Note: Methodology, explanation of analysis and biological background on Eagle Lake studies are contained within the Eagle River Chain-wide Management Plan document.

8.4 Eagle Lake

An Introduction to Eagle Lake

Eagle Lake, Vilas County, is a deep, lowland drainage lake with a maximum depth of 34 feet, a mean depth of 16 feet, and a surface area of approximately 575 acres. The lake is fed via upstream Voyageur Lake (Eagle River) and Scattering Rice Lake (Deerskin River) and drains into downstream Otter Lake. Eagle Lake's surficial watershed encompasses approximately 147,735 acres. Aquatic plant studies conducted by Onterra in 2012 and 2014 located 29 native aquatic plant species, of which slender naiad was the most common. One non-native plant, Eurasian water-milfoil is present within Eagle Lake.

Field Survey Notes

The native aquatic plants slender naiad (Najas flexilis) and wild celery (Vallisneria americana) were the most frequently encountered during the 2012 point-intercept survey. Large, monotypic stands of the native northern water milfoil (Myriophyllum sibiricum) were also observed along the lake's eastern shore.

Photo 8.4 Eagle Lake, Vilas County

Lake at a Glance* – Eagle Lake

Morphology	
Acreage	575
Maximum Depth (ft)	34
Mean Depth (ft)	16
Volume (acre-feet)	9,200
Shoreline Complexity	2.2
Vegetation	
Curly-leaf Survey Date	July 8, 2014
Comprehensive Survey Date	August 2, 2012
Number of Native Species	25
Threatened/Special Concern Species	Vasey's pondweed (*Potamogeton vaseyi*)
Exotic Plant Species	Eurasian water milfoil (*Myriophyllum spicatum*)
Simpson's Diversity	0.90
Average Conservatism	6.5
Water Quality	
Wisconsin Lake Classification	Deep, Lowland Drainage
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Watershed to Lake Area Ratio	253:1

**These parameters/surveys are discussed within the Chain-wide portion of the management plan.*

8.4.1 Eagle Lake Water Quality

Water quality data was collected from Eagle Lake on six occasions in 2014/2015. Onterra staff sampled the lake for a variety of water quality parameters including total phosphorus, chlorophyll-*a*, Secchi disk clarity, temperature, and dissolved oxygen. Please note that the data in these graphs represent concentrations and depths taken during the growing season (April-October), summer months (June-August) or winter (February-March) 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 2014/2015, any historical data was researched and are included within this report as available.

Near-surface total phosphorus concentration data are available from Eagle Lake in 1979, 1992, 2000-2005, and 2014. In 2014, the average summer near-surface total phosphorus concentration was 26.3 µg/L, slightly higher than the median value of 23.0 µg/L for other deep, lowland drainage lakes throughout Wisconsin and the median value of 21.0 µg/L for lakes within the Northern Lakes and Forests ecoregion (Figure 8.4.1-1). With the exception of the average growing season total phosphorus concentration in 2004 (discussed on next page), near-surface total phosphorus concentrations in Eagle Lake have been relatively consistent over the time period for which data are available. Trends analysis indicates that no trends (positive or negative) in near-surface total phosphorus concentrations are occurring in Eagle Lake at this time. Overall, weighted average near-surface total phosphorus concentrations in Eagle Lake fall within the *good* category for deep, lowland drainage lakes in Wisconsin.

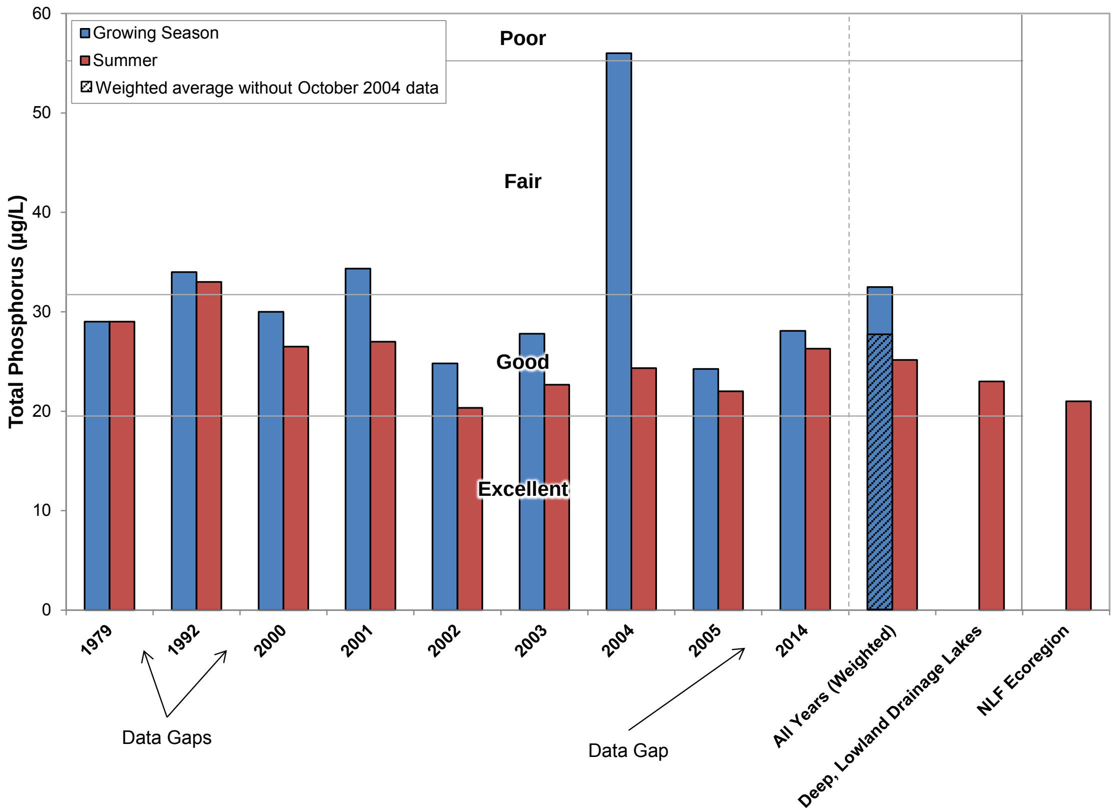


Figure 8.4.1-1. Eagle Lake, statewide deep, lowland drainage lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

On October 12, 2004, a near-surface total phosphorus concentration of 185 µg/L was measured in Eagle Lake, approximately seven times higher than the growing season average concentration. Adding validation to this measurement, chlorophyll-*a* concentrations were also found to have increased substantially from 14.6 µg/L in August to 69.7 µg/L in October, indicating there was likely a noticeable algae bloom on Eagle Lake in the fall of 2004. Unfortunately, data from upstream lakes in 2004 are not available, so it is not known if this phosphorus originated upstream within the chain or within Eagle Lake. However, given the near-bottom total phosphorus data that area available from Eagle Lake, it is possible that this large increase in phosphorus measured in 2004 originated from within Eagle Lake through the process of internal nutrient loading.

Figure 8.4.1-2 displays near-surface and near-bottom total phosphorus concentrations collected from Eagle Lake in 2014 and the winter of 2015. As illustrated, near-bottom phosphorus concentrations in the late-May and during the summer months was approximately two to three times the concentrations measured near the surface. The higher concentrations of phosphorus measured near the bottoms during these sampling events is an indication that phosphorus is being released from bottom sediments and into the hypolimnion, or the colder, bottom layer of water. During these sampling events the lake was found to be stratified with little or no oxygen measured within the hypolimnion. The absence of oxygen in the water near the sediments allows phosphorus to be released from the sediment and into the water. Most of the time, this process is likely contributing minimal amounts of phosphorus to Eagle Lake. As discussed within the Chain-Wide Section, internal nutrient loading generally becomes a concern when near-bottom phosphorus concentrations exceed 200 µg/L.

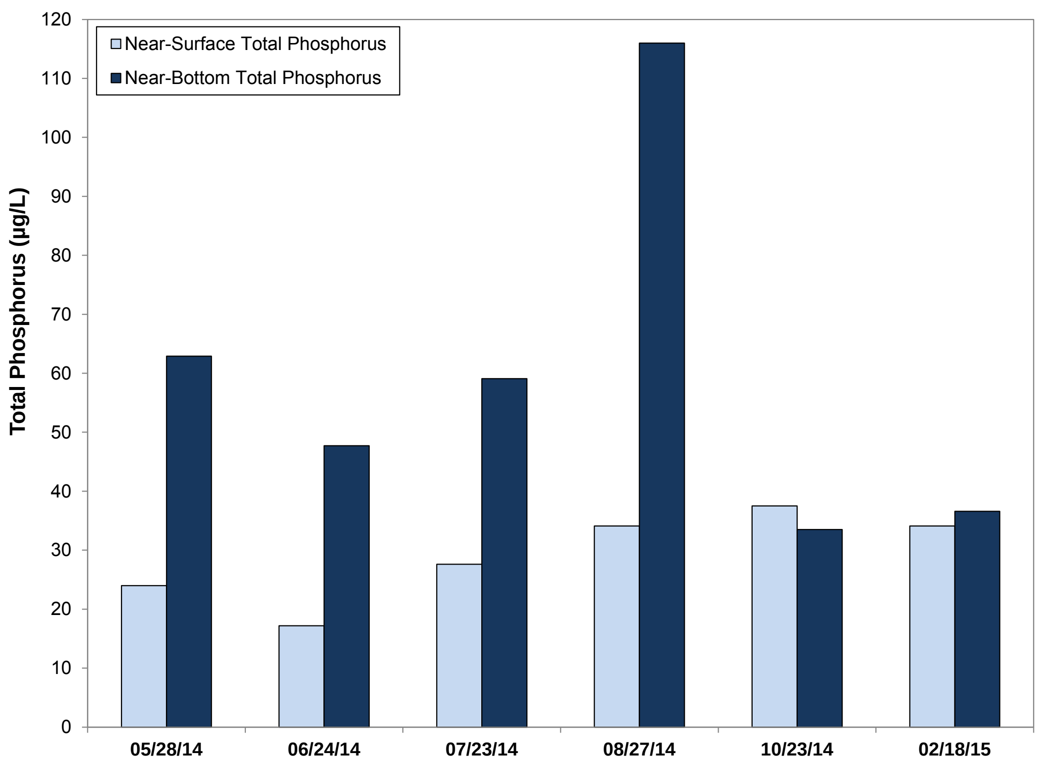


Figure 8.4.1-2. Eagle Lake growing season 2014 and winter 2015 near-surface and near-bottom total phosphorus concentrations.

