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

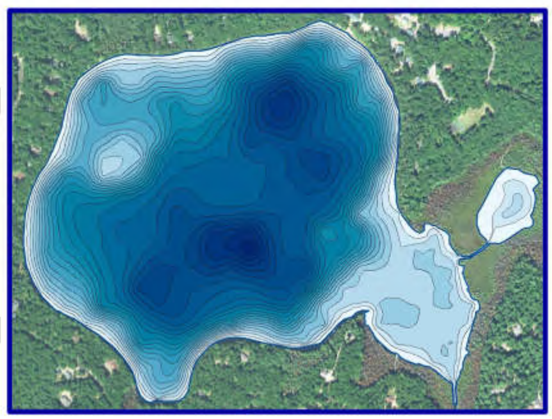
8.6 Moon Lake

An Introduction to Moon Lake

Moon Lake, Vilas County, is a 133-acre, oligotrophic deep seepage lake with a maximum depth of 42 feet and a mean depth of 19 feet (Alma and Moon Lakes – Map 1). Its watershed encompasses approximately 345 acres and is comprised mainly of intact upland forests. Being a seepage lake, Moon Lake does not have any inflowing or outflowing streams, but is connected via a small channel to Alma Lake. In 2019, 38 native aquatic plant species were located in Moon Lake, of which dwarf watermilfoil (*Myriophyllum tenellum*) was the most common. The non-native wetland plant green-arrow arum (*Peltandra virginica*) was located in the connected Engle Bog in 2019.

Lake at a Glance - Moon Lake

Morphology	
LakeType	Deep Seepage Lake
Surface Area (Acres)	133
Max Depth (feet)	38
Mean Depth (feet)	17
Perimeter (Miles)	2.0
Shoreline Complexity	1.5
Watershed Area (Acres)	345
Watershed to Lake Area Ratio	2:1
Water Quality	
Trophic State	Oligotrophic
Limiting Nutrient	Phosphorus
Avg Summer P (μg/L)	11.0
Avg Summer Chl-α (μg/L)	2.5
Avg Summer Secchi Depth (ft)	16.5
Summer pH	7.0
Alkalinity (mg/L as $CaCO_3$)	<2.5
Vegetation (2019)	
Number of Native Species	38
NHI-Listed Species	Northeastern bladderwort (*Utricularia resupinata*)
Exotic Species	Green arrow-arum (*Peltandra virginica*)
Average Conservatism	7.2
Floristic Quality	33.9
Simpson's Diversity (1-D)	0.91



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

8.6.1 Moon 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.

Water quality data were collected from Moon Lake on five occasions in 2019, by both Onterra staff and citizen lake volunteers. The lake was sampled for a variety of water quality parameters including total phosphorus, chlorophyll-*a*, Secchi disk depth, temperature, and dissolved oxygen. Please note that the data in these graphs represent concentrations and depths taken during the growing season (April-October) and summer months (June-August) as indicated with each dataset. Furthermore, unless otherwise noted, the phosphorus and chlorophyll-*a* data represent only surface samples. In addition to sampling efforts completed in 2019 any historical data was researched and are included within this report as available.

Near-surface total phosphorus data from Moon Lake are available from 1979 and annually from 1998-2019 (Figure 8.6.1-1). Average summer total phosphorus concentrations ranged from 6.8 µg/L in 2013 to 16.0 µg/L in 1999. The weighted summer average total phosphorus concentration is 11.0 µg/L and falls into the *excellent* category for deep seepage lakes in Wisconsin. Moon Lake's summer average total phosphorus concentrations are lower than the median values for both deep seepage lakes in the state and all lake types in the Northern Lakes and Forests (NLF) ecoregion. While phosphorus concentrations in Moon Lake have fluctuated over the period from 1998-2019, these fluctuations are likely driven by changes in water levels and precipitation over this period. Trends analysis indicates no statistically valid trends (positive or negative) in phosphorus concentrations have occurred over this period.

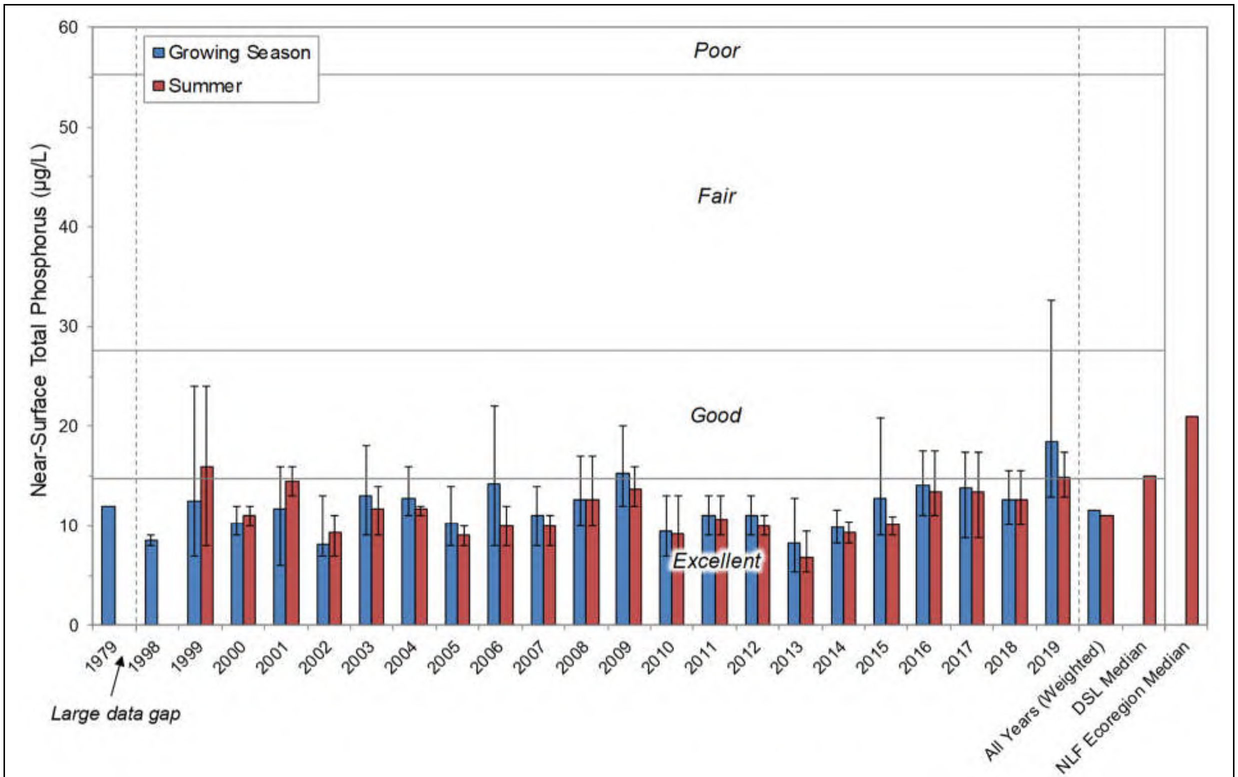


Figure 8.6.1-1. Moon Lake average annual near-surface total phosphorus concentrations and median near-surface total phosphorus concentrations for state-wide deep seepage lakes (DSL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

As discussed in the primer section, internal nutrient loading is a process by which phosphorus (and other nutrients) are released from sediments when bottom waters become devoid of oxygen (anoxic). Internal nutrient loading is more prevalent in deeper lakes which experience summer stratification or in shallow lakes that are highly productive where high rates of decomposition deplete oxygen near the sediment-water interface. Often as lakes become more productive over time, internal nutrient loading increases.

In certain instances, this sediment-released phosphorus can be mobilized to surface waters during the summer where it can fuel nuisance algal blooms. Lake managers often try and determine if internal nutrient loading is a significant source of phosphorus in a lake, particularly when an increasing trend in phosphorus is observed. Although the bottom waters were devoid of oxygen in July in Moon Lake, phosphorus concentrations in the near bottom water were not significantly higher than surface water. This indicates that internal loading is not a significant source of phosphorus in Moon Lake.

Chlorophyll-*a* data are available from Moon Lake from 1979 and annually from 1998-2019 (Figure 8.6.1-2). Average summer chlorophyll-*a* concentrations ranged from 1.7 µg/L in 1999 to 5.0 µg/L in 2018. Moon Lake's summer average chlorophyll-*a* concentration is 2.5 µg/L and falls into the *excellent* category for deep seepage lakes in Wisconsin. Moon Lake's summer average chlorophyll-*a* concentrations are lower than the median values for deep seepage lakes in the state and all lake types in the NLF ecoregion. Unlike Alma Lake, chlorophyll-*a* concentrations were not higher during the period 2003-2012. Instead concentrations have generally been stable although mean summer concentrations were highest in 2003 and 2018. It is not clear why were higher in these years as phosphorus concentrations did not show the same trend.

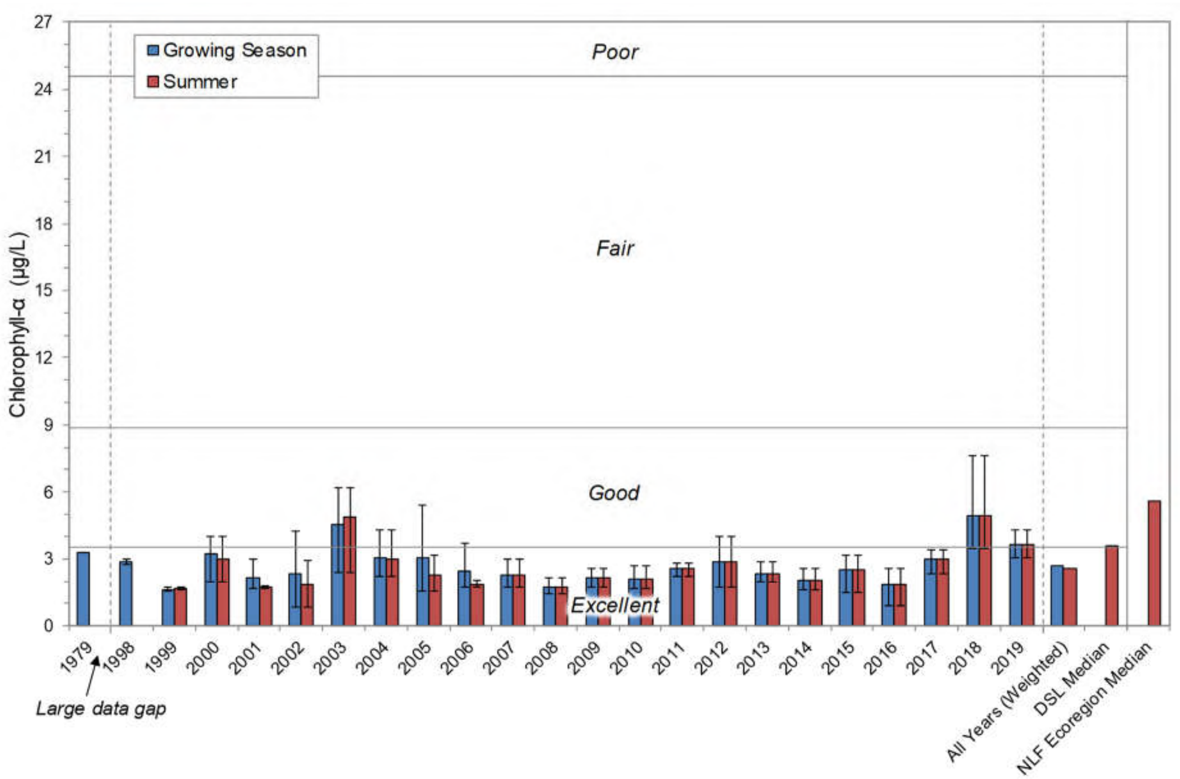


Figure 8.6.1-2. Moon Lake average annual chlorophyll-α concentrations and median chlorophyll-α concentrations for state-wide deep seepage lakes (DSL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Secchi disk depth data are available from Moon Lake intermittently from 1979, 1986-1989 and 1992-2019 (Figure 8.6.1-3). Average summer Secchi disk depths ranged from 12.6 feet in 2019 to 20.5 feet in 2006. The weighted summer average Secchi disk depth is 16.3 feet and falls into the *excellent* category for deep seepage lakes in Wisconsin. Moon Lake's weighted summer average Secchi disk depth exceeds the median values for both deep seepage lakes in the state and for all lake types in the NLF ecoregion.

