8.6 CRYSTAL LAKE

8.6.1 An Introduction to Crystal Lake

Crystal Lake, Oneida County, is a drainage lake with a maximum depth of nine feet and a surface area of 124 acres. This eutrophic lake has a relatively large watershed when compared to the size of the lake. Crystal Lake contains 26 native plant species, of which floating-leaf bur-reed was the most common plant. No exotic plants were observed during the 2011 lake surveys.

Field Survey Notes

A shallow, dark lake consisting primarily of mucky substrate. Few sampling locations held aquatic plants. No exotic aquatic plant species observed during 2011 field work.

Photo 8.6.1-1 Crystal Lake, Oneida County

Lake at a Glance – Crystal Lake

Morphology	
Acreage	124
Maximum Depth (ft)	9
Mean Depth (ft)	5
Volume (acre-feet)	648
Shoreline Complexity	3.0
Vegetation	
Curly-leaf Survey Date	June 22, 2011
Comprehensive Survey Date	August 4 & 5, 2011
Number of Native Species	26
Threatened/Special Concern Species	-
Exotic Plant Species	-
Simpson's Diversity	0.80
Average Conservatism	6.4
Water Quality	
Wisconsin Lake Classification	Shallow, lowland drainage
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Watershed to Lake Area Ratio	63:1

8.6.2 Crystal Lake Watershed Assessment

Crystal Lake's watershed is 7,964 acres in size. Compared to Crystal Lake's size of 124 acres, this makes for an incredibly large watershed to lake area ratio of 63:1.

Exact land cover calculation and modeling of nutrient input to Crystal Lake will be completed towards the end of this project (in 2015-2016). By this time, the latest satellite imagery (and thus the most accurate land cover delineation) will be available. Additionally, when water quality sampling of the upper reaches of the chain is completed, these results will be input to predictive models and thus make the modeling of nutrient input to the entire chain more accurate.

As mentioned previously in the Chain-wide Watershed 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 late summer of 2011, Crystal Lake's immediate shoreline was assessed in terms of its development. Crystal Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 1.8 miles of natural/undeveloped and developed-natural shoreline (66% of the entire shoreline) were observed during the survey (Figure 8.6.2-1). 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, 0.3 miles of urbanized and developed–unnatural shoreline (12% of the total shoreline) was observed. If restoration of the Crystal 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. The Crystal Lake Map 1 displays the location of these shoreline lengths around the entire lake.

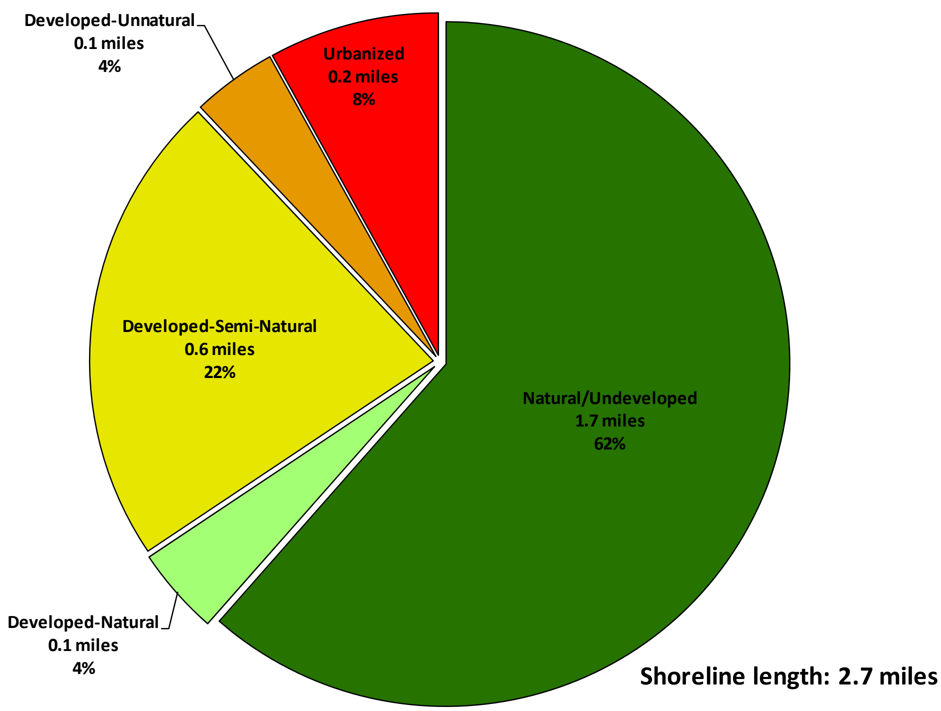

Figure 8.6.2-1. Crystal Lake shoreland categories and total lengths. Based upon a late summer 2011 survey. Locations of these categorized shorelands can be found on the Crystal Lake Map 1.

