Musser Lake
Drawdown Monitoring Report

Price County, Wisconsin

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INTRODUCTION

Photo 1. Musser Lake, Price County, Wisconsin.

Musser Lake, Price County, is an approximate 533-acre eutrophic impoundment on the Elk River with a maximum depth of 15 feet (Map 1). It has a relatively large watershed encompassing approximately 85 square miles with the majority of the land cover being comprised of intact forests and wetlands. While the Elk River is Musser Lake's primary tributary, the lake is also fed via Chase Creek, Popple Creek, and Musser Creek.

In 2002, the non-native, invasive aquatic plant species curly-leaf pondweed (*Potamogeton crispus*; CLP) was discovered in Musser Lake. In 2004, the Wisconsin Department of Natural Resources (WDNR) completed a series of aquatic plant surveys and identified 38 locations that contained CLP, ranging in size from a few plants to colonized areas of approximately 900 square feet. The majority of the CLP was located near the lake's main boat landing and within the nutrient-rich sediments at the mouth of Popple Creek. Herbicide treatments targeting areas of CLP began in Musser Lake in 2005.

The Musser Lake Association (MLA) obtained a three-year WDNR Aquatic Invasive Species (AIS) Early-Detection and Response Grant in 2008 to aid in funding ongoing CLP control efforts. In 2009, the WDNR advocated that the MLA create a WDNR-approved comprehensive lake management plan to more formally document the CLP population within the lake and develop a long-term strategy to control the population at the lake-wide level. In addition, an approved lake management plan would make the MLA eligible to receive additional WDNR grant funds to address CLP through an AIS Established Population Control (EPC) Grant. In August 2009, the MLA contracted with Onterra and they successfully received a WDNR Lake Management Planning Grant to conduct comprehensive studies on the lake in 2010 and develop a lake management plan.

Curly-leaf pondweed peak-biomass surveys were conducted by Onterra in June 2010 and 2011, and results of these surveys indicated the CLP population had increased in density and area when compared to the WDNR data gathered in 2004. While the MLA had taken an active role in in the effort to reduce the CLP within Musser Lake, it was believed that the control strategies implemented had only been successful in reducing the density of CLP locally in areas where navigation and recreational activities had been impeded, and were not effective at reducing the CLP population lake-wide.

Traditionally, CLP management consists of numerous annual herbicide treatments conducted in the spring of each year. The goal of these treatments is to kill each year's CLP plants before they are able to produce and deposit turions (asexual reproductive structures). Following multiple years of annual herbicide treatments, the turion base within the sediment becomes exhausted and the CLP population declines. Because these turions have been shown to remain viable in the sediment for five to seven years, typical CLP management includes multiple annual herbicide treatments of the same area(s).

The *Musser Lake Comprehensive Management Plan* (Onterra 2013) contains numerous management goals pertaining to Musser Lake that were developed by Onterra ecologists and members of the MLA. One of these goals is to "control existing and prevent further aquatic invasive species infestations within Musser Lake." One of the management actions under this goal was to initiate a large-scale herbicide application strategy to control CLP within the lake; however, there were concerns about the likelihood of success because the rate of water flow through the lake may be too high to achieve the necessary herbicide concentrations and exposure times required to cause CLP mortality. Because of these concerns, the WDNR supported conducting a one-year trial treatment and they considered the action eligible for WDNR AIS-EPC Grant funds. In February 2012, the MLA successfully applied for grant funds within this category (ACEI-118-12).

Following the submission of a treatment permit in early April 2012 and a subsequent multi-agency review by the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), the proposed CLP treatment on Musser Lake was suspended due to concerns regarding the proximity of northern wild rice (*Zizania palustris*) communities. Based upon laboratory and outdoor growth chamber research, wild rice has been shown to be vulnerable to early-season herbicide treatments. Closer investigation of this and additional research may identify potential herbicide use patterns that would minimize the impact on wild rice. It is anticipated that continued management discussions between the WDNR, GLIFWC, and private consultants will result in a solution to implement AIS management strategies in wild rice waters.

In September of 2011, the Price County Dams Department applied for a WDNR cost-share grant to perform maintenance on the Musser Dam in 2013 which impounds Musser Lake. The maintenance work required that the water within Musser Lake be drawn down by six feet, and the water levels would begin to be slowly lowered in the late-summer to minimize impacts to recreation and tourism.

Bob Lepke, Price County Dam Tender, was actively involved with an earlier draw down on Lac Sault Dore (aka Soo Lake) and understood the potential of this technique for aquatic invasive species (AIS) control. While the maintenance work was only scheduled to take a month to complete, the water within Musser Lake would remain drawn down by five feet over the winter of 2013/2014. Because the permit was in the name of Price County, the Dam Tender lead the charge to hold the various public meetings in advance of the drawdown to inform lake stakeholders and provide them an opportunity to offer input. The Price County Dams Department received the cost-share grant and then in December 2012, applied for a WDNR permit to move forward with the drawdown of Musser Lake.

Refilling the lake in fall could potentially have detrimental impacts to reptiles (e.g. turtles) and amphibians (e.g. frogs and salamanders) which would have chosen shallow, muddy areas of the dewatered lake to burrow and hibernate for the winter. If the lake were refilled after these animals went into hibernation, they would almost certainly drown. And as indicated earlier, the use of a drawdown to control AIS further justified holding the lake at a lowered level throughout the winter.

Little information exists within the scientific literature regarding CLP's response to winter water level drawdowns, and lake managers wanted to take the opportunity on Musser Lake to determine whether this was a viable management option for controlling CLP within Musser Lake. It was theorized that a winter drawdown at minimum would impact the CLP plants that sprouted in the fall with above-ground biomass in areas that were dewatered and exposed to freezing conditions. However, it was not known if the drawdown would have a significant impact on the viable turions deposited in the sediments.

In downstream Lac Sault Dore, a winter water level drawdown of six feet associated with dam maintenance was conducted over the winter of 2010/2011. Similar studies were initiated on this system to document the response of the lake's invasive Eurasian water milfoil (*Myriophyllum spicatum*; EWM) and native aquatic plant populations. These studies revealed that the occurrence of EWM within the lake decreased by over 99%, and while some native aquatic plant species that maintain above-ground biomass over the winter experienced declines in their occurrence, no native plant species were lost.

As discussed, little information is available on the short- and long-term response of CLP to winter water level drawdowns, and studies were conducted on Musser Lake pre- and post-drawdown to monitor its effects on the CLP and native aquatic plant populations. The information gathered would not only determine if winter drawdowns are a viable CLP management tool for Musser Lake, but would also help guide CLP management on similar systems in Wisconsin. This report discusses the effects of the 2013/2014 water level drawdown on Musser Lake's CLP and native aquatic plant community following surveys completed the year immediately following the drawdown (2014) and one-year post-drawdown (2015). This report is a continuation of the 2014 report which detailed the drawdown's effects the year immediately following the drawdown.