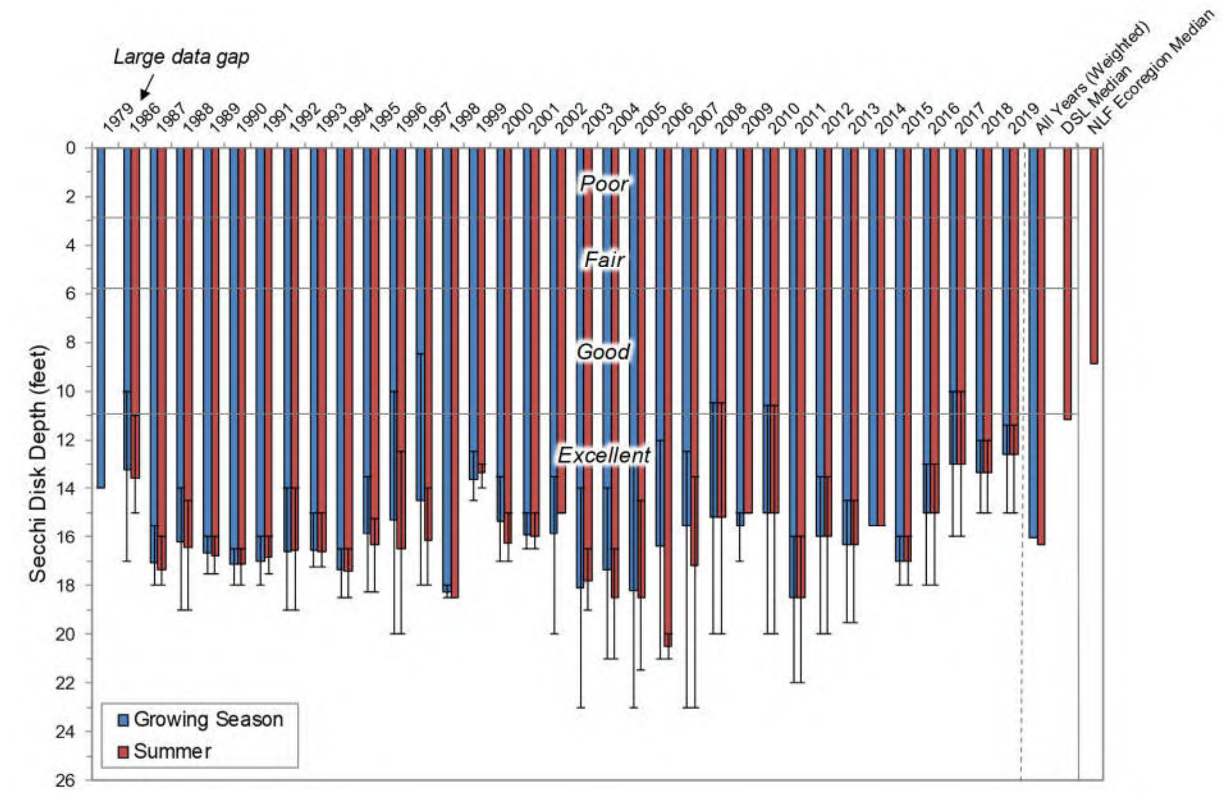


Figure 8.6.1-3. Moon Lake average annual Secchi disk depths and median Secchi disk depths for state-wide deep seepage lakes (DSL) and Northern Lakes and Forests (NLF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

Overall, Secchi disk depth in Moon Lake has been highly correlated with chlorophyll-*a* concentrations. However, there has been a decreasing trend in water clarity in recent years from despite no increasing trend in chlorophyll-*a* concentrations. This may indicate that a factor other than algae is influencing water clarity in Moon Lake. Given the increase in annual precipitation in recent years, Moon Lake could contain higher concentrations of dissolved humic compounds which decrease water clarity. 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 was measured in Moon Lake in 2019 at 10 SU (standard units), indicating the lake's water was *slightly tea-colored*. In 2019, water in Engle Bog (connected to Moon Lake) was observed to be very dark in color, and these compounds are likely flowing into Moon Lake, reducing water clarity. It is important to note that Alma Lake's water clarity is still very high, but the slight reduction in clarity observed in recent years is likely due to increased inputs of these dissolved organic compounds from higher precipitation.

Limiting Plant Nutrient of Moon Lake

Using midsummer nitrogen and phosphorus concentrations from Moon Lake, a nitrogen:phosphorus ratio of 33:1 was calculated. This finding indicates that Moon Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that phosphorus is the primary nutrient regulating algal production.

Moon Lake Trophic State

Figure 8.6.1-4 contains the Trophic State Index (TSI) values for Moon Lake. These TSI values are calculated using summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk depth data collected as part of this project along with available 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 chlorophyll-*a* (and Secchi disk depth) in Moon Lake indicate the lake has been on average in an oligotrophic state. However, more recently and at present, the lake is in a mesotrophic state. Moon Lake's productivity is less than other deep seepage lakes in Wisconsin and lower than all lake types within the NLF ecoregion.

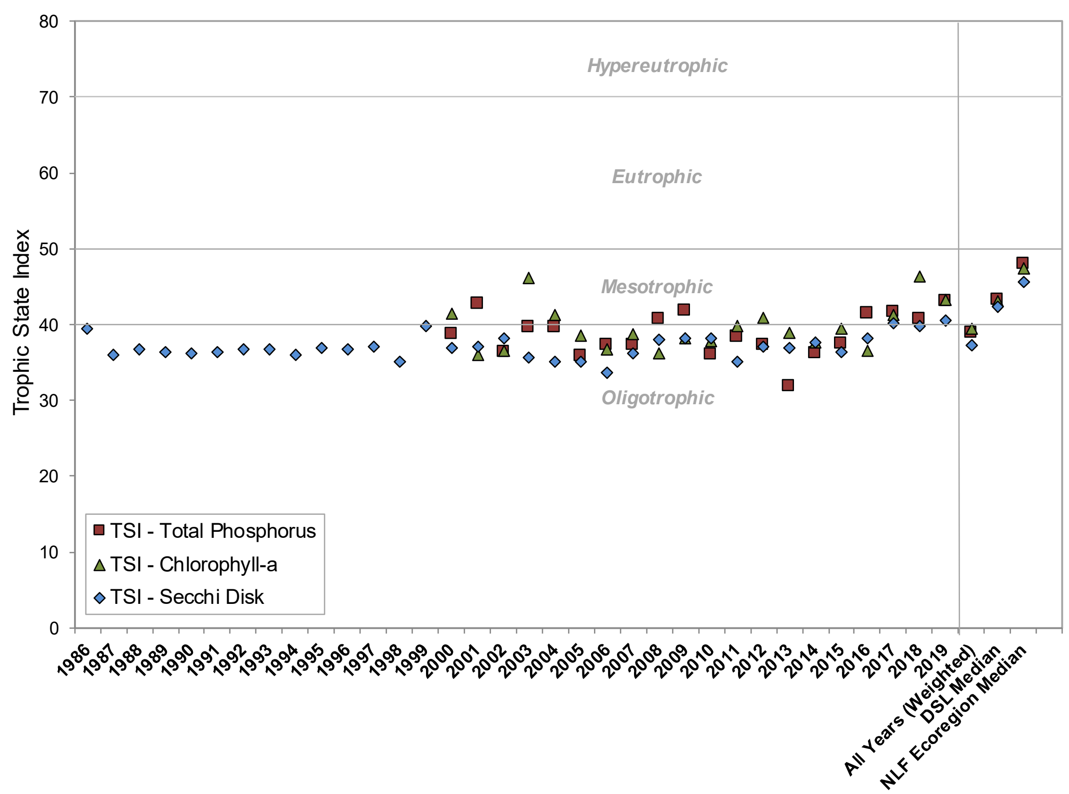


Figure 8.6.1-4. Moon Lake, statewide deep seepage lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Moon Lake

Dissolved oxygen and temperature were measured in Moon Lake by Onterra staff in July but the other times were measured by citizen volunteers. Onterra staff measured the profiles to a depth of 38 feet whereas the citizens only measured a maximum depth of 25 feet. Profiles depicting these data are displayed in Figure 8.6.1-5.

Moon Lake is *dimictic*, meaning the lake remains stratified during the summer and completely mixes, or turns over, in the spring and in the 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 Moon Lake's deeper nature, 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 organ matter within this layer depletes available oxygen. The profile collected in July were deeper than in June and August and showed that the bottom waters were devoid of oxygen. This can sometimes result in a significant amount of phosphorus being released from the sediments but this did not occur in Moon Lake. In fall, as surface temperatures cool, the entire water column is again able to mix, which re-oxygenates the hypolimnion.

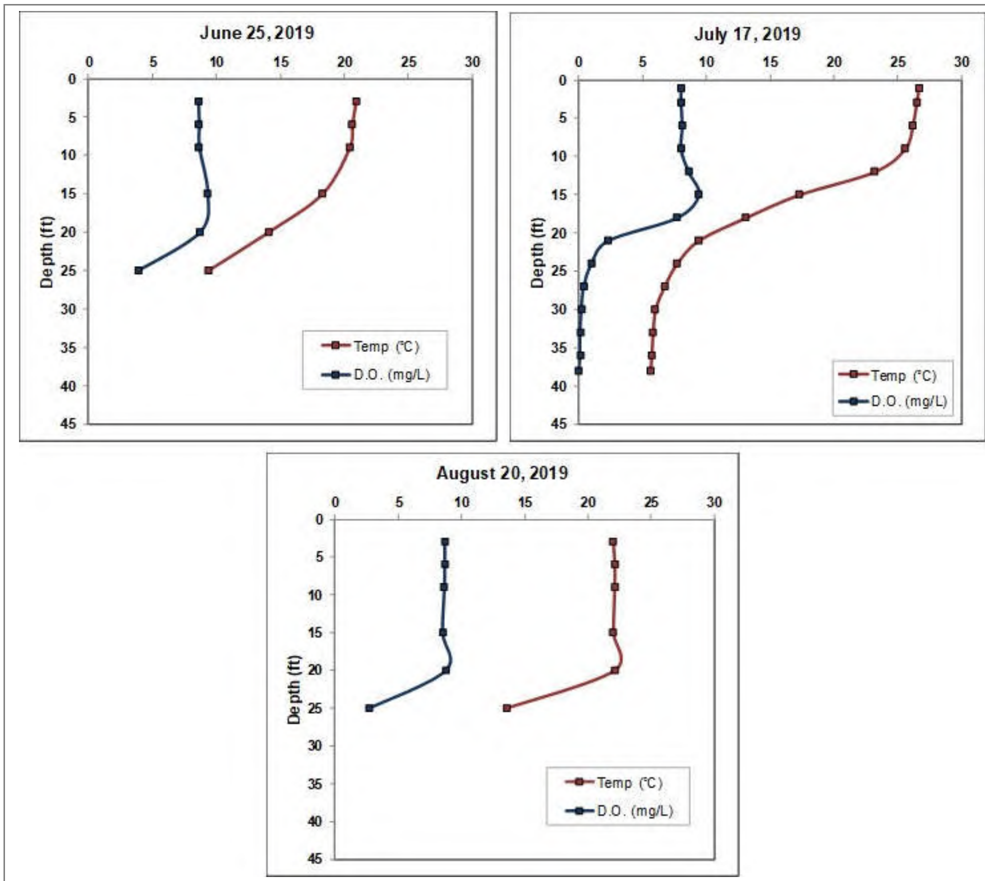


Figure 8.6.1-5. Moon Lake 2019 dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Moon Lake

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

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-) and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw and Nimphius 1985). The mid-summer pH of the water in Moon Lake was found to be neutral with a value of 7.0 and falls within the normal range for Wisconsin Lakes.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Moon Lake was below the detection limit which is 2.5 mg/L (mg/L as $CaCO_3$), indicating that the lake has a high sensitivity lower pH values from acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Moon Lake's pH of 7.0 falls within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Moon Lake was found to be 1.9 mg/L, meaning it is unlikely to support the growth of zebra mussels.

8.6.2 Moon Lake Watershed Assessment

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

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

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

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

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

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

(WDNR PUB FR-093 2010). In summary, any forestry activities that occur within Moon Lake's watershed must be implemented under this framework and should not impart significant impacts to the lake's water quality.

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

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

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

Watershed Modeling

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

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

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

Moon Lake Watershed Assessment

Moon Lake’s watershed encompasses approximately 345 acres (Figure 8.6.2-1 and Alma & Moon Lakes – Map 2). While Moon Lake shares a connection with Alma Lake, there are no tributaries flowing into or out of either of these lakes. The low alkalinity of these lakes indicates that most of their water originates directly from precipitation. Water leaves these lakes through evaporation and groundwater.

