

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

8.1 Cranberry Lake

An Introduction to Cranberry Lake

Cranberry Lake, Oneida and Vilas County, is a shallow, lowland drainage lake with a maximum depth of 23 feet, a mean depth of 9 feet, and a surface area of approximately 929 acres. It is the upstream-most lake in the Lower Eagle River Chain, and is fed and drained via the Eagle River. The lake is currently in a eu trophic state, and has a surficial watershed that encompasses approximately 97,792 acres. In 2012, 52 native aquatic plant species were located in the lake, of which slender naiad (*Najas flexilis*) was the most common. Four non-native plants, Eurasian water milfoil, purple loosestrife, pale-yellow iris, and yellow garden loosestrife were observed growing in the lake or along the shoreline in 2012.

Field Survey Notes

Cranberry Lake is a productive lake with a diverse aquatic plant community, particularly within the upstream channel. Two relatively rare aquatic plant species, apline pondweed and spiny hornwort, were located in this area. Vasey's pondweed, a state-listed special concern species, is relatively abundant throughout littoral areas of the lake.



Photo 8.1 Cranberry Lake, Oneida and Vilas Counties

Lake at a Glance* – Cranberry Lake

Morphology	
Acreage	929
Maximum Depth (ft)	23
Mean Depth (ft)	9
Volume (acre-feet)	8,361
Shoreline Complexity	7.9
Vegetation	
Curly-leaf Survey Date	July 11, 2013
Comprehensive Survey Date	July 31, 2012
Number of Native Species	52
Threatened/Special Concern Species	Vasey's pondweed (<i>Potamogeton vaseyi</i>)
Exotic Plant Species	Eurasian water milfoil; Purple loosestrife; Pale-yellow iris; Garden yellow loosestrife
Simpson's Diversity	0.92
Average Conservatism	7.0
Water Quality	
Wisconsin Lake Classification	Shallow, Lowland Drainage
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Watershed to Lake Area Ratio	106:1

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

8.1.1 Cranberry Lake Water Quality

Water quality data was collected from Cranberry Lake on six occasions in 2013/2014. 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 2013/2014, any historical data was researched and are included within this report as available.

A fair amount of data exists for two water quality parameters of interest – total phosphorus and chlorophyll-*a* concentrations. In 2013, average summer phosphorus concentrations (35.4 µg/L) were only slightly higher than the median value (33.0 µg/L) for other shallow, lowland drainage lakes in the state (Figure 8.1.1-1) The values measured through this management planning process are similar to several data points which were collected in years past. A weighted value from all available data ranks as *Good* for a shallow, lowland drainage lake.

Total phosphorus surface values from 2013-2014 are compared with bottom-lake samples collected during this same time frame in Figure 8.1.1-2. As displayed in this figure, on several occasions surface and bottom total phosphorus concentrations were similar. However on some occasions, namely during June, July and August of 2013, the bottom phosphorus concentrations were much greater than the relatively low surface concentrations. During these periods, anoxic conditions were recorded near the bottom of the lake through measurement of dissolved oxygen (refer to Figure 8.1.1-6 and associated text). This is an indication of hypolimnetic nutrient recycling, or internal nutrient loading, which is a process discussed further in the Eagle River Chain-wide document. While this process may be contributing some phosphorus to Cranberry Lake's water column, the impacts of nutrient loading are not apparent in the lake's overall water quality; as previously mentioned, Cranberry Lake's surface water total phosphorus values are about the same as the median value for comparable lakes in Wisconsin.

2013 summer average chlorophyll-*a* concentrations (25.7 µg/L) were roughly 2.5 times the median value (9.4 µg/L) for chlorophyll-*a* in other lakes of this type (Figure 8.1.1-3). The 2013 value is almost five times higher than the median for all lakes in the Northern Lakes and Forests ecoregion. A weighted value over all years is considerably higher than these two comparables as well. Despite the higher chlorophyll-*a* reading, the highest of average values in the dataset remain in the lower portion of the *Fair* category for shallow, lowland drainage lakes.

Overall, total phosphorus and chlorophyll-*a* weighted summer averages rank within a TSI category of *Good to Fair*, indicating the lake has enough nutrients for production of aquatic plants, algae, and other organisms but not so much that a water quality issue is present. During 2013 visits to the lake, Onterra ecologists recorded field notes describing good water conditions, though slightly stained water. As explained below, the stained water is not due to nutrients or another form of pollution.

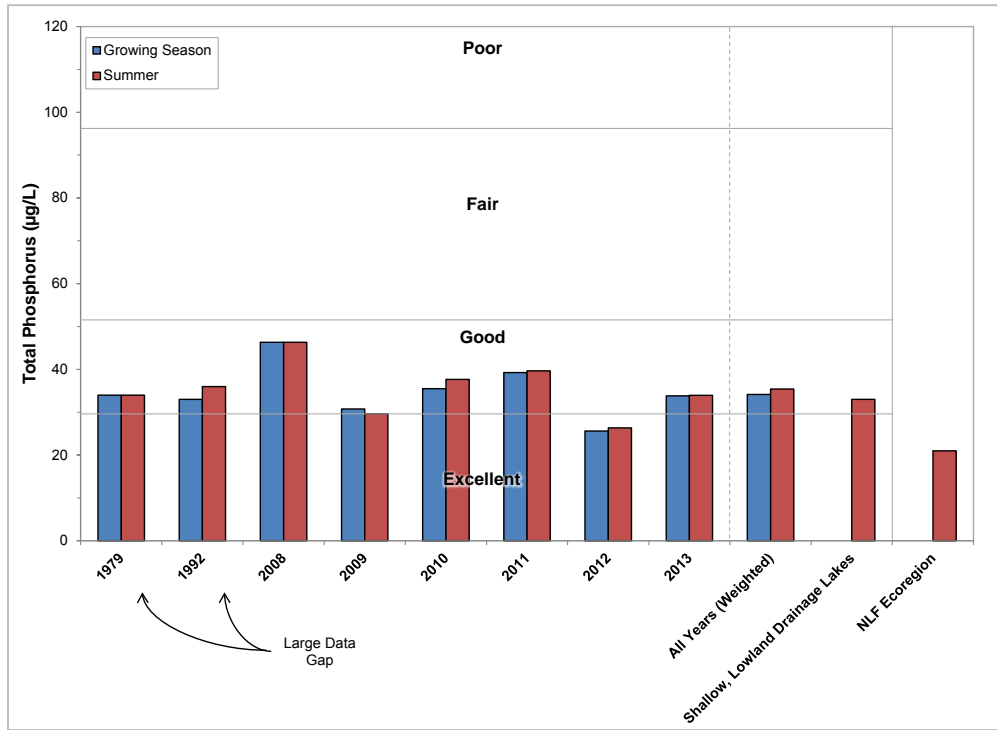


Figure 8.1.1-1. Cranberry Lake, statewide shallow, lowland drainage lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

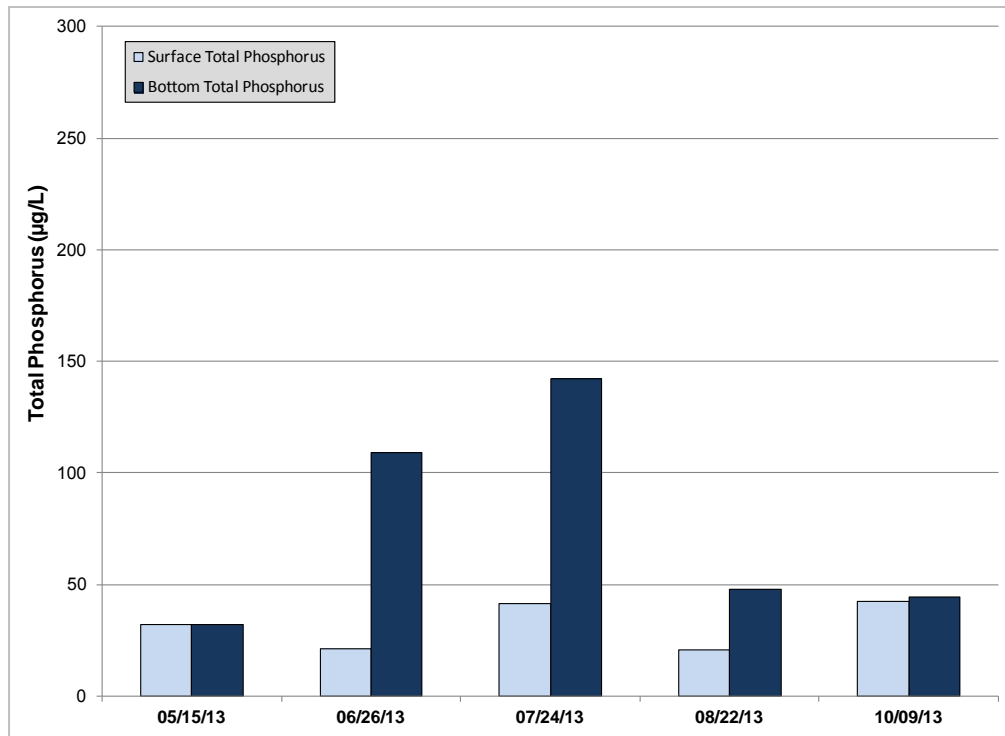


Figure 8.1.1-2. Cranberry Lake surface and bottom total phosphorus values, 2013. Anoxia was observed in the hypolimnion of the lake during summer sampling visits.