However, periodically, like in 2004, conditions that either increase the period of stratification or increase the size of the anoxic hypolimnion may allow for higher amounts of phosphorus to build up within the hypolimnion over the course of the summer. In the fall as surface water temperatures cool, the entire water column of the lake mixes, or turns over, and the phosphorus-rich water near the bottom is mixed throughout the water column delivering phosphorus to the surface. Using the total phosphorus data collected in 2004 and the temperature and dissolved oxygen profiles collected in 2014, it was estimated that the concentration of phosphorus within the hypolimnion in 2004 needed to be around 650 µg/L to create the measured concentration of 185 µg/L throughout the water column at turnover. A hypolimnetic phosphorus concentration of 650 µg/L is high, but is within the realm of possibility. However, as the data indicate, this magnitude of internal nutrient loading on Eagle Lake is relatively rare, and likely only occurs when conditions are ideal.

Like near-surface total phosphorus data, chlorophyll-*a* data from Eagle Lake are available from 1979, 1992, 2000-2005, and 2014. The average summer chlorophyll-*a* concentration straddles the *good-fair* threshold for deep, lowland drainage lakes and is higher than the median value for other deep, lowland drainage lakes in Wisconsin and lakes within the NLF ecoregion (Figure 8.4.1-3). While chlorophyll-*a* concentrations vary between years, trends analysis does not indicate a trend is occurring, positive or negative, over the time period for which data are available. The variability in chlorophyll-*a* concentrations between years is expected given changes in precipitation, temperature, and other environmental conditions between years.

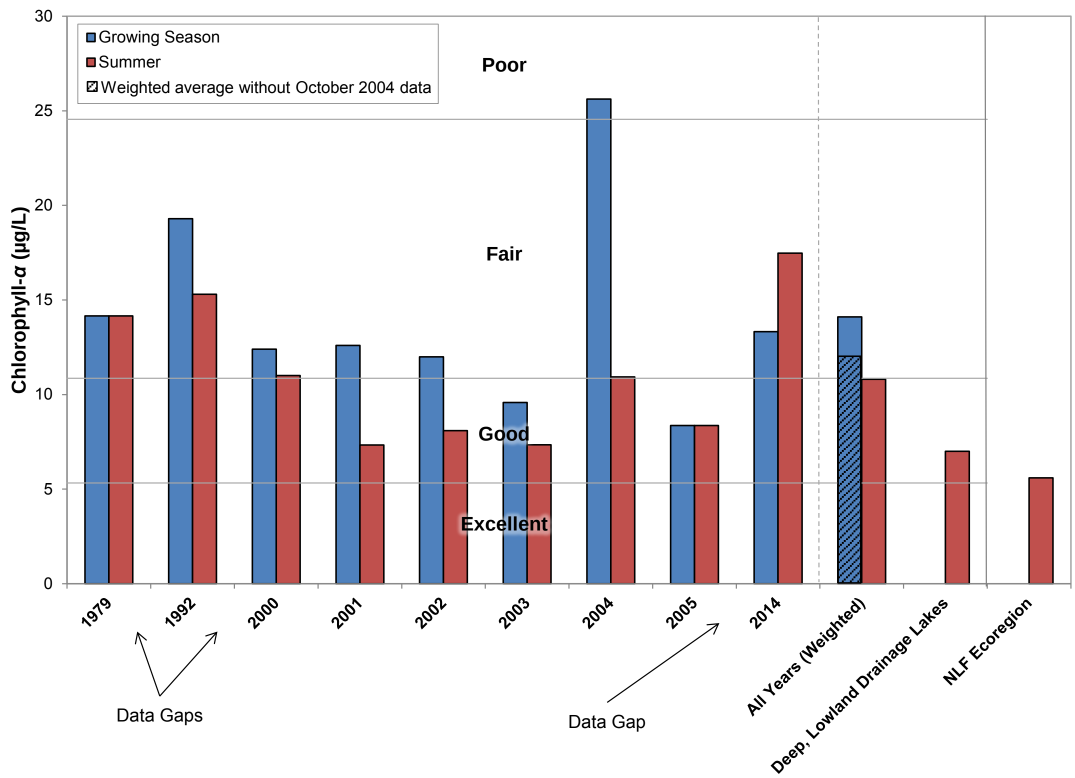


Figure 8.4.1-3. Eagle Lake, statewide deep, lowland drainage lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Secchi disk transparency data are available from Eagle Lake from 1979, 1992, 1993, 1996-2005, 2007, 2008, 2012, and 2014 (Figure 8.4.1-4). The average summer Secchi disk transparency value is 6.3 feet, slightly lower than the median values for other deep, lowland drainage lakes in Wisconsin and for lakes within the NLF ecoregion. While water clarity varies between years, trends analysis indicates water clarity has remained relatively consistent over the time period for which data are available. Overall, water clarity in Eagle Lake falls within the *good* category for deep, lowland drainage lakes.

Secchi disk clarity is influenced by many factors, including plankton production and suspended sediments, which themselves vary due to several environmental conditions such as precipitation, sunlight, and nutrient availability. In Eagle Lake as well as the other lakes in the Eagle River Chain of Lakes, a natural staining of the water plays a role in light penetration, and thus water clarity, as well. The waters of Eagle Lake contain naturally occurring 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 terrestrial and wetland plant species. This natural staining may reduce light penetration into the water column, which reduces visibility and also reduces the growing depth of aquatic vegetation within the lake. *True color* is a measure of water's transparency after suspended materials have been removed and only dissolved compounds remain. Water samples collected in May and July of 2014 were measured for this parameter, and were found to be 40 Platinum-cobalt units (Pt-co units, or PCU). Lillie and Mason (1983) categorized lakes with 0-40 PCU as having low color, 40-100 PCU as medium color, and >100 PCU as high color.

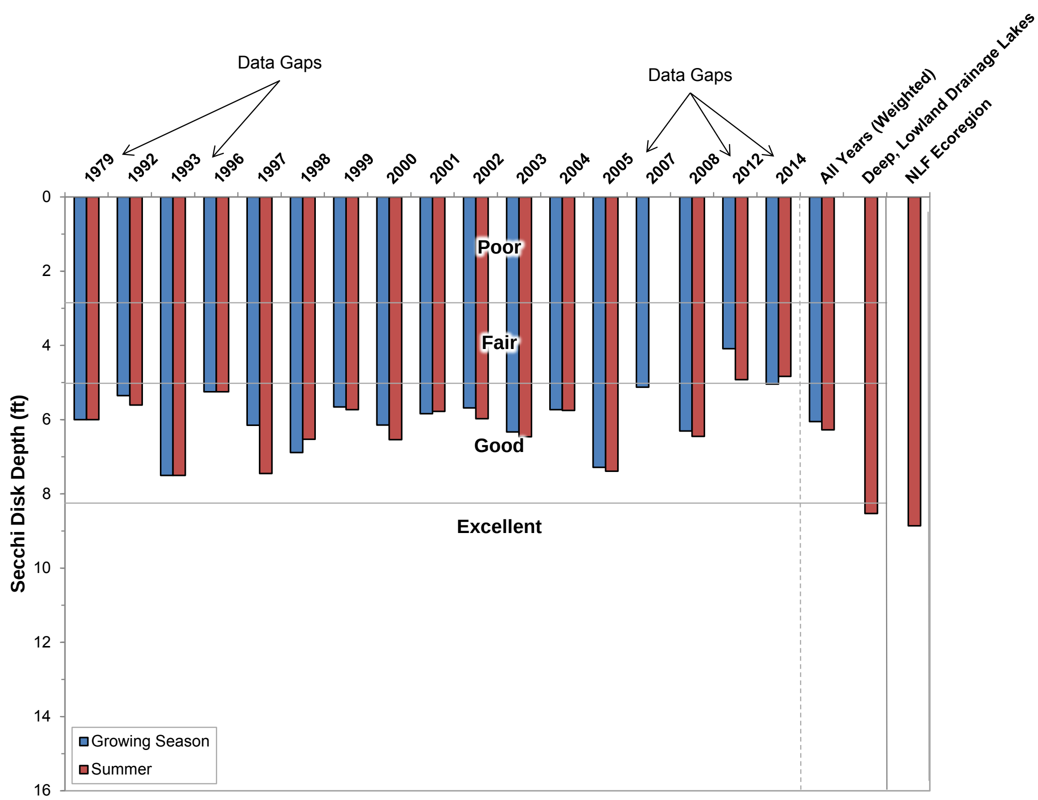


Figure 8.4.1-4. Eagle Lake, statewide deep, lowland drainage lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Eagle Lake Trophic State

The Trophic State Index (TSI) values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from lower mesotrophic to eutrophic (Figure 8.4.1-5). In general, the best values to use in judging a lake's trophic state are total phosphorus and chlorophyll-*a* because factors other than algae can influence water clarity; therefore, relying primarily on total phosphorus and chlorophyll-*a* TSI values, it can be concluded that Eagle Lake is in an eutrophic state.