Approximately 48% (167 acres) of Moon Lake’s watershed is comprised of upland forests, 39% (133 acres) is comprised of the lake’s surface, 9% (33 acres) is comprised of wetlands, 2% (6 acres) is comprised of rural residential development, and 2% (5 acres) is comprised of rural open space (Figure 8.6.2-2). Wisconsin Lakes Modeling Suite (WiLMS) modeling estimated that Moon Lake’s water residence time is approximately three years, meaning the water within the lake is completely replaced on average once every three years.

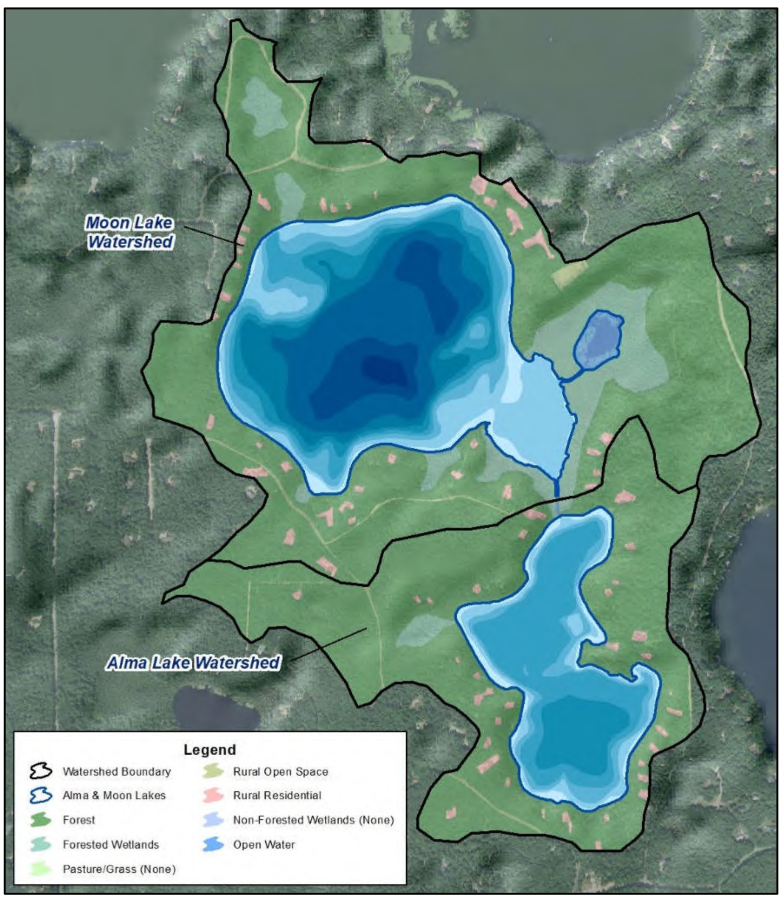


Figure 8.1.2-1. Alma and Moon lakes watershed boundaries and land cover types.

Using the land cover types and their acreages within Moon Lake’s watershed, WiLMS was utilized to estimate the annual potential phosphorus load delivered to the lake. In addition, data obtained from a stakeholder survey sent to Moon Lake riparian property owners in 2019 was also used to estimate the potential phosphorus loading to the lake from riparian septic systems. The model estimated that approximately 41 pounds of phosphorus are loaded to Moon Lake from its watershed on an annual basis (Figure 8.6.2-2).

Of the estimated 41 pounds of phosphorus that are loaded to Moon Lake annually, approximately 51% (21 pounds) originate from direct atmospheric deposition onto the lake's surface, 32% (13 pounds) from upland forests, 8% (3 pounds) from developed shoreland properties, 5% (2 pounds) from wetlands, and 4% (2 pounds) from riparian septic systems (Figure 8.6.2-2).

Using the estimated annual potential phosphorus load of 41 pounds, WiLMS predicted an in-lake growing season average total phosphorus concentration of 15 µg/L, which is slightly higher than the measured growing season mean concentration of 12 µg/L. This indicates that the model is slightly overestimating the amount of phosphorus being loaded to Moon Lake annually, and that there are no significant sources of unaccounted phosphorus (e.g., internal nutrient loading, septic, etc.) being loaded to the lake at this time.

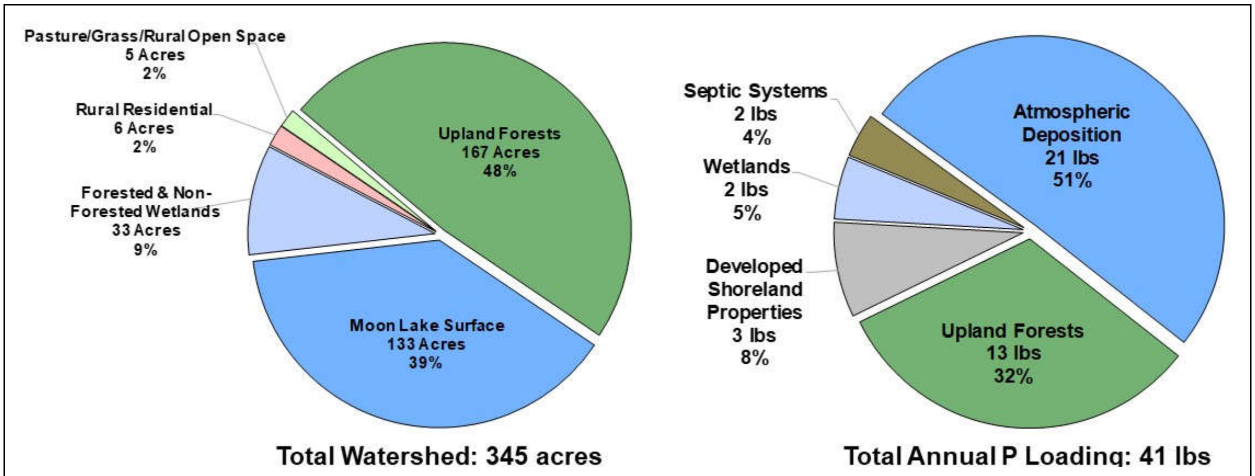


Figure 8.6.2-2. Moon Lake watershed land cover types (left) and estimated annual watershed phosphorus loading (right). Based upon National Land Cover Database (NLCD – Fry et. al 2011).

8.6.3 Moon Lake Shoreland Condition

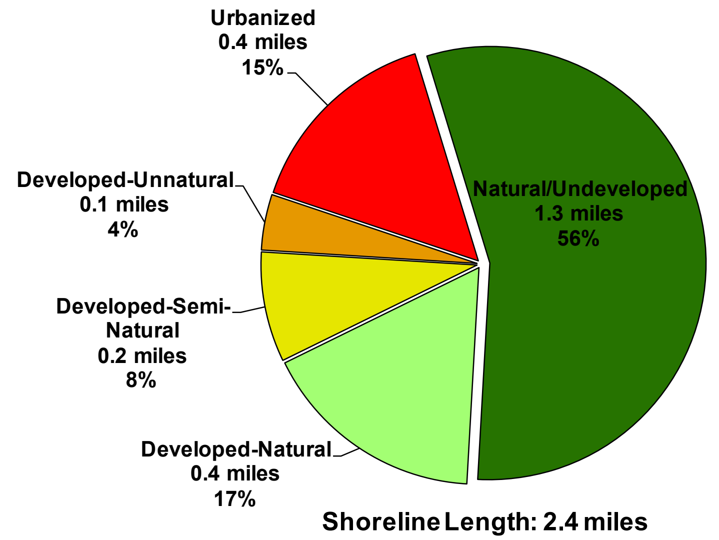


Figure 8.6.3-1. Moon Lake shoreland categories and total lengths. Based upon a fall 2019 survey. Locations of these categorized shorelands can be found on Alma and Moon Lakes Map – 3.

As mentioned previously in the Town-Wide Shoreland Condition Section, one of the most sensitive areas of the watershed is the immediate shoreland area. This area of land is the last source of protection for a lake against surface water runoff, and is also a critical area for wildlife habitat. In fall of 2019, Moon Lake's immediate shoreline was assessed in terms of its level of development.

Moon Lake has stretches of shoreland that fit all of the five shoreland assessment categories, but the majority of the lake's shoreline (1.7 miles or 73% of the total shoreline) have little to no development, categories as natural/undeveloped or developed-natural (Figure 8.6.3-1 and Alma & Moon lakes Map - 3). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 0.5 miles of urbanized and developed-unnatural shoreline (19% of the total shoreline) was observed. If restoration of the Moon Lake shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem.

Coarse Woody Habitat

As part of the shoreland condition assessment, Moon Lake was also surveyed to determine the extent of its coarse woody habitat. Coarse woody habitat was identified, and classified in three size categories (cluster of pieces, 2-8 inches in diameter, and 8+ inches in diameter) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. Pictures descriptions of these categories can be found in the Town-Wide Section 3.4. As discussed earlier, research indicates that fish species prefer some branching as opposed to no branching on coarse woody habitat, and increasing complexity is positively correlated with higher fish species richness, diversity and abundance (Newbrey et al. 2005).

During this survey, 74 total pieces of coarse woody habitat were observed along 2.4 miles of shoreline (Alma and Moon Lakes Map – 4), which yields a coarse woody habitat to shoreline mile ratio of 31:1 (Figure 8.6.3-2). Only instances where emergent coarse woody habitat extended from shore into the water were recorded during the survey. Thirty-two pieces of 2-8 inches in diameter pieces of coarse woody habitat were found, 33 pieces of 8+ inches in diameter pieces of coarse woody habitat were found, and nine instances of clusters of coarse woody habitat were found.

To put this into perspective, Wisconsin researchers have found that in completely undeveloped lakes, an average of 345 coarse woody habitat structures may be found per mile (Christensen et al.

1996). Please note the methodologies between the surveys done on Moon Lake and those cited in this literature comparison are much different, but still provide a valuable insight into what undisturbed shorelines may have in terms of coarse woody habitat. Onterra has completed coarse woody habitat surveys on 111 lakes throughout Wisconsin since 2012, with the majority occurring in the NLF ecoregion on lakes with public access. The number of coarse woody habitat pieces per shoreline mile in Moon Lake falls in the 56th percentile of these 111 lakes.

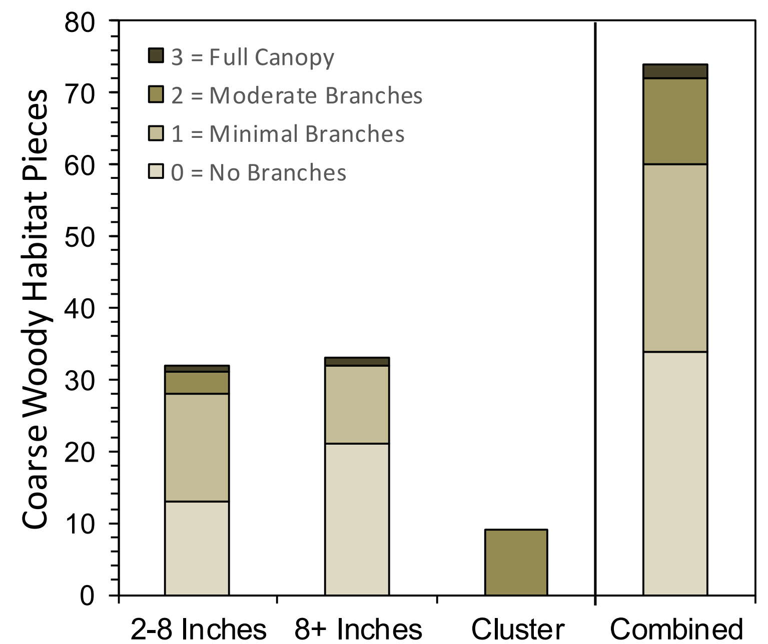


Figure 8.1.3-2. Moon Lake coarse woody habitat survey results. Based upon a Fall of 2019 survey. Locations of the Moon Lake coarse woody habitat can be found Alma and Moon Lakes – Map 4.

8.6.4 Moon Lake Aquatic Vegetation

An Early-Season Aquatic Invasive Species (ESAIS) Survey was conducted by Onterra ecologists on Moon Lake on June 25, 2019. 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. No curly-leaf pondweed was located in Moon Lake during this survey, however, Green arrow-arum (*Peltandra virginica*) was located in Engle Bay. See Figure 8.6.4-10 for locations.

The whole-lake aquatic plant point-intercept survey and emergent and floating-leaf aquatic plant community mapping survey were conducted on Moon Lake by Onterra ecologists on August 6, 2019, Engle bog was mapped separately on August 15, 2019. During these surveys, a total of 32 native aquatic plant species were located (Table 8.6.4-1). One native aquatic plant species present in Moon Lake, northeastern bladderwort, is listed by the Wisconsin Natural Heritage Inventory Program as a species of 'special concern' because it is rare or uncommon in Wisconsin, and there is uncertainty regarding its abundance and distribution within the state. Onterra also completed a whole-lake point-intercept survey on Moon Lake in 2010, and the species located during that survey are also included in Table 8.6.4-1.