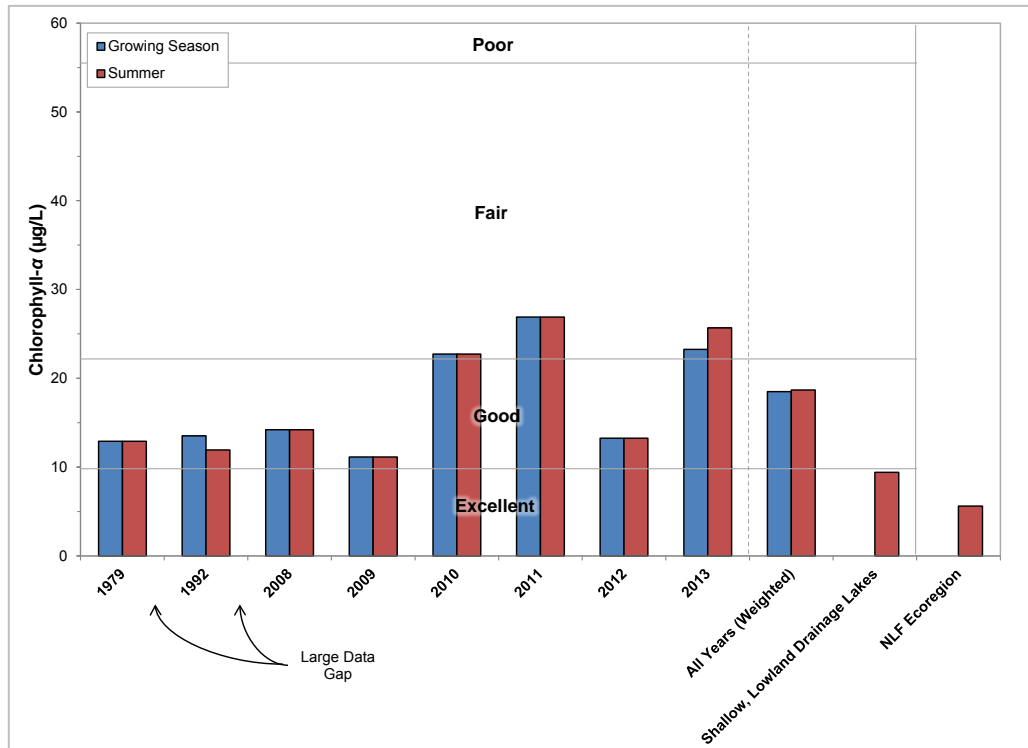


Figure 8.1.1-3. Cranberry Lake, statewide shallow, lowland drainage lakes, and regional chlorophyll-a concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

From the examination of nearly three decades worth of intermittent Secchi disk clarity data, several conclusions can be drawn. First, the clarity of Cranberry Lake’s water can be described as between *Good* and *Excellent* in most years (Figure 8.1.1-4). A weighted average over this timeframe is about the same as the median value for other shallow, lowland drainage lakes in the state but lower than the median value for lakes within the ecoregion. Secondly, there is no apparent trend in the clarity of the water in Cranberry Lake; the data indicate that clarity may differ from one year to the next, but has not gotten “worse” or “better” over this time period. Annual variation is however apparent.

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 Cranberry 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 Cranberry 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” measures the dissolved organic materials in water. Water samples collected in April and July of 2013 were measured for this parameter, and were found to be at 50 and 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.

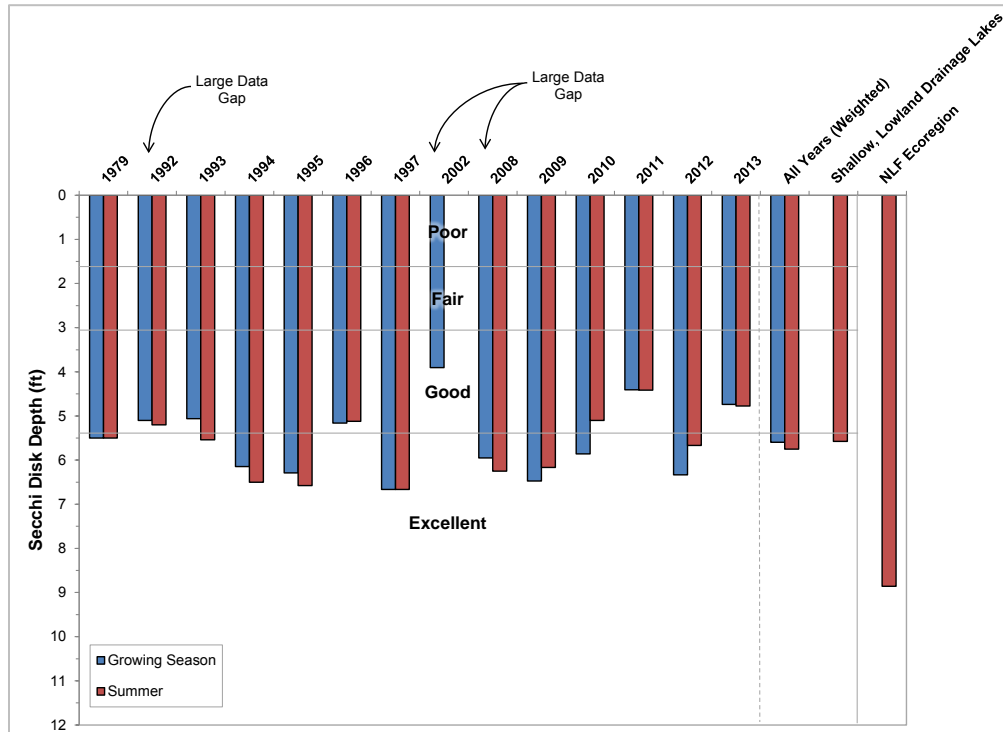


Figure 8.1.1-4. Cranberry Lake, statewide shallow, lowland drainage lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Cranberry Lake Trophic State

The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning the eutrophic category (Figure 8.1.1-5). In general, the best values to use in judging a lake’s trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* TSI values, it can be concluded that Cranberry Lake is in a eutrophic state.

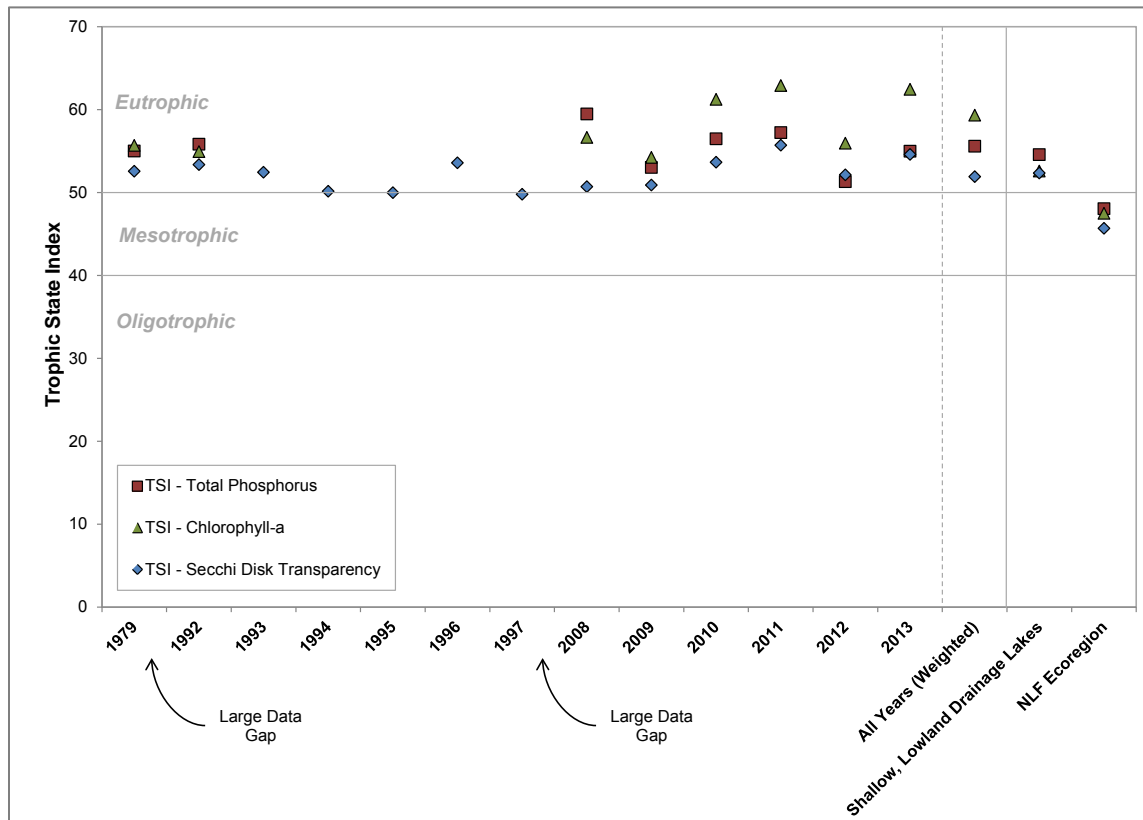


Figure 8.1.1-5. Cranberry Lake, statewide shallow, lowland drainage lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Cranberry Lake

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Cranberry Lake by Onterra staff. Graphs of those data are displayed in Figure 8.1.1-6 for all sampling events.

Cranberry 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 void of oxygen and temperatures remain fairly cool as they were in the spring months. This occurrence is not uncommon in deeper 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. In a relatively large and shallow lake such as Cranberry Lake, this thermal barrier may break during the summer months, re-oxygenating the hypolimnion and potentially releasing some nutrients to surface waters.

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 2014, oxygen levels remained sufficient throughout most of the water column to support most aquatic life in northern Wisconsin lakes.