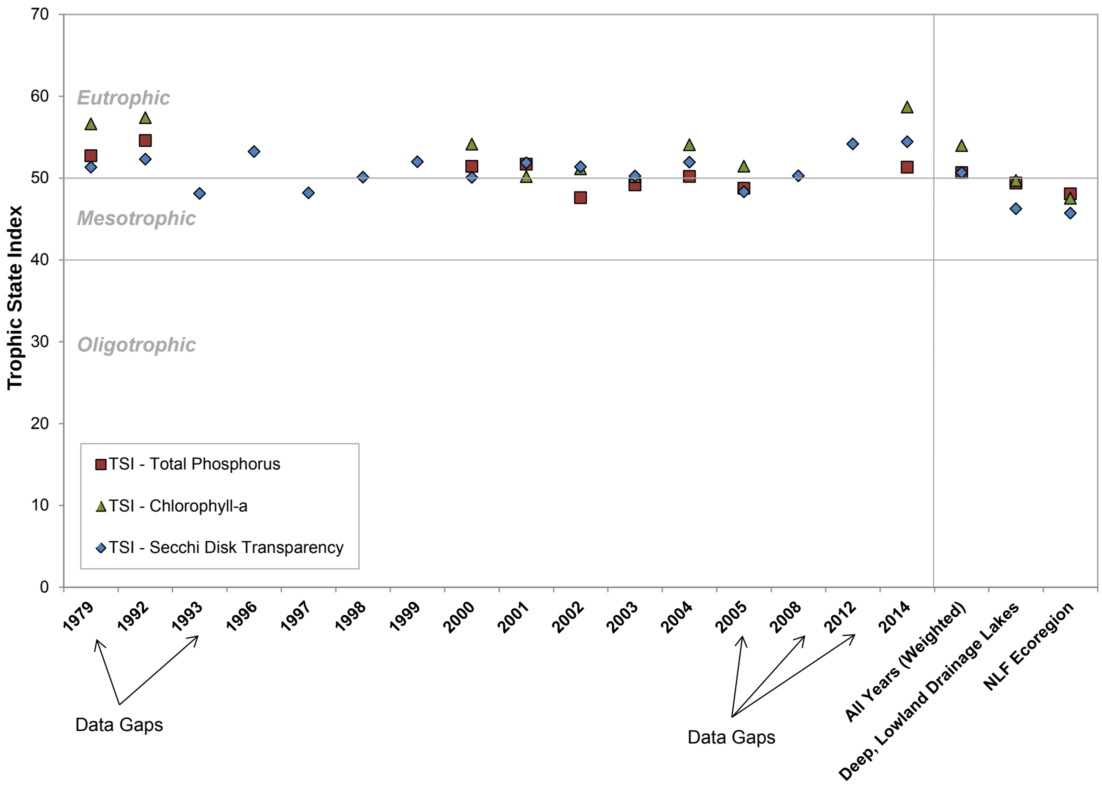


Figure 8.4.1-5. Eagle Lake, statewide deep, lowland drainage lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Eagle Lake

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Eagle Lake by Onterra staff. Graphs of those data are displayed in Figure 8.4.1-6 for all sampling events.

Eagle Lake mixes thoroughly during the spring and fall, when changing air temperatures and gusty winds help to mix the water column. During the summer months, the bottom of the lake becomes devoid of oxygen and temperatures remain fairly cool as they were in the spring months. This occurrence is not uncommon in deep Wisconsin lakes, where wind energy is not sufficient during the summer to mix the entire water column – only the upper portion. During this time, bacteria break down organic matter that has collected at the bottom of the lake and in doing so utilize any available oxygen.

The lake mixes completely again in the fall, re-oxygenating the water in the lower part of the water column. During the winter months, the coldest temperatures are found just under the overlying ice, while oxygen gradually diminishes once again towards the bottom of the lake. In February of 2015, oxygen levels remained sufficient throughout most of the water column to support most aquatic life in northern Wisconsin lakes.

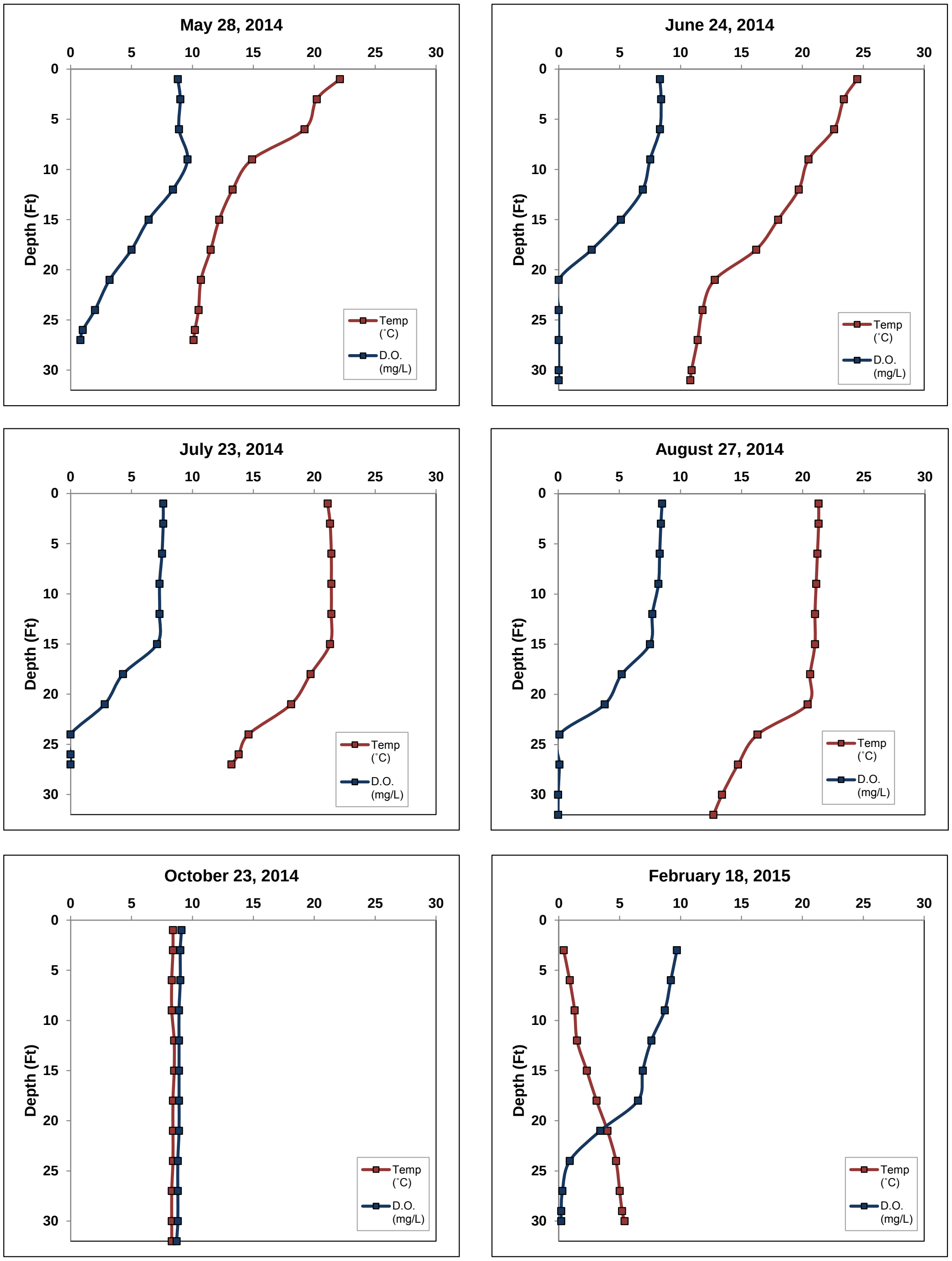


Figure 8.4.1-6. Eagle Lake 2014/2015 dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Eagle 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 Eagle 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 Chain-wide 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. Eagle Lake's surface water pH was measured at roughly 7.6 during May and 7.9 during July of 2014. These values are near or slightly above neutral and fall within the normal range for Wisconsin lakes. Fluctuations in pH with respect to seasonality is common; in-lake processes such as photosynthesis by plants act to reduce acidity by carbon dioxide removal while decomposition of organic matter add carbon dioxide to water, thereby increasing acidity.

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 carbonate form is better at buffering acidity, so lakes with higher alkalinity are less sensitive to acid rain than those with lower alkalinity. The alkalinity in Eagle Lake was measured at 27.9 and 32.6 mg/L as $CaCO_3$ in May and July of 2014, respectively. This indicates 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 Eagle Lake during 2014. Calcium is commonly examined because invasive and native mussels use the element for shell building 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 Eagle Lake's pH of 7.6 – 7.9 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 Eagle Lake was found to be 7.36 mg/L in May and 7.94 mg/L in July of 2014, which are below the optimal range for zebra mussels. Plankton tows were completed by Onterra staff during the summer of 2014 and these samples were processed by the WDNR for larval zebra mussels. Their analysis of the samples was negative for zebra mussel veligers.

8.4.2 Eagle Lake Watershed Assessment

Eagle Lake's watershed is approximately 147,735 acres in size. Compared to its surface area of 581 acres, this makes for a large watershed to lake area ratio of 253:1.

Exact land cover calculation and modeling of nutrient input to Eagle Lake will be completed towards the end of this project (in 2016-2017). 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.

8.4.3 Eagle Lake Shoreland Condition

Shoreland Development

As mentioned previously in the Chain-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 late summer of 2014, Eagle Lake's immediate shoreline was assessed in terms of its development. Eagle Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 2.6 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 8.4.3-1). This constitutes about 54% of Eagle Lake's shoreline. 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, 1.4 miles of urbanized and developed–unnatural shoreline (30%) was observed. If restoration of the Eagle 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. Eagle Lake – Map 1 displays the location of these shoreline lengths around the entire lake.

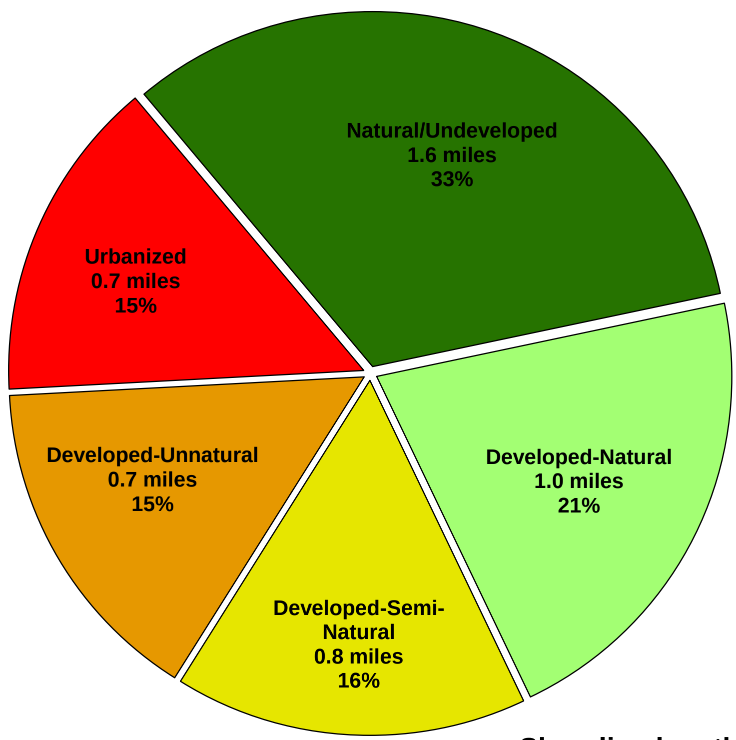


Figure 8.4.3-1. Eagle Lake shoreland categories and total lengths. Based upon a late summer 2014 survey. Locations of these categorized shorelands can be found on Eagle Lake – Map 1.