AQUATIC PLANT MONITORING METHODOLOGIES

Quantitative Aquatic Plant Monitoring

Point-Intercept Surveys

Because the winter water level drawdown in Musser Lake had implications at the lake-wide level, the whole-lake point-intercept survey method as described by the WDNR Bureau of Science Services (Hauxwell et al. 2010) was used to complete lake-wide quantitative evaluations of CLP and native aquatic plant species pre- and post-drawdown. Quantitative evaluation was made through the collection of aquatic plant presence-absence and relative abundance data at approximately 621 point-intercept sampling locations evenly spaced across the lake at a resolution of 57 meters (Figure 1). These surveys were conducted in June 2013 (pre-drawdown), and June 2014 and late-July 2015 (post drawdown) by WDNR staff. In addition, the same whole-lake point-intercept survey was conducted pre-drawdown by Onterra in 2010 as part of Musser Lake's comprehensive lake management plan. Comparing these data collected before and after the drawdown allows for a statistical comparison (Chi-Square analysis) of aquatic plant species' occurrences and a quantitative determination of the drawdowns effects on the plant community at a lake-wide scale.

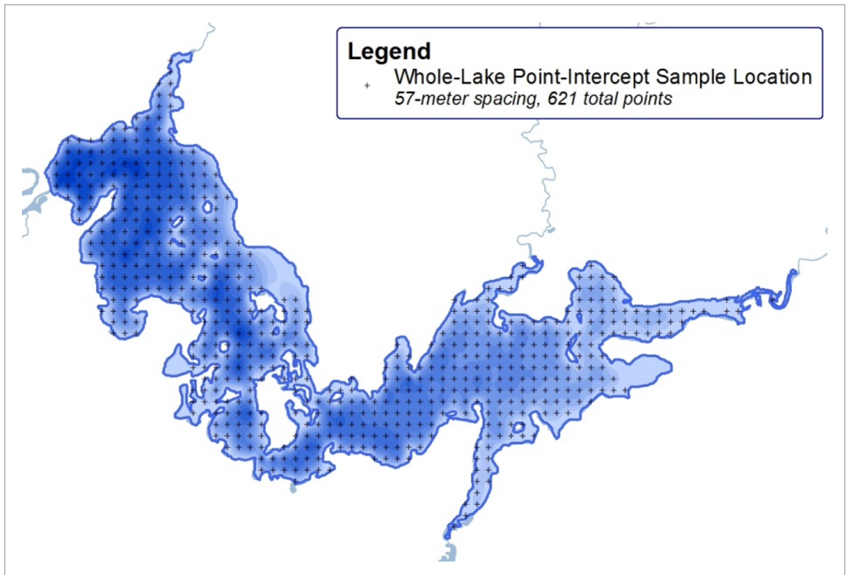


Figure 1. Musser Lake whole-lake point-intercept survey sampling locations.

In addition to pre- and post-drawdown whole-lake point-intercept surveys, pre- and post-drawdown sub-sample point-intercept surveys were conducted in the eastern basin of the lake over the largest and densest area of colonized CLP located in 2013. Like the whole-lake point-intercept survey, the sub-sample survey included the collection of data at pre-determined sampling locations; however these 233 locations were only spaced 20 meters apart and were designed to provide a finer-scale evaluation of CLP's response to the drawdown (Figure 2). The pre- and post-drawdown sub-sample point-intercept surveys were conducted by Onterra in June of 2013, early-July of 2014, and June of 2015.

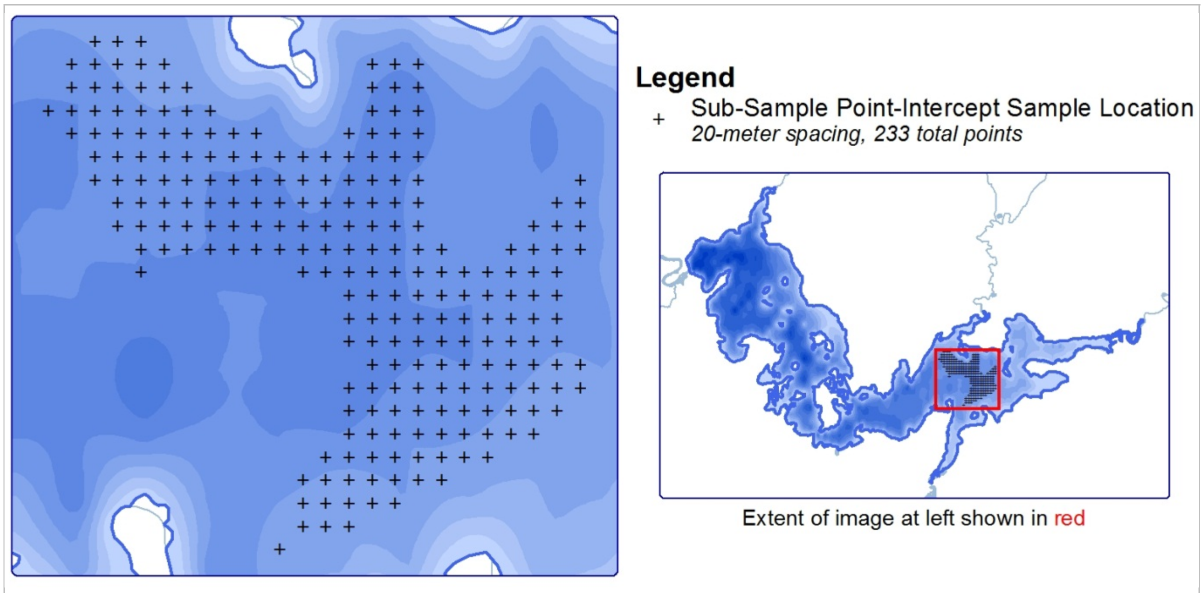


Figure 2. Musser Lake sub-sample point-intercept survey sampling locations.

Turion Sampling

As mentioned, CLP annually produces and deposits asexual reproductive structures called turions prior to naturally senescing (dying back) in early summer. Some of these turions sprout in the fall the same year they were deposited and produce winter foliage that persists under the ice while others remain dormant and sprout at a later time. Because CLP relies solely on the production of turions each year to sustain its population, long-term control of CLP in Musser Lake following the drawdown would only be achieved if many of the turions present in the sediment were exposed and desiccated. To gain further understanding of how turions are impacted by winter drawdowns, the WDNR conducted a CLP turion sampling study pre- and post-drawdown.

The turion sampling study had two primary goals: 1) determine if the overall number of turions decreased following the drawdown, and 2) determine if the number of viable turions (turions able to sprout) decreased following the drawdown. To complete this study, members of the WDNR visited 100 pre-determined sampling locations located within some of the densest areas of CLP mapped in Musser Lake in 2011 (Figure 3). The sampling locations were spaced 20 meters apart within each CLP colony.

In the late-summer of 2013 (pre-drawdown) and 2014 (post-drawdown), WDNR staff navigated to each sampling location and lowered a Petite Ponar Dredge (volume = 2.4L) into the sediment. The contents of the dredge were sifted and washed in a screened bucket, and the number of turions was counted per site. In addition, each turion was determined to be either viable or non-viable. A turion was determined to be viable if it held its shape when lightly squeezed; if it was hollow or collapsed upon being lightly squeezed, it was deemed non-viable.

