Initiate upon invasive species discovery.

Facilitator: RLA Board of Directors (suggested)

Description: In the event that an aquatic invasive species such as Eurasian watermilfoil is located by the trained volunteers, the areas would be marked using GPS and the RLA should contact resource managers (NLDC) immediately. 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 and the results would be used to develop potential control strategies.

Action Steps:

1. RLA contact NLDC (877.543.2085) upon discovery of new invasive species in Birch Lake.

Management Action:	Install aquatic invasive species (AIS) signage at Tamarack/Rainbow lakes public carry-in access location.
Timeframe:	Initiate 2018
Facilitator:	RLA Board of Directors
Description:	Rainbow Lake contains a carry-in public access located on the northern side of the lake where County Highway W crosses Rainbow Creek. At present, this public access location does not contain an AIS awareness sign to inform lake users on AIS prevention. The WDNR is currently offering these signs, posts, and hardware free of charge. To request an AIS boat landing sign, the RLA should contact Tim Campbell (timothy.campbell@wisconsin.gov – 608.26.3531), WDNR AIS Education Specialist, to request a sign for the Rainbow Lake carry-in access. Lake users can also access Tamarack Lake from this launch site, and the RLA should work with Martin Plutowski from Tamarack Lake to coordinate obtaining this AIS signage.
Action Steps:	
1.	Please see above description.

Management Goal 5: Enhance the fishery of Rainbow Lake

Management Action:	Continue work with WDNR fisheries managers to enhance the fishery of Rainbow Lake.
Timeframe:	Continuation of current effort
Facilitator:	RLA Board of Directors (suggested)
Description:	In the 2016 stakeholder survey, fishing was ranked third behind relaxing/entertaining and nature viewing by respondents when asked to rank their top three activities that are important reasons for owning or renting their property on or near Rainbow Lake (Appendix B, Question 17). Respondents indicated that bluegill, crappie, northern pike, and muskellunge were the most sought-after fish by anglers in Rainbow Lake, and 67% of respondents rated the current fishing on Rainbow Lake as either good or excellent (Appendix B, Questions 11 and 12). Approximately 42% of respondents indicated the quality of fishing has gotten somewhat worse since they began fishing on Rainbow Lake, while 42% indicated the quality of fishing has remained the same (Appendix B, Question 13). Rainbow Lake is currently listed as an Area of Special Natural Resource Interest (ASNRI) for harboring naturally reproducing populations of both walleye and muskellunge. The RLA and understands that a multitude of factors such as changes in habitat, water levels, and fishing pressure affect fish communities, and the RLA would like to take an active role in maintaining a healthy fishery to ensure Rainbow Lake remains a high-quality fishing lake for future generations.

Rainbow Lake is currently overseen by WDNR fisheries biologist Hadley Boehm (715.356.5211). In an effort to remain informed on studies pertaining to fisheries in these lakes, the RLA Board of Directors should contact Hadley at least once per year (perhaps during the winter months when field work is not occurring) for a brief summary of activities. In addition, the RLA can discuss management options for maintaining and enhancing the lakes' fishery, which may include changes in angling regulations and/or habitat enhancements.

Action Steps:

See description above.

Please note that study methods and explanations of analyses for Rock Lake can be found within the Town of Winchester Town-wide Management Plan document.

8.6 Rock Lake

An Introduction to Rock Lake

Rock Lake, Vilas County, is a 126-acre shallow lowland, brown-water, eutrophic drainage lake with a maximum depth of 20 feet and a mean depth of 9 feet (Rock Lake – Map 1). Its surficial watershed encompasses approximately 3,624 acres across portions of Vilas County, WI and Gogebic County, MI. Rock Lake is fed by upstream No Mans Lake via No Mans Creek, and the lake drains into downstream North Turtle Lake. In 2017, 42 native aquatic plant species were located within the lake, of which fern-leaf pondweed (*Potamogeton robbinsii*) was the most common. The non-native, invasive wetland plant pale-yellow iris (*Iris pseudacorus*) was located in numerous locations along Rock Lake's shoreline in 2017. To date, no other non-native species have been documented in Rock Lake.

Lake at a Glance - Rock Lake

Morphometry	
LakeType	Shallow Lowland Drainage
Surface Area (Acres)	126
Max Depth (feet)	20
Mean Depth (feet)	9
Perimeter (Miles)	3.9
Shoreline Complexity	6.0
Watershed Area (Acres)	3,624
Watershed to Lake Area Ratio	28:1
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Avg Summer P (µg/L)	26
Avg Summer Chl-α (µg/L)	12
Avg Summer Secchi Depth (ft)	5.7
Summer pH	7.6
Alkalinity (mg/L as $CaCO_3$)	31
Vegetation	
Number of Native Species	42
NHI-Listed Species	Vasey's pondweed (*Potamogeton vaseyi*)
Exotic Species	Pale-yellow Iris (*Iris pseudacorus*)
Average Conservatism	6.9
Floristic Quality	35.6
Simpson's Diversity (1-D)	0.92

Descriptions of these parameters can be found within the town-wide portion of the management plan

8.6.1 Rock Lake Water Quality

It is often difficult to determine the status of a lake's water quality purely through observation. Anecdotal accounts of a lake "getting better" or "getting worse" can be difficult to judge because a) a lake's water quality may fluctuate from year to year based upon environmental conditions such as precipitation, and b) differences in observation and perception of water quality can differ greatly from person to person. It is best to analyze the water quality of a lake through scientific data as this gives a concrete indication as to the health of the lake, and whether its health has

deteriorated or improved. Further, by looking at data for similar lakes regionally and statewide, the status of a lake's water quality can be made by comparison.

In 2017, a stakeholder survey was sent to 52 Rock Lake riparian property owners. Nineteen (37%) of these 52 surveys were completed and returned. Given the relatively low response rate, the results of the stakeholder survey cannot be interpreted as being statistically representative of the population sampled. At best, the results may indicate possible trends and opinions about the stakeholder perceptions of Rock Lake but cannot be stated with statistical confidence. The full survey and results can be found in Appendix B. When asked about Rock Lake's current water quality, 58% of the respondents indicated the water quality is *good* or *excellent*, 32% indicated the water quality is *fair*, 5% indicated the water quality is *poor*, and 5% were unsure (Figure 8.6.1-1). When asked how water quality has changed in Rock Lake since they first visited the lake, 63% of respondents indicated water quality has *remained the same*, 27% indicated the water quality has *somewhat degraded*, 5% indicated it has *severely degraded*, and 5% were unsure (Figure 8.6.1-1).

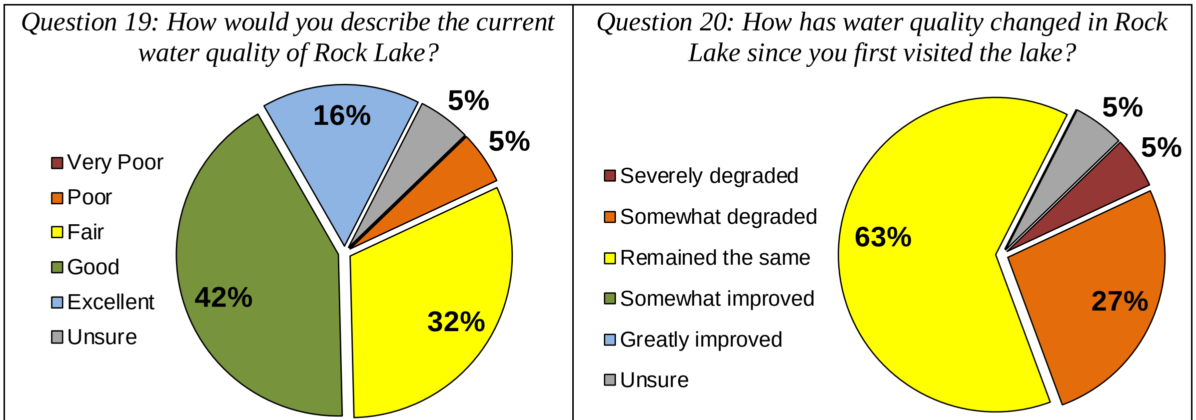


Figure 8.6.1-1. Rock Lake stakeholder survey responses regarding the lake's current and historical water quality. Created using responses from 19 (37%) respondents of 52 surveys distributed.

Near-surface total phosphorus data for Rock Lake are available from 1985, 2005-2009, and 2017 (Figure 8.6.1-2). Average summer total phosphorus concentrations have been relatively stable over the time period for which data are available, and the weighted average summer concertation of 26 µg/L falls within the *excellent* category for shallow lowland drainage lakes in Wisconsin. The average summer phosphorus concentration in 2017 was slightly above average at 30 µg/L, likely due to increased runoff from above-average precipitation. Precipitation data obtained from nearby Manitowish Waters indicates precipitation in 2017 was four inches above average. Rock Lake's phosphorus concentrations are lower than the median concentration for shallow lowland drainage lakes in Wisconsin (33 µg/L) but above the median for all lake types within the Northern Lakes and Forests (NLF) ecoregion (21 µg/L). The available data indicate phosphorus concentrations have been relatively stable in Rock Lake since 2005.

Chlorophyll-*a* concentrations, a measure of phytoplankton abundance, are available from Rock Lake from 1984, 2005-2009, and 2017 (Figure 8.6.1-3). Like total phosphorus concentrations, average summer chlorophyll-*a* concentrations are relatively stable, ranging from *excellent* to *good* for shallow lowland drainage lakes in Wisconsin. Overall, the weighted average summer chlorophyll-*a* concentration is 12 µg/L, falling into the *good* category for Wisconsin's shallow lowland drainage lakes. Rock Lake's average summer chlorophyll-*a* concentration is slightly higher than the median value for shallow lowland drainage lakes (9.4 µg/L) and higher than the median value for all lake types within the NLF ecoregion (5.6 µg/L). The available data indicate that annual chlorophyll-*a* concentrations in Rock Lake have been relatively stable since 2005, and algal production has not increased.

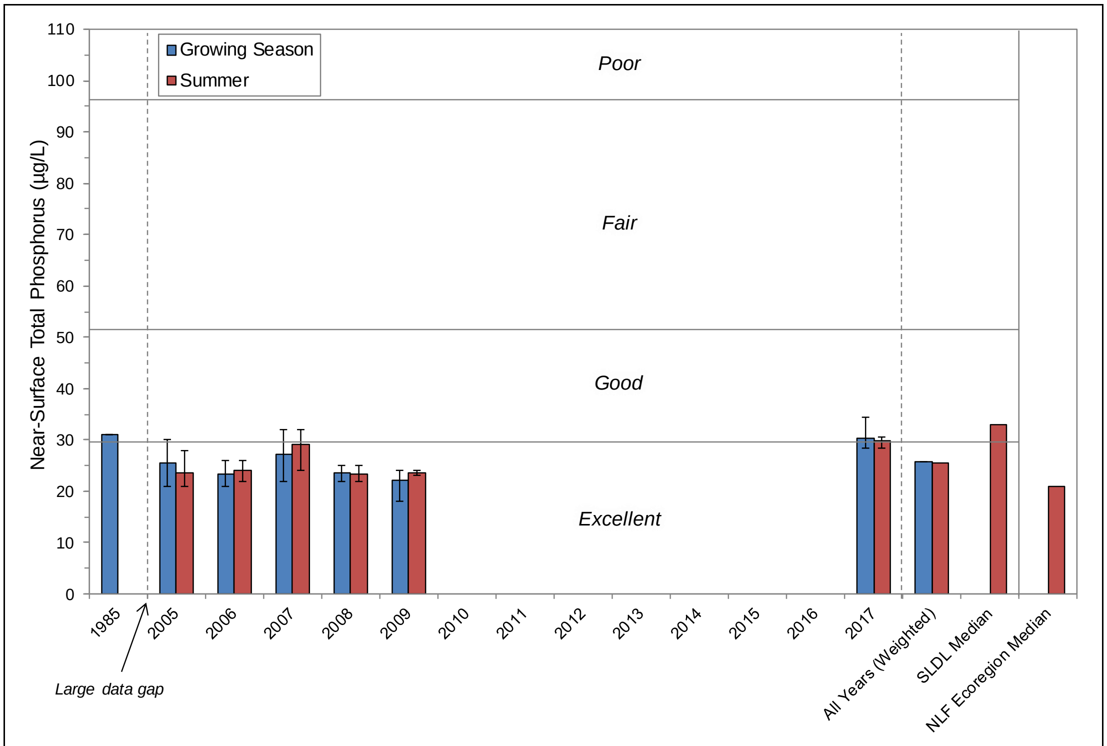


Figure 8.6.1-2. Rock Lake average annual near-surface total phosphorus concentrations and median near-surface total phosphorus concentrations for state-wide shallow lowland drainage lakes (SLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Secchi disk transparency data from Rock Lake are available from 1984, 1985, 1991-2002, 2005, 2007-2010, 2012-2015, and 2017 (Figure 8.6.1-4). These data indicate that water clarity is relatively variable in Rock Lake from year to year, ranging from 4.3 feet in 1991 to 7.9 feet in 1994. The weighted summer average Secchi disk depth is 5.7 feet, falling into the *excellent* category for shallow lowland drainage lakes in Wisconsin. Rock Lake's average summer Secchi disk depth is comparable to the median value for shallow lowland drainage lakes (5.6 feet) but lower than the median value for all lake types within the NLF ecoregion (8.9 feet). Trends analysis of Rock Lake's Secchi disk data indicates no significant trends (positive or negative) in water clarity are occurring over time.

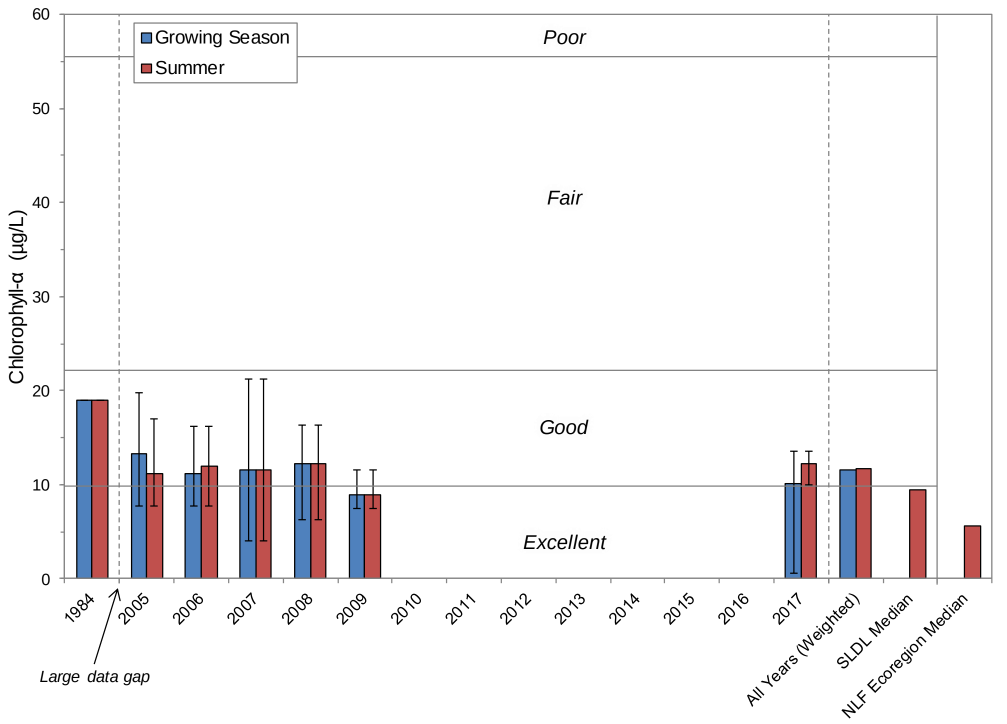


Figure 8.6.1-3. Rock Lake average annual chlorophyll-α concentrations and median chlorophyll-α concentrations for state-wide shallow lowland drainage lakes (SLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Abiotic suspended particulates, such as sediment, can also cause a reduction in water clarity. However, *total suspended solids*, a measure of both biotic and abiotic suspended particles within the water, were low in Rock Lake in 2017 indicating minimal amounts of suspended material within the water. While suspended particles are minimal in Rock Lake, water clarity can also be influenced by dissolved compounds within the water. Many lakes in the northern region of Wisconsin contain higher concentrations of natural dissolved organic acids that originate from decomposing plant material within wetlands in the lake's watershed. In higher concentrations, these dissolved organic compounds give the water a tea-like color or staining and decrease water clarity.

A measure of water clarity once all of the suspended material (i.e. phytoplankton and sediments) have been removed, is termed *true color*, and measures how the clarity of the water is influenced by dissolved components. True color values measured from Rock Lake in 2017 averaged 65 SU (standard units), indicating the lake's water is *tea-colored*. The high concentrations of dissolved organic acids in the lake reduce the water's clarity. It is important to note that the tea-colored water in Rock Lake is natural, and is not an indication of degraded conditions.

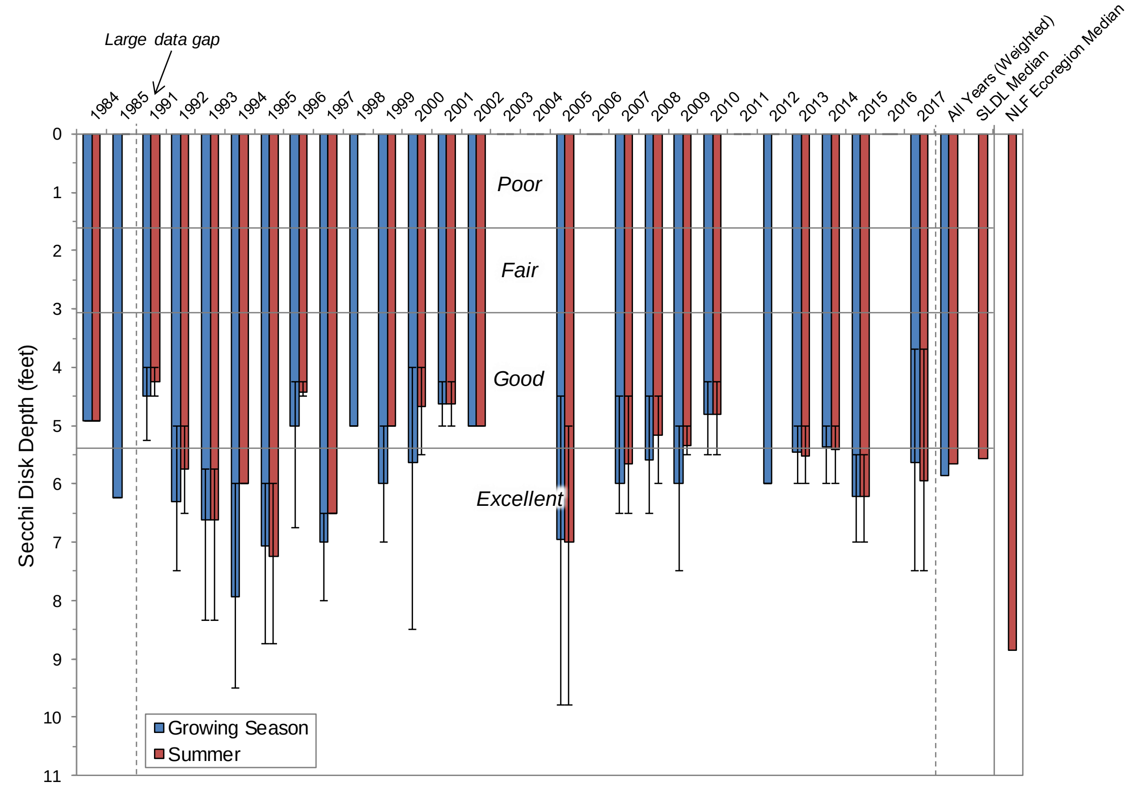


Figure 8.6.1-4. Rock Lake average annual Secchi disk depths and median Secchi disk depths for state-wide shallow lowland drainage lakes (SLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

To determine if internal nutrient loading (discussed in town-wide section of management plan) is a significant source of phosphorus in Rock Lake, near-bottom phosphorus concentrations are compared against those collected from the near-surface. Near-bottom total phosphorus concentrations were measured on three occasions from Rock Lake in 2017 and once in 2018 (Figure 8.6.1-5). Near-bottom total phosphorus concentrations were similar to those measured at the surface on all sampling locations and were not elevated. This indicates that the release of phosphorus from bottom sediments in Rock Lake is not a significant source of phosphorus to the lake. Given that Rock Lake is a shallow lake, it does not stratify for long periods in the summer allowing anoxia to develop in bottom waters.

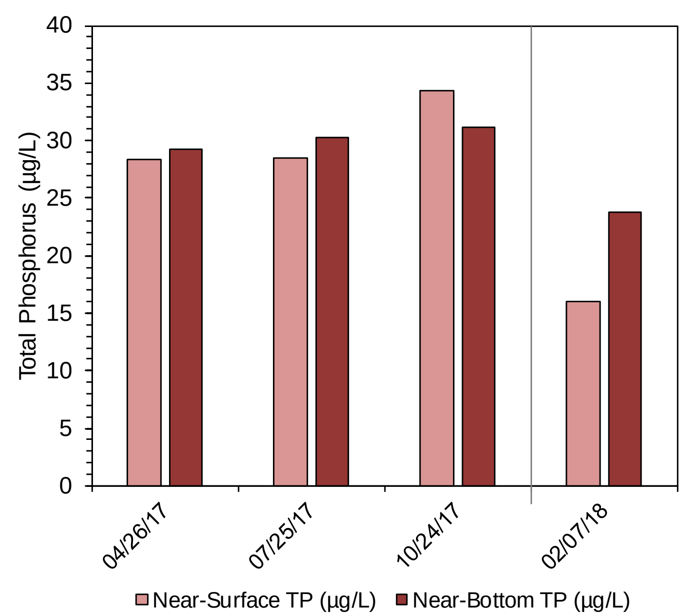


Figure 8.6.1-5. Rock Lake near-bottom total phosphorus concentrations and corresponding near-surface total phosphorus concentrations measured in 2017 and 2018.

Rock Lake Trophic State

Figure 8.6.1-6 contains the Trophic State Index (TSI) values for Rock Lake calculated from the data collected in 2017 along with historical data. These TSI values are calculated using summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency data. In general, the best values to use in assessing a lake's trophic state are chlorophyll-*a* and total phosphorus, as water clarity can be influenced by other factors other than phytoplankton such as dissolved organic compounds. The closer the calculated TSI values for these three parameters are to one another indicates a higher degree of correlation. The weighted TSI values for total phosphorus and chlorophyll-*a* (and Secchi disk depth) in Rock Lake indicate the lake is at present in a lower eutrophic state. Rock Lake's productivity is similar to the productivity of other shallow lowland drainage lakes throughout Wisconsin and higher when compared to the productivity of all lake types within the NLF ecoregion. It should be noted that Rock Lake was likely naturally eutrophic prior to Euro-American settlement, and its eutrophic status is not believed to be the result of human activity.

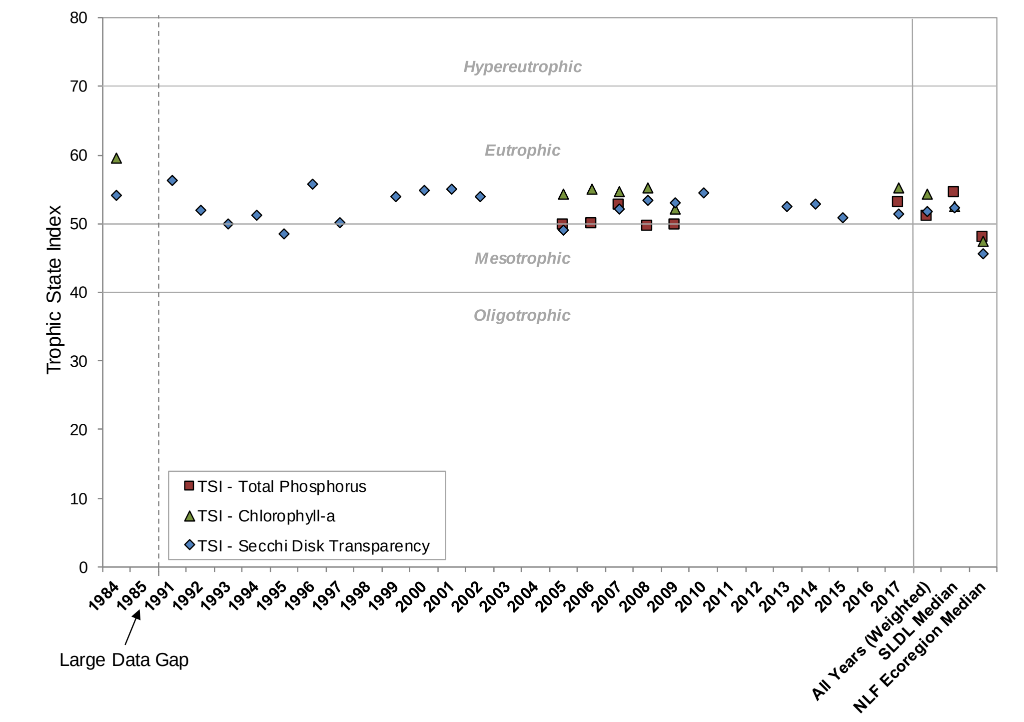


Figure 8.6.1-6. Rock Lake, statewide shallow lowland drainage lakes (SLDL), and Northern Lakes and Forests (NLF) ecoregion lakes Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Rock Lake

Dissolved oxygen and temperature profile data were collected during each water quality sampling events conducted by Onterra ecologists. These data are displayed in Figure 8.6.1-7. The temperature and dissolved oxygen data collected in 2017 indicate that Rock Lake did not develop strong, thermal stratification during the summer. The lake's shallow nature facilitates wind-driven mixing of the water column and the lake does not experience strong stratification. The loss of oxygen leading to fish kills can occur in shallow, productive lakes in winter. Heavy snow over ice reduces light penetration, leading to a reduction in oxygen production through photosynthesis by plants and algae. In productive lakes, the decomposition of organic matter rapidly depletes available oxygen. With the ice preventing atmospheric diffusion of oxygen into the water, low or no oxygen conditions can develop leading to fish stress or mortality.

Dissolved oxygen concentrations measured under the ice in Rock Lake in 2018 were relatively low, ranging from 3.8 – 4.2 mg/L. While fish are able to survive at these lower levels of dissolved oxygen, these concentrations are approaching levels that can lead to fish stress and mortality. Given Rock Lake is a shallow, productive lake, these lower dissolved oxygen concentrations in winter are not unexpected. However, because Rock Lake possesses an inflowing tributary and is connected to downstream North Turtle Lake, fish are likely able to find sufficient oxygen levels in these areas in winter.

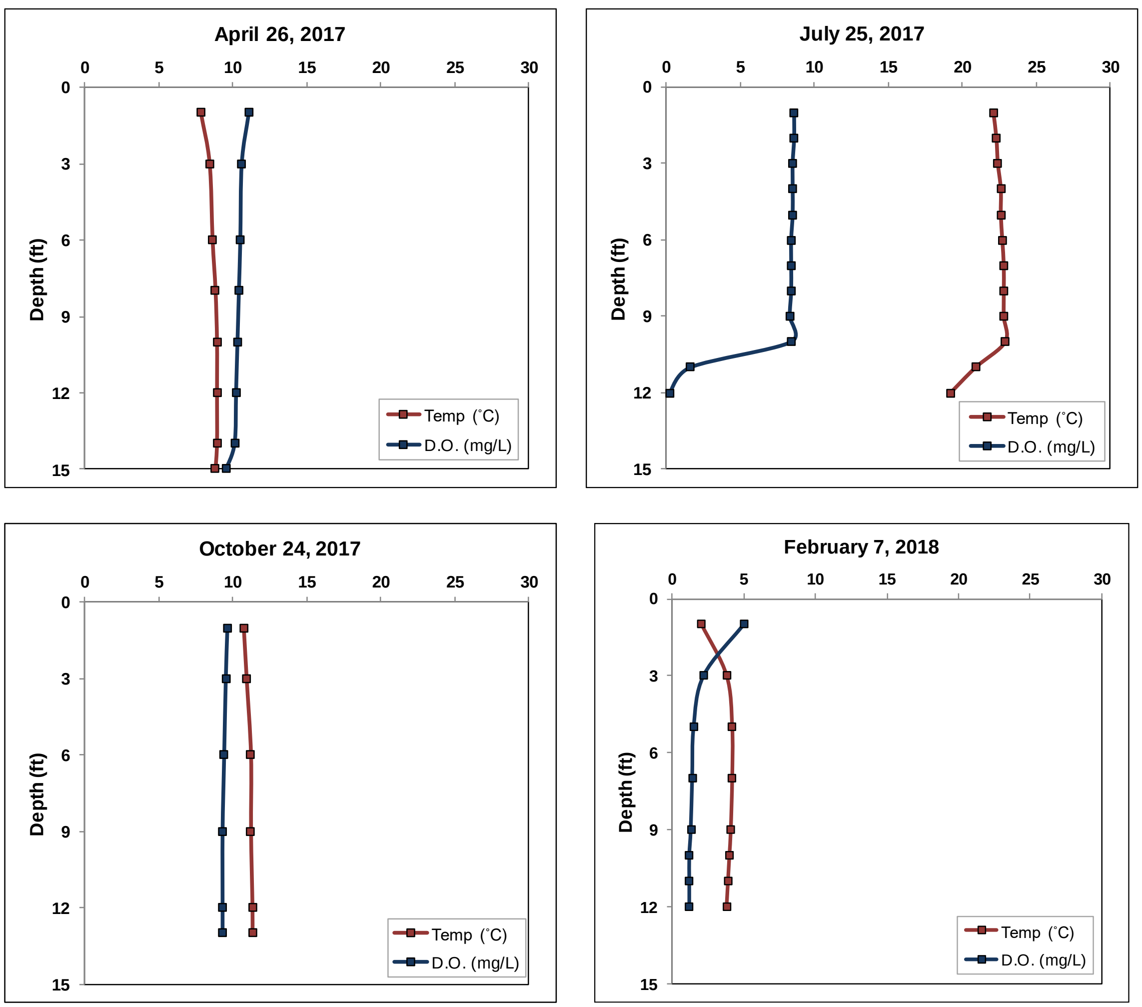


Figure 8.6.1-7. Rock Lake 2017/18 dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected from Rock Lake

The previous section is centered on parameters relating to Rock Lake's trophic state. 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 Rock 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.

As the Town-wide Section explains, the pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is thus an index of the lake's acidity. Rock Lake's mid-summer surface water pH was measured at 7.6 in 2017. This value indicates Rock Lake's water is alkaline and falls within the normal range for Wisconsin lakes. Fluctuations in pH with respect to seasonality are common; in-lake processes such as photosynthesis by plants act to reduce acidity by carbon dioxide removal while decomposition of organic matter adds carbon dioxide to water, thereby increasing acidity. A lake's pH is primarily determined by the water's alkalinity, or a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. Rock Lake's average alkalinity measured in 2017 was 30.7 mg/L as $CaCO_3$. This value falls within the expected range for northern Wisconsin lakes, and indicates that while Rock Lake is considered a softwater lake, it is not sensitive to fluctuations in pH from acid rain.

Water quality samples collected from Rock Lake in 2017 were also analyzed for calcium. Calcium concentrations, along with pH, are currently being used to determine if a waterbody is suitable to support the invasive zebra mussel, as these animals require calcium for the construction of their shells. Zebra mussels typically require higher calcium concentrations than Wisconsin's native mussels, and lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The accepted suitable pH range for zebra mussels is 7.0 – 9.0, and Rock Lake's pH falls within this range. Rock Lake's calcium concentration in 2017 was 8.8 mg/L, indicating the lake has *very low susceptibility* to zebra mussel establishment. Plankton tows were completed by Onterra ecologists at three locations in Rock Lake in 2017 that underwent analysis for the presence of zebra mussel veligers, their planktonic larval stage. Analysis of these samples were negative for zebra mussel veligers, and Onterra ecologists did not observe any adult zebra mussels during the 2017 surveys.

Rock Lake was placed on the 303(d) list of impaired waterbodies for contaminated fish tissue by mercury in 1998. While mercury is found naturally in the environment due to volcanic eruptions and weathering of rocks, the majority of the mercury found in Wisconsin's waterbodies is the result of coal-fired power plants and the release of mercury into the atmosphere. Mercury is deposited into lakes, rivers, and streams through precipitation and the deposition of dust particles where it converted into its mobile and harmful form, methylmercury. Methylmercury becomes stored in bodies of aquatic animals, and concentrations tend to be highest in those species at the top of the food chain. In humans, mercury affects the nervous system and is of special concern for unborn children, infants, and children. For advice on eating fish from Rock Lake, please see the Rock Lake Fisheries Data Integration Section (Section 8.6.6).

8.6.2 Rock Lake Watershed Assessment

Rock Lake's surficial watershed encompasses approximately 3,624 acres (Figure 8.6.2-1 and Rock Lake – Map 2) yielding a watershed to lake area ratio of 28:1. Rock Lake's direct watershed is comprised of land cover types including forests (42%), wetlands (48%), open water (14%), rural open space (6%), pasture/grass (1%), and rural residential areas (<1%) (Figure 8.6.2-1). Wisconsin Lakes Modeling Suite (WiLMS) modeling indicates that Rock Lake's residence time is approximately 0.26 years, or the water within the lake is completely replaced approximately 3.8 times per year.

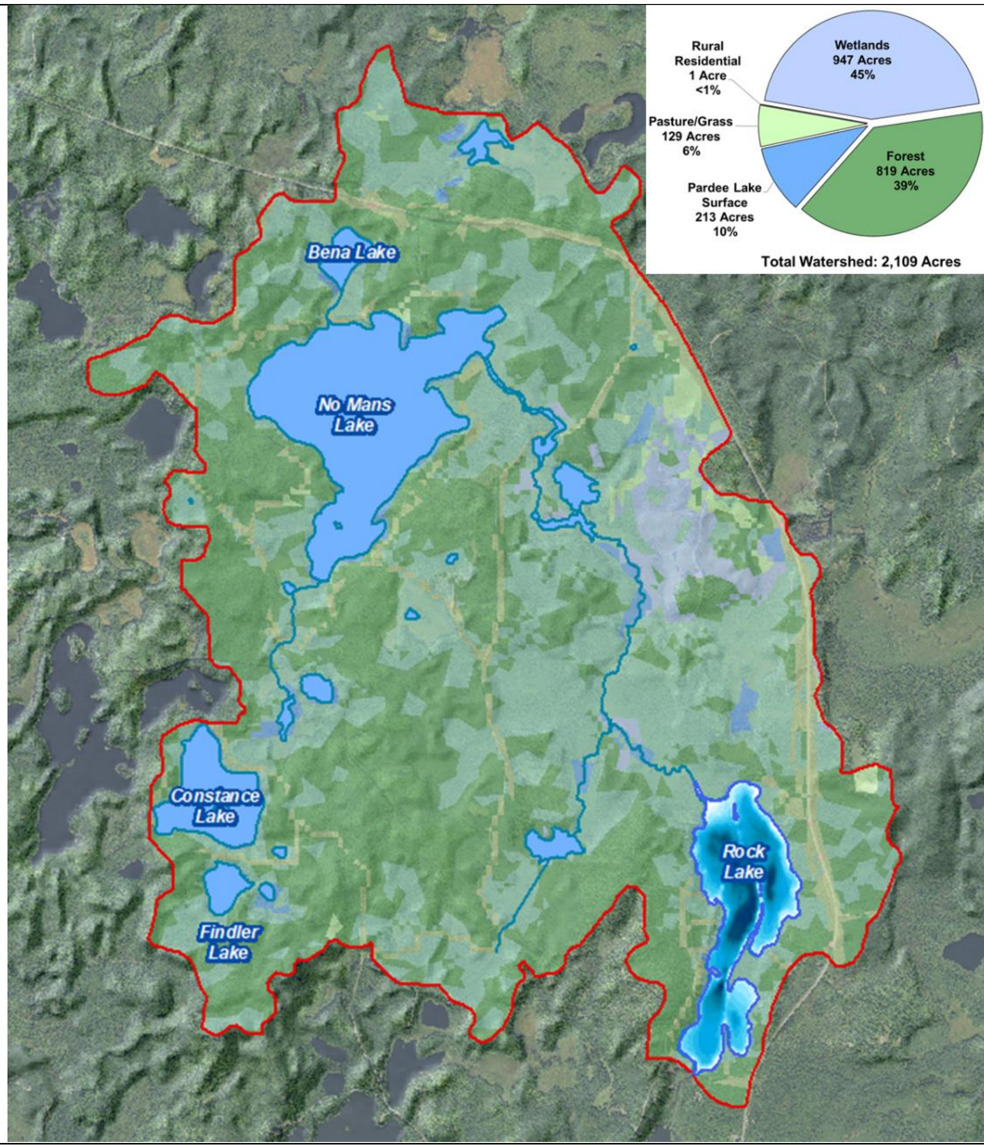


Figure 8.6.2-1. Rock Lake watershed boundary (red line) and proportion of land cover types. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

While total phosphorus data from upstream lakes are typically used for more accurate modeling, no phosphorus data are available from No Mans Lake. Using the land cover types within Rock Lake's watershed, WiLMS was utilized to estimate the annual potential phosphorus load delivered to Rock Lake from its watershed. In addition, data obtained from a stakeholder survey sent to

Rock Lake riparian property owners in 2017 was also used to estimate the amount of phosphorus loading to the lake from riparian septic systems. The model estimated that approximately 381 pounds of phosphorus are delivered to Rock Lake from its watershed on an annual basis (Figure 8.6.2-2).

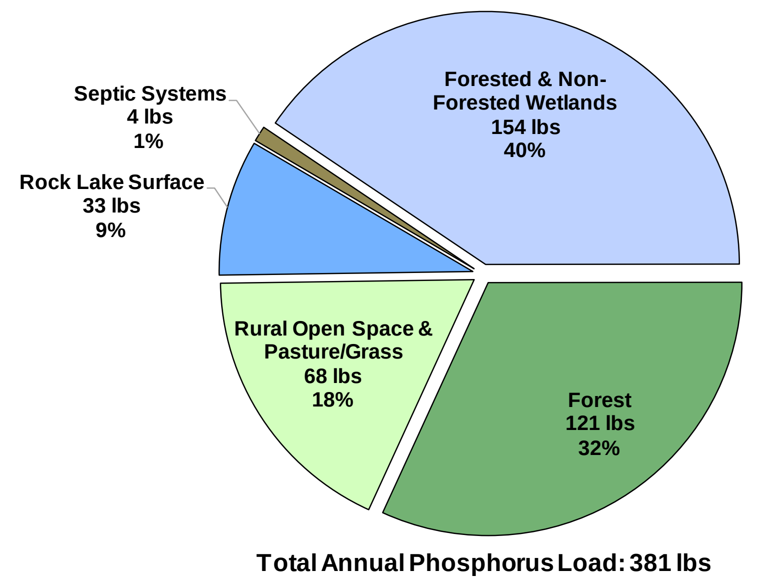


Figure 8.6.2-2. Rock Lake estimated potential annual phosphorus loading. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Of the estimated 381 pounds of phosphorus being delivered to Rock Lake on an annual basis, approximately 154 lbs (40%) originate from wetlands, 121 lbs (32%) originate from forests, 68 lb (18%) originate from rural/open space and pasture/grass, 33 lbs (9%) originate from direct atmospheric deposition onto the lake's surface, and 4 lbs (1%) originate from riparian septic systems (Figure 8.6.2-2).

Using the estimated annual potential phosphorus load, WiLMS predicted an in-lake growing season average total phosphorus concentration of 24 µg/L in Rock Lake. This predicted in-lake phosphorus concentration is nearly identical to the measured growing season phosphorus concentration of 25 µg/L. The similarity between predicted and measured concentrations is an indication that the watershed was modeled accurately and there are no significant sources of unaccounted phosphorus entering the lake.

8.6.3 Rock Lake Shoreland Condition

Shoreland Development

As is discussed within the Town-wide Section, one of the most sensitive areas of a lake's watershed is the immediate shoreland zone. This transition zone between the aquatic and terrestrial environment is the last source of protection for the lake against pollutants originating from roads, driveways, and yards above, and is also a critical area for wildlife habitat and overall lake ecology. In the fall of 2017, the immediate shoreland of Rock Lake was assessed in terms of its development, and the shoreland zone was characterized with one of five shoreland development categories ranging from urbanized to completely undeveloped.

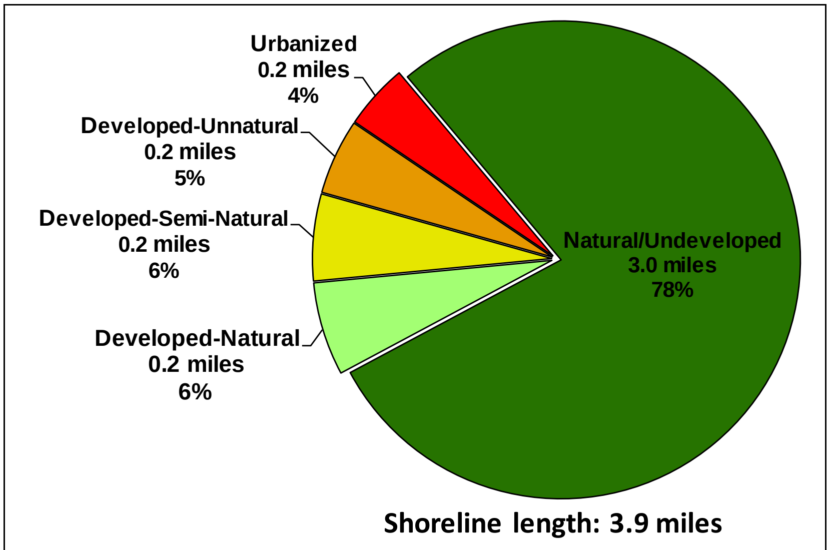


Figure 8.6.3-1. Rock Lake shoreland categories and total lengths. Based upon a fall 2017 survey. Locations of these categorized shorelands can be found on Rock Lake - Map 3.

The 2017 survey revealed that Rock Lake has stretches of shoreland that fit all five shoreland assessment categories (Figure 8.6.3-1). In total, 3.2 miles (84%) of the 3.9-mile shoreland zone were categorized as natural/undeveloped or developed-natural or shoreland types that provide the most benefit to the lake and should be left in their natural state if possible. Approximately 0.4 miles (9%) of the shoreland was categorized as developed-unnatural or urbanized, shoreland areas which provide little benefit to and may actually adversely impact the lake. If restoration of Rock Lake's shoreland is to occur, primary focus should be placed on these highly developed shoreland areas. Rock Lake – Map 3 displays the locations of these shoreland categories around the entire lake.

Coarse Woody Habitat

A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey on Rock Lake in 2017. Coarse woody habitat was identified, and classified in several size categories (2-8 inches diameter, >8 inches diameter and cluster) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed in the Town-wide Section, 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 et al. 2005).

During the coarse woody habitat survey on Rock Lake, a total of 198 pieces were observed along 3.9 miles of shoreline, yielding a coarse woody habitat to shoreline mile ratio of 51:1 (Figure 8.6.3-2). Onterra ecologists have completed these surveys on 98 Wisconsin lakes since 2012, and Rock Lake falls in the 88th percentile for the number of coarse woody habitat pieces per shoreline mile.

Refraining from removing these woody habitats from the shoreland area will ensure this high-quality habitat remains in Rock Lake. The locations of these coarse woody habitat pieces are displayed on Rock Lake – Map 4.

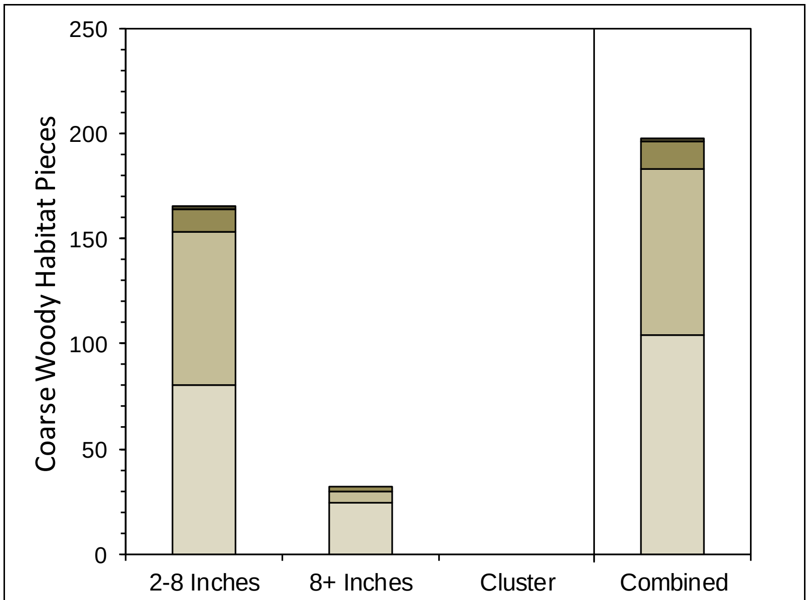


Figure 8.6.3-2. Rock Lake coarse woody habitat survey results. Based upon a fall 2017 survey. Locations of Rock Lake coarse woody habitat can be found on Rock Lake – Map 4.

8.6.4 Rock Lake Aquatic Vegetation

An Early-Season Aquatic Invasive Species (ESAIS) Survey was conducted by Onterra ecologists on Rock Lake on June 30, 2017. While the intent of this survey is to locate any potential non-native species within the lake, the primary focus is to locate occurrences of the non-native curly-leaf pondweed which should be at or near its peak growth at this time. Fortunately, no curly-leaf pondweed was located in Rock Lake in 2017, and it is believed that curly-leaf pondweed is not present within the lake or exists at an undetectable level. However, pale-yellow iris, a non-native wetland plant, was located in numerous locations along Rock Lake's shoreline in 2017. Because of its ecological significance, pale-yellow iris in Rock Lake is discussed further in the subsequent Non-Native Aquatic Plants subsection.

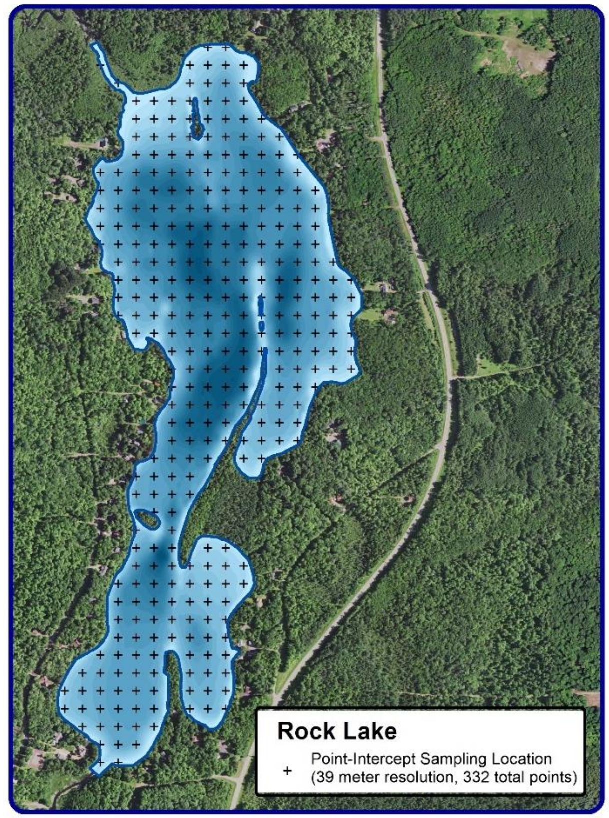


Figure 8.6.4-1. Rock Lake whole-lake point-intercept survey sampling locations.

The whole-lake aquatic plant point-intercept survey and emergent and floating-leaf aquatic plant community mapping survey were conducted on Rock Lake by Onterra ecologists on July 18 and 19, 2017 (Figure 8.6.4-1). During these surveys, a total of 43 aquatic plant species were located, one of which is considered to be a non-native, invasive species: pale-yellow iris (Table 8.6.4-1).

Lakes in Wisconsin vary in their morphometry, water chemistry, substrate composition, and management, all factors which influence aquatic plant community composition. In late September of 2017, Onterra ecologists completed an acoustic survey on Rock Lake (bathymetric results on Rock Lake – Map 1). The sonar-based technology records aquatic plant bio-volume, or the percentage of the water column that is occupied by aquatic plants at a given location. Data pertaining to Rock Lake's substrate composition were also recorded during this survey. The sonar records substrate hardness, ranging from the hardest substrates (i.e. rock and sand) to the more flocculent, softer organic sediments.

Data regarding substrate hardness collected during the 2017 acoustic survey showed that substrate hardness varies widely in shallow areas of Rock Lake with both the hardest and softest substrates in the lake occurring within 1.0-6.0 feet of water (Figure 8.6.4-2). The softer substrates occurred near the mouth of No Mans Creek on the north side of the lake and in the northern area the bay in the southeastern part of the lake. However, most of the shallower areas around the lake contained rock or sand. 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 areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because of the different habitat types that are available.

Table 8.6.4-1. List of aquatic plant species located in Rock Lake during Onterra 2017 aquatic plant surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2017 (Onterra)
Emergent	*Acorus americanus*	Sweetflag	7	I
	Carex utriculata	Common yellow lake sedge	7	I
	Decodon verticillatus	Water-willow	7	I
	Dulichium arundinaceum	Three-way sedge	9	I
	Eleocharis palustris	Creeping spikerush	6	I
	Equisetum fluviatile	Water horsetail	7	I
	Iris pseudacorus	Pale-yellow iris	Exotic	I
	Pontederia cordata	Pickerelweed	9	I
	Sagittaria latifolia	Common arrowhead	3	I
	Schoenoplectus acutus	Hardstem bulrush	5	X
	Sparganium americanum	Eastern bur-reed	8	I
	Sparganium eurycarpum	Common bur-reed	5	I
FL	*Brasenia schreberi*	Watershield	7	I
	Nuphar variegata	Spatterdock	6	X
	Nymphaea odorata	White water lily	6	X
	Sparganium fluctuans	Floating-leaf bur-reed	10	X
Submersed	*Bidens beckii*	Water marigold	8	X
	Callitriche palustris	Common water starwort	8	I
	Ceratophyllum demersum	Coontail	3	X
	Ceratophyllum echinatum	Spiny hornwort	10	X
	Chara spp.	Muskgrasses	7	X
	Elodea canadensis	Common waterweed	3	X
	Elodea nuttallii	Slender waterweed	7	X
	Heteranthera dubia	Water stargrass	6	X
	Isoetes spp.	Quillwort spp.	8	X
	Lobelia dortmanna	Water lobelia	10	X
	Myriophyllum farwellii	Farwell's watermilfoil	9	I
	Myriophyllum sibiricum	Northern watermilfoil	7	X
	Najas flexilis	Slender naiad	6	X
	Nitella spp.	Stoneworts	7	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton berchtoldii	Slender pondweed	7	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	I
	Potamogeton foliosus	Leafy pondweed	6	I
	Potamogeton gramineus	Variable-leaf pondweed	7	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X
	Potamogeton robbinsii	Fern-leaf pondweed	8	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	X
	Potamogeton vaseyi	Vasey's pondweed	10	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Utricularia vulgaris	Common bladderwort	7	X
	Vallisneria americana	Wild celery	6	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submersed and Emergent
X = Located on rake during point-intercept survey; I = Incidental Species

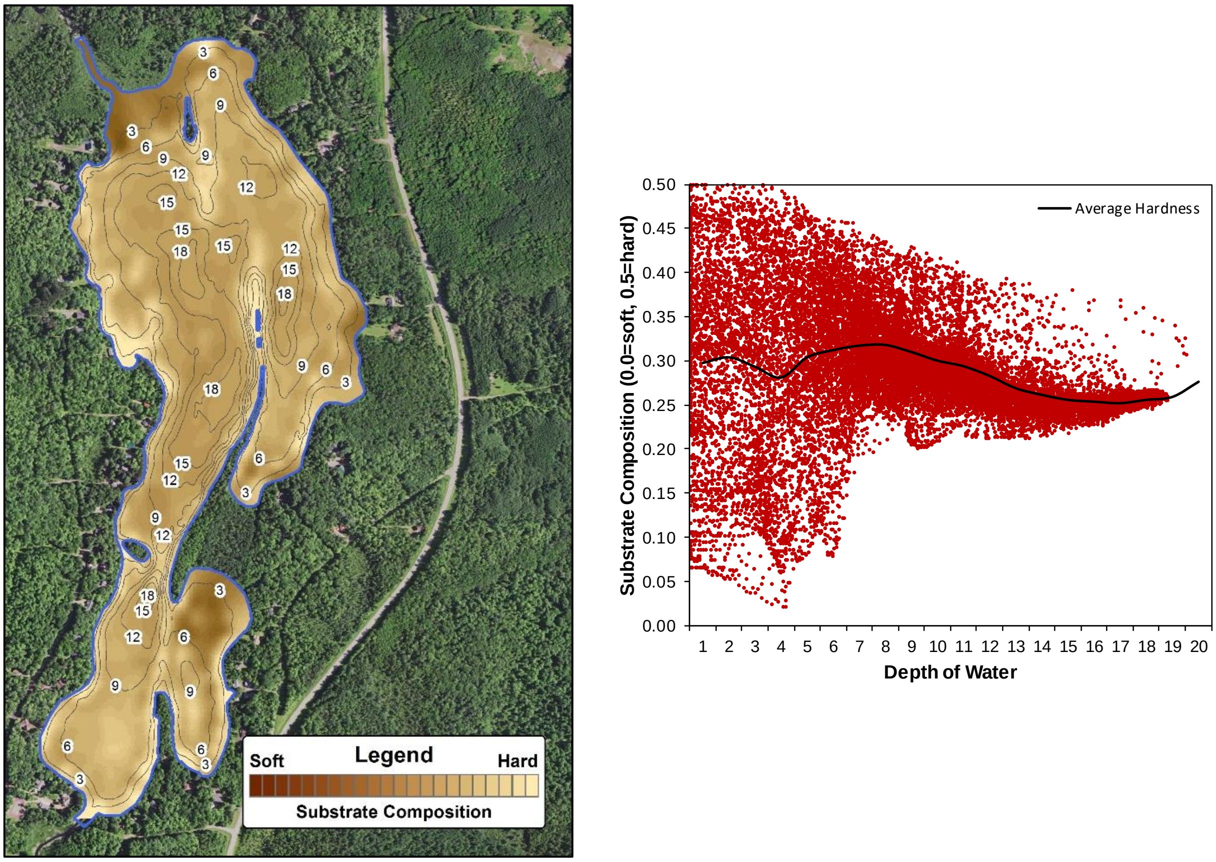


Figure 8.6.4-2. Rock Lake spatial distribution of substrate hardness (left) and substrate hardness across water depth (right). Individual data points are displayed in red. Creating using data from September 2017 acoustic survey.

The acoustic survey also recorded aquatic plant bio-volume throughout the entire lake. As mentioned earlier, aquatic plant bio-volume is the percentage of the water column that is occupied by aquatic plants. The 2017 aquatic plant bio-volume data are displayed in Figure 8.6.4-3 and Rock Lake – Map 6. Areas where aquatic plants occupy most or all of the water column are indicated in red while areas of little to no aquatic plant growth are displayed in blue. The 2017 whole-lake point-intercept survey found aquatic plants growing to a maximum depth of 8 feet. However, the majority of aquatic plant growth occurs within 1.0-4.0 feet of water. The 2017 acoustic survey indicated approximately 18% of Rock Lake's area is occupied by aquatic vegetation, while the remaining 82% of the lake is too deep and light-limited to support aquatic plant growth.

As mentioned, aquatic plants were recorded growing to a maximum depth of 8 feet in 2017. Of the 146 point-intercept sampling locations that fell at or shallower than the maximum depth of plant growth (littoral zone), approximately 39% contained aquatic vegetation. Aquatic plant rake fullness data collected in 2017 indicates that 22% of the 146 littoral sampling locations contained vegetation with a total rake fullness rating (TRF) of 1, 11% had a TRF rating of 2, and 6% had a TRF rating of 3 (Figure 8.6.4-5). These data indicate that aquatic plant occurrence and density in Rock Lake is relatively low.

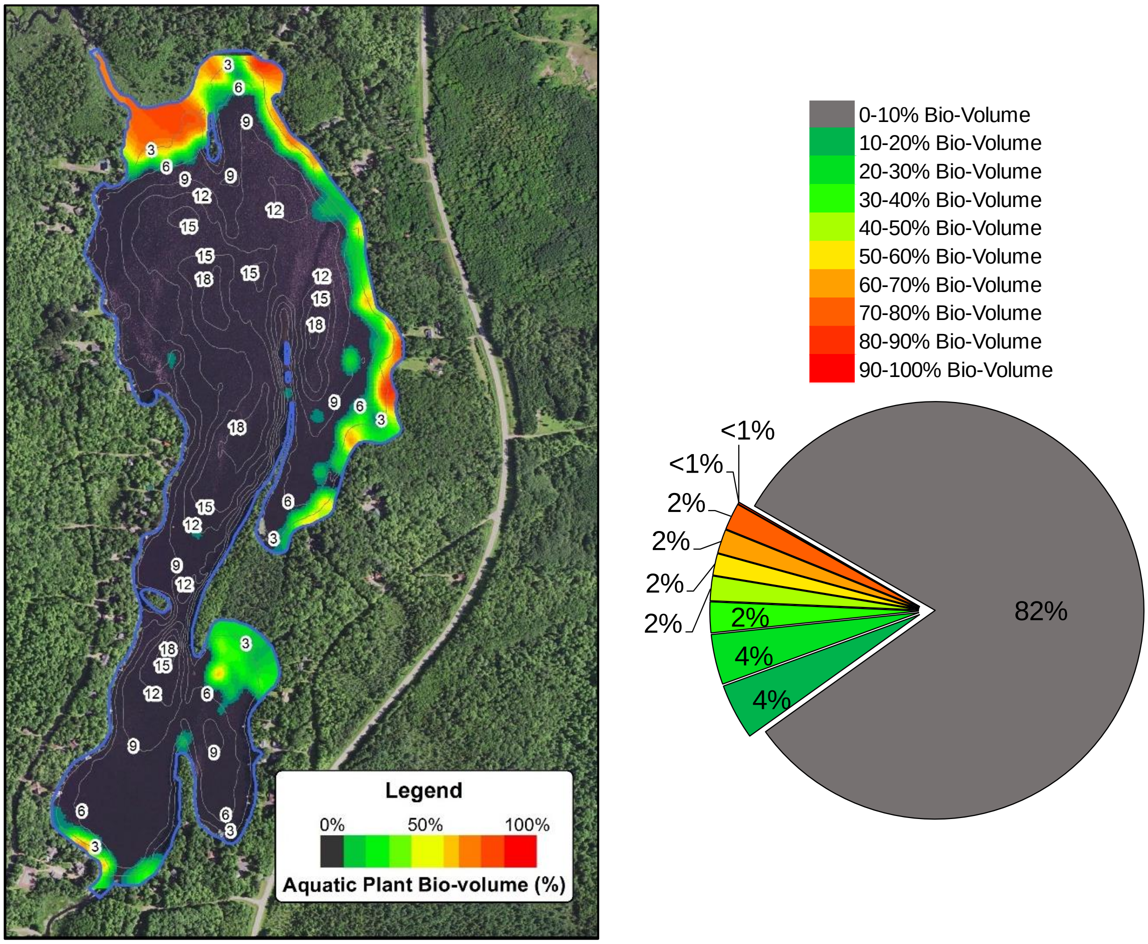


Figure 8.6.4-4. Rock Lake 2017 aquatic plant bio-volume. Created using data from September 2017 acoustic survey data.

While the acoustic mapping is an excellent survey for understanding the distribution and levels of aquatic plant growth throughout the lake, this survey does not determine what aquatic plant species are present. Whole-lake point-intercept surveys are used to quantify the abundance of individual species within the lake. Of the 43 aquatic plant species located in Rock Lake in 2017, 27 were encountered directly on the rake during the whole-lake point-intercept survey (Figure 8.6.4-6). 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 relatively rare within the plant community. Of the 27 species directly sampled with the rake during the point-intercept survey, fern-leaf pondweed, wild celery, and stoneworts were the three-most frequently encountered aquatic plant species (Figure 8.6.4-6).

Fern-leaf pondweed was the most frequently encountered aquatic plant species in Rock Lake in 2017 with a littoral frequency of occurrence of 18% (Figure 8.6.4-6). 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 Rock Lake, fern-leaf pondweed was most abundant between 2.0 and 5.0 feet of water.

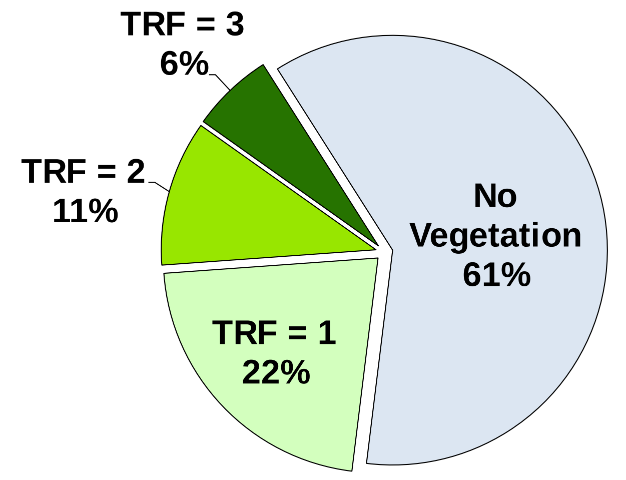


Figure 8.6.4-5. Rock Lake 2017 aquatic vegetation total rake fullness ratings (TRF). Created from data collected during the 2017 whole-lake point-intercept survey (N = 146).

Wild celery, also known as tape or eelgrass, was the second-most frequently encountered aquatic plant species in Rock Lake in 2017 with a littoral frequency of occurrence of 16% (Figure 8.3.4-6). 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. Rock Lake's areas of sand/cobble and low light conditions as a result of its stained water favor for abundance of wild celery. In 2017, wild celery was most abundant over hard substrates in water 2.0-4.0 feet deep.

Stoneworts, a genus of macroalgae, were the third-most frequently encountered aquatic plant in Rock Lake in 2017 with a littoral frequency of occurrence of 9% (Figure 8.3.4-6). Stoneworts can grow relatively large and form dense beds along the lake bottom, supplying oxygen to deeper waters and providing structural habitat for micro- and macroinvertebrates and fish. Little is known about the life histories and distribution of stonewort species in Wisconsin; however, it is known that stoneworts require high quality water and are indicators of good environmental health. Stoneworts were most abundant between 5.0 and 7.0 feet of water in Rock Lake.

Submersed aquatic plants can be grouped into one of two general categories based upon their morphological growth form and habitat preferences. These two groups include species of the *isoetid* growth form and those of the *elodeid* growth form. Plants of the isoetid growth form are small, slow-growing, inconspicuous submerged plants (Photo 8.6.4-2). These species often have evergreen, succulent-like leaves and are usually found growing in sandy/rocky soils within near-shore areas of a lake (Boston and Adams 1987, Vestergaard and Sand-Jensen 2000).

In contrast, aquatic plant species of the elodeid growth form have leaves on tall, erect stems which grow up into the water column, and are the plants that lake users are likely more familiar with (Photo 8.6.4-2). It is important to note that the definition of these two groups is based solely on morphology and physiology and not on species' relationships. For example, dwarf-water milfoil (*Myriophyllum tenellum*) is classified as an isoetid, while all of the other milfoil species in Wisconsin such as northern water milfoil (*Myriophyllum* sibiricum) are classified as elodeids.

Alkalinity, as it relates to the amount of bicarbonate within the water, is the primary water chemistry factor for determining a lake's aquatic plant community composition in terms of isoetid versus elodeid growth forms (Vestergaard and Sand-Jensen 2000). Most aquatic plant species of the elodeid growth form cannot inhabit lakes with little or no alkalinity because their carbon demand for photosynthesis cannot be met solely from the dissolved carbon dioxide within the water and must be supplemented from dissolved bicarbonate.

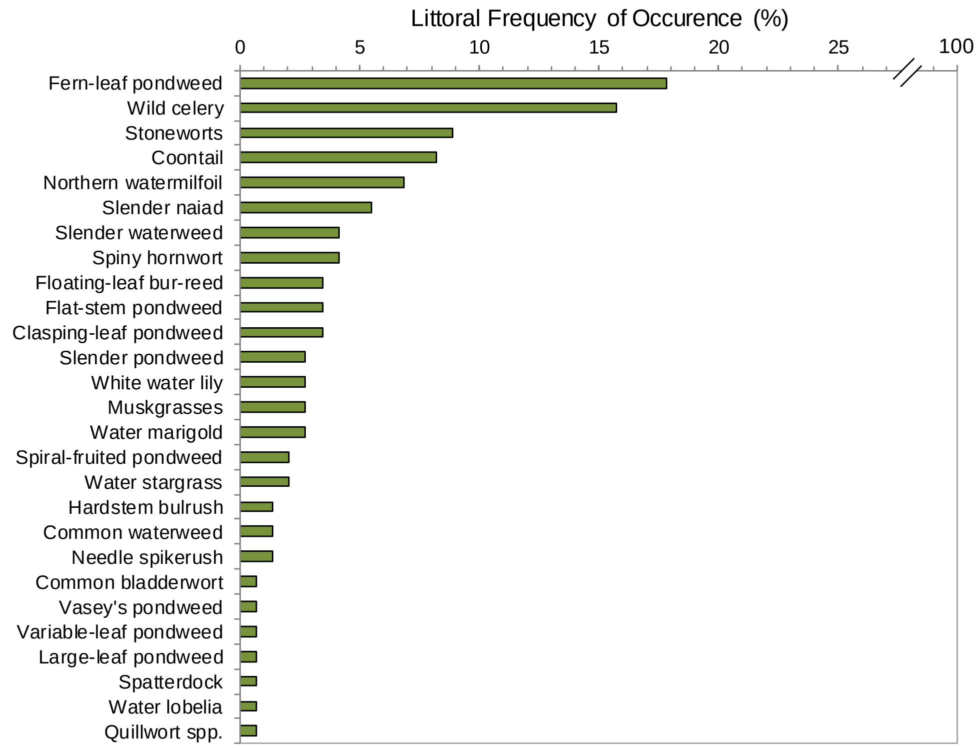


Figure 8.6.4-6. Rock Lake 2017 littoral frequency of occurrence of aquatic plant species. Created using data from 2017 whole-lake point-intercept survey.

Photo 8.6.4-2. Lake quillwort (*Isoetes lacustris*) of the isoetid growth form (left) and variable pondweed (*Potamogeton gramineus*) and fern pondweed (*P. robbinsii*) of the elodeid growth form (right).

On the other hand, aquatic plant species of the isoetid growth form can thrive in lakes with little or no alkalinity because they have the ability to derive carbon dioxide directly from the sediment, and many also have a modified form of photosynthesis to maximize their carbon storage (Madsen et al. 2002). While isoetids are able to grow in lakes with higher alkalinity, their short stature makes them poor competitors for space and light against the taller elodeid species. Thus, isoetids are most prevalent in lakes with little to no alkalinity where they can avoid competition from elodeids. However, in lakes with moderate alkalinity, like Rock Lake, the aquatic plant community can be comprised of isoetids growing beneath a scattered canopy of the larger elodeids. Isoetid communities are vulnerable to sedimentation and eutrophication (Smolders et al. 2002), and a number are listed as special concern (e.g. northeastern bladderwort) or threatened in Wisconsin due to their rarity and susceptibility to environmental degradation.

As discussed in the Town-Wide 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 native species encountered on the rake during 2017 point-intercept survey on Rock Lake and their conservatism values were used to calculate the FQI of Rock Lake's aquatic plant community (equation shown below).

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

Figure 8.6.4-7 compares the 2017 FQI components of Rock Lake to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) ecoregion and lakes throughout Wisconsin. The native species richness, or number of native aquatic plant species located on the rake in 2017 (27) falls above the median value for lakes in the NLFL ecoregion (21) and for lakes throughout Wisconsin (19) (Figure 3.3.4-7). The average conservatism of the 27 native aquatic plant species located in Rock Lake in 2017 was 6.9, exceeding the median average conservatism values for lakes within the NLFL ecoregion (6.7) and lakes throughout Wisconsin (6.3) (Figure 3.3.4-7). This indicates that a higher proportion of Rock Lake's aquatic plant community is comprised of environmentally-sensitive species, or species with higher conservatism values.