Coarse Woody Habitat

A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey. 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 Eagle River Chain-wide document, 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.

During this survey, 154 total pieces of coarse woody habitat were observed along 4.9 miles of shoreline, which gives Eagle Lake a coarse woody habitat to shoreline mile ratio of 31:1 (Figure 8.4.3-2). Locations of coarse woody habitat are displayed on Eagle Lake – Map 2. 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).

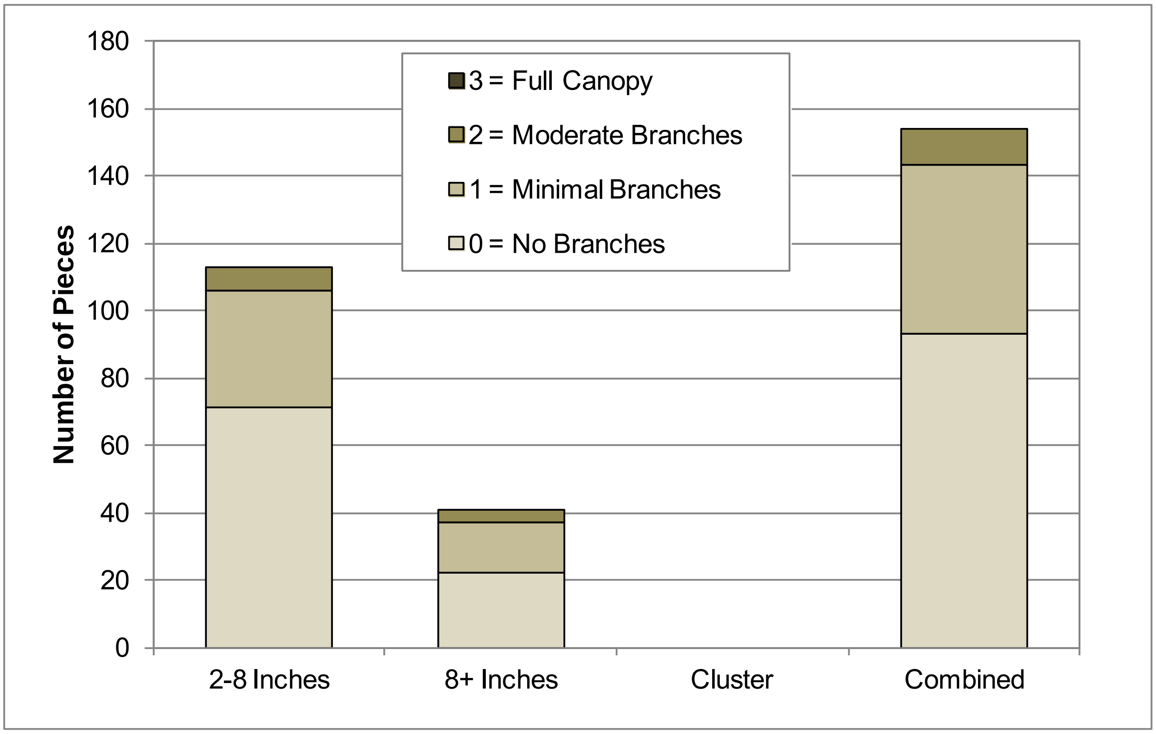


Figure 8.4.3-2. Eagle Lake coarse woody habitat survey results. Based upon a late summer 2014 survey. Locations of Eagle Lake coarse woody habitat can be found on Eagle Lake – Map 2.

8.4.4 Eagle Lake Aquatic Vegetation

An early season aquatic invasive species survey was conducted on Eagle Lake on July 8, 2014. 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 curly-leaf pondweed which should be at or near its peak growth at this time. During this meander-based survey of the littoral zone, Onterra ecologists did not locate any occurrences of curly-leaf pondweed.

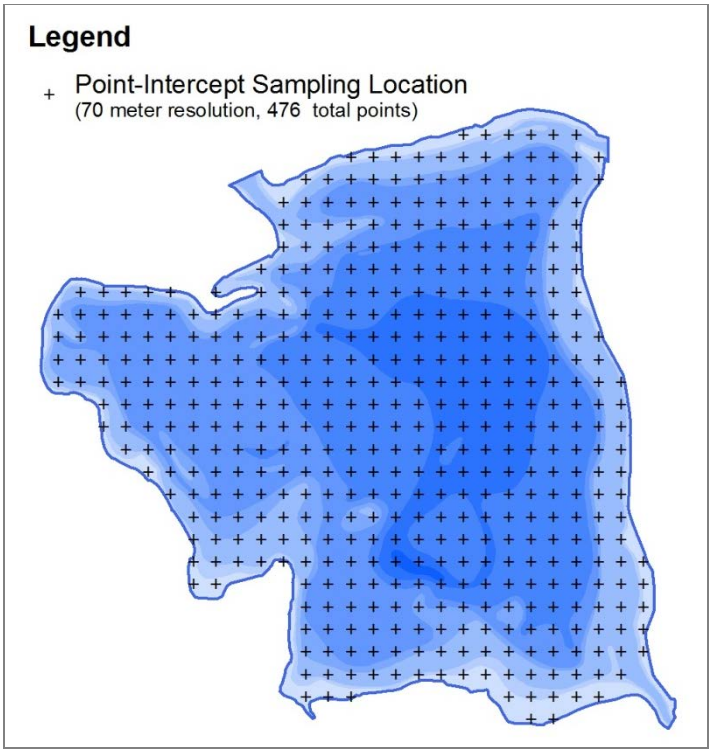


Figure 8.4.4-1. Point-intercept sampling locations on Eagle Lake.

The whole-lake aquatic plant point-intercept survey was conducted on Eagle Lake by Onterra on August 2, 2012 (Figure 8.2.4-1), while the aquatic plant community mapping survey was conducted on July 30, 2014. During these surveys, a total of 30 aquatic plant species were located, only one of which is considered to be a non-native, invasive species: Eurasian water milfoil (Table 8.4.4-1). One native plant species located, Vasey's pondweed (*Potamogeton vaseyi*), 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.

As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. Approximately 84% of the point-intercept locations within littoral areas contained sand, 6% contained fine, organic sediments (muck), and 10% contained rock. The majority of the shallow, near-shore areas contained sand and/or rock, while the deeper areas of the littoral zone were comprised of muck. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky 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 the different habitat types that are available.

During the 2012 point-intercept survey, aquatic plants were found growing to a maximum depth of 9.0 feet, substantially lower than the 17.0 feet recorded during the 2006 survey. As discussed within the Water Quality Section, water quality in terms of light availability fluctuates from year to year and water clarity was likely higher in 2006 allowing plants to grow deeper. The water within the Lower Eagle River Chain of Lakes is considered 'stained,' or contains dissolved organic compounds which gives the water a tea-like color. These compounds scatter light and limit the amount that can penetrate vertically into the water column. Thus, the growth of aquatic plants within the chain's lakes is restricted to shallower areas where they can receive enough light to photosynthesize.

Table 8.4.4-1 displays the aquatic plant species located in Eagle Lake during the Onterra 2012 point-intercept survey. All of the species recorded in 2006, with the exception of white water crowfoot and arrowhead rosette, were recorded in 2012. An additional 12 species were located during the 2012 and 2014 surveys compared that were not recorded in 2006.

Table 8.4.4-1. Aquatic plant species located in Eagle Lake during 2006 and 2012/2014 aquatic plant surveys.

Growth Form	Scientifc Name	Common Name	Coefficient of Conservatism (C)	2006 (NEI)	2012/2014 (Onterra)
E	*Eleocharis palustris*	Creeping spikerush	6	X	X
E	*Pontederia cordata*	Pickerelweed	9		I
E	*Schoenoplectus acutus*	Hardstem bulrush	5		I
E	*Schoenoplectus tabernaemontani*	Softstem bulrush	4	X	X
E	*Sparganium eurycarpum*	Common bur-reed	5		I
FL	*Nuphar variegata*	Spatterdock	6	X	X
FL	*Nymphaea odorata*	White water lily	6	X	I
FL/E	*Sparganium fluctuans*	Floating-leaf bur-reed	10		I
Submergent	*Bidens beckii*	Water marigold	8		X
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X
Submergent	*Chara* spp.	Muskgrasses	7	X	X
Submergent	*Elodea canadensis*	Common waterweed	3	X	X
Submergent	*Heteranthera dubia*	Water stargrass	6	X	X
Submergent	*Isoetes* spp.	Quillwort species	8		X
Submergent	*Myriophyllum sibiricum*	Northern water milfoil	7	X	X
Submergent	*Myriophyllum spicatum*	Eurasian water milfoil	Exotic	X	X
Submergent	*Najas flexilis*	Slender naiad	6	X	X
Submergent	*Nitella* spp.	Stoneworts	7	X	X
Submergent	*Potamogeton amplifolius*	Large-leaf pondweed	7	X	X
Submergent	*Potamogeton epihydrus*	Ribbon-leaf pondweed	8		X
Submergent	*Potamogeton pusillus*	Small pondweed	7	X	X
Submergent	*Potamogeton richardsonii*	Clasping-leaf pondweed	5	X	X
Submergent	*Potamogeton robbinsii*	Fern pondweed	8	X	X
Submergent	*Potamogeton spirillus*	Spiral-fruited pondweed	8		X
Submergent	*Potamogeton strictifolius*	Stiff pondweed	8		X
Submergent	*Potamogeton vaseyi**	Vasey's pondweed	10	X	X
Submergent	*Potamogeton zosteriformis*	Flat-stem pondweed	6	X	X
Submergent	*Ranunculus aquatilis*	White water crowfoot	8	X	
Submergent	*Utricularia vulgaris*	Common bladderwort	7		X
Submergent	*Vallisneria americana*	Wild celery	6	X	X
S/E	*Sagittaria* sp. (rosette)	Arrowhead sp. (rosette)	N/A	X	
FF	*Spirodela polyrhiza*	Greater duckweed	5		X

E = Emergent, 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
** = Species listed as 'special concern' in Wisconsin*

Of the 121 point-intercept sampling locations that fell at or below the maximum depth of plant growth in 2012, approximately 74% contained aquatic vegetation. Eagle Lake – Map 3 displays the point-intercept locations that contained aquatic vegetation in 2012, and the total rake fullness (TRF) ratings at those locations. Most of the aquatic vegetation in 2012 was located within shallower areas of the lake, mainly near shore throughout the lake. Thirty-nine percent of the point-intercept locations had a total rake fullness rating of 1, 24% had a total rake fullness rating of 2, and 11% had the highest total rake fullness rating of 3. Total rake fullness ratings were not recorded during the 2006 survey, so a comparison cannot be made.