8.6.3 Crystal Lake Water Quality

During 2011/2012, water quality data was collected from Crystal Lake on six occasions. Onterra staff sampled the lake for a variety of water quality parameters including total phosphorus, chlorophyll-*a*, Secchi disk clarity, temperature, and dissolved oxygen. Additionally, historical databases were searched for any prior data that may have been collected on Crystal Lake. Only a single historical record was turned up for each of the three water quality parameters – in 1979. No additional data was discovered, leaving only the 2011/2012 data available for analysis.

Crystal Lake total phosphorus and chlorophyll-*a* values can be found in Table 8.6.3-1. In 2011, summer total phosphorus concentrations averaged 72.0 µg/L, which is considerably higher than the median value for other shallow, lowland drainage lakes in the state of Wisconsin (33.0 µg/L). The 2011 average summer chlorophyll-*a* concentration (5.9 µg/L) is somewhat lower than the average for other shallow, lowland drainage lakes statewide (median = 9.4 µg/L). The total phosphorus average ranks as *Fair* within the WiSCALM narrative, while the chlorophyll-*a* average value ranks as *Excellent*.

Measurements of Secchi disk clarity were taken in Crystal Lake during 2011 field visits as well. The summer average was 1.5 feet, ranking as *Poor* within the Trophic State Index and falling below the median for other Wisconsin shallow, lowland drainage lakes (5.6 feet). It is interesting to note that while total phosphorus values are exceptionally high, an elevated abundance of algae was not picked up through chlorophyll-*a* sampling. It is possible that the water clarity of the lake is limiting the algal and plant growth, more so than the abundance of nutrients, which are sufficient for algae and plant growth. During the aquatic plant surveys that took place on Crystal Lake in 2011, plants were found growing to a maximum depth of seven feet; however, the vast majority of plants grew to only 4 feet of depth. This is an added testament to the *Poor* water clarity in Crystal Lake.

Secchi disk clarity is often tied to algal abundance – the more algae in the water column, the less clear the water will be. However Secchi disk clarity is influenced by many other factors which themselves vary due to several environmental conditions such as precipitation, sunlight, and nutrient availability. In Crystal Lake and the rest of the Three Lakes Chain of lakes, a natural staining of the water plays a role in light penetration, and thus water clarity, as well. The darker waters of Crystal Lake contain many organic acids that are washed into the lake from nearby wetlands. The acids are not harmful to humans or aquatic species; they are by-products of decomposing wetland plant species. This natural staining reduces light penetration into the water column, which reduces visibility but also reduces the growing depth of aquatic vegetation within the lake.

Table 8.6.3-1. Crystal Lake, state-wide shallow, lowland drainage lakes, and regional values for water quality parameters. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

	Secchi (feet)				Chlorophyll-a (µg/L)				Total Phosphorus (µg/L)			
	Growing Season		Summer		Growing Season		Summer		Growing Season		Summer	
Year	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean	Count	Mean
1979	1	1.5	1	1.5	1	5.2	1	5.2	1	13.0	1.0	13.0
2011	5	1.6	3	1.5	5	7.8	3	5.9	5	70.8	3.0	72.0
All Years (Weighted)		1.6		1.5		7.3		5.7		61.2		57.3
Shallow, Lowland Drainage Lakes				5.6				9.4				33.0
NLF Ecoregion				8.9				5.6				21.0

Crystal Lake Trophic State

The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values fall into categories of mesotrophic (chlorophyll-*a*) and eutrophic (phosphorus and Secchi disk clarity). Values above 50 are generally classified as being within the eutrophic category; two of Crystal Lake's water quality parameters fall above this benchmark (Table 8.6.3-2). Therefore, it can be concluded that Crystal Lake is in a eutrophic state.