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

During the 2019 point-intercept survey, information regarding substrate type was collected at locations sampled with a pole-mounted rake (less than 15 feet). These data indicate that 34% of the point-intercept locations in 15 feet of water or less contained soft organic sediments, 53% contained sand, and 13% contained rock (Figure 8.6.4-1). Sampling locations with sand and/or rock were primarily located in shallower, near-shore areas, while the majority of sampling locations with organic sediments were located in the shallow bay leading

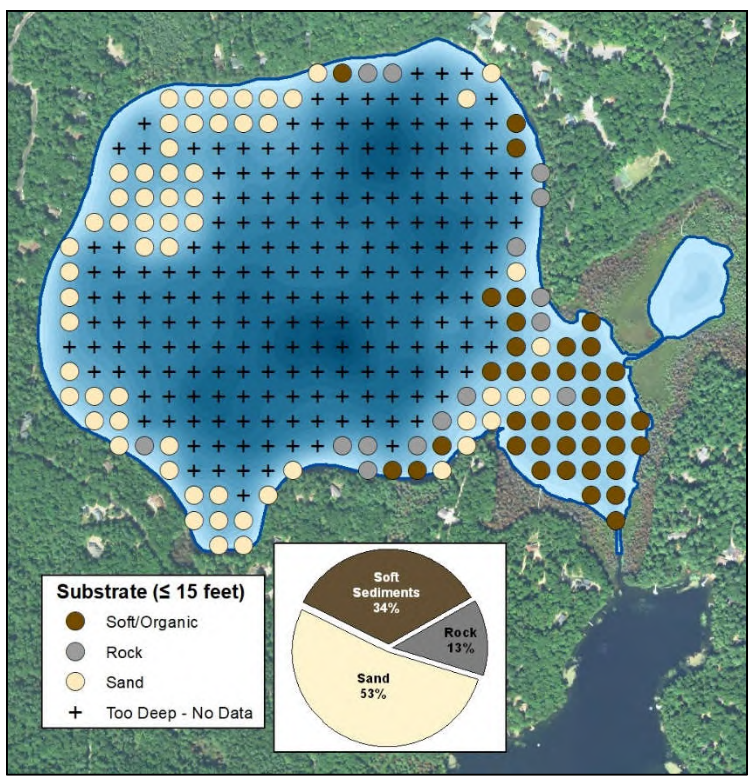


Figure 8.6.4-1. Moon Lake substrate types as determined from the 2019 point-intercept survey. Please note substrate types can only be determined at sampling locations in 15 feet of water or less.

to the channel that connects to Alma lake. The combination of both soft and hard substrates in Moon Lake creates habitat types which support different aquatic plant community assemblages.

Table 8.6.4-1. Aquatic plant species located in Moon Lake during 2010 and 2019 aquatic plant surveys.

Growth Form	Scientific Name	Common Name	Status in Wisconsin	Coefficient of Conservatism	2010	2019
Emergent	*Calla palustris*	Water arum	Native	9	I	I
	Carex comosa	Bristly sedge	Native	5		I
	Comarum palustre	Marsh cinquefoil	Native	8		I
	Dulichium arundinaceum	Three-way sedge	Native	9	I	I
	Eleocharis obtusa	Blunt spikerush	Native	3	I	
	Eleocharis palustris	Creeping spikerush	Native	6	X	I
	Iris versicolor	Northern blue flag	Native	5		I
	Juncus effusus	Soft rush	Native	4		I
	Peltandra virginica	Green arrow-arum	Non-Native - Locally Esablished	N/A		I
	Schoenoplectus acutus	Hardstem bulrush	Native	5	I	I
	Schoenoplectus tabernaemontani	Softstem bulrush	Native	4		I
	Scirpus cyperinus	Wool grass	Native	4		I
	Typha latifolia	Broad-leaved cattail	Native	1		I
	Zizania palustris	Northern wild rice	Native	8	X	
FL	*Brasenia schreberi*	Watershield	Native	7	X	X
	Nuphar variegata	Spatterdock	Native	6	I	I
	Nymphaea odorata	White water lily	Native	6	X	I
	Sparganium angustifolium	Narrow-leaf bur-reed	Native	9	X	I
Submergent	*Ceratophyllum demersum*	Coontail	Native	3	X	X
	Ceratophyllum echinatum	Spiny hornwort	Native	10		I
	Chara spp.	Muskgrasses	Native	7	X	X
	Elatine minima	Waterwort	Native	9	X	
	Elodea canadensis	Common waterweed	Native	3	X	X
	Elodea nuttallii	Slender waterweed	Native	7		X
	Eriocaulon aquaticum	Pipewort	Native	9	X	X
	Gratiola aurea	Golden pert	Native	10	X	
	Heteranthera dubia	Water stargrass	Native	6	X	
	Isoetes spp.	Quillwort spp.	Native	8	X	X
	Lobelia dortmanna	Water lobelia	Native	10	X	X
	Myriophyllum tenellum	Dwarf watermilfoil	Native	10	X	X
	Najas flexilis	Slender naiad	Native	6		X
	Nitella spp.	Stoneworts	Native	7	X	X
	Potamogeton amplifolius	Large-leaf pondweed	Native	7	X	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	Native	8	I	
	Potamogeton pusillus	Small pondweed	Native	7	X	X
	Potamogeton spirillus	Spiral-fruited pondweed	Native	8	X	X
	Ranunculus flammula	Creeping spearwort	Native	9	X	X
	Sagittaria sp. (rosette)	Arrowhead sp. (rosette)	Native	N/A	X	X
	Utricularia resupinata	Northeastern bladderwort	Native - Special Concern	9	X	X
	Utricularia vulgaris	Common bladderwort	Native	7		X
	Vallisneria americana	Wild celery	Native	6	X	X
SE	*Eleocharis acicularis*	Needle spikerush	Native	5	X	X
	Juncus pelocarpus	Brown-fruited rush	Native	8	X	X
	Sagittaria cristata	Crested arrowhead	Native	9		I
	Sagittaria graminea	Grass-leaved arrowhead	Native	9	I	
	Schoenoplectus subterminalis	Water bulrush	Native	9	I	X

X = Located on rake during point-intercept survey; I = Incidentally located; not located on rake during point-intercept survey
FL = Floating-leaf; SE = Submergent and/or Emergent

The maximum depth of plant growth is largely going to be determined by water clarity. In general, aquatic plants grow to a depth of two to three times the average Secchi disk depth. Moon Lake's mean Secchi disk depth in 2019 was 12.6 feet, and aquatic plants were recorded growing to a maximum depth of 26 feet. Moon Lake's high water clarity allows for sufficient light availability at deeper depths to support aquatic plant growth.

The littoral frequency of occurrence of vegetation in Moon Lake in 2019 was 51% compared to 76% in 2010, representing a 33% decrease in the occurrence of vegetation over this period (Figure 8.6.4-2). Total rake fullness ratings were not yet part of the point-intercept survey methodology in 2010, but total rake fullness ratings recorded in 2019 indicated overall biomass of aquatic plants in Moon Lake is low. Approximately 83% of the sampling locations that contained aquatic vegetation in 2019 had a total rake fullness rating of 1, 13% a rating of 2, and 4% a rating of 3.

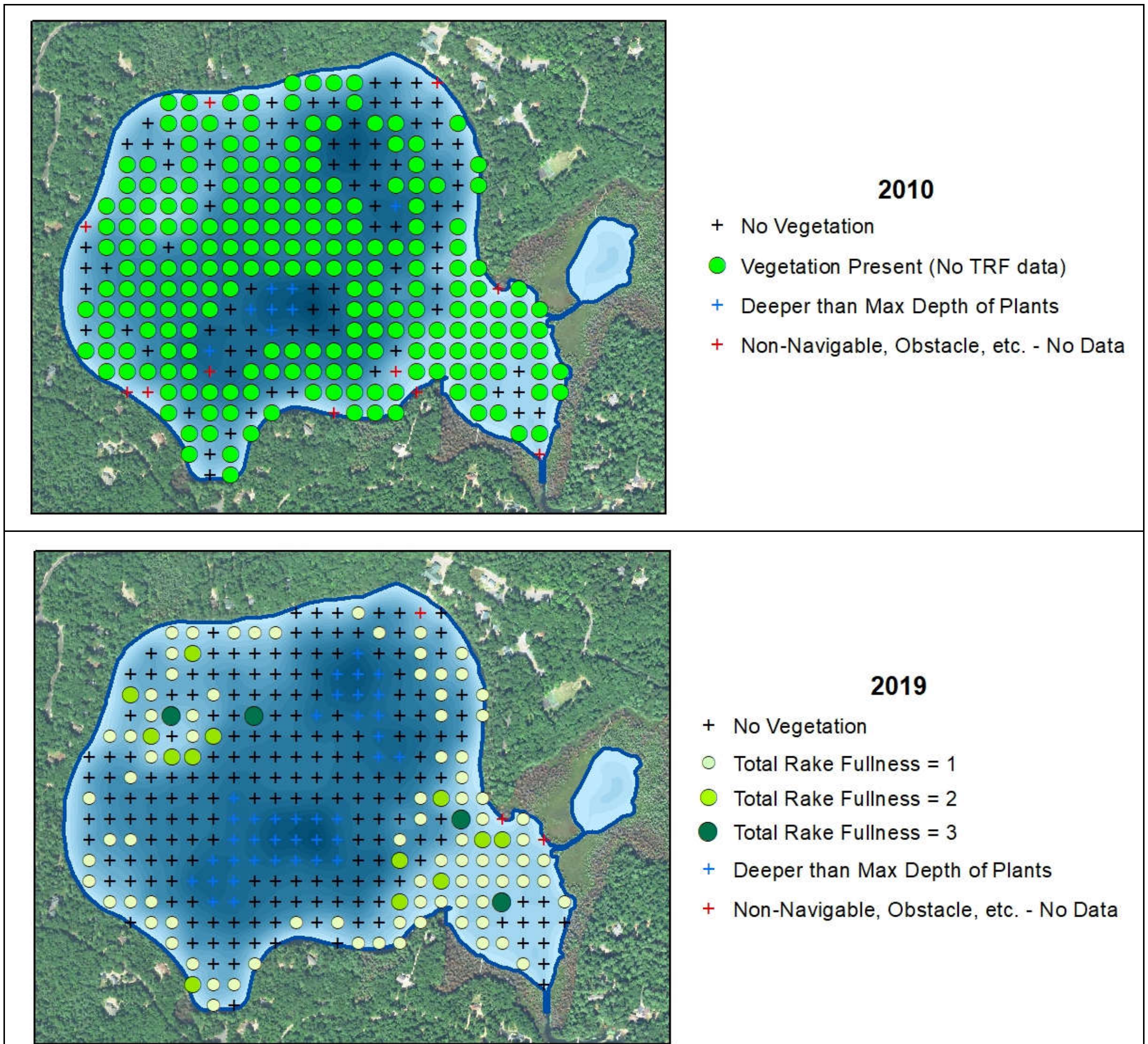


Figure 8.6.4-2. Distribution of aquatic vegetation in Moon Lake in 2010 and 2019 illustrating reduction in vegetation occurrence in deeper areas. Total rake fullness (TRF) data not recorded in 2010. Littoral frequency of occurrence of vegetation in 2010 was 76% (n = 290) and 51% in 2019 (n = 201). Created using data from Onterra 2010 and 2019 point-intercept surveys.

The reduction in overall aquatic plant occurrence in Moon Lake in 2019 is believed to be primarily driven by changes in water levels over this period. Water depth data collected during the point-intercept surveys indicates that the mean depth of sampling points increased from 15.6 feet in 2010 to 18.8 feet in 2019, indicating water levels in Moon Lake were approximately 3.0 feet higher in 2019 when compared to 2010. While Secchi disk depths were very similar in 2010 and 2019 indicating water clarity has not changed, the increase in water levels has resulted in decreased light availability to plants in deeper areas of Moon Lake's littoral zone.

Figure 8.6.4-2 illustrates that the most of the vegetation loss in Moon Lake between 2010 and 2019 has been in the deepest areas of the littoral zone, between 16 and 29 feet. Most of this vegetation loss can be attributed to a reduction in one species: slender stoneworts (*Nitella flexilis*). Slender stonewort is a macroalgae which often inhabits deeper areas beyond most vascular plants. In 2010, slender stonewort was most abundant plant in Moon Lake, primarily inhabiting deeper areas between 17.0 and 29.0 feet of water. In 2019, slender stonewort was not located at any of the sampling points within this depth range, and was only located at a few sampling locations at depths of 5-6 feet.