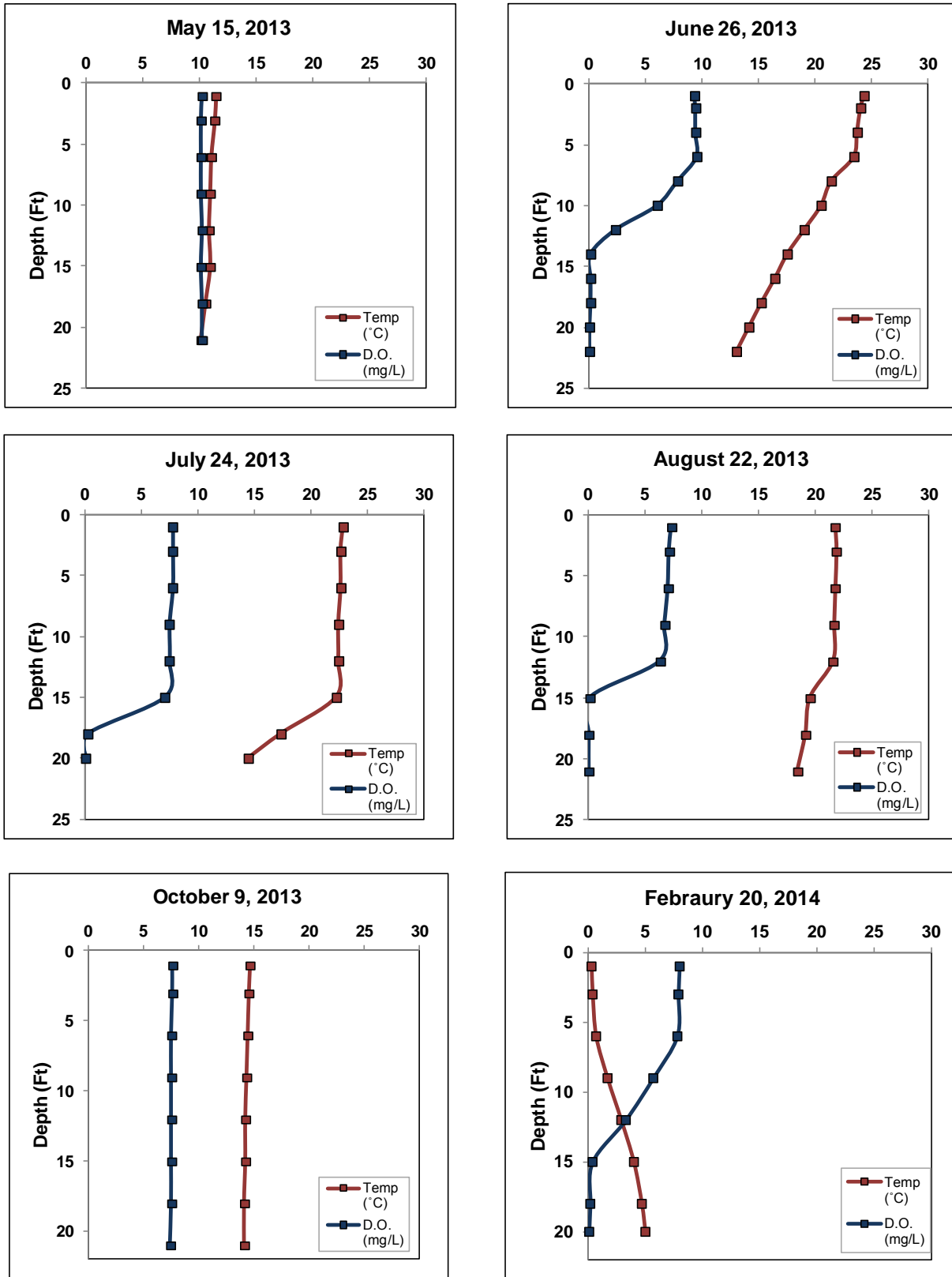


Figure 8.1.1-6. Cranberry Lake 2013/2014 dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Cranberry 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 Cranberry Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include; pH, alkalinity, calcium, and true color.

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. Cranberry Lake's surface water pH was measured at roughly 6.9 during May and 8.1 during July of 2013. 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 adds 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 Cranberry Lake was measured at 27.0 mg/L as $CaCO_3$ in April and 30.7 in July of 2013. This indicates that the lake has a substantial capacity to resist fluctuations in pH and is not sensitive to acid rain.

Samples of calcium were also collected from Cranberry Lake during 2013. 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 Cranberry Lake's pH of 6.9 – 8.1 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 Cranberry Lake was found to be 7.16 mg/L in June and 8.25 mg/L in August of 2013, which is below the lower range for zebra mussels. Plankton tows were completed by Onterra staff during the summer of 2013 and these samples were processed by the WDNR for larval zebra mussels. *Results to be included within the next draft.*

True color is a measure of water clarity once suspended material (i.e. algae, sediments) has been removed is called true color. True color measures the amount of light scattered and absorbed by organic materials dissolved within the water. Many lakes in the northern region of Wisconsin have natural dissolved organic materials from decomposing plant material delivered from wetlands within the watershed. These give the water a tea-like color and decrease water clarity. Cranberry Lake had an average true color value of 45.0 SU (standard units), indicating the water is most often tea-colored. Lakes with large areas of forests and wetlands within their watersheds tend to have tea-colored or stained water, as these dissolved organic materials within the lake's water originate from decaying vegetation within the watershed.

8.1.2 Cranberry Lake Watershed Assessment

Cranberry Lake's watershed is approximately 97,792 acres in size. Compared to its surface area of 929 acres, this makes for a large watershed to lake area ratio of 106:1.

Exact land cover calculation and modeling of nutrient input to Cranberry 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.

8.1.3 Cranberry 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 2013, Cranberry Lake's immediate shoreline was assessed in terms of its development. Cranberry Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 7.3 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 8.2.3-1). This constitutes about 50% of Cranberry 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, 3.3 miles of urbanized and developed-unnatural shoreline (22%) was observed. If restoration of the Cranberry 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. Cranberry Lake - Map 1 displays the location of these shoreline lengths around the entire lake.

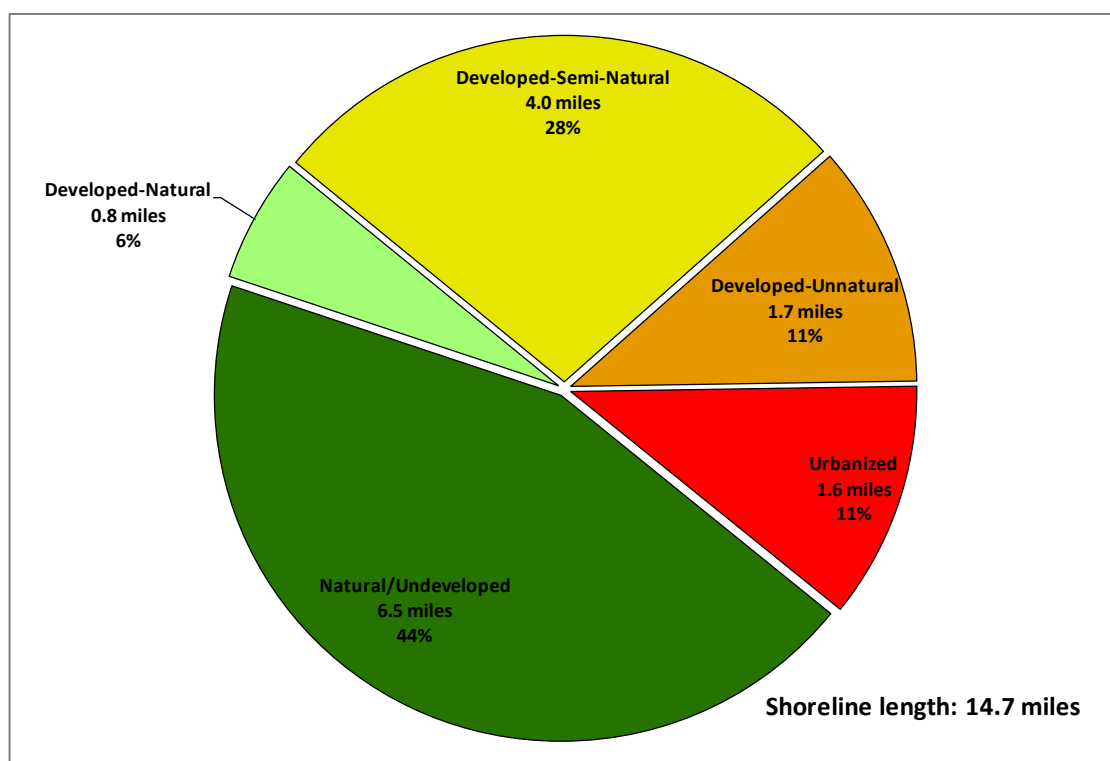


Figure 8.1.3-1. Cranberry Lake shoreland categories and total lengths. Based upon a late summer 2013 survey. Locations of these categorized shorelands can be found on Cranberry Lake - Map 1.

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, 233 total pieces of coarse woody habitat were observed along 14.7 miles of shoreline, which gives Cranberry Lake a coarse woody habitat to shoreline mile ratio of 16:1. Locations of coarse woody habitat are displayed on Cranberry 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).

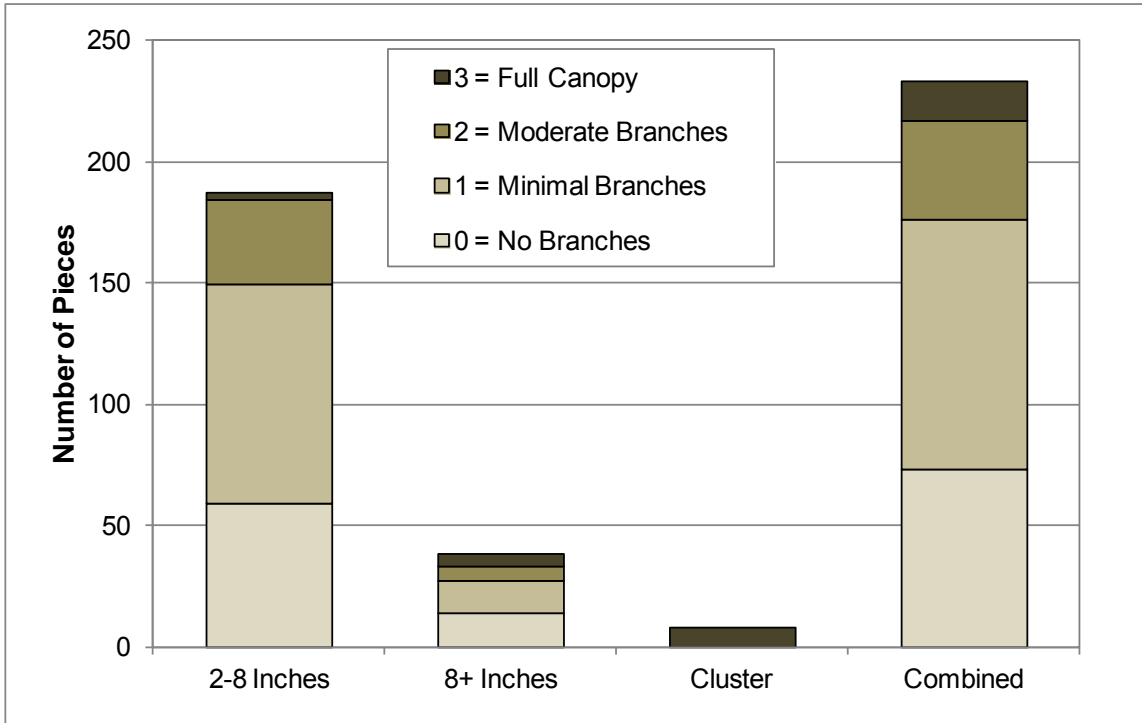


Figure 8.1.3-2. Cranberry Lake coarse woody habitat survey results. Based upon a late summer 2013 survey. Locations of Cranberry Lake coarse woody habitat can be found on Cranberry Lake - Map 2.

8.1.4 Cranberry Lake Aquatic Vegetation

An early season aquatic invasive species survey was conducted on Cranberry Lake on July 11, 2013. 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.

The whole-lake aquatic plant point-intercept survey was conducted on Cranberry Lake by Onterra on July 31, 2012 (Figure 8.1.4-1), while the aquatic plant community mapping survey was conducted on August 14 and 15, 2013. During these surveys, a total of 56 aquatic plant species were located, four of which is considered to be a non-native, invasive species: Eurasian water milfoil, purple loosestrife, pale-yellow iris, and yellow garden loosestrife (Table 8.1.4-1). 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.