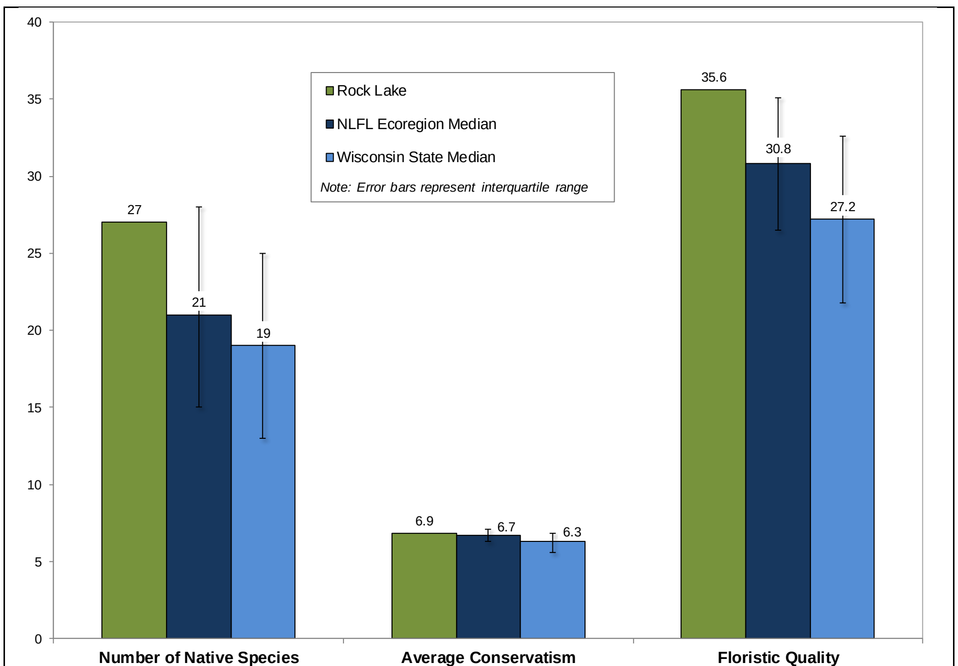


Figure 8.6.4-7. Rock Lake Floristic Quality Assessment. Created using data from Onterra 2017 whole-lake point-intercept survey. Analysis follows Nichols (1999).

Using Rock Lake's native aquatic plant species richness and average conservatism yields a high FQI value of 35.6 (Figure 8.6.4-7). Rock Lake's FQI value exceeds the median values for lakes within the NLFL ecoregion (30.8) and the state (27.2). Overall, the FQI analysis indicates that the aquatic plant community found in Rock Lake is of higher quality than the majority of lakes within the NLFL ecoregion and lakes throughout the state.

As explained in the Town-wide section, 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 Rock Lake contains a high number of native aquatic plant species, one may 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 Rock Lake's diversity value ranks. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 212 lakes within the NLFL ecoregion (Figure 8.6.4-8). Using the data collected from the 2017 point-intercept survey, Rock Lake's aquatic plant was found to have high species diversity with a Simpson's Diversity Index value of 0.92. In other words, if two individual aquatic plants were randomly sampled from Rock Lake in 2017, there would be a 92% probability that they would be different species. Rock Lake's Simpson's Diversity value exceeds the upper quartiles for lakes in the NLFL ecoregion and lakes throughout Wisconsin.

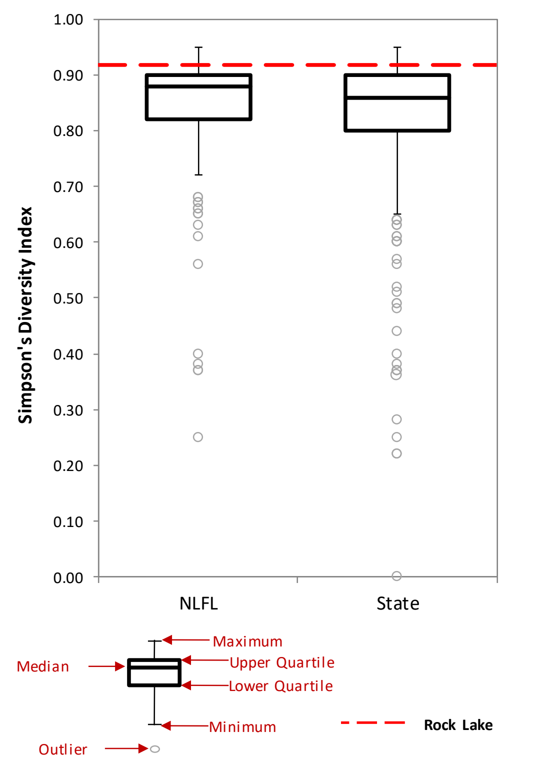


Figure 8.6.4-8. Rock Lake species diversity index. Created using data from Onterra 2016 point-intercept survey.

One way to visualize Rock Lake's high species diversity is to look at the relative occurrence of aquatic plant species. Figure 8.1.4-9 displays the relative frequency of occurrence of aquatic plant species created from the 2017 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 fern-leaf pondweed was found at 18% of the littoral sampling locations in Rock Lake in 2017, its relative frequency of occurrence was 17%. Explained another way, if 100 plants were randomly sampled from Rock Lake in 2017, 17 of them would be fern-leaf pondweed. Rock Lake contains a wide array of habitat types in terms of substrate composition and sheltered versus open water. The variety of habitat types in Rock Lake allows the lake to support a higher number of species and also increases diversity.

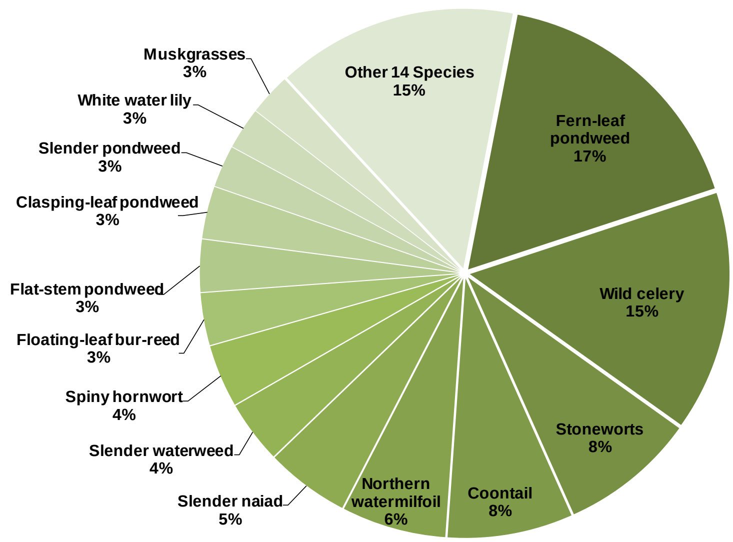


Figure 8.6.4-9. Rock Lake 2017 relative frequency of occurrence of aquatic plant species. Created using data from 2017 point-intercept survey.

In 2017, Onterra ecologists also conducted a survey aimed at mapping emergent and floating-leaf aquatic plant communities in Rock Lake. This survey revealed Rock Lake contains approximately 11 acres of these communities comprised of 16 plant species (Rock Lake – Map 7 and Table 8.6.4-2). These native emergent and floating-leaf plant communities provide valuable fish and wildlife habitat that is important to the ecosystem of the lake. These areas are particularly important during times of fluctuating water levels, since structural habitat of fallen trees and other forms of course-woody habitat can be quite sparse along the shores of receding water lines. The community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, and a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Rock Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development.

Table 8.6.4-2. Rock Lake 2017 acres of emergent and floating-leaf aquatic plant communities. Created using data from 2017 aquatic plant community mapping survey.

Plant Community	Acres
Emergent	3.8
Floating-leaf	4.7
Mixed Emergent & Floating-leaf	2.4
Total	**11.0**

Non-native Aquatic Plants in Rock Lake

Pale-Yellow Iris

Pale yellow iris (*Iris pseudacorus*; Photo 8.6.4-4 and Rock Lake – Map 8) is a large, showy iris with bright yellow flowers. Native to Europe and Asia, this species was sold commercially in the United States for ornamental use and has since escaped into Wisconsin's wetland areas forming large monotypic colonies and displacing valuable native wetland species. Pale-yellow iris was located growing along the shorelines of Rock Lake by NLDC and Onterra staff in 2017 (Rock Lake – Map 7). There are a number of control strategies that can be used to control pale-yellow iris. A strategy for managing pale-yellow iris on Rock Lake is discussed within the Turtle Chain Implementation Plan.

Photo 8.6.4-4. Pale-yellow iris (*Iris pseudacorus*), a non-native, invasive wetland plant found along the shorelines of Rock Lake in 2017. Photo credit Onterra.

8.6.5 Aquatic Invasive Species in Rock Lake

As of 2017, the only non-native species documented in Rock Lake is pale-yellow iris (*Iris pseudacorus;* discussed in previous section). However, the non-native rusty crayfish (*Orconectes rusticus*) has been documented in downstream North Turtle Lake, and it is likely that rusty crayfish are present in Rock Lake. Rusty crayfish were introduced to Wisconsin from the Ohio River Basin in the 1960's likely via anglers' discarded bait. In addition to displacing native crayfish (*O. virilis* and *O. propinquus*), rusty crayfish also degrade the aquatic habitat by reducing aquatic plant abundance and diversity and have also been shown to consume fish eggs. While there is currently no control method for eradicating rusty crayfish from a waterbody, aggressive trapping and removal has been shown to significantly reduce populations and minimize their ecological impact. While it is possible these species are present in Rock Lake, their presence has not been officially verified.

8.6.6 Rock Lake 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 Rock Lake. The goal of this section is to provide an overview of some of the data that exists. Although current fish 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 Biologist Hadley Boehm (WDNR 2017 & GLIFWC 2017).

Rock 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 Rock 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 algae, 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 8.6.6-1.

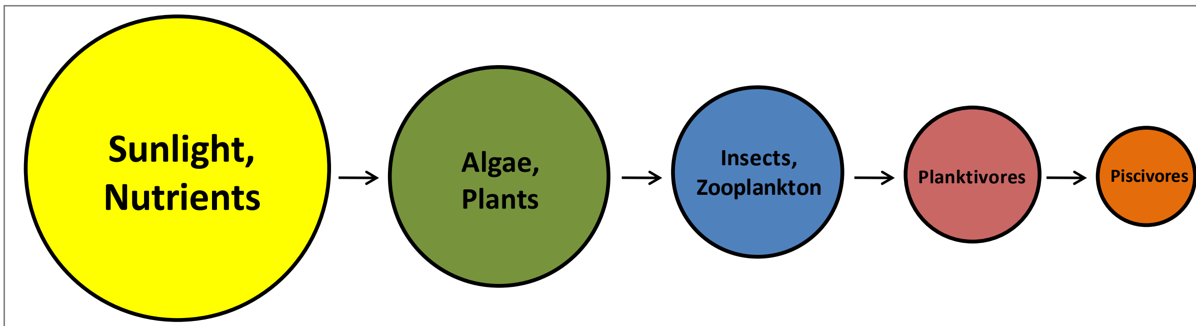


Figure 8.6.6-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section (Section 8.6.1), Rock Lake is a eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means Rock Lake should be able to support sizable populations of predatory fish (piscivores) because the supporting food chain is relatively robust. Table 8.6.6-1 shows the popular game fish present in the system. Although not an exhaustive list of fish species in the lake, additional fish species found in past surveys of Rock Lake include common shiner (*Luxilus cornutus*), golden shiner (*Notemigonus crysoleucas*), greater redhorse (*Moxostoma valenciennesi*), and white sucker (*Catostomus commersonii*).

Table 8.6.6-1. Gamefish present in Rock Lake with corresponding biological information (Becker, 1983).

Common Name (*Scientific Name*)	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie (*Pomoxis nigromaculatus*)	7	May - June	Near Chara or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill (*Lepomis macrochirus*)	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass (*Micropterus salmoides*)	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge (*Esox masquinongy*)	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Pumpkinseed (*Lepomis gibbosus*)	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass (*Ambloplites rupestris*)	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass (*Micropterus dolomieu*)	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch (*Perca flavescens*)	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

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 8.6.6-1). 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 electroshocking (Photograph 8.6.6-1). 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 easy for fisheries technicians to net and place into a livewell to recover. Contrary to what some may believe, electroshocking 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 these data to make recommendations and informed decisions on managing the future of the fishery.


Photograph 8.6.6-1. 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 fry, fingerling, or adult fish in a waterbody that were raised in permitted hatcheries (Photograph 8.6.6-2). Stocking of 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. Rock Lake was stocked from 1972 to 1974 with walleye (Table 8.6.6-2).

Photograph 8.6.6-2. Fingerling Walleye. Photo courtesy of WDNR.

Table 8.6.6-2. Stocking data available for walleye in Rock Lake (1972-1974).

Year	Species	Strain (Stock)	Age Class	# Fish Stocked	Avg Fish Length (in)
1972	Walleye	Unspecified	Fingerling	3,000	3
1974	Walleye	Unspecified	Fingerling	3,000	3

Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the second-most important reason for owning property on or near Rock Lake (Question #17). Figure 8.6.6-2 displays the fish that Rock Lake stakeholders enjoy catching the most, with walleye and crappie being the most popular. Approximately 76% of these same respondents believed that the quality of fishing on the lake was either fair or poor (Figure 8.6.6-3). Approximately 70% of respondents who fish Rock Lake believe the quality of fishing has been somewhat or much worse since they started fishing the lake (Figure 8.6.6-3).

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. Creel surveys were completed on Rock, South Turtle and North Turtle Lakes during the 1991-92 and 2010-11 fishing seasons (Table 8.6.6-5).

Total angler effort was somewhat higher in 1991-92 (20.5 hours/acre) compared to the 2010-11 season (18.1 hours/acre). Anglers directed the largest amount of effort towards walleye and muskellunge during both the 2010-11 and 1991-92 seasons (Table 8.6.6-5).

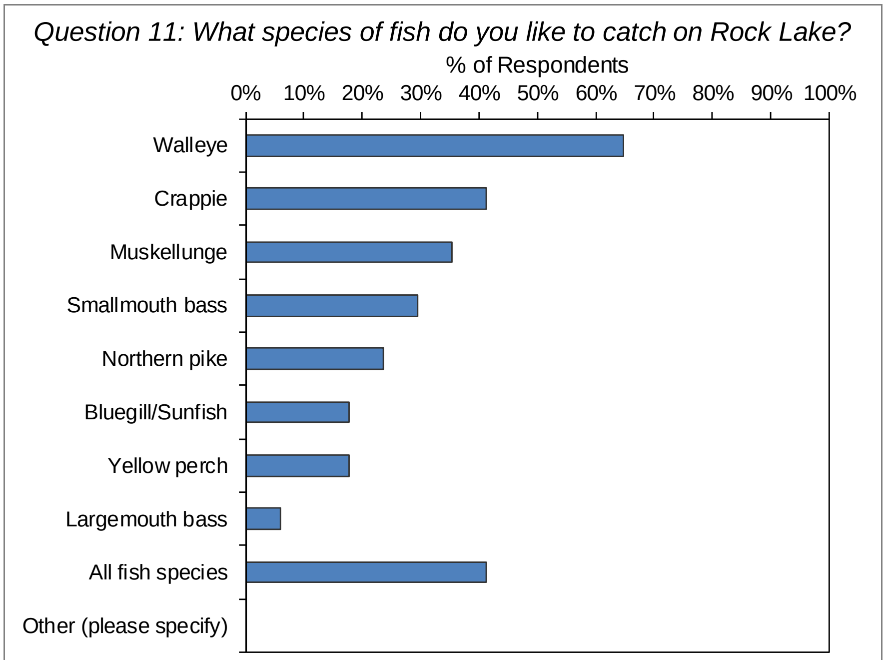


Figure 8.6.6-2. Stakeholder survey response Question 11. Created based on data from 19 respondents of 52 surveys sent (37%).

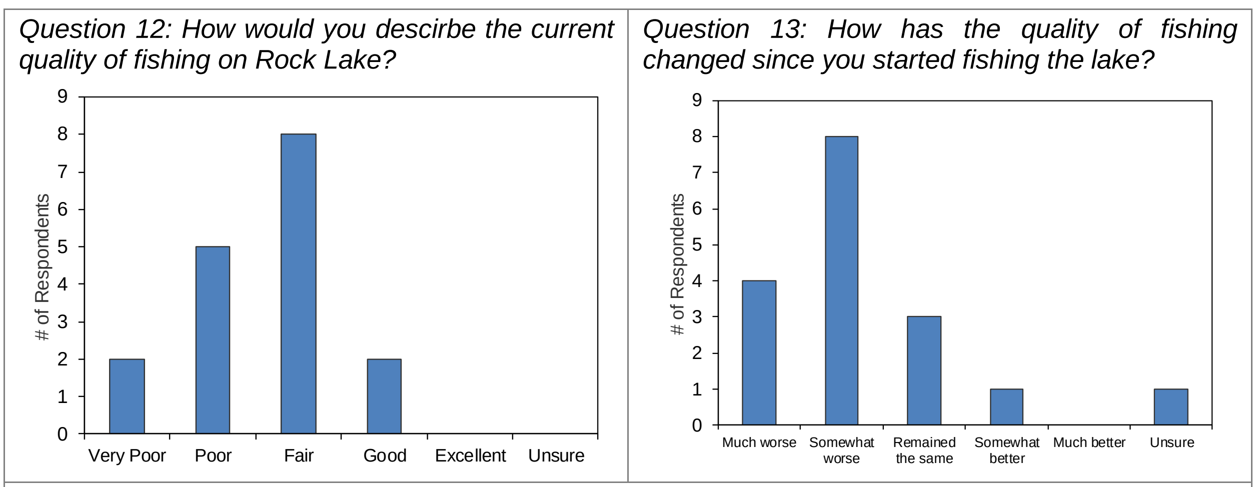


Figure 8.6.6-3. Stakeholder survey responses to questions 12 and 13. Created based on data from 19 respondents of 52 surveys sent (37%).

Table 8.6.6-5. Creel Survey data for 1991-92 and 2010-11 fishing seasons.

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
Largemouth Bass	1991	20.5	0	0	0	0	0		
	2010	18.1	0.9	30	0.1	0	0	11.3	
Muskellunge	1991	20.5	6.7	84	0.2	0	0	45.5	
	2010	18.1	6	95	0.3	0	0	31.7	
Northern Pike	1991	20.5	0.6	62	0.2	11	0	36.2	
	2010	18.1	0.5	51	0.1	5	0	5.6	
Smallmouth Bass	1991	20.5	0.7	179	0.5	33	0.1	5.7	32.2
	2010	18.1	1.9	484	1.3	19	0.1	1.9	67.1
Walleye	1991	20.5	11.3	4457	12.1	117	0.3	0.9	37.5
	2010	18.1	10.2	2501	6.8	1249	3.4	1.5	3

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. These numbers provide a standardized way to compare fish caught in different sampling years depending on gear used (fyke net or electrofishing). Data are analyzed in many ways by fisheries biologists to better understand the fishery and how it should be managed.

Gamefish

The gamefish present in Rock Lake represent different population dynamics depending on the species. The results for the stakeholder survey show landowners prefer to catch walleye on Rock Lake (Figure 8.6.6-2). A 2010 WDNR fisheries survey conducted on Rock Lake showed a low density of walleye (WDNR 2010).

Panfish

Panfish (crappie) are the most sought-after panfish in Rock Lake according the stakeholder survey. The WDNR 2010 fisheries survey found abundant populations of yellow perch with moderate numbers of black crappie and bluegill (WDNR 2010).

Rock 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 8.6.6-4). Rock 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.

While within the ceded territory, Rock Lake has not experienced a spearfishing harvest. A small quota for walleye harvest has been listed for the Rock Lake in recent years; however, no spearing efforts have been undertaken.

Figure 8.6.6-4. Location of Town of Winchester within the Native American Ceded Territory (GLIFWC 2017). This map was digitized by Onterra; therefore, it is a representation and not legally binding.

Rock 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, evade 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 have substrates largely comprised of sand and rock 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 do 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 over soft sediments as well. According to the point-intercept survey conducted by Onterra in 2017, 78% of the substrate sampled in the littoral zone of Rock Lake were soft sediments, 16% was composed of rock, and 6% were composed of sand sediments.

Woody Habitat

As discussed in the Shoreland Condition section (Section 8.6.3), the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines over the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass 2006). A fall 2017 survey completed on Rock Lake documented 198 pieces of coarse woody along the shores of Rock Lake, resulting in a ratio of approximately 51 pieces per mile of shoreline. When compared to the other 98 lakes Onterra has completed coarse woody habitat surveys on since 2012, Rock Lake falls in the 88th percentile for the number of course woody habitat pieces per shoreline mile.

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. 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 8.6.6-3). 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 other partner contributions.


Photograph 8.6.6-3. Examples of fish sticks (left) and half-log habitat structures (right). (Photos by WDNR).

Fish cribs are a fish habitat structure that are placed on the lakebed. Installing fish cribs may 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. Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 8.6.6-3). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills 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 are spawning reefs. Spawning reefs typically consist of small rubble in a shallow area near the shoreline and are mainly installed to enhance 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 indicated the addition of rock substrate did not significantly improve walleye reproduction (WDNR 2004).

Placement of a fish habitat structures in a lake does not require 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. The Town of Winchester should 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 Rock Lake.

Regulations

Regulations for Rock Lake gamefish species as of April 2018 are displayed in Table 8.6.6-4. 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 8.6.6-4. WDNR fishing regulations for Rock Lake (As of April 2018).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	25	None	Open All Year
Smallmouth bass (Early Season)	Catch and release only	None	May 5, 2018 to June 15, 2018
Smallmouth bass	5	14"	June 16, 2018 to March 3, 2019
Largemouth bass	5	14"	May 5, 2018 to March 3, 2019
Muskellunge and hybrids	1	40"	May 26, 2018 to November 30, 2018
Northern pike	5	None	May 5, 2018 to March 3, 2019
Walleye, sauger, and hybrids	3	None but only 1 fish over 14" is allowed.	May 5, 2018 to March 3, 2019
Bullheads	Unlimited	None	Open All Year

General Waterbody Restrictions: Motor Trolling is allowed with 1 hook, bait, or lure per angler, and 3 hooks, baits, or lures maximum per boat.

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.

As discussed in the Rock Lake Water Quality section (Section 8.6.1), Rock Lake was placed on the 303(d) list of impaired waterbodies for contaminated fish tissue by mercury in 1998. General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 8.6.6-5. 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 8.6.6-5. 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/)

8.7 North Turtle Lake

An Introduction to North Turtle Lake

North Turtle Lake, Vilas County, is a 368-acre deep lowland (two-story), brown-water, mesotrophic drainage lake with a maximum depth of 51 feet and a mean depth of 21 feet (North Turtle Lake – Map 1). Its surficial watershed encompasses approximately 12,901 acres across portions of Vilas County, WI and Gogebic County, MI. Primary tributaries flowing into North Turtle Lake include Rock Creek from the north and Rainbow Creek from the northeast. North Turtle Lake drains into the northern portion of South Turtle Lake and the Turtle River. In 2017, 35 native aquatic plant species were located within the lake, of which wild celery (*Vallisneria americana*) was the most common. The non-native, invasive wetland plant pale-yellow iris (*Iris pseudacorus*) was located in a few locations along North Turtle Lake's shoreline in 2017. To date, rusty crayfish (*Orconectes rusticus*) have been the only other non-native species documented in North Turtle Lake.

Lake at a Glance - North Turtle Lake

Morphometry	
LakeType	Deep Lowland Drainage (Two-Story)
Surface Area (Acres)	368
Max Depth (feet)	51
Mean Depth (feet)	21
Perimeter (Miles)	5.6
Shoreline Complexity	4.4
Watershed Area (Acres)	12,901
Watershed to Lake Area Ratio	34:1
Water Quality	
Trophic State	Mesotrophic
Limiting Nutrient	Phosphorus
Avg Summer P (µg/L)	16
Avg Summer Chl-α (µg/L)	5
Avg Summer Secchi Depth (ft)	8.4
Summer pH	7.6
Alkalinity (mg/L as $CaCO_3$)	30
Vegetation	
Number of Native Species	35
NHI-Listed Species	Vasey's pondweed (*Potamogeton vaseyi*)
Exotic Species	Pale-yellow Iris (*Iris pseudacorus*)
Average Conservatism	6.8
Floristic Quality	27.0
Simpson's Diversity (1-D)	0.86

Descriptions of these parameters can be found within the town-wide portion of the management plan

8.7.1 North Turtle Lake Water Quality

It is often difficult to determine the status of a lake's water quality purely through observation. Anecdotal accounts of a lake "getting better" or "getting worse" can be difficult to judge because a) a lake's water quality may fluctuate from year to year based upon environmental conditions such as precipitation, and b) differences in observation and perception of water quality can differ greatly from person to person. It is best to analyze the water quality of a lake through scientific data as this gives a concrete indication as to the health of the lake, and whether its health has

deteriorated or improved. Further, by looking at data for similar lakes regionally and statewide, the status of a lake's water quality can be made by comparison.

In 2017, a stakeholder survey was sent to 116 North Turtle Lake riparian property owners. Forty-five (39%) of these 116 surveys were completed and returned. Given the relatively low response rate, the results of the stakeholder survey cannot be interpreted as being statistically representative of the population sampled. At best, the results may indicate possible trends and opinions about the stakeholder perceptions of North Turtle Lake but cannot be stated with statistical confidence. The full survey and results can be found in Appendix B.

When asked about North Turtle Lake's current water quality, 82% of survey respondents indicated the water quality is *good* or *excellent*, 16% indicated the water quality is *fair*, and 2% indicated the water quality is *poor* (Figure 8.7.1-1). When asked how water quality has changed in North Turtle Lake since they first visited the lake, 80% of respondents indicated water quality has *remained the same*, 2% indicated it has *somewhat improved*, 9% indicated the water quality has *somewhat degraded*, 2% indicated it has *severely degraded*, and 7% were unsure (Figure 8.7.1-1).

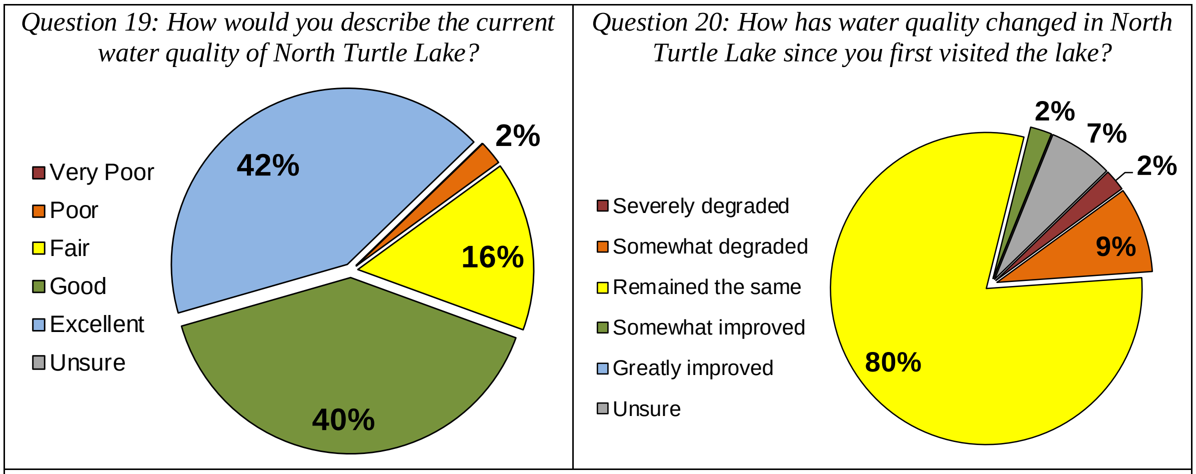


Figure 8.7.1-1. North Turtle Lake stakeholder survey responses regarding the lake's current and historical water quality. Created using responses from 45 (39%) respondents of 116 surveys distributed.

As is discussed in the Town-Wide Report, two-story lakes like North Turtle Lake are deep lakes which thermally stratify during the summer and have the potential to support a cold, oxygenated hypolimnion (bottom waters) and coldwater fish populations (e.g. cisco, lake trout). Maintaining sufficient oxygen within the deep, cold waters of the hypolimnion in summer is essential if coldwater fish populations are to survive. Higher levels of nutrients and therefore biological production/decomposition can result in an increased rate of oxygen demand and a loss of oxygen from bottom waters in summer. Because of this, two-story lakes have the most stringent phosphorus thresholds of Wisconsin's lakes to ensure that this coldwater habitat is preserved.

Near-surface total phosphorus data for North Turtle Lake are available from 1985, 1993-2009, and 2012-2017 (Figure 8.7.1-2). Average summer total phosphorus concentrations have been somewhat variable from year to year, but overall have been relatively stable over the time period for which data are available. The weighted average summer total phosphorus concentration is 16 µg/L, falling into the *good* category for Wisconsin's two-story lakes. The average summer phosphorus concentration in 2017 was slightly above average at 18 µg/L, likely due to increased runoff from above-average precipitation. Precipitation data obtained from nearby Manitowish Waters indicates precipitation in 2017 was four inches above average. North Turtle Lake's phosphorus concentrations are lower than the median concentration for deep lowland drainage lakes in Wisconsin (23 µg/L) and lower than the median for all lake types within the Northern Lakes and Forests (NLF) ecoregion (21 µg/L). Trends analysis indicates there are no statistically valid trends (positive or negative) in total phosphorus concentrations over time in North Turtle Lake.

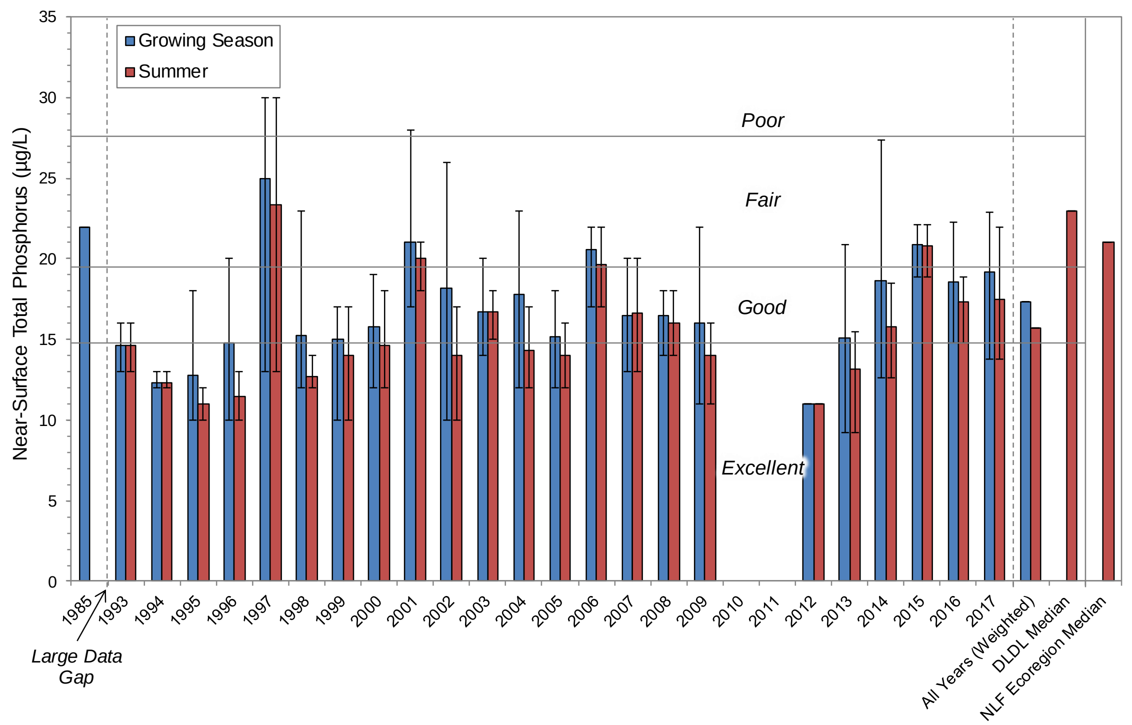


Figure 8.7.1-2. North Turtle Lake average annual near-surface total phosphorus concentrations, thresholds for two-story lakes, and median near-surface total phosphorus concentrations for deep lowland drainage lakes (DLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Chlorophyll-*a* concentrations, a measure of phytoplankton abundance, are available from North Turtle Lake from 1984, 1993-2009, and 2012-2017 (Figure 8.7.1-3). Like total phosphorus concentrations, average summer chlorophyll-*a* concentrations are somewhat variable from year to year, ranging from 1.5 µg/L in 1995 to 10.7 µg/L in 2014. The weighted average summer chlorophyll-*a* concentration is 5.4 µg/L, straddling the line between *good* and *fair* for two-story lakes in Wisconsin. Summer chlorophyll-*a* concentrations in 2017 were slightly below average at 5.1 µg/L. North Turtle Lake's average summer chlorophyll-*a* concentration is lower than the median concentration for Wisconsin's deep lowland drainage lakes (7.0 µg/L) and lower than the median concentration for all lake types within the NLF ecoregion (5.6 µg/L). Like total phosphorus, trends analysis indicates no statistically valid trends (positive or negative) in chlorophyll-*a* concentrations are occurring over time in North Turtle Lake.

Secchi disk transparency data from North Turtle Lake are available from 1984-1985, 1991-2015, and 2017 (Figure 8.7.1-4). These data indicate water clarity has remained relatively stable over this time period. The weighted summer average Secchi disk depth is 8.4 feet, falling into the *good* category for two-story lakes in Wisconsin. North Turtle Lake's average summer Secchi disk depth is slightly below the median depth for Wisconsin's deep lowland drainage lakes (8.5 feet) and the median depth for all lake types within the NLF ecoregion (8.9 feet). Average summer Secchi disk depth in 2017 was 6.3 feet, over two feet below average. Given chlorophyll-*a* concentrations were below average in 2017, this indicates a factor other than increased algal production resulted in lower water clarity in 2017. As is discussed further, the lower water clarity was likely a result of higher concentrations of dissolved organic compounds entering the lake due to increased precipitation in 2017. Trends analysis of North Turtle Lake's Secchi disk data indicates no statistically valid trends (positive or negative) in water clarity are occurring over time.

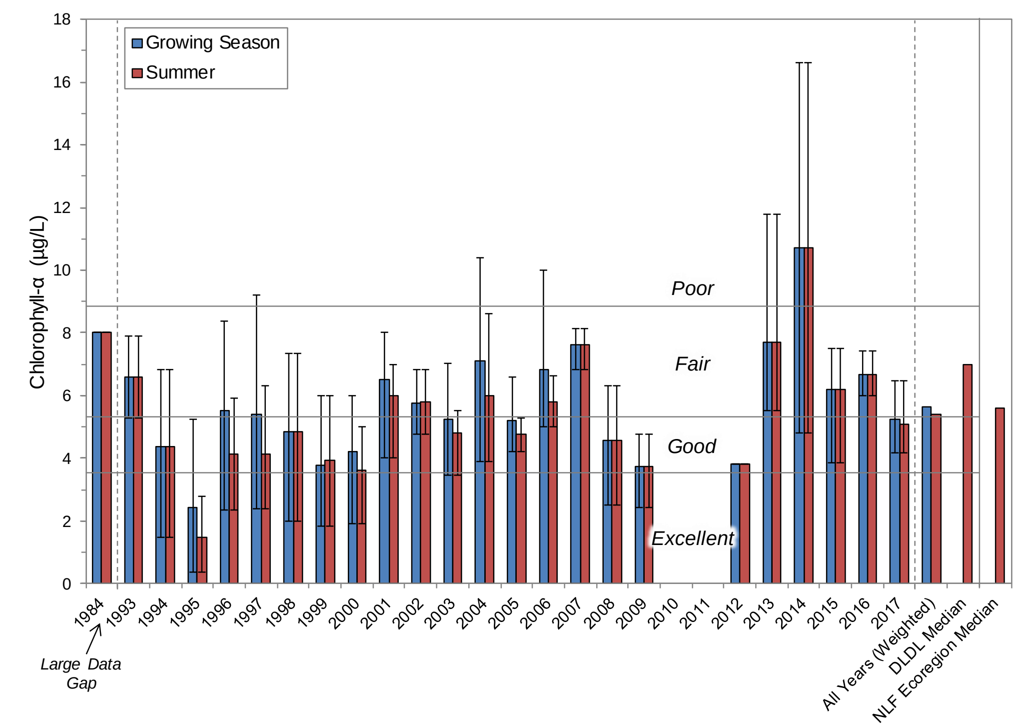


Figure 8.7.1-3. North Turtle Lake average annual chlorophyll-α concentrations, thresholds for two-story lakes, and median chlorophyll-α concentrations for state-wide deep lowland drainage lakes (DLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Abiotic suspended particulates, such as sediment, can also cause a reduction in water clarity. However, *total suspended solids*, a measure of both biotic and abiotic suspended particles within the water, were low in North Turtle Lake in 2017 indicating minimal amounts of suspended material within the water. While suspended particles are minimal in North Turtle Lake, water clarity can also be influenced by dissolved compounds within the water. Many lakes in the northern region of Wisconsin contain higher concentrations of natural dissolved organic acids that originate from decomposing plant material within wetlands in the lake's watershed. In higher concentrations, these dissolved organic compounds give the water a tea-like color or staining and decrease water clarity.

A measure of water clarity once all of the suspended material (i.e. phytoplankton and sediments) have been removed, is termed *true color*, and measures how the clarity of the water is influenced by dissolved components. True color values measured from North Turtle Lake in 2017 averaged 40 SU (standard units), indicating the lake's water is *lightly tea-colored* to *tea-colored*. Higher precipitation in 2017 likely resulted in a higher concentration of these dissolved organic acids in the lake, reducing water clarity below average. It is important to note that the tea-colored water in North Turtle Lake is natural, and is not an indication of degraded conditions.

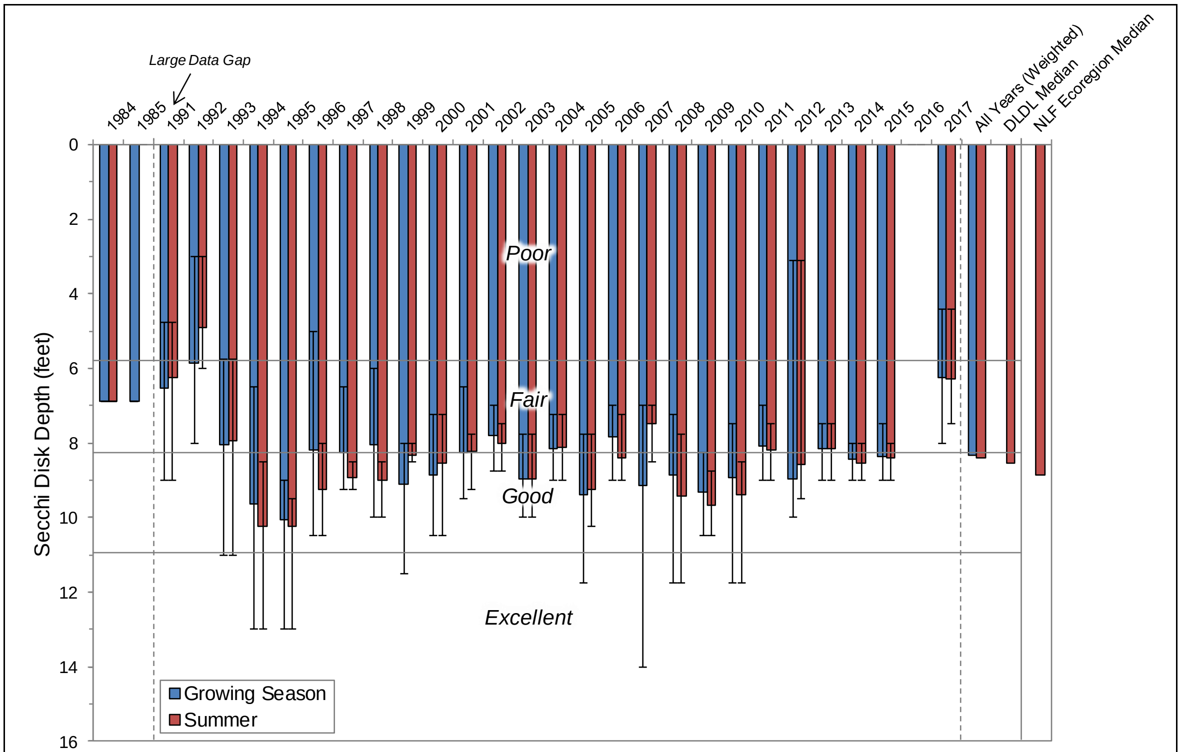


Figure 8.7.1-4. North Turtle Lake average annual Secchi disk depths, thresholds for two-story lakes, and median Secchi disk depths for state-wide deep lowland drainage lakes (DLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

To determine if internal nutrient loading (discussed in town-wide section of management plan) is a significant source of phosphorus in North Turtle Lake, near-bottom phosphorus concentrations are compared against those collected from the near-surface. Near-bottom total phosphorus concentrations were measured on three occasions from North Turtle Lake in 2017 and once in 2018 (Figure 8.7.1-5). Near-surface and near-bottom total phosphorus concentrations are also available from 1993, 1994, 1995, and 1996. These data indicate that near-bottom concentrations were higher when compared to surface concentrations during summer stratification. However, these bottom concentrations are relatively low and indicate the internal loading of phosphorus is not a significant source of phosphorus to North Turtle Lake.

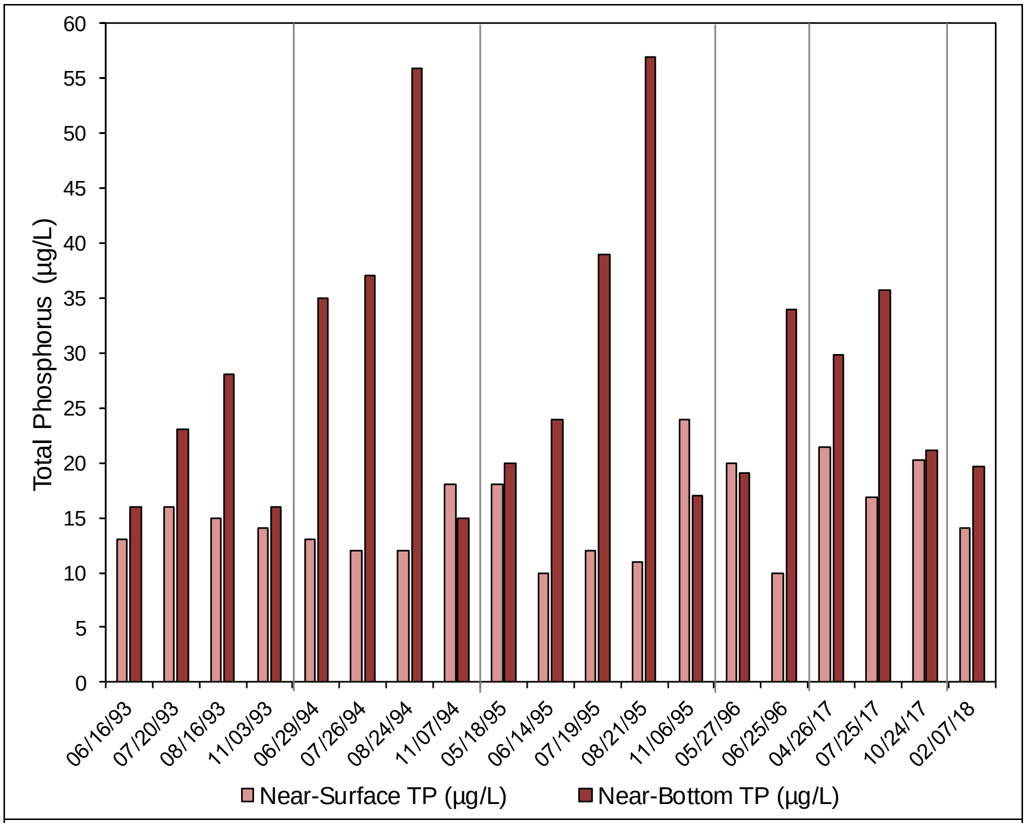


Figure 8.7.1-5. North Turtle Lake near-bottom total phosphorus concentrations and corresponding near-surface total phosphorus concentrations measured in 2017 and 2018.

North Turtle Lake Trophic State

Figure 8.7.1-6 contains the Trophic State Index (TSI) values for North Turtle Lake calculated from the data collected in 2017 along with historical data. These TSI values are calculated using summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency data. In general, the best values to use in assessing a lake's trophic state are chlorophyll-*a* and total phosphorus, as water clarity can be influenced by other factors other than phytoplankton such as dissolved organic compounds. The closer the calculated TSI values for these three parameters are to one another indicates a higher degree of correlation. The weighted TSI values for total phosphorus and chlorophyll-*a* (and Secchi disk depth) in North Turtle Lake indicate the lake is at present in a mesotrophic state. North Turtle Lake's productivity is lower when compared to other deep lowland drainage lakes in Wisconsin and to other lakes within the NFL ecoregion.

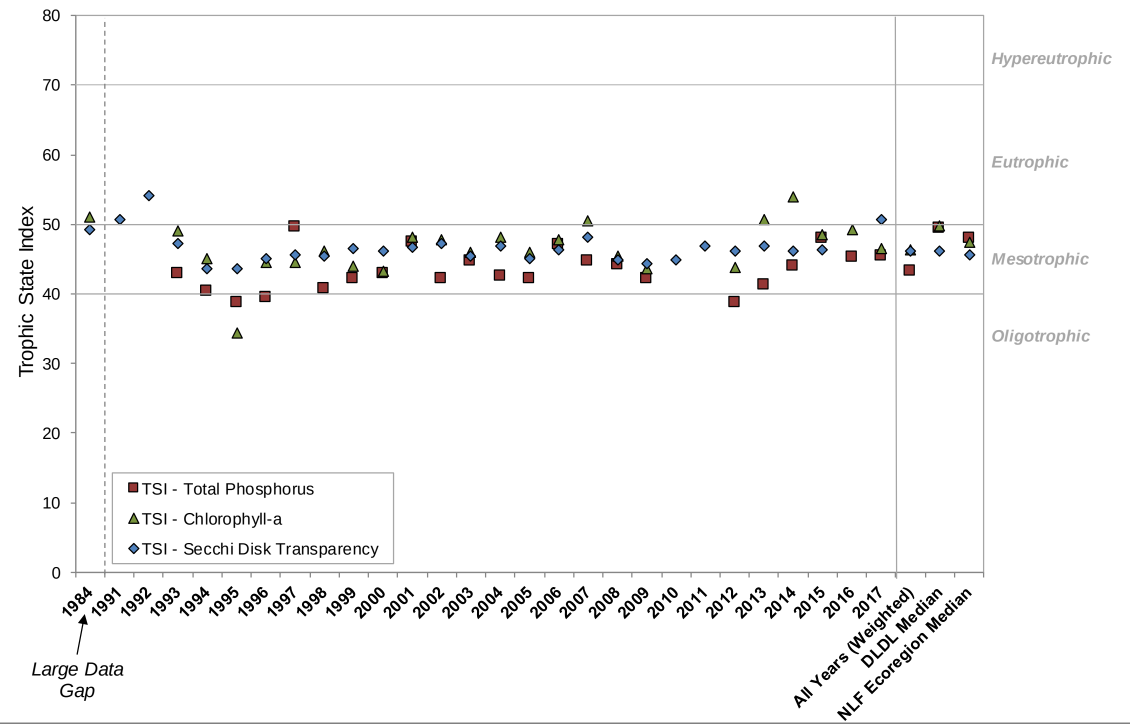


Figure 8.7.1-6. North Turtle Lake, statewide deep lowland drainage lakes (DLDL), and Northern Lakes and Forests (NLF) ecoregion lakes Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in North Turtle Lake

Dissolved oxygen and temperature profile data were collected during each water quality sampling events conducted by Onterra ecologists and North Turtle Lake CLMN volunteers. These data are displayed in Figure 8.7.1-7. The temperature and dissolved oxygen data collected in 2017 indicate that North Turtle Lake developed and maintained thermal stratification over the summer, and the hypolimnion remained largely oxygenated over this period (two-story lake). Water of 30 feet and deeper began experiencing anoxic conditions in September but became oxygenated again with fall mixing. Dissolved oxygen concentrations measured through the ice in February of 2018 indicate there was sufficient oxygen (6.3 – 11.5 mg/L) throughout the entire water column to support aquatic life. Being a deeper lake, winter fish kills due to low oxygen are not a concern on North Turtle Lake.

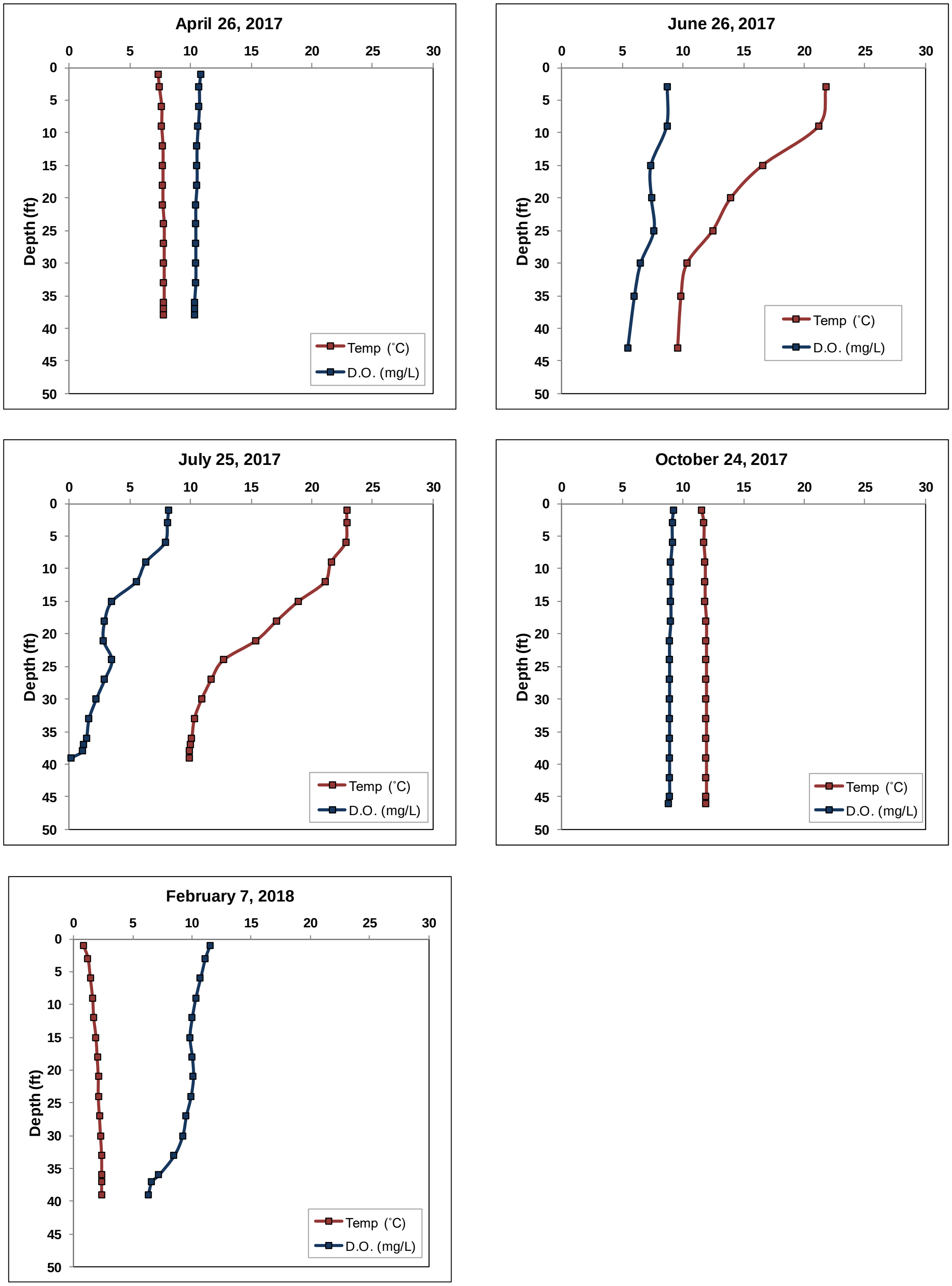


Figure 8.7.1-7. North Turtle Lake 2017/18 dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected from North Turtle Lake

The previous section is centered on parameters relating to North Turtle Lake's trophic state. 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 North Turtle 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.

As the Town-wide Section explains, the pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is thus an index of the lake's acidity. North Turtle Lake's mid-summer surface water pH was measured at 7.6 in 2017. This value indicates North Turtle Lake's water is alkaline and falls within the normal range for Wisconsin lakes. Fluctuations in pH with respect to seasonality are common; in-lake processes such as photosynthesis by plants act to reduce acidity by carbon dioxide removal while decomposition of organic matter adds carbon dioxide to water, thereby increasing acidity. A lake's pH is primarily determined by the water's alkalinity, or a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. North Turtle Lake's average alkalinity measured in 2017 was 30.1 mg/L as $CaCO_3$. This value falls within the expected range for northern Wisconsin lakes, and indicates that while North Turtle Lake is considered a softwater lake, it is not sensitive to fluctuations in pH from acid rain.

Water quality samples collected from North Turtle Lake in 2017 were also analyzed for calcium. Calcium concentrations, along with pH, are currently being used to determine if a waterbody is suitable to support the invasive zebra mussel, as these animals require calcium for the construction of their shells. Zebra mussels typically require higher calcium concentrations than Wisconsin's native mussels, and lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The accepted suitable pH range for zebra mussels is 7.0 – 9.0, and North Turtle Lake's pH falls within this range. North Turtle Lake's calcium concentration in 2017 was 10.1 mg/L, indicating the lake has *very low susceptibility* to zebra mussel establishment. Plankton tows were completed by Onterra ecologists at three locations in North Turtle Lake in 2017 that underwent analysis for the presence of zebra mussel veligers, their planktonic larval stage. Analysis of these samples were negative for zebra mussel veligers, and Onterra ecologists did not observe any adult zebra mussels during the 2017 surveys.

North Turtle Lake was placed on the 303(d) list of impaired waterbodies for contaminated fish tissue by mercury in 1998. While mercury is found naturally in the environment due to volcanic eruptions and weathering of rocks, the majority of the mercury found in Wisconsin's waterbodies is the result of coal-fired power plants and the release of mercury into the atmosphere. Mercury is deposited into lakes, rivers, and streams through precipitation and the deposition of dust particles where it converted into its mobile and harmful form, methylmercury. Methylmercury becomes stored in bodies of aquatic animals, and concentrations tend to be highest in those species at the top of the food chain. In humans, mercury affects the nervous system and is of special concern for unborn children, infants, and children. For advice on eating fish from North Turtle Lake, please see the North Turtle Lake Fisheries Data Integration Section (Section 8.7.6).

8.7.2 North Turtle Lake Watershed Assessment

North Turtle Lake's surficial watershed encompasses approximately 12,901 acres (Figure 8.7.2-1 and North Turtle Lake – Map 2) yielding a watershed to lake area ratio of 34:1. North Turtle Lake's direct watershed is comprised of land cover types including forests (38%), wetlands (39%), pasture/grass and rural open space (8%), and rural residential areas (<1%) (Figure 8.7.2-2). Wisconsin Lakes Modeling Suite (WiLMS) modeling indicates that North Turtle Lake's residence time is approximately 0.63 years, or the water within the lake is completely replaced approximately 1.6 times per year.

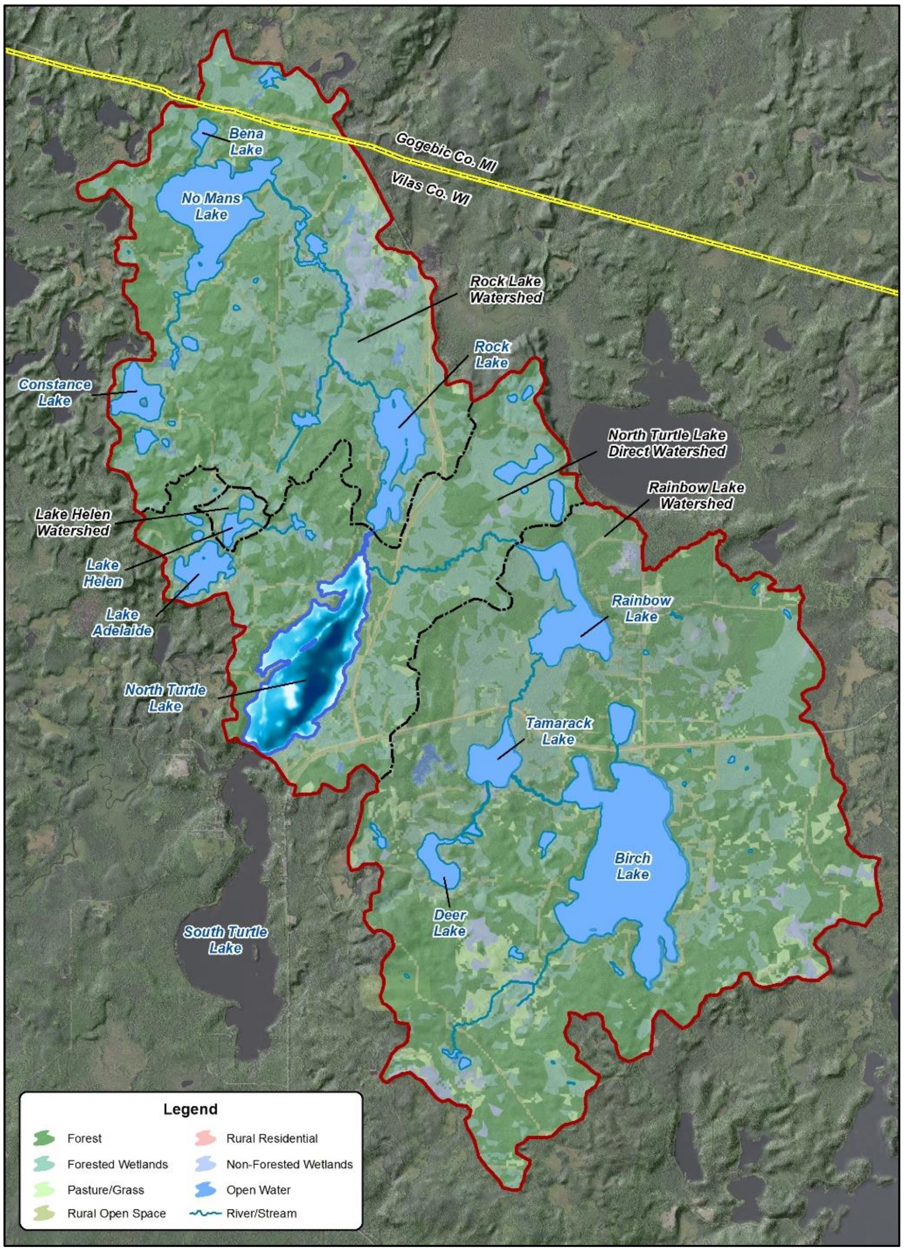


Figure 8.7.2-1. North Turtle Lake watershed boundary (red line) and land cover types. Black dashed lines indicate subwatersheds used in WiLMS modeling. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

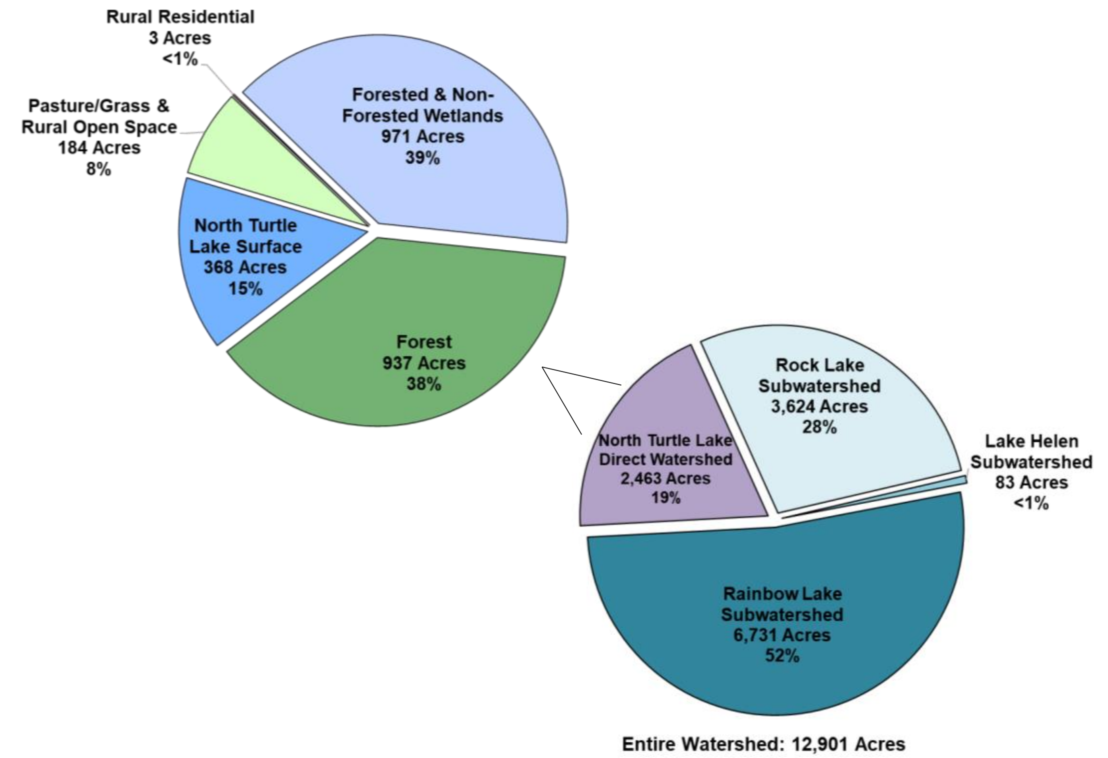


Figure 8.7.2-2. North Turtle Lake proportion of land cover types within its direct watershed and subwatersheds used in WiLMS modeling.

Using the land cover types within North Turtle Lake's direct watershed and available phosphorus data from upstream Rainbow Lake, Rock Lake, and Lake Helen, WiLMS was utilized to estimate the annual potential phosphorus load delivered to North Turtle Lake from its watershed. In addition, data obtained from a stakeholder survey sent to North Turtle Lake riparian property owners in 2017 was also used to estimate the amount of phosphorus loading to the lake from riparian septic systems. The model estimated that approximately 1,011 pounds of phosphorus are delivered to North Turtle Lake from its watershed on an annual basis (Figure 8.7.2-3).

Of the estimated 1,011 pounds of phosphorus being delivered to North Turtle Lake on an annual basis, approximately 691 pounds (68%) originates from the Rainbow Lake, Rock Lake, and Lake Helen subwatersheds, while the remaining 320 pounds (32%) originates from the lake's direct watershed (Figure 8.7.2-3). Watershed modeling indicates that Rainbow and Rock lakes retain approximately 30% of the phosphorus they receive, acting as nutrient sinks and exporting higher-quality water downstream to North Turtle Lake. Studies have shown that upstream lakes often retain phosphorus and reduce phosphorus concentrations in downstream lakes (Zhang et al. 2012).

Within North Turtle Lake's direct watershed, atmospheric deposition onto the lake's surface accounts for 99 pounds or 10% of the annual load, wetlands account for 86 pounds (9%), forests account for 75 pounds (7%), pasture/grass and rural open space account for 49 pounds (5%), and riparian septic systems account for 10 pounds (1%) (Figure 8.7.2-3). Using the estimated annual potential phosphorus load, WiLMS predicted an in-lake growing season average total phosphorus concentration of 19 µg/L, which is similar to the measured growing season average of 17 µg/L. The similarity between predicted and measured phosphorus concentrations indicates that the lake's watershed was modeled accurately and that there are no significant sources of unaccounted phosphorus being loaded to North Turtle Lake.

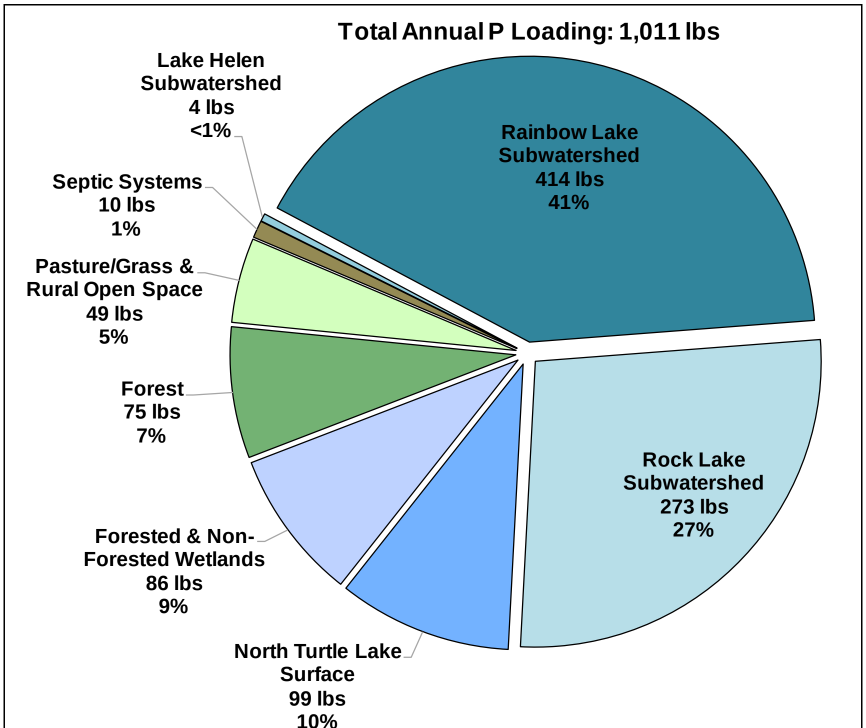


Figure 8.7.2-3. North Turtle Lake estimated potential annual phosphorus loading. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

8.7.3 North Turtle Lake Shoreland Condition

Shoreland Development

As is discussed within the Town-wide Section, one of the most sensitive areas of a lake's watershed is the immediate shoreland zone. This transition zone between the aquatic and terrestrial environment is the last source of protection for the lake against pollutants originating from roads, driveways, and yards above, and is also a critical area for wildlife habitat and overall lake ecology. In the fall of 2017, the immediate shoreland of North Turtle Lake was assessed in terms of its development, and the shoreland zone was characterized with one of five shoreland development categories ranging from urbanized to completely undeveloped.

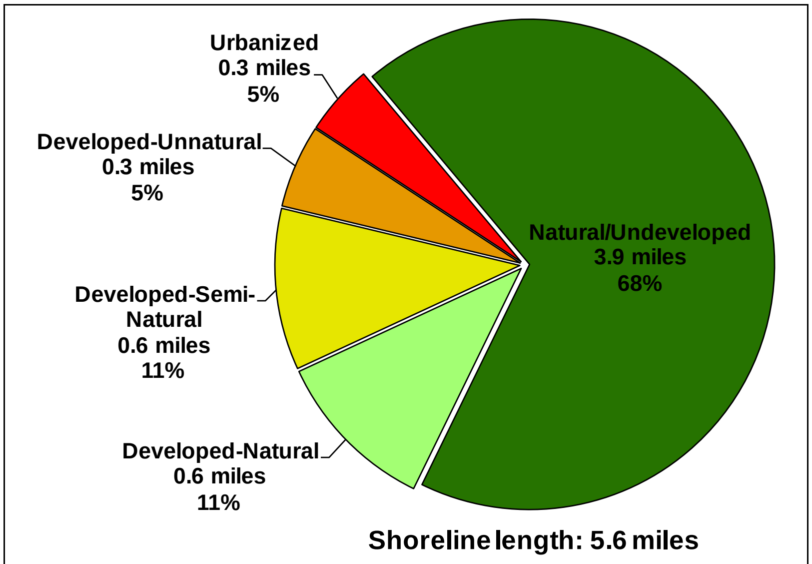


Figure 8.7.3-1. North Turtle Lake shoreland categories and total lengths. Based upon a fall 2017 survey. Locations of these categorized shorelands can be found on North Turtle Lake - Map 3.

The 2017 survey revealed that North Turtle Lake has stretches of shoreland that fit all five shoreland assessment categories (Figure 8.7.3-1). In total, 4.5 miles (79%) of the 5.6-mile shoreland zone were categorized as natural/undeveloped or developed-natural or shoreland types that provide the most benefit to the lake and should be left in their natural state if possible. Approximately 0.6 miles (10%) of the shoreland was categorized as developed-unnatural or urbanized, shoreland areas which provide little benefit to and may actually adversely impact the lake. If restoration of North Turtle Lake's shoreland is to occur, primary focus should be placed on these highly developed shoreland areas. North Turtle Lake – Map 3 displays the locations of these shoreland categories around the entire lake.

Coarse Woody Habitat

A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey on North Turtle Lake in 2017. Coarse woody habitat was identified, and classified in several size categories (2-8 inches diameter, >8 inches diameter and cluster) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed in the Town-wide Section, 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 et al. 2005).

During the coarse woody habitat survey on North Turtle Lake, a total of 175 pieces were observed along 5.6 miles of shoreline, yielding a coarse woody habitat to shoreline mile ratio of 31:1 (Figure 8.7.3-2). Onterra ecologists have completed these surveys on 98 Wisconsin lakes since 2012, and North Turtle Lake falls in the 58th percentile for the number of coarse woody habitat pieces per shoreline mile. Refraining from removing these woody habitats from the shoreland area will ensure this high-quality habitat remains in North Turtle Lake. The locations of these coarse woody habitat pieces are displayed on North Turtle Lake – Map 4.