Seasonal and longer-term water level fluctuations are natural in Wisconsin's lakes and play an essential ecological role (e.g., maintaining emergent plant communities). Water level fluctuations are most pronounced in seepage lakes like Moon Lake where water levels are largely determined by precipitation and groundwater. While Moon Lake has seen a significant decline in the overall occurrence of aquatic vegetation between 2010 and 2019, this reduction is believed to be due to higher water levels and the resulting reduced light availability in deeper areas of the littoral zone. It is expected that when water levels recede again in the future, aquatic plant abundance will again increase.

The data from the two point-intercept surveys completed on Moon Lake can be used to compare how the occurrence of individual species have changed between the 2010 and 2019 surveys. The littoral frequencies of occurrence of aquatic plant species which had a littoral occurrence of at least 5% in one of the four point-intercept surveys are displayed in Figure 8.6.4-3.

In 2010, slender stonewort was the most frequently-encountered species in Moon Lake with a frequency of occurrence of 36.3% (Figure 8.6.4-3). In 2019, its frequency of occurrence had declined to 0.9%, representing a statistically valid reduction in occurrence of 97.5%. Similarly, the occurrence of brown-fruited rush (*Juncus pelocarpus*) declined by 44.5%. Muskgrasses were the only species to have a statistically significant increase in their occurrence from 2.1% in 2010 to 7.3% in 2019, an increase of 242.9%. The occurrences of dwarf watermilfoil, northeastern bladderwort, common waterweed, and quillworts were not statistically different between the two surveys. All of these changes are believed to be primarily driven by the 3-foot water level increase that has occurred between these two surveys. Similar changes have been observed on other area seepage lakes (e.g., Anvil Lake, Vilas County and Squash Lake, Oneida County).

The data that continues to be collected from Wisconsin lake's is revealing that aquatic plant communities are highly dynamic, and populations of individual species have the capacity to fluctuate, sometimes greatly, in their occurrence from year to year and over longer periods of time. These fluctuations are driven by a combination of interacting natural factors including variations in water levels, temperature, ice and snow cover (winter light availability), nutrient availability, changes in water flow, water clarity, length of the growing season, herbivory, disease, and competition (Lacoul and Freedman 2006).

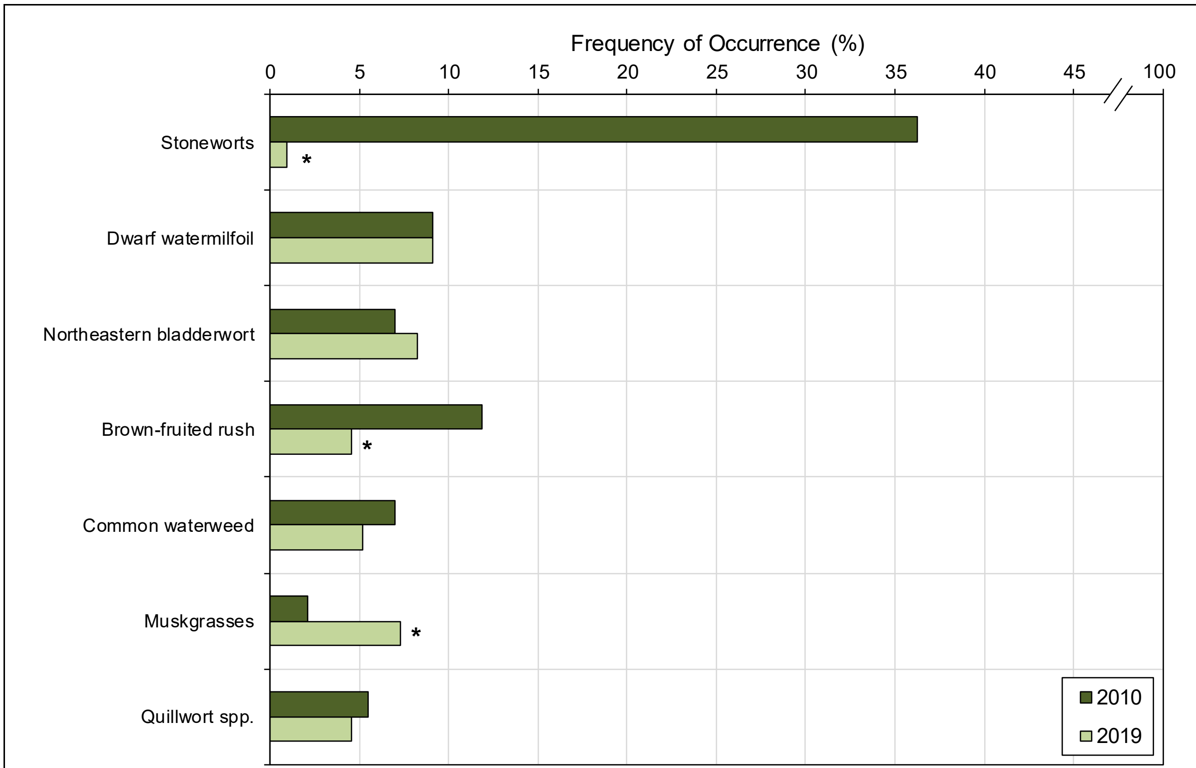


Figure 8.6.4-3. Littoral frequency of occurrence of select aquatic plant species in Moon Lake from 2010 and 2019 point-intercept surveys. Species with a littoral frequency of occurrence of at least 5% in one of the two surveys are displayed. Created using data from Onterra 2010 and 2019 point-intercept surveys.

Lakes with diverse aquatic plant communities are believed to 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. One may assume that because a lake has a high number of aquatic plant species that it also has high species diversity. However, species diversity is influenced by both the number of species and how evenly they a 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 Moon Lake's diversity values rank. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 212 lakes within the NLFL Ecoregion. The Simpson's Diversity Index values were calculated for Moon Lake using the 2010 and 2019 point-intercept survey data. Moon Lake's species diversity has increased from a value of 0.85 in 2010 to 0.91 in 2019 (Figure 8.6.4-4).

In other words, if two plants were randomly sampled from two locations in Moon Lake in 2010, there would have been an 85% probability that the plants would be two different species. In 2019, this probability increased to 91%. The reduction in overall plant occurrence yet increase species diversity in Moon Lake between 2010 and 2019 may seem contradictory. However, since 2010, Moon Lake has seen large reductions in the occurrence of the most dominant and widespread species within the lake, resulting in more evenness in their relative abundance. Moon Lake's species diversity in 2019 falls above the upper quartile value (0.90) for lakes in the NLFL ecoregion.

One way to visualize the diversity of Moon Lake's plant community is to examine the relative frequency of occurrence of aquatic plant species. Relative frequency of occurrence is used to evaluate how often each plant species is encountered in relation to all the other species found. For example, while stoneworts were found at 41% of the littoral sampling locations in 2010 (littoral occurrence), their relative frequency of occurrence was 34% (Figure 8.6.4-5).

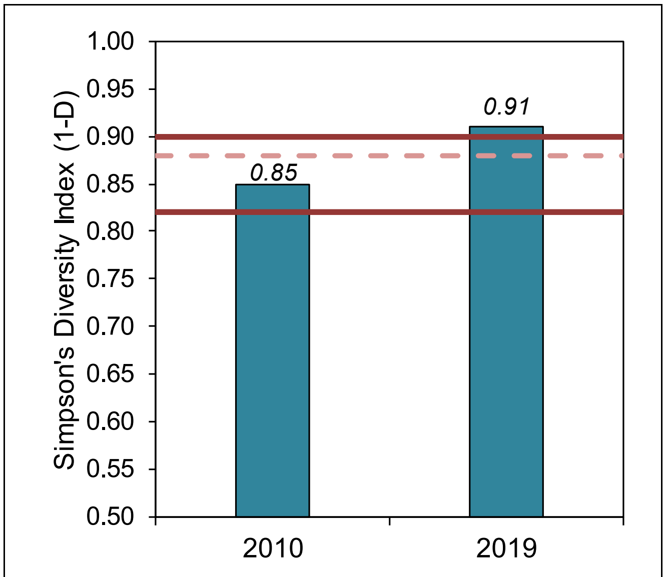


Figure 8.6.4-4. Moon Lake Simpson's Diversity Index. Red solid lines represent NLFL upper and lower quartiles; light red dashed line represents NLFL median. Regional and state values calculated with Onterra & WDNR data.

Explained another way, if 100 plants were randomly sampled from Moon Lake in 2010, 34 of them would have been stoneworts, 9 would be dwarf watermilfoil, etc. In 2010, 60% of Moon Lake's plant community was comprised of just four species: stoneworts, dwarf watermilfoil, northeastern bladderwort, and brown-fruited rush. This dominance of the plant community by a few number of species resulted in lower species diversity. In 2019, seven species comprised 60% of the plant community, indicating a reduction in the occurrence of dominant species and a more even distribution in abundance of all species.

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 (Figure 8.6.4-6). 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).

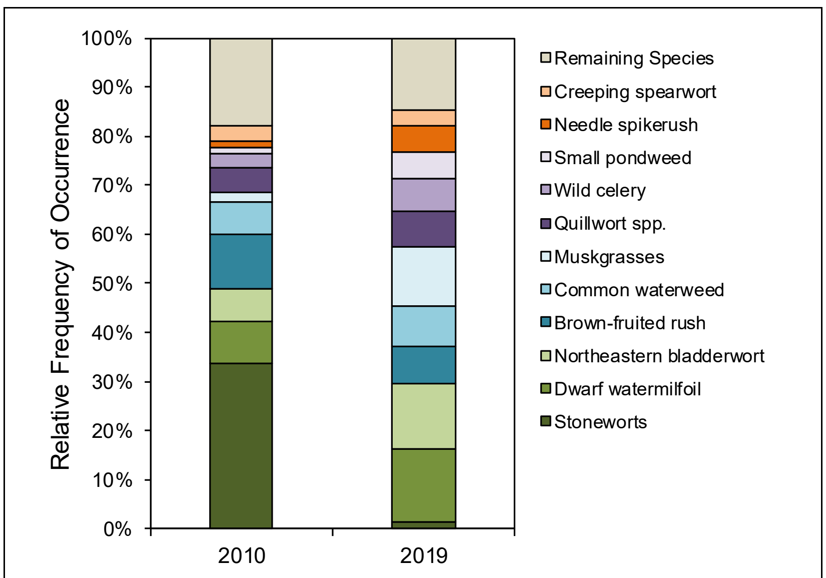


Figure 8.6.4-5. Moon Lake aquatic plant relative frequency of occurrence. Created using data from Onterra 2010 and 2019 point-intercept surveys.

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 (Figure 8.6.4-6). 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 watermilfoil (*Myriophyllum tenellum*) is classified as an isoetid, while all of the other milfoil species in Wisconsin such as northern watermilfoil (*Myriophyllum sibiricum*) are classified as elodeids.

Figure 8.6.4-6. Lake quillwort (*Isoetes lacustris*) of the isoetid growth form (left) and large-leaf pondweed (*Potamogeton amplifolius*) of the elodeid growth form (right). Photo credit: Onterra.

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 like Moon Lake that have little to no alkalinity where they can avoid competition from elodeids.

In the other Town of Saint Germain lakes which have more moderate alkalinity levels, isoetids are generally restricted to shallower, wave-swept areas where elodeids are unable to grow, or scattered amongst less dense elodeid communities where light can penetrate to the bottom. Isoetid communities are vulnerable to sedimentation and eutrophication (Smolders et al. 2002), and a number are listed as special concern or threatened in Wisconsin due to their rarity and susceptibility to environmental degradation.

Using the aquatic plant species recorded on the rake during the point-intercept surveys completed on Moon Lake, the Floristic Quality Index (FQI) was also calculated for each survey (Figure 8.6.4-7). Native plant species richness, or the number of native species recorded on the rake was 25 in 2010 and 22 in 2019. Average species conservatism was 7.7 in 2010 and 7.2 in 2019, while the FQI was 38.5 in 2010 and 33.9 in 2019. Moon Lake's species richness is similar to the median values for lakes in the NLFL ecoregion (21) and the state (19). Moon Lake's average conservatism values are higher than the median values for both the ecoregion (6.7) and the state (6.3), indicating the lake supports a higher number of environmentally-sensitive species. Moon Lake's FQI values also exceed both the median values for ecoregion lakes (30.8) and the state (27.2).

Overall, this analysis shows that Moon Lake's aquatic plant community is of higher quality when compared to the majority of lakes in the ecoregion and the state. The reduction in Moon Lake's FQI value between 2010 and 2019 is likely due to the overall reduction in aquatic plant abundance due to higher water levels, and it is not an indication of degrading conditions.