Of the 25 aquatic plant species recorded on the rake during the 2012 point-intercept survey, slender naiad, wild celery, small pondweed, and Vasey's pondweed were the four-most frequently encountered (Figure 8.4.4-2). Slender naiad, the most abundant aquatic plant in Eagle Lake in 2012 had a littoral occurrence of nearly 44%. 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.
1997).

Wild celery, or tape grass, was the second-most abundant aquatic plant encountered in 2012 with a littoral occurrence of approximately 41%. This species has bundles of long submersed leaves that are flat and ribbon-like which emerge from a basil rosette and provide excellent structural habitat for aquatic organisms. Spreading rapidly via rhizomes, wild celery is often found growing in large colonies where their extensive root systems stabilize bottom sediments. In mid- to late-summer, the coiled flower stalks of wild celery can be observed at or near the surface, and following pollination, large banana-shaped seed pods can also be seen. These seed pods have been shown to be an important food source for waterfowl (Borman et al. 1997).

Small pondweed was the third-most abundant aquatic plant encountered in Eagle Lake in 2012, with a littoral occurrence of approximately 30%. Small pondweed is one of several narrow-leaved pondweed species that can be found in Wisconsin. In Catfish Lake, it was observed growing in tall, dense stands, which provide excellent structural habitat for aquatic organisms. Unlike two other narrow-leaved pondweed species located in Catfish Lake, spiral-fruited and Vasey's pondweeds, small pondweed does not produce floating-leaves.

Vasey's pondweed was the forth-most frequently encountered aquatic plant species in 2012. As mentioned previously, Vasey's pondweed is listed as a special concern species due to its rarity and uncertainty regarding its abundance in Wisconsin. Like spiral-fruited pondweed, Vasey's pondweed is a narrow-leaf pondweed, but its leaves are much finer than spiral-fruited pondweed. Vasey's pondweed also produces floating leaves, which can be seen at the surface in shallow water. The occurrence of Vasey's pondweed within Eagle Lake is an indicator of a high-quality environment.

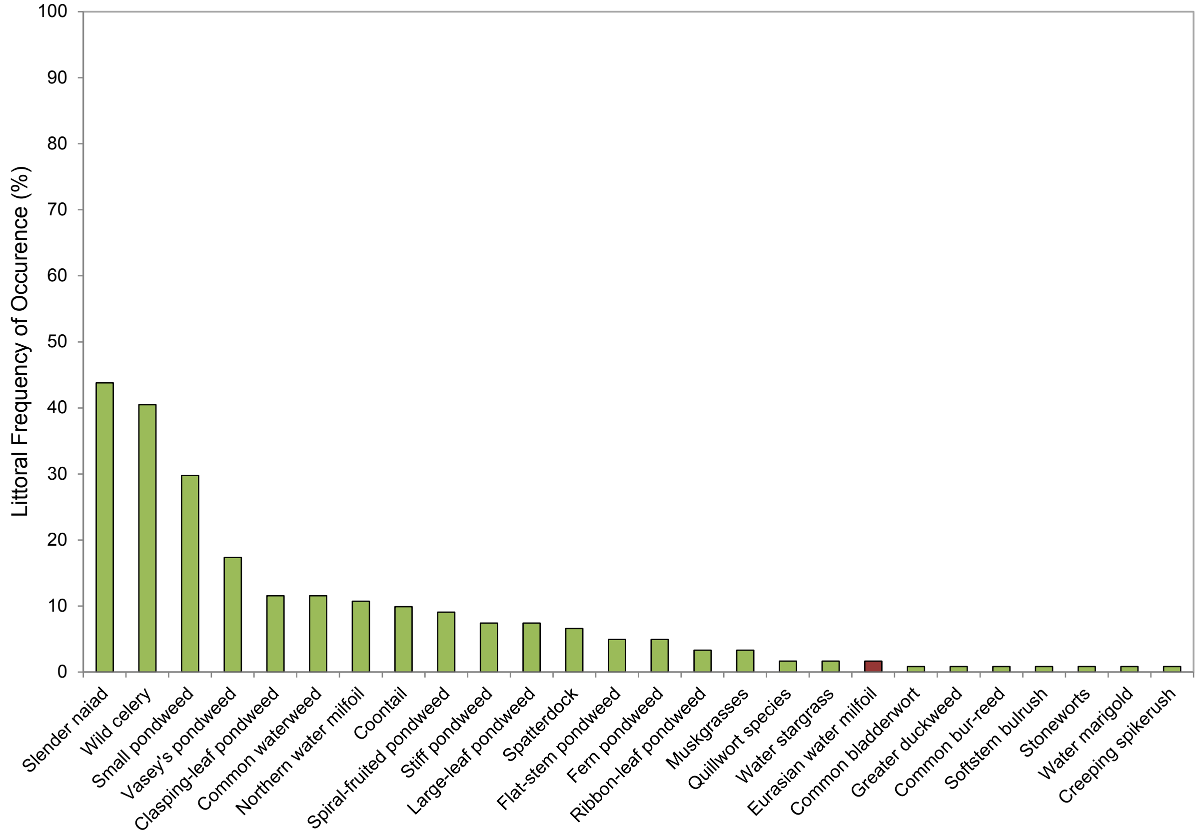


Figure 8.4.4-2. Eagle Lake 2012 aquatic plant littoral frequency of occurrence. Created using data from 2012 aquatic plant point-intercept survey. Non-native species are indicated in red.

To determine if the 2008-2012 Eurasian water milfoil control project on Eagle Lake had any detectable impacts to the native aquatic plant community, and to determine if the control project was successful at reducing the Eurasian water milfoil population, Chi-square distribution analysis ($\alpha = 0.05$) was used to determine if there were any statistically valid changes in the occurrences of aquatic plant species from 2006 to 2012. Figure 4.4-3 displays the littoral occurrences of Eurasian water milfoil and native aquatic plant species that had a littoral occurrence of at least 5% in one of the two surveys. The figure divides the plants into dicots and non-dicots, as dicots are thought to be more susceptible to the 2,4-D herbicide treatments that were occurring in Eagle Lake.

As illustrated, the occurrence of Eurasian water milfoil in Eagle Lake was reduced by a statistically valid 74%, from an occurrence of 6.4% in 2006 to 1.7% in 2012. No native plant species exhibited statistically valid reductions in their occurrence from 2006 to 2012, while eight species saw statistically valid increases in occurrence. The fact no native species were shown to have statistically valid declines in occurrence indicates that the Eurasian water milfoil control program on Eagle Lake did not have any detectable adverse impacts to the populations of native plants.

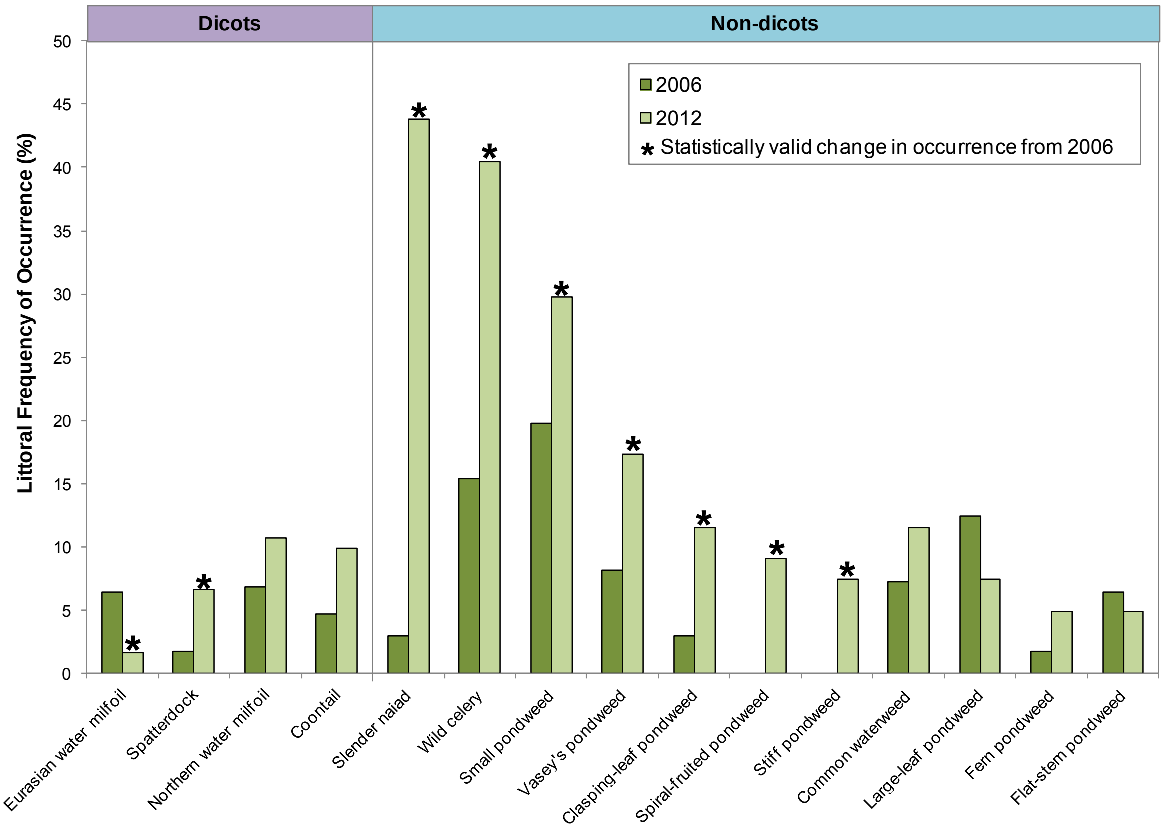


Figure 8.4.4-3. Eagle Lake littoral frequency of occurrence of select aquatic plant species from 2006 and 2012 point-intercept surveys. Please note that only those native species with an occurrence of at least 5% in one of the two surveys are displayed. Created using data from 2006 and 2012 point-intercept surveys.