Table 8.6.3-2. Crystal Lake, state-wide shallow, lowland drainage lakes, and regional Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Year	TP	Chl-a	Secchi
1979	41.1	46.8	71.3
2011	65.8	48.0	71.3
All Years (Weighted)	62.5	47.7	71.3
Shallow, Lowland Drainage Lakes	54.6	52.6	52.4
NLF Ecoregion	48.1	47.5	45.7

Dissolved Oxygen and Temperature in Crystal Lake

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Crystal Lake by Onterra staff. Graphs of those data are displayed in Figure 8.6.3-1 for all sampling events.

Crystal Lake remained thoroughly mixed throughout the spring, summer and fall months in 2011. This is not uncommon in lakes that are moderate in size and fairly shallow. Energy from the wind is sufficient to mix the lake from top to bottom, distributing oxygen throughout the epilimnion and hypolimnion and keeping water temperatures fairly constant within the water column.

Dissolved oxygen concentrations remained sufficient throughout the open water months for warm water fish species. In the winter months, when ice cover and limited oxygen production from plants reduces oxygen content of the water, there is often concern that the levels of oxygen may dip below what is necessary for fish in the lake. Although oxygen concentrations decreased near the bottom of Crystal Lake, levels remained high enough in the upper half of the water column.

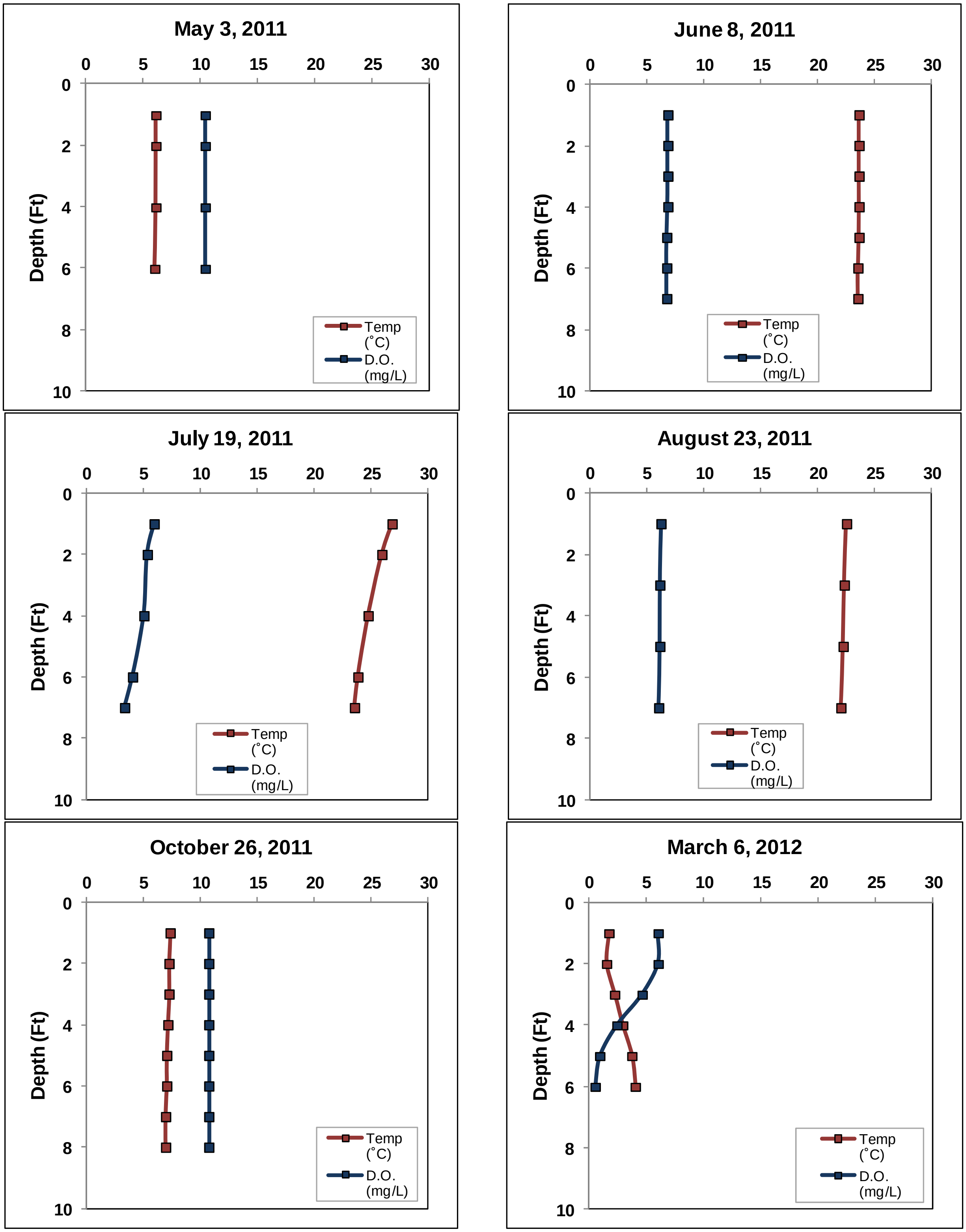

Figure 8.6.3-1. Crystal Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Crystal 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 Crystal 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 Chainwide Water Quality 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. Crystal Lake's pH was measured at 6.8 in the summer months of 2011. This value is near neutral and falls within the normal range for Wisconsin lakes.

A lake's pH is primarily determined by the amount of alkalinity that is held within the water. Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. Lakes with low alkalinity have higher amounts of the bicarbonate compound (HCO_3^-) while lakes with a higher alkalinity have more of the carbonate compound of alkalinity ($CO_3^{=}$). The bicarbonate form is better at buffering acidity, so lakes with higher alkalinity are less resistant to acid rain than those with lower alkalinity. The alkalinity in Crystal Lake was measured at 15.9 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain.

Samples of calcium were also collected from Crystal Lake during the summer of 2011. Calcium is commonly examined because invasive and native mussels use the element to build shells and in reproduction. Invasive mussels typically require higher calcium concentrations than native mussels. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Crystal Lake's pH of 6.8 falls slightly outside of 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 Crystal Lake was found to be 4.2 mg/L, falling well below the optimal range for zebra mussels. Plankton tows were completed by Onterra staff during the summer of 2011 and these samples were processed by the WDNR for larval zebra mussels. No veligers (larval zebra mussels) were found within these samples.