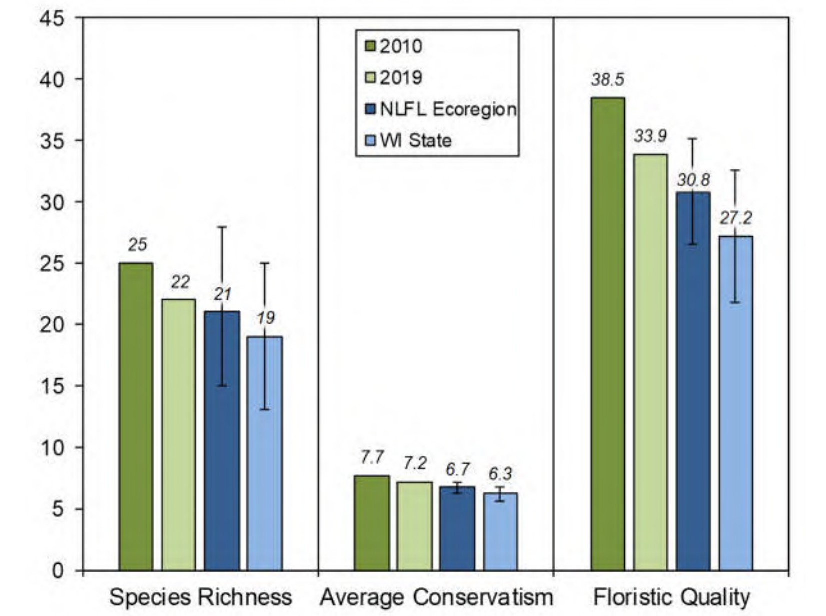


Figure 8.6.4-7. Moon Lake Floristic Quality Assessment. Error bars represent interquartile range. Created using data from Onterra 2010 and 2019 point-intercept surveys. Regional and state medians calculated with Onterra and WDNR data. Analysis follows Nichols 1999.

One native aquatic plant species, northeastern bladderwort (*Utricularia resupinata;* Figure 8.6.4-8), that is listed as special concern in Wisconsin was re-located in Moon Lake in 2019. Species are listed as special concern by the WDNR's Natural Heritage Conservation Program when a problem with abundance or distribution is suspected but not yet proven, and this designation is to focus attention on these species before they become threatened or endangered.

Northeastern bladderwort is one of nine bladderwort species found in Wisconsin, and one of two species found in Moon Lake. Bladderworts are *insectivorous*, meaning they supplement their nutrient demand by trapping and digesting small insects and crustaceans. These plants possess small sac-like bladders containing small hairs, which when touched by unsuspecting prey trigger a door on the trap to open rapidly drawing in water and the insect. Trapped within the bladder, the insect is slowly digested. Northeastern bladderwort is often difficult to locate, as the plant is relatively small and the majority of the plant is buried within the substrate. It produces small pink flowers above the surface of water, typically in years when water levels are lower. In Moon Lake, northeastern bladderwort was found growing in shallow, near-shore areas. Its littoral frequency of occurrence in 2019 of 13.4% is significantly higher than its occurrence of 6.5% in 2010.

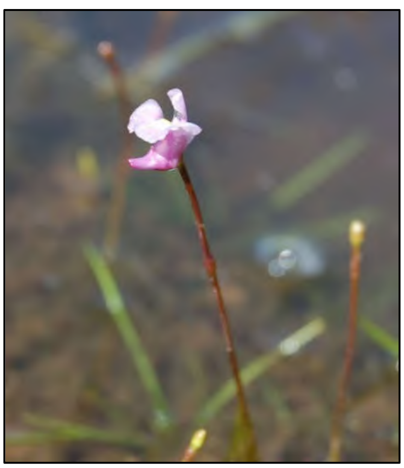


Figure 8.6.4-8. Flower of northeastern bladderwort (*Utricularia resupinata*), a rare native aquatic plant listed as special concern found in Moon Lake. Photo credit: Onterra.

In 2019, Onterra ecologists also re-mapped emergent and floating-leaf aquatic plant communities in Moon Lake (Alma and Moon Lakes – Map 5). Figure 8.6.4-9 illustrates that the size of these communities has fluctuated since they were first mapped by NES Ecological Services in 2004. These communities have fluctuated between 1.5 acres in 2004, 7.7 acres in 2010, and 4.7 acres in 2019. These communities often respond to changes in water levels, often expanding in size during periods of lower water levels and contracting again when water levels increase. In Moon Lake, these communities are primarily comprised of watershield (*Brasenia schreberi*) and white water lily (*Nymphaea odorata*). The full list of species found in these communities can be found in Table 8.6.4-1.

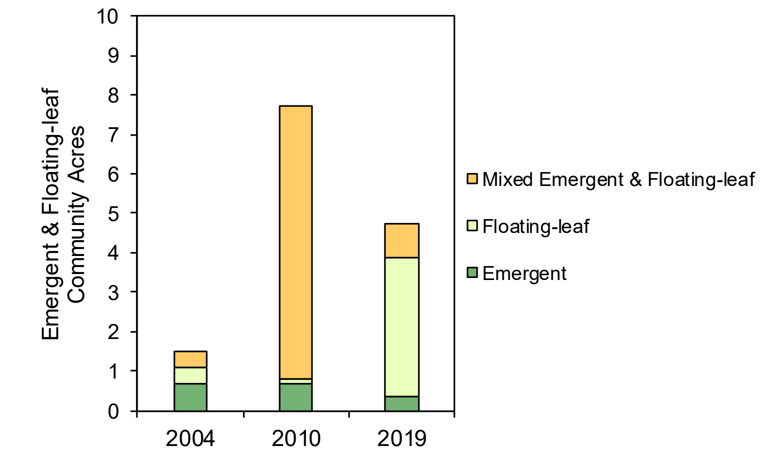


Figure 8.6.4-9. Moon Lake emergent and floating-leaf community acres from 2004, 2010, and 2019. Change in acreage likely due to fluctuations in water levels over this period.

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.

While Moon Lake has seen a reduction in the occurrence of aquatic vegetation in 2019 when compared to 2010, the lake still maintains a high-quality native aquatic plant community comprised of a number of environmentally-sensitive species. Changes in water levels, specifically a 3-foot water level increase, is likely the primary driver of the changes observed in Moon Lake's plant community. Riparian property owners should be educated on the importance of Moon Lake's aquatic plant community and the role it plays in the lake's overall ecology, and conservation of this soft water plant community should be a priority.

Non-Native Aquatic Plants in Moon Lake

Green Arrow-arum (Peltandra virginica)

Green arrow-arum is a perennial wetland plant native to wetlands in eastern and central North America (Figure 8.6.4-10). Its distribution in Wisconsin is sparse, and there is ongoing debate as to whether populations in Wisconsin were introduced or represent disjunct populations at the western edge of its native range. Green arrow-arum can form large clumps and colonies, but it does not appear to be behaving aggressively in the wetlands where it has been found in Wisconsin. It is similar in appearance to native arrowhead (*Sagittaria*) species, so it is possible this plant is more widespread than suggested and may be overlooked.

A population of green arrow-arum can be found growing within the emergent marsh community in Engle Bog which is connected to Moon Lake (Moon Lake – Map 5). In 2019, the population was comprised of clumps and colonies within the emergent marsh that encircles the open water. While this plant was observed in 2006, its population was not mapped at the time. Future surveys will help determine how the population in Engle Bog is behaving.

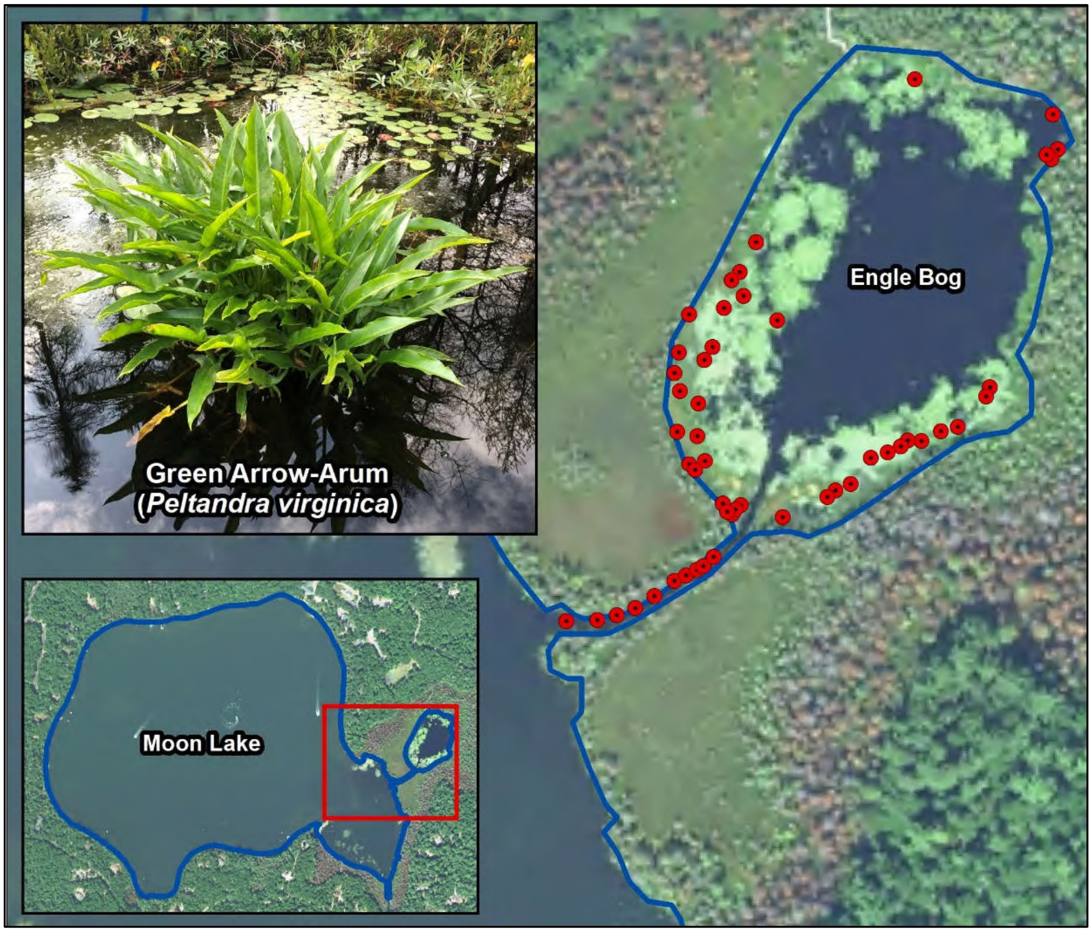
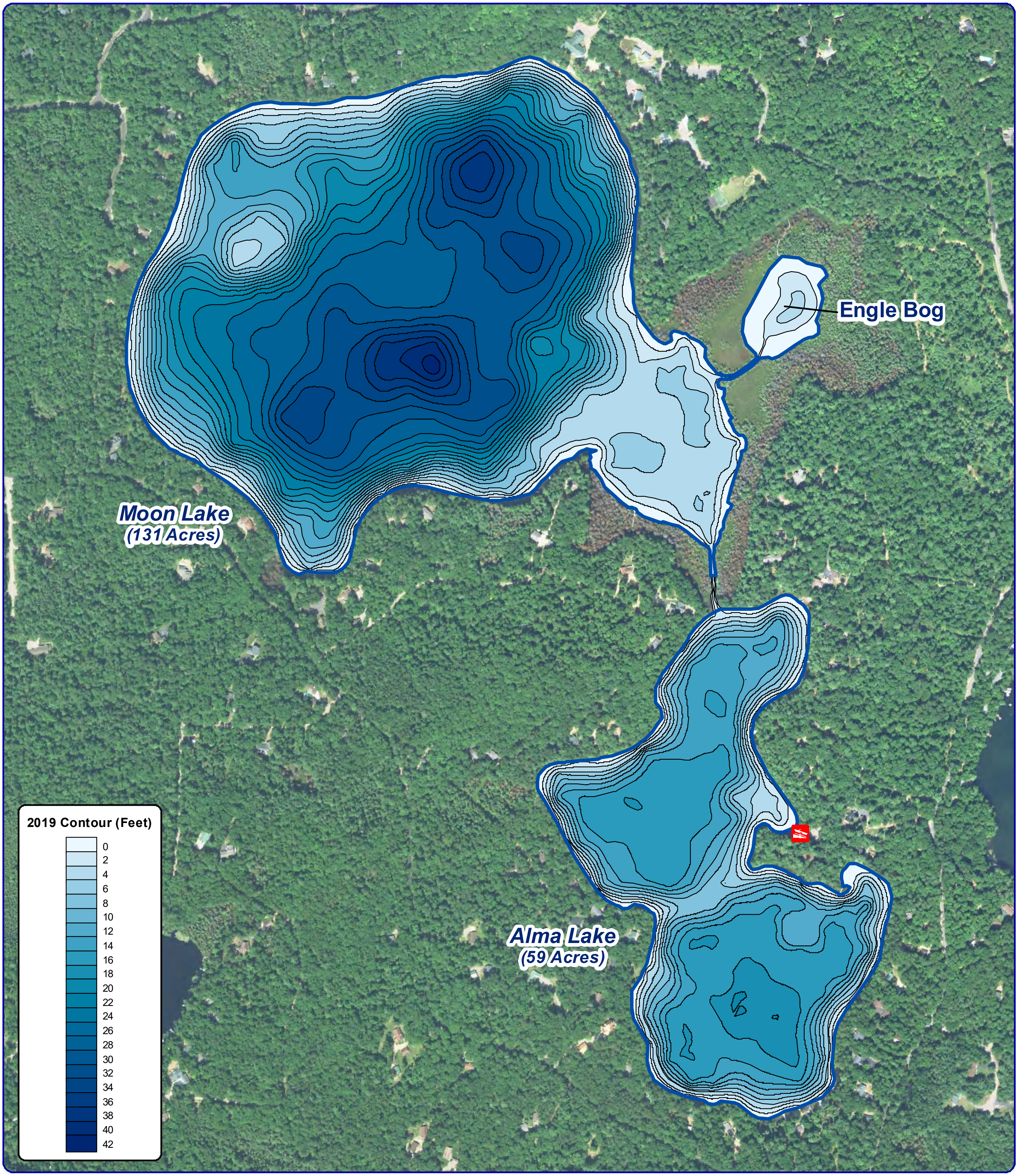