As discussed in the primer section, the calculations used for 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 does not include incidental species. For example, while a total 30 native aquatic plant species were located in Eagle Lake during the 2012 survey, 25 were encountered on the rake and four were incidentally located. These 25 native species and their conservatism values were used to calculate the FQI of Eagle Lake's aquatic plant community in 2012 (equation shown below). The FQI was also calculated based on the species located during the 2006 survey.

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

Figure 8.2.4-4 compares the FQI components of Eagle Lake from the 2006 and 2012 point-intercept surveys to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) Ecoregion as well as the entire State of Wisconsin. In 2012, Eagle Lake's native species richness (25) is significantly higher than the median values for lakes within the ecoregion and the state. The average conservatism value in 2012 (6.6) is slightly lower than the ecoregional median but above the state median. Combining Eagle Lake's 2012 native species richness and average conservatism values yields an exceptionally high FQI value of 32.8, which greatly exceeds the ecoregional and state median values (Figure 8.2.4-4). The FQI values from 2012 are also higher than those calculated from point-intercept survey in 2006, indicating that the quality of Eagle Lake's aquatic plant community has not been degraded by the Eurasian water milfoil control project. This analysis indicates that Eagle Lake's aquatic plant community is of higher quality than the majority of lakes within the ecoregion and the entire state.

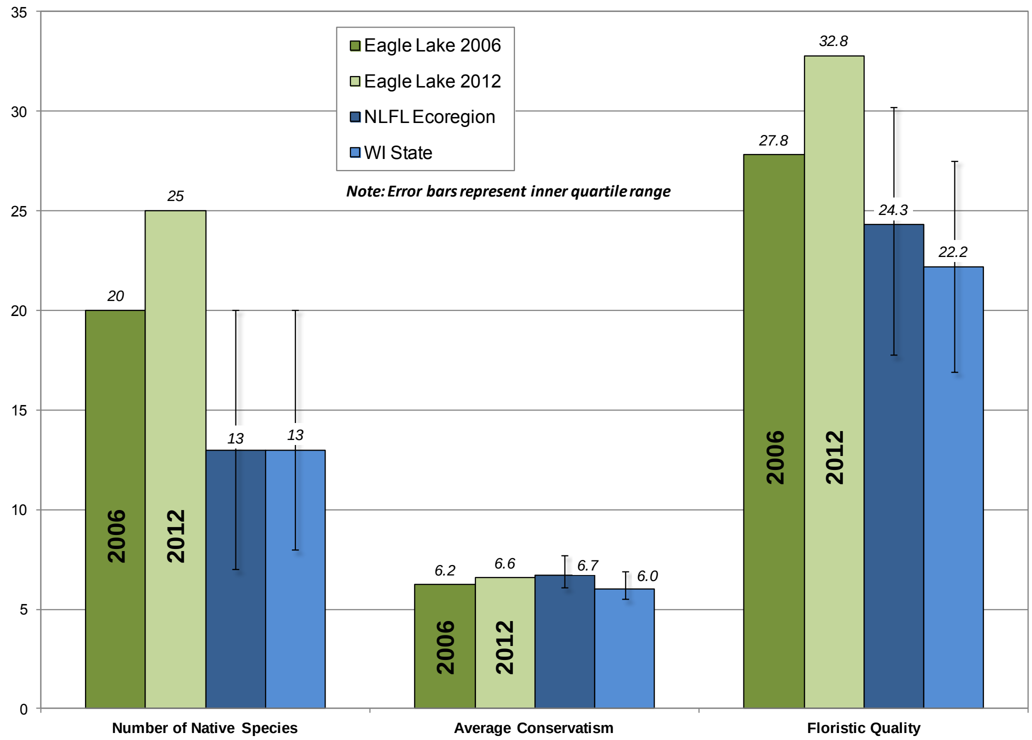


Figure 8.4.4-4. Eagle Lake Floristic Quality Index values. Created using data from 2006 and 2012 point-intercept surveys. Analysis follows Nichols (1999) where NLFL = Northern Lakes and Forests Lakes Ecoregion.

As explained in the primer 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 Eagle Lake contains a high number of native aquatic plant species, one may assume the aquatic plant community also 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 Eagle Lake's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLF Ecoregion (Figure 4.4-5). Using the data collected form the 2012 point-intercept survey, Eagle Lake's aquatic plant community was shown to have exceptionally high species diversity with a Simpson's diversity value of 0.90, falling above the upper quartile value for lakes in both the ecoregion and the state. Eagle Lake's 2012 diversity was found to be the same as the diversity calculated from data collected in 2006.

Figure 8.2.4-6 displays the relative frequency of occurrence of aquatic plant species in Eagle Lake from the 2012 point-intercept survey and illustrates relative abundance of species within the community to one another; the aquatic plant community is not overly dominated by a single or few species, which would create a less-diverse community.

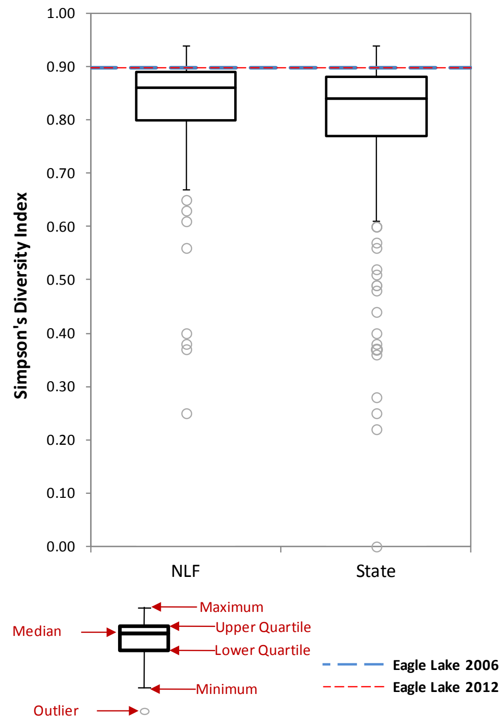


Figure 8.4.4-5. Eagle Lake species diversity index. Created using data from 2006 and 2012 poi nt-intercept surveys. Ecoregion data provided by WDNR Science Services.

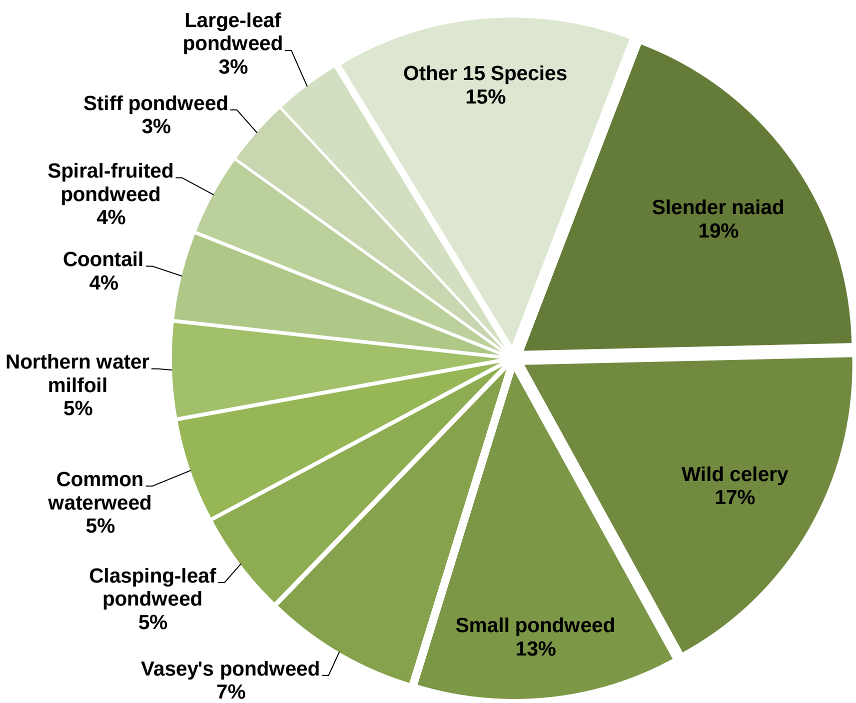


Figure 8.4.4-6. Eagle Lake 2012 aquatic plant relative frequency of occurrence. Created using data from 2012 aquatic plant point-intercept survey.

The 2014 aquatic plant community mapping survey revealed that Eagle Lake contains approximately 11.8 acres of emergent and floating-leaf aquatic plant communities (Table 8.4.4-2, Eagle Lake – Map 4). Eight emergent and floating-leaf aquatic plant species were located in the lake in 2012 and 2014 (Table 8.4.4-2). These plant communities provide valuable fish and wildlife habitat important to the ecosystem of the lake. 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 Eagle Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development.

Table 8.4.4-2. Acres of emergent and floating-leaf aquatic plant communities in Eagle Lake. Created using data from 2014 aquatic plant community mapping survey.

Plant Community	Acres
Emergent	0.0
Floating-Leaf	10.0
Mixed Emergent & Floating-Leaf	1.8
Total	**11.8**

8.4.4 Eagle Lake Implementation Plan

The Implementation Plan below is a result of collaborative efforts between Eagle Lake stakeholders, ERCLA, and ecologists/planners from Onterra. This plan provides goals and actions created to protect the quality and integrity of Eagle Lake and will serve as reference for keeping stakeholders on track and focused upon these science-driven management activities.

While the lakes within the Lower Eagle River Chain of Lakes are relatively similar in terms of their water quality and aquatic plant communities, each lake possesses its own unique attributes. This uniqueness leads to the need to create individual plans aimed at managing the specific needs of each individual lake. Some of the lakes within the Lower Eagle River Chain (i.e. Scattering Rice Lake) have more complicated management needs than others, but in general most lakes' needs center on protecting the current quality of the lake and restoring/protecting immediate shoreland areas. The Chain-wide Implementation Plan will serve each of the project lakes well in terms of protecting their current condition as a chain. Eagle Lake's Implementation Plan illustrates how Eagle Lake stakeholders should proceed in implementing applicable portions of the Chain-wide Implementation Plan for their lake.