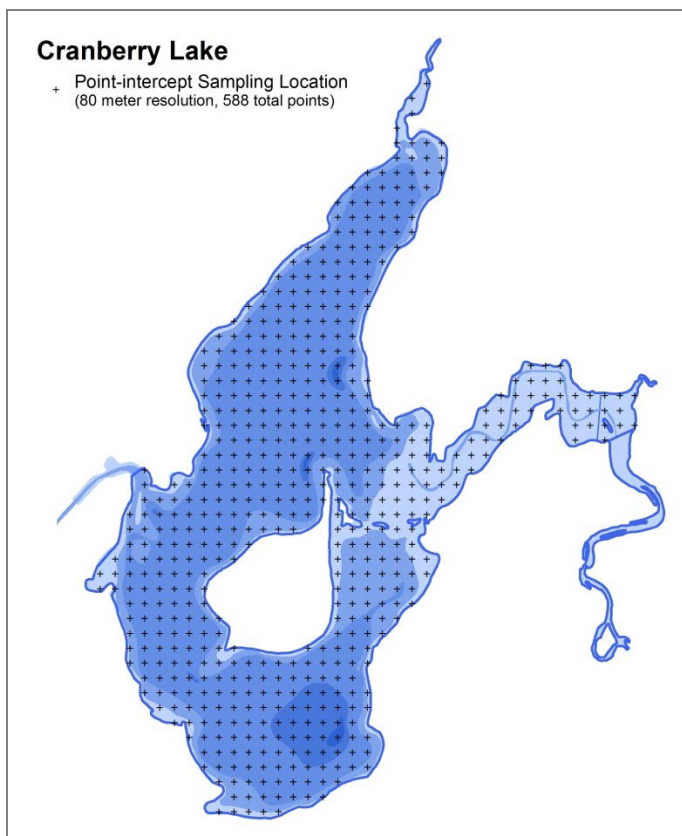


Figure 8.1.4-1. Point-intercept locations on Cranberry Lake.

As discussed in the primer section, sediment data were collected at each sampling location within the littoral zone during the point-intercept survey. Approximately 57% of the point-intercept locations within littoral areas contained fine, organic sediments (muck), 39% contained sand, and 4% 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 12 feet, the same as in 2006. 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 8.1.4-1. Aquatic plant species located in Cranberry Lake during 2006 and 2012/2013 aquatic plant surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2006 (NEI)	2012/2013 (Onterra)
E	<i>Calla palustris</i>	Water arum	9		I
	<i>Carex comosa</i>	Bristly sedge	5		I
	<i>Carex crinita</i>	Fringed sedge	6		I
	<i>Carex utriculata</i>	Common yellow lake sedge	7		I
	<i>Decodon verticillatus</i>	Water-willow	7		I
	<i>Dulichium arundinaceum</i>	Three-way sedge	9		I
	<i>Eleocharis palustris</i>	Creeping spikerush	6		I
	<i>Equisetum fluviatile</i>	Water horsetail	7		I
	<i>Iris pseudacorus</i>	Pale-yellow iris	Exotic		I
	<i>Iris versicolor</i>	Northern blue flag	5		I
	<i>Lysimachia vulgaris</i>	Yellow garden loosestrife	Exotic		I
	<i>Lythrum salicaria</i>	Purple loosestrife	Exotic		I
	<i>Pontederia cordata</i>	Pickereelweed	9		X
	<i>Sagittaria latifolia</i>	Common arrowhead	3		I
	<i>Sagittaria rigida</i>	Stiff arrowhead	8		I
	<i>Sagittaria</i> sp. (sterile)	Arrowhead sp. (sterile)	N/A		I
	<i>Schoenoplectus acutus</i>	Hardstem bulrush	5		I
<i>Schoenoplectus tabernaemontani</i>	Softstem bulrush	4		I	
<i>Typha</i> spp.	Cattail spp.	1		I	
FL	<i>Brasenia schreberi</i>	Watershield	7		X
	<i>Nuphar variegata</i>	Spatterdock	6	X	X
	<i>Nymphaea odorata</i>	White water lily	6	X	X
FL/E	<i>Sparganium americanum</i>	Eastern bur-reed	8		I
	<i>Sparganium androcladum</i>	Shining bur-reed	8		X
	<i>Sparganium angustifolium</i>	Narrow-leaf bur-reed	9		X
	<i>Sparganium emersum</i>	Short-stemmed bur-reed	8		I
	<i>Sparganium eurycarpum</i>	Common bur-reed	5		I
	<i>Sparganium fluctuans</i>	Floating-leaf bur-reed	10		X
Submergent	<i>Bidens beckii</i>	Water marigold	8		X
	<i>Ceratophyllum demersum</i>	Coontail	3	X	X
	<i>Ceratophyllum echinatum</i>	Spiny hornwort	10		X
	<i>Chara</i> spp.	Muskgrasses	7	X	
	<i>Elodea canadensis</i>	Common waterweed	3	X	X
	<i>Heteranthera dubia</i>	Water stargrass	6		X
	<i>Myriophyllum sibiricum</i>	Northern water milfoil	7	X	X
	<i>Myriophyllum spicatum</i>	Eurasian water milfoil	Exotic	X	X
	<i>Myriophyllum verticillatum</i>	Whorled water milfoil	8	X	X
	<i>Najas flexilis</i>	Slender naiad	6	X	X
	<i>Nitella</i> spp.	Stoneworts	7	X	X
	<i>Potamogeton alpinus</i>	Alpine pondweed	9		I
	<i>Potamogeton amplifolius</i>	Large-leaf pondweed	7	X	X
	<i>Potamogeton ephedrus</i>	Ribbon-leaf pondweed	8		X
	<i>Potamogeton foliosus</i>	Leafy pondweed	6		X
	<i>Potamogeton hybrid</i>	Hybrid pondweed	N/A		X
	<i>Potamogeton natans</i>	Floating-leaf pondweed	5	X	I
	<i>Potamogeton pusillus</i>	Small pondweed	7	X	X
	<i>Potamogeton richardsonii</i>	Clasping-leaf pondweed	5		X
	<i>Potamogeton robbinsii</i>	Fern pondweed	8	X	X
	<i>Potamogeton spirillus</i>	Spiral-fruited pondweed	8	X	X
	<i>Potamogeton strictifolius</i>	Stiff pondweed	8		X
	<i>Potamogeton vaseyi</i> *	Vasey's pondweed	10	X	X
	<i>Potamogeton zosteriformis</i>	Flat-stem pondweed	6	X	X
	<i>Sagittaria</i> sp. (rosette)	Arrowhead rosette	N/A		X
	<i>Sparganium</i> sp.	Bur-reed sp.	N/A	X	
<i>Utricularia vulgaris</i>	Common bladderwort	7	X	X	
<i>Vallisneria americana</i>	Wild celery	6	X	X	
S/E	<i>Eleocharis acicularis</i>	Needle spikerush	5		X
FF	<i>Lemna trisulca</i>	Forked duckweed	6		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 309 point-intercept sampling locations that fell at or below the maximum depth of plant growth in 2012, approximately 55% contained aquatic vegetation. This is higher than what was found in the 2006 survey where approximately 39% of the littoral sampling locations contained aquatic vegetation. Cranberry Lake – Map 3 displays the point-intercept locations that contained aquatic vegetation in 2012, and the total rake fullness ratings at those locations. Most of the aquatic vegetation in 2012 was located within shallower areas of the lake, mainly near shore and in the western portion of the lake up into the channel. Twenty-four percent of the point-intercept locations had a total rake fullness (TRF) rating of 2, 17% had a total rake fullness rating of 1, and 14% 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.

Table 8.1.4-1 displays the aquatic plant species located in Cranberry Lake during the 2006 Northern Environmental, Inc. (NEI) and Onterra 2012 point-intercept surveys. All of the plants that surveyors had located in 2006 were re-recorded in 2012. An additional 13 native aquatic plant species were located in 2012 that had not been recorded in 2006, including two relatively rare, sensitive species: spiny hornwort and alpine pondweed. This increase in the number of species recorded in 2012 is likely due to differences in the aquatic plant identification abilities of the surveyors.

Of the 33 aquatic plant species recorded on the rake during the 2012 point-intercept survey, slender naiad, spiral-fruited pondweed, wild celery, and Vasey's pondweed were the four-most frequently encountered (Figure 8.1.4-2). Slender naiad, the most abundant aquatic plant in Cranberry Lake in 2012 with a littoral occurrence of nearly 30%, 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.

Spiral-fruited pondweed was the second-most abundant aquatic plant encountered in 2012, with a littoral occurrence of approximately 19%. As its name indicates, this plant produces fruit with a distinct coiled embryo and is one of several narrow-leaved pondweed species that can be found in Wisconsin. In mid-summer, the floating leaves of spiral-fruited pondweed can be observed on the surface in shallow water (Photo 8.1.4-1). The submersed leaves are long and narrow, and are usually curved. Like slender naiad, spiral-fruited pondweed is food and habitat source for wildlife.

Wild celery, or tape grass, was the third-most abundant aquatic plant encountered in 2012 with a littoral occurrence of approximately 19%. This species has bundles of long submersed leaves that are flat and ribbon-like which emerge from a basal 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).