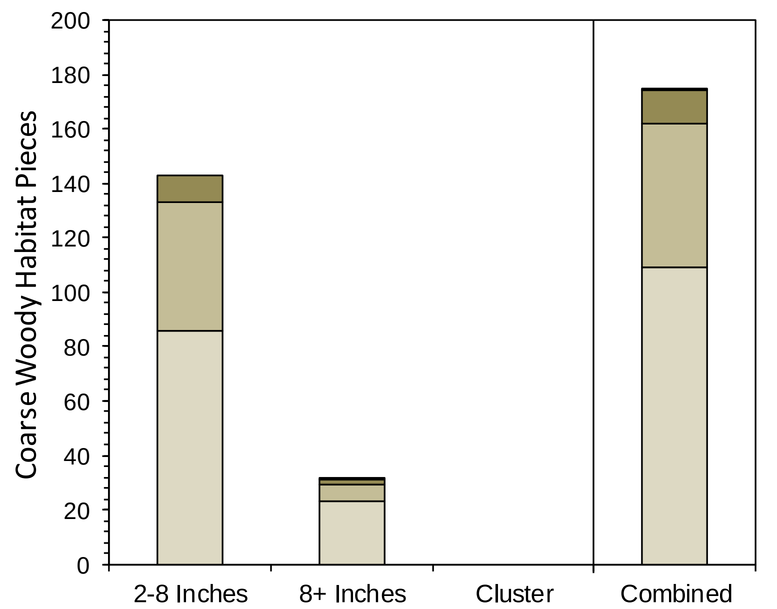


Figure 8.7.3-2. North Turtle Lake coarse woody habitat survey results. Based upon a fall 2017 survey. Locations of North Turtle Lake coarse woody habitat can be found on North Turtle Lake – Map 4.

8.7.4 North Turtle Lake Aquatic Vegetation

An Early-Season Aquatic Invasive Species (ESAIS) Survey was conducted by Onterra ecologists on North Turtle Lake on June 30, 2017. While the intent of this survey is to locate any potential non-native species within the lake, the primary focus is to locate occurrences of the non-native curly-leaf pondweed which should be at or near its peak growth at this time. Fortunately, no curly-leaf pondweed was located in North Turtle Lake in 2017, and it is believed that curly-leaf pondweed is not present within the lake or exists at an undetectable level. However, pale-yellow iris, a non-native wetland plant, was located in a few locations along North Turtle Lake's shoreline in 2017. Because of its ecological significance, pale-yellow iris in North Turtle Lake is discussed further in the subsequent Non-Native Aquatic Plants subsection.

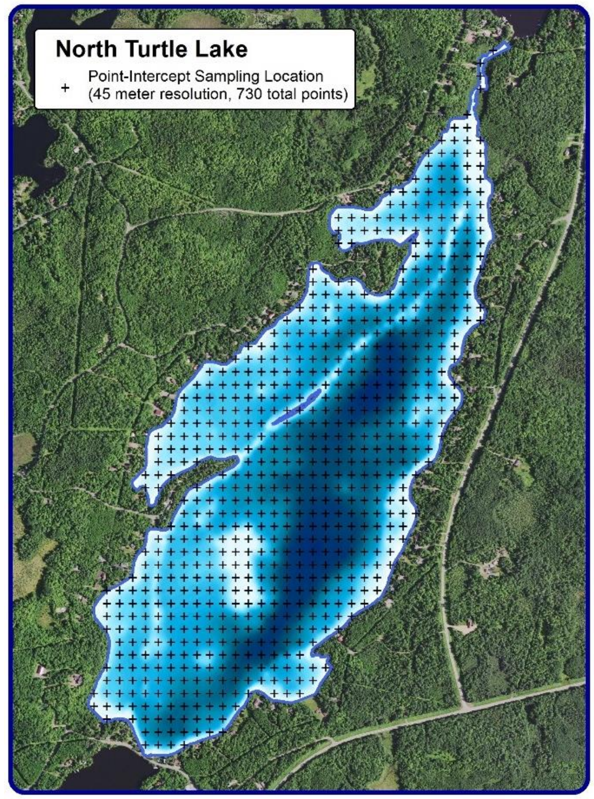


Figure 8.7.4-1. North Turtle Lake whole-lake point-intercept survey sampling locations.

The whole-lake aquatic plant point-intercept survey and emergent and floating-leaf aquatic plant community mapping survey were conducted on North Turtle Lake by Onterra ecologists on July 18, 2017 (Figure 8.7.4-1). During these surveys, a total of 36 aquatic plant species were located, one of which is considered to be a non-native, invasive species: pale-yellow iris (Table 8.7.4-1).

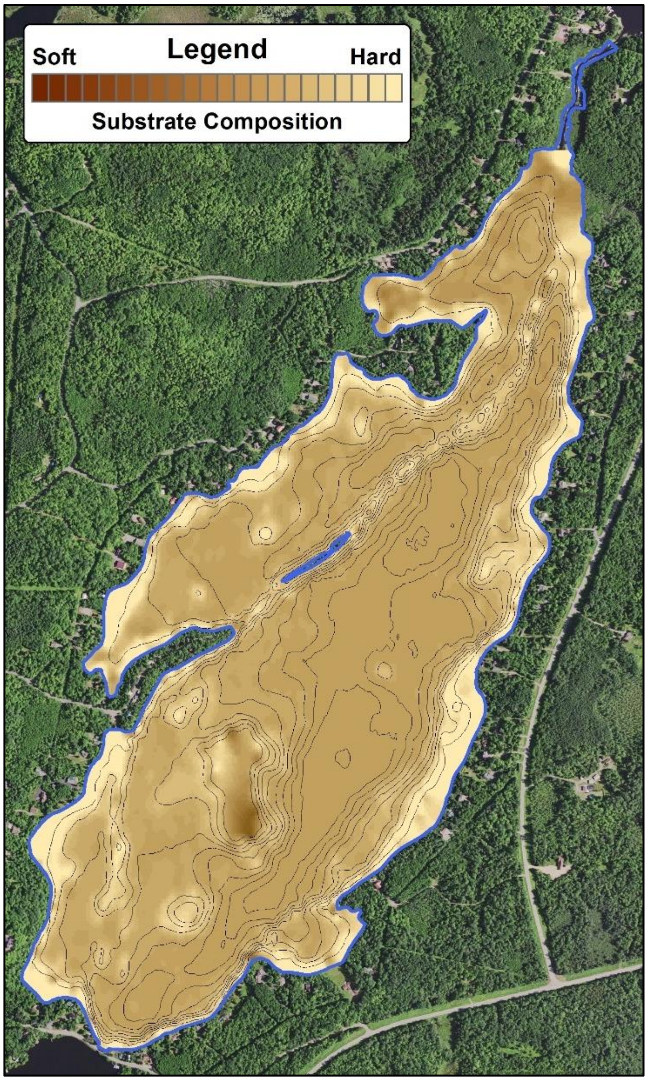
Lakes in Wisconsin vary in their morphometry, water chemistry, substrate composition, and management, all factors which influence aquatic plant community composition. In late September of 2017, Onterra ecologists completed an acoustic survey on North Turtle Lake (bathymetric results on North Turtle Lake – Map 1). The sonar-based technology records aquatic plant bio-volume, or the percentage of the water column that is occupied by aquatic plants at a given location. Data pertaining to North Turtle Lake's substrate composition were also recorded during this survey. The sonar records substrate hardness, ranging from the hardest substrates (i.e. rock and sand) to the more flocculent, softer organic sediments.

Data regarding substrate hardness collected during the 2017 acoustic survey showed that shallower areas of North Turtle Lake from 1-15 feet are primarily comprised of hard substrates, rock and sand (Figure 8.7.4-2). Softer substrates were located in a shallow area in the south-central area of the lake and near the mouth of Rainbow Creek. Beyond 15 feet, substrates are relatively hard and uniform to the deepest areas of the lake. 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 areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because of the different habitat types that are available.

Table 8.7.4-1. List of aquatic plant species located in North Turtle Lake during Onterra 2017 aquatic plant surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2017 (Onterra)
Emergent	*Carex utriculata*	Common yellow lake sedge	7	I
	Decodon verticillatus	Water-willow	7	I
	Dulichium arundinaceum	Three-way sedge	9	I
	Eleocharis palustris	Creeping spikerush	6	I
	Equisetum fluviatile	Water horsetail	7	I
	Glyceria canadensis	Rattlesnake grass	7	I
	Iris pseudacorus	Pale-yellow iris	Exotic	I
	Iris versicolor	Northern blue flag	5	I
	Pontederia cordata	Pickerelweed	9	I
	Sagittaria latifolia	Common arrowhead	3	I
	Schoenoplectus acutus	Hardstem bulrush	5	X
	Sparganium americanum	American bur-reed	8	X
	Sparganium eurycarpum	Common bur-reed	5	I
	Sparganium sp. (sterile)	Bur-reed sp. (sterile)	N/A	I
FL	*Brasenia schreberi*	Watershield	7	I
	Nuphar variegata	Spatterdock	6	X
	Nymphaea odorata	White water lily	6	I
	Sparganium fluctuans	Floating-leaf bur-reed	10	I
Submersed	*Bidens beckii*	Water marigold	8	X
	Ceratophyllum demersum	Coontail	3	X
	Chara spp.	Muskgrasses	7	X
	Isoetes lacustris	Lake quillwort	8	X
	Myriophyllum sibiricum	Northern watermilfoil	7	X
	Myriophyllum tenellum	Dwarf watermilfoil	10	X
	Najas flexilis	Slender naiad	6	X
	Nitella spp.	Stoneworts	7	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	I
	Potamogeton gramineus	Variable-leaf pondweed	7	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X
	Potamogeton robbinsii	Fern-leaf pondweed	8	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	I
	Potamogeton vaseyi	Vasey's pondweed	10	I
	Utricularia vulgaris	Common bladderwort	7	I
	Vallisneria americana	Wild celery	6	X
S/E	*Sagittaria cuneata*	Arum-leaved arrowhead	7	I
	Sagittaria graminea	Grass-leaved arrowhead	9	I

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submersed and Emergent
X = Located on rake during point-intercept survey; I = Incidental Species



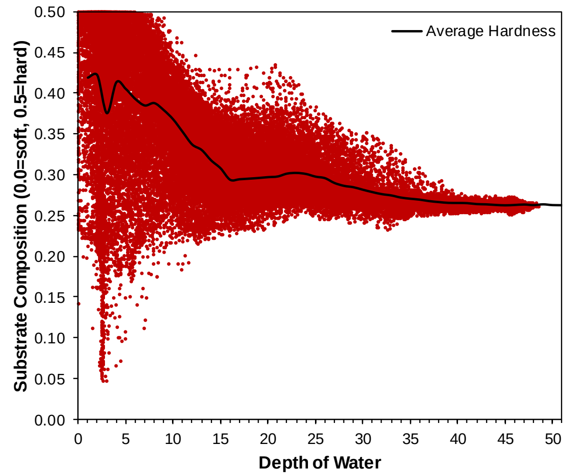


Figure 8.7.4-2. North Turtle Lake spatial distribution of substrate hardness (left) and substrate hardness across water depth (right). Depth contours represent 5-foot intervals. Individual data points are displayed in red. Creating using data from September 2017 acoustic survey.

The acoustic survey also recorded aquatic plant bio-volume throughout the entire lake. As mentioned earlier, aquatic plant bio-volume is the percentage of the water column that is occupied by aquatic plants. The 2017 aquatic plant bio-volume data are displayed in Figure 8.7.4-3 and North Turtle Lake – Map 6. Areas where aquatic plants occupy most or all of the water column are indicated in red while areas of little to no aquatic plant growth are displayed in blue. The 2017 whole-lake point-intercept survey found aquatic plants growing to a maximum depth of 8 feet. However, the majority of aquatic plant growth occurs within 2.0-4.0 feet of water. The 2017 acoustic survey indicated approximately 5% (18 acres) of North Turtle Lake's area is occupied by aquatic vegetation, while the remaining 95% of the lake contains unsuitable substrates or is too deep to support aquatic plant growth.

As mentioned, aquatic plants were recorded growing to a maximum depth of 8 feet in 2017. Of the 138 point-intercept sampling locations that fell at or shallower than the maximum depth of plant growth (littoral zone), approximately 23% contained aquatic vegetation. Aquatic plant rake fullness data collected in 2017 indicates that 19% of the 138 littoral sampling locations contained vegetation with a total rake fullness rating (TRF) of 1, 3% had a TRF rating of 2, and 1% had a TRF rating of 3 (Figure 8.7.4-5).

The acoustic and point-intercept survey data indicate that aquatic plant occurrence and biomass in North Turtle Lake is low. Of the eight Winchester project lakes studied to date, North Turtle Lake has the lowest littoral frequency of occurrence of vegetation of 24% compared to an average of 57%. Most of the aquatic plant growth occurs in the shallower area within the south-central area of the lake and over the softer substrates in the northern portion of the lake. The low occurrence of aquatic vegetation in North Turtle Lake is likely due to two main factors: 1) the lakes morphometry which consists of steep slopes and a small littoral zone, and 2) substrates largely comprised of rock and sand which are unsuitable for most aquatic plant species.

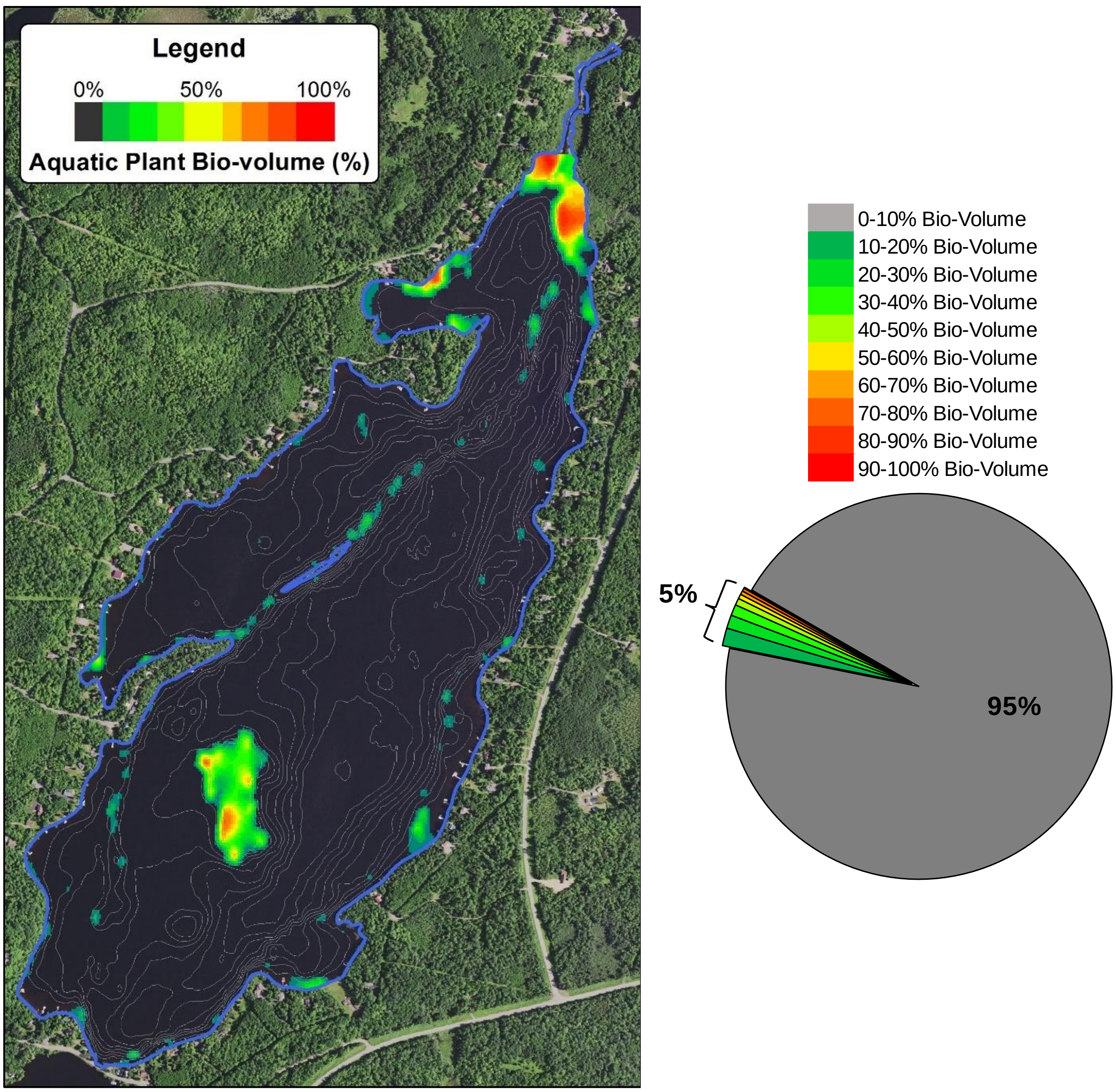


Figure 8.7.4-4. North Turtle Lake 2017 aquatic plant bio-volume. Contour lines are 5-foot intervals. Created using data from September 2017 acoustic survey data.

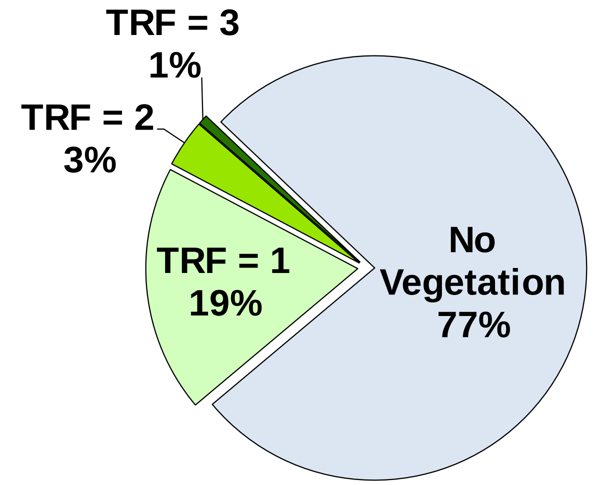


Figure 8.7.4-5. North Turtle Lake 2017 aquatic vegetation total rake fullness ratings (TRF). Created from data collected during the 2017 whole-lake point-intercept survey (N = 138).

Of North Turtle Lake's 368 acres, approximately 77 acres (21%) is littoral zone, or areas of the lake 8.0 feet deep or less that receive adequate light to support aquatic plant growth. In addition, the majority of the littoral zone is comprised of rock and sand. Rock substrate can be impenetrable by aquatic plant roots while sand is often nutrient-poor (Lacoul and Freedman 2006). The low abundance of aquatic plant growth in North Turtle Lake is not an indication of degraded conditions, but the result of the lake's morphometry and substrate composition.

While the acoustic mapping is an excellent survey for understanding the distribution and levels of aquatic plant growth throughout the lake, this survey does not determine what aquatic plant species are present. Whole-lake point-intercept surveys are used to quantify the abundance of individual species within the lake. Of the 36 aquatic plant species located in North Turtle Lake in 2017, 16 were encountered directly on the rake during the whole-lake point-intercept survey (Figure 8.7.4-6). The remaining 20 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 relatively rare within the plant community. Of the 16 species directly sampled with the rake during the point-intercept survey, wild celery, variable-leaf pondweed, and muskgrasses were the three-most frequently encountered aquatic plant species (Figure 8.7.4-6).

Wild celery, also known as tape or eelgrass, was the most frequently encountered aquatic plant species in North Turtle Lake in 2017 with a littoral frequency of occurrence of 11% (Figure 8.7.4-6). 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. North Turtle Lake's areas of sand/cobble and low light conditions as a result of its stained water favor the dominance of wild celery. In 2017, wild celery was most abundant over hard substrates in water 3.0-4.0 feet deep.

Variable-leaf pondweed and muskgrasses were the second-most frequently encountered aquatic plant species in North Turtle Lake in 2017 with a littoral occurrence of 9% each (Figure 8.7.4-6). Variable-leaf pondweed is one of several broad-leaf pondweed species that can be found in Wisconsin, and the plants size and leaf shape can vary widely depending on its growing conditions. This plant produces long, thin stems with alternating lance-shaped leaves and is typically found growing over firmer substrates. In North Turtle Lake, variable-leaf pondweed was often found growing with wild celery and muskgrasses.

Muskgrasses are a genus of macroalgae of which there are seven species in Wisconsin. Muskgrasses require lakes with good water clarity, and their large beds help to stabilize bottom sediments. Studies have also shown that muskgrasses sequester phosphorus in the calcium carbonate incrustations which form on these plants, aiding in improving water quality by making the phosphorus unavailable to phytoplankton (Coops 2002). Muskgrasses were found in association with wild celery and variable-leaf pondweed in North Turtle Lake.

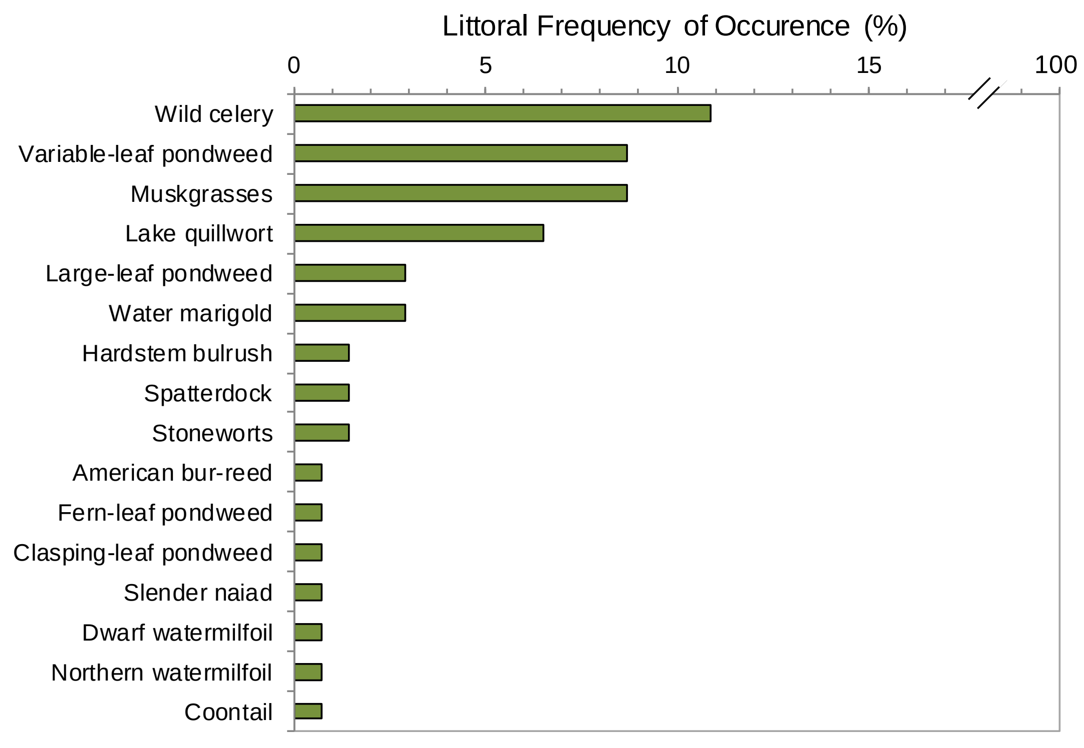


Figure 8.7.4-6. North Turtle Lake 2017 littoral frequency of occurrence of aquatic plant species. Created using data from 2017 whole-lake point-intercept survey.

Submersed aquatic plants can be grouped into one of two general categories based upon their morphological growth form and habitat preferences. These two groups include species of the *isoetid* growth form and those of the *elodeid* growth form. Plants of the isoetid growth form are small, slow-growing, inconspicuous submerged plants (Photo 8.7.4-2). These species often have evergreen, succulent-like leaves and are usually found growing in sandy/rocky soils within near-shore areas of a lake (Boston and Adams 1987, Vestergaard and Sand-Jensen 2000).

In contrast, aquatic plant species of the elodeid growth form have leaves on tall, erect stems which grow up into the water column, and are the plants that lake users are likely more familiar with (Photo 8.7.4-2). It is important to note that the definition of these two groups is based solely on morphology and physiology and not on species' relationships. For example, dwarf-water milfoil (*Myriophyllum tenellum*) is classified as an isoetid, while all of the other milfoil species in Wisconsin such as northern water milfoil (*Myriophyllum* sibiricum) are classified as elodeids.

Alkalinity, as it relates to the amount of bicarbonate within the water, is the primary water chemistry factor for determining a lake's aquatic plant community composition in terms of isoetid versus elodeid growth forms (Vestergaard and Sand-Jensen 2000). Most aquatic plant species of the elodeid growth form cannot inhabit lakes with little or no alkalinity because their carbon demand for photosynthesis cannot be met solely from the dissolved carbon dioxide within the water and must be supplemented from dissolved bicarbonate.

Photo 8.7.4-2. Lake quillwort (*Isoetes lacustris*) of the isoetid growth form (left) and variable pondweed (*Potamogeton gramineus*) and fern pondweed (*P. robbinsii*) of the elodeid growth form (right).

On the other hand, aquatic plant species of the isoetid growth form can thrive in lakes with little or no alkalinity because they have the ability to derive carbon dioxide directly from the sediment, and many also have a modified form of photosynthesis to maximize their carbon storage (Madsen et al. 2002). While isoetids are able to grow in lakes with higher alkalinity, their short stature makes them poor competitors for space and light against the taller elodeid species. Thus, isoetids are most prevalent in lakes with little to no alkalinity where they can avoid competition from elodeids. However, in lakes with moderate alkalinity, like North Turtle Lake, the aquatic plant community can be comprised of isoetids growing beneath a scattered canopy of the larger elodeids. Isoetid communities are vulnerable to sedimentation and eutrophication (Smolders et al. 2002), and a number are listed as special concern (e.g. northeastern bladderwort) or threatened in Wisconsin due to their rarity and susceptibility to environmental degradation.

As discussed in the Town-Wide 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 native species encountered on the rake during 2017 point-intercept survey on North Turtle Lake and their conservatism values were used to calculate the FQI of North Turtle Lake's aquatic plant community (equation shown below).

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

Figure 8.7.4-7 compares the 2017 FQI components of North Turtle Lake to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) ecoregion and lakes throughout Wisconsin. The native species richness, or number of native aquatic plant species located on the rake in 2017 (16) falls below the median value for lakes in the NLFL ecoregion (21) and for lakes throughout Wisconsin (19) (Figure 8.7.4-7). The lower species richness is likely due to North Turtle Lake's morphometry and substrate composition as discussed previously. The average conservatism of the

16 native aquatic plant species located in North Turtle Lake in 2017 was 6.8, exceeding the median average conservatism values for lakes within the NLFL ecoregion (6.7) and lakes throughout Wisconsin (6.3) (Figure 8.7.4-7). This indicates that a higher proportion of North Turtle Lake's aquatic plant community is comprised of environmentally-sensitive species, or species with higher conservatism values.

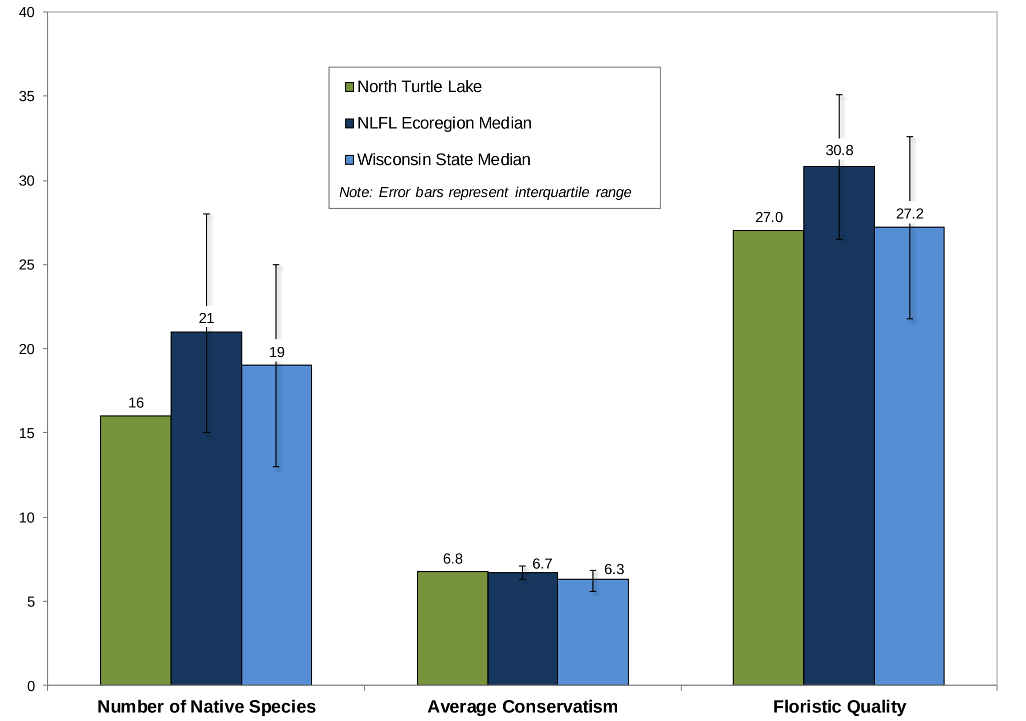


Figure 8.7.4-7. North Turtle Lake Floristic Quality Assessment. Created using data from Onterra 2017 whole-lake point-intercept survey. Analysis follows Nichols (1999).

Using North Turtle Lake's native aquatic plant species richness and average conservatism yields an FQI value of 27.0 (Figure 8.7.4-7). North Turtle Lake's FQI value falls below the median values for lakes within the NLFL ecoregion (30.8) and near the median value for lakes throughout the state (27.2). North Turtle Lake's lower FQI value is due to its lower species richness value, and as discussed earlier, is the result of natural conditions within the lake and is not an indication of environmental degradation. Overall, the FQI analysis indicates that the aquatic plant community found in North Turtle Lake contains fewer species than the majority of lakes in Wisconsin, but the species that are present are environmentally-sensitive and indicate high-quality conditions.

As explained in the Town-wide section, 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 North Turtle Lake contains a lower number of aquatic plant species, one may assume the aquatic plant community has low 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 North Turtle Lake's diversity value ranks. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 212 lakes within the NLFL ecoregion (Figure 8.7.4-8). Using the data collected from the 2017 point-intercept survey, North Turtle Lake's aquatic plant was found to have high species diversity with a Simpson's Diversity Index value of 0.86. In other words, if two individual aquatic plants were randomly sampled from North Turtle Lake in 2017, there would be an 86% probability that they would be different species. North Turtle Lake's Simpson's Diversity value falls below the median value for lakes in the NLF ecoregion (0.88) but is comparable to the median value for lakes throughout Wisconsin (0.86).

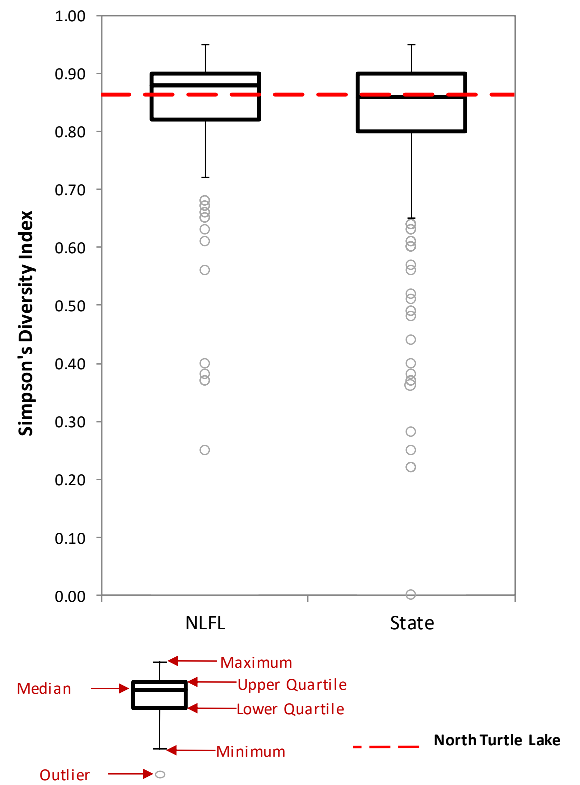


Figure 8.7.4-8. North Turtle Lake species diversity index. Created using data from Onterra 2016 point-intercept survey.

One way to visualize North Turtle Lake's species diversity is to look at the relative occurrence of aquatic plant species. Figure 8.1.4-9 displays the relative frequency of occurrence of aquatic plant species created from the 2017 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 11% of the littoral sampling locations in North Turtle Lake in 2017, its relative frequency of occurrence was 22%. Explained another way, if 100 plants were randomly sampled from North Turtle Lake in 2017, 22 of them would be wild celery.

In 2017, Onterra ecologists also conducted a survey aimed at mapping emergent and floating-leaf aquatic plant communities in North Turtle Lake. This survey revealed North Turtle Lake contains approximately 11 acres of these communities comprised of 19 plant species (North Turtle Lake – Map 7 and Table 8.7.4-2). These native emergent and floating-leaf plant communities provide valuable fish and wildlife habitat that is important to the ecosystem of the lake. These areas are particularly important during times of fluctuating water levels, since structural habitat of fallen trees and other forms of course-woody habitat can be quite sparse along the shores of receding water lines. The community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, and a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within North Turtle Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development.

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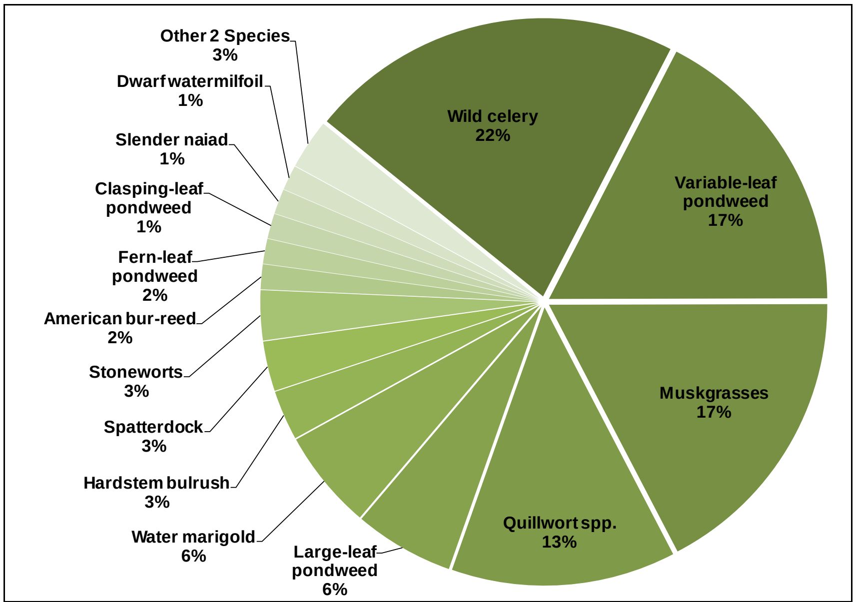


Figure 8.7.4-9. North Turtle Lake 2017 relative frequency of occurrence of aquatic plant species. Created using data from 2017 point-intercept survey.

Table 8.7.4-2. North Turtle Lake 2017 acres of emergent and floating-leaf aquatic plant communities. Created using data from 2017 aquatic plant community mapping survey.

Plant Community	Acres
Emergent	5.4
Floating-leaf	0.8
Mixed Emergent & Floating-leaf	4.5
Total	**10.8**

Non-native Aquatic Plants in North Turtle Lake

Pale-Yellow Iris

Pale yellow iris (*Iris pseudacorus*; Photo 8.7.4-4 and North Turtle Lake – Map 8) is a large, showy iris with bright yellow flowers. Native to Europe and Asia, this species was sold commercially in the United States for ornamental use and has since escaped into Wisconsin's wetland areas forming large monotypic colonies and displacing valuable native wetland species. Pale-yellow iris was located growing in a few locations along the shorelines of North Turtle Lake by NLDC and Onterra staff in 2017 (North Turtle Lake – Map 7). There are a number of control strategies that can be used to control pale-yellow iris. A strategy for managing pale-yellow iris on North Turtle Lake is discussed within the Turtle Chain Implementation Plan.

Photo 8.7.4-4. Pale-yellow iris (*Iris pseudacorus*), a non-native, invasive wetland plant found along the shorelines of North Turtle Lake in 2017. Photo credit Onterra.

8.7.5 Aquatic Invasive Species in North Turtle Lake

As of 2017, the only non-native species other than pale-yellow iris documented in North Turtle Lake is the rusty crayfish (*Orconectes rusticus*) has been documented in downstream North Turtle Lake, and it is likely that rusty crayfish are present in North Turtle Lake. Rusty crayfish were introduced to Wisconsin from the Ohio River Basin in the 1960's likely via anglers' discarded bait. In addition to displacing native crayfish (*O. virilis* and *O. propinquus*), rusty crayfish also degrade the aquatic habitat by reducing aquatic plant abundance and diversity and have also been shown to consume fish eggs. While there is currently no control method for eradicating rusty crayfish from a waterbody, aggressive trapping and removal has been shown to significantly reduce populations and minimize their ecological impact.

8.7.6 North Turtle Lake 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 North Turtle Lake. The goal of this section is to provide an overview of some of the data that exists. Although current fish 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 Biologist Hadley Boehm (WDNR 2017 & GLIFWC 2017).

North Turtle 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 North Turtle 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 algae, 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 8.7.6-1.

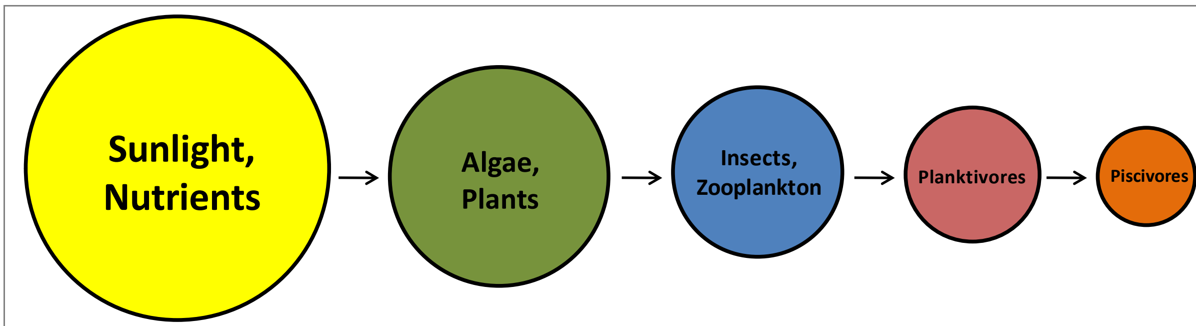


Figure 8.7.6-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, North Turtle Lake is a mesotrophic system, meaning it has a moderate amount of nutrients and thus a moderate amount of primary productivity. This is relative to an oligotrophic system, which contains fewer nutrients (less productive) and a eutrophic system, which contains more nutrients (more productive). Simply put, this means North Turtle

Lake should be able to support an appropriately sized population of predatory fish (piscivores) when compared to eutrophic or oligotrophic systems. Table 8.7.6-1 shows the popular game fish present in the system. Although not an exhaustive list of fish species in the lake, additional species documented in past surveys of North Turtle Lake include burbot (*Lota lota*), white sucker (*Catostomus commersonii*), and the greater redhorse (*Moxostoma valenciennesi*).

Table 8.7.6-1. Gamefish present in North Turtle Lake with corresponding biological information (Becker, 1983).

Common Name (*Scientific Name*)	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie (*Pomoxis nigromaculatus*)	7	May - June	Near Chara or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill (*Lepomis macrochirus*)	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Cisco (*Coregonus artedii*)	22	Late November - Early December	Various shoreline substrates.	Microscopic zooplankton, aquatic insect larvae, adult mayflies, stoneflies, bottom-dwelling invertebrates.
Largemouth Bass (*Micropterus salmoides*)	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge (*Esox masquinongy*)	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike (*Esox lucius*)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed (*Lepomis gibbosus*)	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass (*Ambloplites rupestris*)	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass (*Micropterus dolomieu*)	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch (*Perca flavescens*)	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

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 8.7.6-1). 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 electroshocking (Photograph 8.7.6-1). 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 easy for fisheries technicians to net and place into a livewell to recover. Contrary to what some may believe, electroshocking 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 these data to make recommendations and informed decisions on managing the future of the fishery.

Photograph 8.7.6-1. 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 fry, fingerling or adult fish in a waterbody that were raised in permitted hatcheries (Photograph 8.7.6-2). Stocking of 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. North Turtle Lake was stocked from 1972 to 1980 with muskellunge and walleye (Table 8.7.6-2). Stocking of walleye is not needed as North Turtle is considered a naturally reproducing walleye water by the WDNR.

Photograph 8.7.6-2. Fingerling Muskellunge.

Table 8.7.6-2. Stocking data available for North Turtle Lake (1972-1980).

Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
1976	Muskellunge	Fingerling	400	7
1980	Muskellunge	Fingerling	700	10
1972	Walleye	Fingerling	19,000	3
1974	Walleye	Fingerling	7,000	3
1977	Walleye	Fingerling	17,000	3

Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the second important reason for owning property on or near North Turtle Lake (Question #17). Figure 8.7.6-2 displays the fish that North Turtle Lake stakeholders enjoy catching the most, with walleye and smallmouth bass being the most common being the most popular. Approximately 71% of these same respondents believed that the quality of fishing on the lake was either good or fair (Figure 8.7.6-3). Approximately 86% of respondents who fish North Turtle Lake believe the quality of fishing has remained the same or is somewhat worse since they first started fishing the lake (Figure 8.7.6-3).

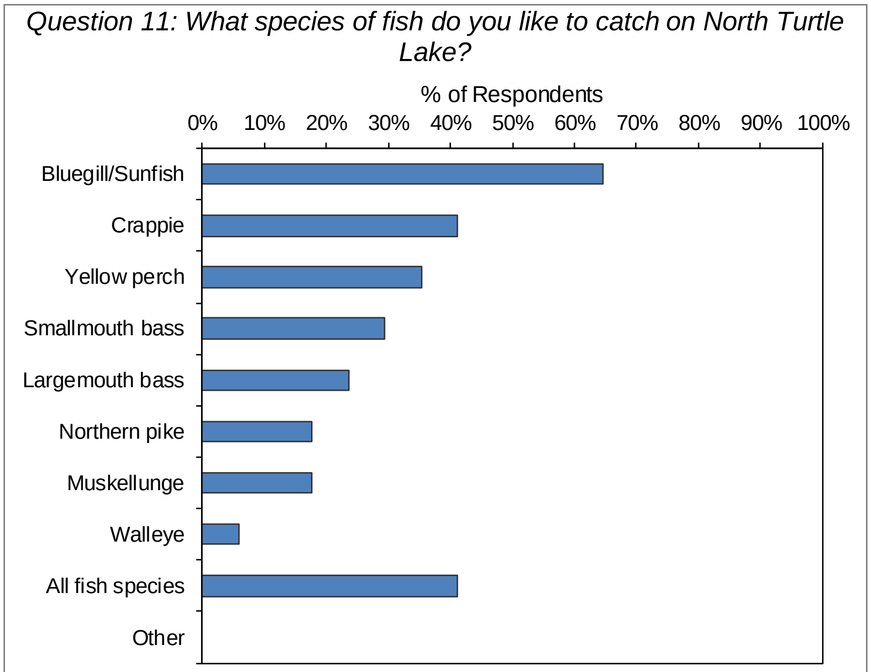


Figure 8.7.6-2. Stakeholder survey response Question 11. Created based on data from 45 respondents of 116 surveys sent (39%).

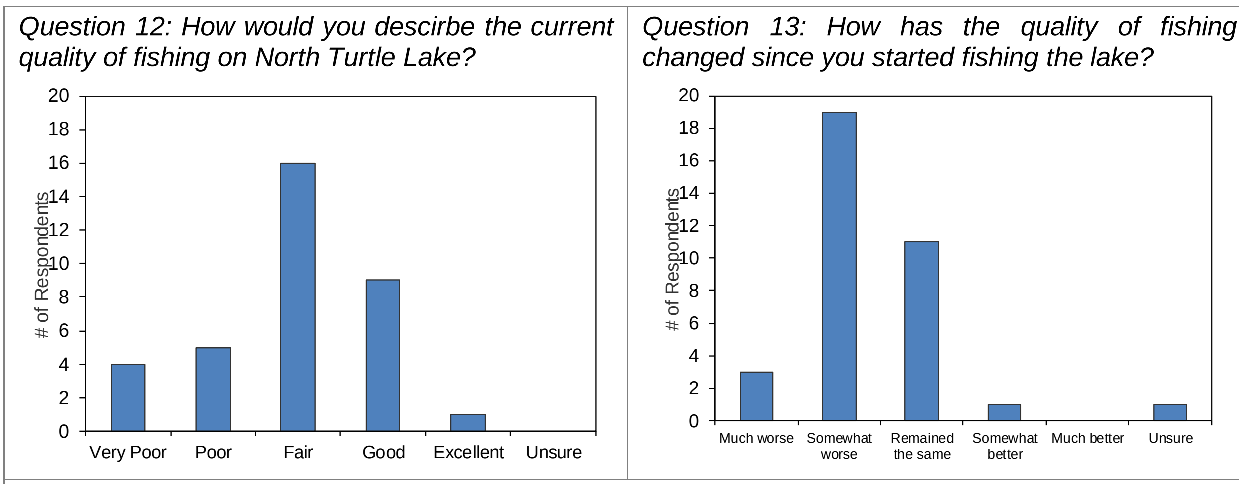


Figure 8.7.6-3. Stakeholder survey responses to questions 12 and 13. Created based on data from 45 respondents of 116 surveys sent (39%).

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. Creel surveys were completed on Rock, South Turtle and North Turtle Lakes during the 1991-92 and 2010-11 fishing seasons (Table 8.7.6-3).

Total angler effort was somewhat higher in 1991-92 (20.5 hours/acre) compared to the 2010-11 season (18.1 hours/acre). Anglers directed the largest amount of effort towards walleye and muskellunge during both the 2010-11 and 1991-92 seasons (Table 8.7.6-3).

Table 8.7.6-3. Creel Survey data for 1991-92 and 2010-11 fishing seasons.

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
Largemouth Bass	1991	20.5	0	0	0	0	0		
	2010	18.1	0.9	30	0.1	0	0	11.3	
Muskellunge	1991	20.5	6.7	84	0.2	0	0	45.5	
	2010	18.1	6	95	0.3	0	0	31.7	
Northern Pike	1991	20.5	0.6	62	0.2	11	0	36.2	
	2010	18.1	0.5	51	0.1	5	0	5.6	
Smallmouth Bass	1991	20.5	0.7	179	0.5	33	0.1	5.7	32.2
	2010	18.1	1.9	484	1.3	19	0.1	1.9	67.1
Walleye	1991	20.5	11.3	4457	12.1	117	0.3	0.9	37.5
	2010	18.1	10.2	2501	6.8	1249	3.4	1.5	3

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. These numbers provide a standardized way to compare fish caught in different sampling years depending on gear used (fyke net or electrofishing). Data is analyzed in many ways by fisheries biologists to better understand the fishery and how it should be managed.

Gamefish

The gamefish present on North Turtle Lake represent different population dynamics depending on the species. The results for the stakeholder survey show landowners prefer to catch walleye on North Turtle Lake (Figure 8.7.6-2). A 2010 WDNR fisheries survey conducted on North Turtle Lake showed a high density of walleye (WDNR 2010).

Panfish

Abundant populations of yellow perch were present after the 2010 WDNR fisheries survey (WDNR 2010). The results for the stakeholder survey show anglers prefer to catch crappie on South Turtle Lake (Figure 8.7.6-2).

North Turtle 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 8.7.6-4). North Turtle 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, either by spear harvest or angler harvest, is a highly regimented and dictated process.

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 is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. 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 tribal or recreational harvesting means.

Figure 8.7.6-4. Location of Town of Winchester within the Native American Ceded Territory (GLIFWC 2017). This map was digitized by Onterra; therefore, it is a representation and not legally binding.

By March 15th of each year the relevant tribal communities may declare a proportion of the total safe harvest on each lake. This declaration represents the maximum number of fish that can be taken by tribal spear harvesters or netters annually (Spangler, 2009). 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 state-wide 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).

Spear harvesters are able to 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 2016). 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 spear harvesters may only take two walleye over 20 inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIWC 2016). 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 spear harvesters. Harvest of a particular species ends once the declaration is met. In 2011, a new reporting requirement went into effect on lakes with smaller declarations.

Walleye open water spear harvest records from 1999-2017 in North Turtle Lake are provided in Figure 8.7.6-5. As many as 150 walleye have been harvested from the lake in the past (2017), but the average harvest is roughly 30 fish per year. Spear harvesters on average have taken 26% of the declared quota. Additionally, on average, 11% of walleye harvested have been female.

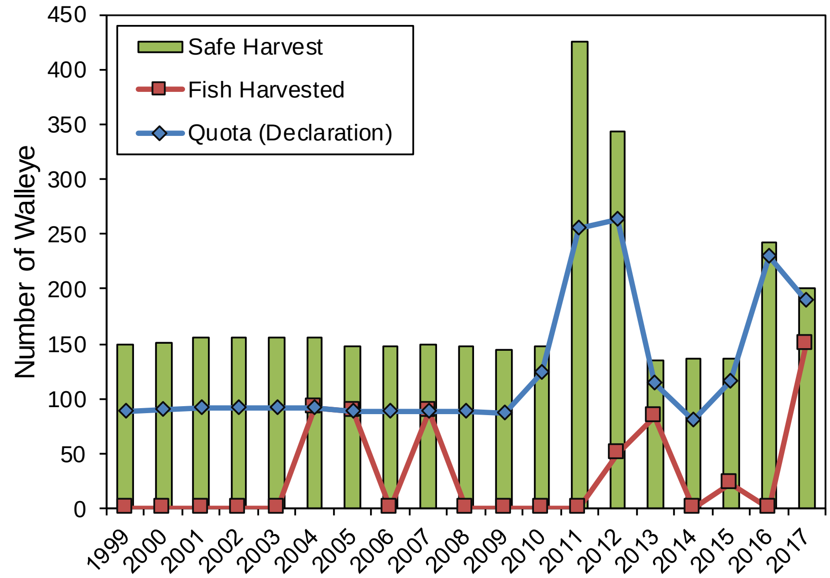


Figure 8.7.6-5. North Turtle Lake walleye spear harvest data. (GLIFWC 1999-2017).

Muskellunge open water spear harvest records from 1999-2017 in North Turtle Lake are provided in Figure 8.7.6-6. At most, 1 muskellunge has been harvested from the lake in the past (2007), while in most years zero muskellunge are harvested. Spear harvesters on average have taken 1% of the declared quota.

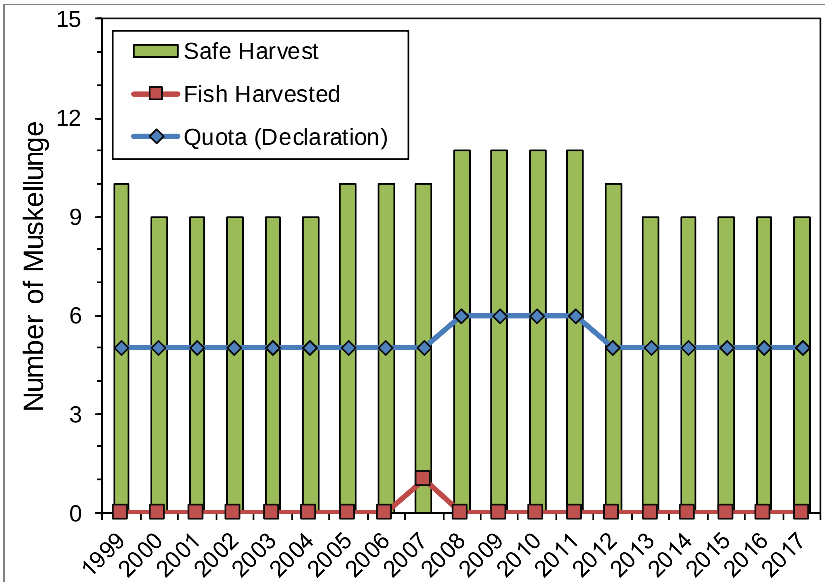


Figure 8.7.6-6. North Turtle Lake muskellunge spear harvest data. (GLIFWC 1999-2017).

North Turtle 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, evade 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 have substrates largely comprised of sand and rock 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 do 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 over soft sediments as well. According to the point-intercept survey conducted by Onterra in 2017, 37% of the substrate sampled in the littoral zone of North Turtle Lake were sand sediments, 32% composed of soft sediments and 31% composed of rock.

Woody Habitat

As discussed in the Shoreland Condition section (Section 8.7.3), the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass 2006). A fall 2017 survey documented 175 pieces of coarse woody along the shores of North Turtle Lake, resulting in a ratio of approximately 31 pieces per mile of shoreline. When compared to the other 98 lakes Onterra has completed coarse woody habitat surveys on since 2012, North Turtle Lake falls in the 58th percentile for the number of course woody habitat pieces per shoreline mile.

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. 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 8.7.6-3). 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 other partner contributions.

Photograph 8.7.6-3. Examples of fish sticks (left) and half-log habitat structures (right). (Photos by WDNR).

Fish cribs are a fish habitat structure that are placed on the lakebed. Installing fish cribs may 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. Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 8.7.6-3). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills 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 are spawning reefs. Spawning reefs typically consist of small rubble in a shallow area near the shoreline and are mainly installed to enhance 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 indicated the addition of rock substrate did not significantly improve walleye reproduction (WDNR 2004).

Placement of a fish habitat structures in a lake does not require 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. The Town of Winchester should 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 North Turtle Lake.

Regulations

Regulations for North Turtle Lake gamefish species as of April 2018 are displayed in Table 8.7.6-4. 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 8.7.6-4. WDNR fishing regulations for North Turtle Lake (As of April 2018).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	25	None	Open All Year
Smallmouth bass (Early Season)	Catch and release only	None	May 5, 2018 to June 15, 2018
Smallmouth bass	5	14"	June 16, 2018 to March 3, 2019
Largemouth bass	5	14"	May 5, 2018 to March 3, 2019
Muskellunge and hybrids	1	40"	May 26, 2018 to November 30, 2018
Northern pike	5	None	May 5, 2018 to March 3, 2019
Walleye, sauger, and hybrids	3	None but only 1 fish over 14" is allowed.	May 5, 2018 to March 3, 2019
Bullheads	Unlimited	None	Open All Year

General Waterbody Restrictions: Motor Trolling is allowed with 1 hook, bait, or lure per angler, and 3 hooks, baits, or lures maximum per boat.

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.

As discussed in the North Turtle Lake Water Quality section (Section 8.6.1), North Turtle Lake was placed on the 303(d) list of impaired waterbodies for contaminated fish tissue by mercury in 1998. General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 8.7.6-7. 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 8.7.6-7. 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/)

Please note that study methods and explanations of analyses for South Turtle Lake can be found within the Town of Winchester Town-wide Management Plan document.

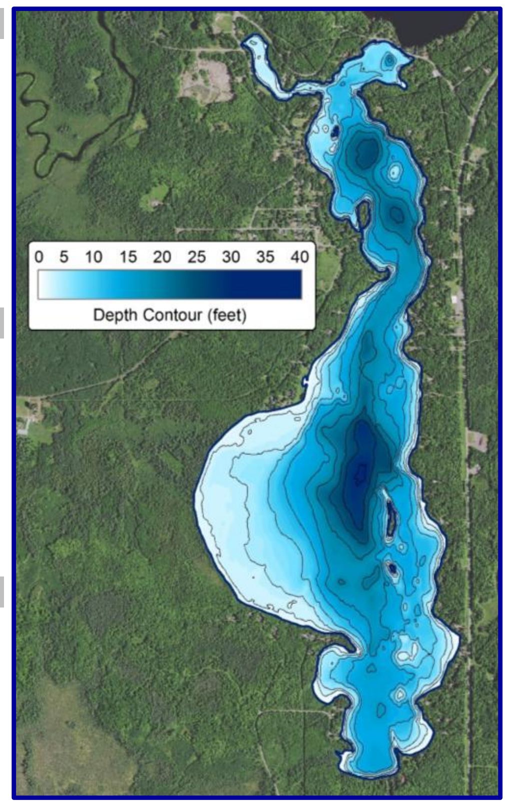
8.8 South Turtle Lake

An Introduction to South Turtle Lake

South Turtle Lake, Vilas County, is a 488-acre deep lowland, brown-water, mesotrophic drainage lake with a maximum depth of 40 feet and a mean depth of 14 feet (South Turtle Lake – Map 1). Its surficial watershed encompasses approximately 15,357 acres across portions of Vilas County, WI and Gogebic County, MI. North Turtle Lake flows into South Turtle Lake from the north and the lake is drained by the Turtle River to the northeast. In 2017, 39 native aquatic plant species were located within the lake, of which fern-leaf pondweed (*Potamogeton robbinsii*) was the most common. The non-native, invasive wetland plant pale-yellow iris (*Iris pseudacorus*) was located in a few locations along South Turtle Lake's shoreline in 2017. To date, no other non-native species have been documented in South Turtle Lake.

Lake at a Glance - South Turtle Lake

Morphometry	
LakeType	Deep Lowland Drainage
Surface Area (Acres)	488
Max Depth (feet)	40
Mean Depth (feet)	14
Perimeter (Miles)	7.7
Shoreline Complexity	6.1
Watershed Area (Acres)	15,357
Watershed to Lake Area Ratio	31:1
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Avg Summer P (µg/L)	22
Avg Summer Chl-α (µg/L)	9
Avg Summer Secchi Depth (ft)	7.4
Summer pH	7.7
Alkalinity (mg/L as $CaCO_3$)	36
Vegetation	
Number of Native Species	39
NHI-Listed Species	Vasey's pondweed (*Potamogeton vaseyi*)
Exotic Species	Pale-yellow Iris (*Iris pseudacorus*)
Average Conservatism	6.6
Floristic Quality	32.8
Simpson's Diversity (1-D)	0.90



Descriptions of these parameters can be found within the town-wide portion of the management plan

8.8.1 South Turtle Lake Water Quality

It is often difficult to determine the status of a lake's water quality purely through observation. Anecdotal accounts of a lake "getting better" or "getting worse" can be difficult to judge because a) a lake's water quality may fluctuate from year to year based upon environmental conditions such as precipitation, and b) differences in observation and perception of water quality can differ greatly from person to person. It is best to analyze the water quality of a lake through scientific data as this gives a concrete indication as to the health of the lake, and whether its health has deteriorated or improved. Further, by looking at data for similar lakes regionally and statewide, the status of a lake's water quality can be made by comparison.

In 2017, a stakeholder survey was sent to 120 South Turtle Lake riparian property owners. Thirty-seven (31%) of these 120 surveys were completed and returned. Given the relatively low response rate, the results of the stakeholder survey cannot be interpreted as being statistically representative of the population sampled. At best, the results may indicate possible trends and opinions about the stakeholder perceptions of South Turtle Lake but cannot be stated with statistical confidence. The full survey and results can be found in Appendix B.

When asked about South Turtle Lake's current water quality, 73% of respondents indicated the water quality is *good* or *excellent* and 27% indicated the water quality is *fair* (Figure 8.8.1-1). When asked how water quality has changed in South Turtle Lake since they first visited the lake, 57% of respondents indicated water quality has *remained the same*, 40% indicated it has *somewhat* or *severely degraded*, and 3% indicated the water quality has *somewhat improved* (Figure 8.8.1-1). As is discussed in this section, water quality data do indicate that phosphorus and algal production have increased in South Turtle Lake over the past 25 years.

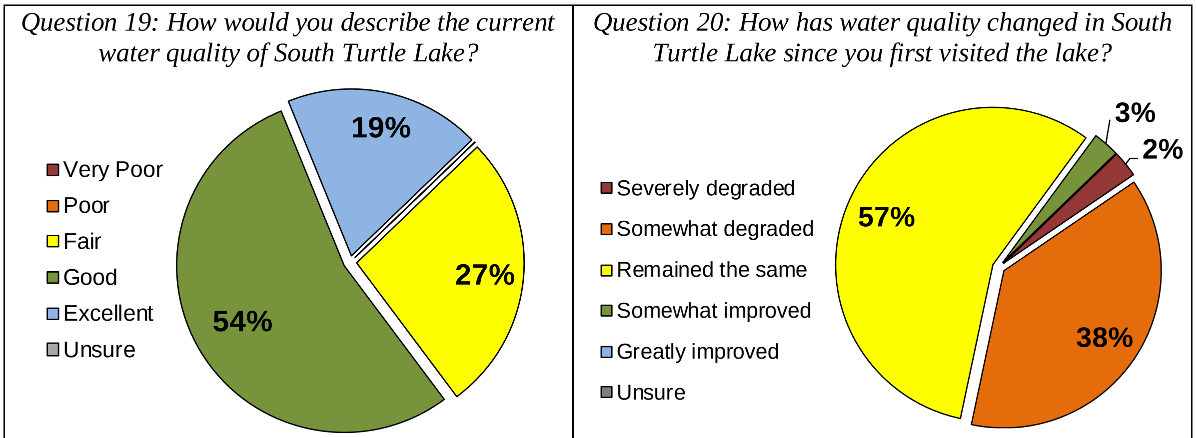


Figure 8.8.1-1. South Turtle Lake stakeholder survey responses regarding the lake's current and historical water quality. Created using responses from 37 (31%) respondents of 120 surveys distributed.

As is discussed further in the South Turtle Lake Watershed Section (Section 8.8.2), South Turtle Lake is classified as a lowland system because its watershed is approximately 24 square miles in area, greatly exceeding the watershed area threshold of 4 square miles or less used to classify lakes as headwater systems. However, given the close proximity of the inlet from North Turtle Lake and the Turtle River outlet, Onterra ecologists believe the majority of the water flowing into South Turtle Lake from North Turtle Lake flows out through the Turtle River and does not mix throughout South Turtle Lake proper.

It is believed most of the water in South Turtle Lake originates from its direct or local watershed and not from North Turtle Lake. In other words, the water quality in South Turtle Lake is largely dependent on its direct watershed and not on water originating from North Turtle Lake. For this reason, Onterra ecologists believe South Turtle Lake functions like a headwater as opposed to a lowland system and water quality data from South Turtle Lake should be compared to other deep headwater lakes in Wisconsin. As is discussed in the South Turtle Lake Watershed Section, watershed modeling agrees with this conclusion that the North Turtle Lake watershed has little influence on South Turtle Lake's water quality.

Near-surface total phosphorus data for South Turtle Lake are available from 1985, 1992-1999, and 2003-2017 (Figure 8.8.1-2). The weighted average summer total phosphorus concentration is 22 µg/L, falling into the *good* category for deep headwater drainage lakes in Wisconsin. The average summer phosphorus concentration in 2017 was above average at 26 µg/L. South Turtle Lake's average summer total phosphorus concentration is higher than the median concentration for Wisconsin's deep headwater drainage lakes and for all lake types within the NLF ecoregion.

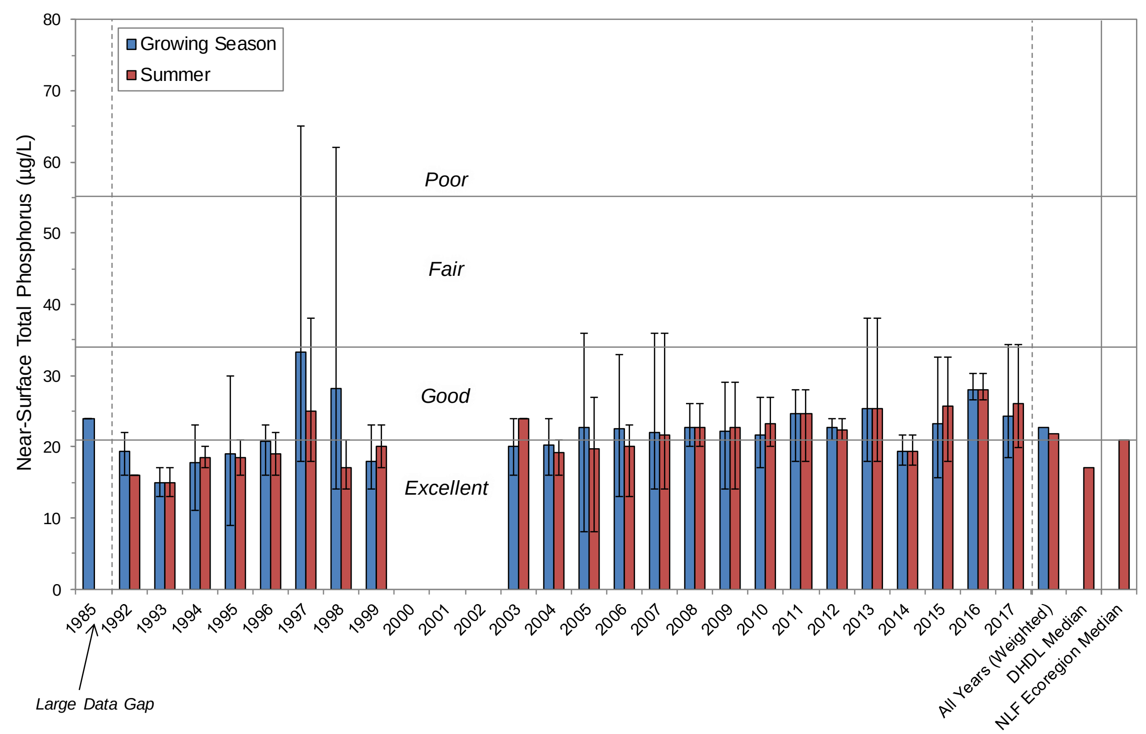


Figure 8.8.1-2. South Turtle Lake average annual near-surface total phosphorus concentrations and median near-surface total phosphorus concentrations for state-wide deep headwater drainage lakes (DHDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Trends analysis (simple linear regression) of South Turtle Lake's annual average summer phosphorus concentrations from 1992-2017 indicated a statistically valid (p-value <0.001), increasing trend (R^2 = 0.58) in concentration has occurred over this time period (Figure 8.8.1-3). Average summer total phosphorus concentrations have increased from an average of approximately 16 µg/L in 1992 to 25 µg/L in 2017. When significant increases in phosphorus 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 result in increased nutrient runoff to the lake. Examination of South Turtle Lake's direct watershed using aerial imagery available from 1992-2017 did not reveal any significant changes in land cover, indicating the increase in phosphorus is not likely due to disturbances within the watershed.

Changes in phosphorus 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 changes in phosphorus concentrations measured in South Turtle Lake, annual precipitation data were obtained from a monitoring station in nearby Manitowish Waters. Analyses showed no significant relationship between annual precipitation and phosphorus concentrations in South Turtle Lake, indicating the increase in phosphorus over this time period was likely not due to increases in external inputs from the watershed.

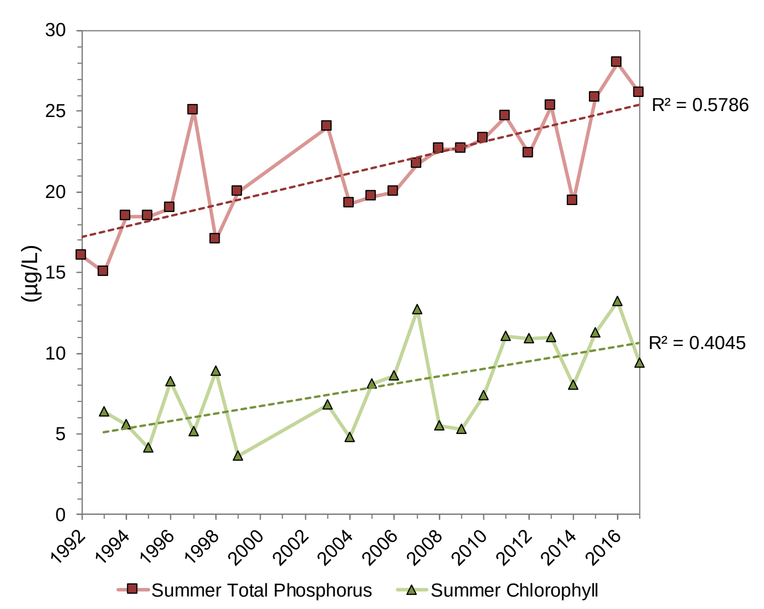


Figure 8.8.1-3. Linear regressions of average summer near-surface total phosphorus and chlorophyll-α concentrations in South Turtle Lake from 1992-2017. Both trends were statistically valid (p-value ≤ 0.001).

Because the measured increase in phosphorus since the early 1990s is likely not due to increases in the external input of phosphorus to the lake, the available water quality data suggest this phosphorus may be originating from within the lake itself through a process known as *internal nutrient loading*. Internal nutrient loading involves the release of phosphorus (and other nutrients) from lake bottom sediments into the overlying water. In general, lakes tend to act as phosphorus sinks, meaning they accumulate phosphorus over time within lake sediments. In most lakes, there is a net movement of phosphorus from the water to bottom sediments where it accumulates. 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.

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, they become less dense and float atop a 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 water of 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 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. These deep lakes remain stratified throughout the summer (and winter) and experience only two complete mixing events (turnover) per year, one in spring and one in fall (dimictic lakes). In deep 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 nuisance algal 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 shallow, polymictic lakes, or moderately shallow 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.

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 (transition zone or thermocline) and hypolimnion (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. South Turtle Lake has an Osgood Index value of 3.0, indicating it is a polymictic system.

An increase in external nutrient input and resulting increase in biological production through natural or human-made processes causes increased decomposition and oxygen demand in bottom waters. When oxygen demand reaches a rate at which anoxic conditions develop, sediment-bound nutrients which had largely been unavailable for biological use are released into the overlying water. If these nutrients become available for biological use through one of the mobilization processes discussed previously, this can lead to the consumption of more oxygen and the release of more nutrients from bottom sediments. The initial onset of anoxia in bottom waters can result in a positive feedback cycle where more nutrients and released (Cole and Weihe 2016). As a result, the lake may shift to a higher nutrient state.