Figure 8.6.4-10. Engle Bog (Moon Lake) August 2019 locations of green arrow-arum. Locations indicated by green circles.



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www.onterra-eco.com

Sources:
Hydro: WDNR
Bathymetry: WDNR, digitized by Onterra
Orthophotography: 2018 NAIP
Map Date: March 3, 2020 BTB
File Name Map1_Alma-Moon_Location.mxd

Project Location in Wisconsin

Legend

Alma & Moon Lakes Project Boundary

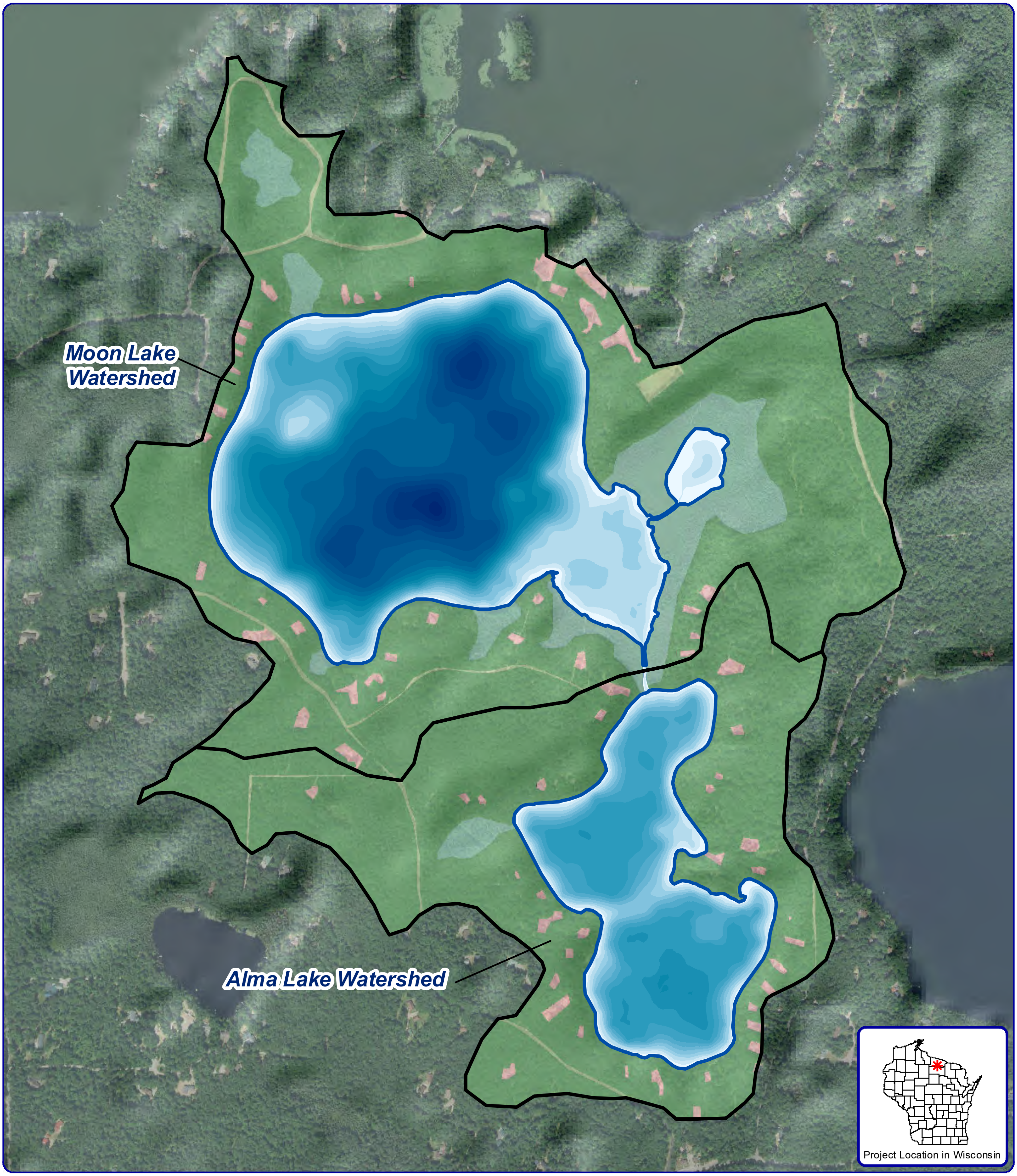
Public Boat Launch

Alma & Moon Lakes - Map 1

Town of Saint Germain

Vilas County, Wisconsin

Project Location & Lake Boundaries



N W E S

890

Feet

Legend

- Watershed Boundary
- Alma & Moon Lakes
- Forest
- Forested Wetlands
- Pasture/Grass (None)
- Rural Open Space
- Rural Residential
- Non-Forested Wetlands (None)
- Open Water

Alma & Moon Lakes - Map 2

Town of Saint Germain

Vilas County, Wisconsin

Watershed Boundaries & Land Cover Types

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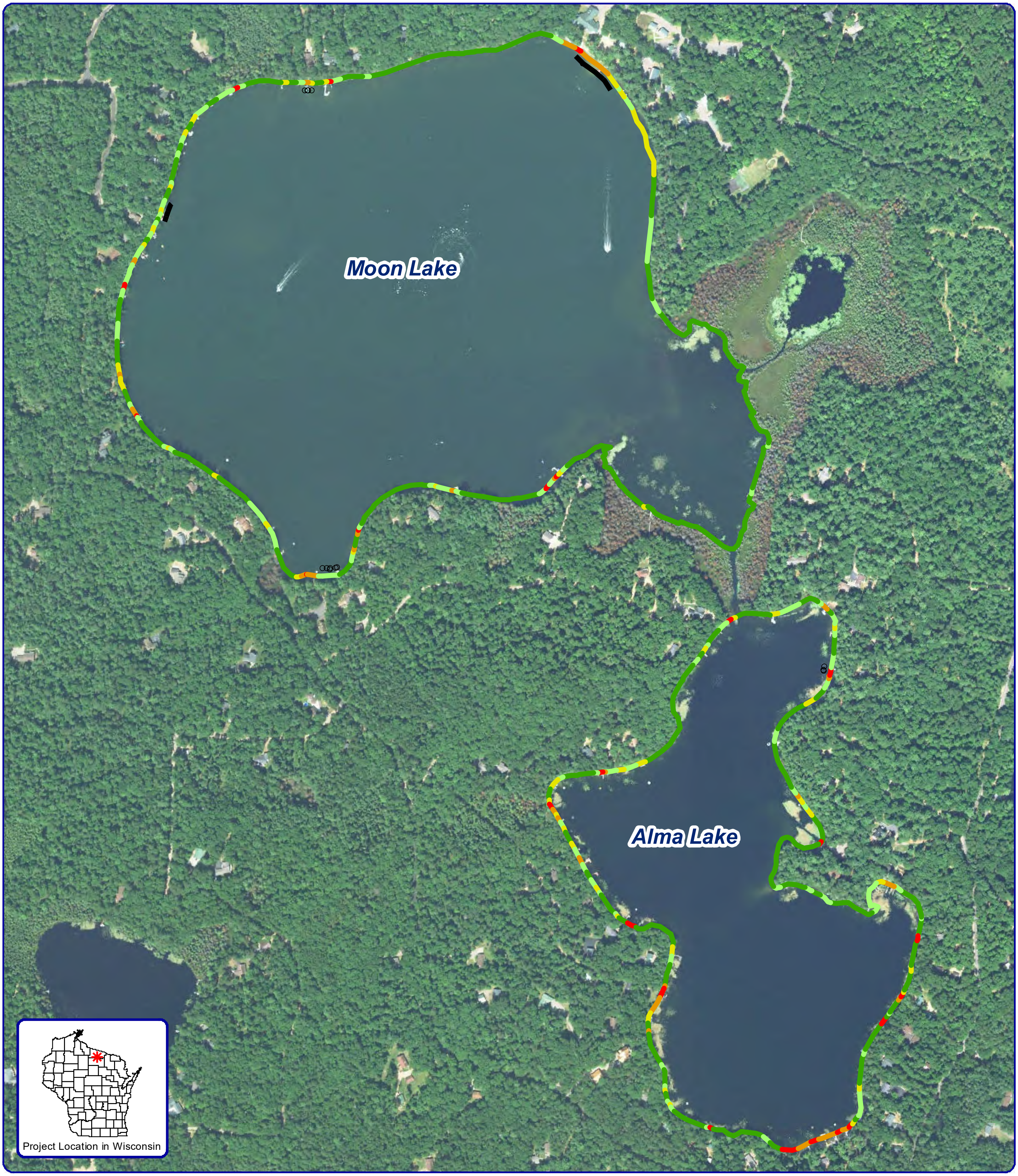
Sources:
Hydro: WDNR
Watershed: Onterra 2019
Orthophotography: 2018 NAIP
Map Date: March 3, 2020 BTB
File Name Map2_Alma-Moon_WS.mxd



N
W E
S

625
Feet

Legend

- Natural/Undeveloped
- Developed-Natural
- Developed-Semi-Natural
- Developed-Unnatural
- Urbanized