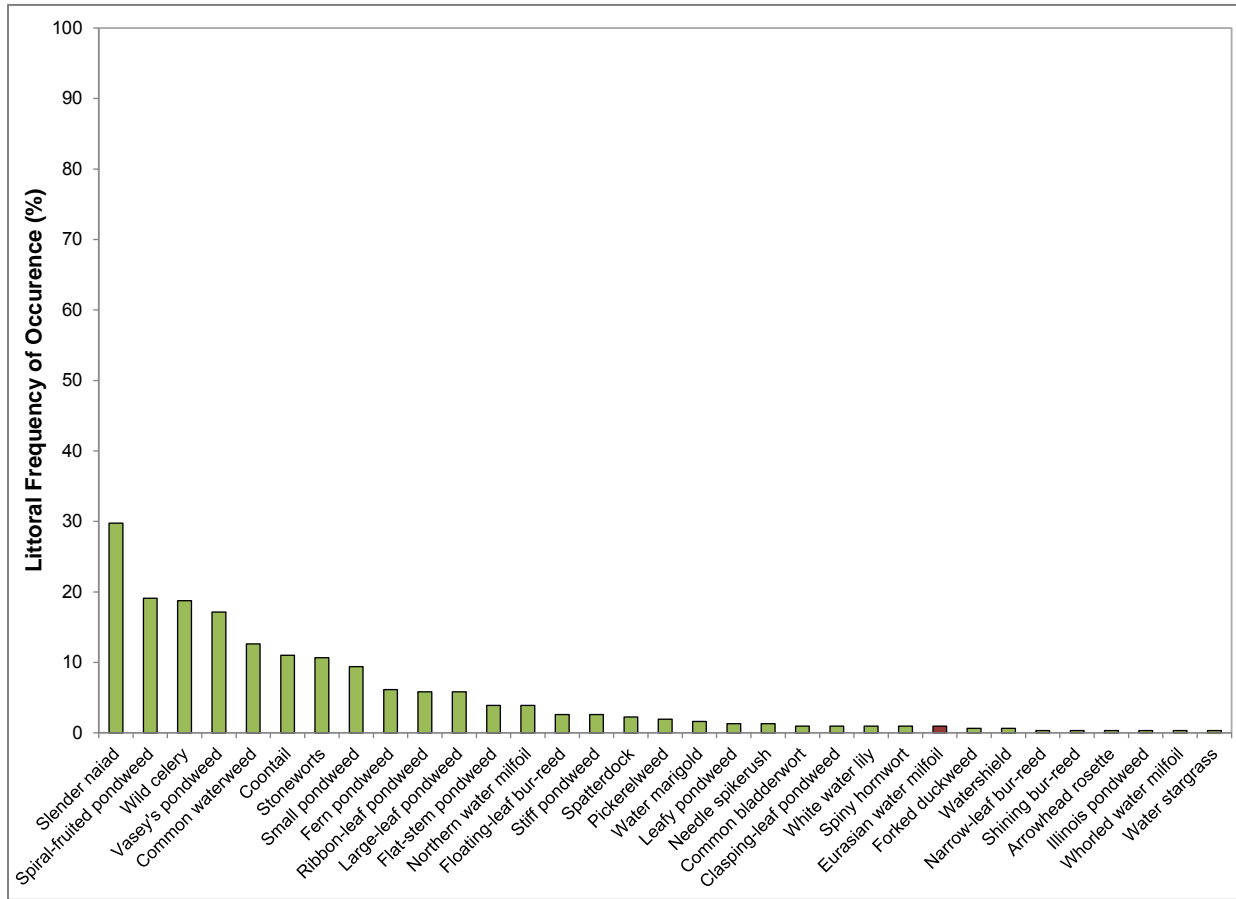


Figure 8.1.4-2. Cranberry Lake 2012 aquatic plant littoral frequency of occurrence. Created using data from 2012 aquatic plant point-intercept survey. Non-native species are indicated in red.

Vasey’s pondweed was the fourth-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 Cranberry Lake is an indicator of a high-quality environment.

To determine if the 2008-2012 Eurasian water milfoil control project on Cranberry 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 8.1.4-3 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 Cranberry Lake.

As illustrated, the occurrence of Eurasian water milfoil in Cranberry Lake was found to be not statistically different from 2006 to 2012, and had a littoral occurrence of around 1% in both surveys. However, from the annual Eurasian water milfoil mapping surveys, it is clear that Eurasian water milfoil within Cranberry Lake did increase since 2006. Had point-intercept surveys been conducted on an annual basis, this likely would have been captured. It is believed that the herbicide treatments have been effective at reducing and maintaining a low population of Eurasian water milfoil in Cranberry Lake. Five of the native aquatic plant species that had an occurrence of at least 5% in 2006 or 2012 saw statistically valid increases in their littoral occurrence, while the other five did not have statistically different occurrences from 2006 to 2012 (Figure 8.1.4-3). From these data, it appears that the Eurasian water milfoil control program has not had any detectable adverse effects on any of the aquatic plant species' populations in Cranberry Lake.

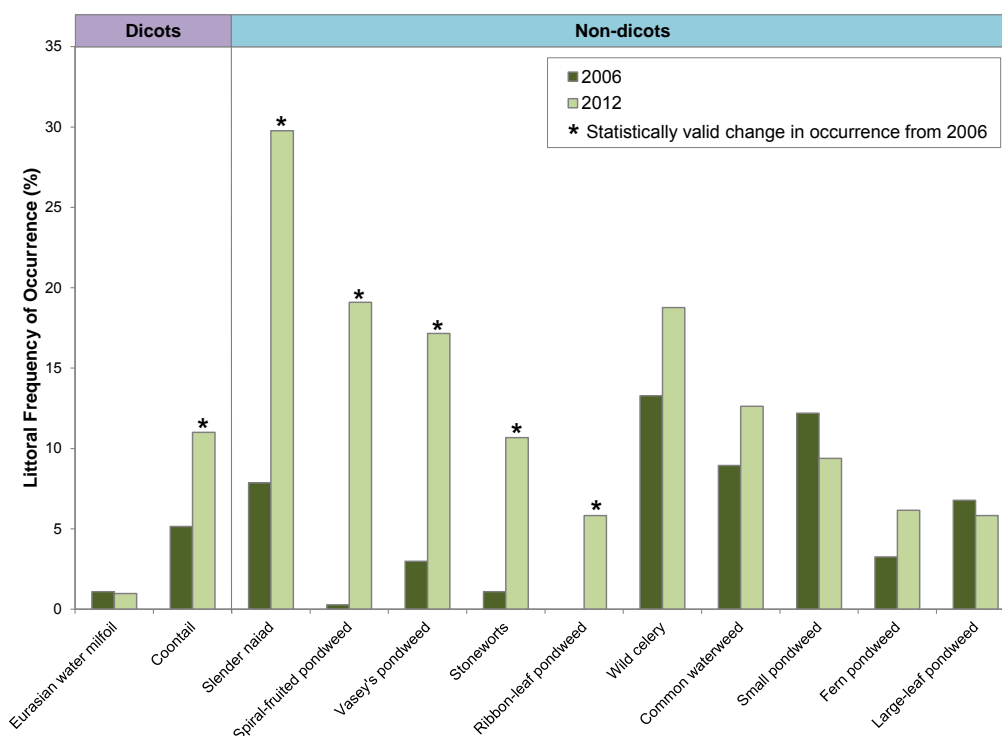


Figure 8.1.4-3. Cranberry Lake littoral frequency of occurrence of select aquatic plant species from 2006 and 2012 point-intercept surveys. Please note that only those native species with an occurrence of at least 5% in one of the two surveys are displayed. Created using data from 2006 and 2012 point-intercept 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 34 native aquatic plant species were located in Cranberry Lake during the 2012 survey, 32 were encountered on the rake and two were incidentally located. These 32 native species and their conservatism values were used to calculate the FQI of Cranberry Lake's aquatic plant community in 2012 (equation on next page). The FQI was also calculated based on the species located during the 2006 survey.

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

Figure 8.1.4-4 compares the FQI components of Cranberry 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, Cranberry Lake’s native species richness (32) is significantly higher than the median values for lakes within the ecoregion and the state. The average conservatism value in 2012 (7.0) is also exceeds the ecoregional and state medians. Combining Cranberry Lake’s 2012 native species richness and average conservatism values yields an exceptionally high FQI value of 39.6, which greatly exceeds the ecoregional and state median values (Figure 8.1.4-4). The FQI values from 2012 are also much higher than those calculated from point-intercept survey in 2006, indicating that the quality of Cranberry Lake’s aquatic plant community has not been diminished by the Eurasian water milfoil control project. This analysis indicates that Cranberry Lake’s aquatic plant community is of higher quality than the majority of lakes within the ecoregion and the entire state.

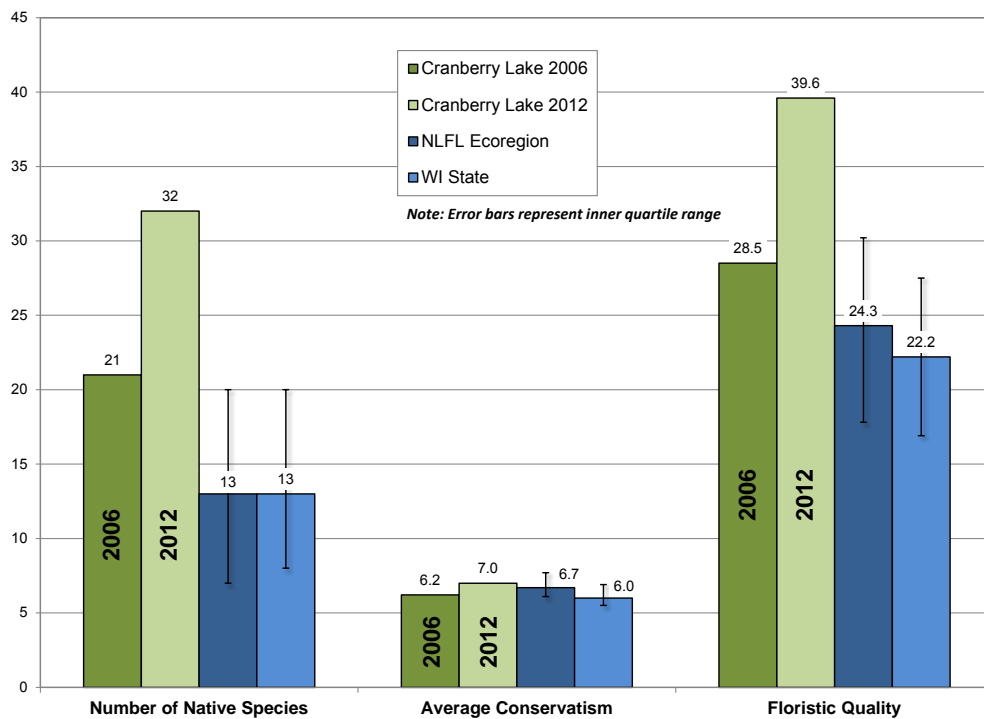


Figure 8.1.4-4. Cranberry Lake Floristic Quality Index values. Created using data from 2006 and 2012 point-intercept surveys. Analysis follows Nichols (1999) where NLFL = Northern Lakes and Forests Lakes Ecoregion.

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 Cranberry 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 Cranberry Lake's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLF Ecoregion (Figure 8.1.4-5). Using the data collected from the 2012 point-intercept survey, Cranberry Lake's aquatic plant community was shown to have exceptionally high species diversity with a Simpson's diversity value of 0.92, falling above the upper quartile value for lakes in both the ecoregion and the state. Cranberry Lake's 2012 diversity was very similar to the diversity calculated from data collected during the 2006 point-intercept survey (0.91).