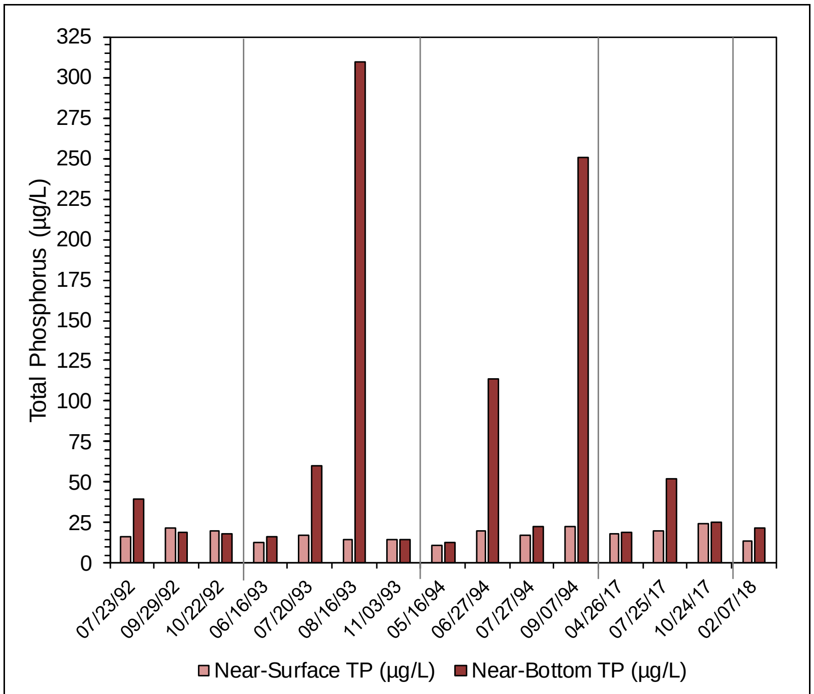


Figure 8.8.1-4. South Turtle Lake available near-bottom and corresponding near-surface total phosphorus concentrations.

In South Turtle Lake, data collected in 2017 along with available historical data indicate that internal nutrient loading does occur in South Turtle Lake. The first indication that internal nutrient loading occurs in South Turtle Lake is the concentration of phosphorus within the anoxic hypolimnion during the summer months. Summer hypolimnetic phosphorus concentrations are available from 1992, 1993, 1994, and 2017 (Figure 8.8.1-4). Mid-summer hypolimnetic phosphorus was not overly elevated in 2017 with a concentration of 52 µg/L, but concentrations measured in 1993 and 1994 exceeded 250 µg/L. These higher hypolimnetic phosphorus concentrations indicate internal nutrient loading does occur during summer stratification in South Turtle Lake. It is not necessarily significant that measured concentrations in the bottom waters were higher in 1993 and 1994 compared with 2017. The samples in 1993 and 1994 may have been collected during an extended period of stratification while the 2017 sample may have been collected shortly after the lake had mixed.

These higher hypolimnetic phosphorus during summer stratification are not unique to South Turtle Lake. Other Winchester project lakes including Harris, Birch, and Rainbow lakes also had similar hypolimnetic phosphorus concentrations during summer stratification. However, these lakes were found to maintain strong thermal stratification during the summer, and the phosphorus released from bottom sediments into the hypolimnion was not mobilized to the surface until fall mixing. In South Turtle Lake, historical temperature and dissolved oxygen profiles indicate that the epilimnion gets driven deeper over the course of the summer, cutting into the metalimnion (transition zone or thermocline) and hypolimnion and presumably mobilizing sediment-released nutrients to surface waters (Figure 8.8.1-5). This entrainment of phosphorus from the hypolimnion to the epilimnion is believed to have occurred in the summer of 2017 which resulted in a near-surface phosphorus “pulse” in August, where phosphorus concentrations increased by 10 µg/L (Figure 8.8.1-6).

The increasing trend in phosphorus in South Turtle Lake is an indication that internal nutrient loading is having a growing effect on the lake’s water quality. Closer examination of the phosphorus data shows that the largest increase in phosphorus concentration has occurred in July and August (Figure 8.8.1-7), adding weight to the idea that phosphorus is being entrained from bottom waters to the surface following deepening of the epilimnion. Average June phosphorus concentrations from 1992-1999 and more recently from 2003-2017 are relatively similar at 18 and

19 µg/L, respectively (Figure 8.8.1-7). However, average July and August phosphorus concentrations have increased from 18 µg/L and 17 µg/L in 1992-1999 to 23 µg/L and 27 µg/L, respectively.

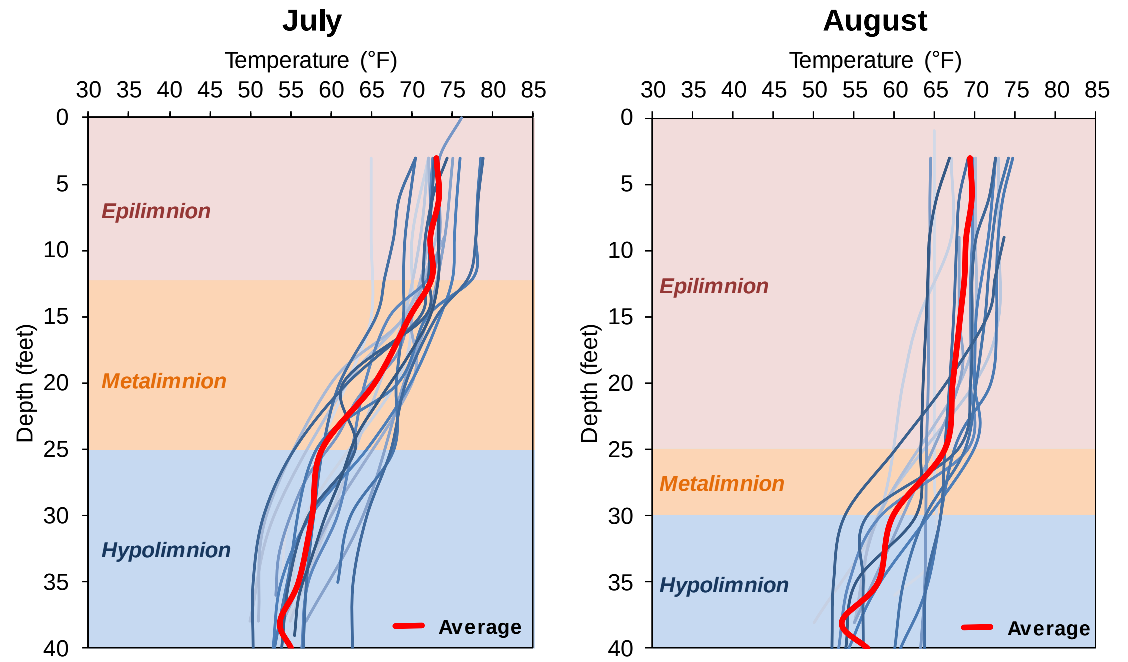


Figure 8.8.1-5. South Turtle Lake temperature profiles from July (1993-2017) and August (1992-2015) and average epilimnetic, metalimnetic, and hypolimnetic depths. These temperature profiles illustrate the deepening of the epilimnion from July to August resulting in the likely entrainment of sediment-released phosphorus from the anoxic metalimnion/hypolimnion to the epilimnion.

Increasing productivity in South Turtle Lake is also evidenced from dissolved oxygen profiles collected from 1993-1999, 2003, and 2017 (Figure 8.8.1-8). For most years from 1993-1999, South Turtle Lake maintained oxygenated conditions within bottom waters in July. In July of 2003 and 2017, bottom waters approximately 20 feet and deeper were found to be anoxic. Bacterial decomposition of organic matter which falls from surface waters consumes oxygen within the metalimnion and hypolimnion. The accelerated loss of oxygen in bottom waters in South Turtle Lake is an indication of eutrophication, or the lake becoming more productive. The increasing duration of anoxia in bottom waters is likely leading to more phosphorus being released from bottom sediments. The mobilization of this phosphorus from bottom waters to the surface is increasing biological production, which in turn increases biological decomposition and the consumption of more oxygen. This positive-feedback cycle is believed to be process resulting in increasing phosphorus concentrations in South Turtle Lake.

The initial onset of anoxia in bottom waters within a lake can be caused by increasing external nutrient inputs from the watershed due to human development. In Kentuck Lake (Forest and Vilas counties), sediment core analysis revealed that external nutrient input began to increase following disturbances within the watershed (logging and shoreline development). While the increase in external nutrient input was gradual, it eventually led to higher productivity within the lake and the onset of anoxia in bottom waters. Internal nutrient loading became a significant source of phosphorus for Kentuck Lake in the 1970s, which has since made the lake significantly more productive (Onterra 2018). The development of anoxia in bottom waters and release of sediment-bound nutrients in South Turtle Lake may also be the result of historical watershed disturbances which increased external nutrient input to the lake.

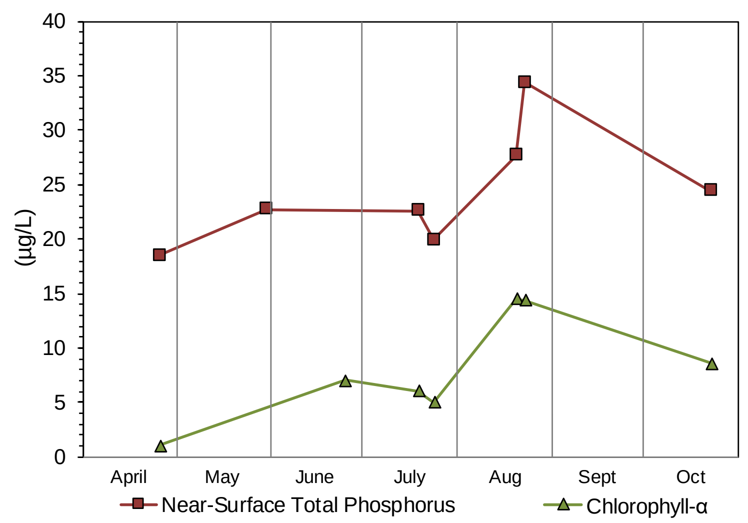


Figure 8.8.1-6. South Turtle Lake 2017 near-surface total phosphorus and chlorophyll-α concentrations illustrating "pulse" of phosphorus in August presumed to be caused by entrainment from the hypolimnion.

The presumed increasing magnitude of internal nutrient loading in South Turtle Lake could also be related to climate. Kraemer et al. (2015) found that average water temperature in lakes are increasing worldwide, and consequently are experiencing longer periods of stratification. These longer periods of stratification can result in longer periods of anoxia and release of nutrients from bottom sediments (Battarbee et al. 2012).

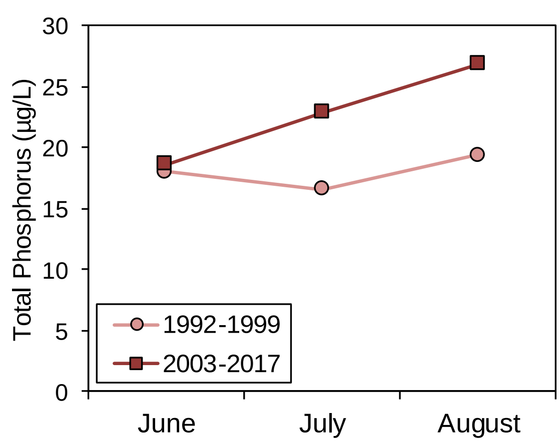


Figure 8.8.1-7. South Turtle Lake average summer near-surface total phosphorus concentrations from 1992-1999 and 2003-2017. These data illustrate that the largest increase in phosphorus concentration over this period has occurred in July and August.

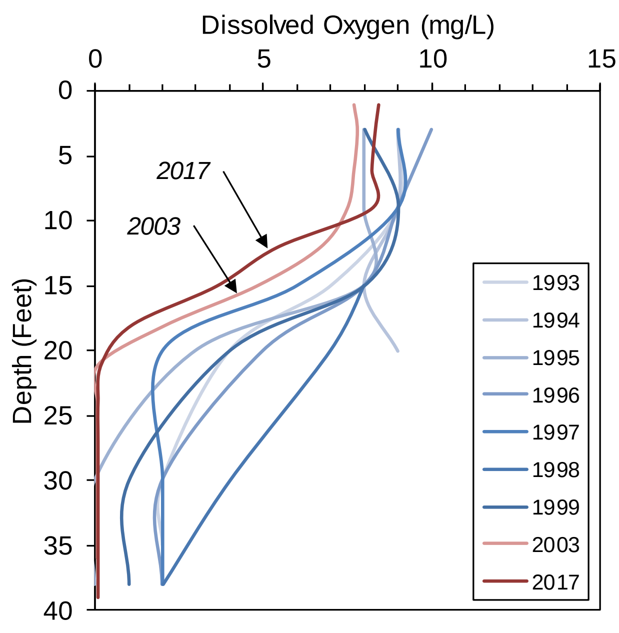


Figure 8.8.1-8. South Turtle Lake July dissolved oxygen profiles from 1993-1999, 2003, and 2017. The increased anoxia in bottom waters in 2003 and 2017 is an indication of eutrophication, or increasing nutrient concentrations and productivity.

More detailed studies of South Turtle Lake could be completed to accurately quantify the amount of phosphorus originating from internal nutrient loading. However, while phosphorus concentrations have increased over the past 25 years, summer phosphorus concentrations still fall into the *good* category for Wisconsin's deep headwater drainage lakes. Ongoing monitoring of the lake's water quality through the CLMN program will reveal if phosphorus concentrations continue to increase over time. If phosphorus concentrations continue to increase and algal blooms become more frequent, additional studies should be completed to determine if there are any applicable management strategies (e.g. alum treatment) that could be implemented to reduce the internal release of phosphorus from deep-water bottom sediments.

Chlorophyll-*a* concentrations, a measure of phytoplankton abundance, are available from South Turtle Lake from 1984, 1993-1999, and 2003-2017 (Figure 8.8.1-9). As expected, chlorophyll-*a* concentrations have seen a statistically valid (p-value = 0.001) increasing trend (R^2 = 0.40) over the time period from 1993-2017 corresponding with the increase in total phosphorus concentrations. The weighted average summer chlorophyll-*a* concentration is 8.4 µg/L, falling into the *good* category for deep headwater drainage lakes in Wisconsin. Summer chlorophyll-*a* concentrations in 2017 were slightly above average at 9.4 µg/L. South Turtle Lake's average summer chlorophyll-*a* concentration is higher than the median concentration for Wisconsin's deep headwater drainage lakes (5.0 µg/L) and higher than the median concentration for all lake types within the NLF ecoregion (5.6 µg/L).

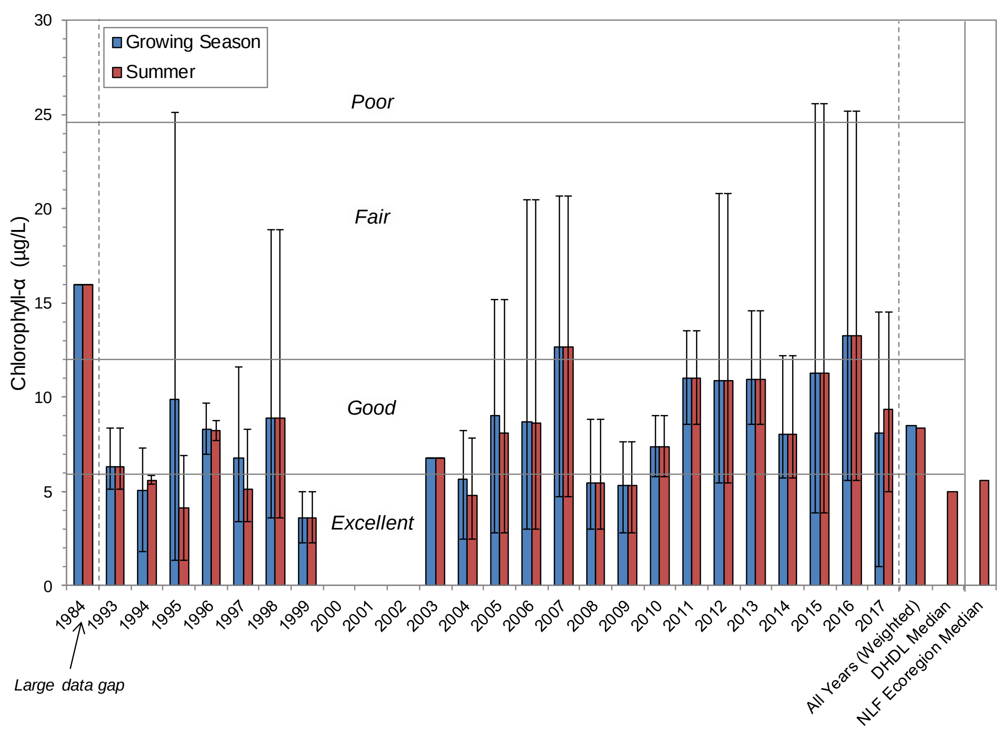


Figure 8.8.1-9. South Turtle Lake average annual chlorophyll-α concentrations and median chlorophyll-α concentrations for state-wide deep headwater drainage lakes (DHDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

While average summer chlorophyll-*a* concentrations in South Turtle Lake fall into the *good* category, the lake was placed on the 303(d) list of impaired waterbodies in 2018 for chlorophyll concentrations which exceed the threshold for recreational use. Every two years, this list of lakes that are not meeting water quality standards under the Clean Water Act are submitted by the state to the Environmental Protection Agency. Wisconsin's deep drainage lakes are considered impaired for chlorophyll concentrations exceed 20 µg/L for >5% of the days between July 15 and September 15.

Using chlorophyll data from 2012-2016 in South Turtle Lake, the WDNR found that chlorophyll concentrations exceeded 20 µg/L greater than 5% of the days between July 15 and September 15 of these years, and the lake was placed on the list of impaired waters in 2018. This list aids managers in determining possible management actions that are required to meet water quality standards. While chlorophyll concentrations exceed the recreational threshold, total phosphorus concentrations fall below the recreational threshold of 30 µg/L.

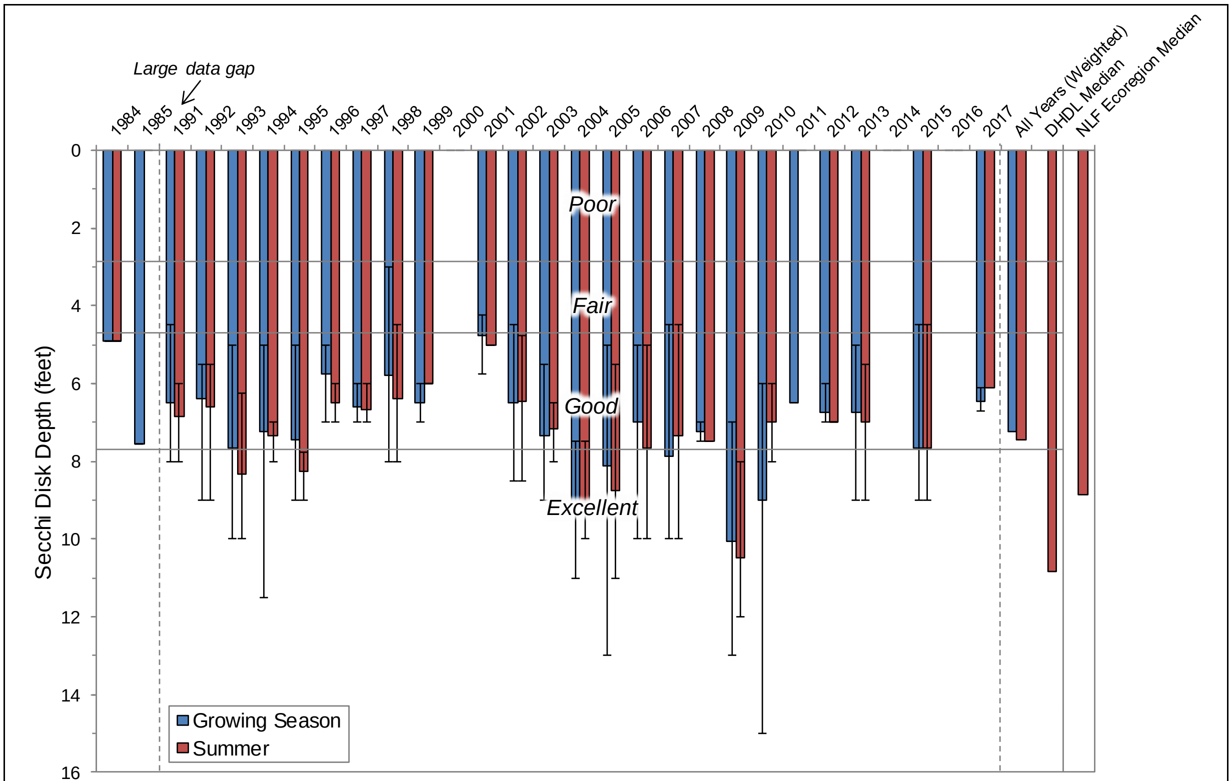


Figure 8.8.1-10. South Turtle Lake average annual Secchi disk depth and median Secchi disk depth for state-wide deep headwater drainage lakes (DHDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Secchi disk transparency data from South Turtle Lake are available from 1984-1985, 1991-1999, 2001-2013, 2015, and 2017 (Figure 8.8.1-10). The weighted summer average Secchi disk depth is 7.4 feet, falling into the *good* category for deep headwater lakes in Wisconsin. South Turtle Lake's average summer Secchi disk depth is lower than the median depth for Wisconsin's deep headwater drainage lakes (10.8 feet) and the median depth for all lake types within the NLF ecoregion (8.9 feet). Average summer Secchi disk depth in 2017 was below average at 6.1 feet. Despite an increase in chlorophyll-*a* concentrations from 1993-2017, there has been no statistically valid trend (positive or negative) in average summer Secchi disk depth over this period (p-value = 0.55) (Figure 8.8.1-11).

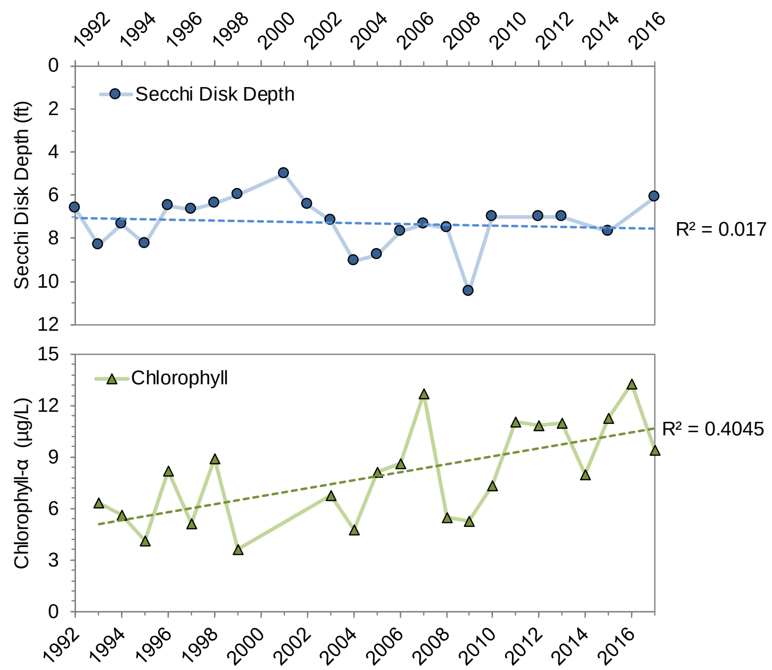


Figure 8.8.1-11. South Turtle Lake linear regressions of average summer Secchi disk depth (1992-2017) and chlorophyll-α (1993-2017). Change in Secchi disk depth was not statistically valid (p-value = 0.55); change in chlorophyll concentrations was statistically valid (p-value = 0.001).

Water clarity in South Turtle Lake has not declined despite increased algal production because its water clarity is largely regulated by dissolved humic substances. These humic substances originate from decaying vegetation within wetlands and forests and give the water a brown or tea-like color. A measure of water clarity once all of the suspended material (i.e. phytoplankton and sediments) have been removed, is termed *true color*, and measures how the clarity of the water is influenced by dissolved components. True color values measured from South Turtle Lake in 2017 averaged 40 SU (standard units), indicating the lake's water is *lightly tea-colored* to *tea-colored*.

Based on the average summer chlorophyll-*a* concentration of 6.0 µg/L from 1993-1999 in South Turtle Lake, the average summer Secchi disk depth was predicted to be 9.4 feet. However, the measured average summer Secchi disk depth during this period was 7.1 feet, over two feet lower than predicted. This is an indication that a factor other than phytoplankton, likely dissolved humic substances, were influencing water clarity. Based on the average summer chlorophyll-*a* concentration from 2003-2017 of 8.9 µg/L, average summer Secchi disk depth was predicted to be 7.7 feet, identical to the measured Secchi disk depth during this period. This indicates that the concentration of dissolved organic compounds may have declined when compared to the early 1990s, and water clarity in South Turtle Lake is currently regulated primarily by phytoplankton production. In 2017, Secchi disk depth was approximately 1.0 foot lower than predicted based upon chlorophyll concentrations. Above average precipitation in 2017 likely resulted in a higher input of dissolved humic substances and reducing water clarity. It is important to note that the tea-colored water in South Turtle Lake is natural, and is not an indication of degraded conditions.

South Turtle Lake Trophic State

Figure 8.8.1-12 contains the Trophic State Index (TSI) values for South Turtle Lake calculated from the data collected in 2017 along with historical data. These TSI values are calculated using summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency data. In general, the best values to use in assessing a lake's trophic state are chlorophyll-*a* and total phosphorus, as water clarity can be influenced by other factors other than phytoplankton such as dissolved humic substances. The closer the calculated TSI values for these three parameters are to one another indicates a higher degree of correlation.

The TSI values for South Turtle Lake indicate that the lake was historically in a mesotrophic state and has transitioned to a eutrophic state around 2011. In 2017, TSI values for both phosphorus and chlorophyll indicated eutrophic conditions. While the weighted mean TSI values using available data falls within the mesotrophic category, recent data indicates the lake is currently in a eutrophic state. As discussed previously, the increase in South Turtle Lake's productivity is believed to be due to increasing effects from internal nutrient loading. South Turtle Lake's productivity is higher when compared to the majority of deep headwater drainage lakes in Wisconsin and all lakes within the NLF ecoregion.

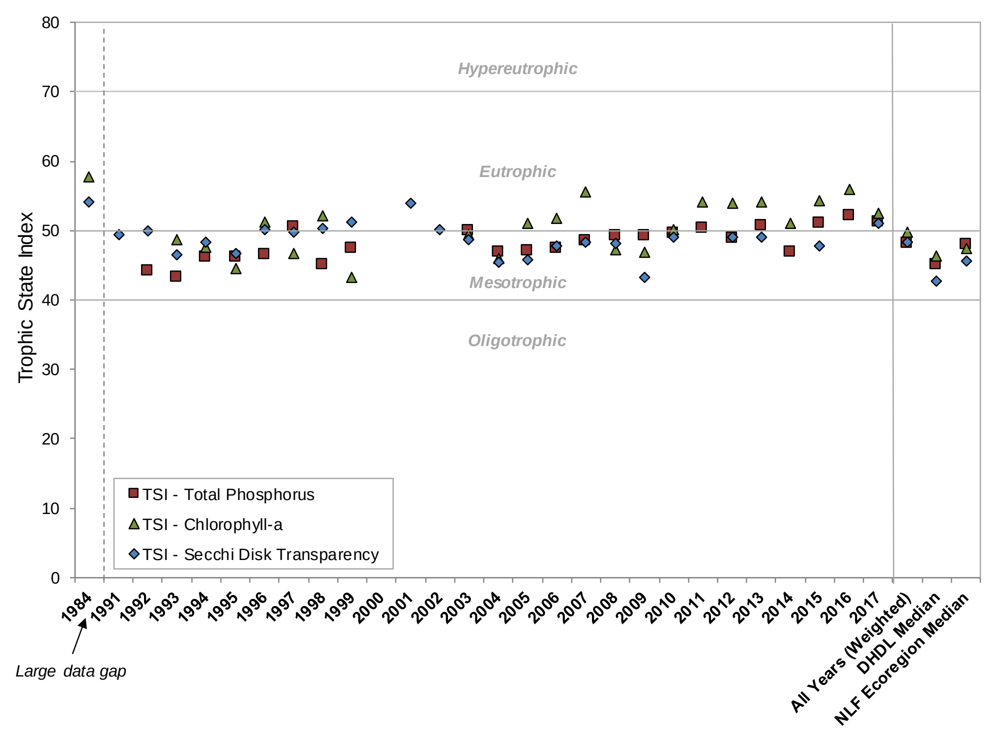


Figure 8.8.1-12. South Turtle Lake, statewide deep headwater drainage lakes (DHDL), and Northern Lakes and Forests (NLF) ecoregion lakes Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in South Turtle Lake

Dissolved oxygen and temperature profile data were collected during each water quality sampling events conducted by Onterra ecologists and South Turtle Lake CLMN volunteers. These data are displayed in Figure 8.8.1-13. The temperature and dissolved oxygen data collected in 2017 indicate that South Turtle Lake developed and maintained thermal stratification over the summer. Bottom waters were found to be anoxic in July at 20 feet and deeper. While historical temperature and dissolved oxygen profiles indicate the epilimnion in South Turtle Lake gets driven deeper over the course of the summer, profile data were not collected in August of 2017. In October 2017, temperature and dissolved oxygen were relatively uniform throughout the water column indicating fall mixing had occurred. Temperature and dissolved oxygen profiles were also collected through the ice in February of 2018. This sampling found that South Turtle Lake maintained sufficient oxygen throughout the water column to support aquatic life under the ice and that winter fish kills are not a concern.

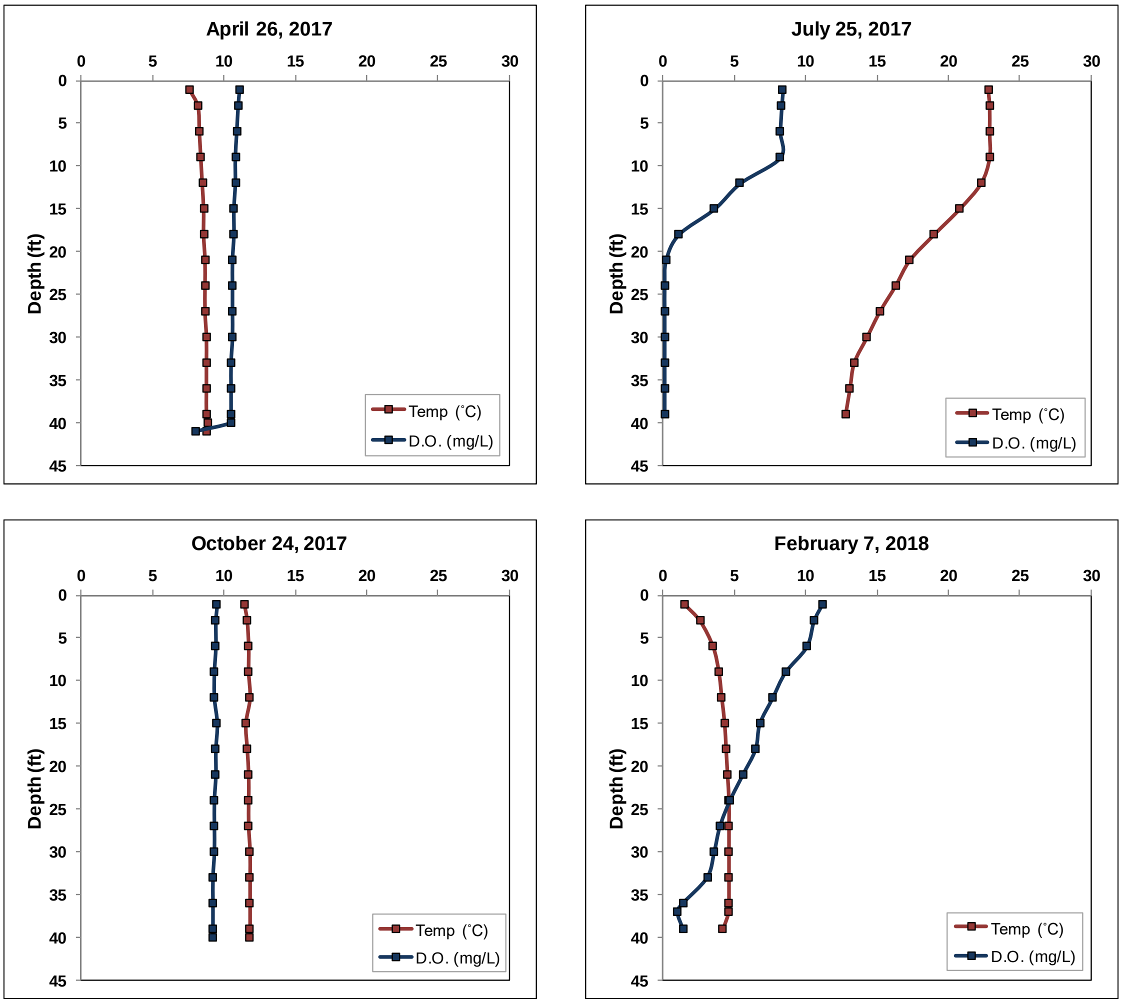


Figure 8.8.1-13. South Turtle Lake 2017/18 dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected from South Turtle Lake

The previous section is centered on parameters relating to South Turtle Lake's trophic state. 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 South Turtle 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.

As the Town-wide Section explains, the pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is thus an index of the lake's acidity. South Turtle Lake's mid-summer surface water pH was measured at 7.7 in 2017. This value indicates South Turtle Lake's water is alkaline and falls within the normal range for Wisconsin lakes. Fluctuations in pH with respect to seasonality are common; in-lake processes such as photosynthesis by plants act to reduce acidity by carbon dioxide removal while decomposition of organic matter adds carbon dioxide to water, thereby increasing acidity. A lake's pH is primarily determined by the water's alkalinity, or a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. South Turtle Lake's average alkalinity measured in 2017 was 36.4 mg/L as $CaCO_3$. This value falls within the expected range for northern Wisconsin lakes, and indicates that while South Turtle Lake is considered a softwater lake, it is not sensitive to fluctuations in pH from acid rain.

Water quality samples collected from South Turtle Lake in 2017 were also analyzed for calcium. Calcium concentrations, along with pH, are currently being used to determine if a waterbody is suitable to support the invasive zebra mussel, as these animals require calcium for the construction of their shells. Zebra mussels typically require higher calcium concentrations than Wisconsin's native mussels, and lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The accepted suitable pH range for zebra mussels is 7.0 – 9.0, and South Turtle Lake's pH falls within this range. South Turtle Lake's calcium concentration in 2017 was 11.7 mg/L, indicating the lake has *very low susceptibility* to zebra mussel establishment. Plankton tows were completed by Onterra ecologists at three locations in South Turtle Lake in 2017 that underwent analysis for the presence of zebra mussel veligers, their planktonic larval stage. Analysis of these samples were negative for zebra mussel veligers, and Onterra ecologists did not observe any adult zebra mussels during the 2017 surveys.

As discussed earlier in this section, South Turtle Lake was recently placed on the 303(d) list of impaired waters due to chlorophyll concentrations which exceed the recreational threshold. South Turtle Lake was also placed on the 303(d) list for contaminated fish tissue by mercury in 1998. While mercury is found naturally in the environment due to volcanic eruptions and weathering of rocks, the majority of the mercury found in Wisconsin's waterbodies is the result of coal-fired power plants and the release of mercury into the atmosphere. Mercury is deposited into lakes, rivers, and streams through precipitation and the deposition of dust particles where it converted into its mobile and harmful form, methylmercury. Methylmercury becomes stored in bodies of aquatic animals, and concentrations tend to be highest in those species at the top of the food chain. In humans, mercury affects the nervous system and is of special concern for unborn children, infants, and children. For advice on eating fish from South Turtle Lake, please see the South Turtle Lake Fisheries Data Integration Section (Section 8.8.6).

8.8.2 South Turtle Lake Watershed Assessment

South Turtle Lake's surficial watershed encompasses approximately 15,356 acres (Figure 8.8.2-1 and South Turtle Lake – Map 2) yielding a watershed to lake area ratio of 34:1. However, as mentioned in the South Turtle Lake Water Quality Section (Section 8.8.1), given the close proximity of the inlet from North Turtle Lake and the Turtle River outlet, Onterra ecologists believe the majority of the water flowing into South Turtle Lake from North Turtle Lake flows out through the Turtle River and does not mix throughout South Turtle Lake proper. In other words, it is believed that the North Turtle Lake watershed has minimal influence on South Turtle Lake's water quality and its water quality is primarily influenced from its local or direct watershed. For this reason, modeling of South Turtle Lake's watershed involved estimations of phosphorus loading from its direct watershed and phosphorus inputs from the North Turtle Lake watershed were excluded.

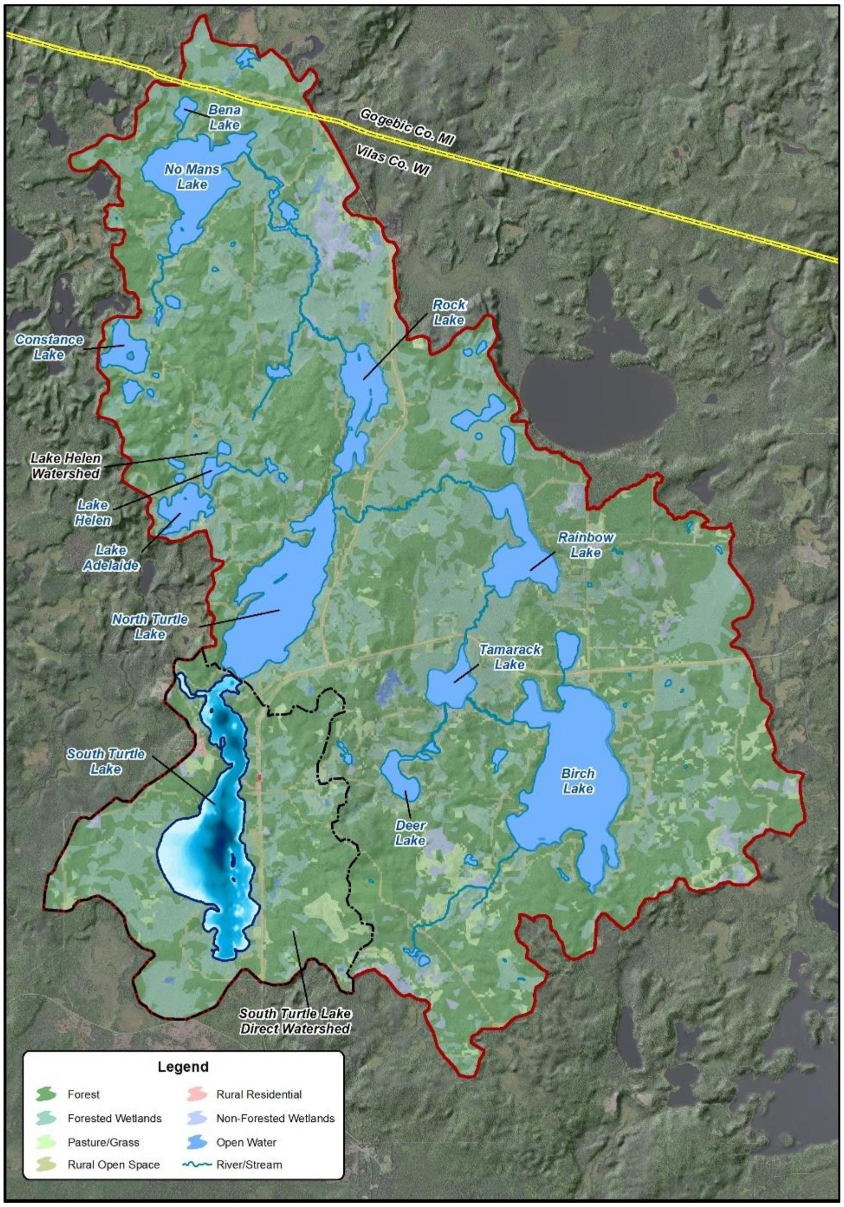


Figure 8.8.2-1. South Turtle Lake watershed boundary (red line), direct watershed (black dashed line) and land cover types. Black dashed lines indicate subwatersheds used in WiLMS modeling. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

South Turtle Lake's direct watershed encompasses approximately 2,455 acres and is comprised of land cover types including forests (43%), wetlands (27%), the lake's surface itself (20%), pasture/grass and rural open space (8%), and rural residential areas (<1%) (Figure 8.8.2-2). Wisconsin Lakes Modeling Suite (WiLMS) modeling indicates that South Turtle Lake's water residence time is approximately 2.7 years, or the water within the lake is completely replaced once every 2.7 years.

Using the land cover types within South Turtle Lake's direct watershed, WiLMS was utilized to estimate the annual potential phosphorus load delivered to South Turtle Lake. In addition, data obtained from a stakeholder survey sent to South Turtle Lake riparian property owners in 2017 was also used to estimate the amount of phosphorus loading to the lake from riparian septic systems. The model estimated that approximately 551 pounds of phosphorus are delivered to South Turtle Lake from its watershed on an annual basis (Figure 8.8.2-3).

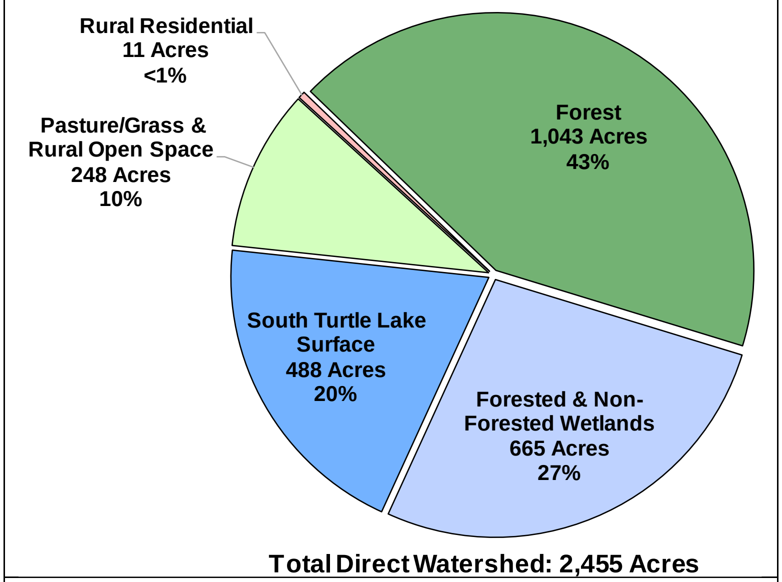


Figure 8.8.2-2. South Turtle Lake estimated potential annual phosphorus loading. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Using the estimated annual potential phosphorus load of 351 pounds, WiLMS predicted an in-lake growing season average total phosphorus concentration of 19 µg/L, which is 18% lower than the measured weighted average growing season mean of 23 µg/L and 23% lower than the measured growing season mean in 2017 of 24 µg/L. The higher measured phosphorus relative to the model-predicted phosphorus is an indication that an additional source of phosphorus is likely being loaded to South Turtle Lake that was not accounted for within the model. As is discussed in the South Turtle Lake Water Quality Section (Section 8.8.1), it is believed that phosphorus released from bottom sediments during summer stratification is being mobilized to the surface in late-summer through entrainment. The WiLMS modeling indicates that in order to achieve the measured concentrations of phosphorus in South Turtle Lake, and additional 100-200 pounds of phosphorus have to be loaded to the lake annually. Given the available data, it is believed this additional phosphorus originates from internal nutrient loading.

With the addition of the estimated internal nutrient loading, it is estimated that South Turtle Lake receives an average of 441-551 pounds of phosphorus per year (Figure 8.8.2-2). Internal nutrient loading accounts for approximately 36% of this load, direct atmospheric deposition onto the lake's surface accounts for 24%, forests account for 15%, pasture/grass and rural open space account for 12%, wetlands account for 11%, and riparian septic systems account for an estimated 11%.

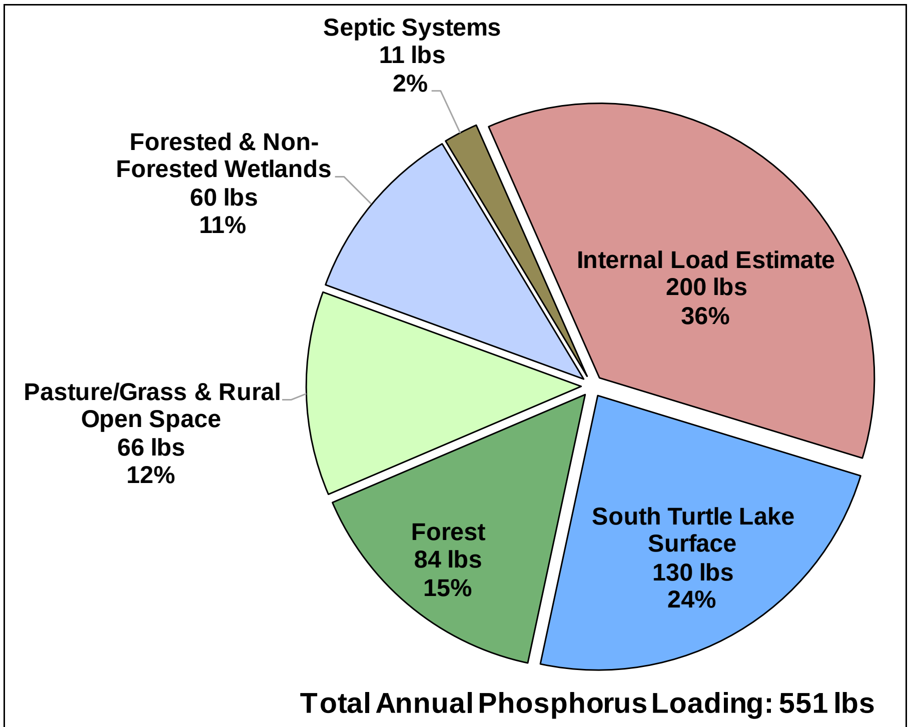


Figure 8.8.2-3. South Turtle Lake estimated potential annual phosphorus loading. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

8.8.3 South Turtle Lake Shoreland Condition

Shoreland Development

As is discussed within the Town-wide Section, one of the most sensitive areas of a lake's watershed is the immediate shoreland zone. This transition zone between the aquatic and terrestrial environment is the last source of protection for the lake against pollutants originating from roads, driveways, and yards above, and is also a critical area for wildlife habitat and overall lake ecology. In the fall of 2017, the immediate shoreland of South Turtle Lake was assessed in terms of its development, and the shoreland zone was characterized with one of five shoreland development categories ranging from urbanized to completely undeveloped.

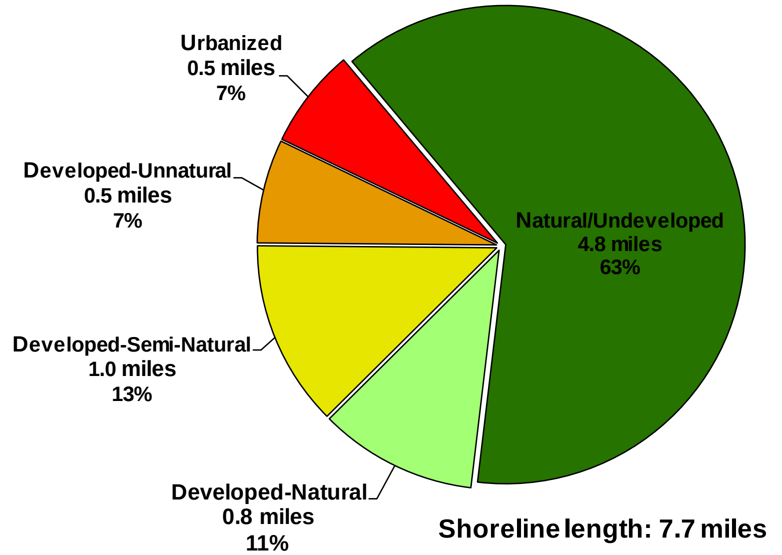


Figure 8.8.3-1. South Turtle Lake shoreland categories and total lengths. Based upon a fall 2017 survey. Locations of these categorized shorelands can be found on South Turtle Lake - Map 3.

The 2017 survey revealed that South Turtle Lake has stretches of shoreland that fit all five shoreland assessment categories (Figure 8.8.3-1). In total, 5.6 miles (74%) of the 7.7-mile shoreland zone were categorized as natural/undeveloped or developed-natural or shoreland types that provide the most benefit to the lake and should be left in their natural state if possible. Approximately 1.0 miles (14%) of the shoreland was categorized as developed-unnatural or urbanized, shoreland areas which provide little benefit to and may actually adversely impact the lake. If restoration of South Turtle Lake's shoreland is to occur, primary focus should be placed on these highly developed shoreland areas. South Turtle Lake – Map 3 displays the locations of these shoreland categories around the entire lake.

Coarse Woody Habitat

A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey on South Turtle Lake in 2017. Coarse woody habitat was identified, and classified in several size categories (2-8 inches diameter, >8 inches diameter and cluster) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed in the Town-wide Section, 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 et al. 2005).

During the coarse woody habitat survey on South Turtle Lake, a total of 299 pieces were observed along 7.7 miles of shoreline, yielding a coarse woody habitat to shoreline mile ratio of 39:1 (Figure 8.8.3-2). Onterra ecologists have completed these surveys on 98 Wisconsin lakes since 2012, and South Turtle Lake falls in the 75th percentile for the number of coarse woody habitat pieces per shoreline mile. Refraining from removing these woody habitats from the shoreland area will ensure this high-quality habitat remains in South Turtle Lake. The locations of these coarse woody habitat pieces are displayed on South Turtle Lake – Map 4.

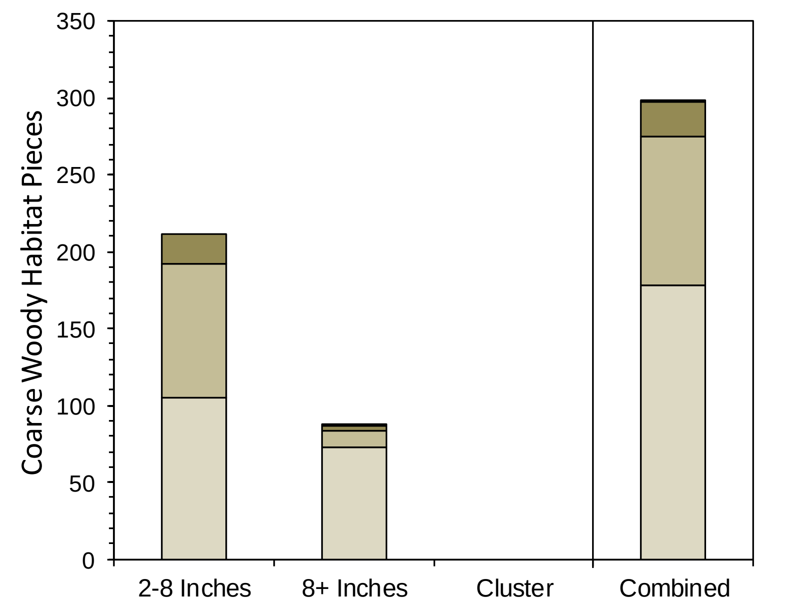


Figure 8.8.3-2. South Turtle Lake coarse woody habitat survey results. Based upon a fall 2017 survey. Locations of South Turtle Lake coarse woody habitat can be found on South Turtle Lake – Map 4.

8.8.4 South Turtle Lake Aquatic Vegetation

An Early-Season Aquatic Invasive Species (ESAIS) Survey was conducted by Onterra ecologists on South Turtle Lake on June 27 and 28, 2017. While the intent of this survey is to locate any potential non-native species within the lake, the primary focus is to locate occurrences of the non-native curly-leaf pondweed which should be at or near its peak growth at this time. Fortunately, no curly-leaf pondweed was located in South Turtle Lake in 2017, and it is believed that curly-leaf pondweed is not present within the lake or exists at an undetectable level. However, pale-yellow iris, a non-native wetland plant, was located in a few locations along South Turtle Lake's shoreline in 2017. Because of its ecological significance, pale-yellow iris in South Turtle Lake is discussed further in the subsequent Non-Native Aquatic Plants subsection.

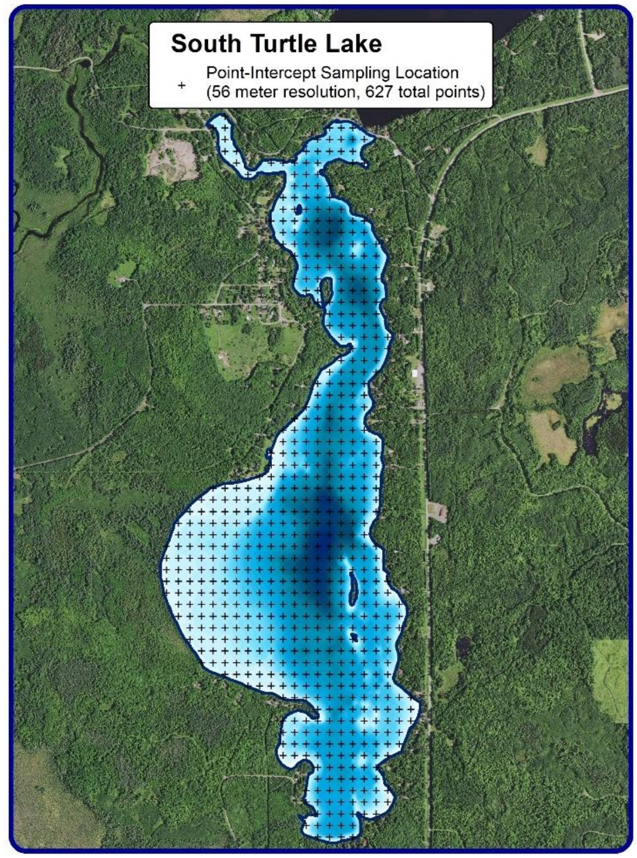


Figure 8.8.4-1. South Turtle Lake whole-lake point-intercept survey sampling locations.

The whole-lake aquatic plant point-intercept survey and emergent and floating-leaf aquatic plant community mapping survey were conducted on South Turtle Lake by Onterra ecologists on July 17 and 18, 2017 (Figure 8.8.4-1). During these surveys, a total of 41 aquatic plant species were located, one of which is considered to be a non-native, invasive species: pale-yellow iris (Table 8.8.4-1).

Lakes in Wisconsin vary in their morphometry, water chemistry, substrate composition, and management, all factors which influence aquatic plant community composition. In late September of 2017, Onterra ecologists completed an acoustic survey on South Turtle Lake (bathymetric results on South Turtle Lake – Map 1). The sonar-based technology records aquatic plant bio-volume, or the percentage of the water column that is occupied by aquatic plants at a given location. Data pertaining to South Turtle Lake's substrate composition were also recorded during this survey. The sonar records substrate hardness, ranging from the hardest substrates (i.e. rock and sand) to the more flocculent, softer organic sediments.

Data regarding substrate hardness collected during the 2017 acoustic survey showed that shallower areas of South Turtle Lake from approximately 1 to 10 feet contained both the hardest and softest substrates within the lake. The shallowest areas within the large bay on the southwest side of the lake contained some of the softest substrates, while hard substrates were found throughout shallower areas elsewhere around the lake. Beyond 10 feet to the deepest areas in the lake, substrates were moderately hard and more uniform when compared to shallower areas. 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 areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because of the different habitat types that are available.

Table 8.8.4-1. List of aquatic plant species located in South Turtle Lake during Onterra 2017 aquatic plant surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2017 (Onterra)
Emergent	*Acorus americanus*	Sweetflag	7	I
	Carex comosa	Bristly sedge	5	I
	Carex retrorsa	Retrorse sedge	6	I
	Decodon verticillatus	Water-willow	7	I
	Dulichium arundinaceum	Three-way sedge	9	I
	Eleocharis palustris	Creeping spikerush	6	I
	Equisetum fluviatile	Water horsetail	7	I
	Iris pseudacorus	Pale yellow iris	Exotic	I
	Iris versicolor	Northern blue flag	5	I
	Pontederia cordata	Pickerelweed	9	I
	Sagittaria latifolia	Common arrowhead	3	I
	Schoenoplectus acutus	Hardstem bulrush	5	X
FL	*Brasenia schreberi*	Watershield	7	X
	Nuphar variegata	Spatterdock	6	X
	Nymphaea odorata	White water lily	6	X
	Sparganium fluctuans	Floating-leaf bur-reed	10	X
Submersed	*Bidens beckii*	Water marigold	8	X
	Ceratophyllum demersum	Coontail	3	X
	Ceratophyllum echinatum	Spiny hornwort	10	X
	Chara spp.	Muskgrasses	7	X
	Elodea canadensis	Common waterweed	3	X
	Elodea nuttallii	Slender waterweed	7	X
	Fontinalis sphagnifolia	Rolled water moss	N/A	X
	Heteranthera dubia	Water stargrass	6	X
	Isoetes spp.	Quillwort spp.	8	I
	Myriophyllum sibiricum	Northern watermilfoil	7	X
	Najas flexilis	Slender naiad	6	X
	Nitella spp.	Stoneworts	7	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton gramineus	Variable-leaf pondweed	7	X
	Potamogeton natans	Floating-leaf pondweed	5	I
	Potamogeton praelongus	White-stem pondweed	8	X
	Potamogeton pusillus	Small pondweed	7	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X
	Potamogeton robbinsii	Fern-leaf pondweed	8	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	I
	*Potamogeton vaseyi**	Vasey's pondweed	10	I
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Utricularia vulgaris	Common bladderwort	7	X
	Vallisneria americana	Wild celery	6	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free
X = Located on rake during point-intercept survey; I = Incidental Species
** = Species listed as special concern in Wisconsin by WDNR Natural Heritage Inventory*

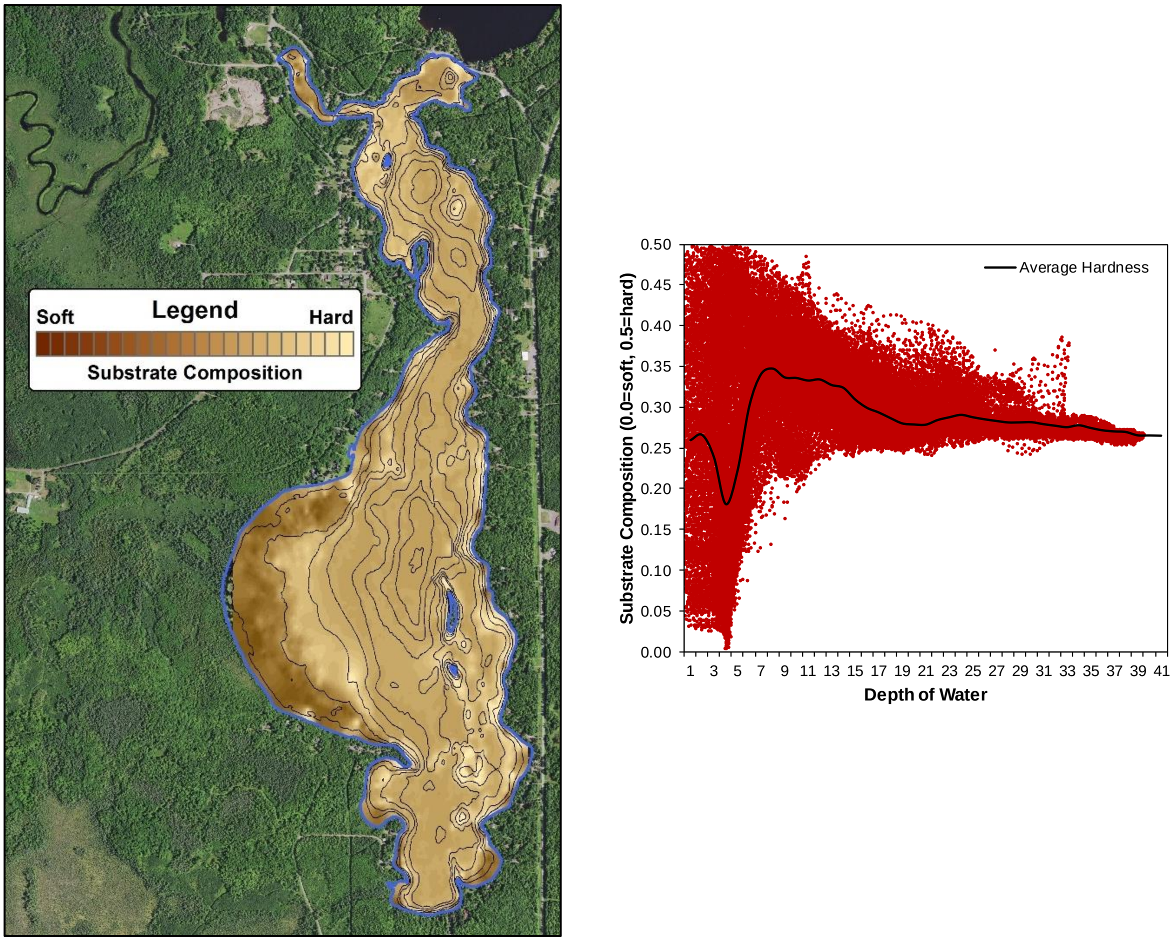


Figure 8.8.4-2. South Turtle Lake spatial distribution of substrate hardness (left) and substrate hardness across water depth (right). Depth contours represent 5-foot intervals. Individual data points are displayed in red. Creating using data from September 2017 acoustic survey.

The acoustic survey also recorded aquatic plant bio-volume throughout the entire lake. As mentioned earlier, aquatic plant bio-volume is the percentage of the water column that is occupied by aquatic plants. The 2017 aquatic plant bio-volume data are displayed in Figure 8.8.4-3 and South Turtle Lake – Map 6. Areas where aquatic plants occupy most or all of the water column are indicated in red. The 2017 whole-lake point-intercept survey found aquatic plants growing to a maximum depth of 10 feet. However, the majority of aquatic plant growth occurs within 3.0-7.0 feet of water. The 2017 acoustic survey indicated approximately 24% (117 acres) of South Turtle Lake's area is occupied by aquatic vegetation, while the remaining 76% of the lake contains unsuitable substrates or is too deep to support aquatic plant growth.

As mentioned, aquatic plants were recorded growing to a maximum depth of 10 feet in 2017. Of the 247 point-intercept sampling locations that fell at or shallower than the maximum depth of plant growth (littoral zone), approximately 61% contained aquatic vegetation. Aquatic plant rake fullness data collected in 2017 indicates that 22% of the 247 littoral sampling locations contained vegetation with a total rake fullness rating (TRF) of 1, 14% had a TRF rating of 2, and 25% had a TRF rating of 3 (Figure 8.8.4-4). These TRF ratings indicate that the biomass of aquatic vegetation in South Turtle Lake is moderate.

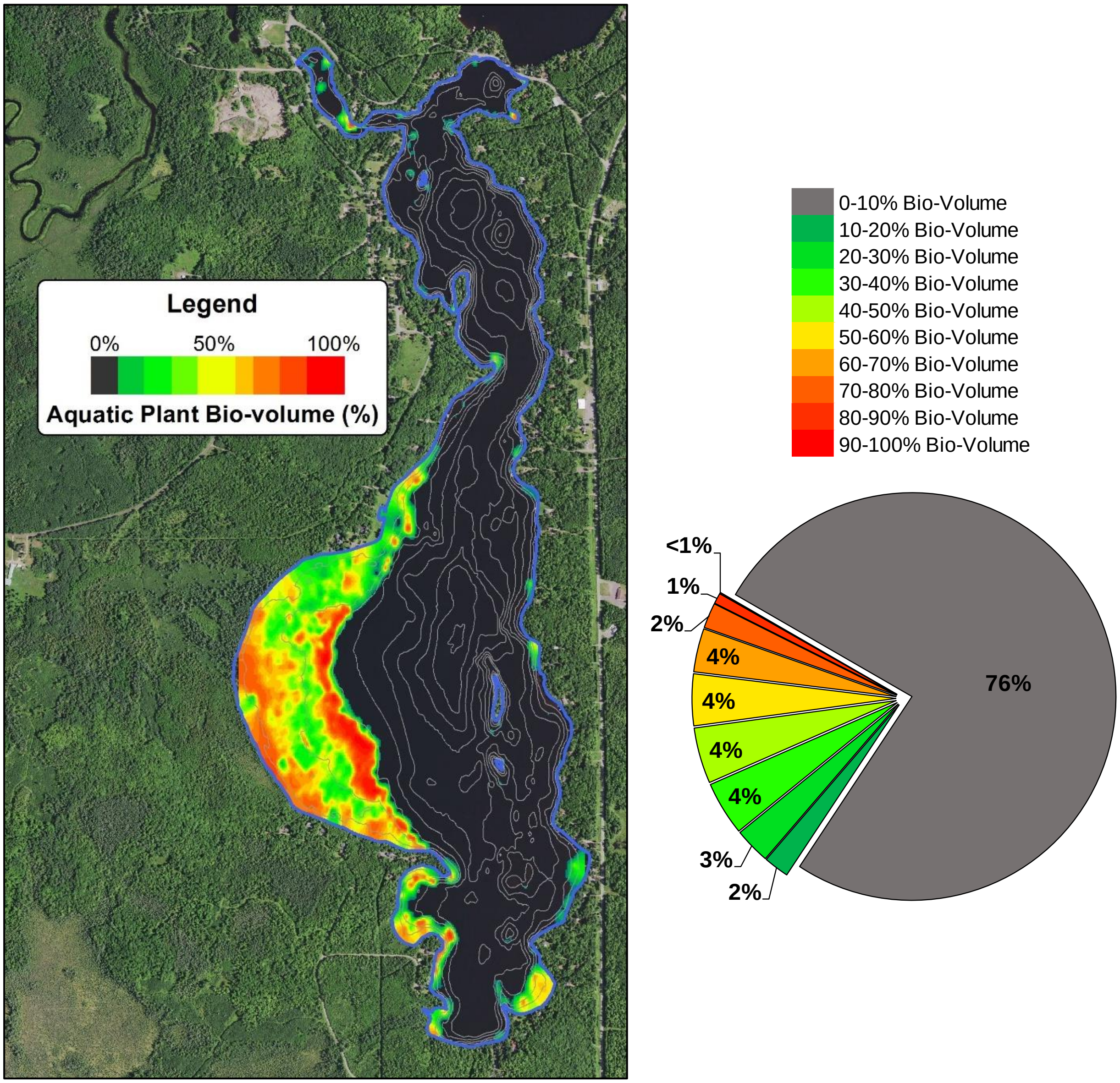


Figure 8.8.4-3. South Turtle Lake 2017 aquatic plant bio-volume. Contour lines are 5-foot intervals. Created using data from September 2017 acoustic survey data.

While the acoustic mapping is an excellent survey for understanding the distribution and levels of aquatic plant growth throughout the lake, this survey does not determine what aquatic plant species are present. Whole-lake point-intercept surveys are used to quantify the abundance of individual species within the lake. Of the 41 aquatic plant species located in South Turtle Lake in 2017, 26 were encountered directly on the rake during the whole-lake point-intercept survey (Figure 8.8.4-6). The remaining 15 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 relatively rare within the plant community. Of the 26 species directly sampled with the rake during the point-intercept survey, fern-leaf pondweed, small pondweed, and wild celery were the three most frequently encountered aquatic plant species (Figure 8.8.4-5).

Fern-leaf pondweed was the most frequently encountered aquatic plant species in South Turtle Lake in 2017 with a littoral frequency of occurrence of 35% (Figure 8.8.4-5). 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 South Turtle Lake, fern-leaf pondweed, fern-leaf pondweed was most abundant between 4.0 and 6.0 feet of water over areas of soft sediment.

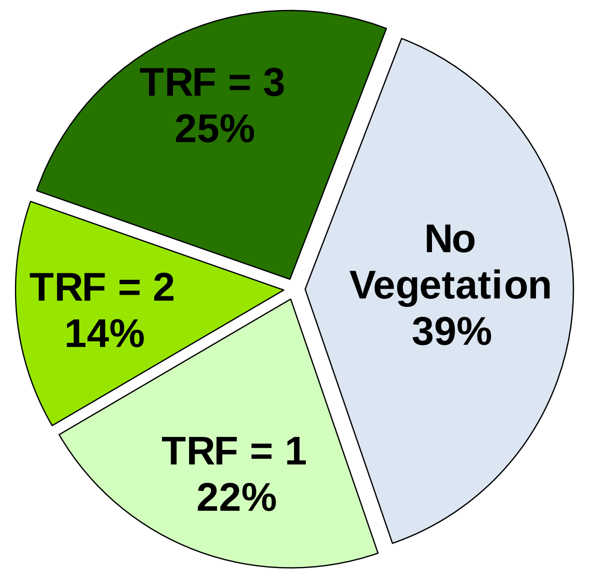


Figure 8.8.4-4. South Turtle Lake 2017 aquatic vegetation total rake fullness ratings (TRF). Created from data collected during the 2017 whole-lake point-intercept survey (N = 247).