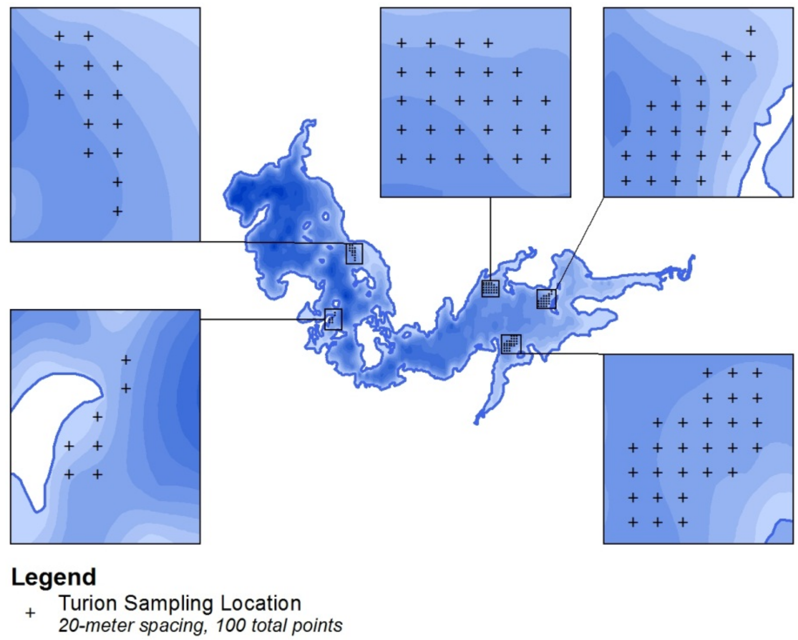


Figure 3. Musser Lake turion sampling locations.

The turions that passed the viability test in the field were collected and brought back to the lab where they placed under conditions that would initiate sprouting. The turions were chilled in a dark refrigerator at 41-45°F for one week in a 2L plastic bag covered with aluminum foil. After one week, the turions were placed in an aquarium with daily average temperatures of 81-85°F for two weeks with 10 hours of light and 14 hours of dark. The turions that began sprouting were counted and removed. With these data, they were able to compare the percentage of turions that were able to sprout pre- and post-drawdown.

Qualitative Aquatic Plant Monitoring

Curly-Leaf Pondweed

Using sub-meter GPS technology, CLP locations were mapped the year prior to the water level drawdown (2013) in early summer when CLP is at or near its peak growth, in the early summer immediately following drawdown (2014), and the early summer one year following the drawdown (2015). The CLP population was mapped by using either 1) point-based or 2) area-based methodologies. Large colonies >40 feet in diameter were mapped using polygons (areas) and were qualitatively attributed a density rating based upon a five-tiered scale from *Highly Scattered* to *Surface Matting*. Point-based techniques were applied to CLP locations that were considered as *Small Plant Colonies* (<40 feet in diameter), *Clumps of Plants*, or *Single or Few Plants*. Qualitative monitoring of changes in the CLP population includes comparing spatial data reflecting CLP locations and densities during the peak-growth stages the summer before the summer immediately following the drawdown.

Northern Wild Rice

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842, within which Musser Lake falls. The Great Lakes Indian Fish and Wildlife Commission represents the eleven Chippewa Tribal Nations within the Upper Midwest to protect and enhance the natural resources of the ceded territory, particularly as they relate to the treaty rights of the member tribes.

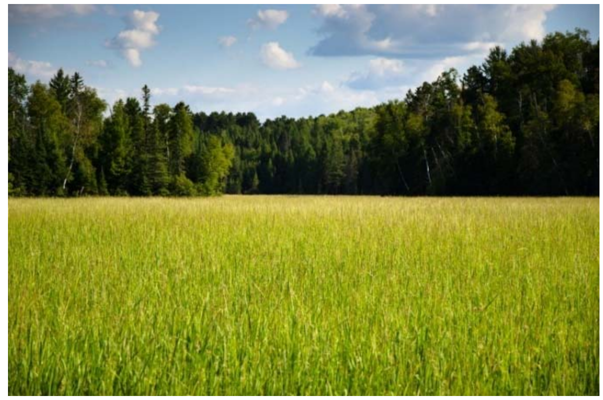


Photo 2. Northern wild rice (*Zizania palustris*) population on a northern Wisconsin lake.

Northern wild rice (Photo 2) is a valuable emergent grass found in Musser Lake. In addition to the ecosystem services this plant provides, it also holds great cultural significance to the Native American communities of this area. For this reason, GLIFWC focuses on the "preservation and enhancement of manoomin (wild rice) in ceded territory lakes." The state of Wisconsin works actively with GLIFWC to review all activities that have the potential to negatively impact wild rice populations. While the use of herbicides to control aquatic invasive species has broad intentions of benefiting the lake ecosystem, the herbicides may have the capacity to impact non-target plants such as wild rice.

Little information exists regarding the impacts of aquatic herbicides on wild rice, particularly as it applies to collateral effects on wild rice associated with targeted herbicide treatments of aquatic invasive species in lakes. Natural wild rice populations are known to fluctuate greatly and unpredictably from year to year; therefore, linking population changes of wild rice to herbicide use in field settings can be problematic. Two studies (Nelson et al 2003; Madsen et al. 2008) evaluated the effects of various herbicides and concentrations on wild rice within outdoor mesocosums (tanks that replicate natural conditions). While this research concludes that wild rice is susceptible to aquatic herbicides, closer investigation of this research may identify potential herbicide use patterns that would minimize the impact on wild rice.

While no herbicide treatments occurred on Musser Lake from 2013-2015, wild rice populations were delineated in all three years to gain insight into how these populations respond to a winter water level drawdown. In addition, having a multi-year dataset of wild rice locations may provide insight into whether potential future herbicide applications are directly affecting the population. While it is understood that wild rice populations fluctuate from year to year, if a drastic reduction in the wild rice population is observed that has not been observed on similar, non-treated systems, lake managers will be able to attribute the change to the herbicide application.

In 2013, northern wild rice populations were mapped by GLIFWC staff, and in 2014 and 2015, northern wild rice populations were mapped by Onterra. Similar to the qualitative methodologies used to map and compare CLP colonies and densities, a methodology has been developed by Onterra to monitor changes in wild rice populations over time in which wild rice colonies are specifically delineated and assigned a two-tiered density rating (dense or sparse).

RESULTS & DISCUSSION

Primer on Data Analysis & Data Interpretation

Native aquatic plants are an important element in every healthy aquatic ecosystem, providing food and habitat to wildlife, improving water quality, and stabilizing bottom sediments (Photo 3). Because most aquatic plants are rooted in place and are unable to relocate in wake of environmental alterations, they are often the first community to indicate that changes may be occurring within the system. Aquatic plant communities can respond in variety of ways; there may be increases or declines in the occurrences of some species, or a complete loss. Or, certain growth forms, such as emergent and floating-leaf communities may disappear from certain areas of the waterbody. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide relevant information for making management decisions.

Photo 3. Native aquatic plants are an important component in maintaining a healthy aquatic ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of the whole-lake point-intercept surveys conducted on Musser Lake, plant samples were collected from plots laid out on a grid that covered the lake (Figure 1). Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, the occurrences of aquatic plant species are displayed as their *littoral frequency of occurrence*. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are equal to or less than the maximum depth of plant growth (littoral zone), and is displayed as a percentage. For the sub-sample point-intercept surveys, the occurrence of CLP is displayed as its *frequency of occurrence*. Frequency of occurrence is calculated simply by dividing the total number of sub-sample point-intercept locations by the number of locations that contained CLP.