Chain-wide Implementation Plan – Specific to Eagle Lake

Chain-wide Management Goal 1: Maintain Current Water Quality Conditions

Management Action:	Continue water clarity monitoring in Eagle Lake through the WDNR Citizen Lake Monitoring Network (CLMN).
Timeframe:	Continuation of current effort
Facilitator:	David Tidmarsh, current Eagle Lake CLMN volunteer
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 will likely aid in an earlier definition of what may be causing the trend. The Citizens Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality data on their lake. Volunteers trained as a part of the CLMN program begin by collecting Secchi disk transparency data annually. If funding is available, the lake group may enter into the *advanced program* and collect water chemistry data (chlorophyll-a and total phosphorus). The Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring. As a part of this program, these data are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS).

Volunteers from Eagle Lake have been collecting water quality data intermittently since 1993. Eagle Lake is not currently enrolled in the advanced water program and is currently collecting water clarity data. As is discussed within the Chain-Wide Implementation Plan, if additional funding should become available to include additional lakes within the chain in the advanced monitoring program, Scattering Rice Lake and Watersmeet have been given priority due to their positions within the chain. Eagle Lake currently has an active volunteer (David Tidmarsh) who collects and enters water quality data into the WDNR's SWIMS database on an annual basis. Eagle Lake (and ERCLA) recognizes the importance of continuing this effort which will supply them and resource managers with valuable data about their lake. Moving forward, it is the responsibility of David Tidmarsh, the current CLMN volunteer, to notify Dave Mueller, the current chair of the ERCLA Lakes and Shores Committee and coordinator of the chain's CLMN volunteers, when a change in the collection volunteer occurs or is needed. Dave (or the current Lakes and Shores Committee chair) will contact Sandra 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.

Action Steps:

1. David Tidmarsh, current CLMN volunteer, continues to collect water quality data and enter data into WDNR SWIMS database.
2. David Tidmarsh, current CLMN volunteer, notifies Dave Mueller or current Lakes and Shores Committee chair when a new Eagle Lake volunteer is needed.

Chain-wide Management Goal 2: Lessen the Impact of Shoreline Development on the Eagle River Chain of Lakes

<u>Management Action:</u> Investigate restoring highly developed shoreland areas on the Eagle River Chain of Lakes.

Description: As part of the planning project, the entire shoreline of Eagle Lake was categorized based on the amount of development present. The results of this survey revealed that approximately 30% (1.4 miles) of the shoreline are in an urbanized or developed-unnatural state, 16% (0.8 miles) is in a developed-semi-natural state, and 54% (2.6 miles) is in a developed-natural or natural/undeveloped state. Continuing research indicates that the shoreland zone is a critical component of a lake's ecology through providing both pollutant buffering and wildlife habitat. In addition, natural shoreland areas also increase the lake's aesthetic appeal.

ERCLA's Shores Subcommittee will be working with Quita Sheehan from the Vilas County Land and Water Department to gather information on initiating and conducting shoreland restoration projects. The Shores Subcommittee will serve as a contact point for property owners who are interested in pursuing shoreland restoration on their property. Interested property owners may contact ERCLA for more information on shoreland restoration plans, financial assistance, and benefits of implementation.

Management Action: Preserve natural shoreland areas on the Eagle River Chain of Lakes.

Description: While approximately 30% of Eagle Lake's shoreline is in a highly-developed state, approximately 54% of the shoreline contains little to no development. Preservation of these natural areas is very important for the lake's overall health, and owners of these properties should be educated on the benefits their shoreland is providing to Eagle Lake and to the entire chain.

The shoreland areas delineated as Natural and Developed-Natural should be prioritized for education initiatives and physical preservation. The ERCLA Shores Subcommittee will work with appropriate entities to research grant programs and other pertinent information that will aid ERCLA in preserving the Eagle River Chain's shoreland. This would be accomplished through education of property owners, or direct preservation of land through implementation of conservation easements or land trusts that the property owner would approve of. Eagle Lake stakeholders may assist in this management action by attending educational events held by ERCLA and by aiding in distributing ERCLA materials to Eagle Lake property owners.

Management Action: Investigate with WDNR and private landowners to expand coarse woody habitat in the Eagle River Chain of Lakes.

Description: During the Eagle Lake shoreland assessment, approximately 31 pieces of coarse woody habitat (CWH) per shoreline mile were observed. 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, and also aid in reducing shoreline erosion.

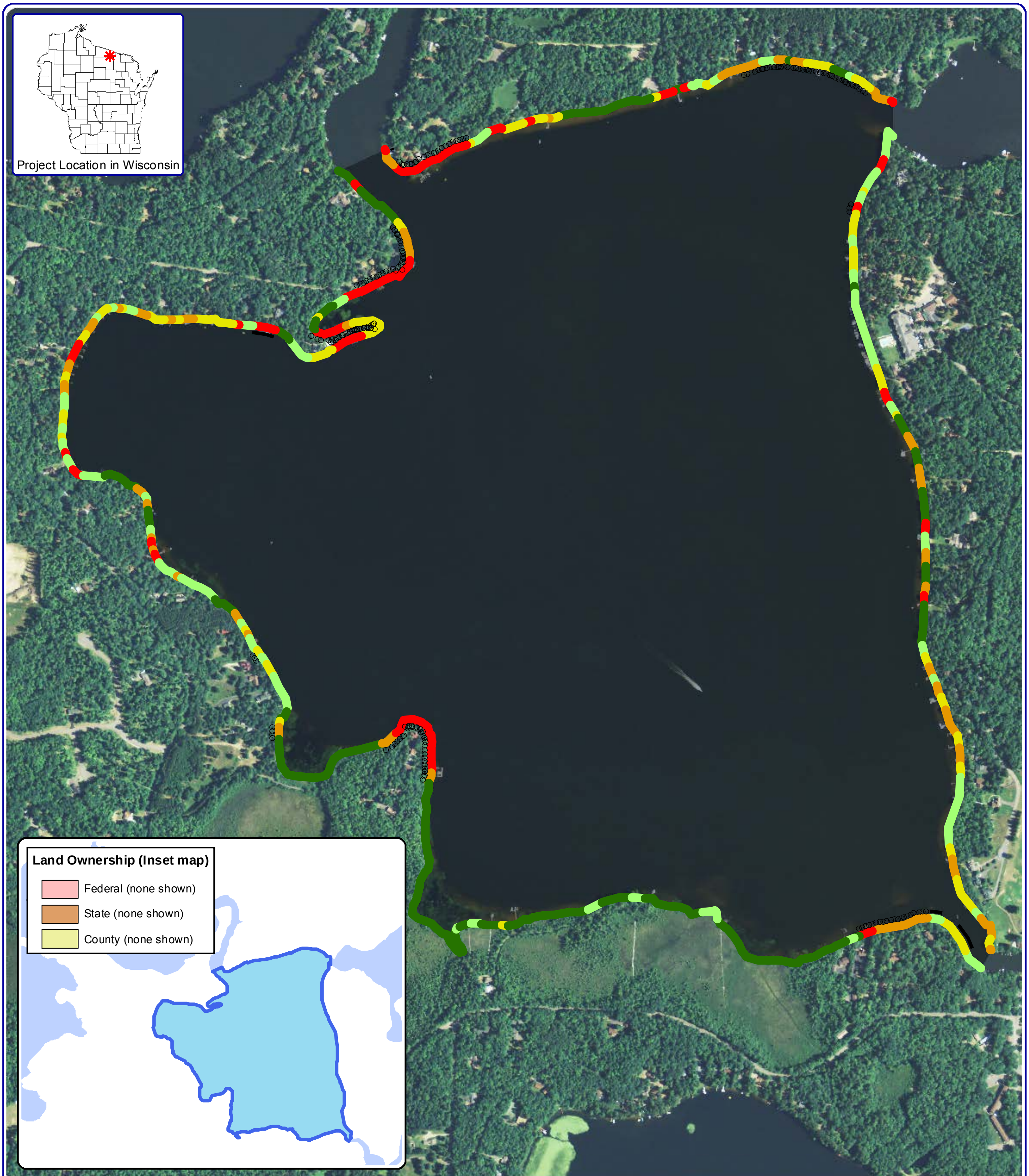
The ERCLA Shores Subcommittee will encourage its membership to implement coarse woody habitat projects along their shoreland properties. Habitat design and location placement would be determined in accordance with the WDNR fisheries biologist. Eagle Lake stakeholders interested in implementing a coarse woody habitat project along their property or who have questions about the benefits of coarse woody habitat should contact ERCLA.

Chain-wide Management Goal 3: Actively Manage Existing and Reduce the Likelihood of Further Aquatic Invasive Species Establishment within the Eagle River Chain of Lakes

Management Action:	Continue annual monitoring of aquatic invasive species on the Lower Eagle River Chain of Lakes.
Description:	Of the aquatic invasive species currently present in the Lower Eagle River Chain of Lakes, Eurasian water milfoil, purple loosestrife, pale-yellow iris, and garden yellow loosestrife are currently being actively managed. Eagle Lake stakeholders may participate in a variety of ways to aid in managing aquatic invasive species in Eagle Lake and throughout the chain. Those who are interested in participating in aquatic invasive species monitoring and management should contact ERCLA. Eagle Lake stakeholders can keep themselves up to date on aquatic invasive species matters through attending WDNR training sessions, media releases, or participating in Eagle Lake Association and ERCLA meetings. Eagle Lake stakeholders can also participate in the active annual monitoring of Eurasian water milfoil, purple loosestrife, pale-yellow iris, and garden yellow loosestrife on Eagle Lake and/or volunteer to conduct watercraft inspections at designated boat landings in accordance with the Clean Boats Clean Waters Program. Additionally, Eagle Lake stakeholders can also report sightings of aquatic invasive species to ERCLA and remove occurrences of purple loosestrife, pale-yellow iris, and/or garden yellow loosestrife on their property in accordance with methods determined by ERCLA and the Vilas County Invasive Species Coordinator.