Small pondweed was the second-most frequently encountered aquatic plant in South Turtle Lake in 2017 with a littoral occurrence of 15% (Figure 8.8.4-5). Small pondweed is one of several narrow-leaf pondweed (*Potamogeton*) species that can be found in Wisconsin. While their name suggests these plants are small in stature, small pondweed often produces long stems (up to 17 feet; Onterra, personal obs.) with alternate, linear-shaped leaves. Small pondweed can often form dense colonies, and larger colonies of small pondweed were observed in the large bay on the southwest side of South Turtle Lake in 2017. Their dense network of stems and leaves provide excellent structural habitat and aid in reducing sediment resuspension. Small pondweed was most abundant between 6.0 and 9.0 feet in South Turtle Lake.

Wild celery, also known as tape or eelgrass, was the third-most frequently encountered aquatic plant species in South Turtle Lake in 2017 with a littoral frequency of occurrence of 13% (Figure 8.8.4-5). 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. South Turtle Lake's areas of sand/cobble and low light conditions as a result of its stained water favor the dominance of wild celery. In 2017, wild celery was most abundant over hard substrates in water 2.0-5.0 feet deep in South Turtle Lake.

Submersed aquatic plants can be grouped into one of two general categories based upon their morphological growth form and habitat preferences. These two groups include species of the *isoetid* growth form and those of the *elodeid* growth form. Plants of the isoetid growth form are small, slow-growing, inconspicuous submerged plants (Photo 8.8.4-2). These species often have evergreen, succulent-like leaves and are usually found growing in sandy/rocky soils within near-shore areas of a lake (Boston and Adams 1987, Vestergaard and Sand-Jensen 2000).

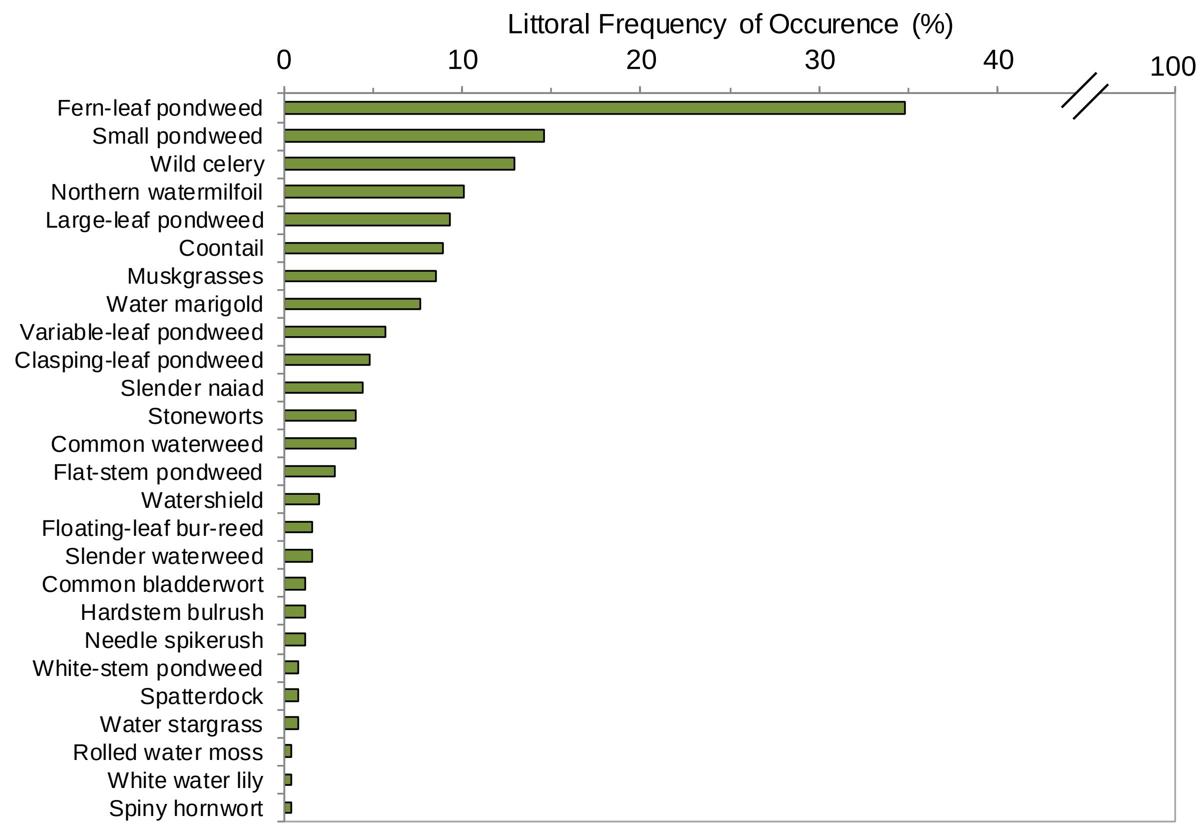


Figure 8.8.4-5. South Turtle Lake 2017 littoral frequency of occurrence of aquatic plant species. Created using data from 2017 whole-lake point-intercept survey.

In contrast, aquatic plant species of the elodeid growth form have leaves on tall, erect stems which grow up into the water column, and are the plants that lake users are likely more familiar with (Photo 8.8.4-2). It is important to note that the definition of these two groups is based solely on morphology and physiology and not on species' relationships. For example, dwarf-water milfoil (*Myriophyllum tenellum*) is classified as an isoetid, while all of the other milfoil species in Wisconsin such as northern water milfoil (*Myriophyllum* sibiricum) are classified as elodeids.

Alkalinity, as it relates to the amount of bicarbonate within the water, is the primary water chemistry factor for determining a lake's aquatic plant community composition in terms of isoetid versus elodeid growth forms (Vestergaard and Sand-Jensen 2000). Most aquatic plant species of the elodeid growth form cannot inhabit lakes with little or no alkalinity because their carbon demand for photosynthesis cannot be met solely from the dissolved carbon dioxide within the water and must be supplemented from dissolved bicarbonate.

On the other hand, aquatic plant species of the isoetid growth form can thrive in lakes with little or no alkalinity because they have the ability to derive carbon dioxide directly from the sediment, and many also have a modified form of photosynthesis to maximize their carbon storage (Madsen et al. 2002). While isoetids are able to grow in lakes with higher alkalinity, their short stature makes them poor competitors for space and light against the taller elodeid species. Thus, isoetids are most prevalent in lakes with little to no alkalinity where they can avoid competition from elodeids. However, in lakes with moderate alkalinity, like South Turtle Lake, the aquatic plant community can be comprised of isoetids growing beneath a scattered canopy of the larger elodeids. Isoetid communities are vulnerable to sedimentation and eutrophication (Smolders et al. 2002), and a number are listed as special concern (e.g. northeastern bladderwort) or threatened in Wisconsin due to their rarity and susceptibility to environmental degradation.

Photo 8.8.4-2. Lake quillwort (*Isoetes lacustris*) of the isoetid growth form (left) and variable pondweed (*Potamogeton gramineus*) and fern pondweed (*P. robbinsii*) of the elodeid growth form (right).

As discussed in the Town-Wide 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 native species encountered on the rake during 2017 point-intercept survey on South Turtle Lake and their conservatism values were used to calculate the FQI of South Turtle Lake's aquatic plant community (equation shown below).

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

Figure 8.8.4-6 compares the 2017 FQI components of South Turtle Lake to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) ecoregion and lakes throughout Wisconsin. The native species richness, or number of native aquatic plant species located on the rake in 2017 (26) falls above the median value for lakes in the NLFL ecoregion (21) and for lakes throughout Wisconsin (19) (Figure 8.8.4-7). The average conservatism of the 26 native aquatic plant species located in South Turtle Lake in 2017 was 6.6, falling just below the median average conservatism values for lakes within the NLFL ecoregion (6.7) but above the median value for lakes throughout Wisconsin (6.3) (Figure 8.8.4-7). This indicates that a higher proportion of South Turtle Lake's aquatic plant community is comprised of environmentally-sensitive species, or species with higher conservatism values.

Using South Turtle Lake's native aquatic plant species richness and average conservatism yields a high FQI value of 33.4 (Figure 8.8.4-6). South Turtle Lake's FQI value exceeds the median values for lakes within the NLFL ecoregion (30.8) and the median value for lakes throughout the state (27.2). Overall, the FQI analysis indicates that the aquatic plant community found in South Turtle Lake is of higher quality when compared to the majority of lakes in Wisconsin.

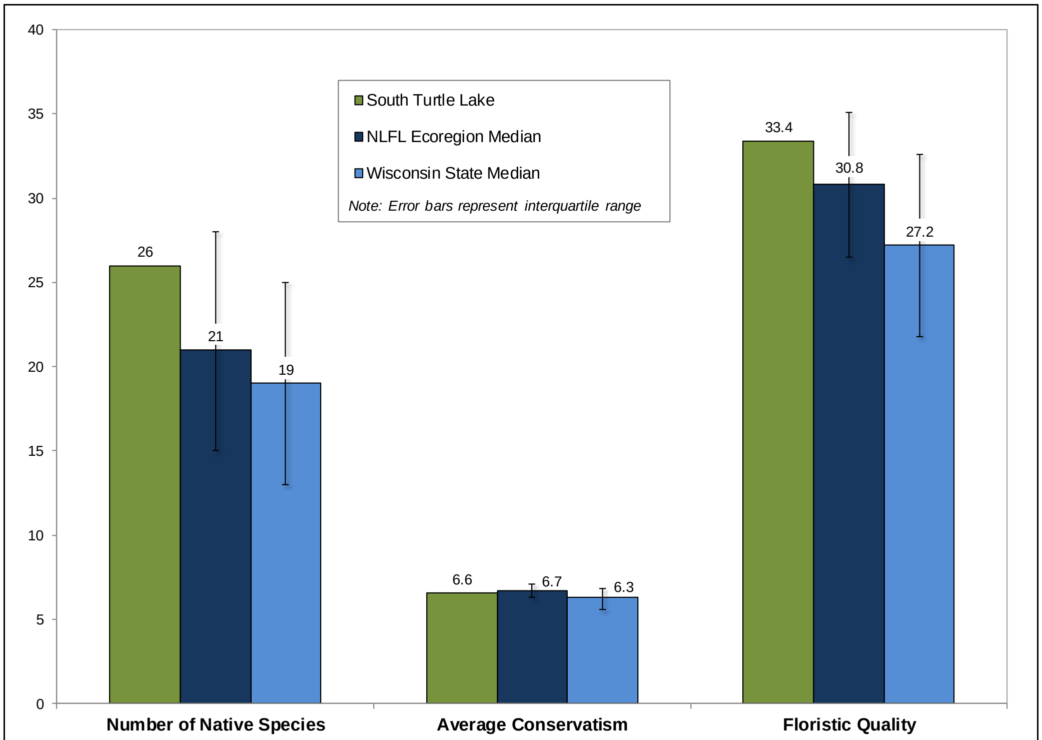


Figure 8.8.4-6. South Turtle Lake Floristic Quality Assessment. Created using data from Onterra 2017 whole-lake point-intercept survey. Analysis follows Nichols (1999).

As explained in the Town-wide section, 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 South Turtle Lake contains a lower number of aquatic plant species, one may assume the aquatic plant community has low 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 South Turtle Lake's diversity value ranks. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 212 lakes within the NLFL ecoregion (Figure 8.8.4-7). Using the data collected from the 2017 point-intercept survey, South Turtle Lake's aquatic plant was found to have high species diversity with a Simpson's Diversity Index value of 0.90. In other words, if two individual aquatic plants were randomly sampled from South Turtle Lake in 2017, there would be a 90% probability that they would be different species. South Turtle Lake's Simpson's Diversity exceeds 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 South Turtle Lake's species diversity is to look at the relative occurrence of aquatic plant species. Figure 8.1.4-8 displays the relative frequency of occurrence of aquatic plant species created from the 2017 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 fern-leaf pondweed was found at 35% of the littoral sampling locations in South Turtle Lake in 2017, its relative frequency of occurrence was 24%. Explained another way, if 100 plants were randomly sampled from South Turtle Lake in 2017, 24 of them would be fern-leaf pondweed.

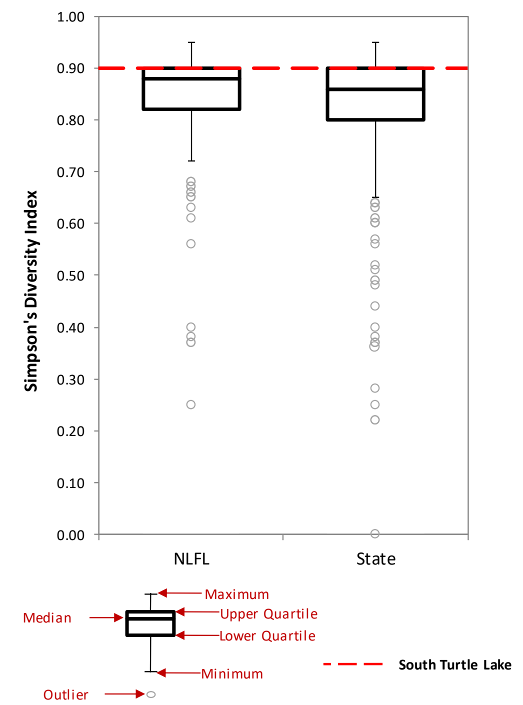


Figure 8.8.4-7. South Turtle Lake species diversity index. Created using data from Onterra 2016 point-intercept survey.

In 2017, Onterra ecologists also conducted a survey aimed at mapping emergent and floating-leaf aquatic plant communities in South Turtle Lake. This survey revealed South Turtle Lake contains approximately 23 acres of these communities comprised of 16 plant species (South Turtle Lake – Map 7 and Table 8.8.4-2). These native emergent and floating-leaf plant communities provide valuable fish and wildlife habitat that is important to the ecosystem of the lake. These areas are particularly important during times of fluctuating water levels, since structural habitat of fallen trees and other forms of course-woody habitat can be quite sparse along the shores of receding water lines. The community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, and a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within South Turtle Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development.

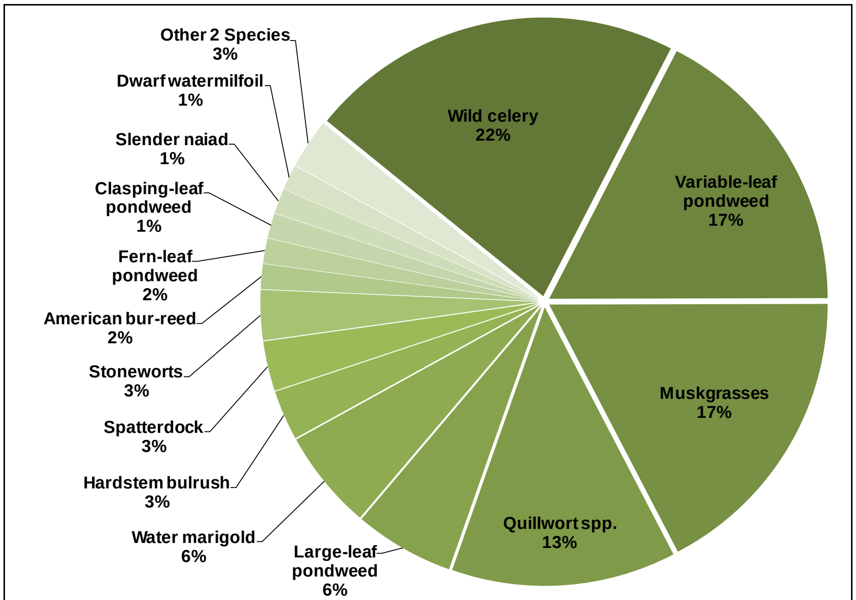


Figure 8.8.4-9. South Turtle Lake 2017 relative frequency of occurrence of aquatic plant species. Created using data from 2017 point-intercept survey.

Table 8.8.4-2. South Turtle Lake 2017 acres of emergent and floating-leaf aquatic plant communities. Created using data from 2017 aquatic plant community mapping survey.

Plant Community	Acres
Emergent	6.7
Floating-leaf	13.0
Mixed Emergent & Floating-leaf	3.7
Total	**23.3**

Non-native Aquatic Plants in South Turtle Lake

Pale-Yellow Iris

Pale yellow iris (*Iris pseudacorus*; Photo 8.8.4-4 and South Turtle Lake – Map 8) is a large, showy iris with bright yellow flowers. Native to Europe and Asia, this species was sold commercially in the United States for ornamental use and has since escaped into Wisconsin's wetland areas forming large monotypic colonies and displacing valuable native wetland species. Pale-yellow iris was located growing in a few locations along the shorelines of South Turtle Lake by NLDC and Onterra staff in 2017 (South Turtle Lake – Map 7). There are a number of control strategies that can be used to control pale-yellow iris. A strategy for managing pale-yellow iris on South Turtle Lake is discussed within the Turtle Chain Implementation Plan.

Photo 8.8.4-4. Pale-yellow iris (*Iris pseudacorus*), a non-native, invasive wetland plant found along the shorelines of South Turtle Lake in 2017. Photo credit Onterra.

8.8.5 Aquatic Invasive Species in South Turtle Lake

As of 2017, the only non-native species documented in South Turtle Lake is pale-yellow iris (*Iris pseudacorus*). However, the non-native rusty crayfish (*Orconectes rusticus*) has been documented in North Turtle Lake, and it is likely that rusty crayfish are present in South Turtle Lake. Rusty crayfish were introduced to Wisconsin from the Ohio River Basin in the 1960's likely via anglers' discarded bait. In addition to displacing native crayfish (*O. virilis* and *O. propinquus*), rusty crayfish also degrade the aquatic habitat by reducing aquatic plant abundance and diversity and have also been shown to consume fish eggs. While there is currently no control method for eradicating rusty crayfish from a waterbody, aggressive trapping and removal has been shown to significantly reduce populations and minimize their ecological impact. While it is possible these species are present in South Turtle Lake, their presence has not been officially verified.

8.8.6 South Turtle Lake 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 South Turtle Lake. The goal of this section is to provide an overview of some of the data that exists. Although current fish 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 Biologist Hadley Boehm (WDNR 2017 & GLIFWC 2017).

South Turtle 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 South Turtle 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 algae, 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 8.8.6-1.

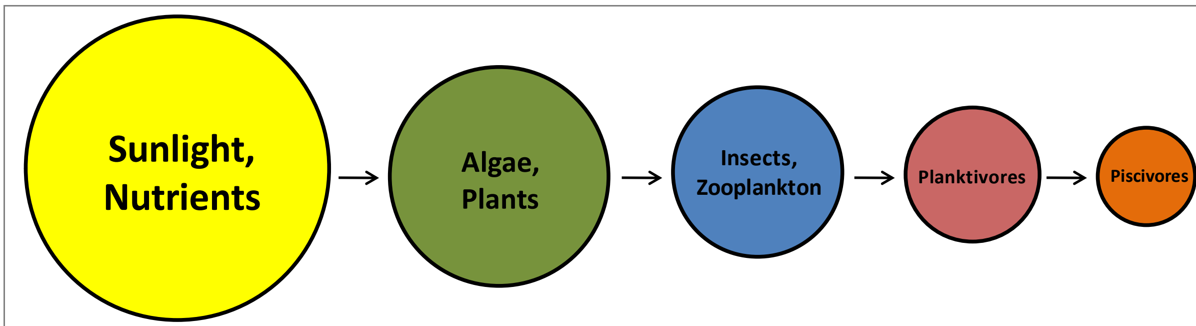


Figure 8.8.6-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section (Section 8.8.1), South Turtle Lake is a eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means South Turtle Lake should be able to support sizable populations of predatory fish (piscivores) because the supporting food chain is relatively robust. Table 8.8.6-1 shows the popular game fish present in the system. Although not an exhaustive list of fish species in the lake, additional species documented in past surveys of South Turtle Lake include burbot (*Lota lota*), white sucker (*Catostomus commersonii*), and the greater redhorse (*Moxostoma valenciennesi*).

Table 8.8.6-1. Gamefish present in South Turtle Lake with corresponding biological information (Becker, 1983).

Common Name (*Scientific Name*)	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie (*Pomoxis nigromaculatus*)	7	May - June	Near Chara or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill (*Lepomis macrochirus*)	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Cisco (*Coregonus artedii*)	22	Late November - Early December	Various shoreline substrates.	Microscopic zooplankton, aquatic insect larvae, adult mayflies, stoneflies, bottom-dwelling invertebrates.
Largemouth Bass (*Micropterus salmoides*)	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge (*Esox masquinongy*)	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike (*Esox lucius*)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed (*Lepomis gibbosus*)	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass (*Ambloplites rupestris*)	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass (*Micropterus dolomieu*)	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch (*Perca flavescens*)	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

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 8.8.6-1). 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 electroshocking (Photograph 8.8.6-1). 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 easy for fisheries technicians to net and place into a livewell to recover. Contrary to what some may believe, electroshocking 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 these data to make recommendations and informed decisions on managing the future of the fishery.


Photograph 8.8.6-1. 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 fry, fingerling or adult fish in a waterbody that were raised in permitted hatcheries (Photograph 8.8.6-2). Stocking of 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. South Turtle Lake was stocked from 1972 to 2000 with muskellunge and walleye (Tables 8.8.6-2 and 8.8.6-3).

Photograph 8.8.6-2. Fingerling Muskellunge.

Table 8.8.6-2. Stocking data available for muskellunge in South Turtle Lake (1980-2000).

Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
1980	Muskellunge	Fingerling	900	10
1987	Muskellunge	Fingerling	1,500	12
1989	Muskellunge	Fingerling	500	11
1991	Muskellunge	Fingerling	250	11
1992	Muskellunge	Fingerling	250	11
1996	Muskellunge	Fingerling	368	10.8
1998	Muskellunge	Large Fingerling	450	12.2
2000	Muskellunge	Large Fingerling	450	10.8

Table 8.8.6-3. Stocking data available for walleye in South Turtle Lake (1972-1977).

Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
1972	Walleye	Fingerling	22,500	3
1974	Walleye	Fingerling	10,000	3
1977	Walleye	Fingerling	22,000	3

Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the second important reason for owning property on or near South Turtle Lake (Question #17). Figure 8.8.6-2 displays the fish that South Turtle Lake stakeholders enjoy catching the most, with bluegill/sunfish and walleye being the most popular. Approximately 34% of these same respondents believed that the quality of fishing on the lake was good, 25% believed fair and 28% believed poor (Figure 8.8.6-3). Approximately 72% of respondents who fish South Turtle Lake believe the quality of fishing has been somewhat or much worse since they started fishing the lake (Figure 8.8.6-3).

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. Creel surveys were completed on Rock, South Turtle and South Turtle Lakes during the 1991-92 and 2010-11 fishing seasons (Table 8.8.6-5).

Question 11: What species of fish do you like to catch on South Turtle Lake?

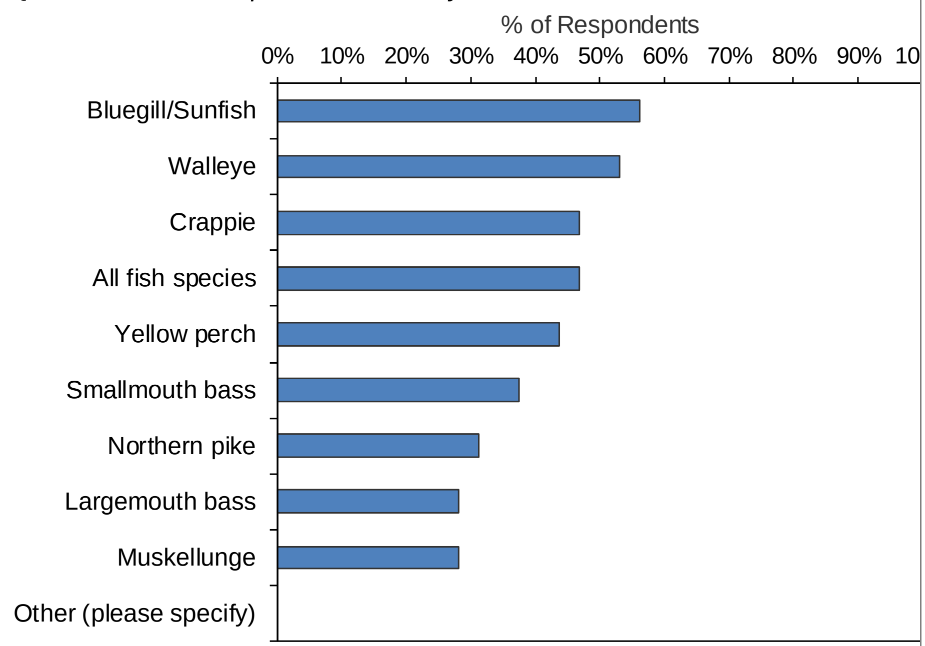


Figure 8.8.6-2. Stakeholder survey response Question 11. Created based on data from 37 respondents of 120 surveys sent (39%).

Question 12: How would you descirbe the current quality of fishing on South Turtle Lake?

Question 13: How has the quality of fishing changed since you started fishing the lake?

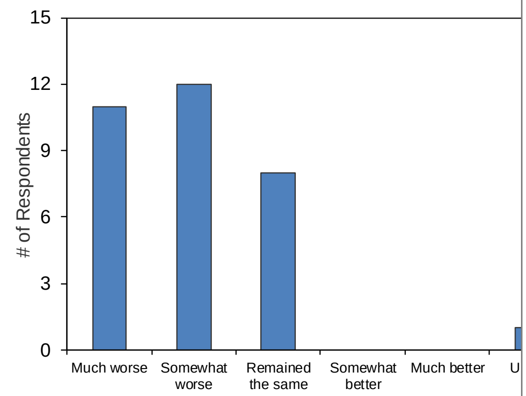


Figure 8.8.6-3. Stakeholder survey responses to questions 12 and 13. Created based on data from 37 respondents of 120 surveys sent (39%).

Total angler effort was somewhat higher in 1991-92 (20.5 hours/acre) compared to the 2010-11 season (18.1 hours/acre). Anglers directed the largest amount of effort towards walleye and muskellunge during both the 2010-11 and 1991-92 seasons (Table 8.8.6-5).

Table 8.8.6-5. Creel Survey data for 1991-92 and 2010-11 fishing seasons.

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
Largemouth Bass	1991	20.5	0	0	0	0	0		
	2010	18.1	0.9	30	0.1	0	0	11.3	
Muskellunge	1991	20.5	6.7	84	0.2	0	0	45.5	
	2010	18.1	6	95	0.3	0	0	31.7	
Northern Pike	1991	20.5	0.6	62	0.2	11	0	36.2	
	2010	18.1	0.5	51	0.1	5	0	5.6	
Smallmouth Bass	1991	20.5	0.7	179	0.5	33	0.1	5.7	32.2
	2010	18.1	1.9	484	1.3	19	0.1	1.9	67.1
Walleye	1991	20.5	11.3	4457	12.1	117	0.3	0.9	37.5
	2010	18.1	10.2	2501	6.8	1249	3.4	1.5	3

Fish Populations and Trends

Utilizing the above-mentioned fish sampling techniques and specialized formulas, WDNR fisheries biologists can estimate populations and determine trends of captured fish species. These numbers provide a standardized way to compare fish caught in different sampling years depending on gear used (fyke net or electrofishing). Data is analyzed in many ways by fisheries biologists to better understand the fishery and how it should be managed.

Gamefish

The gamefish present on South Turtle Lake represent different population dynamics depending on the species. The results for the stakeholder survey show landowners prefer to catch walleye on South Turtle Lake (Figure 8.8.6-2). A 2010 WDNR fisheries survey conducted on South Turtle Lake showed a moderate density of walleye (WDNR 2010).

Panfish

Abundant populations of yellow perch were present with moderate numbers of black crappie, bluegill and rock bass found after the 2010 WDNR fisheries survey (WDNR 2010). The results for the stakeholder survey show anglers prefer to catch bluegill/sunfish on South Turtle Lake (Figure 8.8.6-2).

South Turtle 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 8.8.6-4). South Turtle 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, either by spear harvest or angler harvest, is a highly regimented and dictated process.

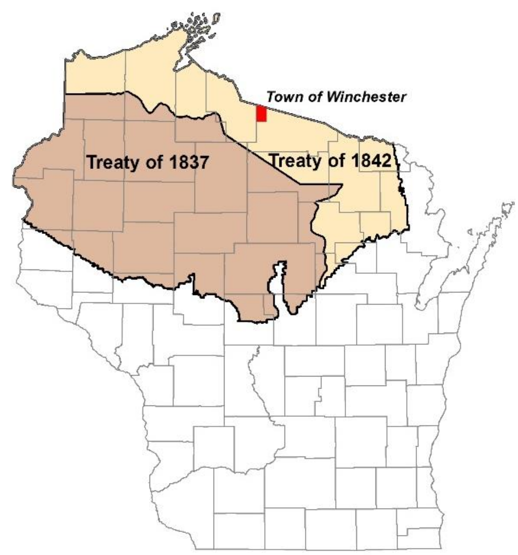


Figure 8.8.6-4. Location of Town of Winchester within the Native American Ceded Territory (GLIFWC 2017). This map was digitized by Onterra; therefore, it is a representation and not legally binding.

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 is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. 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 tribal or recreational harvesting means.

By March 15th of each year the relevant tribal communities may declare a proportion of the total safe harvest on each lake. This declaration represents the maximum number of fish that can be taken by tribal spear harvesters or netters annually (Spangler, 2009). 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 state-wide 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).

Spear harvesters are able to 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 2016). 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 spear harvesters may only take two walleye over 20 inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIWC 2016). 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 spear harvesters. Harvest of a particular species ends once the declaration is met. In 2011, a new reporting requirement went into effect on lakes with smaller declarations.

Walleye open water spear harvest records from 1999-2017 in South Turtle Lake are provided in Figure 8.8.6-5. As many as 151 walleye have been harvested from the lake in the past (2010), but the average harvest is roughly 46 fish per year. Spear harvesters on average have taken 38% of the declared quota. Additionally, on average, 8% of walleye harvested have been female.

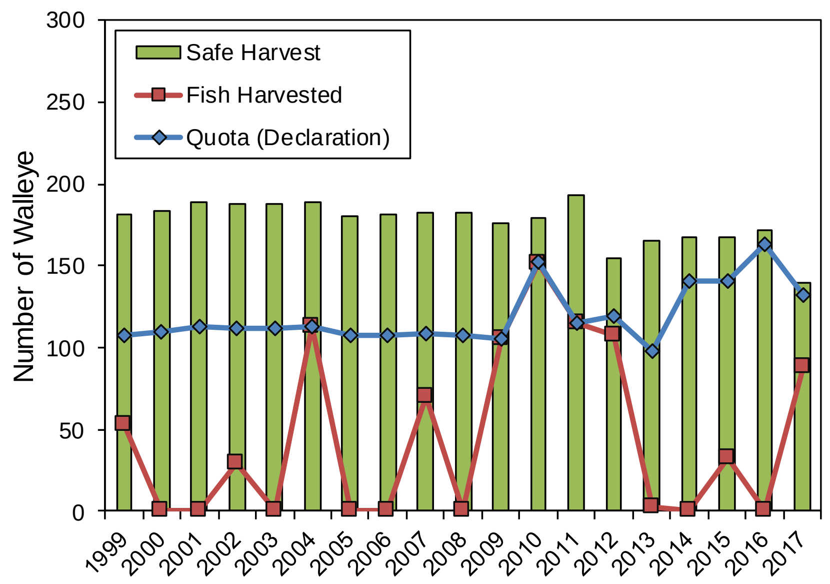


Figure 8.8.6-5. South Turtle Lake walleye spear harvest data. (GLIFWC 1999-2017).

Muskellunge open water spear harvest records from 1999-2017 in South Turtle Lake are provided in Figure 8.8.6-6. A maximum of one muskellunge has been harvested from the lake in the past (2007), while most years have seen zero muskellunge harvested. Spear harvesters on average have taken 0% of the declared quota.

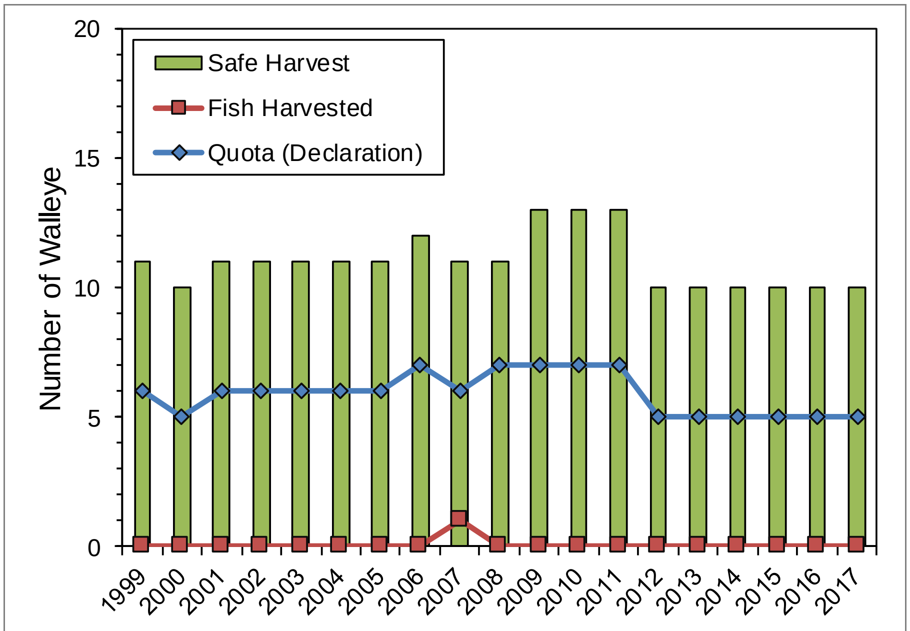


Figure 8.8.6-6. South Turtle Lake muskellunge spear harvest data. (GLIFWC 1999-2017).

South Turtle 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, evade 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 have substrates largely comprised of sand and rock 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 do 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 over soft sediments as well. According to the point-intercept survey conducted by Onterra in 2017, 54% of the substrate sampled in the littoral zone of South Turtle Lake were soft sediments, 25% was composed of sand and 21% were composed of rock sediments.

Woody Habitat

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass 2006). A fall 2017 survey documented 299 pieces of coarse woody along the shores of South Turtle Lake, resulting in a ratio of approximately 39 pieces per mile of shoreline. When compared to the other 98 lakes Onterra has completed coarse woody habitat surveys on since 2012, South Turtle Lake falls in the 75^{h} percentile for the number of course woody habitat pieces per shoreline mile.

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. 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 8.8.6-3). 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 other partner contributions.

Photograph 8.8.6-3. Examples of fish sticks (left) and half-log habitat structures (right). (Photos by WDNR).

Fish cribs are a fish habitat structure that are placed on the lakebed. Installing fish cribs may 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. Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 8.8.6-3). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills 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 are spawning reefs. Spawning reefs typically consist of small rubble in a shallow area near the shoreline and are mainly installed to enhance 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 indicated the addition of rock substrate did not significantly improve walleye reproduction (WDNR 2004).

Placement of a fish habitat structures in a lake does not require 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. The Town of Winchester should 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 South Turtle Lake.

Regulations

Regulations for South Turtle Lake gamefish species as of April 2018 are displayed in Table 8.8.6-6. 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 8.8.6-6. WDNR fishing regulations for South Turtle Lake (As of April 2018).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	25	None	Open All Year
Smallmouth bass (Early Season)	Catch and release only	None	May 5, 2018 to June 15, 2018
Smallmouth bass	5	14"	June 16, 2018 to March 3, 2019
Largemouth bass	5	14"	May 5, 2018 to March 3, 2019
Muskellunge and hybrids	1	40"	May 26, 2018 to November 30, 2018
Northern pike	5	None	May 5, 2018 to March 3, 2019
Walleye, sauger, and hybrids	3	None but only 1 fish over 14" is allowed.	May 5, 2018 to March 3, 2019
Bullheads	Unlimited	None	Open All Year

General Waterbody Restrictions: Motor Trolling is allowed with 1 hook, bait, or lure per angler, and 3 hooks, baits, or lures maximum per boat.

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.

As discussed in the South Turtle Lake Water Quality section (Section 8.8.1), South Turtle Lake was placed on the 303(d) list of impaired waterbodies for contaminated fish tissue by mercury in 1998. General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 8.8.6-7. 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 8.8.6-7. 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/)

8.8.7 Turtle Lakes Chain Implementation Plan

The Implementation Plan presented in this section was created through the collaborative efforts of the Turtle Lakes Chain Association (TLCA) Planning Committee, Onterra ecologists, and North Lakeland Discovery Center (NLDC) and WDNR staff. It represents the path the TLCA will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Turtle Lakes Chain stakeholders as portrayed by the members of the Planning Committee and the communications between Planning Committee members and the chain stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the chain, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Maintain Current Water Quality Conditions

Management Action:	Continue monitoring of Turtle Lakes Chain water quality through the WDNR Citizens Lake Monitoring Network (CLMN).
Timeframe:	Continuation and expansion of current effort
Facilitator:	TLCA 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. Continued monitoring of all chain lakes can lead to early detection of potential negative trends and may lead to the reason to why the trend is developing. 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 the TLCA have been measuring Secchi disk transparency on Rock Lake and Secchi disk transparency, total phosphorus, and chlorophyll-*a* on North and South Turtle Lakes for many years. The TLCA realizes the importance of continuing this effort which will supply them with valuable data about the chain. Funding from the WDNR for advanced water quality monitoring (addition of total phosphorus and chlorophyll-*a* over Secchi disk transparency) has been increasingly difficult to acquire as the list of lakes desiring to be in the advanced program increases in the Northern Region of the WDNR. Rock Lake intercepts a portion of the surface water flowing into North Turtle Lake, acting as a sedimentation basin North Turtle, therefore, it is important to monitor more than Secchi disk transparency in Rock Lake. While attempting to get Rock Lake into the advanced water quality category of the CLMN program will be the first step and primary objective, the TLCA will consider approaching the Town of Winchester to assist in funding the analysis of water samples of total

phosphorus and chlorophyll-*a* from Rock Lake through the Wisconsin State Lab of Hygiene. It is important to have the samples analyzed through the state lab not only because it is an excellent analytics lab, but also because the data is automatically loaded into the WDNR database, Surface Water Integrated Monitoring System (SWIMS). This may be a workable solution for the Town as other lake groups and lakes in the Town may make the same inquiry.

As discussed in the South Turtle Lake Water Quality Section 8.8.1, an increasing trend in total phosphorus concentrations was discovered as a part of this planning project. While the lake's water quality is currently considered as good, it is very important to continue water quality monitoring to confirm if the trend is continuing, leveling off, or declining. Continued CLMN water quality monitoring is obviously important for South Turtle Lake because it is the source of long-term trend data.

Maintaining the volunteer force to continue this important task requires diligence on the part of the TCLA. The Board of Directors will confirm each year that the current CLMN volunteers will continue the monitoring on all three lakes. If new volunteers are needed, the Board of Directors will recruit them and contact Sandy Wickman (715.365.8951), or the appropriate WDNR/UW-Extension staff, to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. 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 SWIMS by the volunteer.

Action Steps:

1. Board of Directors contacts Sandy Wickman (715.365.8951) to add Rock Lake to the advanced water quality program waiting list.
2. Board of Directors confirm annually that current volunteers will continue to monitor their respective lakes.
3. New volunteer(s) contact Sandy Wickman (715.365.8951) as needed.
4. Volunteer(s) reports results to WDNR SWIMS database and to TCLA members during annual meeting.

Management Goal 2: Control Existing AIS in the Turtle Lakes Chain and Prevent Further AIS Introductions

Management Action:	Continue Clean Boats Clean Waters watercraft inspections at Turtle Lakes Chain public access sites.
Timeframe:	Continuation current effort
Potential Grant:	WDNR Clean Boats Clean Waters Grant
Facilitator:	TLCA Board of Directors
Description:	Volunteers from the TLCA have completed over 220 hours of Clean Boats Clean Waters (CBCW) monitoring as a part of the volunteer efforts put forth as an inkind match for the planning project. The association understands the importance of this program in preventing the introduction of AIS to the Turtle Lakes Chain; therefore, it will strive to continue this program beyond the completion of the Town of Winchester Management Planning Project. The CBCW program benefits extend beyond the actual physical prevention of AIS introduction by literally stopping infested watercraft from being launched into the system, by spreading important information to watercraft owners regarding their potential role in spreading AIS. The primary hinderance to this activity is often the willingness of lake group members to volunteer to participate in the program. While this is likely the best source of labor for this program because it assures buy-in, and subsequently quality, conscientious inspectors, it is not always realistic for a lake group to be able to produce sufficient volunteers. Unfortunately, the lack of volunteer involvement often leads to the demise of the program on some lakes. The TLCA will complete actions (see below) aimed at increasing volunteerism on the lake; therefore, staffing the Turtle Lakes Chain CBCW program with volunteers from the association will be the primary objective. If sufficient volunteers cannot be enlisted, the association will consider hiring inspectors through the Town of Winchester, NLDC, and/or Vilas County. The WDNR has a streamlined application process allowing qualified lake groups to apply for funding for CBCW program activities. Grant funding is available for 75% of project costs up to a maximum of $4,000 per boat landing or pair of landings. The remaining 25% of the project cost must come from the project sponsor in the form of cash, donated labor or services, or “in-kind” items. These grants are reimbursement grants, meaning all costs must first be paid by project sponsor before reimbursement can be requested from the DNR. A 25% advance payment will be automatically provided to help get the project started. More information can be found on the WDNR Surface Water Grants website (dnr.wi.gov/aid/surfacewater.html).

Action Steps:

1. Board of Directors recruits a volunteer to act as the CBCW program coordinator for the TLCA.
2. Board of Directors and program coordinator recruit volunteers for the chain CBCW program.
3. Volunteers attend CBCW training session.
4. Coordinator schedules volunteers to assure public access sites will be staffed at the busiest times of the year.
5. CBCW coordinator reports results to WDNR SWIMS database and to TCLA members during annual meeting.

Management Action: Coordinate annual volunteer monitoring for Aquatic Invasive Species in the Turtle Lakes Chain.

Timeframe: Begin 2019

Facilitator: TLCA Board of Directors

Description: In lakes without Eurasian watermilfoil and other submersed invasive species like curly-leaf pondweed, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. One way in which lake residents can spot early infestations of AIS is through conducting "Lake Sweeps" on their lake. During a lake sweep, volunteers monitor the entire area of the system in which plants grow (littoral zone) twice annually in search of non-native plant species. This program uses an "adopt-a-shoreline" approach where volunteers are responsible for surveying specified areas of the system.

In order for accurate data to be collected during these sweeps, volunteers must be able to identify non-native species such as Eurasian watermilfoil and curly-leaf pondweed. Distinguishing these plants from native look-a-likes is very important.

To effectively facilitate this program, the TLCA has recruited two volunteers from each lake to act as Lake Representatives. The Lake Representatives will facilitate the volunteer monitoring on their respective lake, communicate with local experts if suspect plants are located, and report monitoring results at the TLCA annual meeting. The Lake Representatives would initiate the rapid response plan detailed below.

The TLCA will initially recruit volunteers at the group's annual meeting by displaying a map with shorelines of each lake divided into relatively equal sections. Volunteers can then write their names next to a section and provide contact information on a separate form. The

Lake Representatives for each lake will then utilize that list to set up the monitoring program on each lake.

The Lake Representatives from Rock Lake will also work with NLDC staff and riparian property owners to remove pale-yellow iris from the lake's shoreline.

In association with this action and the rapid response plan action below, the TLCA has added an "AIS Alert" section to their website with information on AIS, including pictures and Lake Representative contact information. This feature can be used by lake users if they believe they have located an AIS in the Turtle Lakes Chain.

Action Steps:

1. Board of Directors maintains volunteers to act as Lake Representatives for each of the three lakes.
2. Lake Representatives coordinate to create map and contact form to facilitate initial volunteer recruitment.
3. Lake Representatives introduce program through TLCA website and The Rag, present the program at TLCA annual meeting, and ask for volunteers.
4. Lake Representatives contact volunteers and set up training session with NLDC or other qualified agency, like Vilas County.
5. Lake Representatives coordinate surveys, collect results, and report on those results at annual meeting.

<u>Management Action:</u>	Initiate rapid response plan following detection of new AIS
Timeframe:	If/When Necessary
Facilitator:	Board of Directors
Description:	If volunteers locate a suspected new AIS within the Turtle Lakes Chain, the location would be marked (e.g. GPS, maker buoy) and a specimen would be taken to the NLDC or to the Vilas County Land Conservation Department for verification. If the suspected specimen is indeed a non-native species, the WDNR will fill out an incident form and develop a strategy to determine the population level within the lake. The lake would be professionally surveyed, either by agency personnel or a private consulting firm during that species' peak growth phase. If the AIS is a NR40 prohibited species (i.e. red swamp crayfish, starry stonewort, hydrilla, etc.), the WDNR may take an active role in the response. If the AIS is a NR40 restricted species (i.e. purple loosestrife, curly-leaf pondweed, Eurasian watermilfoil, etc.), the TLCA would need to reach out to a consultant to develop a formal monitoring and/or control strategy. The WDNR would be able to help financially through the AIS Grant Program's Early Detection and Response Grant. This grant

	program is non-competitive and doesn't have a specific application deadline, but is offered on a first-come basis to the sponsor of project waters that contain new infestations (found within less than 5% of the lake and officially documented less than 5 years from grant application date). Currently this program will fund up to 75% percent of monitoring and control costs, up to $20,000.
Action Steps:	
	See description above

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

Management Action:	Promote lake protection and enjoyment through stakeholder education.
Timeframe:	Continuation of current efforts
Facilitator:	Board of Directors
Description:	Education represents an effective tool to address many lake issues. The TLCA distributes a newsletter, The Rag, twice each year to its membership, and has developed a website (www.thetlca.org), which is the official repository of the TLCA information. These mediums allow for communication with association members, but increasing the level of communication is important within a management group because it facilitates the spread of important association news, educational topics, volunteer opportunities, and even social happenings. The TLCA will continue to make the education of lake-related issues a priority. These may include educational materials, awareness events, and demonstrations for lake users as well as activities which solicit local and state government support. *Example Educational Topics* • Specific topics brought forth in other management actions • Aquatic invasive species identification • Basic lake ecology • Boating safety (promote existing guidelines, Lake Use Information handout) • Swimmers itch • Shoreline habitat restoration and protection • Noise and light pollution • Fishing regulations and overfishing • Minimizing disturbance to spawning fish • Dam operation and water levels • Recreational use of the lakes
Action Steps:	

	See description above.

Management Action:	Continue TLCA's involvement with other entities that have responsibilities in managing (management units) the Turtle Lakes Chain
Timeframe:	Continuation of current efforts
Facilitator:	Board of Directors
Description:	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 governmental while others organizations rely on voluntary participation. It is important that the TLCA 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 8.9-1
Action Steps:	
	See table guidelines on the next pages.

Table 8.9-1 Management Partner List.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Town of Winchester Lakes Committee	Committee Chair (Rolf Ethun,715.686.2139, rolfappraisals@centurytel.net)	Town resource for lake property owners and lake groups	As needed.	Involved in lake management activities, monitoring, implementation, funding, volunteer recruitment. May be contacted regarding ordinance questions, and for information on community events.
Great Lakes Indian Fish and Wildlife Commission	General (715.682.6619)	Resource management within Ceded Territory	As needed.	Collaborate on lake related studies, AIS management, inform of meetings, etc.
Vilas County Lakes & Rivers Association (VCLRA)	President (Tom Ewing, president@vclra.us)	Protects Vilas Co. waters through facilitating discussion and education.	Twice a year or as needed.	Become aware of training or education opportunities, partner in special projects, or networking on other topics pertaining to Vilas Co. waterways.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Wisconsin Department of Natural Resources	Fisheries Biologist (Eric Wegleitner, 715.356.5211 Ext 246)	Manages the fish populations and fish habitat enhancement efforts.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery.
	Lakes Coordinator (Kevin Gauthier, 715.356.5211)	Oversees management plans, grants, all lake activities.	As needed.	Information on planning/AIS projects, grant applications or to seek advice on other lake issues.
	Environmental Grant Specialist (Jill Sunderland, 715.635.4167)	Oversees financial aspects of grants.	As needed.	Information on grant financials and reimbursement, CBCW grant applications.
	Conservation Warden (Matt Meade, 715.329.0615)	Oversees regulations handed down by the state.	As needed. May call the WDNR violation tip hotline for anonymous reporting (1-800-847-9367, 24 hours a day).	Contact regarding suspected violations pertaining to recreational activity, include fishing, boating safety, ordinance violations, etc.
	Water Resources Mgmt Specialist (Sandra Wickman, 715.365.8951, Sandra.Wickman@wisconsin.gov)	Provides training and assistance on CLMN monitoring, methods, and data entry.	Twice a year or more as needed.	Arrange for training as needed, report monitoring activities.
	Trout Lake Station staff (Susan Knight and Carol Warden (715.356.9494)	Conducts lake research on multiple levels	As needed.	Can be contacted for identification or consultation on AIS.
Vilas County Sheriff Dept.	715.479.4441 non-emergency, 911 for emergencies only.	Perform law enforcement duties to protect lakes, especially pertaining to compliance with boating safety rules.	As needed.	Contact regarding suspected violations pertaining to boating safety rules on the lake.
University of Wisconsin Extension Office	Lake Specialist (Pat Goggin, 715.365.8943, Patrick.Goggin@wisconsin.gov)	Provides guidance for lakes, shoreline restoration, and outreach/education.	As needed.	Contact for shoreland remediation/restoration techniques, outreach/education.
North Lakeland Discovery Center	Executive Director (John Heusinkveld, 715.543.2085, john@discoverycenter.net) Water Program Coordinator (Emily Heald, 715.543.2085, water@discoverycenter.net)	Educates and inspires connection to the natural state of the Northwoods	As needed.	Project sponsor. Direct resource for AIS education and monitoring needs, operates aquatic education programs and assists with volunteer recruitment.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Vilas County Land and Water Conservation Department	Lake Conservation Specialist (Cathy Higley, 715.479.3738, cahigl@vilascountywi.gov)	Oversees AIS monitoring and education activities county-wide.	Twice a year or more as issues arise.	AIS training and ID, monitoring techniques, CBCW training, report summer activities.
	Lake Conservation Specialist (Mariquita (Quita) Sheehan, 715.479.3721, mashee@vilascountywi.gov)	Oversees conservation efforts for lake grants and projects.	Twice a year or more as needed.	Contact for shoreland remediation/restoration techniques and cost-share procedures, wildlife damage programs, education and outreach documents.
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	Those interested may attend WL's annual conference to keep up-to-date on lake issues. WL reps can assist on grant issues, AIS training, habitat enhancement techniques, etc.

Management Goal 4: Improve Turtle Lakes Chain Ecological Health and Fishery Resource

<u>Management Action:</u>	Educate stakeholders on the importance of shoreland condition and shoreland restoration on Turtle Lakes Chain.
Timeframe:	Initiate 2019
Facilitator:	Board of Directors
Description:	As discussed in the Shoreland Condition Section, the shoreland zone of a lake is highly important to the ecology of a lake. When shorelands are developed, the resulting impacts on a lake range from a loss of biological diversity to impaired water quality. Because of its proximity to the waters of the lake, even small disturbances to a natural shoreland area can produce ill effects. Approximately 11% of Turtle Lakes Chain's shoreline is considered completely urbanized or developed unnatural. This limits shoreland habitat, but it also reduces natural buffering of shoreland runoff and allows nutrients to enter the chain. Because property owners may have little experience with or be uncertain about restoring a shoreland to its natural state, the TLCA will educate chain property owners regarding shoreland restoration opportunities. This would include inviting Vilas County staff (see Table 8.9-1) to present on the subject at an association meeting. The WDNR's Healthy Lakes Initiative Grant program allows 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 Vilas County. • 75% state share grant with maximum award of $25,000; up to 10% state share for technical assistance • Maximum of $1,000 per 350 ft^2 of native plantings (best practice cap) • Implemented according to approved technical requirements (WDNR, County, Municipal, etc.) and complies with local shoreland zoning ordinances • Must be at least 350 ft^2 of contiguous lakeshore; 10 feet wide • Landowner must sign Conservation Commitment pledge to leave project in place and provide continued maintenance for 10 years • Additional funding opportunities for water diversion projects and rain gardens (maximum of $1,000 per practice) also available
Action Steps:	See description above

Management Action:	Coordinate with WDNR and private landowners to expand coarse woody habitat in Turtle Lakes Chain
Timeframe:	Initiate 2020
Facilitator:	Board of Directors

Description:	Turtle Lakes Chain stakeholders realize the complexities and capabilities of the chain ecosystem with respect to the fishery it can produce. With this, an opportunity for education and habitat enhancement is present in order to help the ecosystem reach its maximum fishery potential. Often, property owners will remove downed trees, stumps, etc. from a shoreland area because these items may impede watercraft navigation, shore-fishing, or swimming. However, these naturally occurring woody pieces serve as crucial habitat for a variety of aquatic organisms, particularly fish. The Shoreland Condition Section and Fisheries Data Integration Section discuss the benefits of coarse woody habitat in detail.
	
	The WDNR's Healthy Lakes Initiative Grant allows partial cost coverage for coarse woody habitat improvements (referred to as "fish sticks"). 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.
	• 75% state share grant with maximum award of $25,000; up to 10% state share for technical assistance
	• Maximum of $1,000 per cluster of 3-5 trees (best practice cap)
	• Implemented according to approved technical requirements (WDNR Fisheries Biologist) and complies with local shoreland zoning ordinances
	• Buffer area (350 ft^2) at base of coarse woody habitat cluster must comply with local shoreland zoning or:
	    o The landowner would need to commit to leaving the area un-mowed
	    o The landowner would need to implement a native planting (also cost share through this grant program available)
	• Coarse woody habitat improvement projects require a general permit from the WDNR
	• Landowner must sign Conservation Commitment pledge to leave project in place and provide continued maintenance for 10 years

Action Steps:	
1.	Board member contacts WDNR Lakes Coordinator and WDNR Fisheries Biologist to gather information on initiating and conducting coarse woody habitat projects. This step is important to

	assure that the action will meet the fisheries goals of the WDNR fisheries management specialists.
2.	The TLCA will encourage property owners that have enhanced coarse woody habitat to serve as demonstration sites.

Please note that study methods and explanations of analyses for Circle Lily Lake can be found within the Town of Winchester Town-wide Management Plan document.

8.9 Circle Lily Lake

An Introduction to Circle Lily Lake

Circle Lily Lake, Vilas County, is a 235-acre deep lowland, brown-water, mesotrophic drainage lake with a maximum depth of 37 feet and a mean depth of 19 feet (Circle Lily Lake – Map 1). Its surficial watershed encompasses approximately 5,887 acres across portions of Vilas and Iron counties, WI. Toy Lake drains into Circle Lily Lake and the outflow from Circle Lily Lake enters the Manitowish River. In 2018, 33 native aquatic plant species were located within the lake, of which slender naiad (*Najas flexilis*) was the most common. No exotic aquatic plants were found in Circle Lily Lake during the 2018 surveys.

Lake at a Glance - Circle Lily Lake

Morphometry	
LakeType	Deep Lowland Drainage
Surface Area (Acres)	235
Max Depth (feet)	37
Mean Depth (feet)	19
Perimeter (Miles)	3.9
Shoreline Complexity	3.3
Watershed Area (Acres)	5,887
Watershed to Lake Area Ratio	24:1
Water Quality	
Trophic State	Mesotrophic
Limiting Nutrient	Phosphorus
Avg Summer P (μg/L)	19.7
Avg Summer Chl-α (μg/L)	6.9
Avg Summer Secchi Depth (ft)	5.6
Summer pH	7.7
Alkalinity (mg/L as $CaCO_3$)	31.8
Vegetation	
Number of Native Species	33
NHI-Listed Species	None
Exotic Species	None
Average Conservatism	7.2
Floristic Quality	35.8
Simpson's Diversity (1-D)	0.94

Descriptions of these parameters can be found within the town-wide portion of the management plan

8.9.1 Circle Lily Lake Water Quality

It is often difficult to determine the status of a lake's water quality purely through observation. Anecdotal accounts of a lake "getting better" or "getting worse" can be difficult to judge because a) a lake's water quality may fluctuate from year to year based upon environmental conditions such as precipitation, and b) differences in observation and perception of water quality can differ greatly from person to person. It is best to analyze the water quality of a lake through scientific data as this gives a concrete indication as to the health of the lake, and whether its health has deteriorated or improved. Further, by looking at data for similar lakes regionally and statewide, the status of a lake's water quality can be made by comparison.

In 2018, a stakeholder survey was sent to 30 Circle Lily Lake riparian property owners. Sixteen (53%) of these 30 surveys were completed and returned. Given the relatively high response rate, the results of the stakeholder survey can be considered reasonably representative of the population sampled, although typically a benchmark of a 60% response rate is required to analyze the results with statistical validity. The full survey and results can be found in Appendix B.

When asked about Circle Lily Lake's current water quality, 75% of respondents indicated the water quality is *good* or *excellent* and 19% indicated the water quality is *fair* (Figure 8.9.1-1). When asked how water quality has changed in Circle Lily Lake since they first visited the lake, 69% of respondents indicated water quality has *remained the same* and 19% indicated it has *somewhat* or *severely degraded* (Figure 8.9.1-1). As is discussed in this section, water quality data do indicate that phosphorus and algal production is unchanged in Circle Lily Lake over the past 15 years.

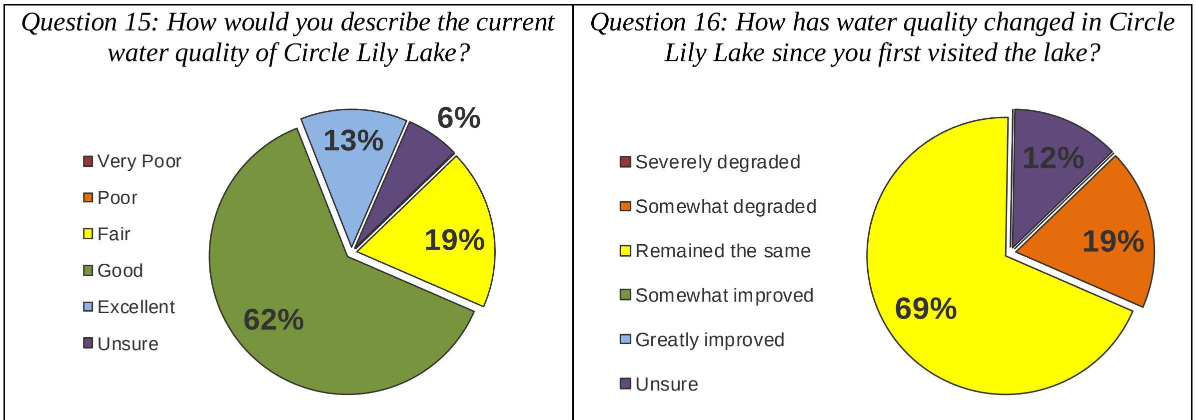


Figure 8.9.1-1. Circle Lily Lake stakeholder survey responses regarding the lake's current and historical water quality. Created using responses from 16 (53%) respondents of 30 surveys distributed.

Near-surface total phosphorus data for Circle Lily Lake are available from 2003 and annually from 2007-2018 (Figure 8.9.1-2). Average summer total phosphorus concentrations are moderately variable, and range from *excellent* to *good* for deep lowland drainage lakes in Wisconsin. The weighted average summer total phosphorus concentration of 19.7 µg/L using all data falls on the border between the *excellent* and *good* categories for deep lowland drainage lakes in Wisconsin. The summer mean phosphorus concentration measured in 2018 was 16.6 µg/L which is lower than the historical average. Circle Lily Lake's total phosphorus concentrations fall below median concentrations for other deep lowland drainage lakes in Wisconsin (23.0 µg/L) and for all lake types within the Northern Lakes and Forests (NLF) ecoregion (21.0 µg/L).

While phosphorus concentrations in Circle Lily Lake are variable from year to year, there are no apparent trends (positive or negative) occurring over the time period for which data are available. The variation in phosphorus concentrations between years is likely due to differences in annual precipitation and the amount of surface runoff from the watershed. The stained water in Circle Lily lake is an indication that the lake receives a significant portion of its water from surface sources within its watershed, primarily water that has passed through forests and wetlands.

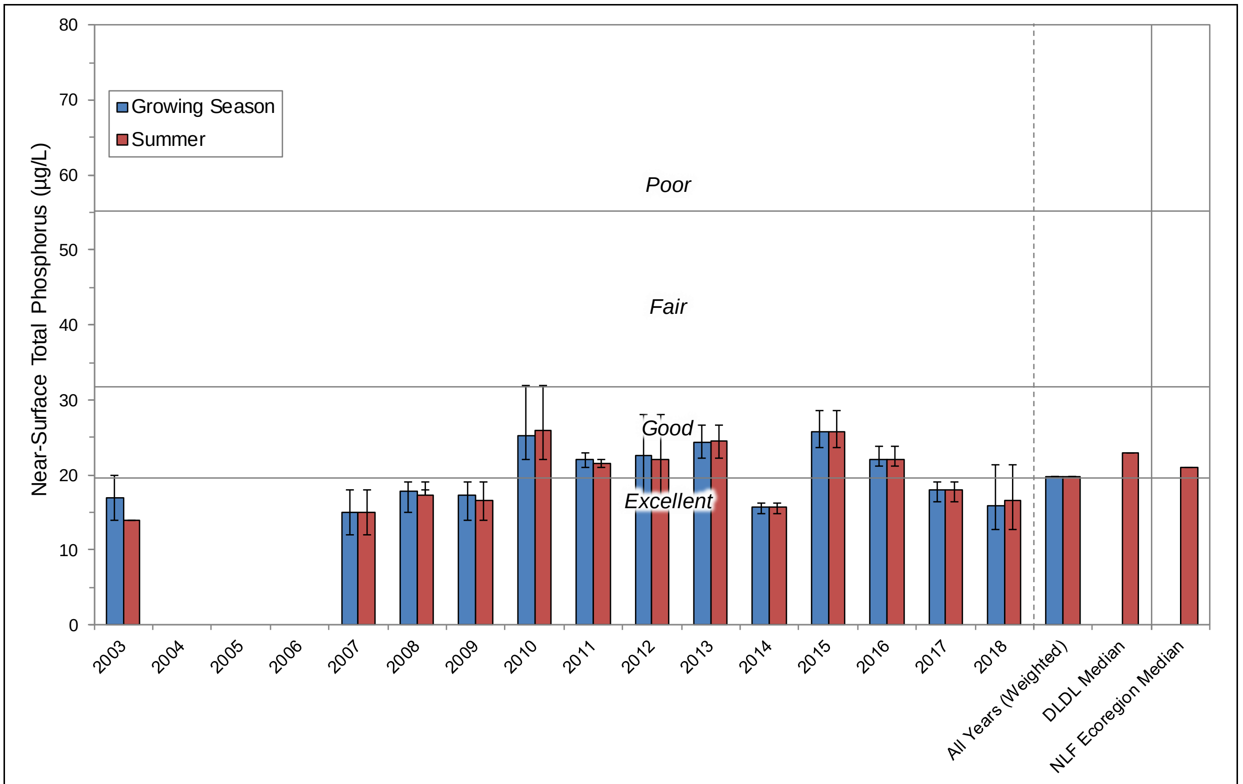


Figure 8.9.1-2. Circle Lily Lake average annual near-surface total phosphorus concentrations and median near-surface total phosphorus concentrations for state-wide deep lowland drainage lakes (DLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Chlorophyll-*a* concentrations, a measure of phytoplankton abundance, are available for Circle Lily Lake from 2003 and annually from 2007-2018 (Figure 8.9.1-3). Chlorophyll-*a* concentrations are more variable from year to year than phosphorus, ranging from *excellent* to *good* in all years except 2013, for deep lowland drainage lakes in Wisconsin. Overall, the weighted average summer chlorophyll-*a* concentration is low at 6.9 µg/L, placing the lake in the *good* category. Chlorophyll-*a* concentrations were highest in 2013 when the average summer concentration was 20.8 µg/L. Total phosphorus concentrations were also higher than normal that summer. As will be discussed below, this year experienced higher than normal precipitation and this resulted in additional nutrients entering Circle Lily Lake. Chlorophyll-*a* concentrations measured in 2018 were slightly lower than the historical average, with a growing season average of 6.5 µg/L. Circle Lily Lake's chlorophyll-*a* concentrations fall below median concentrations for other deep lowland drainage lakes in Wisconsin (7.0 µg/L) and are higher than all lake types within the NLF ecoregion (5.6 µg/L). The low level of phytoplankton production in Circle Lily Lake is a result of the low concentrations of phosphorus, the nutrient regulating phytoplankton production. Trends analysis indicates that like total phosphorus, chlorophyll-*a* concentrations have remained stable over the time period for which data are available, and no trends (positive or negative) are occurring over time.

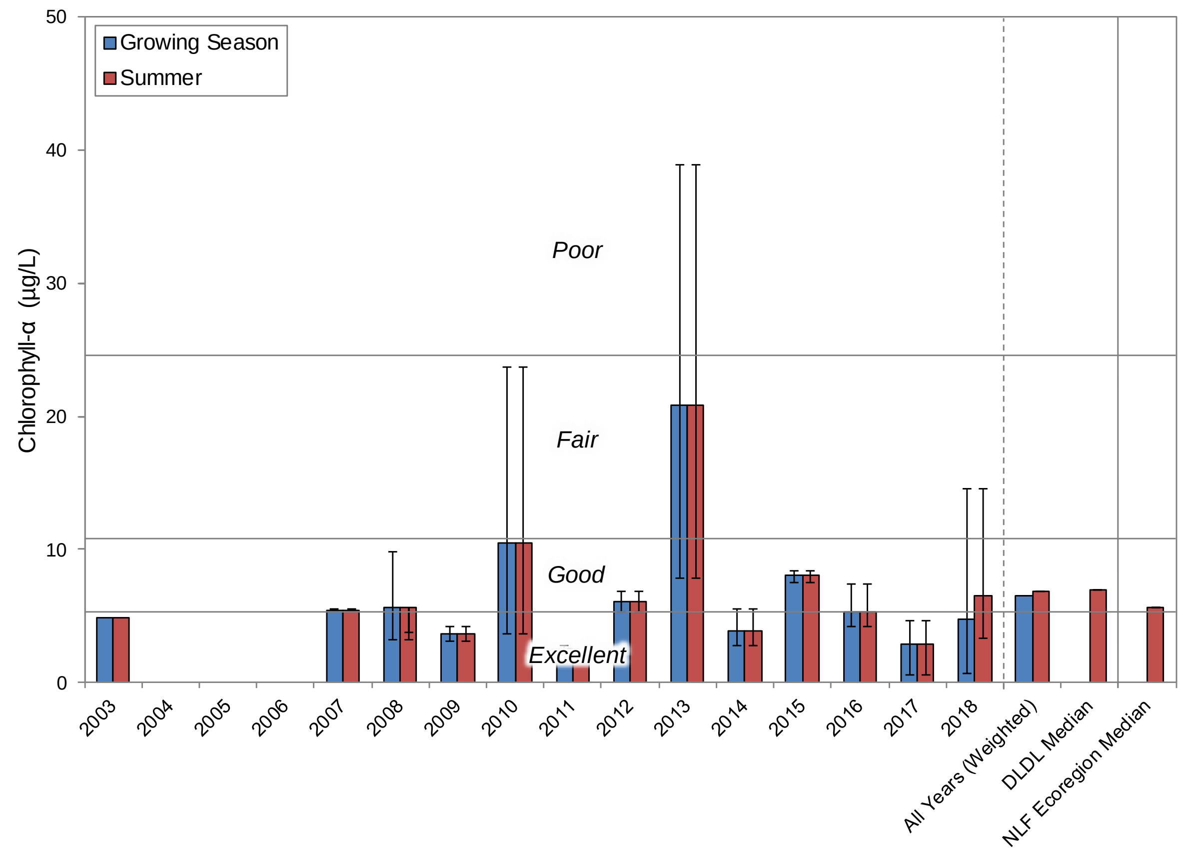


Figure 8.9.1-3. Circle Lily Lake average annual chlorophyll-α concentrations and median chlorophyll-α concentrations for state-wide deep lowland drainage lakes (DLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

A longer record is available of Secchi disk transparency data than for phosphorus or chlorophyll-*a*. The record is available from Circle Lily Lake for 1996 through 2003 and 2007 through 2018 (Figure 8.9.1-4). Average annual Secchi disk depths range from *good* to *excellent* for deep lowland drainage lakes in Wisconsin. The weighted summer average Secchi disk depth in Circle Lily Lake is 5.6 feet, falling into the *good* category for Wisconsin's deep lowland drainage lakes. Circle Lily Lake's average summer Secchi disk depth is worse than the median values for deep lowland drainage lakes in Wisconsin and for all lake types within the NLF ecoregion. Water clarity in Circle Lily Lake is lower than expected based upon the low chlorophyll-*a* concentrations, and is an indication that a factor other than phytoplankton is influencing water clarity.