Floristic Quality Assessment

The floristic quality of a lake is calculated using its native aquatic plant species richness and those species' average conservatism values. Species richness is simply the number of aquatic plant species that occur in the lake, and for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values (C-value) for each of those species in its calculation. A species coefficient of conservatism value indicates that species' likelihood of being found in an undisturbed system. The values range from 1 to 10. Species that can tolerate environmental disturbance and can be located in disturbed systems have lower coefficients, while species that are less tolerant to environmental disturbance and are restricted to high quality systems have higher values. For example, coontail (*Ceratophyllum* *demersum*), a submergent native aquatic plant species with a C-value of 3, has a higher tolerance to disturbed conditions and is often found thriving in lakes with higher nutrient levels and low water clarity. Other species, like algal-leaf pondweed (*Potamogeton confervoides*) with a C-value of 10, are intolerant of environmental disturbance and require minimally disturbed, high quality environments to survive.

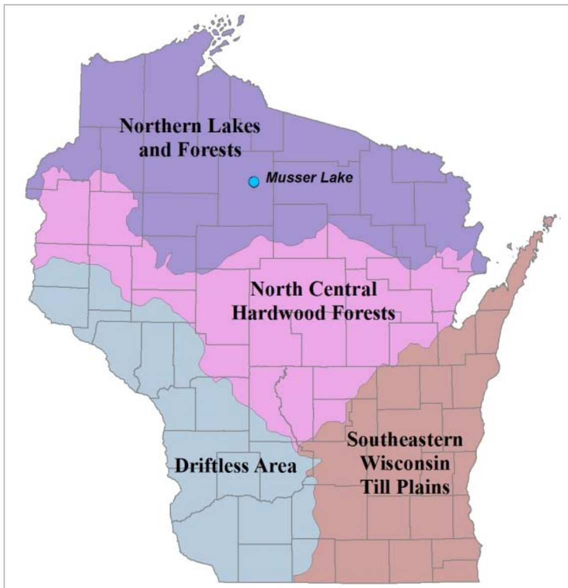


Figure 4. Location of Musser Lake within the ecoregions of Wisconsin. After Nichols (1999).

On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept survey. Musser Lake falls within the Northern Lakes and Forests *ecoregion* of Wisconsin (Figure 4), and the floristic quality of its aquatic plant community will be compared to other flowages within this ecoregion as well as the entire State of Wisconsin. Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems within the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Ecoregional and state-wide medians were calculated from whole-lake point-intercept surveys conducted on 392 lakes throughout Wisconsin by Onterra and WDNR ecologists.

Musser Lake Water Level Drawdown Monitoring Results

Water Level Drawdown

The water level drawdown in Musser Lake began on September 9, 2013 at a rate of three inches per day to allow reptiles, amphibians, mussels, and other aquatic wildlife to migrate with the receding water (Figure 5). By September 30, 2013, water levels were 5.0 feet below full pool. Water levels were lowered even further temporarily in mid-November to a maximum of 6.3 feet below full pool so work could be done on the dam's bay sills. Following this work, water levels were raised and maintained around 5.0 feet below pool for the remainder of the winter, and water levels were returned to full pool in the spring by late-April.

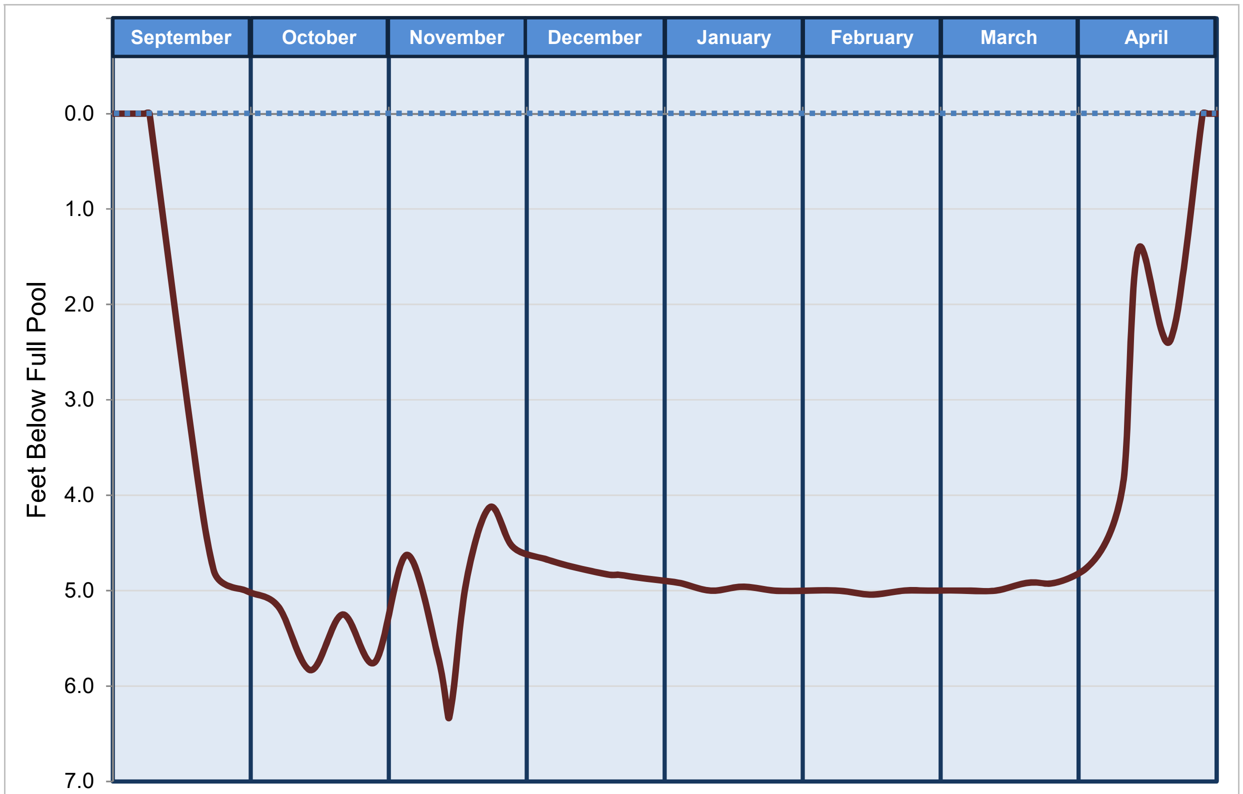


Figure 5. Musser Lake water levels from September 2013 to May 2014. Created using Musser Dam gauge data reported by Bob Lepke, Price County Dams Tender.

The winter of 2013-2014 (December, January, and February) was the coldest since records began (1908) for many cities in northern Wisconsin (Wisconsin State Climatology Office), and the average winter temperature in Phillips near Musser Lake was 5.8°F (Figure 6). There were only six days between December 4, 2013 and March 9, 2014 that saw temperatures above freezing, and between January 13 and February 18, 2014, there were 37 consecutive days with temperatures below freezing. These long-lasting cold conditions were ideal for maximizing potential desiccation and freezing of exposed CLP plants and turions.

However, snow has a high insulating capacity and studies have shown that temperatures near the ground can be around 32°F even when air temperatures fall to -20°F (Palm and Tveitereid 1979). Data from Phillips indicates that this area received approximately 14.4 inches of snow from

December 2013 through February 2014, and it is likely that this snow provided the exposed CLP plants and turions some buffering capacity against the extreme cold during the drawdown.