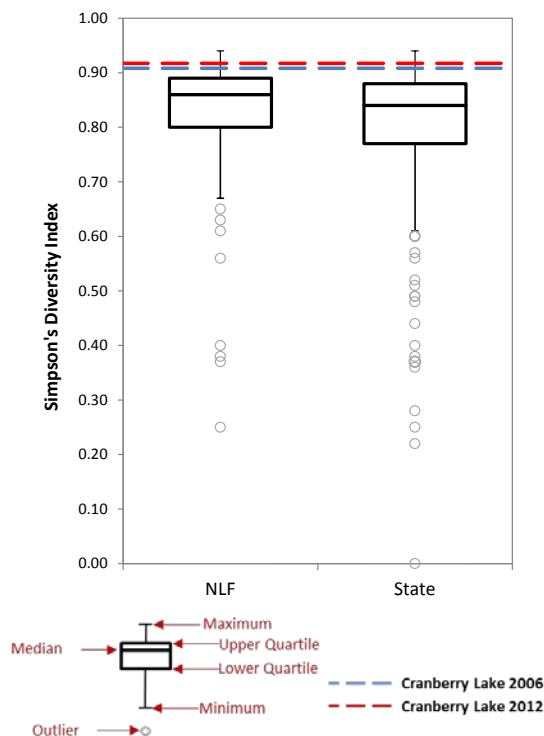


Figure 8.1.4-5. Cranberry Lake species diversity index. Created using data from 2006 and 2012 point-intercept surveys. Ecoregion data provided by WDNR Science Services.

Figure 8.1.4-6 displays the relative frequency of occurrence of aquatic plant species in Cranberry 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.

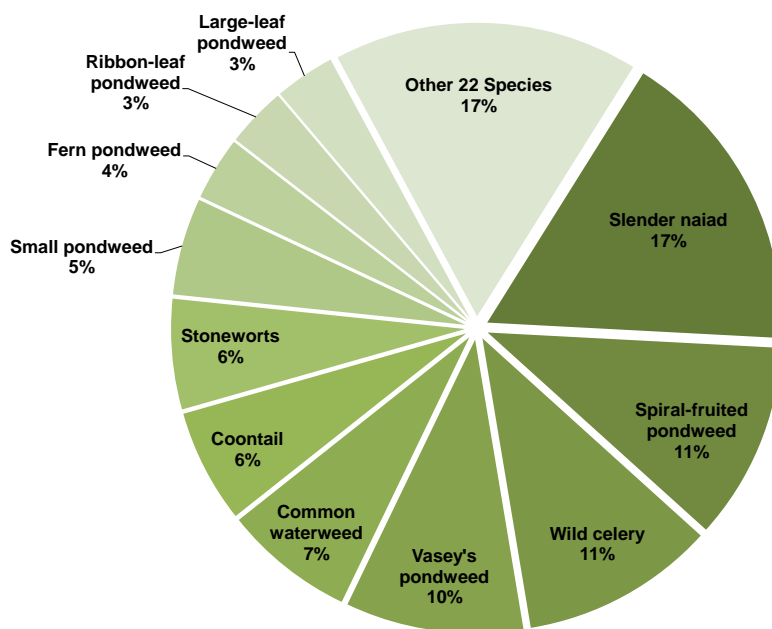


Figure 8.1.4-6. Cranberry Lake 2012 aquatic plant relative frequency of occurrence. Created using data from 2012 aquatic plant point-intercept survey.

Overall, the 2012 point-intercept survey on Cranberry Lake indicated that there have been no detectable adverse lake-wide impacts to any of the lake’s native aquatic plant species and to the entire community over the course of the five-year Eurasian water milfoil control project. The native species richness, average conservatism, Floristic Quality, and species diversity all increased from 2006 to 2012. A Eurasian water milfoil treatment did occur in 2012 and information regarding this treatment can be found in the Lower Eagle River Chain 2012 Treatment Report (January 2013).

The 2013 aquatic plant community mapping survey revealed that Cranberry Lake contains approximately 72.3 acres of emergent and floating-leaf aquatic plant communities (Table 8.1.4-2, Cranberry Lake – Map 4 and 5). Twenty-six emergent and floating-leaf aquatic plant species were located in the lake in 2012 (Table 8.1.4-1). 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 Cranberry Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development.

Table 8.1.4-2. Acres of emergent and floating-leaf aquatic plant communities in Cranberry Lake. Created using data from 2013 aquatic plant community mapping survey.

Plant Community	2013 Acres
Emergent	4.7
Floating-Leaf	6.5
Mixed Emergent & Floating-Leaf	61.1
Total	72.3

8.1.5 Cranberry Lake Implementation Plan

The Implementation Plan below is a result of collaborative efforts between Cranberry Lake stakeholders, ERCLA, and ecologists/planners from Onterra. This plan provides goals and actions created to protect the quality and integrity of Cranberry 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. Cranberry Lake's Implementation Plan illustrates how Cranberry Lake stakeholders should proceed in implementing applicable portions of the Chain-wide Implementation Plan for their lake.

Chain-wide Implementation Plan – Specific to Cranberry Lake

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

Management Action: Continue advanced water quality monitoring of Cranberry Lake's through the WDNR Citizen Lake Monitoring Network (CLMN).

Timeframe: Continuation of current effort

Facilitator: Carole Linn, current Cranberry 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 Cranberry Lake have been collecting water quality data since 1992. The lake is currently enrolled in the advanced monitoring program and has an active volunteer (Carole Linn) who collects and enters water quality data into the WDNR's SWIMS database on an annual basis. Cranberry 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 Carole Linn, 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. Carole Linn, current CLMN volunteer, continues to collect water quality data and enter data into WDNR SWIMS database.
2. Carole Linn, current CLMN volunteer, notifies Dave Mueller or current Lakes and Shores Committee chair when a new Cranberry Lake volunteer is needed.

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

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

Description: As part of the planning project, the entire shoreline of Cranberry Lake was categorized based on the amount of development present. The results of this survey revealed that approximately 22% (3.3 miles) of the shoreline are in an urbanized or developed-unnatural state, 28% (4.0 miles) is in a developed-semi-natural state, and 50% (7.3 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 22% of Cranberry Lake’s shoreline is in a highly-developed state, approximately 50% 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 Cranberry 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. Cranberry Lake stakeholders may assist in this management action by attending educational events held by ERCLA and by aiding in distributing ERCLA materials to Cranberry 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 Cranberry Lake shoreland assessment, approximately 16 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. Cranberry 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. Cranberry Lake stakeholders may participate in a variety of ways to aid in managing aquatic invasive species in Cranberry Lake and throughout the chain. Those who are interested in participating in aquatic invasive species monitoring and management should contact ERCLA.

Cranberry Lake stakeholders can keep themselves up to date on aquatic invasive species matters through attending WDNR training sessions, media releases, or participating in Cranberry Lake Association and ERCLA meetings. Cranberry Lake stakeholders can also participate in the active annual monitoring of Eurasian water milfoil, purple loosestrife, pale-yellow iris, and garden yellow loosestrife on Cranberry Lake and/or volunteer to conduct watercraft inspections at designated boat landings in accordance with the Clean Boats Clean Waters Program. Additionally, Cranberry 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.

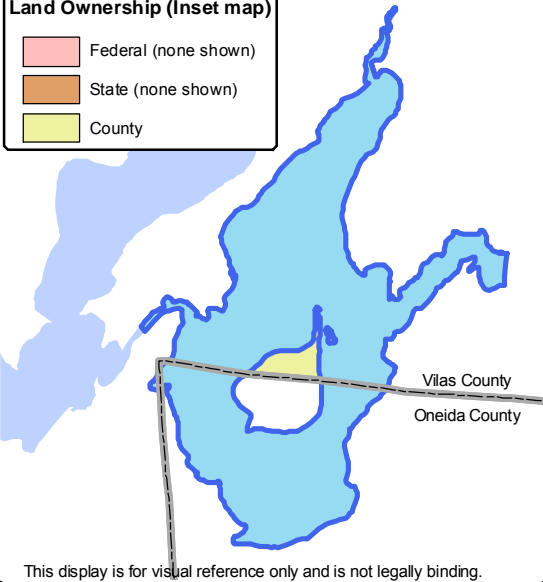
Management Goal 4: Continue and Expand Awareness and Education of Lake Management and Stewardship Matters to Eagle River Chain of Lakes Riparians and the General Public

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.

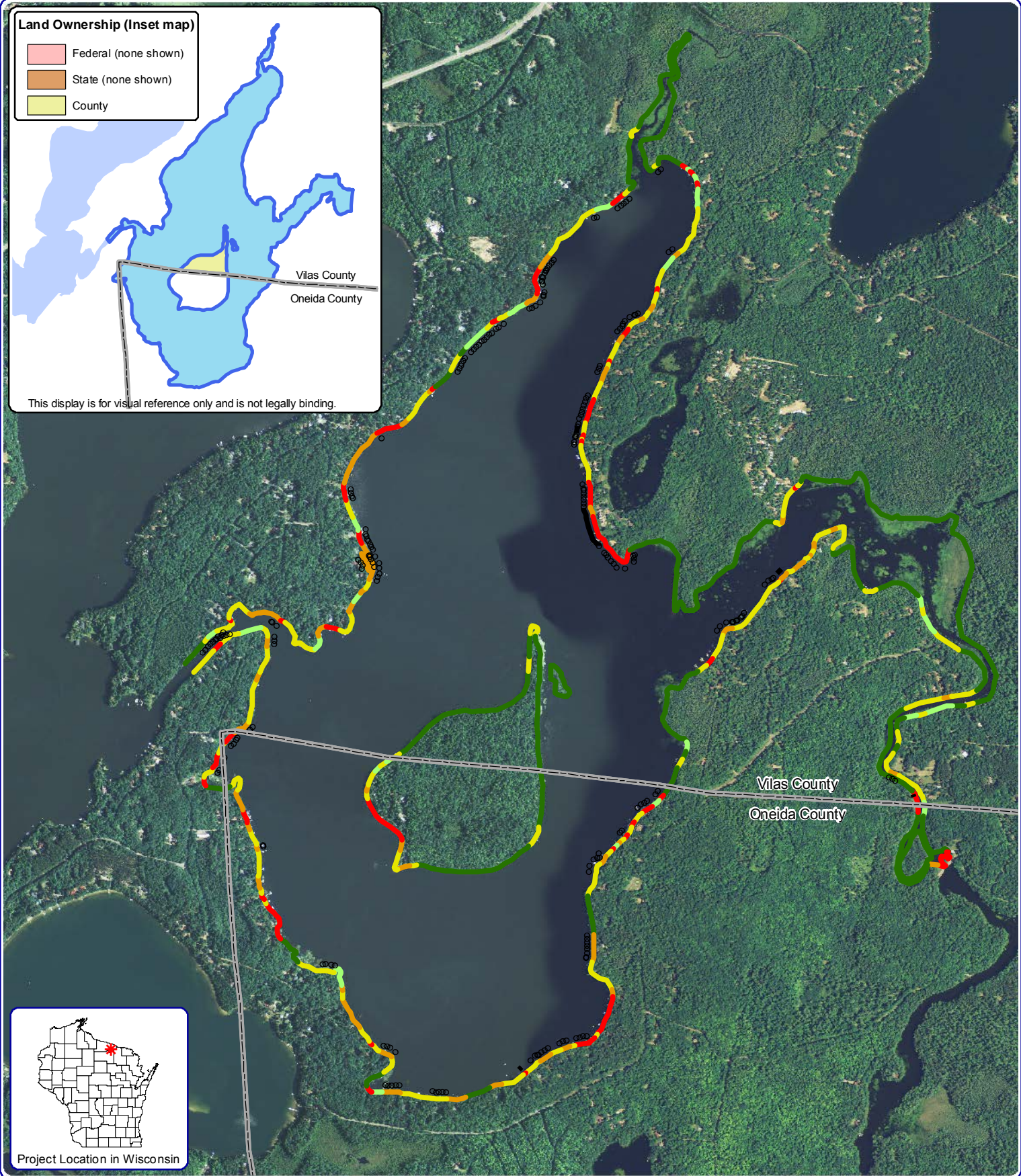
Description: Cranberry Lake stakeholders can assist in the implementation of this action by actively participating in ERCLA-associated educational initiatives. Participation may include attending presentations and trainings of educational topics, volunteering at local and regional events, participating in ERCLA committees, or simply notifying ERCLA of concerns regarding Cranberry Lake and its stakeholders.