Seawall

- Masonry/Wood/Metal
- Rip-Rap

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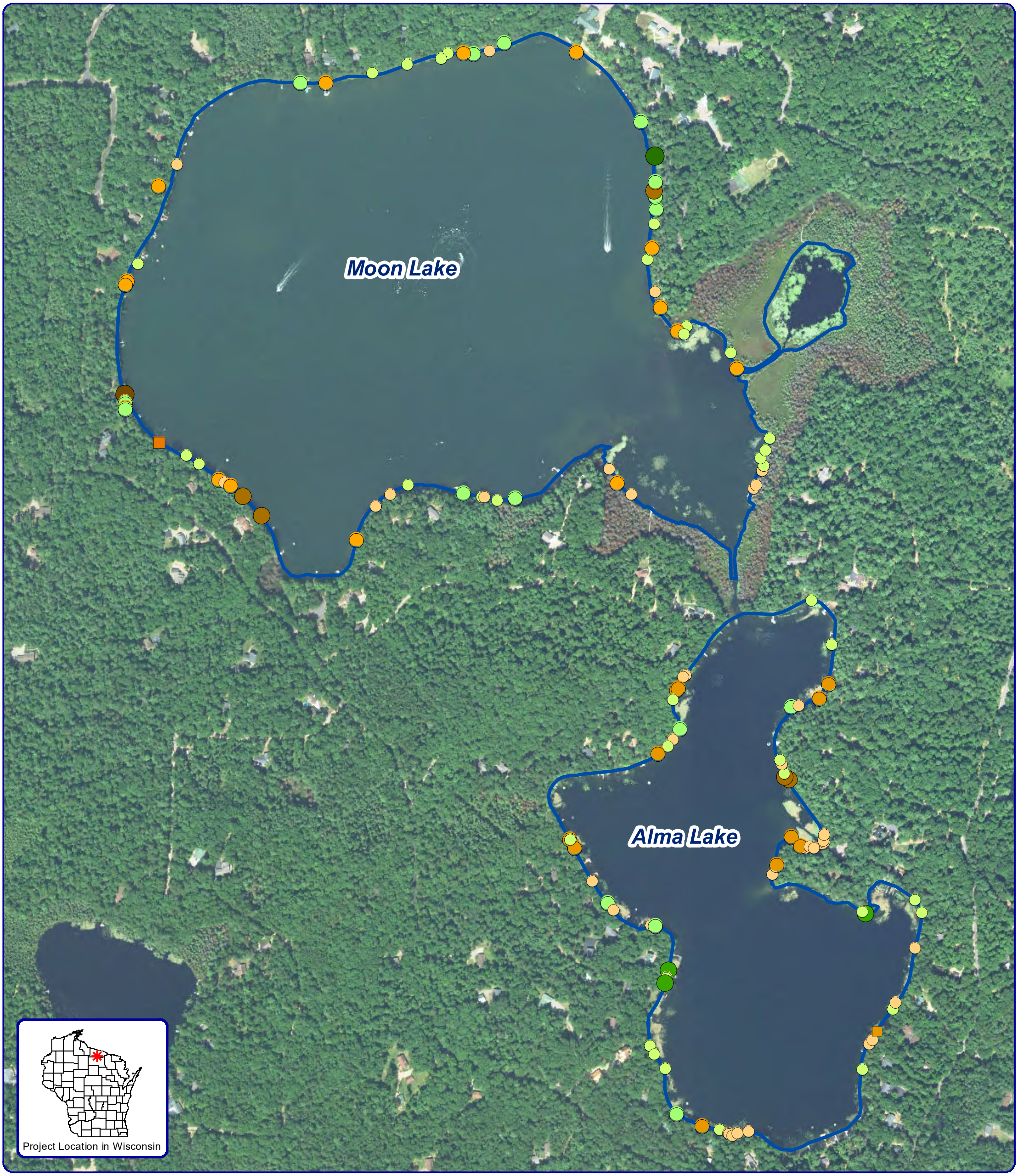
Sources:
Hydro: WDNR
Shoreland: Onterra 2019
Orthophotography: 2018 NAIP
Map Date: March 3, 2020 BTB
File Name Map3_Alma-Moon_SCA.mxd

Alma & Moon Lakes - Map 3
Town of Saint Germain
Vilas County, Wisconsin

2019 Shoreland Condition Assessment



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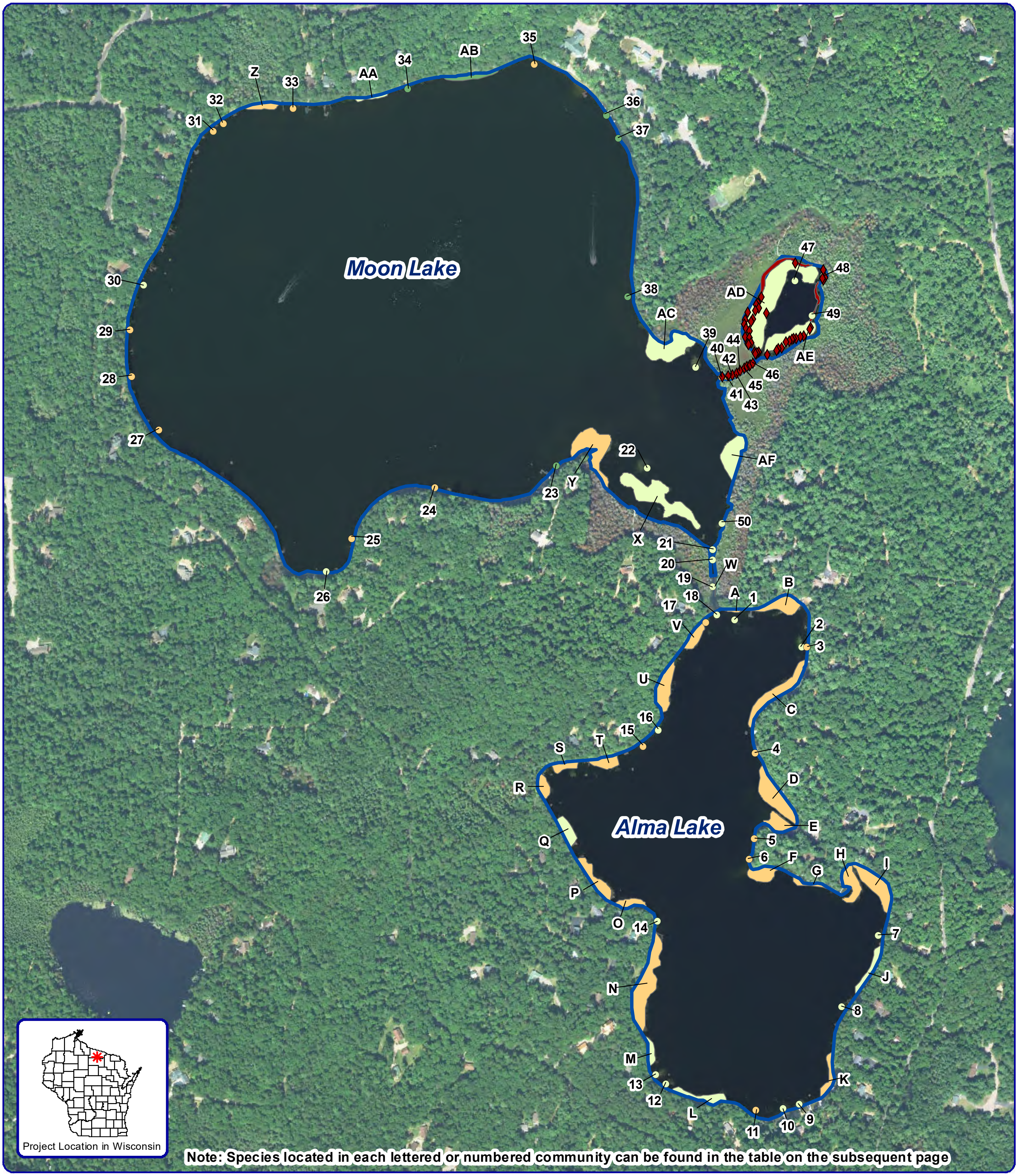
Sources:
Hydro: WDNR
CWH: Onterra 2019
Orthophotography: 2018 NAIP
Map Date: March 3, 2020 BTB
File Name Map4_Alma-Moon_CWH.mxd

Alma & Moon Lakes - Map 4

Town of Saint Germain

Vilas County, Wisconsin

2019 Coarse Woody Habitat Assessment



660
Feet

Large Plant Community
- Native - Emergent
- Native - Floating-leaf
- Native - Mixed Floating-leaf & Emergent
- Non-Native - Green-arrow arum

Small Plant Community
- Native - Emergent
- Native - Floating-leaf
- Native - Mixed Floating-leaf & Emergent
- Non-Native - Green-arrow arum

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Sources:
Hydro: WDNR
Plants: Onterra 2019
Orthophotography: 2018 NAIP
Map Date: March 3, 2020 BTB
File Name Map5_Alma-Moon_CM.mxd

Alma & Moon Lakes - Map 5
Town of Saint Germain
Vilas County, Wisconsin
2019 Emergent & Floating-leaf Aquatic Plant Communities

Alma Lake 2019 Emergent & Floating-Leaf Plant Species

Corresponding Community Polygons and Points are displayed on Alma & Moon Lakes- Map 5

Large Plant Community (Polygons)

Floating-leaf	Species 1	Species 2	Species 3	Species 4	Species 5	Species 6	Species 7	Species 8	Acres
A	Watershield	White water lily							0.20
Floating-leaf & Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**	**Acres**
B	Watershield	White water lily	Three-way sedge						0.21
C	Watershield	Three-way sedge	White water lily						0.17
D	Watershield	Spatterdock	Water arum	White water lily					0.36
E	Watershield	White water lily	Three-way sedge						0.13
F	Watershield	Water arum							0.14
G	Watershield	White water lily	Water arum						0.29
H	Watershield	White water lily	Three-way sedge	Wool-grass					0.79
I	Watershield	White water lily	Wool-grass						0.16
J	Watershield	Common rush	Creeping spikerush	Three-way sedge					0.03
K	Watershield	White water lily	Water smartweed	Sedge sp. (sterile)	Stalked Woolgrass	Common rush	Creeping spikerush	Wool-grass	0.32
L	Watershield	White water lily	Sedge sp. (sterile)	Creeping spikerush					0.46
M	Watershield	Sedge sp. (sterile)	White water lily	Water arum	Three-way sedge				0.56
N	Watershield	White water lily	Three-way sedge	Sedge sp. (sterile)					0.21
O	Watershield	Sedge sp. (sterile)	Woolgrass						0.22
P	Watershield	Sedge sp. (sterile)	Common rush	Woolgrass	Three-way sedge	White water lily			0.08
Q	Watershield	Sedge sp. (sterile)	White water lily						0.44
R	Watershield	Sedge sp. (sterile)	Black-girdled wool-grass	Woolgrass	Common rush	Three-way sedge			0.28

Small Plant Community (Points)

Floating-leaf	Species 1	Species 2	Species 3	Species 4	Species 5	Species 6	Species 7	Species 8
1	Watershield							
2	White water lily							
3	Watershield	White water lily						
4	Watershield	Narrow-leaf bur-reed						
Floating-leaf & Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**
5	Watershield	Creeping spikerush	Three-way sedge					
6	Watershield	Creeping spikerush	Sedge sp. (sterile)					
7	Watershield	Sedge sp. (sterile)						
8	Watershield	Three-way sedge						
9	Watershield	Creeping spikerush	White water lily					
10	Watershield	White water lily	Three-way sedge	Creeping spikerush				
11	Watershield	White water lily	Narrow-leaf bur-reed	Creeping spikerush				

Species are listed in order of dominance within the community; Scientifc names can be found in the species list in Alma Lake Aquatic Vegetation Section 8.1.4

Moon Lake 2019 Emergent & Floating-Leaf Plant Species

Corresponding Community Polygons and Points are displayed on Alma & Moon Lakes - Map 5

Large Plant Community (Polygons)									
Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**	**Acres**
A	Creeping spikerush	Hardstem bulrush							0.15
B	Arrow Arum								0.20
Floating-leaf	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**	**Acres**
C	Watershield	Bur-reed sp. (sterile)	Spatterdock	White water lily					0.43
D	Watershield	White water lily	Bur-reed sp. (sterile)	Spatterdock					0.61
E	Watershield	White water lily							0.80
F	Spatterdock	Watershield							1.23
G	Spatterdock	Watershield	White water lily						0.46
Floating-leaf & Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**	**Acres**
H	Creeping spikerush	Narrow-leaf bur-reed	Soft rush						0.12
I	Creeping spikerush	Watershield	White water lily	Spatterdock	Water arum	Arrowhead sp. (sterile)	Three-way sedge		0.65
J	Creeping spikerush	Narrow-leaf bur-reed							0.06

Small Plant Community (Points)								
Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**
1	Creeping spikerush	Iris sp.	Hardstem bulrush					
2	Creeping spikerush							
3	Arrow Arum							
Floating-leaf	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**
4	White water lily	Spatterdock	Watershield					
5	Watershield							
6	Narrow-leaf bur-reed	Watershield						
7	White water lily	Watershield						
8	Spatterdock							
9	Spatterdock	White water lily						
10	Spatterdock	Watershield						
Floating-leaf & Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Species 8**
11	Creeping spikerush	White water lily	Narrow-leaf bur-reed					
12	Creeping spikerush	Narrow-leaf bur-reed						
13	Creeping spikerush	Wool-grass	Arrowhead sp. (sterile)					
14	Creeping spikerush	White water lily						
15	Narrow-leaf bur-reed	Watershield	Creeping spikerush					
16	White water lily	Narrow-leaf bur-reed	Creeping spikerush					
17	Creeping spikerush	Narrow-leaf bur-reed						
18	Narrow-leaf bur-reed	Creeping spikerush	White water lily					
19	Spatterdock	Arrow Arum	Water arum					
20	Arrow Arum	Watershield						
21	Watershield	Arrow Arum	Spatterdock	White water lily				
22	Arrow Arum	Spatterdock						
23	Arrow Arum	White water lily	Spatterdock					
24	Arrow Arum	Spatterdock						
25	Arrow Arum	Spatterdock	Water arum	Watershield				

Species are listed in order of dominance within the community; Scientifc names can be found in the species list in the Moon Lake Aquatic Vegetation Section 8.6.4