Abiotic suspended particulates, such as sediment, can also cause a reduction in water clarity. However, *total suspended solids*, a measure of both biotic and abiotic suspended particles within the water, were low in Circle Lily Lake in 2018 indicating minimal amounts of suspended material within the water. While suspended particles are minimal in Circle Lily Lake, water clarity can also be influenced by dissolved compounds within the water. Many lakes in the northern region of Wisconsin contain higher concentrations of natural dissolved organic acids that originate from decomposing plant material within wetlands in the lake's watershed. In higher concentrations, these dissolved organic compounds give the water a tea-like color or staining and decrease water clarity.

A measure of water clarity once all of the suspended material (i.e. phytoplankton and sediments) have been removed, is termed *true color*, and measures how the clarity of the water is influenced by dissolved components. True color values measured from Circle Lily Lake in 2018 averaged 95 SU (standard units), indicating the lake's water is *highly tea-colored*. Based on Circle Lily Lake's chlorophyll-*a* concentrations measured in 2018, Secchi disk transparency was predicted to be approximately 7.1 feet; however, the high concentrations of dissolved organic acids in the lake reduce the water's clarity to the measured growing season average of 4.9 feet. It is important to note that the tea-colored water in Circle Lily Lake is natural, and is not an indication of degraded conditions.

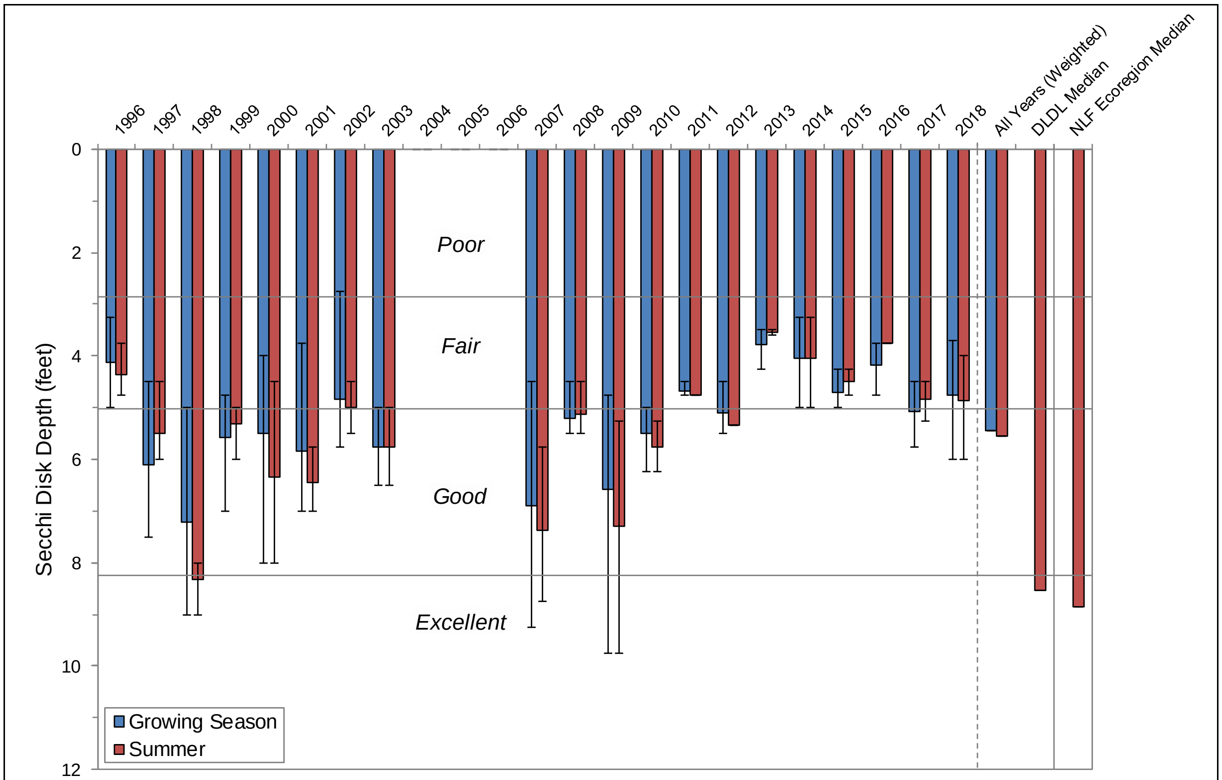


Figure 8.9.1-4. Circle Lily Lake average annual Secchi disk depths and median Secchi disk depths for state-wide deep lowland drainage lakes (DLDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

While total phosphorus and chlorophyll-*a* concentrations have remained relatively stable in Circle Lily Lake, the Secchi disk transparency data indicate that water clarity since 2011 has been lower when compared to historical data going back to 1996. The average growing season Secchi disk depth from 1996-2010 was 6.0 feet compared to an average of 4.5 feet from 2011-2018. However, this decline in average Secchi disk depth of 1.5 feet does not correspond with an increase in chlorophyll-*a* concentrations over this same time period, indicating that an increase in phytoplankton abundance is not the cause of decreased water clarity within the lake.

Precipitation data obtained from nearby Hurley, WI indicate that annual precipitation has been above average in four of the six years since 2011 (Figure 8.9.1-5). This increase in precipitation likely flushed a greater amount of dissolved organic compounds from coniferous forests and wetlands in Circle Lily Lake's watershed into the lake, resulting in reduced water clarity. Precipitation in 2018 was above average, and despite low chlorophyll-*a* concentrations, water clarity was reduced due to increased staining of the water by these dissolved compounds. Given the large areas of coniferous wetlands in Circle Lily Lake's watershed, it is to be expected that larger amounts of these dissolved compounds will be delivered to the lake during years with higher precipitation. The lower water clarity in recent years has also been observed in Birch, Harris, Hiawatha, and Rainbow lakes and is believed to be the result of increased precipitation and input of dissolved organic compounds.

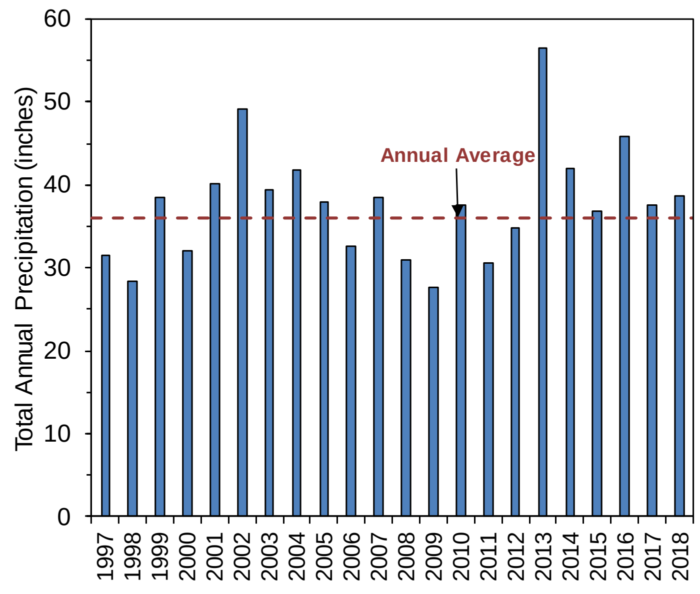


Figure 8.9.1-5. Total annual precipitation measured in Hurley, WI. Data obtained from Midwestern Regional Climate Center (2019).

To determine if internal nutrient loading (discussed in town-wide section of management plan) is a significant source of phosphorus in Circle Lily Lake, near-bottom phosphorus concentrations are compared against those collected from the near-surface. Near-bottom total phosphorus concentrations were measured on three occasions from Circle Lily Lake in 2018 (Figure 8.9.1-6). As illustrated, on some occasions near-bottom total phosphorus concentrations are similar to those measured near the surface, while on other occasions near-bottom concentrations are slightly higher than near-surface concentrations. The higher concentrations of phosphorus near the bottom occurred when Circle Lily Lake was stratified and the bottom layer of water (hypolimnion) was anoxic. Since the concentrations near the bottom are only slightly higher than concentrations near the surface, internal loading is negligible in Circle Lily Lake.

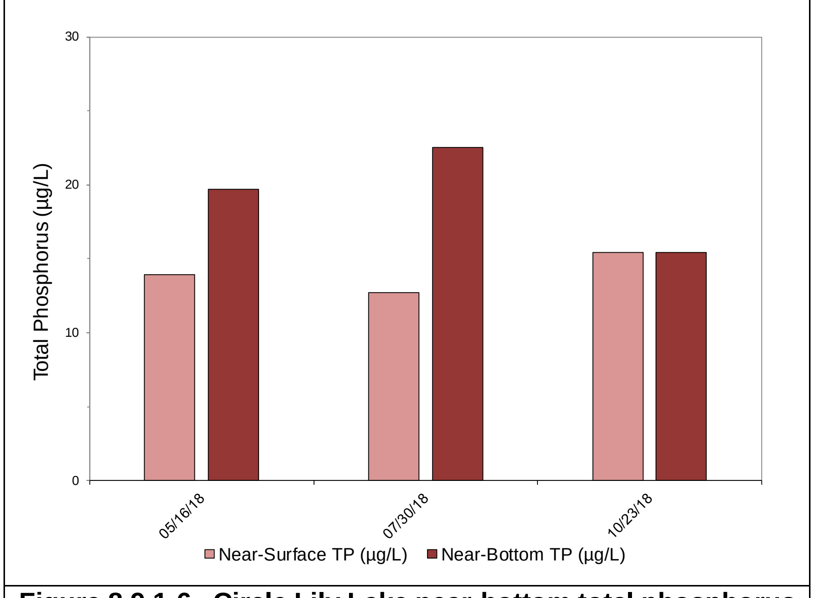


Figure 8.9.1-6. Circle Lily Lake near-bottom total phosphorus concentrations and corresponding near-surface total phosphorus concentrations.

Circle Lily Lake Trophic State

Figure 8.9.1-7 contains the weighted average Trophic State Index (TSI) values for Circle Lily Lake. These TSI values are calculated using summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency data collected as part of this project along with historical data. In general, the best values to use in assessing a lake's trophic state are chlorophyll-*a* and total phosphorus, as water clarity can be influenced by factors other than phytoplankton such as dissolved organic compounds. The closer the calculated TSI values for these three parameters are to one another indicates a higher degree of correlation.

The weighted TSI values for total phosphorus and chlorophyll-*a* in Circle Lily Lake indicate the lake is at present in a mesotrophic, or moderately productive state. Circle Lily Lake's productivity is lower when compared to other deep lowland drainage lakes in Wisconsin and of similar productivity to other lakes within the NLF ecoregion. The TSI values for Secchi disc transparency place the lake in the eutrophic category, but as was explained above, this is because the water is highly stained.

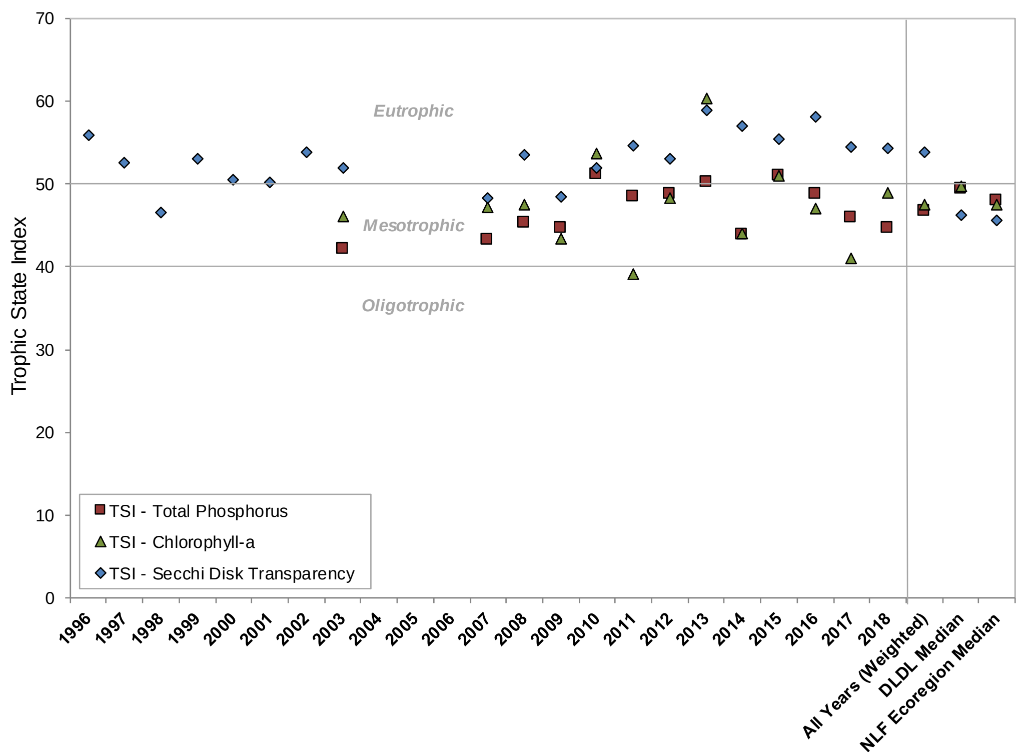


Figure 8.9.1-7. Circle Lily Lake, statewide deep lowland drainage lakes (DLDL), and Northern Lakes and Forests (NLF) ecoregion lakes Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Circle Lily Lake

Dissolved oxygen and temperature profile data were collected during each water quality sampling event conducted by Onterra ecologists. These data are displayed in Figure 8.9.1-8. As mentioned previously, Circle Lily Lake is dimictic, meaning the lake remains stratified during the summer (and winter) and completely mixes, or turns over, once in spring and once 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. Given Circle Lily Lake is deeper, 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 depletes available oxygen. Once anoxia sets in, phosphorus (and other nutrients) are released from bottom sediments into the overlying hypolimnion.

In fall as surface temperatures cool, the entire water column is again able to mix which re-oxygenates the hypolimnion and delivers sediment-released nutrients to the surface. During the winter, the coldest temperatures are found just under the overlying ice, while oxygen gradually declines once again towards the bottom of the lake. In February of 2019, oxygen concentrations remained above 2.0 mg/L throughout the majority of the water column, indicating that fishkills as a result of winter anoxia are not a concern in Circle Lily Lake.

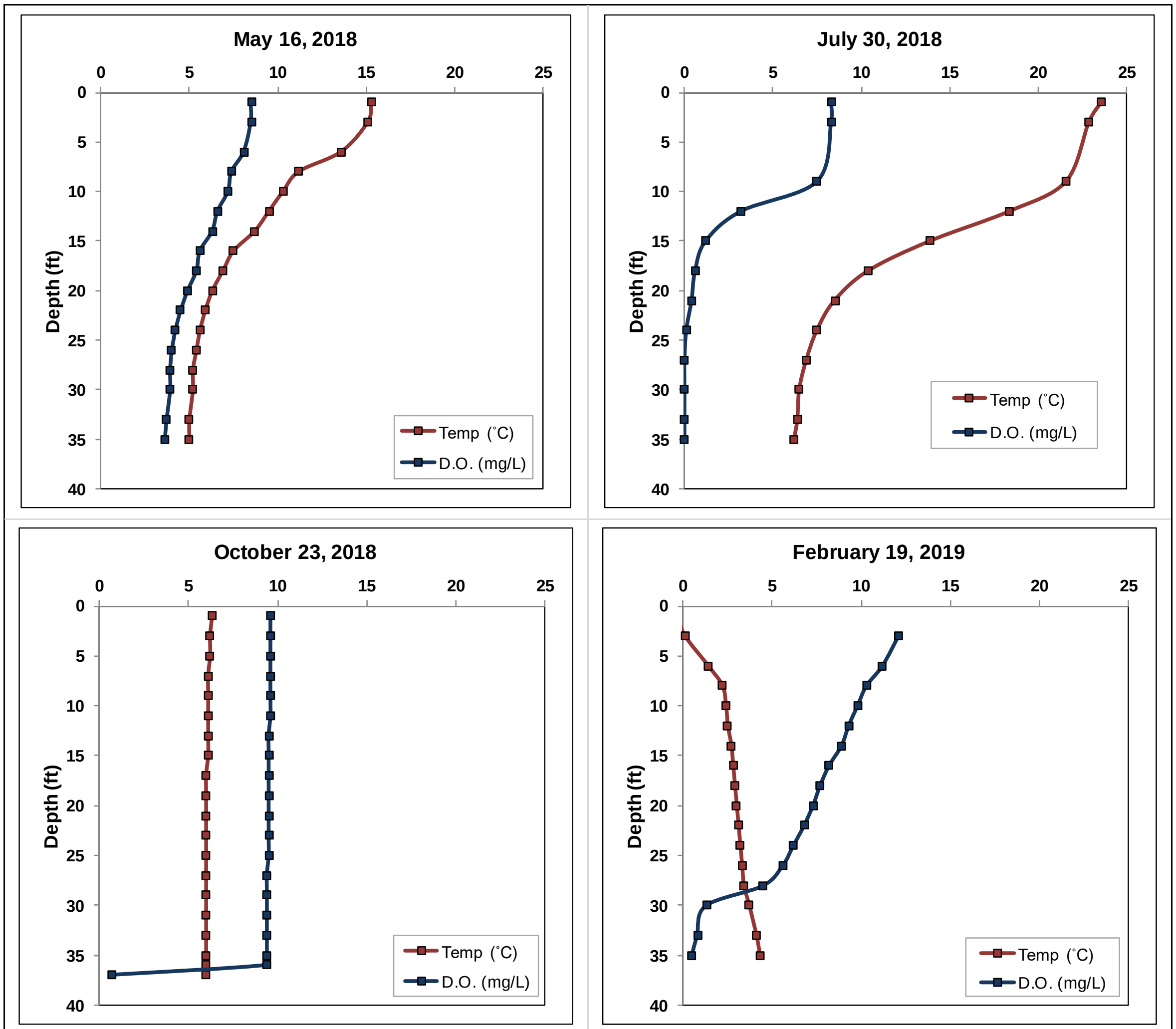


Figure 8.9.1-8. Circle Lily Lake 2018/19 dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected from Circle Lily Lake

The previous section is centered on parameters relating to Circle Lily Lake's trophic state. 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 Circle Lily 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.

As the Town-wide Section explains, the pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is thus an index of the lake's acidity. Circle Lily Lake's mid-summer surface water pH was measured at 7.7 in 2018. This value indicates Circle Lily Lake's water is alkaline and falls within the normal range for Wisconsin lakes. Fluctuations in pH with respect to seasonality are common; in-lake processes such as photosynthesis by plants act to reduce acidity by carbon dioxide removal while decomposition of organic matter adds carbon dioxide to water, thereby increasing acidity. A lake's pH is primarily determined by the water's alkalinity, or a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. Circle Lily Lake's average alkalinity measured in 2018 was 31.8 mg/L as $CaCO_3$. This value falls within the expected range for northern Wisconsin lakes, and indicates that while Circle Lily Lake is considered a softwater lake, it is not sensitive to fluctuations in pH from acid rain.

Water quality samples collected from Circle Lily Lake in 2018 were also analyzed for calcium. Calcium concentrations, along with pH, are currently being used to determine if a waterbody is suitable to support the invasive zebra mussel, as these animals require calcium for the construction of their shells. Zebra mussels typically require higher calcium concentrations than Wisconsin's native mussels, and lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The accepted suitable pH range for zebra mussels is 7.0 – 9.0, and Circle Lily Lake's pH falls within this range. Circle Lily Lake's calcium concentration in 2018 was 9.4 mg/L, indicating the lake has *very low susceptibility* to zebra mussel establishment. Plankton tows were completed by Onterra ecologists at three locations in Circle Lily Lake in 2018 that underwent analysis for the presence of zebra mussel veligers, their planktonic larval stage. Analysis of these samples were negative for zebra mussel veligers, and Onterra ecologists did not observe any adult zebra mussels during the 2018 surveys.

8.9.2 Circle Lily Lake Watershed Assessment

Circle Lily Lake's surficial watershed encompasses approximately 5,898 acres (Figure 8.9.2-1 and Circle Lily Lake – Map 2) yielding a watershed to lake area ratio of 25:1. The watershed is comprised of land cover types including forests (48%), wetlands (39%), pasture/grass/rural open space (9%), the lake surface itself (4%), rural residential areas (<1%), row crops (<1%), and medium density urban (<1%) (Figure 8.9.2-1). Wisconsin Lakes Modeling Suite (WiLMS) modeling indicates that Circle Lily Lake's residence time is approximately 0.67 years, or the water within the lake is completely replaced 1.5 times per year.

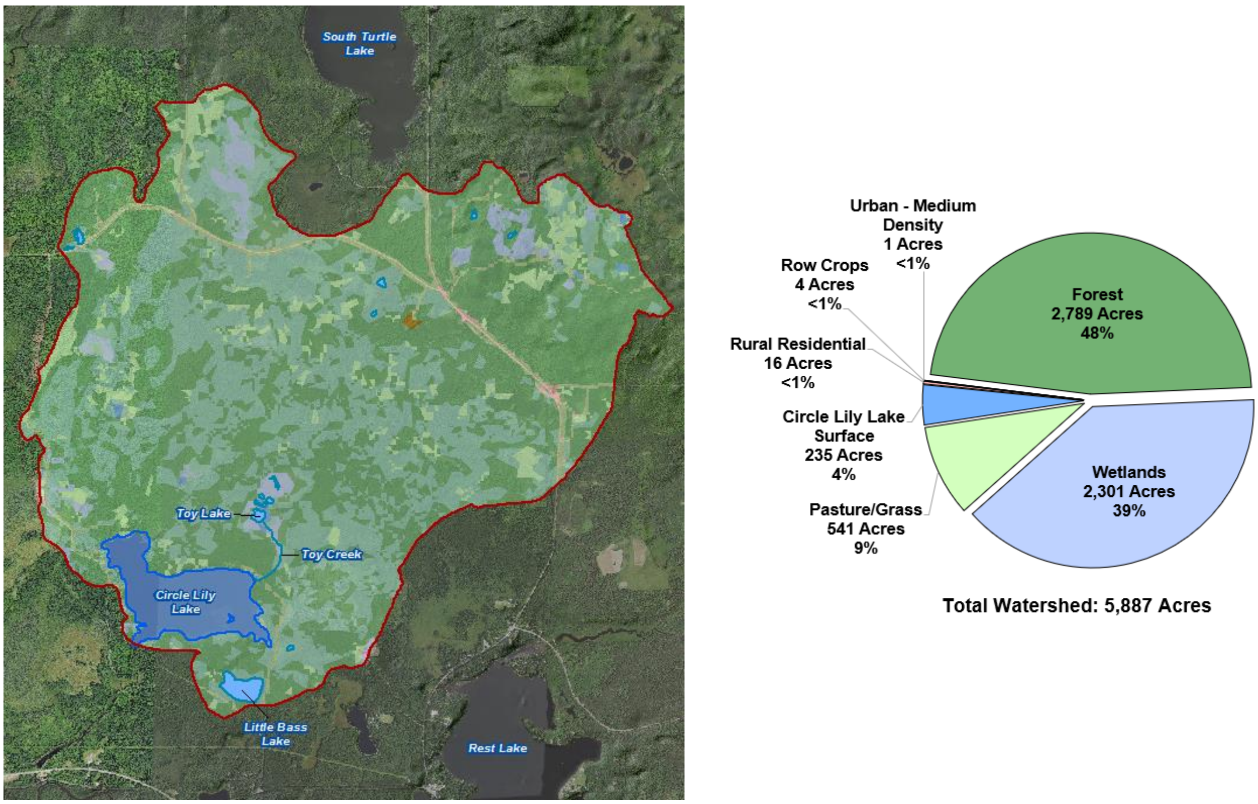


Figure 8.9.2-1. Circle Lily Lake watershed boundary (red line) and proportion of land cover types. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

Using the land cover types and their acreages within Circle Lily Lake's watershed, WiLMS was utilized to estimate the annual potential phosphorus load delivered to Circle Lily Lake from its watershed. In addition, data obtained from a stakeholder survey sent to Circle Lily Lake riparian property owners in 2018 was also used to estimate the amount of phosphorus loading to the lake from riparian septic systems. The model estimated that a total of approximately 646 pounds of phosphorus are delivered to Circle Lily Lake from its watershed on an annual basis (Figure 8.9.2-2).

Of the estimated 646 pounds of phosphorus being delivered to Circle Lily Lake on an annual basis, approximately 225 pounds (35%) originates from forests, 205 pounds (32%) from wetlands, 146 pounds (22%) from areas of pasture/grass, 64 pounds (10%) through direct atmospheric deposition into the lake, from row crops 4 pounds (1%), from rural residential 2 pounds (<1%), and a negligible amount from riparian septic systems, (Figure 8.9.2-2). Using the estimated annual potential phosphorus load, WiLMS predicted an in-lake growing season average total phosphorus concentration of 21 µg/L, which is similar to the measured growing season average total phosphorus concentration of 19.7 µg/L. The similarity between the predicted and measured total phosphorus concentrations in Circle Lily Lake is an indication that this is an accurate model of the lake's watershed and that there are no significant, unaccounted sources of phosphorus entering the lake.

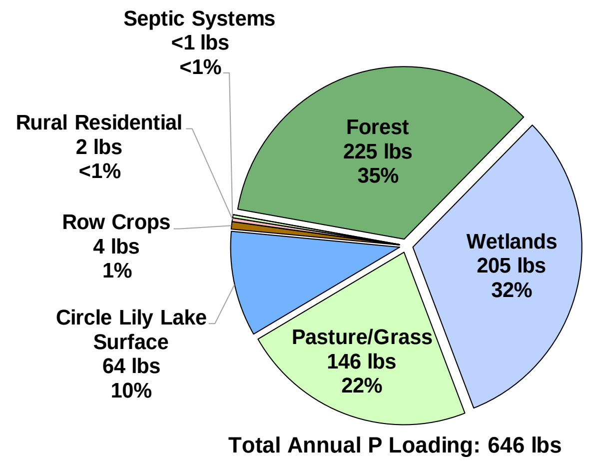


Figure 8.9.2-2. Circle Lily Lake estimated potential annual phosphorus loading. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

8.9.3 Circle Lily Lake Shoreland Condition

Shoreland Development

As is discussed within the Town-wide Section, one of the most sensitive areas of a lake's watershed is the immediate shoreland zone. This transition zone between the aquatic and terrestrial environment is the last source of protection for the lake against pollutants originating from roads, driveways, and yards above, and is also a critical area for wildlife habitat and overall lake ecology. In the fall of 2018, the immediate shoreland of Circle Lily Lake was assessed in terms of its development, and the shoreland zone was characterized with one of five shoreland development categories ranging from urbanized to completely undeveloped.

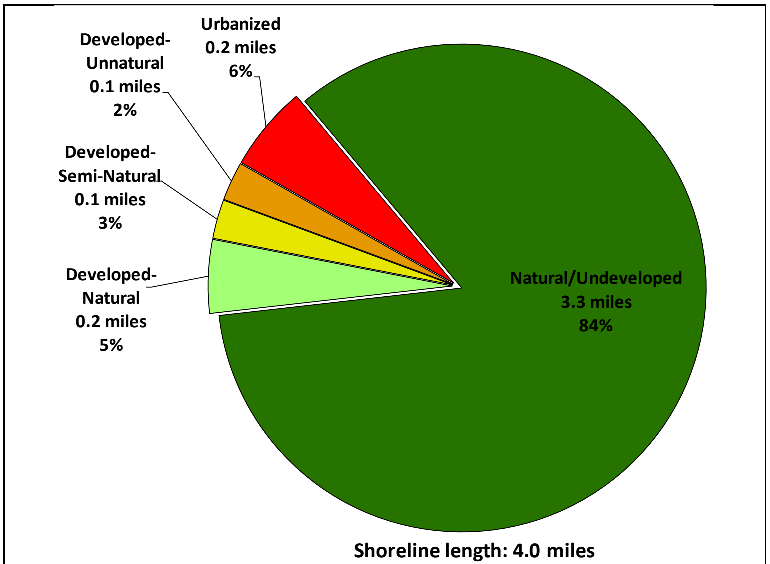


Figure 8.9.3-1. Circle Lily Lake shoreland categories and total lengths. Based upon a fall 2018 survey. Locations of these categorized shorelands can be found on Circle Lily Lake - Map 3.

The 2018 survey revealed that Circle Lily Lake has stretches of shoreland that fit all five shoreland assessment categories (Figure 8.9.3-1). In total, 3.5 miles (89%) of the 4.0-mile shoreland zone were categorized as natural/undeveloped or developed-natural. These shoreland types provide the most benefit to the lake and should be left in their natural state if possible. Approximately 0.3 miles (8%) of the shoreland was categorized as developed-unnatural or urbanized. These shoreland areas provide little benefit to, and may actually adversely impact, the lake. If restoration of Circle Lily Lake's shoreland is to occur, primary focus should be placed on these highly developed shoreland areas. Circle Lily Lake – Map 3 displays the locations of these shoreland categories around the entire lake.

Coarse Woody Habitat

A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey on Circle Lily Lake in 2018. Coarse woody habitat was identified and classified in several size categories (2-8 inches diameter, >8 inches diameter and cluster) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed in the Town-wide Section, 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 et al. 2005).

During the coarse woody habitat survey on Circle Lily Lake, a total of 146 pieces were observed along 4.0 miles of shoreline, yielding a coarse woody habitat to shoreline mile ratio of 37:1 (Figure 8.9.3-2). Onterra ecologists have completed these surveys on 98 Wisconsin lakes since 2012, and Circle Lily Lake falls in the 73rd percentile for the number of coarse woody habitat pieces per shoreline mile. Refraining from removing these woody habitats from the shoreland area will ensure this high-quality habitat remains in Circle Lily Lake. The locations of these coarse woody habitat pieces are displayed on Circle Lily Lake – Map 4.

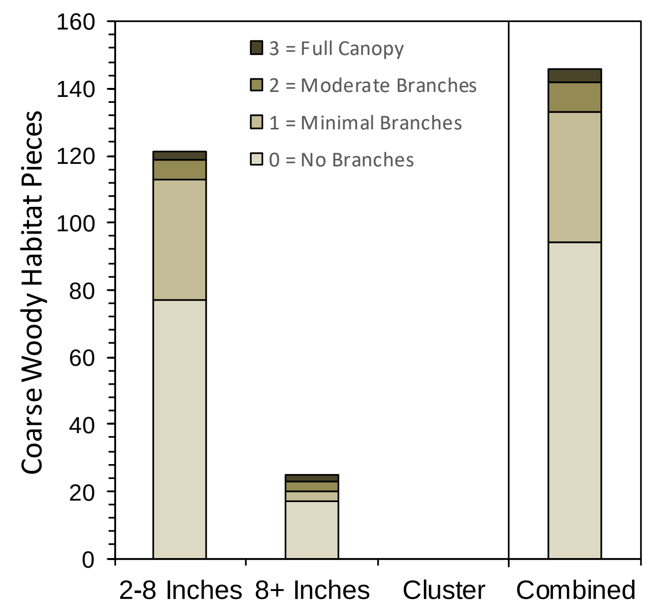


Figure 8.9.3-2. Circle Lily Lake coarse woody habitat survey results. Based upon a fall 2018 survey. Locations of Circle Lily Lake coarse woody habitat can be found on Circle Lily Lake – Map 4.

8.9.4 Circle Lily Lake Aquatic Vegetation

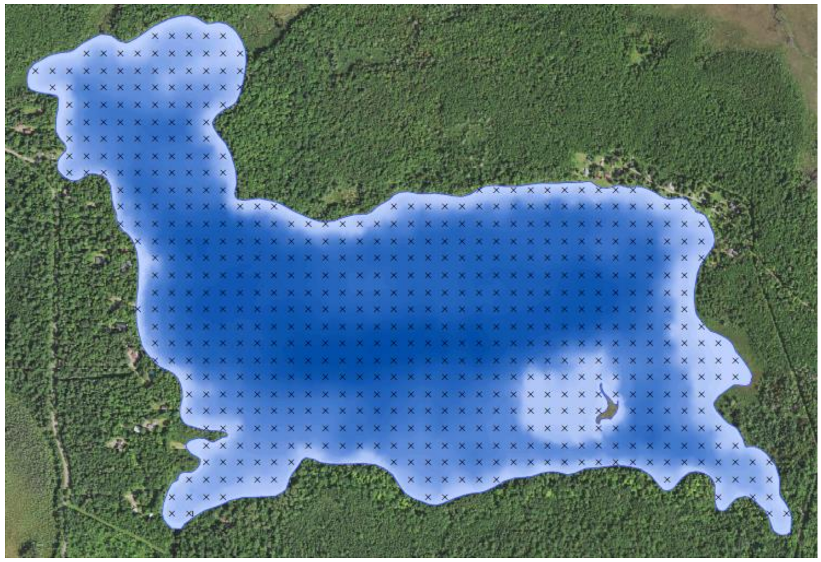


Figure 8.9.4-1. Circle Lily Lake whole-lake point-intercept survey sampling locations (indicated by x). 38-meter resolution; 650 total points

An Early-Season Aquatic Invasive Species (ESAIS) Survey was conducted by Onterra ecologists on Circle Lily Lake on June 25, 2018. While the intent of this survey is to locate any potential non-native species within the lake, the primary focus is to locate occurrences of the non-native curly-leaf pondweed which should be at or near its peak growth at this time. Fortunately, no curly-leaf pondweed was located in Circle Lily Lake in 2018, and it is believed that curly-leaf pondweed is not present within the lake or exists at an undetectable level.

The whole-lake aquatic plant point-intercept survey was conducted on Circle Lily Lake by Onterra ecologists on August 2, 2018 (Figure 8.9.4-1). The emergent and floating-leaf aquatic plant community mapping survey was completed on Circle Lily Lake by Onterra ecologists on August 7, 2018. During these surveys, a total of 33 native aquatic plant species were located (Table 8.9.4-1).

Lakes in Wisconsin vary in their morphometry, water chemistry, substrate composition, and management, all factors which influence aquatic plant community composition. In late September of 2018, Onterra ecologists completed an acoustic survey on Circle Lily Lake (bathymetric results on Circle Lily Lake – Map 1). The sonar-based technology records aquatic plant bio-volume, or the percentage of the water column that is occupied by aquatic plants at a given location. Data pertaining to Circle Lily Lake's substrate composition were also recorded during this survey. The sonar records substrate hardness, ranging from the hardest substrates (i.e. rock and sand) to the more flocculent, softer organic sediments.

Data regarding substrate hardness collected during the 2018 acoustic survey showed that substrate hardness in Circle Lily Lake was not highly variable, with average hardness ranging between 0.26 – 0.31, with the majority being at 0.31 which indicates a moderately hard composition (Figure 8.9.4-2). Unlike a number of the other project lakes which showed harder substrate composition in near-shore areas and softer substrate in deeper areas, Circle Lily Lake showed a fairly consistent composition throughout the lake regardless of depth. These acoustic survey results support the sediment data collected during the point-intercept survey which found a relatively high percentage of the sampling sites to consist of sand (40%) and rock (11%). Soft organic sediments made up a larger percentage of the sampling sites on the other project lakes, but in the case of Circle Lake, only made up 48% of the sites sampled during the point-intercept survey, which is comparatively quite low. 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 areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because of the different habitat types that are available.

Table 8.9.4-1. List of aquatic plant species located in Circle Lily Lake during Onterra 2018 aquatic plant surveys.

Circle Lily

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2018 (Onterra)
Emergent	*Carex sp.*	Sedge sp. (sterile)	N/A	I
Emergent	*Dulichium arundinaceum*	Three-way sedge	9	I
Emergent	*Equisetum fluviatile*	Water horsetail	7	I
Emergent	*Eleocharis palustris*	Creeping spikerush	6	X
Emergent	*Pontederia cordata*	Pickerelweed	9	I
Emergent	*Sagittaria latifolia*	Common arrowhead	3	I
Emergent	*Schoenoplectus acutus*	Hardstem bulrush	5	X
Emergent	*Typha spp.*	Cattail spp.	1	I
FL	*Brasenia schreberi*	Watershield	7	X
FL	*Nuphar x rubrodisca*	Intermediate pondlily	9	I
FL	*Nuphar variegata*	Spatterdock	6	X
FL	*Sparganium fluctuans*	Floating-leaf bur-reed	10	X
Submergent	*Bidens beckii*	Water marigold	8	X
Submergent	*Chara spp.*	Muskgrasses	7	X
Submergent	*Eriocaulon aquaticum*	Pipewort	9	X
Submergent	*Heteranthera dubia*	Water stargrass	6	X
Submergent	*Isoetes echinospora*	Spiny-spored quillwort	8	X
Submergent	*Myriophyllum tenellum*	Dwarf watermilfoil	10	X
Submergent	*Myriophyllum sibiricum*	Northern watermilfoil	7	X
Submergent	*Nitella spp.*	Stoneworts	7	X
Submergent	*Najas flexilis*	Slender naiad	6	X
Submergent	*Potamogeton alpinus*	Alpine pondweed	9	I
Submergent	*Potamogeton pusillus*	Small pondweed	7	X
Submergent	*Potamogeton richardsonii*	Clasping-leaf pondweed	5	X
Submergent	*Potamogeton spirillus*	Spiral-fruited pondweed	8	X
Submergent	*Potamogeton amplifolius*	Large-leaf pondweed	7	X
Submergent	*Potamogeton gramineus*	Variable-leaf pondweed	7	X
Submergent	*Sagittaria sp. (sterile)*	Arrowhead sp. (sterile)	N/A	I
Submergent	*Utricularia vulgaris*	Common bladderwort	7	X
Submergent	*Utricularia purpurea*	Large purple bladderwort	9	X
Submergent	*Vallisneria americana*	Wild celery	6	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X
S/E	*Schoenoplectus subterminalis*	Water bulrush	9	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species

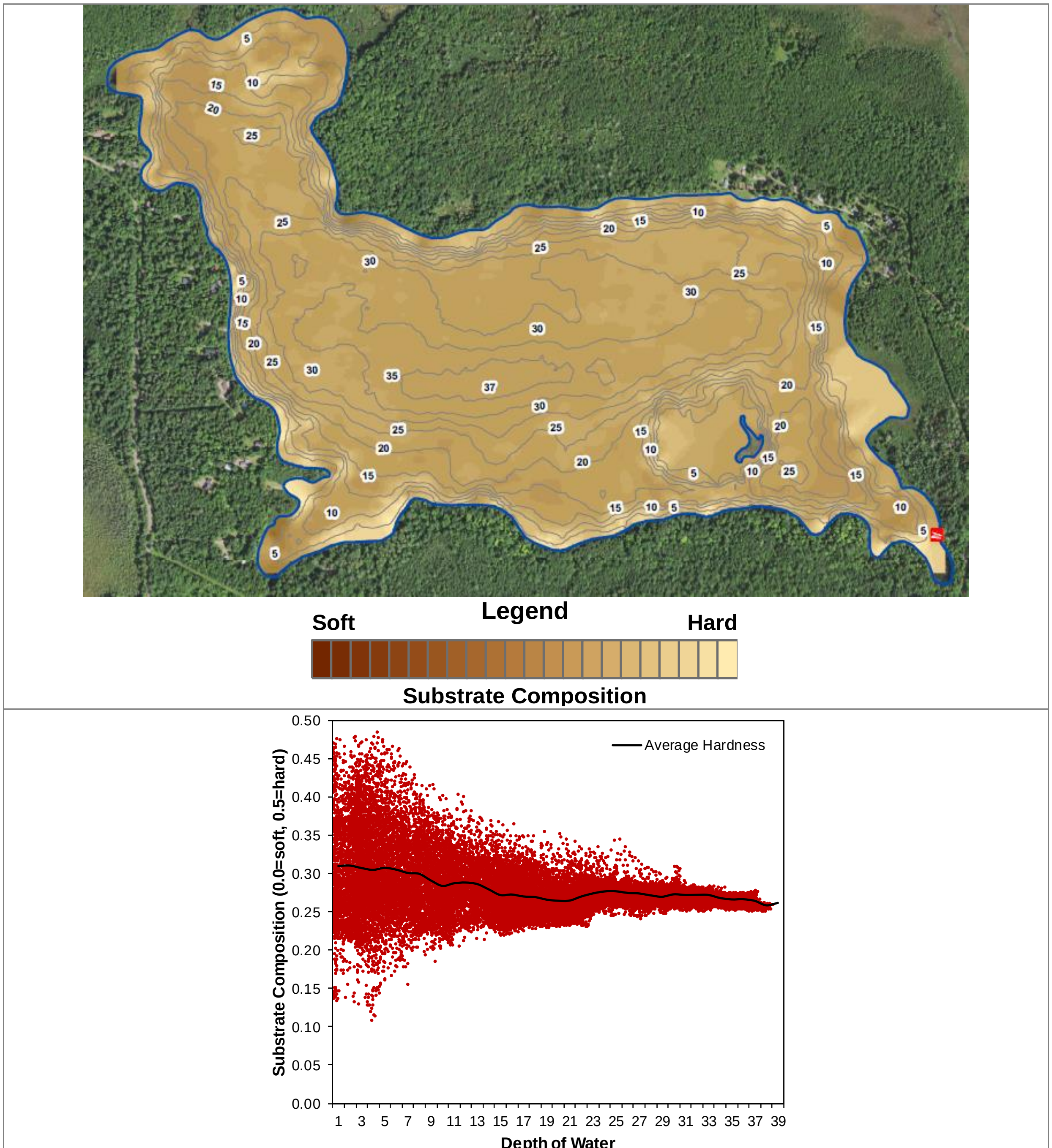


Figure 8.9.4-2. Circle Lily Lake spatial distribution of substrate hardness (top) and substrate hardness across water depth (bottom). Depth contours represent 5-foot intervals. Individual data points are displayed in red. Creating using data from September 2018 acoustic survey.

The acoustic survey also recorded aquatic plant bio-volume throughout the entire lake. As mentioned earlier, aquatic plant bio-volume is the percentage of the water column that is occupied by aquatic plants. The 2018 aquatic plant bio-volume data are displayed in Figure 8.9.4-3 and Circle Lily – Map 6. Areas where aquatic plants occupy most or all of the water column are indicated in red. The majority of aquatic plant growth occurs in Circle Lily Lake within 1.0-5.0 feet of water. The 2018 acoustic survey indicated approximately 17% (39 acres) of Circle Lily

Lake's area is occupied by aquatic vegetation, while the remaining 83% of the lake contains unsuitable substrates or is too deep to support aquatic plant growth.

During the point-intercept survey, aquatic plants were recorded growing to a maximum depth of 5 feet in 2018. Of the 96 point-intercept sampling locations that fell at or shallower than the maximum depth of plant growth (littoral zone), approximately 62% contained aquatic vegetation. Aquatic plant rake fullness data collected in 2018 indicates that 44% of the 96 littoral sampling locations contained vegetation with a total rake fullness rating (TRF) of 1, 15% had a TRF rating of 2, and 4% had a TRF rating of 3 (Figure 8.9.4-4). These TRF ratings indicate that the biomass of aquatic vegetation in Circle Lily Lake is moderate.

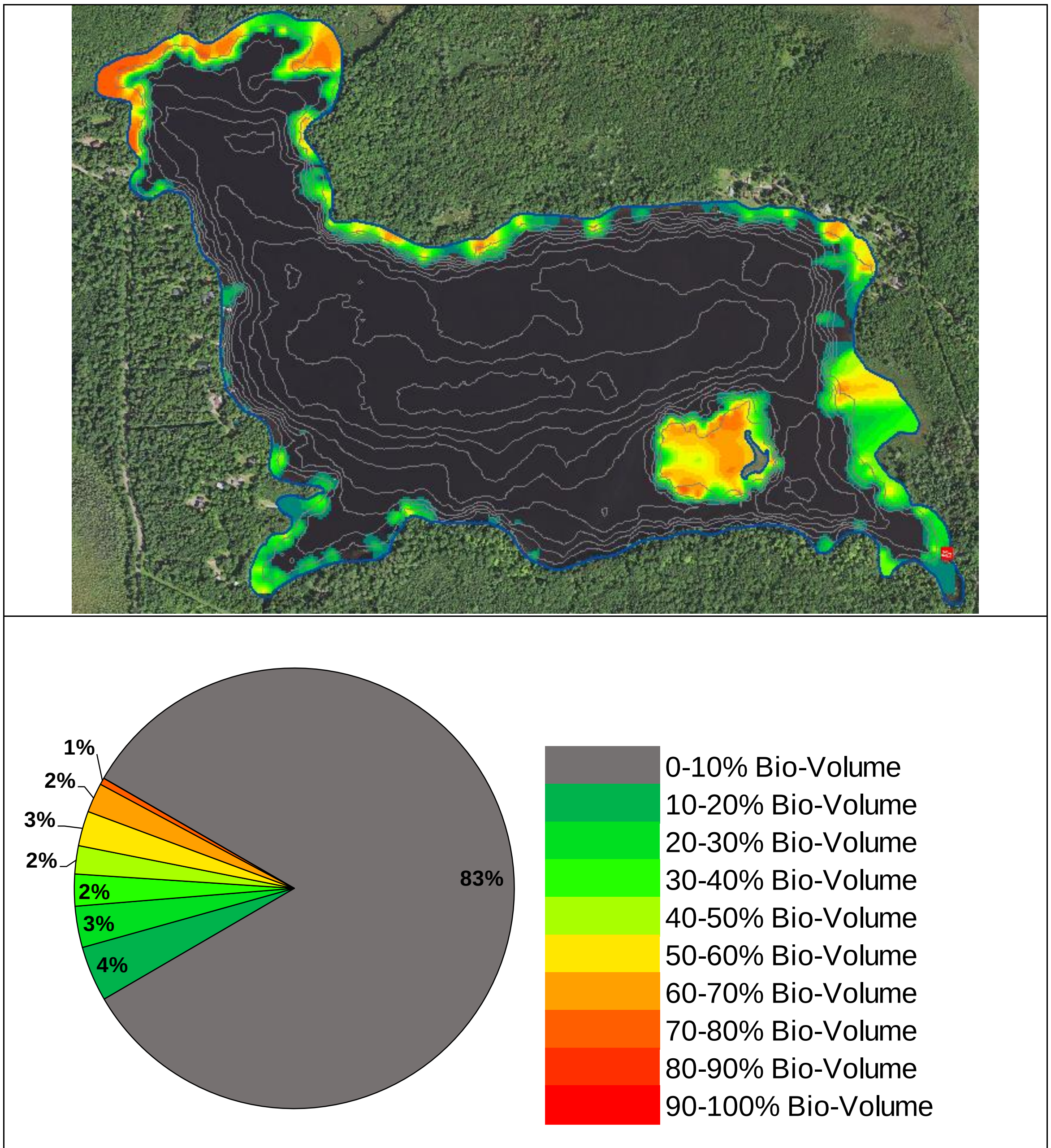


Figure 8.9.4-3. Circle Lily Lake 2018 aquatic plant bio-volume. Contour lines are 5-foot intervals. Created using data from September 2018 acoustic survey data.

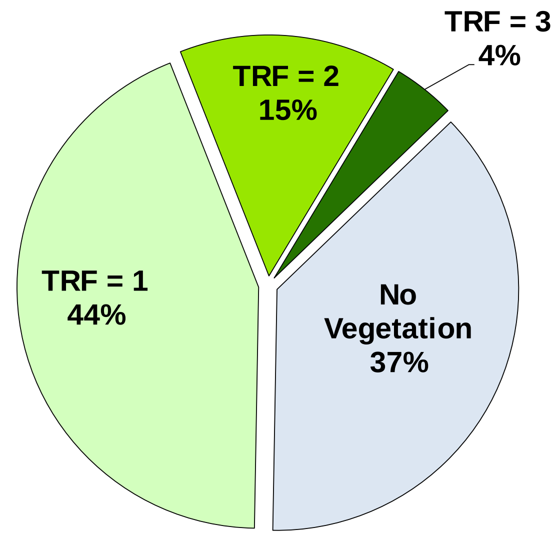


Figure 8.9.4-4. Circle Lily Lake 2018 aquatic vegetation total rake fullness ratings (TRF). Created from data collected during the 2018 whole-lake point-intercept survey (N = 96).

While the acoustic mapping is an excellent survey for understanding the distribution and levels of aquatic plant growth throughout the lake, this survey does not determine which aquatic plant species are present. Whole-lake point-intercept surveys are used to quantify the abundance of individual species within the lake. Of the 33 aquatic plant species located in Circle Lily Lake in 2018, 24 were encountered directly on the rake during the whole-lake point-intercept survey. The remaining 9 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 relatively rare within the plant community. Of the 24 species directly sampled with the rake during the point-intercept survey, slender naiad, variable-leaf pondweed, and floating-leaf bur-reed were the three most frequently encountered aquatic plant species (Figure 8.9.4-5).

Slender naiad was the most frequently encountered aquatic plant species in Circle Lily Lake in 2018 with a littoral frequency of occurrence of approximately 22% (Figure 8.9.4-5). Slender naiad is one of three native naiads 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.

Variable-leaf pondweed was the second most frequently encountered aquatic plant in Circle Lily Lake in 2018 with a littoral occurrence of just under 18% (Figure 8.9.4-5). Variable-leaf pondweed produces long, slender stems with alternating lance-shaped leaves. As its name indicates, this plant can look very different from lake to lake, with some populations having larger leaves and others possessing smaller leaves.

Floating-leaf bur-reed was the third most frequently encountered aquatic plant species in Circle Lily Lake in 2018 with a littoral frequency of occurrence of almost 17% (Figure 8.9.4-5). Floating-leaf bur-reed is an aquatic plant which includes long (2.5 to 5 ft) stems and long (2 to 3.25 ft) linear, ribbon-like leaves. Several species of bur-reed exist in Wisconsin, and while some differences exist in the leaves of these plants, the best way to differentiate between them is by the characteristics of their fruits.

One aquatic plant species of importance located in Circle Lily Lake in 2018 was intermediate pond lily (*Nuphar* x *rubrodisca*). This is a naturally-occurring hybrid between spatterdock (*Nuphar variegata*) and small pond lily (*Nuphar microphylla*). The Natural Heritage Inventory (NHI) lists small pond lily as a special concern plant in Wisconsin due to uncertainty regarding its population and rarity in the state. This species can easily be distinguished from other Nuphar species by its red stigmatic disk in the center of the flower (Photo 8.9.4-1).

Photo 8.9.4-1. Flower of intermediate pond lily. Photo credit: Onterra.

Submersed aquatic plants can be grouped into one of two general categories based upon their morphological growth form and habitat preferences. These two groups include species of the *isoetid* growth form and those of the *elodeid* growth form. Plants of the isoetid growth form are small, slow-growing, inconspicuous submerged plants (Photo 8.9.4-2). These species often have evergreen, succulent-like leaves and are usually found growing in sandy/rocky soils within near-shore areas of a lake (Boston and Adams 1987, Vestergaard and Sand-Jensen 2000).

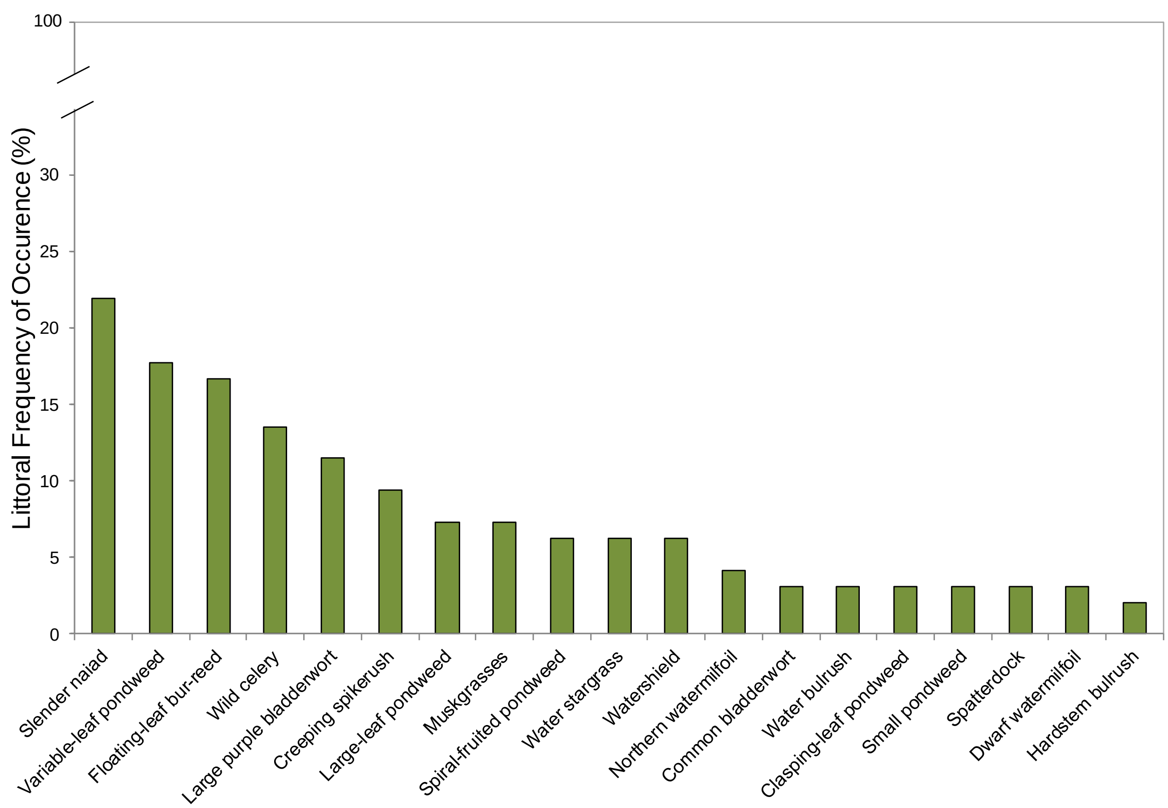


Figure 8.9.4-5. Circle Lily Lake 2018 littoral frequency of occurrence of aquatic plant species. Created using data from 2018 whole-lake point-intercept survey.

In contrast, aquatic plant species of the elodeid growth form have leaves on tall, erect stems which grow up into the water column, and are the plants that lake users are likely more familiar with (Photo 8.9.4-2). It is important to note that the definition of these two groups is based solely on morphology and physiology and not on species' relationships. For example, dwarf-water milfoil (*Myriophyllum tenellum*) is classified as an isoetid, while all of the other milfoil species in Wisconsin such as northern water milfoil (*Myriophyllum* sibiricum) are classified as elodeids.

Alkalinity, as it relates to the amount of bicarbonate within the water, is the primary water chemistry factor for determining a lake's aquatic plant community composition in terms of isoetid versus elodeid growth forms (Vestergaard and Sand-Jensen 2000). Most aquatic plant species of the elodeid growth form cannot inhabit lakes with little or no alkalinity because their carbon demand for photosynthesis cannot be met solely from the dissolved carbon dioxide within the water and must be supplemented from dissolved bicarbonate.

On the other hand, aquatic plant species of the isoetid growth form can thrive in lakes with little or no alkalinity because they have the ability to derive carbon dioxide directly from the sediment, and many also have a modified form of photosynthesis to maximize their carbon storage (Madsen et al. 2002). While isoetids are able to grow in lakes with higher alkalinity, their short stature makes them poor competitors for space and light against the taller elodeid species. Thus, isoetids are most prevalent in lakes with little to no alkalinity where they can avoid competition from elodeids. However, in lakes with moderate alkalinity, like Circle Lily Lake, the aquatic plant community can be comprised of isoetids growing beneath a scattered canopy of the larger elodeids. Isoetid communities are vulnerable to sedimentation and eutrophication (Smolders et al. 2002), and a number are listed as special concern (e.g. northeastern bladderwort) or threatened in Wisconsin due to their rarity and susceptibility to environmental degradation.


Photo 8.9.4-2. Lake quillwort (*Isoetes lacustris*) of the isoetid growth form (left) and variable-leaf pondweed (*Potamogeton gramineus*) and fern pondweed (*P. robbinsii*) of the elodeid growth form (right).

As discussed in the Town-Wide 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 native species encountered on the rake during 2018 point-intercept survey on Circle Lily Lake and their conservatism values were used to calculate the FQI of Circle Lily Lake's aquatic plant community (equation shown below).

FQI = Average Coefficient of Conservatism * √ Number of Native Species

Figure 8.9.4-6 compares the 2018 FQI components of Circle Lily Lake to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) ecoregion and lakes throughout Wisconsin. The native species richness, or number of native aquatic plant species located on the rake in 2018 (24) falls above the median value for lakes in the NLFL ecoregion (21) and for lakes throughout Wisconsin (19) (Figure 8.9.4-6). The average conservatism of the 24 native aquatic plant species located in Circle Lily Lake in 2018 was 7.2, falling above the median average conservatism values for lakes within the NLFL ecoregion (6.7) and above the median value for lakes throughout Wisconsin (6.3) (Figure 8.9.4-6). This indicates that a higher proportion of Circle Lily Lake's aquatic plant community is comprised of environmentally-sensitive species, or species with higher conservatism values.

Using Circle Lily Lake's native aquatic plant species richness and average conservatism yields a high FQI value of 35.1 (Figure 8.9.4-6). Circle Lily Lake's FQI value exceeds the median values for lakes within the NLFL ecoregion (30.8) and the median value for lakes throughout the state (27.2). Overall, the FQI analysis indicates that the aquatic plant community found in Circle Lily Lake is of higher quality when compared to the majority of lakes in Wisconsin.

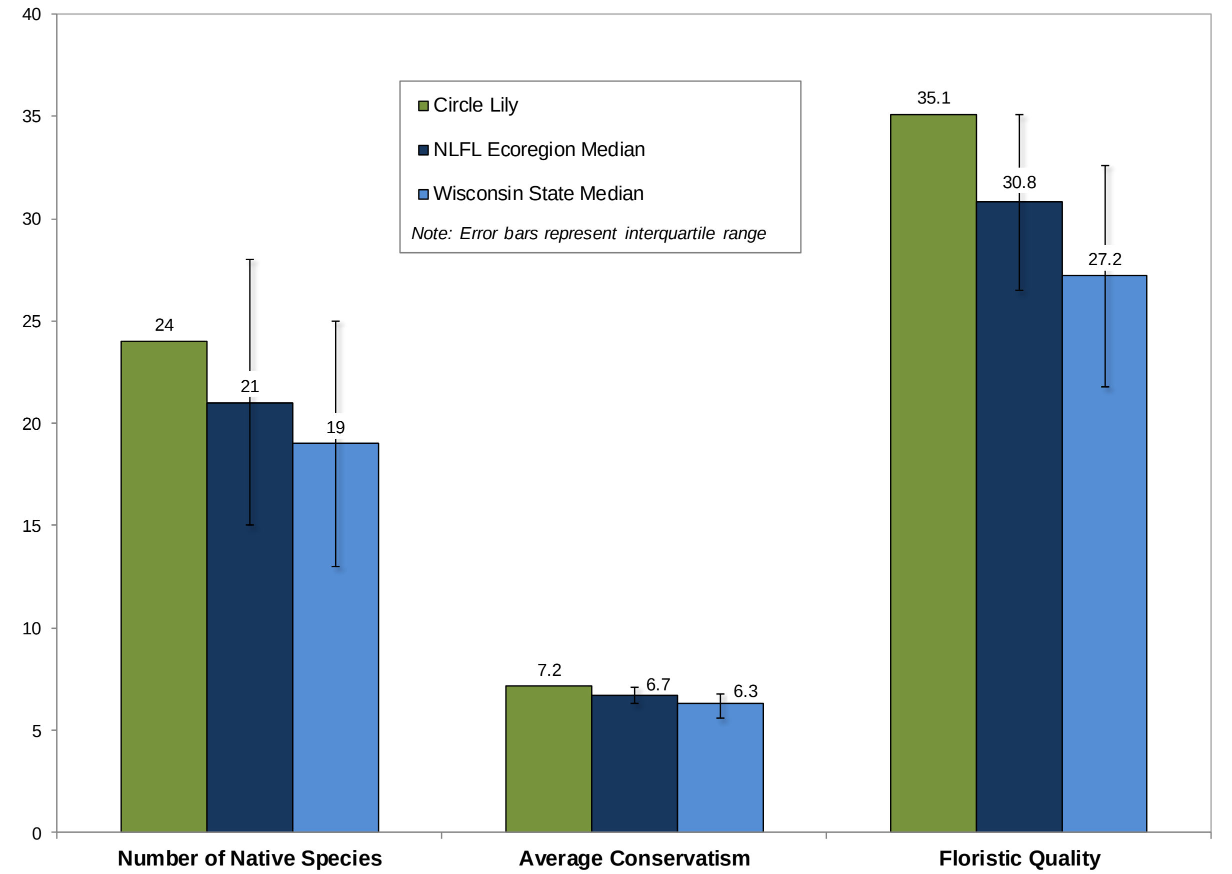


Figure 8.9.4-6. Circle Lily Lake Floristic Quality Assessment. Created using data from Onterra 2018 whole-lake point-intercept survey. Analysis follows Nichols (1999).

As explained in the Town-wide section, 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 Circle Lily Lake contains a higher number of aquatic plant species, one may 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.

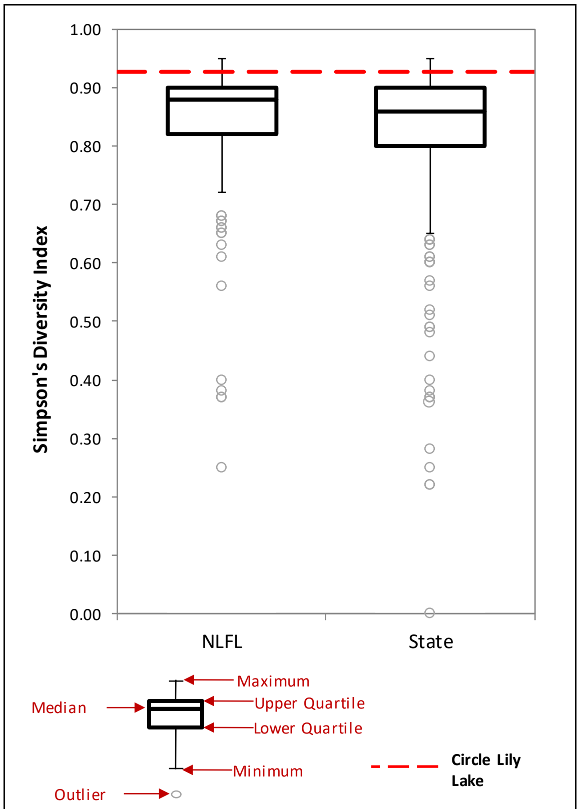


Figure 8.9.4-7. Circle Lily Lake species diversity index. Created using data from Onterra 2018 point-intercept survey.

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 Circle Lily Lake's diversity value ranks. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 212 lakes within the NLFL ecoregion (Figure 8.9.4-7). Using the data collected from the 2018 point-intercept survey, Circle Lily Lake's aquatic plant community was found to have high species diversity with a Simpson's Diversity Index value of 0.93. In other words, if two individual aquatic plants were randomly sampled from Circle Lily Lake in 2018, there would be a 93% probability that they would be different species. Circle Lily Lake's Simpson's Diversity exceeds the median value for lakes in the NLF ecoregion (0.88) and the median value for lakes throughout Wisconsin (0.86).

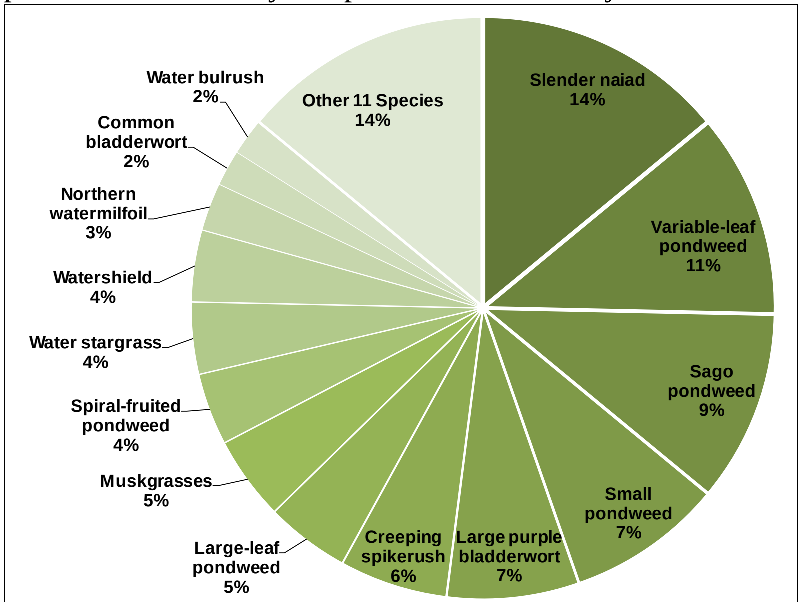


Figure 8.9.4-8. Circle Lily Lake 2018 relative frequency of occurrence of aquatic plant species. Created using data from 2018 point-intercept survey.

One way to visualize Circle Lily Lake's species diversity is to look at the relative occurrence of aquatic plant species. Figure 8.9.4-8 displays the relative frequency of occurrence of aquatic plant species created from the 2018 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 slender naiad was found at 22% of the littoral sampling locations in Circle Lily Lake in 2018, its relative frequency of occurrence was 14%. Explained another way, if 100 plants were randomly sampled from Circle Lily Lake in 2018, 14 of them would be slender naiad.

In 2018, Onterra ecologists also conducted a survey aimed at mapping emergent and floating-leaf aquatic plant communities in Circle Lily Lake. This survey revealed Circle Lily Lake contains approximately 25.3 acres of these communities comprised of 12 plant species (Circle Lily Lake – Map 7 and Table 8.9.4-2). These native emergent and floating-leaf plant communities provide valuable fish and wildlife habitat that is important to the ecosystem of the lake. These areas are particularly important during times of fluctuating water levels, since structural habitat of fallen trees and other forms of course-woody habitat can be quite sparse along the shores of receding water lines. The community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, and a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Circle Lily Lake. This is important because these communities are often negatively affected by recreational use and shoreland development.

Table 8.9.4-2. Circle Lily Lake 2018 acres of emergent and floating-leaf aquatic plant communities. Created using data from 2018 aquatic plant community mapping survey.

Plant Community	Acres
Emergent	4.2
Floating-leaf	1.8
Mixed Emergent & Floating-leaf	19.3
Total	**25.3**

8.9.5 Aquatic Invasive Species in Circle Lily Lake

As of 2018, no aquatic invasive plants have been found in Circle Lily Lake. However, the non-native rusty crayfish (*Orconectes rusticus*) was verified as present in Circle Lily Lake in 2006. Rusty crayfish were introduced to Wisconsin from the Ohio River Basin in the 1960's likely via anglers' discarded bait. In addition to displacing native crayfish (*O. virilis* and *O. propinquus*), rusty crayfish also degrade the aquatic habitat by reducing aquatic plant abundance and diversity and have also been shown to consume fish eggs. While there is currently no control method for eradicating rusty crayfish from a waterbody, aggressive trapping and removal has been shown to significantly reduce populations and minimize their ecological impact.

8.9.6 Circle Lily Lake 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 Circle Lily Lake. The goal of this section is to provide an overview of some of the data that exists. Although current fish 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 Biologist Steve Gilbert (WDNR 2019 & GLIFWC 2018).

Circle Lily 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 Circle Lily 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 algae, 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 8.8.6-1.

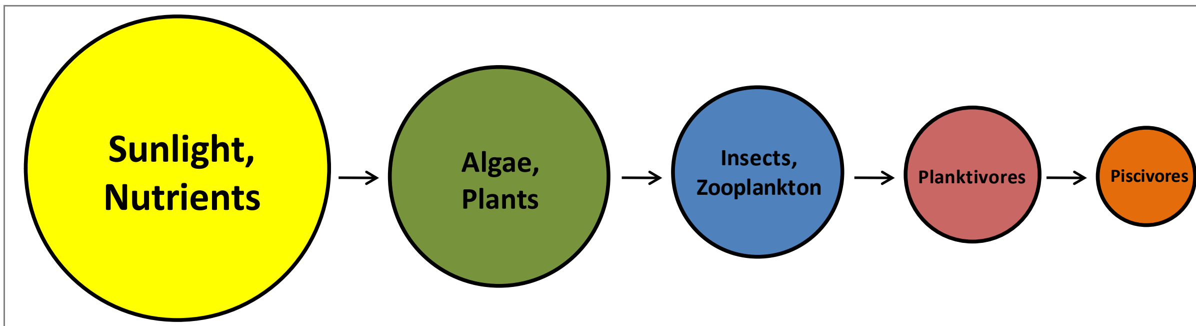


Figure 8.9.6-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Circle Lily is a mesotrophic system, meaning it has a moderate amount of nutrients and thus a moderate amount of primary productivity. This is relative to an oligotrophic system, which contains fewer nutrients (less productive) and a eutrophic system, which contains more nutrients (more productive). Simply put, this means Circle Lily should be able to support an appropriately sized population of predatory fish (piscivores) when compared to eutrophic or oligotrophic systems. Table 8.9.6-1 shows the popular game fish present in the system.

Table 8.9.6-1. Gamefish present in Circle Lily Lake with corresponding biological information (Becker, 1983).

Common Name (*Scientific Name*)	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Largemouth Bass (*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge (*Esox masquinongy*)	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike (*Esox lucius*)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Panfish	9	Dependent on species	Dependent on species	Dependent on species
Smallmouth Bass (*Micropterus dolomieu*)	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish

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 8.9.6-1). 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 8.9.6-1). This is done, often 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 8.9.6-1. 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 8.9.6-2). 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. Circle Lily has been stocked from 1973 to 2015 with walleye and muskellunge (Table 8.9.6-2).