Land Ownership (Inset map)

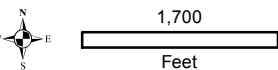
- Federal (none shown)
- State (none shown)
- County



This display is for visual reference only and is not legally binding.



Project Location in Wisconsin



Onterra LLC
 Lake Management Planning
 815 Prosper Rd
 De Pere, WI 54115
 920.338.8860
 www.onterra-eco.com

Sources:
 Orthophotography: NAIP, 2010
 SCA Survey: Onterra, 2013
 Map date: December 2, 2013
 Filename: Cranberry_Map1_SCA_2013.mxd

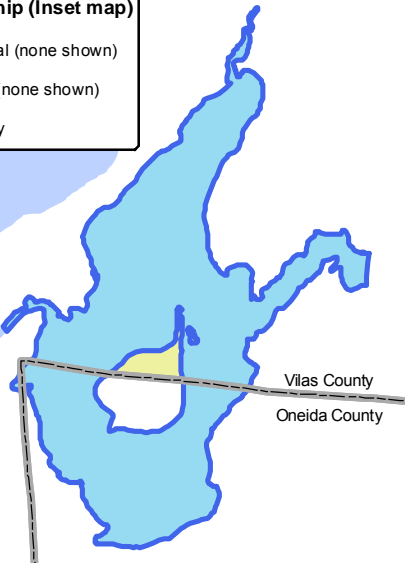
Legend

- Natural/Undeveloped
- Developed-Natural
- Developed-Semi-Natural
- Developed-Unnatural
- Urbanized
- Seawall
- Masonary/Wood/Metal
- Rip-Rap

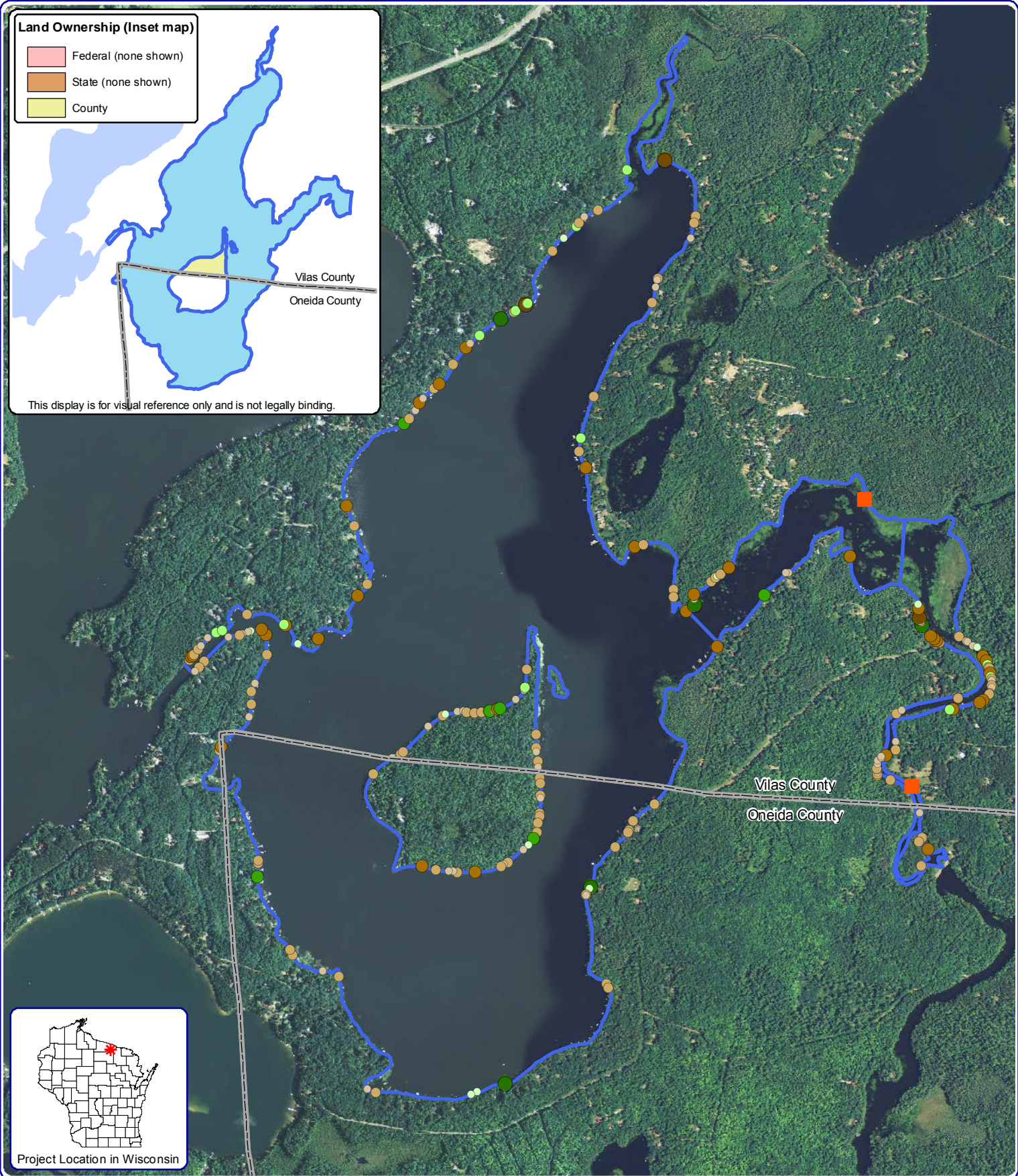
Cranberry Lake - Map 1
 Lower Eagle River
 Chain of Lakes
 Vilas & Oneida Counties, Wisconsin
2013 Shoreland
Condition Assessment

Land Ownership (Inset map)

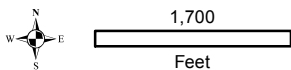
- Federal (none shown)
- State (none shown)
- County



This display is for visual reference only and is not legally binding.



Project Location in Wisconsin



Onterra LLC
 Lake Management Planning
 815 Prosper Rd
 De Pere, WI 54115
 920.338.8860
 www.onterra-eco.com

Sources:
 Orthophotography: NAIP, 2010
 SCA Survey: Onterra, 2013
 Map date: December 2, 2013
 Filename: Cranberry_Map2_CWH_2013.mxd