Management Goal 4: Continue and Expand Awareness and Education of Lake Management and Stewardship Matters to Eagle River Chain of Lakes Riparians and the General Public

Management Action:	ERCLA will continue to promote stakeholder involvement and inform stakeholders of various lake issues as well as the quality of life on the Eagle River Chain of Lakes.
Description:	Eagle Lake stakeholders can assist in the implementation of this action by actively participating in ERCLA-associated educational initiatives. Participation may include attending presentations and trainings of educational topics, volunteering at local and regional events, participating in ERCLA committees, or simply notifying ERCLA of concerns regarding Eagle Lake and its stakeholders.



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815 Prosper Rd
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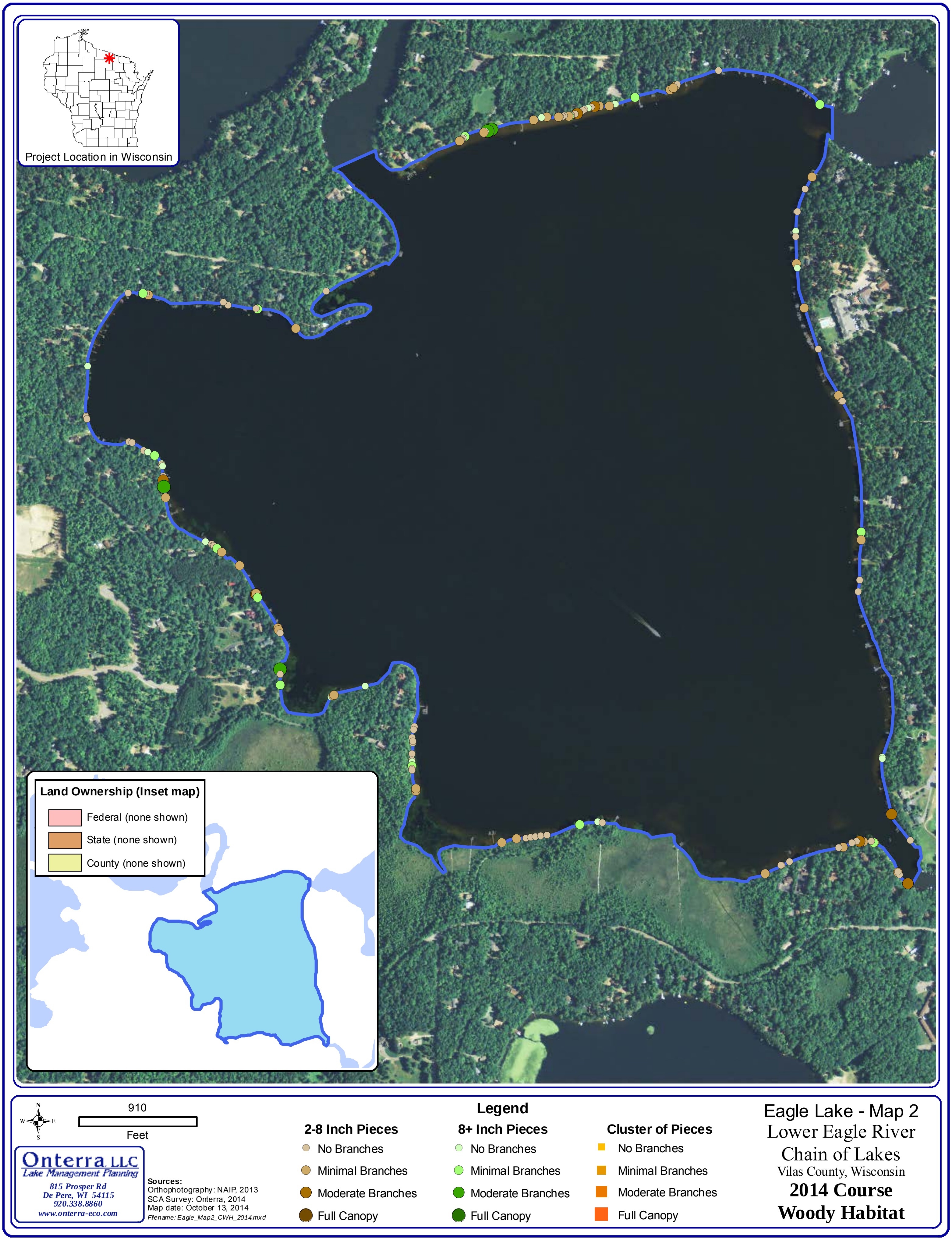
920.338.8860
www.onterra-eco.com

Sources:
Orthophotography: NAIP, 2013
SCA Survey: Onterra, 2014
Map date: October 13, 2014
Filename: Eagle_Map1_SCA_2014.mxd

Eagle Lake - Map 1
Lower Eagle River
Chain of Lakes
Vilas County, Wisconsin
2014 Shoreland Condition Assessment


Project Location in Wisconsin
Land Ownership (Inset map)
Federal (none shown)
State (none shown)
County (none shown)
910
Feet
N
S
E
W
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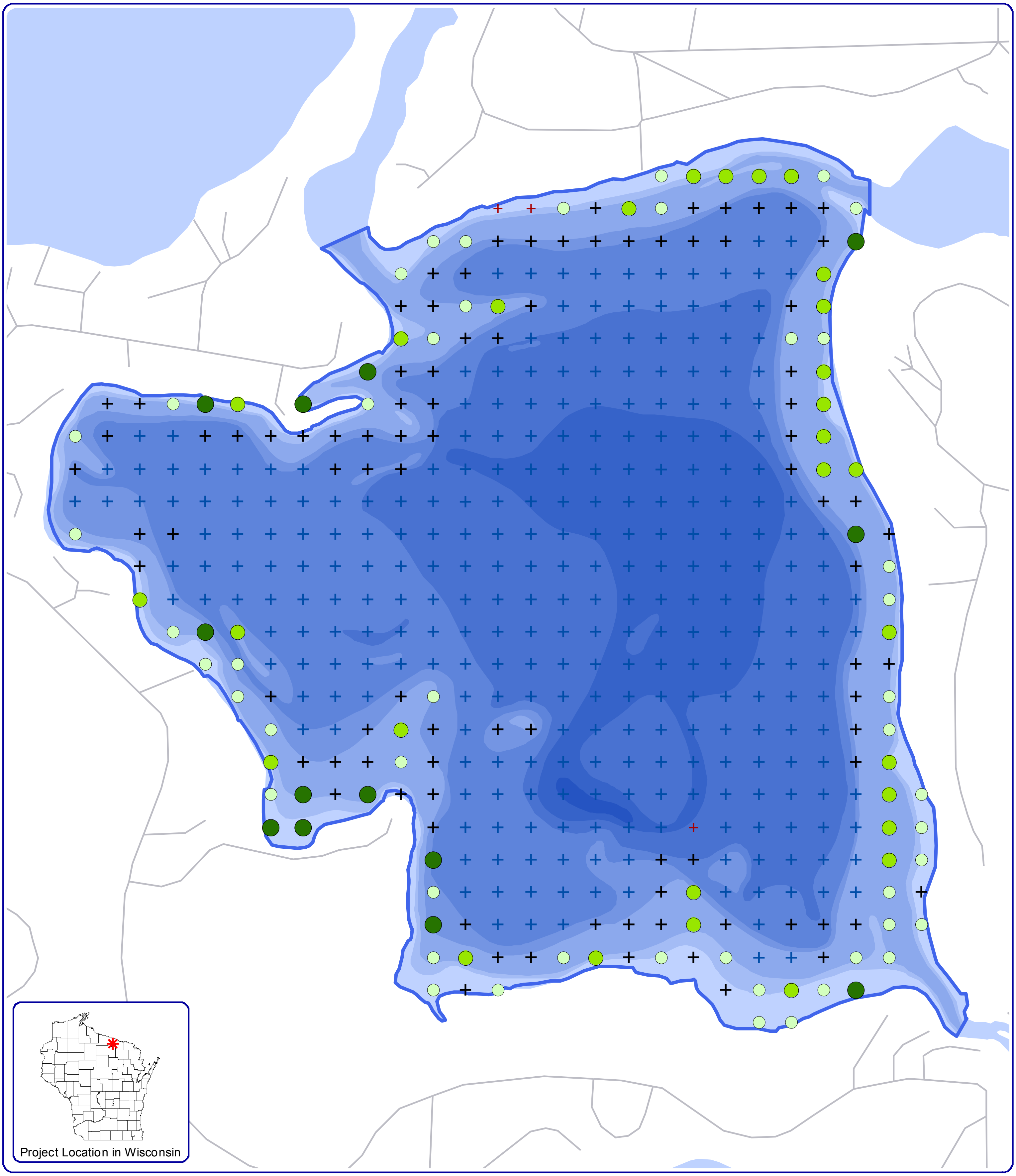
De Pere, WI 54115
920.338.8860
www.onterra-eco.com
Sources:
Orthophotography: NAIP, 2013
SCA Survey: Onterra, 2014
Map date: October 13, 2014
Filename: Eagle_Map2_CWH_2014.mxd
Legend
2-8 Inch Pieces
No Branches
Minimal Branches
Moderate Branches
Full Canopy
8+ Inch Pieces
No Branches
Minimal Branches
Moderate Branches
Full Canopy
Cluster of Pieces
No Branches
Minimal Branches
Moderate Branches
Full Canopy
Eagle Lake - Map 2
Lower Eagle River
Chain of Lakes
Vilas County, Wisconsin
2014 Course
Woody Habitat



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Sources:
Plant Survey: Onterra, 2012
Map date: October 13, 2014
Filename: Eagle_Map3_TRFPI_2012.mxd

Legend

- No Vegetation
- Total Rake Fullness = 1
- Total Rake Fullness = 2
- Total Rake Fullness = 3
- Greater Than Max Depth of Plants
- Non-Navigable

Eagle Lake - Map 3
Lower Eagle River
Chain of Lakes
Vilas County, Wisconsin

2012 Aquatic Plant Distribution

N W E S

910

Feet

Legend

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

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Sources:
Orthophotography: NAIP, 2013
Plant Survey: Onterra, 2014
Map date: October 13, 2014
Filename: Eagle_Map4_Comm_2014.mxd

Eagle Lake - Map 4
Lower Eagle River
Chain of Lakes
Vilas County, Wisconsin

Emergent & Floating-Leaf Aquatic Plant Communities