Photograph 8.9.6-2. Fingerling Muskellunge.

Table 8.9.6-2. Stocking data available for Circle Lily Lake (1973-2015).

Year	Species	Strain (Stock)	Age Class	# Fish Stocked	Avg Fish Length (in)
1982	Muskellunge	Unspecified	Fingerling	400	13
1976	Muskellunge	Unspecified	Fingerling	400	13
2015	Walleye	Mississippi Headwaters	Small Fingerling	7,584	1.7
2013	Walleye	Mississippi Headwaters	Small Fingerling	7,805	2
2011	Walleye	Mississippi Headwaters	Small Fingerling	7,805	1.6
2000	Walleye	Unspecified	Small Fingerling	2,900	4.1
1998	Walleye	Unspecified	Small Fingerling	11,425	2.05
1996	Walleye	Unspecified	Fingerling	11,044	1.8
1994	Walleye	Unspecified	Fingerling	11,017	2.05
1991	Walleye	Unspecified	Fingerling	5,103	3
1989	Walleye	Unspecified	Fingerling	15,480	2.5
1988	Walleye	Unspecified	Fingerling	11,000	2
1987	Walleye	Unspecified	Fingerling	33,000	2
1986	Walleye	Unspecified	Fingerling	11,000	2
1979	Walleye	Unspecified	Fingerling	11,000	2
1975	Walleye	Unspecified	Fingerling	6,000	3
1973	Walleye	Unspecified	Fingerling	6,000	3

Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the second important reason for owning property on or near Circle Lily Lake along with nature viewing (Question #14). Figure 8.9.6-2 displays the fish that Circle Lily Lake stakeholders enjoy catching the most, with bluegill/sunfish and walleye being the most popular. Approximately 46% of these same respondents believed that the quality of fishing on the lake was fair, 31% believed poor and 15% believed good (Figure 8.9.6-3). Approximately 51% of respondents who fish Circle Lily Lake believe the quality of fishing has been somewhat or much worse since they started fishing the lake and 38% of respondents believe the fishing has remained the same (Figure 8.9.6-3).

Question 8: What species of fish do you like to catch on Circle Lily Lake?

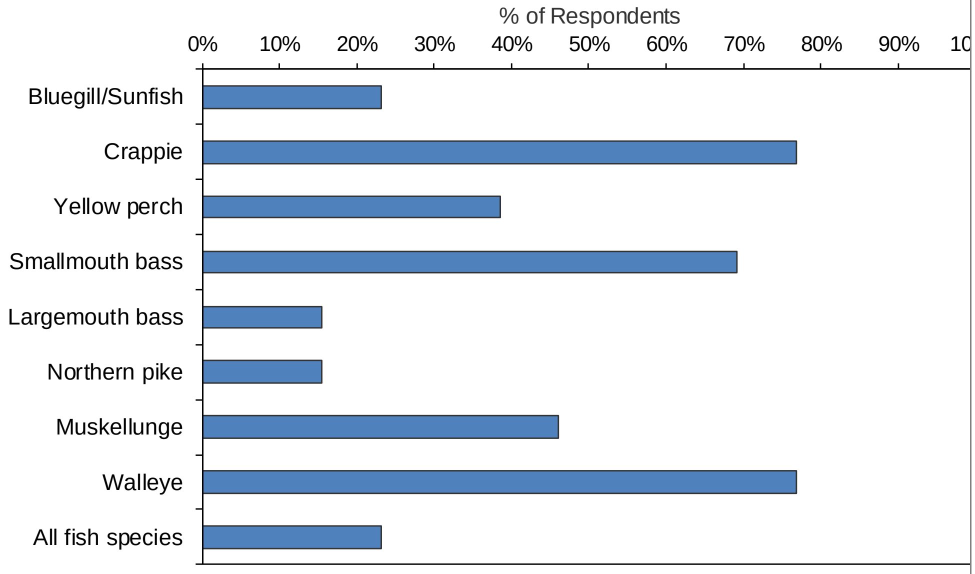
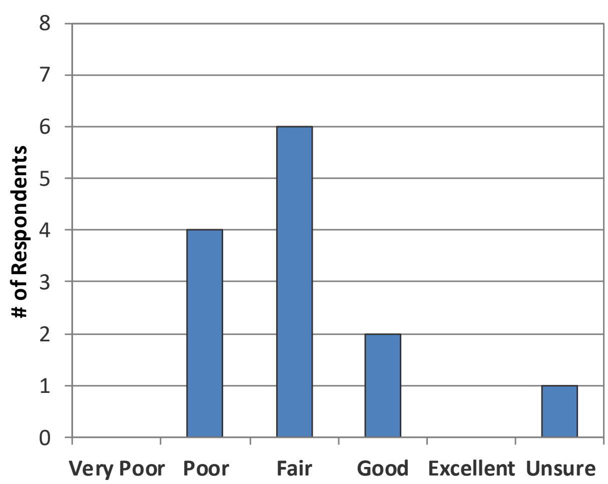


Figure 8.9.6-2. Stakeholder survey response Question 8. Created based on data from 16 respondents of 30 surveys sent (53%).

Question 9: How would you descirbe the current quality of fishing on Circle Lily Lake?



Question 10: How has the quality of fishing changed since you started fishing the lake?

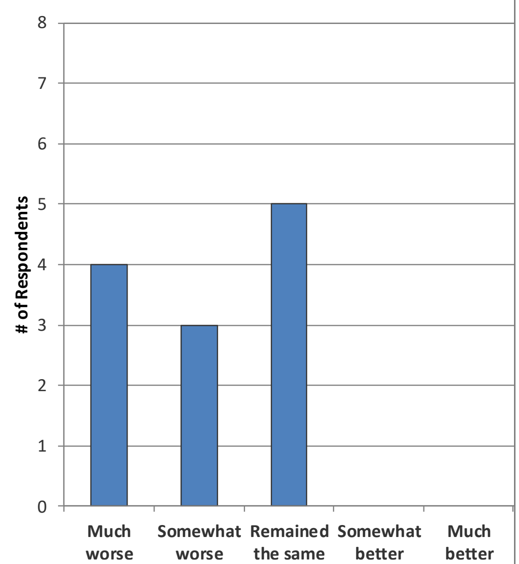


Figure 8.9.6-3. Stakeholder survey responses to questions 9 and 10. Created based on data from 16 respondents of 30 surveys sent (53%).

Circle Lily 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 8.9.6-4). Circle Lily 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. 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 state-wide 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).

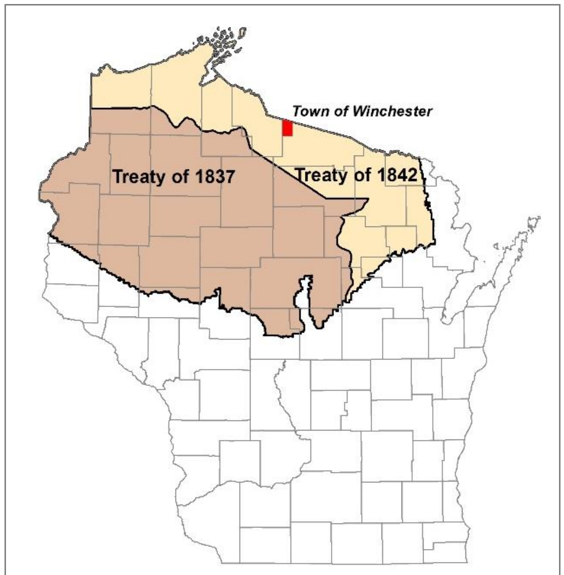


Figure 8.9.6-4. Location of Town of Winchester within the Native American Ceded Territory (GLIFWC 2017). This map was digitized by Onterra; therefore, it is a representation and not legally binding.

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 2016). 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 (GLIWC 2016). 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.

While within the ceded territory, Circle Lily Lake has only experienced one spearfishing harvest occurring in 2012 of two walleye. A small quota for walleye harvest has been listed for the Circle Lily Lake in recent years; however, no other spearing efforts have been undertaken. It is possible that spearing efforts have been concentrated on other larger lakes in the region, which would potentially have a higher estimated safe harvest for both walleye and muskellunge

Circle Lily 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, evade 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 have substrates largely comprised of sand and rock 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 do 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 over soft sediments as well. According to the point-intercept survey conducted by Onterra in 2018, 49% of the substrate sampled in the littoral zone of Circle Lily Lake were soft sediments, 40% was composed of sand and 11% were composed of rock sediments.

Woody Habitat

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass 2006). A fall 2018survey documented 146 pieces of coarse woody along the shores of Circle Lily Lake, resulting in a ratio of approximately 37:1 pieces per mile of shoreline. Fisheries biologists do not suggest a specific number of fish sticks for a lake but rather highly encourage their installation wherever possible. To learn how Circle Lily Lake's coarse woody habitat is compared to other lakes in its region please refer to section 8.9.3.

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. 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 8.9.6-3). 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 other partner contributions.

Photograph 8.9.6-3. Examples of fish sticks (left) and half-log habitat structures (right). (Photos by WDNR).

Fish cribs are a fish habitat structure that are placed on the lakebed. Installing fish cribs may 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. Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 8.9.6-3). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills 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 structures are spawning reefs. Spawning reefs typically consist of small rubble in a shallow area near the shoreline and are mainly installed to enhance 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 indicated the addition of rock substrate did not significantly improve walleye reproduction (WDNR 2004).

Placement of a fish habitat structures in a lake does not require 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 interested, the Town of Winchester, 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 Circle Lily Lake.

Regulations

Regulations for Circle Lily Lake gamefish species as of June 2019 are displayed in Table 8.9.6-3. 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 8.9.6-3. WDNR fishing regulations for Circle Lily Lake (As of June 2019).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	25	None	Open All Year
Smallmouth bass (Early Season)	Catch and release only	None	May 4, 2019 to June 14, 2019
Largemouth bass and smallmouth bass	5	14"	June 15, 2019 to March 1, 2020
Largemouth bass	5	14"	May 4, 2019 to June 14, 2019
Muskellunge and hybrids	1	40"	May 25, 2019 to November 30, 2019
Northern pike	5	None	May 4, 2019 to March 1, 2020
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 4, 2019 to March 1, 2020
Bullheads	Unlimited	None	Open All Year

General Waterbody Restrictions: Motor Trolling is allowed with 1 hook, bait, or lure per angler, and 2 hooks, baits, or lures maximum

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.

As discussed in the Circle Lily Lake Water Quality section (Section 8.9.1), Circle Lily Lake was placed on the 303(d) list of impaired waterbodies for contaminated fish tissue by mercury in 1998. General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 8.9.6-5. 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 8.9.6-5. 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/)

8.9.7 Circle Lily Lake Implementation Plan

The Implementation Plan presented below was created through the collaborative efforts of the Circle Lily Planning Committee, Onterra ecologists, North Lakeland Discovery Center (NLDC), and WDNR staff. It represents the path the Circle Lily riparians will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Circle Lily Lake stakeholders as portrayed by the members of the Planning Committee and communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Increase Riparian Stakeholder Participation in Lake Management Activities

Management Action:	Create the Circle Lily Lake Association.
Timeframe:	As soon as possible.
Facilitator:	Circle Lily Lake Stakeholders
Description:	Currently, there is not a lake association on Circle Lily Lake. This puts the management of the lake at several disadvantages: • There is no lake-based voice for the lake when it comes to management decisions made by local municipalities or state agencies. • The lake cannot access WDNR grant funds. • If an AIS is located in the lake, there is no local organization ready to manage the situation. • There is no organized group whose sole mission is to protect Circle Lily Lake. At present, Circle Lily Lake is considered healthy; however, it will take an organized group of individuals to implement the plan contained in this section – a plan that is designed to keep Circle Lily Lake healthy for coming generations.
Action Steps:	
1.	Gather a small group of individuals from multiple areas of the lake to organize the association, likely act as the first board of directors, and recruit members.
2.	Contact Eric Olson, UW-Extension Lakes Program (see Table 8.9.7-1), for information and guidance on creating a lake association, including recruitment tips, example mission statements and bylaws, and important contacts.

Management Action:		Perform door-to-door or dock-to-dock recruitment of new association members.
Timeframe:		2020
Facilitator:		Circle Lily Lake Stakeholders
Description:		Following an initial mailing to Circle Lily Lake property owners, founding members of the Circle Lily Lake Association will complete door-to-door and dock-to-dock contacts with non-member households. This will be an organized effort beginning with non-member neighbors of current members. Then, the program will expand to other households around the lake.
Action Steps:		
1.	Utilizing a lake property parcel map, the founding members will create a current membership map that resulted from the initial mailing. Vilas County Land Information Dept. can assist in creating the map.	
2.	Founding members and other active association members will first speak to their neighbors that are not members. The program will then branch out to other areas of the lake. Recruiters will be equipped with association information and membership forms. Importantly, information regarding volunteer opportunities will be a part of the association information as well.	
3.	As contacts are made, those initiating the contact will report back to a founding member that is tracking progress on the map. Notes would be added to the map indicating if no contact has been made after several attempts, the owners are not interested, there is follow-up necessary, and/or the household will be joining, etc.	

Please Note: *The management goals and actions described below for Circle Lily Lake assume that the Circle Lily Lake Association (CLLA) has been created and will be facilitator of the actions. While the creation of the association is not absolutely necessary for the implementation of the plan, an association, or other qualified entity, would be necessary to apply for grants described in some of the actions.*

Management Goal 2: Maintain Ecological Health of Circle Lily Lake

Management Action:	Promote lake protection and enjoyment through stakeholder education.
Timeframe:	2020
Facilitator:	Board of Directors
Description:	Education represents an effective tool to address many lake issues. The CLLA will work to create an association website, FaceBook group, member email list, and periodic newsletter. These mediums allow for communication with association members, but increasing the level of communication is important within a management group because it facilitates the spread of important association news, educational topics, volunteer opportunities, and even social happenings. The CLLA will make the education of lake-related issues a priority. These may include educational materials, awareness events, and demonstrations for lake users as well as activities which solicit local and state government support. *Example Educational Topics* • Specific topics brought forth in other management actions • Aquatic invasive species identification • Basic lake ecology • Boating safety (promote existing guidelines, Lake Use Information handout) • Shoreline habitat restoration and protection • Noise and light pollution • Fishing regulations and overfishing • Minimizing disturbance to spawning fish • Realistic expectations for Circle Lily Lake fishery • Results of lake water quality monitoring.
Action Steps:	
	See description above.

Management Action:	Enhance CLLA's involvement with other entities that have responsibilities in managing (management units) Circle Lily Lake
Timeframe:	Continuation of current efforts
Facilitator:	Board of Directors
Description:	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 governmental while others organizations rely on voluntary participation. It is important that the CLLA 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 8.9.7-1
Action Steps:	
	See table guidelines on the following pages.

Table 8.9.7-1 Management Partner List.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Town of Winchester Lakes Committee	Committee Chair (Rolf Ethun,715.686.2139, rolfappraisals@centurytel.net)	Town resource for lake property owners and lake groups	As needed.	Involved in lake management activities, monitoring, implementation, funding, volunteer recruitment. May be contacted regarding ordinance questions, and for information on community events.
Great Lakes Indian Fish and Wildlife Commission	General (715.682.6619)	Resource management within Ceded Territory	As needed.	Collaborate on lake related studies, AIS management, inform of meetings, etc.
Vilas County Lakes & Rivers Association (VCLRA)	President (Tom Ewing, president@vclra.us)	Protects Vilas Co. waters through facilitating discussion and education.	Twice a year or as needed.	Become aware of training or education opportunities, partner in special projects, or networking on other topics pertaining to Vilas Co. waterways.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Wisconsin Department of Natural Resources	Fisheries Biologist (Eric Wegleitner, 715.356.5211 Ext 246)	Manages the fish populations and fish habitat enhancement efforts.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery.
	Lakes Coordinator (Kevin Gauthier, 715.356.5211)	Oversees management plans, grants, all lake activities.	As needed.	Information on planning/AIS projects, grant applications or to seek advice on other lake issues.
	Environmental Grant Specialist (Jill Sunderland, 715.635.4167)	Oversees financial aspects of grants.	As needed.	Information on grant financials and reimbursement, CBCW grant applications.
	Conservation Warden (Matt Meade, 715.329.0615)	Oversees regulations handed down by the state.	As needed. May call the WDNR violation tip hotline for anonymous reporting (1-800-847-9367, 24 hours a day).	Contact regarding suspected violations pertaining to recreational activity, include fishing, boating safety, ordinance violations, etc.
	Water Resources Mgmt Specialist (Sandra Wickman, 715.365.8951, Sandra.Wickman@wisconsin.gov)	Provides training and assistance on CLMN monitoring, methods, and data entry.	Twice a year or more as needed.	Arrange for training as needed, report monitoring activities.
	Trout Lake Station staff (Susan Knight and Carol Warden (715.356.9494)	Conducts lake research on multiple levels	As needed.	Can be contacted for identification or consultation on AIS.
Vilas County Sheriff Dept.	715.479.4441 non-emergency, 911 for emergencies only.	Perform law enforcement duties to protect lakes, especially pertaining to compliance with boating safety rules.	As needed.	Contact regarding suspected violations pertaining to boating safety rules on the lake.
University of Wisconsin Extension Office	Lake Specialist (Pat Goggin, 715.365.8943, Patrick.Goggin@wisconsin.gov)	Provides guidance for lakes, shoreline restoration, and outreach/education.	As needed.	Contact for shoreland remediation/restoration techniques, outreach/education.
North Lakeland Discovery Center	Executive Director (John Heusinkveld, 715.543.2085, john@discoverycenter.net) Water Program Coordinator (Emily Heald, 715.543.2085, water@discoverycenter.net)	Educates and inspires connection to the natural state of the Northwoods	As needed.	Project sponsor. Direct resource for AIS education and monitoring needs, operates aquatic education programs and assists with volunteer recruitment.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Vilas County Land and Water Conservation Department	Lake Conservation Specialist (Cathy Higley, 715.479.3738, cahigl@vilascountywi.gov)	Oversees AIS monitoring and education activities county-wide.	Twice a year or more as issues arise.	AIS training and ID, monitoring techniques, CBCW training, report summer activities.
	Lake Conservation Specialist (Mariquita (Quita) Sheehan, 715.479.3721, mashee@vilascountywi.gov)	Oversees conservation efforts for lake grants and projects.	Twice a year or more as needed.	Contact for shoreland remediation/restoration techniques and cost-share procedures, wildlife damage programs, education and outreach documents.
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	Those interested may attend WL's annual conference to keep up-to-date on lake issues. WL reps can assist on grant issues, AIS training, habitat enhancement techniques, etc.

Management Action:	Monitor water quality through WDNR Citizens Lake Monitoring Network.
Timeframe:	Continuation of current effort.
Facilitator:	CLLA Board of Directors
Description:	Monitoring water quality is an important aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason of why the trend is occurring. Volunteer water quality monitoring, through the Citizen Lake Monitoring Network (CLMN) is currently being conducted on Circle Lily Lake and has been since 1996. The CLMN is a WDNR program in which volunteers are trained to collect water quality information on their lake. Participation in the advanced CLMN program, which includes collecting Secchi disk transparency and sending in water chemistry samples (chlorophyll-a, and total phosphorus) to the Wisconsin State Laboratory of Hygiene for analysis, would be the ultimate objective of this action for the CLLA. The samples are collected three times during the summer and once during the spring. It is 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).

		It will be the Board of Directors responsibility to ensure that a volunteer is prepared to communicate with WDNR representatives and collect water quality samples each year.
Action Steps:		
	1.	Trained CLMN volunteer(s) collects data and report results to WDNR and to association members during annual meeting.
	2.	CLMN volunteer and/or CLLA Board of Directors would facilitate new volunteer(s) as needed
	3.	Coordinator contacts Sandra Wickman (715.365.8951) to acquire necessary materials and training for new volunteer(s)

Management Action:	Work with WDNR fisheries staff to increase proper fish habitat and determine appropriate stocking routine.
Timeframe:	2020
Possible Grant:	WDNR Healthy Lakes Initiative Grant (Fishsticks)
Facilitator:	CLLA Board of Commissioners
Description:	Fishing was the second most important reason for owning property on or near Circle Lily Lake along with nature viewing (Question #14). Over 86% of respondents had fished the lake in the past three years and of those people, over half believe that the quality of fishing has gotten somewhat or much worse since they began fishing on the lake. The CLLA will work with local fisheries biologists to determine what type of fish structure improvements could be made to the lake to improve its fishery. Further, once those improvements are made, determine a stocking routine that will provide quality fishing opportunities on the lake. If the WDNR fisheries biologist supports the addition of coarse woody habitat to Circle Lily Lake, the CLLA could apply for a Healthy Lakes Initiative Grant to fund the project. The WDNR's Healthy Lakes Initiative Grant allows partial cost coverage for coarse woody habitat improvements (referred to as "fish sticks"). 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. • 75% state share grant with maximum award of $25,000; up to 10% state share for technical assistance • Maximum of $1,000 per cluster of 3-5 trees (best practice cap) • Implemented according to approved technical requirements (WDNR Fisheries Biologist) and complies with local shoreland zoning ordinances • Buffer area (350 ft^2) at base of coarse woody habitat cluster must comply with local shoreland zoning or: o The landowner would need to commit to leaving the area un-mowed

	○ The landowner would need to implement a native planting (also cost share through this grant program available) • Coarse woody habitat improvement projects require a general permit from the WDNR • Landowner must sign Conservation Commitment pledge to leave project in place and provide continued maintenance for 10 years
Action Steps:	
1.	See description above.

<u>Management Action:</u>	Coordinate annual volunteer monitoring for Aquatic Invasive Species on Circle Lily Lake.
Timeframe:	Begin 2020
Facilitator:	CLLA Board of Directors
Description:	In lakes without Eurasian watermilfoil and other submersed invasive species like curly-leaf pondweed, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. One way in which lake residents can spot early infestations of AIS is through conducting "Lake Sweeps" on their lake. During a lake sweep, volunteers monitor the entire area of the system in which plants grow (littoral zone) twice annually in search of non-native plant species. This program uses an "adopt-a-shoreline" approach where volunteers are responsible for surveying specified areas of the system. In order for accurate data to be collected during these sweeps, volunteers must be able to identify non-native species such as Eurasian watermilfoil and curly-leaf pondweed. Distinguishing these plants from native look-a-likes is very important. The CLLA will initially recruit volunteers at the group's annual meeting by displaying a map of the Circle Lily Lake shoreline divided into relatively equal sections. Volunteers can then write their names next to a section and provide contact information on a separate form. The CLLA Board of Directors will then utilize that list to set up the monitoring program on the lake. The CLLA Board of Directors will also work with NLDC staff and riparian property owners to remove pale-yellow iris and aquatic forget-me-not from the lake's shoreline.
Action Steps:	
1.	Board of Directors maintains volunteer list to complete shoreline sweeps.

4. Board of Directors contact volunteers and set up training session with NLDC or other qualified agency, like Vilas County.
5. Board of Directors coordinate surveys, collect results, and report on those results at annual meeting and on CLLA website.

<u>Management Action:</u>	Initiate rapid response plan following detection of new AIS
Timeframe:	If/When Necessary
Facilitator:	Board of Directors
Description:	If volunteers locate a suspected new AIS within Circle Lily Lake, the location would be marked (e.g. GPS, maker buoy) and a specimen would be taken to the NLDC or to the Vilas County Land Conservation Department for verification. If the suspected specimen is indeed a non-native species, the WDNR will fill out an incident form and develop a strategy to determine the population level within the lake. The lake would be professionally surveyed, either by agency personnel or a private consulting firm during that species' peak growth phase. If the AIS is a NR40 prohibited species (i.e. red swamp crayfish, starry stonewort, hydrilla, etc.), the WDNR may take an active role in the response. If the AIS is a NR40 restricted species (i.e. purple loosestrife, curly-leaf pondweed, Eurasian watermilfoil, etc.), the CLLA would need to reach out to a consultant to develop a formal monitoring and/or control strategy. The WDNR would be able to help financially through the AIS Grant Program's Early Detection and Response Grant. This grant program is non-competitive and doesn't have a specific application deadline, but is offered on a first-come basis to the sponsor of project waters that contain new infestations (found within less than 5% of the lake and officially documented less than 5 years from grant application date). Currently this program will fund up to 75% percent of monitoring and control costs, up to $20,000.
Action Steps:	
	See description above

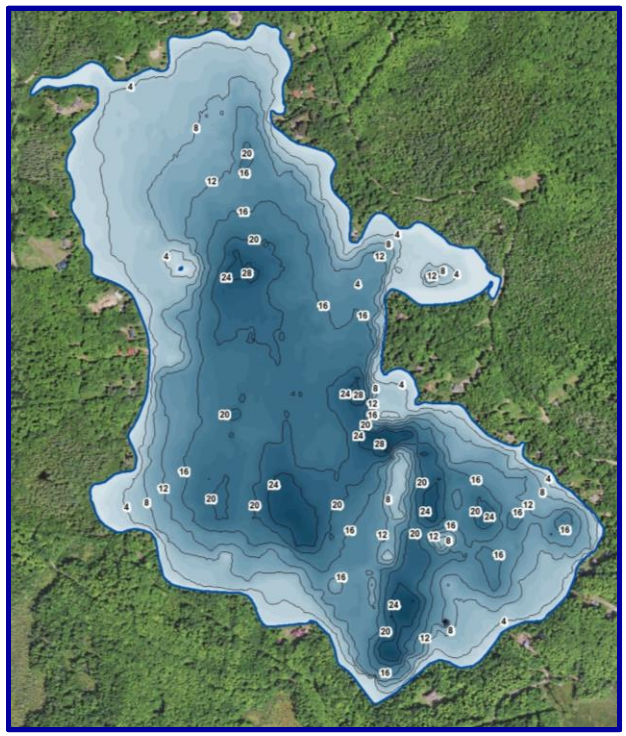
8.10 Pardee Lake

An Introduction to Pardee Lake

Pardee Lake, Iron County, is a 213-acre deep headwater, lightly colored, mesotrophic drainage lake with a maximum depth of 28 feet and a mean depth of 12 feet (Pardee Lake – Map 1). Its surficial watershed encompasses approximately 2,109 acres in Vilas and Iron counties, WI. The lake's watershed contains over ten small lakes. Some of them are seepage lakes and may not drain into Pardee Lake most years while George and Marion lakes periodically drain into Pardee Lake. Pardee Creek leaves Pardee Lake and eventually enters the Turtle River. In 2018, 42 native aquatic plant species were located within the lake, of which fern-leaf pondweed (*Potamogeton robbinsii*) was the most common. The non-native, invasive wetland plants, pale-yellow iris (*Iris pseudacorus*) and aquatic forget-me not (*Myosotis scorpioides*) were located in a few locations along Pardee Lake's shoreline in 2018. To date, no other non-native species have been documented in Pardee Lake.

Lake at a Glance - Pardee Lake

Morphometry	
LakeType	Deep Headwater Drainage
Surface Area (Acres)	213
Max Depth (feet)	28
Mean Depth (feet)	12
Perimeter (Miles)	3.5
Shoreline Complexity	2.9
Watershed Area (Acres)	2,109
Watershed to Lake Area Ratio	9:1
Water Quality	
Trophic State	Meso-eutrophic
Limiting Nutrient	Phosphorus
Avg Summer P (μg/L)	20
Avg Summer Chl-α (μg/L)	10.5
Avg Summer Secchi Depth (ft)	7.9
Summer pH	8.4
Alkalinity (mg/L as $CaCO_3$)	45.7
Vegetation	
Number of Native Species	42
NHI-Listed Species	None
Exotic Species	PYI & FMN
Average Conservatism	6.9
Floristic Quality	36.7
Simpson's Diversity (1-D)	0.82



Descriptions of these parameters can be found within the town-wide portion of the management plan
PYI = Pale-yellow iris (Iris pseudacorus); *FMN = Aquatic forget-me-not (Myosotis scorpioides)*

8.10.1 Pardee Lake Water Quality

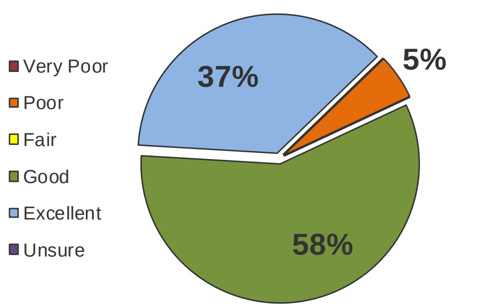
It is often difficult to determine the status of a lake's water quality purely through observation. Anecdotal accounts of a lake "getting better" or "getting worse" can be difficult to judge because a) a lake's water quality may fluctuate from year to year based upon environmental conditions such as precipitation, and b) differences in observation and perception of water quality can differ greatly from person to person. It is best to analyze the water quality of a lake through scientific data as this gives a concrete indication as to the health of the lake, and whether its health has

deteriorated or improved. Further, by looking at data for similar lakes regionally and statewide, the status of a lake's water quality can be made by comparison.

In 2018, a stakeholder survey was sent to 49 Pardee Lake riparian property owners. Twenty (41%) of these 49 surveys were completed and returned. Given the relatively low response rate, the results of the stakeholder survey cannot be interpreted as being statistically representative of the population sampled. At best, the results may indicate possible trends and opinions about stakeholder perceptions of Pardee Lake, but cannot be stated with statistical confidence. The full survey and results can be found in Appendix B.

When asked about Pardee Lake's current water quality, 95% of survey respondents indicated the water quality is *good* or *excellent* and 5% indicated the water quality is *poor* (Figure 8.10.1-1). When asked how water quality has changed in Pardee Lake since they first visited the lake, 58% of respondents indicated water quality has *remained the same* and 26% indicated it has *somewhat improved* while 16% felt the water quality was *somewhat* or *severely degraded* (Figure 8.10.1-1). As is discussed in this section, water quality data do indicate that phosphorus and algal production is unchanged in Pardee Lake over the past 17 years.

Question 15: How would you describe the current water quality of Pardee Lake?



Question 16: How has water quality changed in Pardee Lake since you first visited the lake?

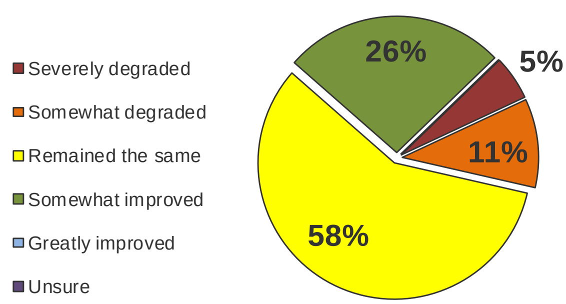


Figure 8.10.1-1. Pardee Lake stakeholder survey responses regarding the lake's current and historical water quality. Created using responses from 20 (41%) respondents of 49 surveys distributed.

Near-surface total phosphorus data for Pardee Lake are available from 1997, annually from 2000-2010 and in 2018 (Figure 8.10.1-2). Average summer total phosphorus concentrations are moderately variable, and range from *excellent* to *good* for deep headwater drainage lakes in Wisconsin. The weighted average summer total phosphorus concentration of 20.0 µg/L using all data places the lake in the *good* category for deep headwater drainage lakes in Wisconsin. Phosphorus concentrations measured in 2018 (16.8 µg/L) were lower than the historical average. Pardee Lake's total phosphorus concentrations are higher than the median concentrations for other deep headwater drainage lakes in Wisconsin (17.0 µg/L) and are similar to all lake types within the Northern Lakes and Forests (NLF) ecoregion (21.0 µg/L).

While phosphorus concentrations in Pardee Lake are variable from year to year, there are no apparent trends (positive or negative) occurring over the time period for which data are available. The variation in phosphorus concentrations between years is likely due to differences in annual precipitation and the amount of surface runoff from the watershed. The somewhat stained water in Pardee lake is an indication that the lake receives some of its water from surface sources within its watershed, primarily water that has passed through forests and wetlands.

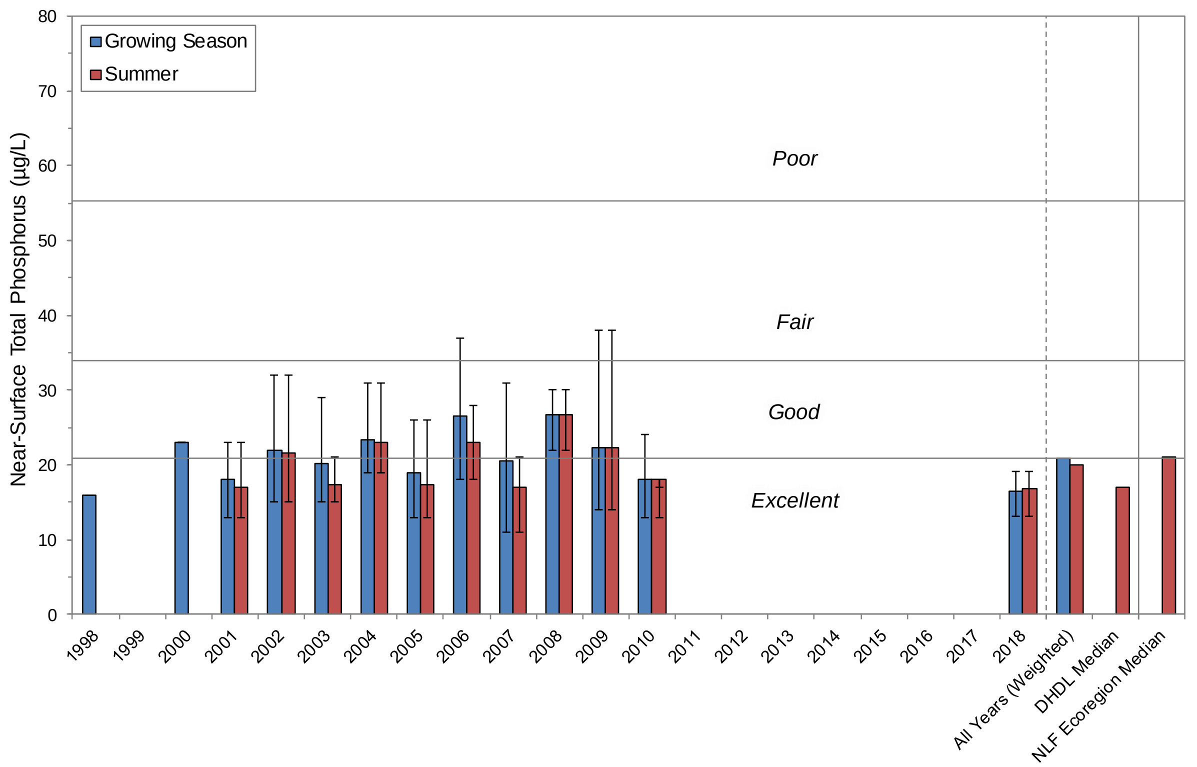


Figure 8.10.1-2. Pardee Lake average annual near-surface total phosphorus concentrations and median near-surface total phosphorus concentrations for state-wide deep headwater drainage lakes (DHDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Chlorophyll-*a* concentrations, a measure of phytoplankton abundance, are available for Pardee Lake from 2000-2010 and 2018 (Figure 8.10.1-3). Chlorophyll-*a* concentrations are more variable from year to year than phosphorus, ranging from *excellent* to *fair* for deep headwater drainage lakes in Wisconsin. Overall, the weighted average summer chlorophyll-*a* concentration is low at 10.5 µg/L, placing the lake in the *good* category although in 2018, the mean summer concentration was lower at 4.2 µg/L, which places the lake in the *excellent* category. Pardee Lake's chlorophyll-*a* concentrations are above the median concentrations for other deep headwater drainage lakes in Wisconsin (5.0 µg/L) and all lake types within the NLF ecoregion (5.6 µg/L). The relatively low level of phytoplankton production in Pardee Lake is a result of the low concentrations of phosphorus, the nutrient regulating phytoplankton production. Although chlorophyll-*a* concentrations were lower in 2018 than during the period 2000-2010, it is uncertain whether this represents an accurate reduction in the lake's algal level. During the earlier period, there is considerable variability from year to year, indicating that algal levels typically fluctuate in Pardee Lake.

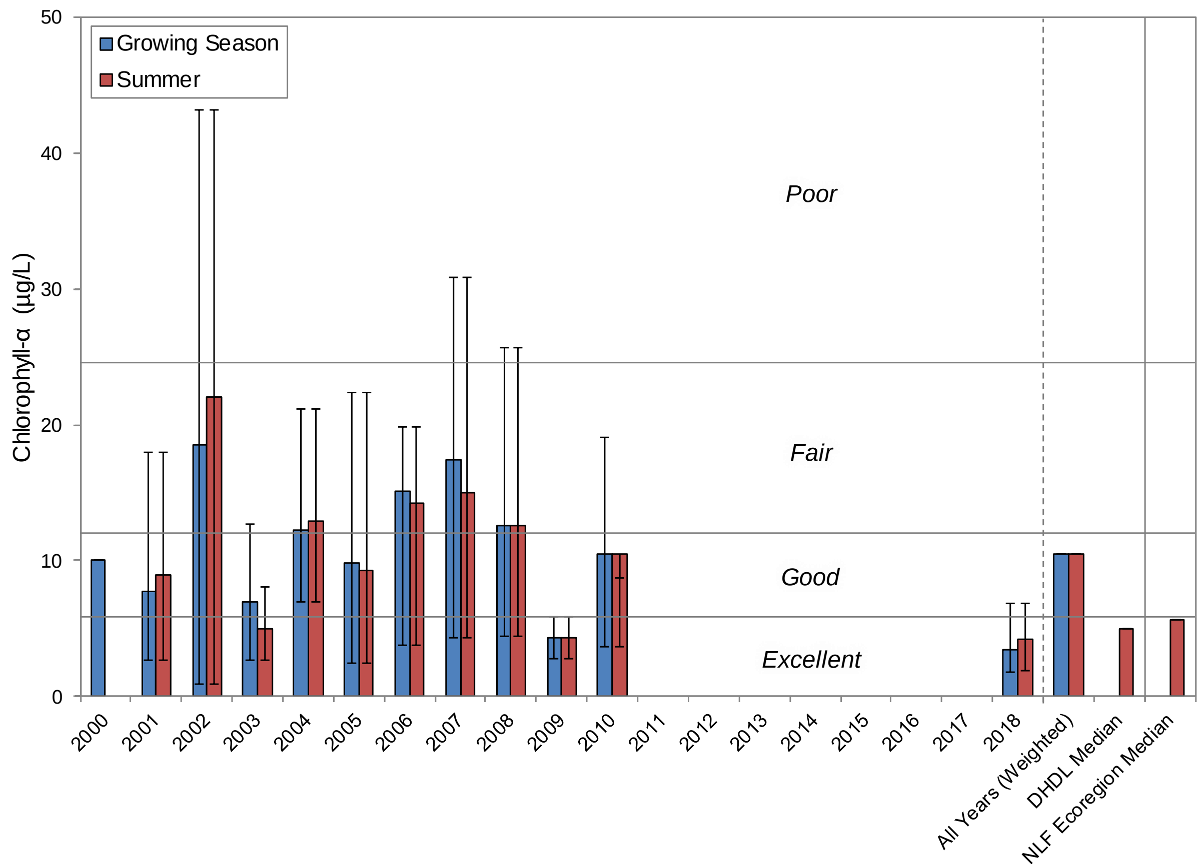


Figure 8.10.1-3. Pardee Lake average annual chlorophyll-α concentrations and median chlorophyll-α concentrations for state-wide deep lowland drainage lakes (DHDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

A longer record and more complete record is available of Secchi disk transparency data than for phosphorus or chlorophyll-*a*. The record is available from Pardee Lake for 1998 through 2012, 2015 and 2016 and 2018 (Figure 8.10.1-4). Average annual Secchi disk depths range from *good* to *excellent* for deep headwater drainage lakes in Wisconsin. The weighted summer average Secchi disk depth in Pardee Lake is 7.9 feet, falling into the *excellent* category for Wisconsin's deep headwater drainage lakes. Pardee Lake's average summer Secchi disk depth is worse than the median values for deep headwater drainage lakes in Wisconsin and for all lake types within the NLF ecoregion. Water clarity in Pardee Lake is similar to what is expected based upon the phosphorus concentrations, and is an indication that the slightly colored water is not significantly reducing water clarity.

Abiotic suspended particulates, such as sediment, can also cause a reduction in water clarity. However, *total suspended solids*, a measure of both biotic and abiotic suspended particles within the water, were low in Pardee Lake in 2018 indicating minimal amounts of suspended material within the water. While suspended particles are minimal in Pardee Lake, water clarity can also be influenced by dissolved compounds within the water. Many lakes in the northern region of Wisconsin contain higher concentrations of natural dissolved organic acids that originate from decomposing plant material within wetlands in the lake's watershed. In higher concentrations, these dissolved organic compounds give the water a tea-like color or staining and decrease water clarity.

A measure of water clarity once all of the suspended material (i.e. phytoplankton and sediments) have been removed, is termed *true color*, and measures how the clarity of the water is influenced by dissolved components. True color values measured from Pardee Lake in 2018 averaged 30 SU (standard units), indicating the lake's water is *lightly tea-colored*. The lower color value for Pardee Lake compared with lakes with more color indicates that even though wetlands are the largest landcover in the watershed, water flow from the wetlands to the lake is reduced compared to the other lakes in this study. The lower concentrations of dissolved organic acids in the lake do not reduce the water's clarity as it does in some of the other lakes. It is important to note that the lightly tea-colored water in Pardee Lake is natural, and is not an indication of degraded conditions.

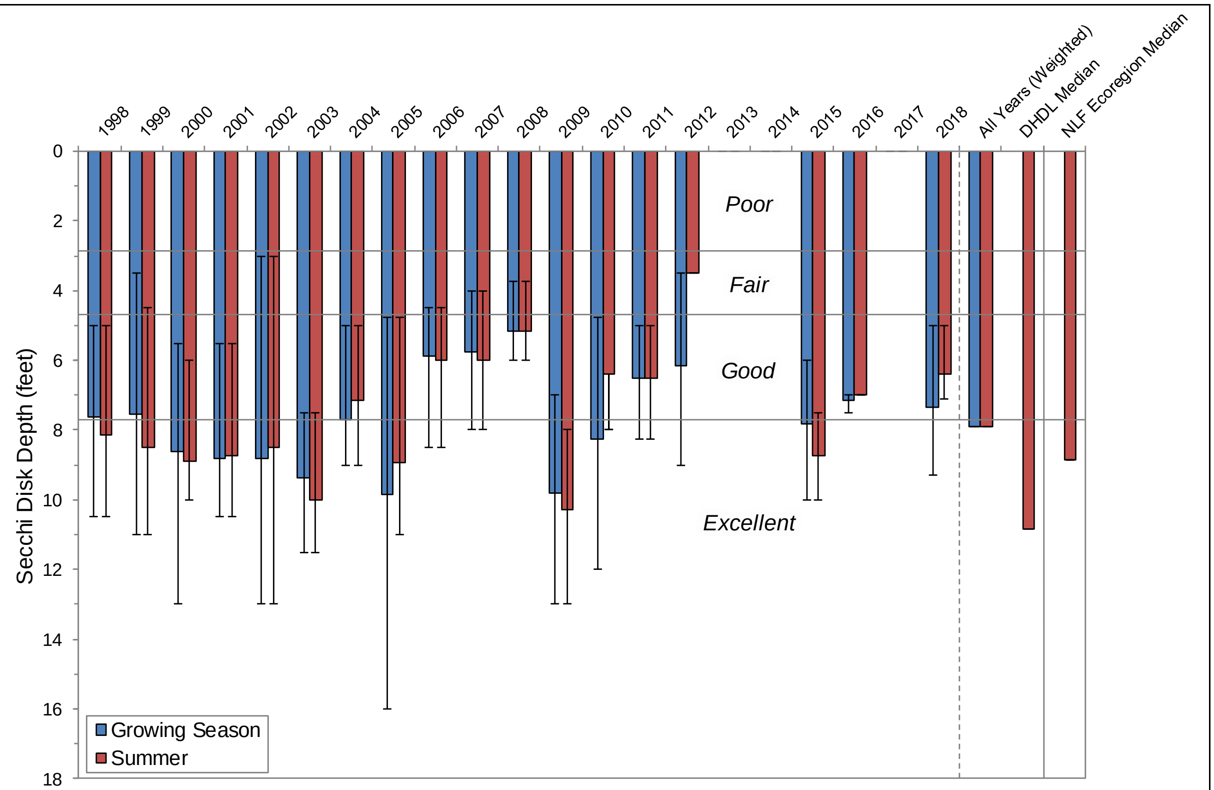


Figure 8.10.1-4. Pardee Lake average annual Secchi disk depths and median Secchi disk depths for state-wide deep headwater drainage lakes (DHDL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

To determine if internal nutrient loading (discussed in town-wide section of management plan) is a significant source of phosphorus in Pardee Lake, near-bottom phosphorus concentrations are compared against those collected from the near-surface. Near-bottom total phosphorus concentrations were measured on five occasions from Pardee Lake in 2018 (Figure 8.10.1-5). As illustrated, on some occasions near-bottom total phosphorus concentrations are similar to those measured near the surface, while on other occasions near-bottom concentrations are higher than near-surface concentrations. The higher concentrations of phosphorus near the bottom occurred when Pardee Lake was stratified and the bottom layer of water (hypolimnion) was anoxic. These

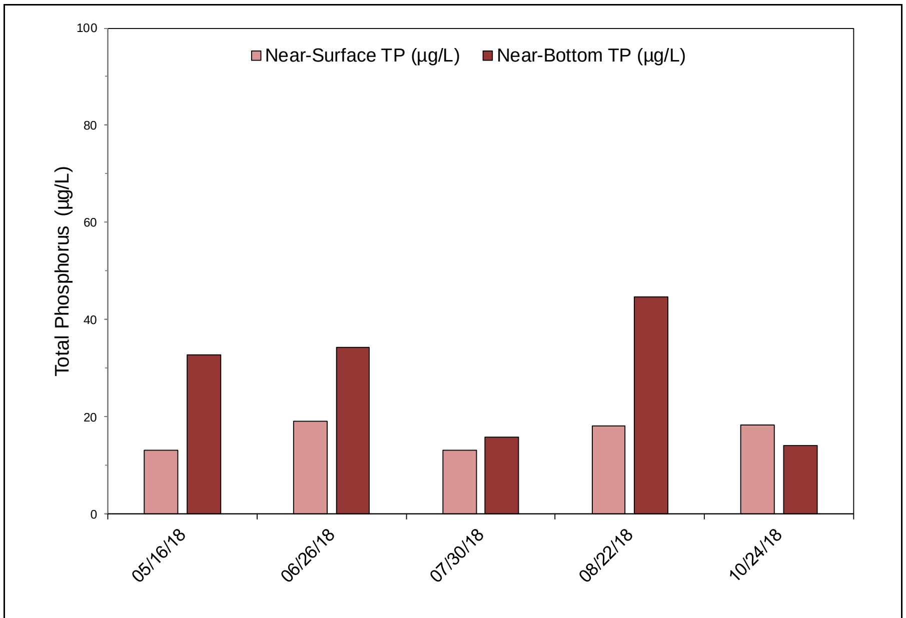


Figure 8.10.1-5. Pardee Lake near-bottom total phosphorus concentrations and corresponding near-surface total phosphorus concentrations.

higher concentrations near the bottom are an indication that phosphorus is being released from bottom sediments into the overlying water during periods of anoxia, or that internal nutrient loading is occurring. However, the concentrations near the bottom are relatively low suggesting that internal loading is not significant in Pardee Lake.

Pardee Lake Trophic State

Figure 8.10.1-6 contains the weighted average Trophic State Index (TSI) values for Pardee Lake. These TSI values are calculated using summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency data collected as part of this project along with historical data. In general, the best values to use in assessing a lake's trophic state are chlorophyll-*a* and total phosphorus, as water clarity can be influenced by other factors other than phytoplankton such as dissolved organic compounds. The closer the calculated TSI values for these three parameters are to one another indicates a higher degree of correlation.

The weighted TSI values for total phosphorus and Secchi disk transparency in Pardee Lake indicate the lake is at present in a mesotrophic, or moderately productive state. The TSI value chlorophyll-*a* is higher and places the lake in the eutrophic category. It appears that algal levels are consistently higher in Pardee Lake than are expected, given the phosphorus concentrations. It is unclear why this is the case. Overall, Pardee Lake's productivity is higher when compared to other deep headwater drainage lakes in Wisconsin and of similar productivity to other lakes within the NLF ecoregion.

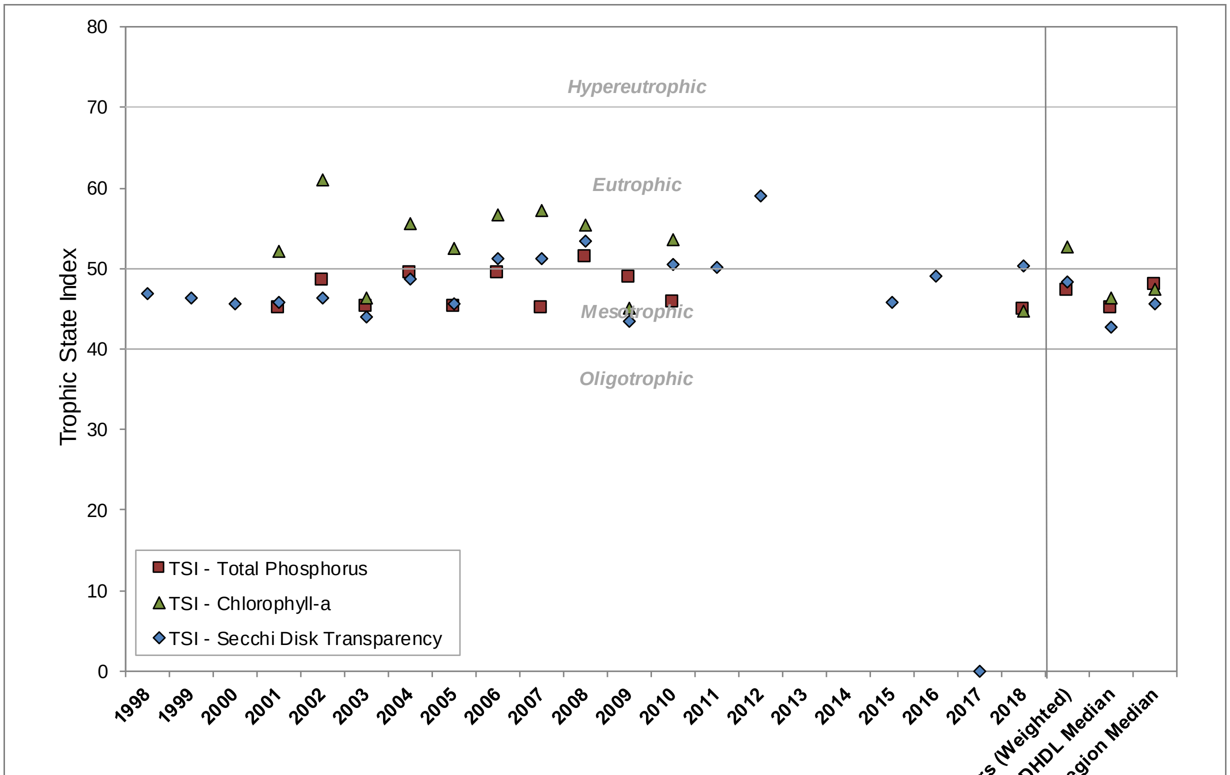


Figure 8.10.1-6. Pardee Lake, statewide deep headwater drainage lakes (DHDL), and Northern Lakes and Forests (NLF) ecoregion lakes Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Pardee Lake

Dissolved oxygen and temperature profile data were collected during each water quality sampling event conducted by Onterra ecologists. These data are displayed in Figure 8.10.1-7. Even though Pardee Lake is classified as a deep lake, it is polymictic meaning it mixes more than during the spring and fall. During the summer, the surface of the lake warms and becomes less dense than the cold layer below, and the lake thermally stratifies. When a windy cool weather occurs, the surface water cools, and the lake mixes. When summer stratification occurs, the bottom layer of water no longer receives atmospheric diffusion of oxygen, and decomposition of organic matter within this layer depletes available oxygen. Once anoxia sets in, phosphorus (and other nutrients) are released from bottom sediments into the overlying hypolimnion. Even though the lake was stratified when it was sampled on July 30, 2018, the higher bottom temperature compared to the June 26 sampling indicates the lake mixed between these sampling events.

In fall as surface temperatures cool, the entire water column is again able to mix which re-oxygenates the hypolimnion and delivers sediment-released nutrients to the surface. During the winter, the coldest temperatures are found just under the overlying ice, while oxygen gradually declines once again towards the bottom of the lake. In February of 2019, oxygen concentrations remained above 2.0 mg/L in the top 10 feet of the water column, indicating that fishkills as a result of winter anoxia are not a concern in Pardee Lake.

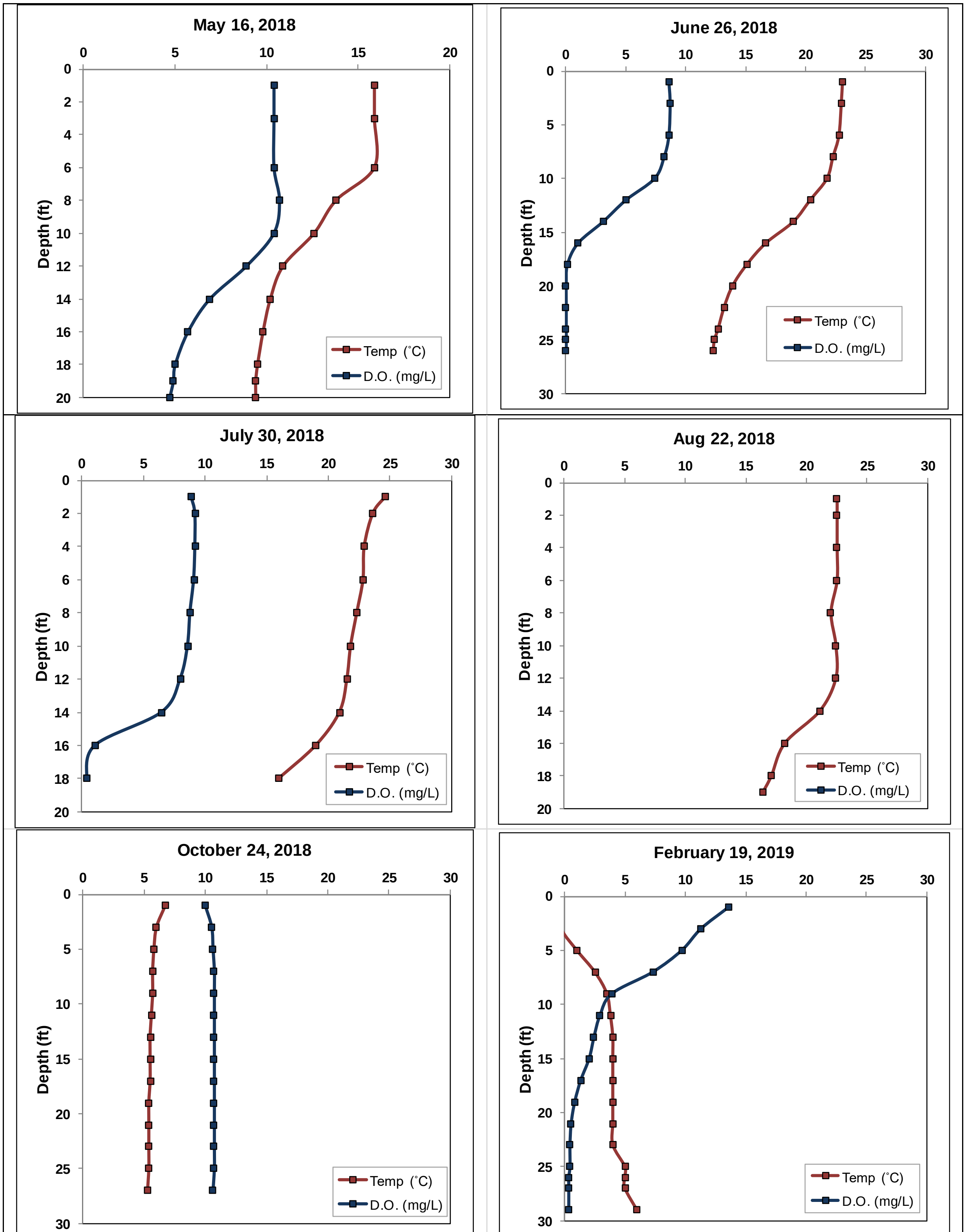


Figure 8.10.1-7. Pardee Lake 2018/19 dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected from Pardee Lake

The previous section is centered on parameters relating to Pardee Lake's trophic state. 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 Pardee 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.

As the Town-wide Section explains, the pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is thus an index of the lake's acidity. Pardee Lake's mid-summer surface water pH was measured at 8.4 in 2018. This value indicates Pardee Lake's water is alkaline and falls within the normal range for Wisconsin lakes. Fluctuations in pH with respect to seasonality are common; in-lake processes such as photosynthesis by plants act to reduce acidity by carbon dioxide removal while decomposition of organic matter adds carbon dioxide to water, thereby increasing acidity. A lake's pH is primarily determined by the water's alkalinity, or a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. Pardee Lake's average alkalinity measured in 2018 was 45.7 mg/L as $CaCO_3$. This value falls within the expected range for northern Wisconsin lakes, and indicates that while Pardee Lake is considered a softwater lake, it is not sensitive to fluctuations in pH from acid rain.

Water quality samples collected from Pardee Lake in 2018 were also analyzed for calcium. Calcium concentrations, along with pH, are currently being used to determine if a waterbody is suitable to support the invasive zebra mussel, as these animals require calcium for the construction of their shells. Zebra mussels typically require higher calcium concentrations than Wisconsin's native mussels, and lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The accepted suitable pH range for zebra mussels is 7.0 – 9.0, and Pardee Lake's pH falls within this range. Pardee Lake's calcium concentration in 2018 was 12.4 mg/L, indicating the lake has *low susceptibility* to zebra mussel establishment. Plankton tows were completed by Onterra ecologists at three locations in Pardee Lake in 2018 that underwent analysis for the presence of zebra mussel veligers, their planktonic larval stage. Analysis of these samples were negative for zebra mussel veligers, and Onterra ecologists did not observe any adult zebra mussels during the 2018 surveys.

8.10.2 Pardee Lake Watershed Assessment

Pardee Lake's surficial watershed encompasses approximately 2,109 acres (Figure 8.10.2-1 and Pardee Lake – Map 2) yielding a watershed to lake area ratio of 9:1. The watershed is comprised of land cover types including wetlands (45%), forests (39%), the lake surface itself (10%), pasture/grass/rural open space (6%), and rural residential areas (<1%) (Figure 8.10.2-1). Wisconsin Lakes Modeling Suite (WiLMS) modeling indicates that Pardee Lake's residence time is approximately 1.1 year, or the water within the lake is completely replaced 0.9 times per year.

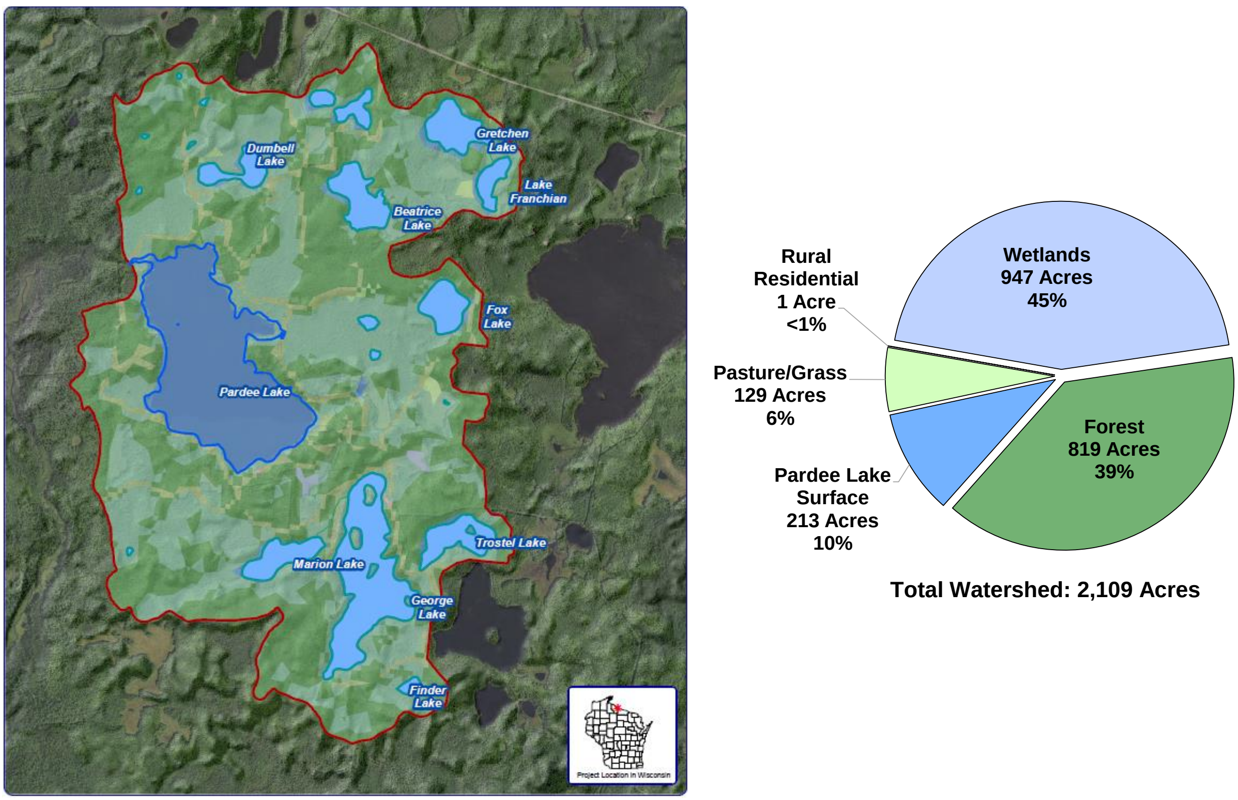


Figure 8.10.2-1. Pardee Lake watershed boundary (red line) and proportion of land cover types. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

Using the land cover types and their acreages within Pardee Lake's watershed, WiLMS was utilized to estimate the annual potential phosphorus load delivered to Pardee Lake from its watershed. In addition, data obtained from a stakeholder survey sent to Pardee Lake riparian property owners in 2018 was also used to estimate the amount of phosphorus loading to the lake from riparian septic systems. The model estimated that a total of approximately 245 pounds of phosphorus are delivered to Pardee Lake from its watershed on an annual basis (Figure 8.10.2-2).

Of the estimated 245 pounds of phosphorus being delivered to Pardee Lake on an annual basis, approximately 84 pounds (34%) originates from wetlands, 66 pounds (27%) from forests, 57 pounds (23%) through direct atmospheric deposition into the lake, 35 pounds (15%) from areas of pasture/grass, and 3 pounds (<1%) from riparian septic systems, (Figure 8.10.2-2). Using the estimated annual potential phosphorus load, WiLMS predicted an in-lake growing season average total phosphorus concentration of 20 µg/L, which is very similar to the measured growing season average total phosphorus concentration of 21 µg/L. The similarity between the predicted and measured total phosphorus concentrations in Pardee Lake is an indication that this is an accurate model of the lake's watershed and that there are no significant, unaccounted sources of phosphorus entering the lake.

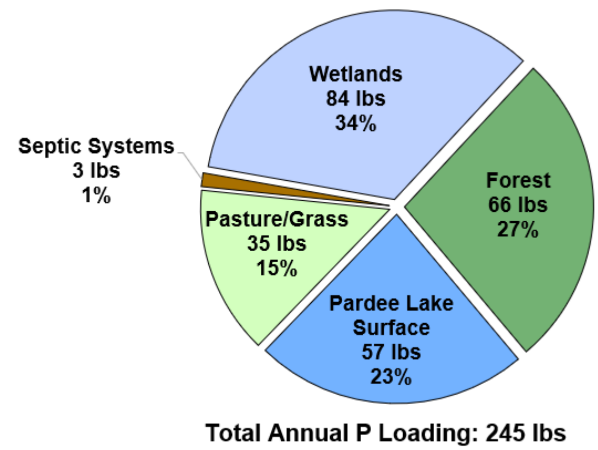


Figure 8.10.2-2. Pardee Lake estimated potential annual phosphorus loading. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Pardee Lake Water Levels

Lake water levels can fluctuate naturally over varied timescales due to changes in precipitation and/or changes in human land use. Natural seasonal and long-term changes in water levels in lakes are beneficial as they generally create more diverse plant and animal communities. Water level fluctuations in drainage lakes, like Pardee Lake, tend to be more moderate when compared to seepage lakes which lack input from streams or rivers and are largely tied to the level of the groundwater aquifer. Even during drier periods, rivers and streams still provide a source of water to drainage lakes. Drainage lakes may show increases in water levels relatively quickly following large rain events.

Beginning in 2010, the NLDC and Pardee Lake volunteers began monitoring Pardee Lake's water levels annually during the open water season (Figure 8.10.2-3). Over the course of this monitoring, Pardee Lake's water levels fluctuated a maximum of 13.9 inches, with a minimum average water level recorded in 2012 and a maximum average water level recorded in 2014. The average intra-annual water level variation from 2010-2018 is 7.5 inches. Water levels in 2016 were approximately 3.0 inches above the 2010-2017 average while water levels in 2018 were near the 2010-2018 average. The data collected from Pardee Lake indicate that water levels tend to fluctuate both intra- and interannually with changes in precipitation levels. Ongoing collection of water level data at Pardee Lake will allow for a better understanding of longer-term changes in water levels.

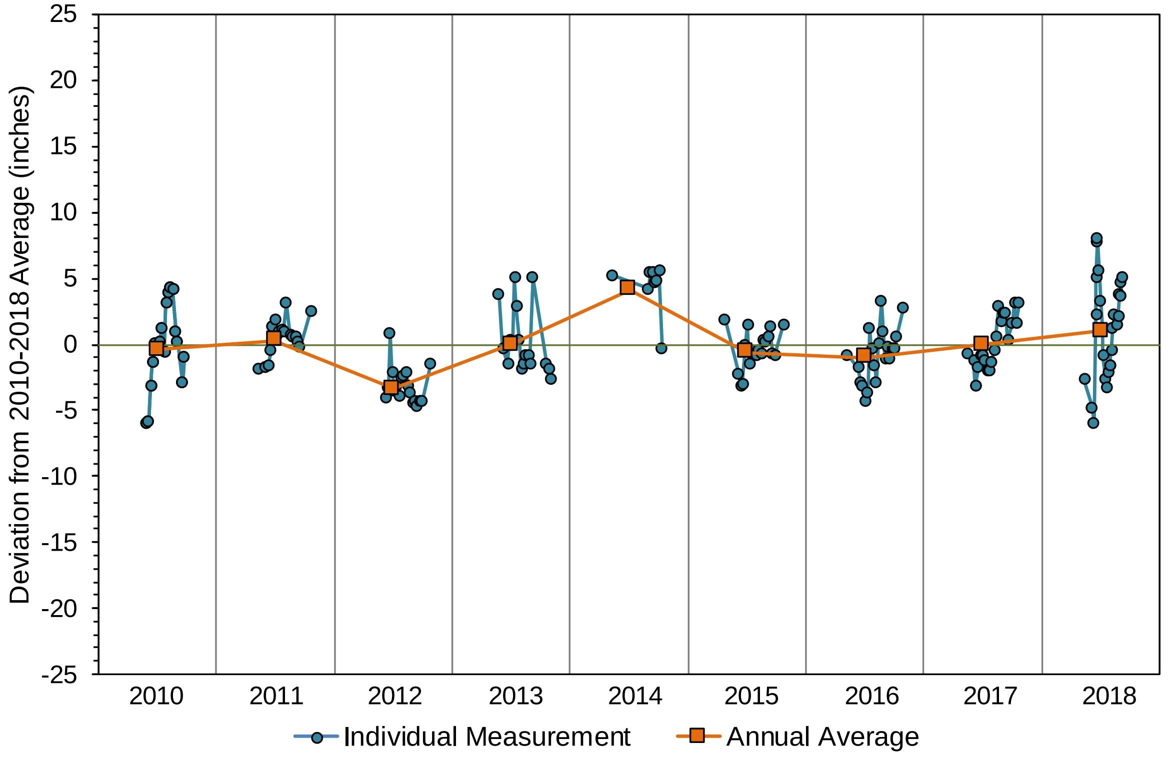


Figure 8.10.2-3. Pardee Lake 2010-2018 water levels. Created using data provided by NLDC.

8.10.3 Pardee Lake Shoreland Condition

Shoreland Development

As is discussed within the Town-wide Section, one of the most sensitive areas of a lake's watershed is the immediate shoreland zone. This transition zone between the aquatic and terrestrial environment is the last source of protection for the lake against pollutants originating from roads, driveways, and yards above, and is also a critical area for wildlife habitat and overall lake ecology. In the fall of 2018, the immediate shoreland of Pardee Lake was assessed in terms of its development, and the shoreland zone was characterized with one of five shoreland development categories ranging from urbanized to completely undeveloped.