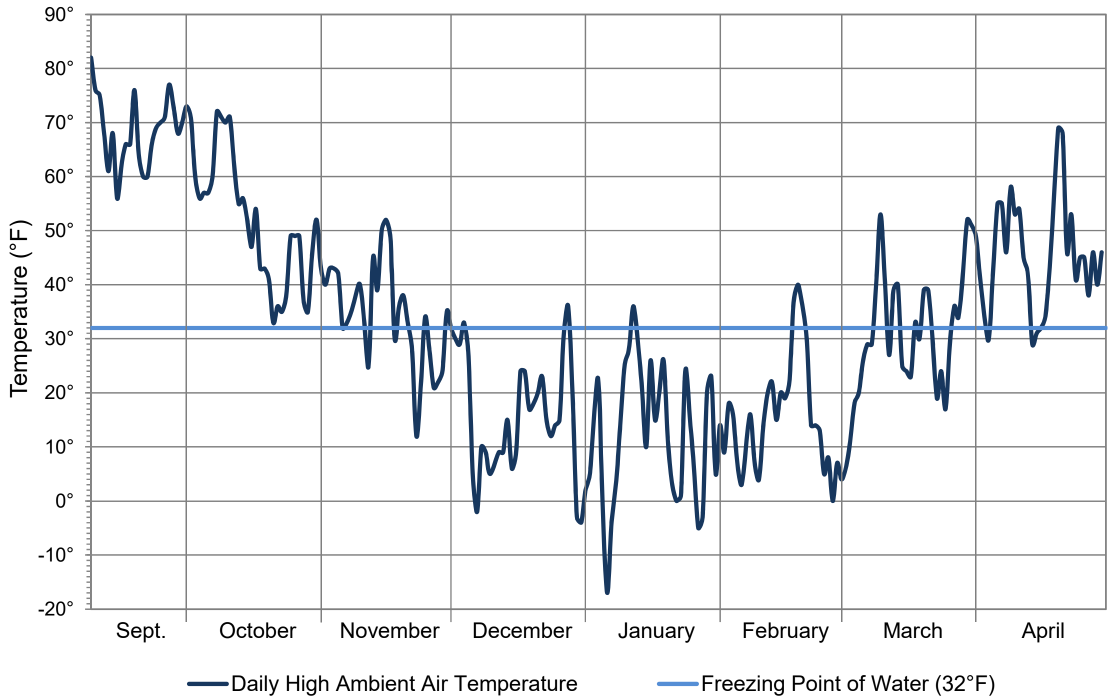


Figure 6. Ambient high air temperatures in Phillips, WI during the period of water level drawdown on Musser Lake. Data obtained from Weather Underground (wundergound.com).

Bathymetric data for Musser Lake were created using depth data collected by the WDNR during their 2013 whole-lake point-intercept survey. Using these data, it is estimated that approximately 375 acres (70%) of the 533-acre lake were dewatered during the 5.0-foot water level drawdown (Figure 7). Sediment data were collected on Musser Lake during the 2010, 2013, 2014, and 2015 whole-lake point-intercept surveys. While it had been expected that some scouring of bottom sediments would occur near the mouths of the inlets due to increased water velocity during the drawdown, the point-intercept data show that the proportion of areas containing soft sediments, sand, and rock were essentially no different pre- and post-drawdown and indicate no significant scouring of bottom sediments occurred (Figure 8).

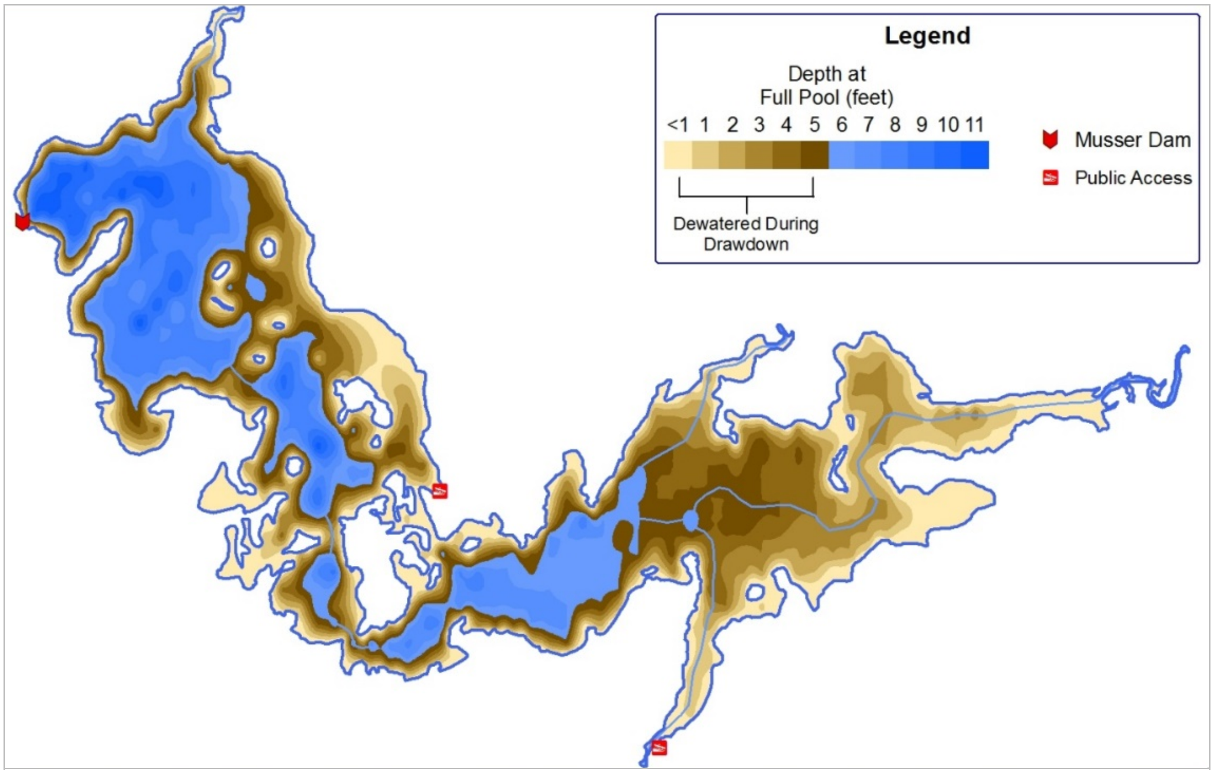


Figure 7. Estimated area dewatered in Musser Lake during 2013/2014 winter 5.0-foot water level drawdown. Area dewatered is approximately 375 acres. Bathymetry data created using data from WDNR June 2013 whole-lake point-intercept survey.