Legend

2-8 Inch Pieces

- No Branches
- Minimal Branches
- Moderate Branches
- Full Canopy

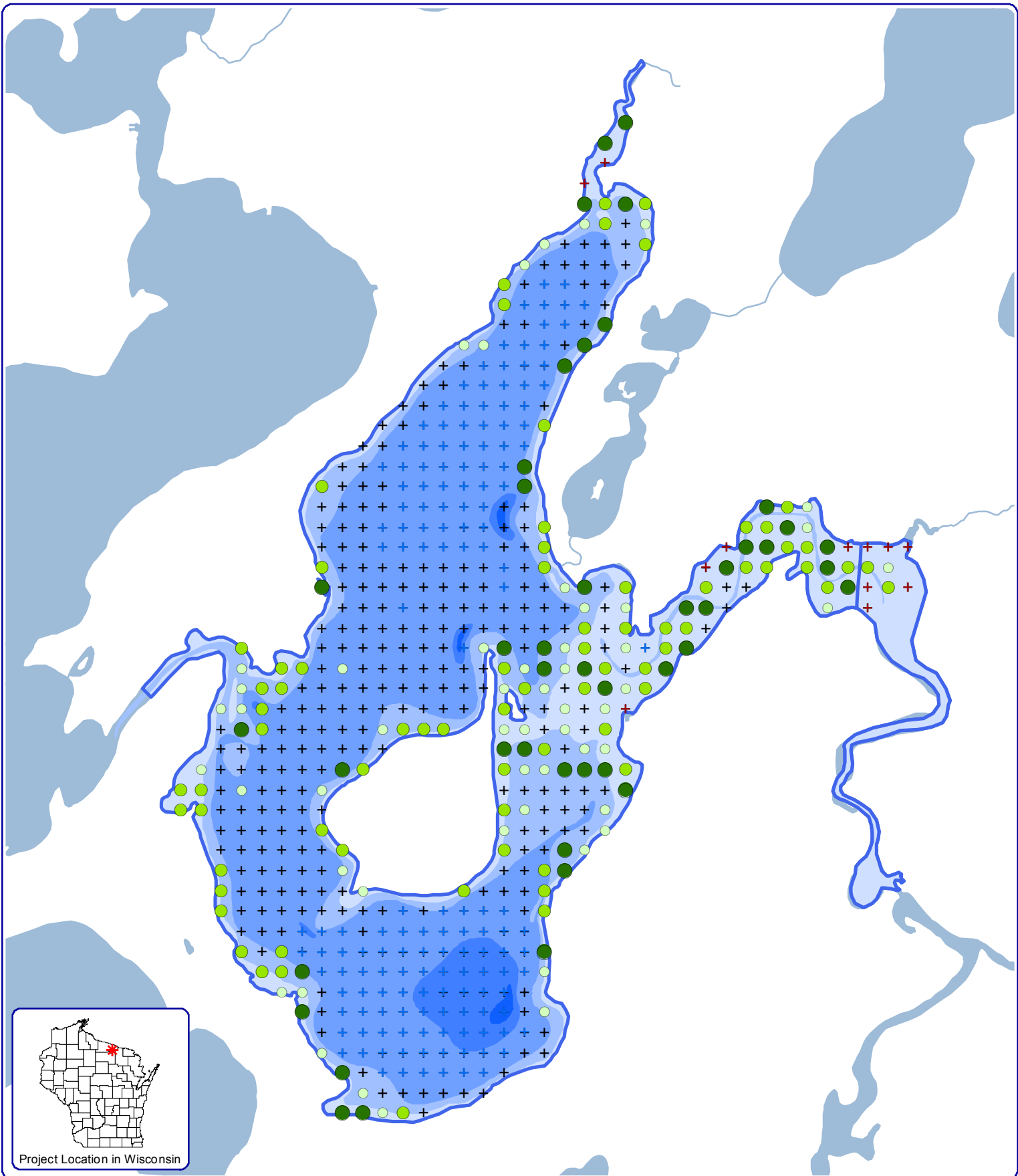
8+ Inch Pieces

- No Branches
- Minimal Branches
- Moderate Branches
- Full Canopy

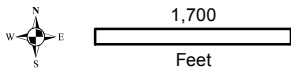
Cluster of Pieces

- No Branches
- Minimal Branches
- Moderate Branches
- Full Canopy

Cranberry Lake - Map 2
 Lower Eagle River
 Chain of Lakes
 Vilas & Oneida Counties, Wisconsin
2013 Course
Woody Habitat



Project Location in Wisconsin



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 Lake Management Planning
 815 Prosper Rd
 De Pere, WI 54115
 920.338.8860
 www.onterra-eco.com

Sources:
 Orthophotography: NAIP, 2010
 SCA Survey: Onterra, 2013
 Map date: December 2, 2013
 Filename: Cranberry_Map3_TRFPI_2012.mxd

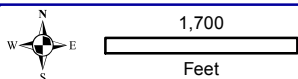
Legend

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

Cranberry Lake - Map 3
 Lower Eagle River
 Chain of Lakes
 Vilas & Oneida Counties, Wisconsin
**2012 Aquatic
 Plant Distribution**



Project Location in Wisconsin



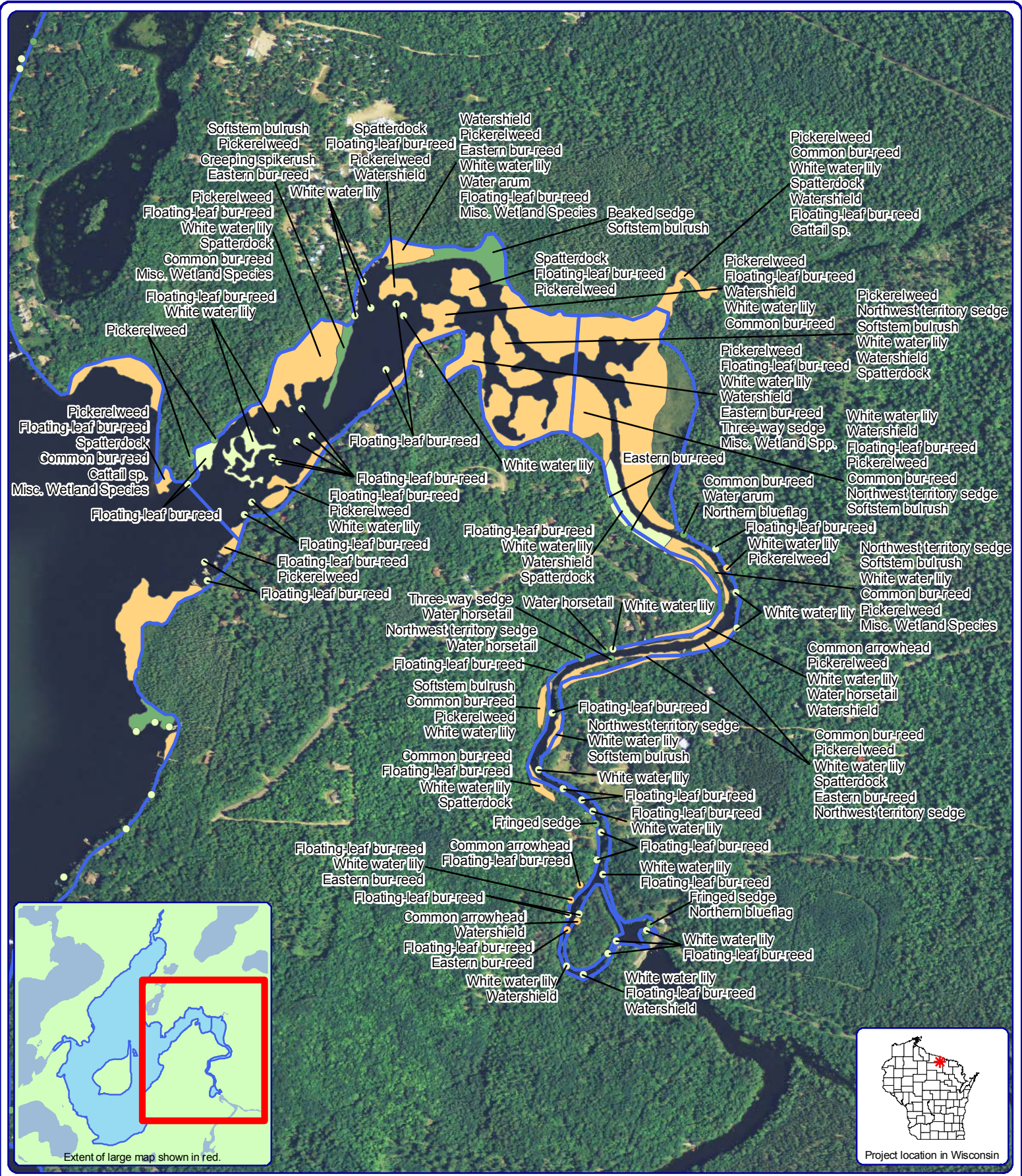
Onterra LLC
 Lake Management Planning
 815 Prosper Road
 De Pere, WI 54115
 920.338.8860
 www.onterra-eco.com

Sources:
 Hydro: WDNR
 Aquatic Plants: Onterra, 2013
 Orthophotography: NAIP, 2010
 Map date: November 11, 2013
 Filename: Cranberry_Map4_Comm_2013.mxd

Legend

- | Large Plant Community | Small Plant Community | Exotic Plant Community |
|--------------------------------|--------------------------------|------------------------|
| Emergent | Emergent | Purple Loosestrife |
| Floating-Leaf | Floating-Leaf | Pale-Yellow Iris |
| Mixed Emergent & Floating-Leaf | Mixed Emergent & Floating-Leaf | |

Cranberry Lake - Map 4
 Lower Eagle River
 Chain of Lakes
 Vilas & Oneida Counties, Wisconsin
Emergent & Floating-Leaf
Aquatic Plant Communities



Softstem bulrush
Pickerelweed
Creeping spikerush
Eastern bur-reed
Pickerelweed
White water lily
Floating-leaf bur-reed
Spatterdock
Common bur-reed
Misc. Wetland Species
Floating-leaf bur-reed
White water lily
Pickerelweed

Spatterdock
Floating-leaf bur-reed
Pickerelweed

Watershield
Pickerelweed
Eastern bur-reed
White water lily
Water arum
Floating-leaf bur-reed
Misc. Wetland Species

Beaked sedge
Softstem bulrush

Pickerelweed
Common bur-reed
White water lily
Spatterdock
Watershield
Floating-leaf bur-reed
Cattail sp.

Pickerelweed
Floating-leaf bur-reed
Watershield
White water lily
Common bur-reed

Pickerelweed
Floating-leaf bur-reed
White water lily
Watershield
Spatterdock

Pickerelweed
Northwest territory sedge
Softstem bulrush
White water lily
Watershield
Spatterdock

Pickerelweed
Floating-leaf bur-reed
White water lily
Watershield
Eastern bur-reed
Three-way sedge
Misc. Wetland Spp.

White water lily
Watershield
Floating-leaf bur-reed
Pickerelweed

Common bur-reed
Water arum
Northern blueflag
Floating-leaf bur-reed
White water lily
Pickerelweed

Northwest territory sedge
Softstem bulrush
White water lily
Common bur-reed
Pickerelweed
Misc. Wetland Species

Floating-leaf bur-reed
White water lily
Watershield
Spatterdock

Water horsetail
White water lily

White water lily

White water lily
Pickerelweed
Misc. Wetland Species

Common arrowhead
Pickerelweed
White water lily
Water horsetail
Watershield

Common bur-reed
Pickerelweed
White water lily
Spatterdock
Eastern bur-reed
Northwest territory sedge

Floating-leaf bur-reed
White water lily
Softstem bulrush

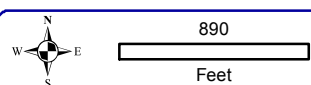
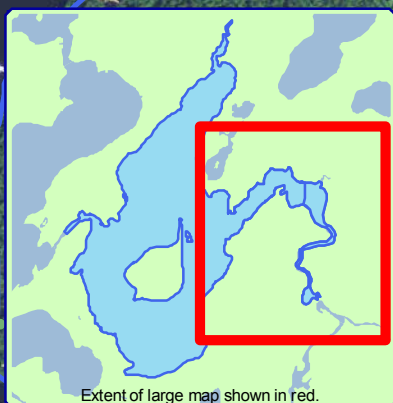
White water lily

Floating-leaf bur-reed
Floating-leaf bur-reed
White water lily
Fringed sedge
Northern blueflag

White water lily
Floating-leaf bur-reed
White water lily
Fringed sedge

White water lily
Floating-leaf bur-reed
Watershield

White water lily
Floating-leaf bur-reed
Watershield



Onterra LLC
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Hydro: WDNR
Aquatic Plants: Onterra, 2013
Orthophotography: NAIP, 2010
Map date: November 11, 2013
Filename: Cranberry_Map5_Channel_Comm_2013.mxd

Legend

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

Cranberry Lake (Channel) - Map 5
Lower Eagle River
Chain of Lakes
Vilas & Oneida Counties, Wisconsin
Emergent & Floating-Leaf
Aquatic Plant Communities