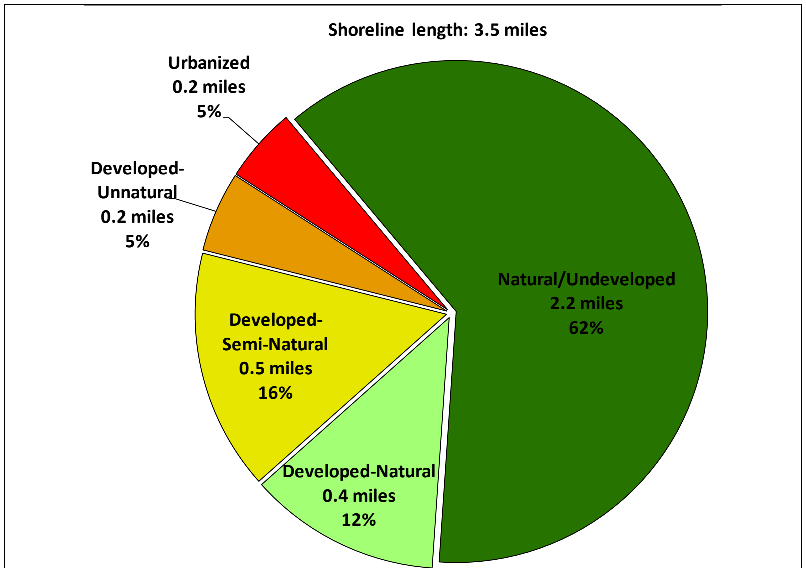


Figure 8.10.3-1. Pardee Lake shoreland categories and total lengths. Based upon a fall 2018 survey. Locations of these categorized shorelands can be found on Pardee Lake - Map 3.

The 2018 survey revealed that Pardee Lake has stretches of shoreland that fit all five shoreland assessment categories (Figure 8.10.3-1). In total, 2.6 miles (74%) of the 3.5-mile shoreland zone were categorized as natural/undeveloped or developed-natural These shoreland types provide the most benefit to the lake and should be left in their natural state if possible. Approximately 0.4 miles (10%) of the shoreland was categorized as developed-unnatural or urbanized. These shoreland areas provide little benefit to and may actually adversely impact the lake. If restoration of Pardee Lake's shoreland is to occur, primary focus should be placed on these highly developed shoreland areas. Pardee Lake – Map 3 displays the locations of these shoreland categories around the entire lake.

Coarse Woody Habitat

A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey on Pardee Lake in 2018. Coarse woody habitat was identified and classified in several size categories (2-8 inches diameter, >8 inches diameter and cluster) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed in the Town-wide Section, 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 et al. 2005).

During the coarse woody habitat survey on Pardee Lake, a total of 305 pieces were observed along 3.5 miles of shoreline, yielding a coarse woody habitat to shoreline mile ratio of 87:1 (Figure 8.10.3-2). Onterra ecologists have completed these surveys on 98 Wisconsin lakes since 2012, and Pardee Lake falls in the 98th percentile for the number of coarse woody habitat pieces per shoreline mile. Refraining from removing these woody habitats from the shoreland area will ensure this high-quality habitat remains in Pardee Lake. The locations of these coarse woody habitat pieces are displayed on Pardee Lake – Map 4.

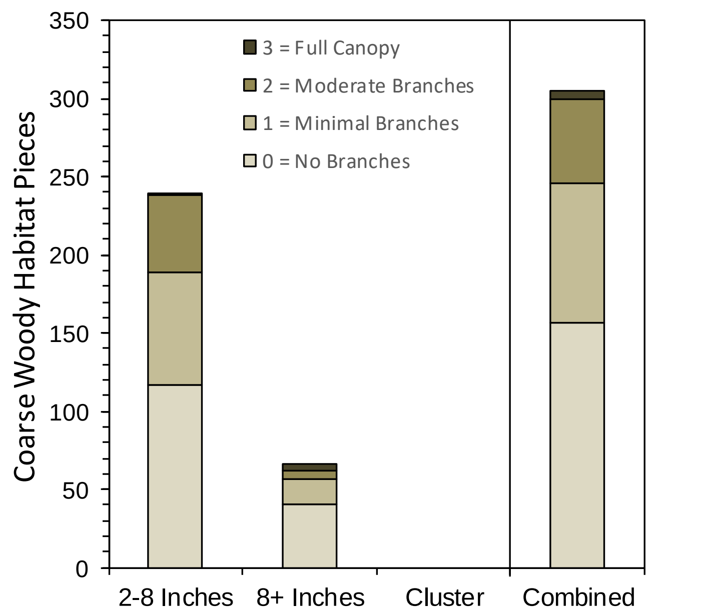


Figure 8.10.3-2. Pardee Lake coarse woody habitat survey results. Based upon a fall 2018 survey. Locations of Pardee coarse woody habitat can be found on Pardee Lake – Map 4.

8.10.4 Pardee Lake Aquatic Vegetation

An Early-Season Aquatic Invasive Species (ESAIS) Survey was conducted by Onterra ecologists on Pardee Lake on June 26, 2018. While the intent of this survey is to locate any potential non-native species within the lake, the primary focus is to locate occurrences of the non-native curly-leaf pondweed which should be at or near its peak growth at this time. Fortunately, no curly-leaf pondweed was located in Pardee Lake in 2018, and it is believed that curly-leaf pondweed is not present within the lake or exists at an undetectable level. However, pale-yellow iris, a non-native wetland plant, was located in a few locations along Pardee Lake's shoreline in 2018. Because of its ecological significance, pale-yellow iris in Pardee Lake is discussed further in the subsequent Non-Native Aquatic Plants subsection.

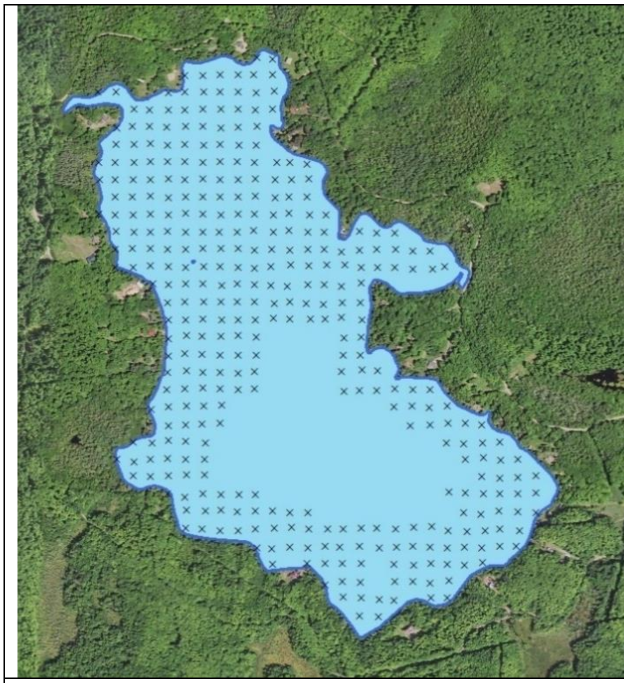


Figure 8.10.4-1. Pardee Lake whole-lake point-intercept survey sampling locations. (43-meter resolution; 455 total points)

The whole-lake aquatic plant point-intercept survey and emergent and floating-leaf aquatic plant community mapping survey were conducted on Pardee Lake by Onterra ecologists on August 8, 2018 (Figure 8.10.4-1). During these surveys, a total of 42 aquatic plant species were located, two of which are considered to be a non-native, invasive species: pale-yellow iris and aquatic forget-me-not (Table 8.10.4-1).

Lakes in Wisconsin vary in their morphometry, water chemistry, substrate composition, and management, all factors which influence aquatic plant community composition. In late September of 2018, Onterra ecologists completed an acoustic survey on Pardee Lake (bathymetric results on Pardee Lake – Map 1). The sonar-based technology records aquatic plant bio-volume, or the percentage of the water column that is occupied by aquatic plants at a given location. Data pertaining to Pardee Lake's substrate composition were also recorded during this survey. The sonar records substrate hardness, ranging from the hardest substrates (i.e. rock and sand) to the more flocculent, softer organic sediments.

Data regarding substrate hardness collected during the 2018 acoustic survey showed that shallower areas of Pardee Lake from approximately 1 to 7 feet contained the softest substrates within the lake (Figure 8.10.4-2). Beyond 10 feet to the deepest areas in the lake, substrates were moderately hard and more uniform when compared to shallower areas. 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 areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because of the different habitat types that are available.

Table 8.10.4-1. List of aquatic plant species located in Pardee Lake during Onterra 2018 aquatic plant surveys.

Pardee Lake

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2018 (Onterra)
Emergent	*Calla palustris*	Water arum	9	I
	Carex hystericina	Porcupine sedge	3	I
	Carex pseudocyperus	Cypress-like sedge	8	I
	Carex sp. 1	Sedge sp. 1	N/A	I
	Eleocharis palustris	Creeping spikerush	6	I
	Grass sp. (sterile)	Grass sp. (sterile)	N/A	I
	Iris pseudacorus	Pale-yellow iris	Exotic	I
	Iris sp.	Iris sp.	N/A	I
	Myosotis scorpioides	Aquatic Forget-me-not	Exotic	I
	Pontederia cordata	Pickerelweed	9	X
	Sagittaria latifolia	Common arrowhead	3	I
	Schoenoplectus acutus	Hardstem bulrush	5	I
	Scirpus cyperinus	Wool grass	4	I
	Sparganium americanum	American bur-reed	8	I
FL	*Brasenia schreberi*	Watershield	7	X
	Nuphar variegata	Spatterdock	6	X
	Nymphaea odorata	White water lily	6	X
	Persicaria amphibia	Water smartweed	5	I
Submergent	*Bidens beckii*	Water marigold	8	X
	Ceratophyllum echinatum	Spiny hornwort	10	X
	Chara spp.	Muskgrasses	7	X
	Ceratophyllum demersum	Coontail	3	X
	Elodea canadensis	Common waterweed	3	X
	Heteranthera dubia	Water stargrass	6	X
	Isoetes echinospora	Spiny-spored quillwort	8	X
	Myriophyllum sibiricum	Northern watermilfoil	7	X
	Nitella spp.	Stoneworts	7	X
	Najas flexilis	Slender naiad	6	X
	Potamogeton foliosus	Leafy pondweed	6	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton pusillus	Small pondweed	7	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X
	Potamogeton robbinsii	Fern-leaf pondweed	8	X
	Ranunculus aquatilis	White water crowfoot	8	X
	Utricularia minor	Small bladderwort	10	X
	Utricularia vulgaris	Common bladderwort	7	X
	Vallisneria americana	Wild celery	6	X
S/E	*Comarum palustre*	Marsh cinquefoil	N/A	I
	Eleocharis acicularis	Needle spikerush	5	X
	Sagittaria graminea	Grass-leaved arrowhead	9	X
	Schoenoplectus subterminalis	Water bulrush	9	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species

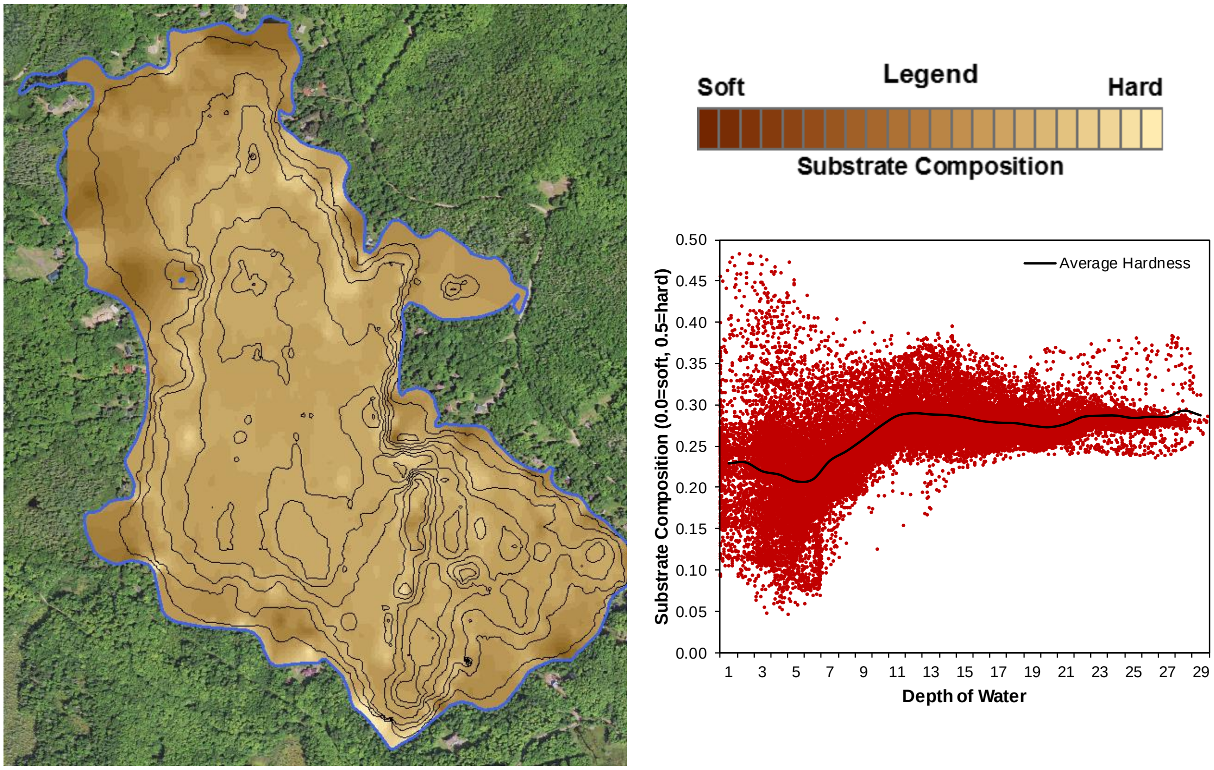


Figure 8.10.4-2. Pardee Lake spatial distribution of substrate hardness (left) and substrate hardness across water depth (right). Depth contours represent 5-foot intervals. Individual data points are displayed in red. Creating using data from September 2018 acoustic survey.

The acoustic survey also recorded aquatic plant bio-volume throughout the entire lake. As mentioned earlier, aquatic plant bio-volume is the percentage of the water column that is occupied by aquatic plants. The 2018 aquatic plant bio-volume data are displayed in Figure 8.10.4-3 and Pardee Lake – Map 6. Areas where aquatic plants occupy most or all of the water column are indicated in red. The 2018 whole-lake point-intercept survey found aquatic plants growing to a maximum depth of 15 feet. However, the majority of aquatic plant growth occurs within 3.0-7.0 feet of water. The 2018 acoustic survey indicated approximately 49% (104 acres) of Pardee Lake's area is occupied by aquatic vegetation, while the remaining 51% of the lake contains unsuitable substrates or is too deep to support aquatic plant growth.

As mentioned, aquatic plants were recorded growing to a maximum depth of 15 feet in 2018. Of the 256 point-intercept sampling locations that fell at or shallower than the maximum depth of plant growth (littoral zone), approximately 71% contained aquatic vegetation. Aquatic plant rake fullness data collected in 2018 indicates that 18% of the 256 littoral sampling locations contained vegetation with a total rake fullness rating (TRF) of 1, 14% had a TRF rating of 2, and 40% had a TRF rating of 3 (Figure 8.10.4-4). These TRF ratings indicate that the biomass of aquatic vegetation in Pardee Lake is relatively dense.

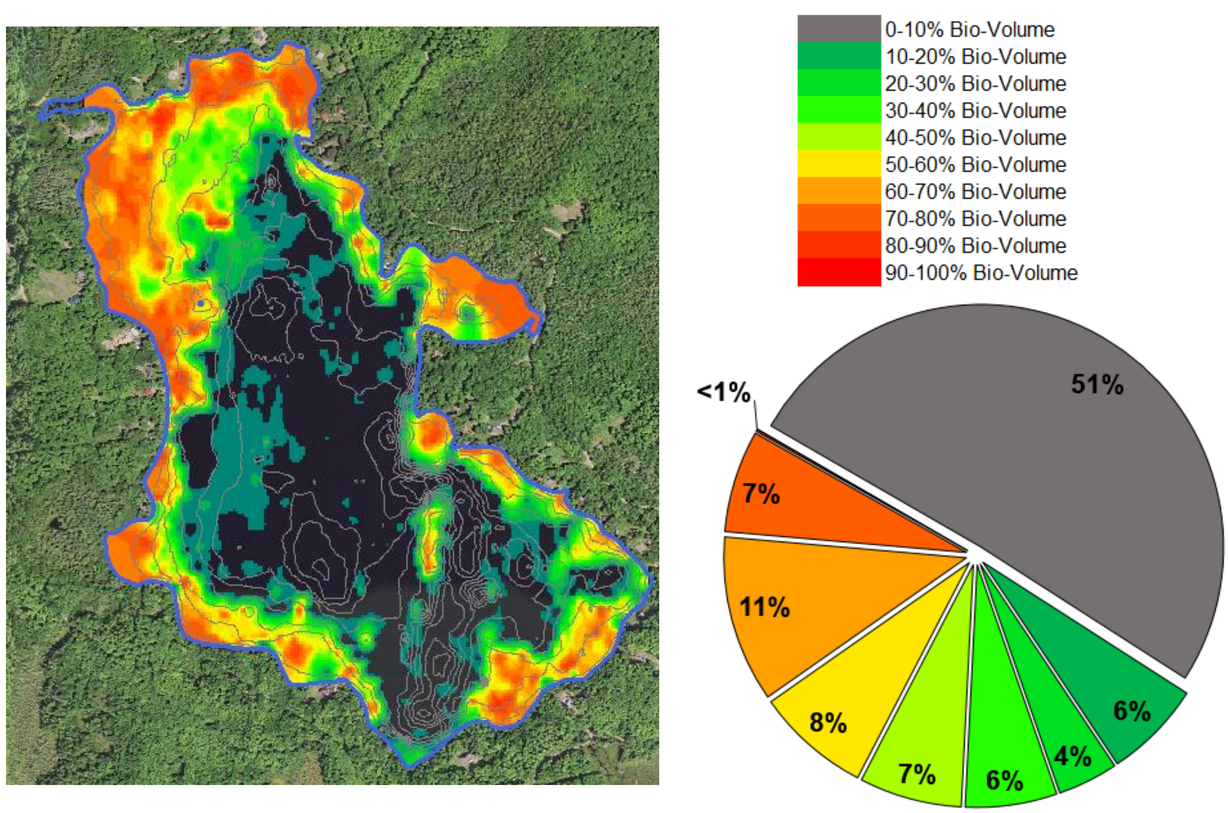


Figure 8.10.4-3. Pardee Lake 2018 aquatic plant bio-volume. Created using data from September 2018 acoustic survey data.

While the acoustic mapping is an excellent survey for understanding the distribution and levels of aquatic plant growth throughout the lake, this survey does not determine which aquatic plant species are present. Whole-lake point-intercept surveys are used to quantify the abundance of individual species within the lake. Of the 42 aquatic plant species located in Pardee Lake in 2018, 28 were encountered directly on the rake during the whole-lake point-intercept survey. The remaining 14 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 relatively rare within the plant community. Of the 28 species directly sampled with the rake during the point-intercept survey, fern-leaf pondweed, coontail, and clasping-leaf pondweed were the three most frequently encountered aquatic plant species (Figure 8.10.4-5).

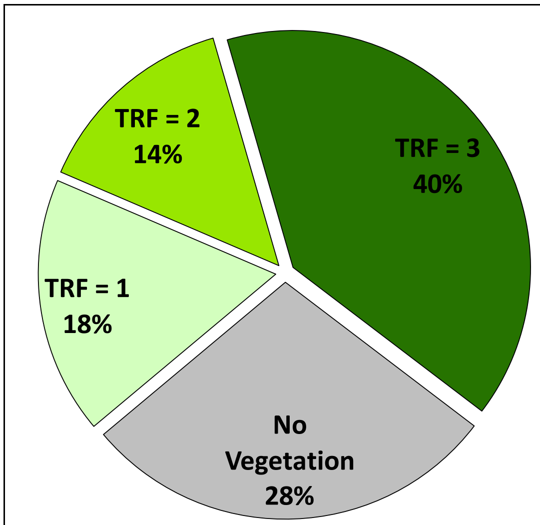


Figure 8.10.4-4. Pardee Lake 2018 aquatic vegetation total rake fullness ratings (TRF). Created with data collected during the 2018 whole-lake point-intercept survey (N = 256).

Fern-leaf pondweed was the most frequently encountered aquatic plant species in Pardee Lake in 2018 with a littoral frequency of occurrence of 57% (Figure 8.10.4-5). 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.

Coontail was the second most frequently encountered aquatic plant in Pardee Lake in 2018 with a littoral occurrence of 19% (Figure 8.10.4-5). Unlike most of the submersed plants found in Wisconsin, coontail does not produce true roots and is often found growing entangled amongst other aquatic plants or matted at the surface. Because it lacks true roots, coontail derives all of its nutrients directly from the water (Gross et al. 2013). This ability in combination with a tolerance for low-light conditions allows coontail to become more abundant in productive waterbodies with lower water clarity. Coontail has the capacity to form dense beds that mat on the water surface. Coontail also provides many benefits to the aquatic community. Its dense whorls for leaves provide excellent structural habitat for aquatic invertebrates and fish, especially in winter as this plant remains green under the ice. In addition, it competes for nutrients that would otherwise be available for free-floating algae and therefore helps to improve water clarity.

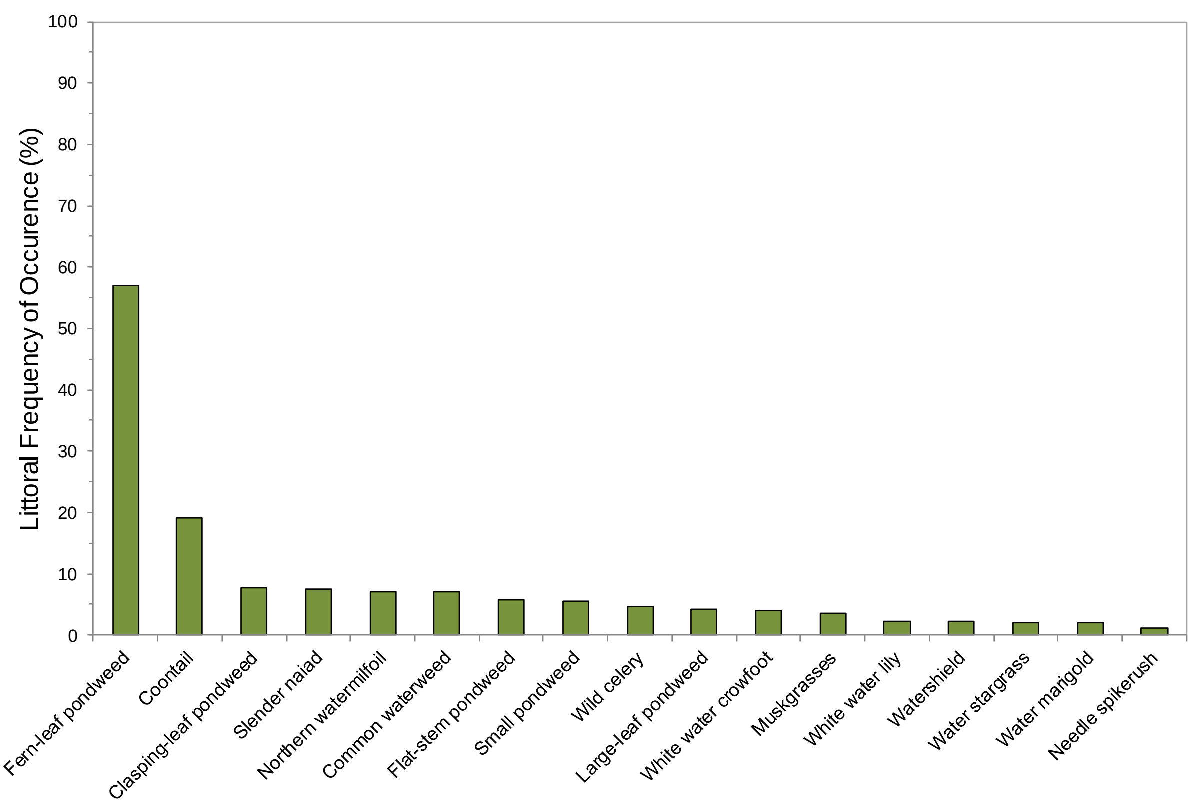


Figure 8.10.4-5. Pardee Lake 2018 littoral frequency of occurrence of aquatic plant species. Created using data from the 2018 whole-lake point-intercept survey.

Clasping-leaf pondweed was the third most frequently encountered aquatic plant species in Pardee Lake in 2018 with a littoral frequency of occurrence of just under 8% (Figure 8.10.4-5). As its name indicates, the submersed leaves of clasping-leaf pondweed clasp or partially wrap around the stem. Clasping-leaf pondweed is often found growing over harder substrates and is tolerant of low-light conditions, often one of the more abundant plants in lakes with stained water in northern Wisconsin. Clasping-leaf pondweed superficially resembles the non-native curly-leaf pondweed and is often misidentified as such. However, the leaf margins of curly-leaf pondweed are serrated where the leaves of clasping-leaf pondweed lack serration. Like other native aquatic plants, clasping-leaf pondweed provides important structural habitat, stabilizes bottom sediments, and its fruits and rhizomes are important sources of food for wildlife.

Submersed aquatic plants can be grouped into one of two general categories based upon their morphological growth form and habitat preferences. These two groups include species of the *isoetid* growth form and those of the *elodeid* growth form. Plants of the isoetid growth form are small, slow-growing, inconspicuous submerged plants (Photo 8.10.4-1; left). These species often have evergreen, succulent-like leaves and are usually found growing in sandy/rocky soils within near-shore areas of a lake (Boston and Adams 1987, Vestergaard and Sand-Jensen 2000).

In contrast, aquatic plant species of the elodeid growth form have leaves on tall, erect stems which grow up into the water column, and are the plants that lake users are likely more familiar with (Photo 8.10.4-1; right). It is important to note that the definition of these two groups is based solely on morphology and physiology and not on species' relationships. For example, dwarf-water milfoil (*Myriophyllum tenellum*) is classified as an isoetid, while all of the other milfoil species in Wisconsin such as northern water milfoil (*Myriophyllum sibiricum*) are classified as elodeids.

Alkalinity, as it relates to the amount of bicarbonate within the water, is the primary water chemistry factor for determining a lake's aquatic plant community composition in terms of isoetid versus elodeid growth forms (Vestergaard and Sand-Jensen 2000). Most aquatic plant species of the elodeid growth form cannot inhabit lakes with little or no alkalinity because their carbon demand for photosynthesis cannot be met solely from the dissolved carbon dioxide within the water and must be supplemented from dissolved bicarbonate.

Photo 8.10.4-1. Lake quillwort (*Isoetes lacustris*) of the isoetid growth form (left) and variable pondweed (*Potamogeton gramineus*) and fern pondweed (*P. robbinsii*) of the elodeid growth form (right).

On the other hand, aquatic plant species of the isoetid growth form can thrive in lakes with little or no alkalinity because they have the ability to derive carbon dioxide directly from the sediment, and many also have a modified form of photosynthesis to maximize their carbon storage (Madsen et al. 2002). While isoetids are able to grow in lakes with higher alkalinity, their short stature makes them poor competitors for space and light against the taller elodeid species. Thus, isoetids are most prevalent in lakes with little to no alkalinity where they can avoid competition from elodeids. However, in lakes with moderate alkalinity, like Pardee Lake, the aquatic plant community can be comprised of isoetids growing beneath a scattered canopy of the larger elodeids. Isoetid communities are vulnerable to sedimentation and eutrophication (Smolders et al. 2002), and a number are listed as special concern (e.g. northeastern bladderwort) or threatened in Wisconsin due to their rarity and susceptibility to environmental degradation.

As discussed in the Town-Wide 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 native species encountered on the rake during 2018 point-intercept survey on Pardee Lake and their conservatism values were used to calculate the FQI of Pardee Lake's aquatic plant community (equation shown below).

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

Figure 8.10.4-6 compares the 2018 FQI components of Pardee Lake to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) ecoregion and lakes throughout Wisconsin. The native species richness, or number of native aquatic plant species located on the rake in 2018 (28) falls above the median value for lakes in the NLFL ecoregion (21) and for lakes throughout Wisconsin (19). The average conservatism of the 28 native aquatic plant species located in Pardee Lake in 2018 was 6.9, falling just above the median average conservatism values for lakes within the NLFL ecoregion (6.7) and above the median value for lakes throughout Wisconsin (6.3). This indicates that a higher proportion of Pardee Lake's aquatic plant community is comprised of environmentally-sensitive species, or species with higher conservatism values.

Using Pardee Lake's native aquatic plant species richness and average conservatism yields a high FQI value of 36.7 (Figure 8.10.4-6). Pardee Lake's FQI value exceeds the median values for lakes within the NLFL ecoregion (30.8) and the median value for lakes throughout the state (27.2). Overall, the FQI analysis indicates that the aquatic plant community found in Pardee Lake is of higher quality when compared to the majority of lakes in Wisconsin.

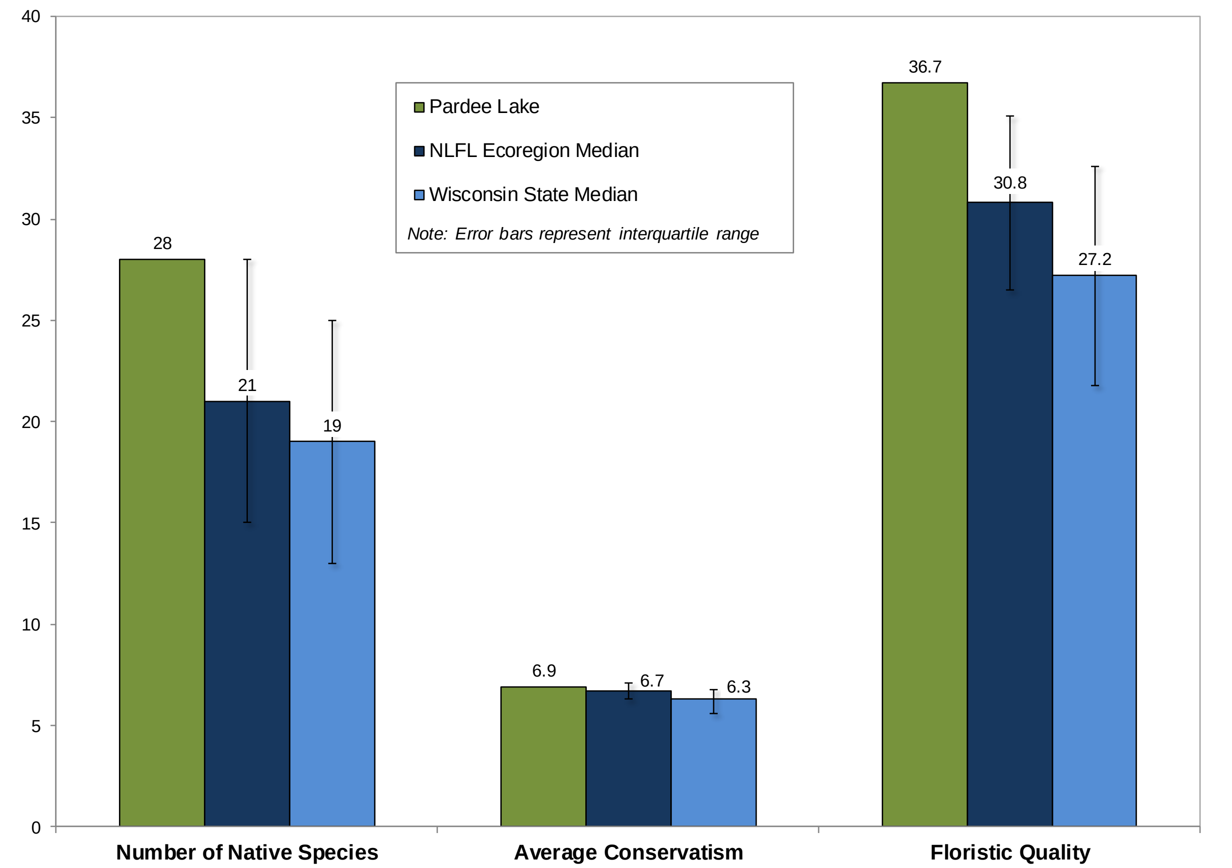


Figure 8.10.4-6. Pardee Lake Floristic Quality Assessment. Created using data from Onterra 2018 whole-lake point-intercept survey. Analysis follows Nichols (1999).

As explained in the Town-wide section, 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 Pardee Lake contains a higher number of aquatic plant species, one may 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 Pardee Lake's diversity value ranks. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 212 lakes within the NLFL ecoregion (Figure 8.10.4-7). Using the data collected from the 2018 point-intercept survey, Pardee Lake's aquatic plant community was found to have a lower than average species diversity with a Simpson's Diversity Index value of 0.82. In other words, if two individual aquatic plants were randomly sampled from Pardee Lake in 2018, there would be an 82% probability that they would be different species. Pardee Lake's Simpson's Diversity falls below 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 Pardee Lake's species diversity is to look at the relative occurrence of aquatic plant species. Figure 8.10.4-8 displays the relative frequency of occurrence of aquatic plant species created from the 2018 whole-lake point-intercept survey and illustrates the 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 fern-leaf pondweed was found at 57% of the littoral sampling locations in Pardee Lake in 2018, its relative frequency of occurrence was 38%. Explained another way, if 100 plants were randomly sampled from Pardee Lake in 2018, 38 of them would be fern-leaf pondweed.

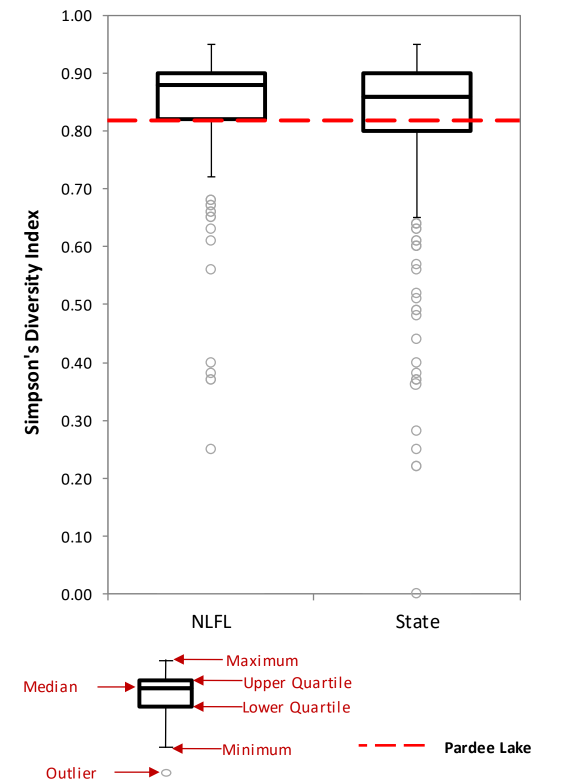


Figure 8.10.4-7. Pardee Lake species diversity index. Created using data from Onterra 2018 point-intercept survey.

In 2018, Onterra ecologists also conducted a survey aimed at mapping emergent and floating-leaf aquatic plant communities in Pardee Lake. This survey revealed Pardee Lake contains 12.7 acres of these communities, comprised of 16 native plant species (Pardee Lake – Map 7 and Table 8.10.4-2). These native emergent and floating-leaf plant communities provide valuable fish and wildlife habitat that is important to the ecosystem of the lake. These areas are particularly important during times of fluctuating water levels, since structural habitat of fallen trees and other forms of course-woody habitat can be quite sparse along the shores of receding water lines. The community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, and a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Pardee Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development.

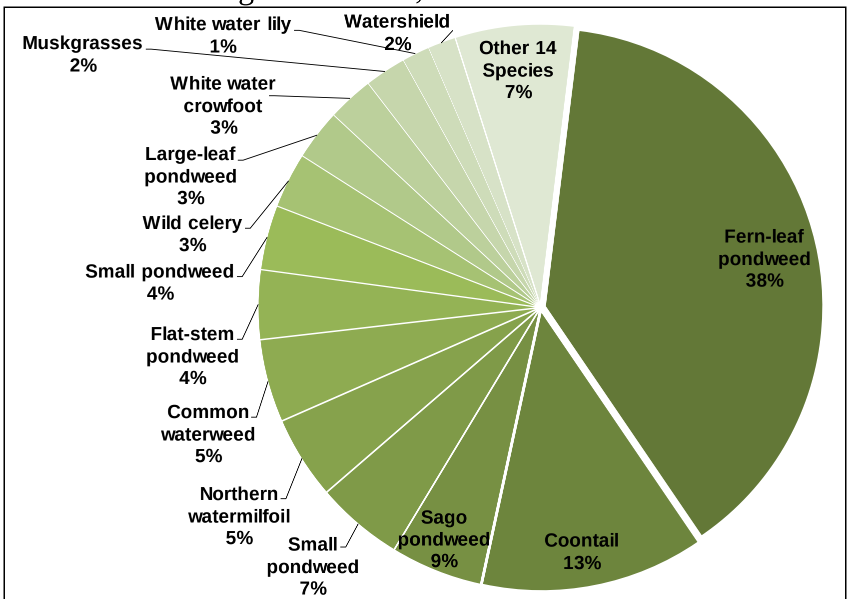


Figure 8.10.4-8. Pardee Lake 2018 relative frequency of occurrence of aquatic plant species. Created using data from 2018 point-intercept survey.

Table 8.10.4-2. Pardee Lake 2018 acres of emergent and floating-leaf aquatic plant communities. Created using data from the 2018 aquatic plant community mapping survey.

Plant Community	Acres
Emergent	1.5
Floating-leaf	0.0
Mixed Emergent & Floating-leaf	11.3
Total	**12.7**

Non-native Aquatic Plants in Pardee Lake

Pale-Yellow Iris

Pale yellow iris (*Iris pseudacorus*; Photo 8.10.4-2) is a large, showy iris with bright yellow flowers. Native to Europe and Asia, this species was sold commercially in the United States for ornamental use and has since escaped into Wisconsin's wetland areas forming large monotypic colonies and displacing valuable native wetland species. Pale-yellow iris was located growing in a few locations along the shorelines of Pardee Lake by Onterra staff in 2018 (Pardee Lake – Map 8). There are a number of control strategies that can be used to control pale-yellow iris. The North Lakeland Discovery Center can be contacted for assistance with possible control methods for this plant.

Photo 8.10.4-2. Pale-yellow iris (*Iris pseudacorus*), a non-native, invasive wetland plant found along the shorelines of Pardee Lake in 2018. Photo credit Onterra.

Aquatic forget-me-not

Aquatic forget-me-not (*Myosotis scorpioides*) is a relatively small, semi-aquatic wetland plant that produces clusters of small bluish flowers. Native to Eurasia, like pale-yellow iris, aquatic forget-me-not has escaped cultivation and invaded wetland habitats across Wisconsin and creates a monotypic ground cover. A small colony of aquatic forget-me-not was located by Onterra on the eastern shoreline of Pardee Lake in 2018. Manual removal by pulling the plants and their roots is likely the best option for control of this plant at this time on Pardee Lake.

8.10.5 Aquatic Invasive Species in Pardee Lake

Aside from non-native plants present at Pardee Lake, two invasive invertebrates have also been reported in the lake. In 2015, the WDNR verified banded mystery snails to be present in Pardee Lake. There are two types of mystery snails found within Wisconsin waters - the Chinese mystery snail (*Cipangopaludina chinensis*) and the banded mystery snail (*Viviparus georgianus*). 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 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 et al. 2010). However, researchers did detect negative impacts to native snail communities when both Chinese mystery snails and the rusty crayfish were present (Johnson et al. 2009).

Freshwater jellyfish (*Craspedacusta sowerbyi*) are believed to have been introduced to the Great Lakes region around 1933 with the first Wisconsin sightings dating back to 1969. They are quite small, growing to about one inch in diameter. These jellyfish are ephemeral, living for only six to seven weeks and then disappearing, sometimes forever. While there is not yet a thorough understanding of how freshwater jellyfish affect their ecosystems, it is thought that they may outcompete other native species for zooplankton. Crayfish are a natural predator of freshwater jellyfish. Freshwater jellyfish were observed in Pardee Lake in 2010. The "observed" status given by the WDNR means that populations have either not been verified by a taxonomic expert, or the species does not have established populations within the lake.

8.10.6 Pardee Lake 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 Pardee Lake. The goal of this section is to provide an overview of some of the data that exists. Although current fish 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 Biologist Zach Lawson (WDNR 2019 & GLIFWC 2018).

Pardee 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 Pardee 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 algae, 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 8.10.6-1.

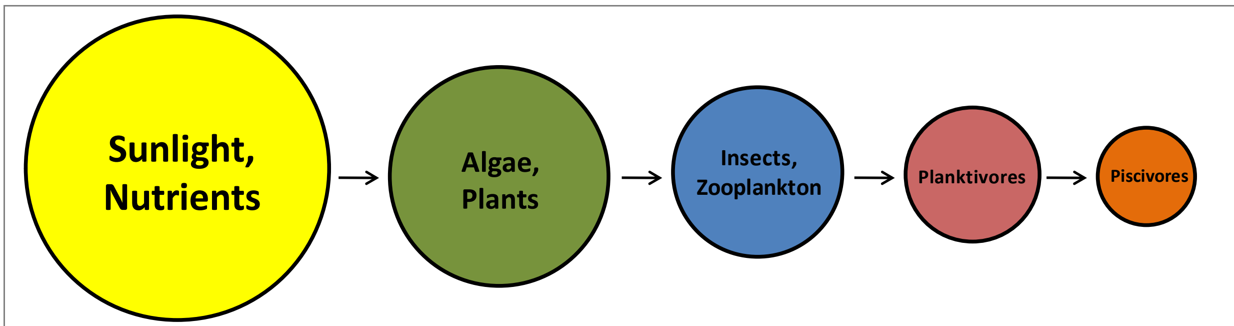


Figure 8.10.6-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Pardee Lake is a mesotrophic system, meaning it has a moderate amount of nutrients and thus a moderate amount of primary productivity. This is relative to an oligotrophic system, which contains fewer nutrients (less productive) and a eutrophic system, which contains more nutrients (more productive). Simply put, this means Pardee Lake should be able to support an appropriately sized population of predatory fish (piscivores) when compared to eutrophic or oligotrophic systems. Table 8.10.6-1 shows the popular game fish present in the system. Although not an exhaustive list of fish species in the lake, additional species documented in past fishery surveys of Pardee Lake include white sucker (*Catostomus commersonii*), hornyhead chub (*Nocomis biguttatus*), blacknose dace (*Rhinichthys obyusus*), johnny darter (*Etheostoma nigrum*), northern sculpin (*Icelinus borealis*) and the golden shiner (*Notemigonus crysoleucas*).

Table 8.10.6-1. Gamefish present in Pardee Lake with corresponding biological information (Becker, 1983).

Common Name (*Scientific Name*)	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie (*Pomoxis nigromaculatus*)	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill (*Lepomis macrochirus*)	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass (*Micropterus salmoides*)	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge (*Esox masquinongy*)	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike (*Esox lucius*)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed (*Lepomis gibbosus*)	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass (*Ambloplites rupestris*)	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass (*Micropterus dolomieu*)	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch (*Perca flavescens*)	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

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 8.10.6-1). 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 8.10.6-1). This is done, often 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 8.10.6-1. 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 fry, fingerling or adult fish in a waterbody that were raised in permitted hatcheries (Photograph 8.10.6-2). Stocking of 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. Pardee Lake has been stocked from 1965 to 2015 with muskellunge and walleye (Table 8.10.6-2).

Photograph 8.10.6-2. Fingerling Muskellunge.

Table 8.10.6-2. Stocking data available for Pardee Lake (1965-2016).

Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
1965	Walleye	Fingerling	1000	-
1970	Walleye	Fingerling	3000	2
1971	Walleye	Fingerling	1900	3
1972	Walleye	Fingerling	2000	3
1974	Walleye	Fingerling	4000	3
1975	Walleye	Fingerling	2000	-
1976	Walleye	Fingerling	1200	2.5
1979	Walleye	Fingerling	600	3
1992	Walleye	Large Fingerling	1000	6
1993	Walleye	Large Fingerling	900	8
1994	Walleye	Large Fingerling	522	6.5
1995	Walleye	Large Fingerling	462	7
1996	Walleye	Large Fingerling	600	6
1997	Walleye	Large Fingerling	700	7.5
1998	Walleye	Large Fingerling	1200	4
2010	Walleye	Large Fingerling	1000	7
2012	Walleye	Large Fingerling	1000	8
2014	Walleye	Large Fingerling	1500	7
2016	Walleye	Large Fingerling	1500	7
2013	Muskellunge	Large Fingerling	70	11
2014	Muskellunge	Large Fingerling	75	11
2016	Muskellunge	Large Fingerling	75	10

Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the second important reason for owning property on or near Pardee Lake along with nature viewing (Question #16). Figure 8.10.6-2 displays the fish that Pardee Lake stakeholders enjoy catching the most, with smallmouth bass and walleye being the most popular. Approximately 38% of these same respondents believed that the quality of fishing on the lake was good, 31% believed fair and 25% believed poor (Figure 8.10.6-3). Approximately 72% of respondents who fish Pardee Lake believe the quality of fishing has been somewhat or much worse since they started fishing the lake (Figure 8.10.6-3).

Question 11: What species of fish do you like to catch on Pardee Lake?

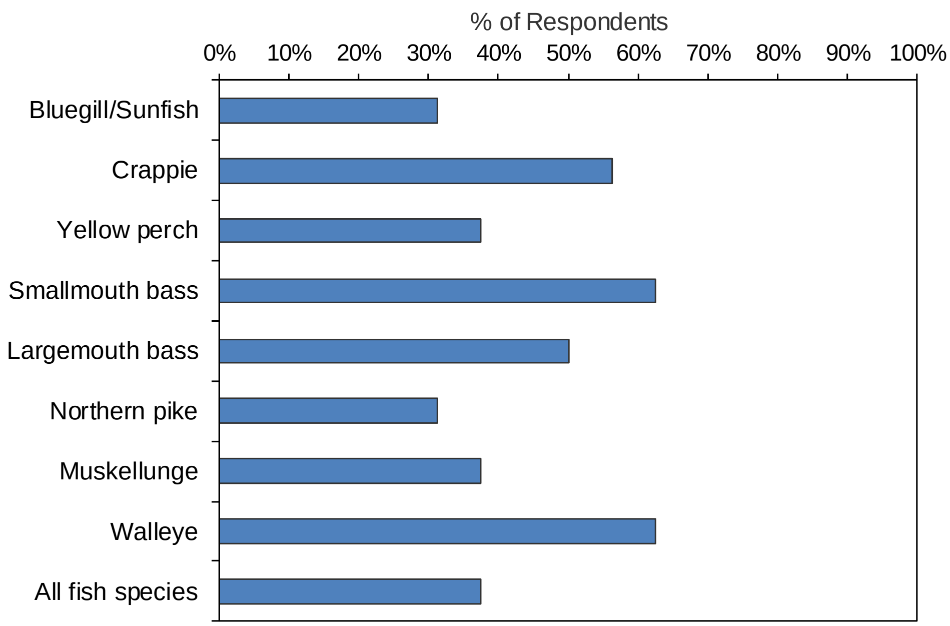
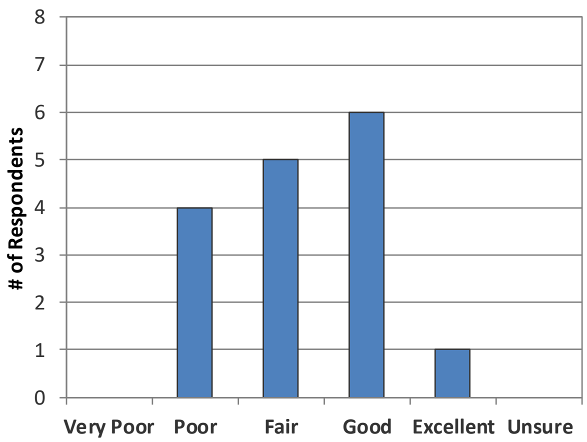


Figure 8.10.6-2. Stakeholder survey response Question 10. Created based on data from 20 respondents of 49 surveys sent (41%).

Question 11: How would you describe the current quality of fishing on Pardee Lake?



Question 12: How has the quality of fishing changed since you started fishing the lake?

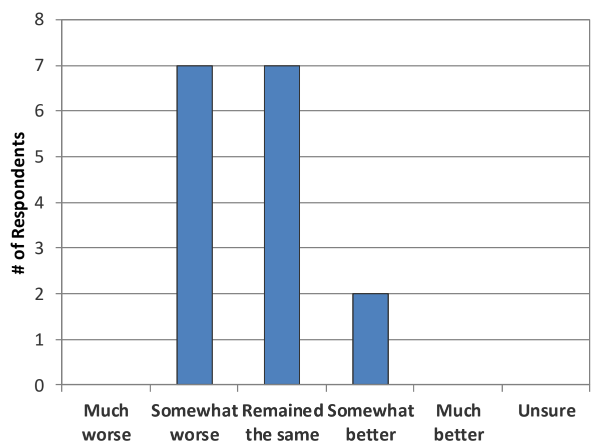


Figure 8.10.6-3. Stakeholder survey responses to questions 11 and 12. Created based on data from 20 respondents of 49 surveys sent (41%).

Fish Populations and Trends

Utilizing the above-mentioned fish sampling techniques and specialized formulas, WDNR fisheries biologists can estimate populations and determine trends of captured fish species. These numbers provide a standardized way to compare fish caught in different sampling years depending on gear used (fyke net or electrofishing). Data is analyzed in many ways by fisheries biologists to better understand the fishery and how it should be managed.

Gamefish

The gamefish present on Pardee Lake represent different population dynamics depending on the species. Brief summaries of gamefish with fishable populations in Pardee Lake are provided based off of personal communications with WDNR fisheries biologist Zach Lawson in 2019 and a fisheries survey completed by Aqua Tech in 2014.

Walleyes are a valued sportfish in Wisconsin. Pardee Lake harbors a walleye population sustained via stocking efforts (WDNR 2019). A fall 1997 fishery survey determined no natural reproduction occurring and stocking was vital to maintain the fishery. Following the 2014 survey, Aqua Tech recommended walleye stocking to continue.

Largemouth bass and **smallmouth bass** are considered abundant in Pardee Lake by Aqua Tech and have good size structure. No stocking events have occurred of either species.

Northern Pike are also considered to have good abundance and average size structure. No stocking events have occurred of this species.

Muskellunge, like walleye, are also considered a valued sportfish of Wisconsin. The 2014 Aqua Tech survey was not designed to assess the muskellunge population however a 40+ inch muskellunge was observed during the survey. According to the Wisconsin Muskellunge Waters updated by the WDNR in 2018, Pardee Lake is a Class B Category 1 muskellunge water. This means it is a self-sustaining intermediate class of muskellunge waters that provides good fishing.

Panfish

The panfish populations are considered by Aqua Tech to be average with bluegill being the most abundant. Black crappie were considered to be the second most abundant. To fully assess the panfish population Aqua Tech recommended completing an early June survey with fyke nets.

Pardee 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 3.6-5). Pardee 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. 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 state-wide 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).

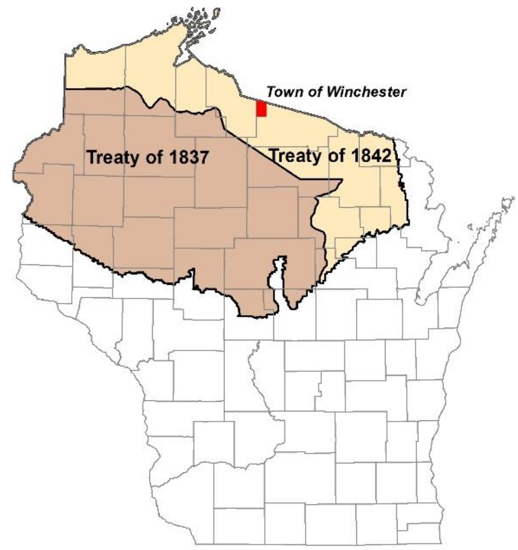


Figure 8.10.6-4. Location of Town of Winchester within the Native American Ceded Territory (GLIFWC 2017). This map was digitized by Onterra; therefore, it is a representation and not legally binding.

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 2016). 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 (GLIWC 2016). 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.

While within the ceded territory, Pardee Lake has not experienced a spearfishing harvest. A small quota for walleye and muskellunge harvest has been listed for Pardee Lake in recent years; however, no spearing efforts have been undertaken. It is possible that spearing efforts have been concentrated on other larger lakes in the region, which would potentially have a higher estimated safe harvest for both walleye and muskellunge.

Pardee 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, evade 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 have substrates largely comprised of sand and rock 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 do 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 over soft sediments as well. According to the point-intercept survey conducted by Onterra in 2018, 77% of the substrate sampled in the littoral zone of Pardee Lake were soft sediments, 8% was composed of sand and 15% were composed of rock sediments.

Woody Habitat

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass 2006). A fall 2018 survey documented 305 pieces of coarse woody along the shores of Pardee Lake, resulting in a ratio of approximately 87 pieces per mile of shoreline.

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. 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 8.10.6-3). 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 other partner contributions.

Photograph 8.10.6-3. Examples of fish sticks (left) and half-log habitat structures (right). (Photos by WDNR).

Fish cribs are a fish habitat structure that are placed on the lakebed. Installing fish cribs may 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. Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 8.10.6-3). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills 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 are spawning reefs. Spawning reefs typically consist of small rubble in a shallow area near the shoreline and are mainly installed to enhance 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 indicated the addition of rock substrate did not significantly improve walleye reproduction (WDNR 2004).

Placement of a fish habitat structures in a lake does not require 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. The Town of Winchester 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 Pardee Lake.

Regulations

Regulations for Pardee Lake gamefish species as of June 2019 are displayed in Table 8.10.6-3. 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 8.10.6-3. WDNR fishing regulations for Pardee Lake (As of June 2019).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	25	None	Open All Year
Smallmouth bass (Early Season)	Catch and release only	None	May 4, 2019 to June 14, 2019
Largemouth and smallmouth bass	5	14"	June 15, 2019 to March 1, 2020
Largemouth bass	5	14"	May 4, 2019 to June 14, 2019
Muskellunge and hybrids	1	40"	May 25, 2019 to November 30, 2019
Northern pike	5	None	May 4, 2019 to March 1, 2020
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 4, 2019 to March 1, 2020
Bullheads	Unlimited	None	Open All Year

General Waterbody Restrictions: Motor Trolling is allowed with 1 hook, bait, or lure per angler, and 2 hooks, baits, or lures maximum per

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.

As discussed in the Pardee Lake Water Quality section (Section 8.10.1), Pardee Lake was placed on the 303(d) list of impaired waterbodies for contaminated fish tissue by mercury in 1998. General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 8.10.6-5. 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 8.10.6-5. 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/)

8.10.7 Pardee Lake Implementation Plan

The Implementation Plan presented below was created through the collaborative efforts of the Pardee Lake Planning Committee, Onterra ecologists, North Lakeland Discovery Center (NLDC), and WDNR staff. It represents the path the Pardee Lake Improvement Association (PLIA) will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Pardee Lake stakeholders as portrayed by the members of the Planning Committee and communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Maintain Ecological Health of Pardee Lake

Management Action:	Promote lake protection and enjoyment through stakeholder education.
Timeframe:	2020
Facilitator:	Board of Directors
Description:	Education represents an effective tool to address many lake issues. The PLIA maintains a website, which is the official repository of the PLIA information. The PLIA also manages a private Facebook group which is only accessible to PLIA members, as well as an email directory for communications pertaining to the lake. These mediums allow for communication among association members, which is important within a management group because it facilitates the spread of important association news, educational topics, volunteer opportunities, and even social happenings. The PLIA will continue to make the education of lake-related issues a priority. These may include educational materials, awareness events, and demonstrations for lake users as well as activities which solicit local and state government support. *Example Educational Topics* • Specific topics brought forth in other management actions • Aquatic invasive species identification • Basic lake ecology • Boating safety (promote existing guidelines, Lake Use Information handout) • Shoreline habitat restoration and protection • Noise and light pollution • Fishing regulations and overfishing • Minimizing disturbance to spawning fish • Pardee Lake dam resolution • Realistic expectation for Pardee Lake fishery

	• Watercraft sanitation information after being on another waterbody • Results of lake water quality monitoring.
Action Steps:	
	See description above.

Management Action:	Continue PLIA's involvement with other entities that have responsibilities in managing (management units) Pardee Lake
Timeframe:	Continuation of current efforts
Facilitator:	Board of Directors
Description:	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 governmental while others organizations rely on voluntary participation. It is important that the PLIA 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 8.10.7-1
Action Steps:	
	See table guidelines on the following pages.

Management Goal 2: Continue Riparian Stakeholder Participation in Lake Management Activities

Management Action:	Update and disburse PLIA new property owner handbook.
Timeframe:	2020
Facilitator:	PLIA Board of Directors
Prospective Grant:	Small-Scale Lake Management Planning Grant
Description:	The PLIA has developed a new property owner handbook; however, it has not been updated since 2004. The PLIA will update the handbook with current PLIA information, educational topics (see action below) and Pardee Lake-specific information. The creation and disbursal of this hand-book could be partially funded through a Small-Scale Lake Management Planning Grant. This grant would provide 67% of project funding up to $3,000 and can include inkind time for the development of the handbook within the grant project time period. If a grant is obtained, it may reduce PLIA costs sufficiently to allow the association to disburse a copy of the updated handbook to all members. Laura MacFarland, WDNR Environmental

	Grant Specialist (See Table 8.10.7-1), can assist with applying for the grant. The UW-Extension Lakes Program (See Table 8.10.7-1), can provide information and content for the handbook.
Action Steps:	
	See description above.

Management Action:	Perform door-to-door or dock-to-dock recruitment of new association members.
Timeframe:	2020
Facilitator:	PLIA Board of Directors
Description:	Many lake groups reach a plateau in their membership levels because any lake resident that would respond to typical written requests to join the organization have already done so. To overcome this recruitment barrier, the PLIA will complete door-to-door and dock-to-dock contacts with non-member households. This will be an organized effort beginning with non-member neighbors by current members. Then, the program will expand to other households around the chain.
Action Steps:	
1.	Utilizing a lake property parcel map, the Board of Directors will create a current membership map. If this map does not exist already, the Vilas County Land Information Dept. can assist in creating the map.
2.	Board of Directors and other active association members will first speak to their neighbors that are not members. The program will then branch out to other areas of the lake. Recruiters will be equipped with PLIA information and membership forms. Importantly, information regarding volunteer opportunities will be a part of the PLIA information as well.
3.	As contacts are made, those initiating the contact will report back to a Director that is tracking progress on the map. Notes would be added to the map indicating if no contact has been made after several attempts, the owners are not interested, there is follow-up necessary, and/or the household will be joining, etc.

Table 8.10.7-1 Management Partner List.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Town of Winchester Lakes Committee	Committee Chair (Rolf Ethun,715.686.2139, rolfappraisals@centurytel.net)	Town resource for lake property owners and lake groups	As needed.	Involved in lake management activities, monitoring, implementation, funding, volunteer recruitment. May be contacted regarding ordinance questions, and for information on community events.
Great Lakes Indian Fish and Wildlife Commission	General (715.682.6619)	Resource management within Ceded Territory	As needed.	Collaborate on lake related studies, AIS management, inform of meetings, etc.
Vilas County Lakes & Rivers Association (VCLRA)	President (Tom Ewing, president@vclra.us)	Protects Vilas Co. waters through facilitating discussion and education.	Twice a year or as needed.	Become aware of training or education opportunities, partner in special projects, or networking on other topics pertaining to Vilas Co. waterways.
Wisconsin Department of Natural Resources	Fisheries Biologist (Eric Wegleitner, 715.356.5211 Ext 246)	Manages the fish populations and fish habitat enhancement efforts.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery.
	Lakes Coordinator (Kevin Gauthier, 715.356.5211)	Oversees management plans, grants, all lake activities.	As needed.	Information on planning/AIS projects, grant applications or to seek advice on other lake issues.
	Environmental Grant Specialist (Jill Sunderland, 715.635.4167)	Oversees financial aspects of grants.	As needed.	Information on grant financials and reimbursement, CBCW grant applications.
	Conservation Warden (Matt Meade, 715.329.0615)	Oversees regulations handed down by the state.	As needed. May call the WDNR violation tip hotline for anonymous reporting (1-800-847-9367, 24 hours a day).	Contact regarding suspected violations pertaining to recreational activity, include fishing, boating safety, ordinance violations, etc.
	Water Resources Mgmt Specialist (Sandra Wickman, 715.365.8951, Sandra.Wickman@wisconsin.gov)	Provides training and assistance on CLMN monitoring, methods, and data entry.	Twice a year or more as needed.	Arrange for training as needed, report monitoring activities.
	Trout Lake Station staff (Susan Knight and Carol Warden (715.356.9494)	Conducts lake research on multiple levels	As needed.	Can be contacted for identification or consultation on AIS.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Vilas County Sheriff Dept.	715.479.4441 non-emergency, 911 for emergencies only.	Perform law enforcement duties to protect lakes, especially pertaining to compliance with boating safety rules.	As needed.	Contact regarding suspected violations pertaining to boating safety rules on the lake.
University of Wisconsin Extension Office	Lake Specialist (Pat Goggin, 715.365.8943, Patrick.Goggin@wisconsin.gov)	Provides guidance for lakes, shoreline restoration, and outreach/education.	As needed.	Contact for shoreland remediation/restoration techniques, outreach/education.
North Lakeland Discovery Center	Executive Director (John Heusinkveld, 715.543.2085, john@discoverycenter.net) Water Program Coordinator (Emily Heald, 715.543.2085, water@discoverycenter.net)	Educates and inspires connection to the natural state of the Northwoods	As needed.	Project sponsor. Direct resource for AIS education and monitoring needs, operates aquatic education programs and assists with volunteer recruitment.
Vilas County Land and Water Conservation Department	Lake Conservation Specialist (Cathy Higley, 715.479.3738, cahigl@vilascountywi.gov)	Oversees AIS monitoring and education activities county-wide.	Twice a year or more as issues arise.	AIS training and ID, monitoring techniques, CBCW training, report summer activities.
	Lake Conservation Specialist (Mariquita (Quita) Sheehan, 715.479.3721, mashee@vilascountywi.gov)	Oversees conservation efforts for lake grants and projects.	Twice a year or more as needed.	Contact for shoreland remediation/restoration techniques and cost-share procedures, wildlife damage programs, education and outreach documents.
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	Those interested may attend WL's annual conference to keep up-to-date on lake issues. WL reps can assist on grant issues, AIS training, habitat enhancement techniques, etc.

Management Action:	Monitor water quality through WDNR Citizens Lake Monitoring Network.
Timeframe:	2020
Facilitator:	PLIA Board of Directors
Description:	Monitoring water quality is an important aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason of why the trend is occurring. Volunteer water quality monitoring, through the Citizen Lake Monitoring Network (CLMN) was being conducted on Pardee Lake until 2010, with some Secchi disk transparency reading being taken until 2016. Currently, the PLIA is not participating in the CLMN program. The CLMN is a WDNR program in which volunteers are trained to collect water quality information on their lake. Participation in the advanced CLMN program, which includes collecting Secchi disk transparency and sending in water chemistry samples (chlorophyll-a, and total phosphorus) to the Wisconsin State Laboratory of Hygiene for analysis, would be the ultimate objective of this action for the PLIA. The samples are collected three times during the summer and once during the spring. It is 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). It will be the Board of Directors responsibility to ensure that a volunteer is prepared to communicate with WDNR representatives and collect water quality samples each year. Partnership with the NLDC should be utilized to continue to monitor water levels in Pardee Lake.
Action Steps:	
1.	Trained CLMN volunteer(s) collects data and report results to WDNR and to association members during annual meeting.
2.	CLMN volunteer and/or PLIA Board of Directors would facilitate new volunteer(s) as needed
3.	Coordinator contacts Sandra Wickman (715.365.8951) to acquire necessary materials and training for new volunteer(s)
4.	Continue to monitor lake levels via partnership with the NLDC.

Management Action:	Work with WDNR fisheries staff to increase proper fish habitat and determine appropriate stocking routine.
Timeframe:	2020
Possible Grant:	WDNR Healthy Lakes Initiative Grant (Fishsticks)
Facilitator:	PLIA Board of Commissioners

Description:	Fishing was the second most important reason for owning property on or near Pardee Lake along with nature viewing (Question #16). Over 84% of respondents had fished the lake in the past three years and of those people, almost half believe that the quality of fishing has gotten somewhat worse since they began fishing on the lake.
	
	The first step in this action should be to complete a fishery study on Pardee Lake. Pardee Lake does not have a public boat landing; therefore, the WDNR prioritizes the completion of a fishery study on Pardee Lake below lakes with public access. The PLIA may need to contract with a private firm to complete the study. This information could then be presented to the local WDNR fisheries biologist (see Table 8.10.7-1).
	
	The PLIA will work with local fisheries biologists to determine what type of fish structure improvements could be made to the lake to improve its fishery. Further, once those improvements are made, determine a stocking routine that will provide quality fishing opportunities on the lake. If the WDNR fisheries biologist supports the addition of coarse woody habitat to Pardee Lake, the PLIA could apply for a Healthy Lakes Initiative Grant to fund the project.
	
	The WDNR's Healthy Lakes Initiative Grant allows partial cost coverage for coarse woody habitat improvements (referred to as "fish sticks"). 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.
	• 75% state share grant with maximum award of $25,000; up to 10% state share for technical assistance
	• Maximum of $1,000 per cluster of 3-5 trees (best practice cap)
	• Implemented according to approved technical requirements (WDNR Fisheries Biologist) and complies with local shoreland zoning ordinances
	• Buffer area (350 ft^2) at base of coarse woody habitat cluster must comply with local shoreland zoning or:
	    o The landowner would need to commit to leaving the area un-mowed
	    o The landowner would need to implement a native planting (also cost share through this grant program available)
	• Coarse woody habitat improvement projects require a general permit from the WDNR
	• Landowner must sign Conservation Commitment pledge to leave project in place and provide continued maintenance for 10 years

Action Steps:	

1.	See description above.

Management Action:	Coordinate annual volunteer monitoring for Aquatic Invasive Species on Pardee Lake.
Timeframe:	Begin 2020
Facilitator:	PLIA Board of Directors
Description:	In lakes without Eurasian watermilfoil and other submersed invasive species like curly-leaf pondweed, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. One way in which lake residents can spot early infestations of AIS is through conducting "Lake Sweeps" on their lake. During a lake sweep, volunteers monitor the entire area of the system in which plants grow (littoral zone) twice annually in search of non-native plant species. This program uses an "adopt-a-shoreline" approach where volunteers are responsible for surveying specified areas of the system. In order for accurate data to be collected during these sweeps, volunteers must be able to identify non-native species such as Eurasian watermilfoil and curly-leaf pondweed. Distinguishing these plants from native look-a-likes is very important. The PLIA will initially recruit volunteers at the group's annual meeting by displaying a map of the Pardee Lake shoreline divided into relatively equal sections. Volunteers can then write their names next to a section and provide contact information on a separate form. The PLIA Board of Directors will then utilize that list to set up the monitoring program on the lake. The PLIA Board of Directors will also work with NLDC staff and riparian property owners to remove pale-yellow iris and aquatic forget-me-not from the lake's shoreline. Continued partnership with the NLDC is of vital importance to provide volunteers and education for AIS management on the lake. Of equal importance is the partnership between the Town of Winchester and the NLDC, and the continued support that the town provides.
Action Steps:	
1.	Board of Directors maintains volunteer list to complete shoreline sweeps.
2.	Board of Directors contacts volunteers and sets up training sessions with NLDC or other qualified agency, like Vilas County.
3.	Board of Directors coordinates surveys, collects results, and reports on those results at annual meeting and on PLIA website.

Management Action:	Initiate rapid response plan following detection of new AIS
Timeframe:	If/When Necessary
Facilitator:	Board of Directors
Description:	If volunteers locate a suspected new AIS within Pardee Lake, the location would be marked (e.g. GPS, maker buoy) and a specimen would be taken to the NLDC or to the Vilas County Land Conservation Department for verification. If the suspected specimen is indeed a non-native species, the WDNR will fill out an incident form and develop a strategy to determine the population level within the lake. The lake would be professionally surveyed, either by agency personnel or a private consulting firm during that species' peak growth phase. If the AIS is a NR40 prohibited species (i.e. red swamp crayfish, starry stonewort, hydrilla, etc.), the WDNR may take an active role in the response. If the AIS is a NR40 restricted species (i.e. purple loosestrife, curly-leaf pondweed, Eurasian watermilfoil, etc.), the PLIA would need to reach out to a consultant to develop a formal monitoring and/or control strategy. The WDNR would be able to help financially through the AIS Grant Program's Early Detection and Response Grant. This grant program is non-competitive and doesn't have a specific application deadline, but is offered on a first-come basis to the sponsor of project waters that contain new infestations (found within less than 5% of the lake and officially documented less than 5 years from grant application date). Currently this program will fund up to 75% percent of monitoring and control costs, up to $20,000.
Action Steps:	
	See description above