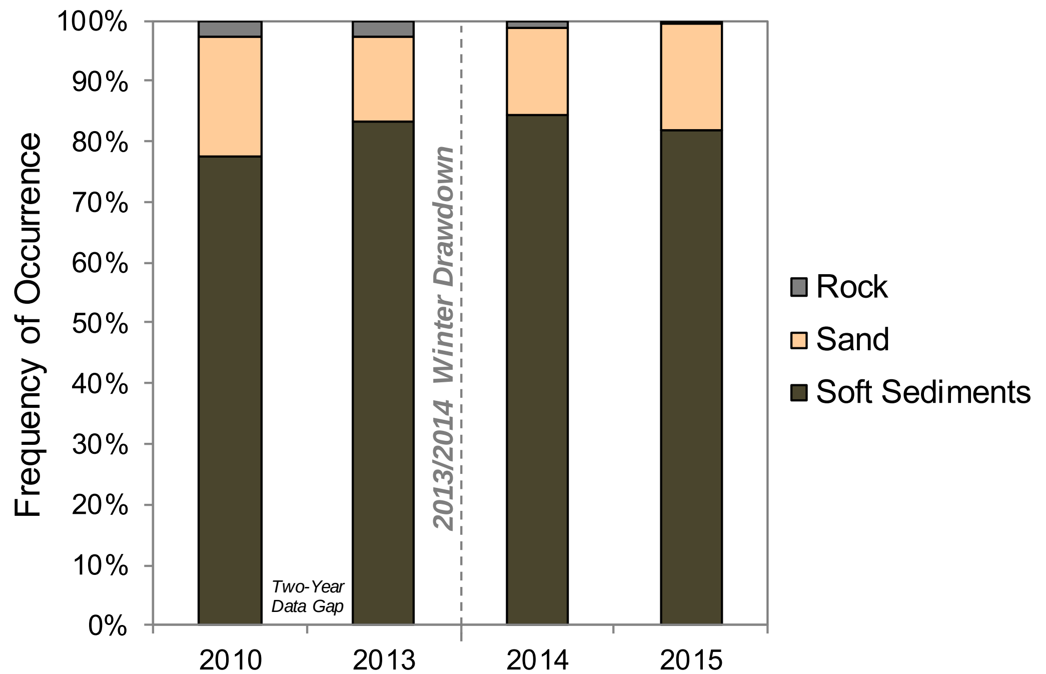


Figure 8. Proportion of sediment types in Musser Lake as determined from 2010 and 2013 pre- and 2014 and 2015 post-drawdown point-intercept surveys. Created using data from Onterra 2010 and WDNR 2013, 2014, and 2015 whole-lake point-intercept surveys.

Curly-leaf Pondweed

Pre-drawdown whole-lake point-intercept surveys were conducted by Onterra on August 18-19, 2010 and June 19, 2013 by WDNR staff; post-drawdown whole-lake point-intercept surveys were conducted by WDNR staff on June 18-19, 2014 and July 27, 2015. Because the 2010 whole-lake point-intercept survey was conducted in August after most of the CLP plants had already senesced, it is not appropriate to use these CLP data as comparison for pre-drawdown lake-wide occurrence of CLP. Similarly, the 2015 point-intercept survey was conducted in late-July when the CLP population was past its peak growth and likely does not fully represent the lake-wide occurrence of CLP at its peak growth in early summer.

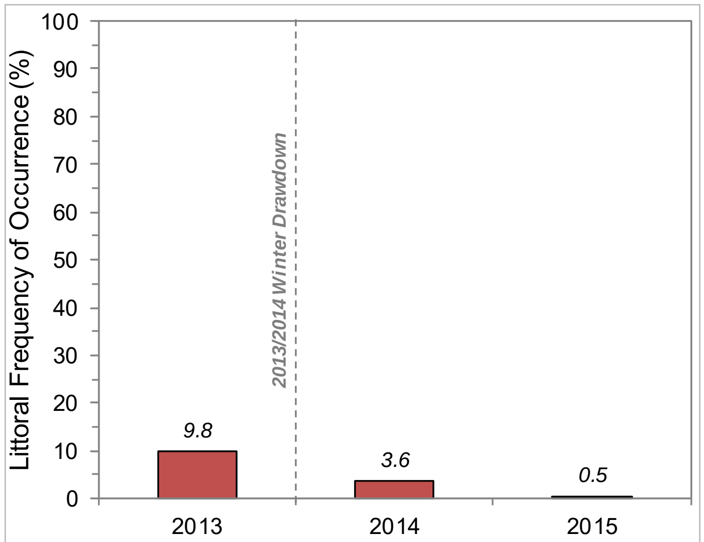


Figure 9. Littoral frequency of occurrence of CLP in Musser Lake from June 2013 (N = 549) pre- and June 2014 (N = 468) and July 2015 (N = 437) post-drawdown whole-lake point-intercept surveys. Change in CLP occurrence is statistically valid at the α = 0.05 level (Chi-square).

Prior to the drawdown in June 2013, CLP had a littoral frequency of occurrence of 9.8% (Figure 9). In the year summer immediately following the winter drawdown, CLP was found to have a lake-wide littoral frequency of occurrence of 3.6% in June 2014, a statistically valid (Chi-square α = 0.05) reduction of 63% when compared to June 2013.

During the June 2013 whole-lake point-intercept survey, the majority of the CLP was encountered in four to five feet of water in the eastern portion of the lake, near the mouths of the Elk River, Popple Creek, and Musser Creek; CLP was present in the western basin, but at a lower occurrence (Figure 10). In 2014, CLP was only located at sampling locations within the eastern basin (Figure 10).