8.6.4 Crystal Lake Aquatic Vegetation

The curly-leaf pondweed survey was conducted on Crystal Lake on June 22, 2011. This meander-based survey did not locate any occurrences of this exotic plant, and it is believed that this species either does not currently exist in Crystal Lake or is present at an undetectable level.

The aquatic plant point-intercept survey was conducted on Crystal Lake on August 4 & 5, 2011 by Onterra. The floating-leaf and emergent plant community mapping survey was completed on August 8th to create the aquatic plant community map (Crystal Lake Map 2). During all surveys, 26 species of native aquatic plants were located in Crystal Lake (Table 8.6.4-1). 12 of these species were sampled directly during the point-intercept survey and are used in the analysis that follows. Aquatic plants were found growing to a depth of seven feet, which is comparable to the other lakes within the Three Lakes Chain of lakes. As discussed later on within this section, many of the plants found in this survey indicate that the overall community is healthy and moderately diverse.

Of the 174 point-intercept locations sampled within the littoral zone, approximately 24% contained aquatic vegetation. Approximately 9% of the point-intercept sampling locations where sediment data was collected at were sand, 91% consisted of a fine, organic substrate (muck) while no rocky substrate was encountered (Chain-wide Fisheries Section, Figure 3.4-5).

Table 8.6.4-1. Aquatic plant species located in the Crystal Lake during the 2011 aquatic plant surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2011 (Onterra)
Emergent	*Calla palustris*	Water arum	9	*I*
	Dulichium arundinaceum	Three-way sedge	9	*I*
	Decodon verticillatus	Water-willow	7	*I*
	Eleocharis palustris	Creeping spikerush	6	*I*
	Iris versicolor	Northern blue flag	5	*I*
	Pontederia cordata	Pickerelweed	9	*X*
	Sagittaria latifolia	Common arrowhead	3	*I*
	Schoenoplectus tabernaemontani	Softstem bulrush	4	*I*
	Scirpus cyperinus	Wool grass	4	*I*
	Typha spp.	Cattail spp.	1	*I*
	Zizania palustris	Northern wild rice	8	*I*
FL	*Brasenia schreberi*	Watershield	7	*I*
	Nuphar variegata	Spatterdock	6	*X*
	Nymphaea odorata	White water lily	6	*X*
FL/E	*Sparganium eurycarpum*	Common bur-reed	5	*I*
	Sparganium emersum	Short-stemmed bur-reed	8	*I*
	Sparganium fluctuans	Floating-leaf bur-reed	10	*X*
Submergent	*Ceratophyllum demersum*	Coontail	3	*X*
	Myriophyllum sibiricum	Northern water milfoil	7	*X*
	Potamogeton robbinsii	Fern pondweed	8	*X*
	Potamogeton zosteriformis	Flat-stem pondweed	6	*X*
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	*X*
	Potamogeton richardsonii	Clasping-leaf pondweed	5	*X*
	Utricularia vulgaris	Common bladderwort	7	*X*
FF	*Lemna turionifera*	Turion duckweed	2	*X*
	Spirodela polyrhiza	Greater duckweed	5	*I*

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

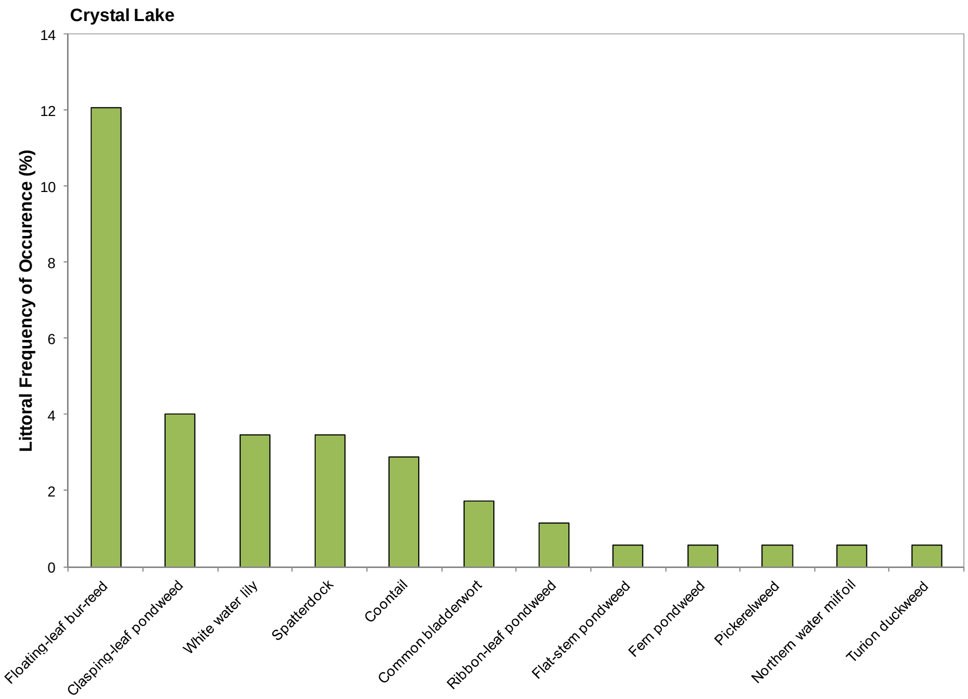

Figure 8.6.4-1 Crystal Lake aquatic plant littoral frequency of occurrence analysis. Chart includes all species encountered during the 2011 point-intercept survey.

Figure 8.6.4-1 (above) shows that floating-leaf bur-reed, clasping-leaf pondweed were the two species encountered most within the point-intercept survey. White water lily and spatterdock were encountered often as well. 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. Clasping-leaf pondweed has oval to somewhat lance-shaped leaves that "clasp" around one-half to three-quarters of the stem circumference. Leaves have 13-21 veins, which is a good characteristic to use in distinguishing this plant from other similar looking plants in the genus *Potamogeton*. White water lily and spatterdock are floating-leaf plants that are commonly found near the shoreline on Wisconsin lakes. White water lilies, as the name implies, are round in shape and produce a white flower. Spatterdock leaves resemble a heart shape and produce yellow roundish flowers in the summer months.

Of the seven milfoil species (genus *Myriophyllum*) found in Wisconsin, only one (northern water milfoil) was found within Crystal Lake. Northern water milfoil, arguably the most common milfoil species in Wisconsin lakes, is frequently found growing in soft sediments and higher water clarity. Northern water milfoil is often falsely identified as Eurasian water milfoil, especially since it is known to take on the reddish appearance of Eurasian water milfoil as the plant reacts to sun exposure as the growing season progresses. The feathery foliage of northern water milfoil traps filamentous algae and detritus, providing valuable invertebrate habitat. Because northern water milfoil prefers high water clarity, its populations are declining state-wide as lakes are becoming more eutrophic.