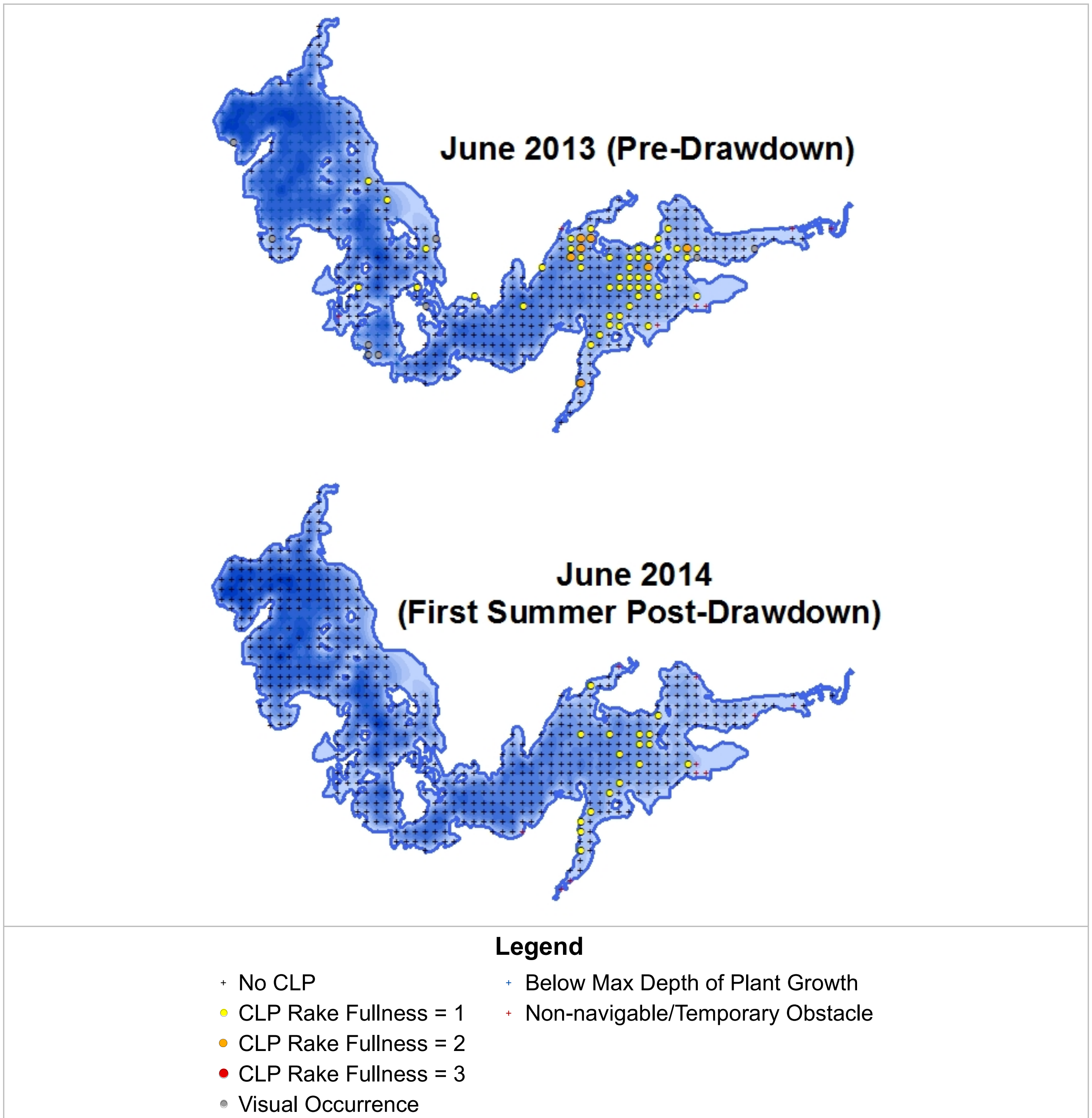


Figure 10. Musser Lake June 2013 pre- and June 2014 post-drawdown whole-lake point-intercept sampling locations containing CLP.

During the July 2015 point-intercept survey, CLP was only recorded on the rake at two sampling locations within the eastern basin, yielding a littoral frequency of occurrence of only 0.5%. However, a number of CLP visual occurrences were recorded in both the eastern and western basins during the 2015 point-intercept survey.

During the point-intercept surveys when CLP was encountered on the rake, it was given a *rake fullness* rating. Rake fullness ratings range from 1 to 3, with 1 denoting a minimal amount of CLP present on the rake and 3 denoting the rake is "overflowing" with CLP. Of the 54 sampling locations that contained CLP in June 2013, 87% had a rake fullness rating of 1 and 13% had a rake fullness rating of 2. Following the drawdown, all locations containing CLP in 2014 and

2015 had a rake fullness rating of 1 indicating that the density of CLP was reduced in addition to a reduction in its occurrence.

The pre-drawdown sub-sample point-intercept survey within the eastern basin of the lake was conducted by Onterra on June 27, 2013. Onterra ecologists had attempted to conduct the first summer post-drawdown sub-sample point-intercept survey on June 17, 2014, but the survey was postponed because the observed CLP plants were still underdeveloped due to the later-than-average ice-out and cooler weather. The first summer post-drawdown sub-sample point-intercept survey was completed a couple weeks later on July 2, 2014. Onterra ecologists completed the second summer post-drawdown sub-sample point-intercept survey on June 24, 2015. In all three years, it is believed that the survey was conducted at the peak growth stage of CLP within Musser Lake.

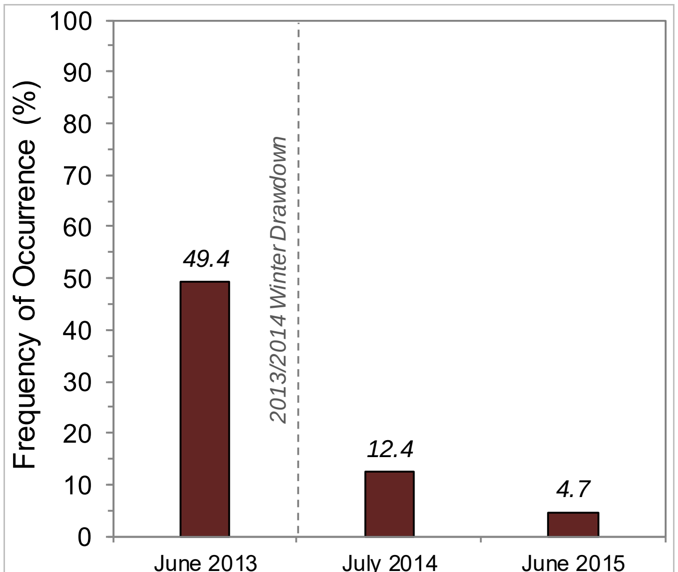


Figure 11. Frequency of occurrence of CLP within sub-sample point-intercept survey locations. Change in CLP occurrence is statistically valid at the α = 0.05 level (Chi-square).

In June 2013 prior to the drawdown, 115 (49%) of the 233 sub-sample point-intercept sampling locations contained CLP (Figure 11 and 12). In the first summer immediately following the drawdown, CLP occurrence declined by 75% with 29 (12%) of the 233 sampling locations containing CLP. The occurrence of CLP declined further in second summer following the drawdown in June 2015 with 11 (4.7%) of the 233 sampling locations containing CLP. The occurrence of CLP in June 2015 represents a statistically valid 90% reduction in CLP occurrence since June 2013 within the area where the sub-sample point-intercept survey was conducted.