26 species of aquatic plants (including incidentals) were found in Crystal Lake and because of this, one may assume that the system would also have a high diversity. As discussed earlier, how evenly the species are distributed throughout the system also influence the diversity. The diversity index for Crystal Lake's plant community (0.80) lies below the Northern Lakes and Forests Lakes ecoregion median value (0.86).

As explained earlier in the Primer on Data Analysis and Data Interpretation Section, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. 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 floating-leaf bur-reed was found at 12% of the sampling locations, its relative frequency of occurrence is 38%. Explained another way, if 100 plants were randomly sampled from Crystal Lake, 38 of them would be floating-leaf bur-reed. Floating-leaf bur-reed is therefore relatively dominant compared to other species within the lake. This distribution can be observed in Figure 8.6.4-2, where together seven species account for 91% of the population of plants within Crystal Lake, while the other five species account for the remaining 9%. Fourteen additional species were located from the lake but not from of the point-intercept survey, and are indicated in Table 8.6.4-1 as incidentals.

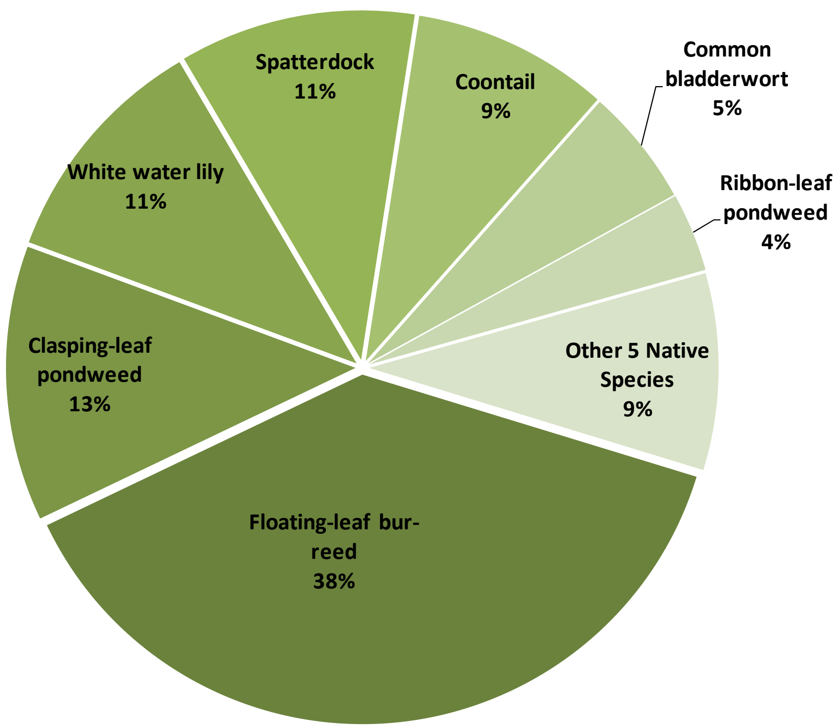

Figure 8.6.4-2 Crystal Lake aquatic plant relative frequency of occurrence analysis. Created using data from 2011 point-intercept survey.

Crystal Lake's average conservatism value (6.4) is lower than the ecoregion median, but higher than the state median. This indicates that the plant community of Crystal Lake is indicative of moderately disturbed system. This is not surprising considering Crystal Lake's plant community has moderate diversity and low species richness. Combining Crystal Lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a value of 22.2 which is below the median value of the ecoregion and equal to the state median value.

Crystal Lake holds numerous areas of emergent and floating-leaf plant communities. The 2011 community map indicates that approximately 19.3 acres of the lake contains these types of plant communities (Crystal Lake Map 2, Table 8.6.4-2). Fifteen floating-leaf and emergent species were located on Crystal Lake (Table 8.2.4-1), all of which provide valuable wildlife habitat.

Table 8.6.4-2. Crystal Lake acres of emergent and floating-leaf plant communities from the 2011 community mapping survey.

Plant Community	Acres
Emergent	2.6
Floating-leaf	14.7
Mixed Floating-leaf and Emergent	2.0
Total	19.3

The community map represents a 'snapshot' of the emergent and floating-leaf plant communities, replications of this survey through time will provide a valuable understanding of the dynamics of these communities within Crystal Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also Lost a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

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