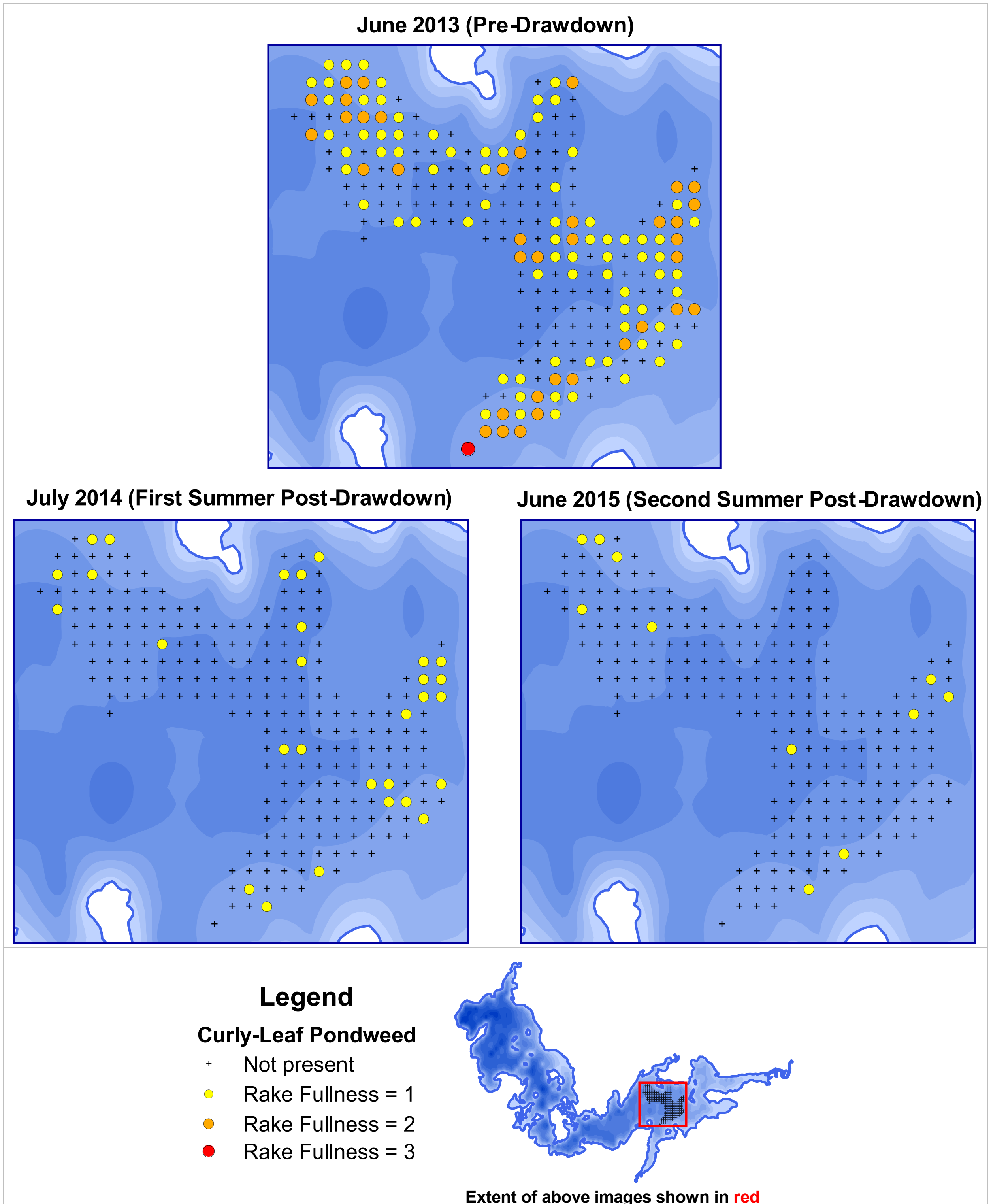


Figure 12. June 2013 pre- and July 2014 and June 2015 post-drawdown CLP locations within sub-sample point-intercept survey area. Created using data from Onterra 2013, 2014, and 2015 sub-sample point-intercept surveys.

During the 2013 pre-drawdown turion sampling survey conducted by the WDNR, a total of 51 viable turions were located after sampling at the 100 pre-determined locations (Figure 13). This equates to a turion density of approximately 22.0 turions/m^2 within the areas sampled (Figure 13). Of the 51 turions that were determined to be viable in 2013, 37 (73%) sprouted under laboratory conditions. During the 2014 turion sampling survey following the drawdown, the total number of turions deemed to be viable encountered from the 100 sampling locations was reduced to 20 (Figure 12), resulting in a density of approximately 8.6 turions/m^2 (Figure 13). This reduction in turion density was statistically valid (two-tailed T-Test α = 0.05). The percentage of turions that sprouted under laboratory conditions also declined, with only 25% (5 turions) of the 20 turions sprouting.

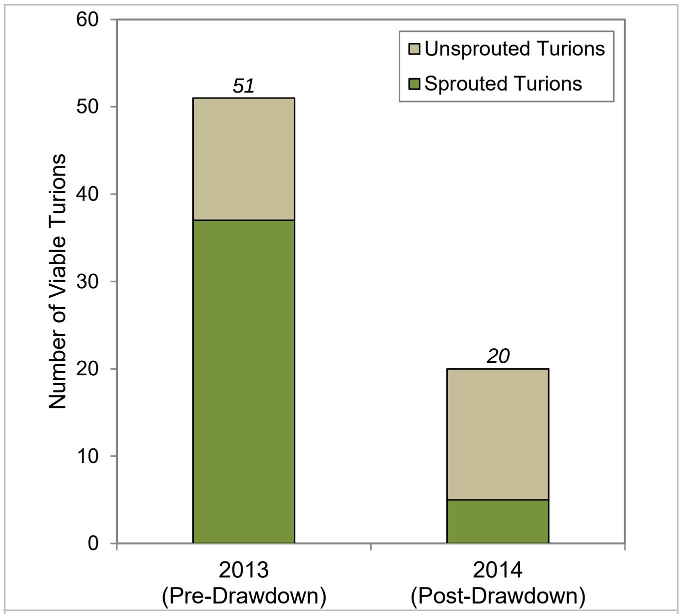


Figure 13. Number of sprouted and un-sprouted viable turions during 2013 pre- and 2014 post-drawdown turion sampling surveys (N = 100). Created using data from WDNR 2013 and 2014 turion surveys.

The qualitative mapping data also indicate a large reduction in Musser Lake's CLP population following the 2013/2014 winter water level drawdown. Prior to the drawdown, qualitative mapping surveys in 2010, 2011, and 2013 found that the density of CLP in Musser Lake had been increasing (Figure 14). In June 2013 just prior to the drawdown, Musser Lake contained approximately 52 acres of colonized CLP, 71% of which was comprised of CLP with *dominant* or greater density rating (Figure 14 and 15). In the summer immediately following the drawdown, acreage of colonized CLP was reduced to 0.0 and all of the CLP observed was comprised of *single or few plants* and *clumps of plants*.

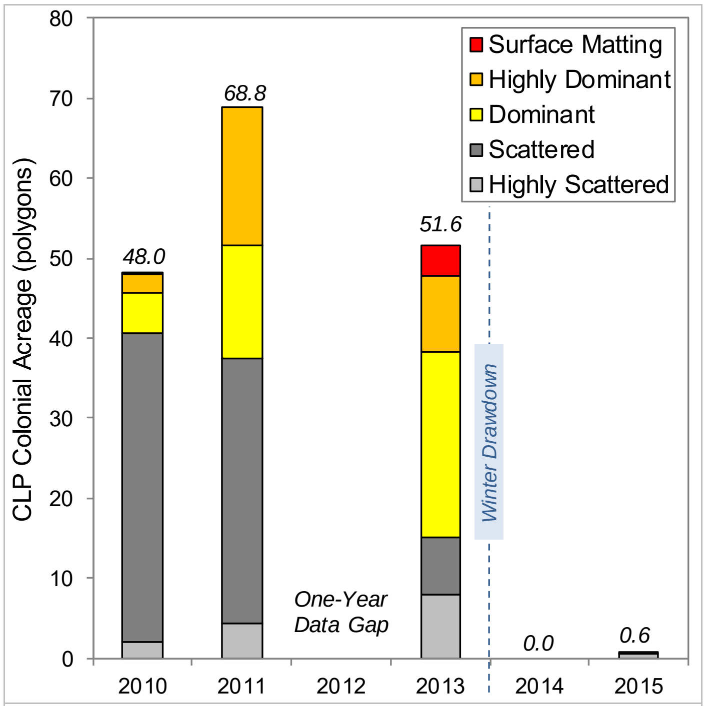


Figure 14. Musser Lake colonial acreage from 2010, 2011, and 2013 pre- and 2014 and 2015 post-drawdown qualitative mapping surveys. Created using data from Onterra 2010, 2011, 2013, 2014, and 2015 mapping surveys.

During the June 2015 mapping survey, approximately 0.6 acres of colonized CLP comprised of *highly scattered* and *scattered* plants were located in eastern and western basins (Figure 14 and 15). In addition, the number of *single or few plants* and *clumps of plants* encountered in 2015 increased in both the eastern and western basins when compared to 2014. While the whole-lake point-intercept survey indicated a lower lake-wide occurrence of CLP in 2015 compared to 2014, this may have been due to the timing of the survey in late-July when many of CLP plants had already senesced. Despite the slight increase in CLP abundance as observed from the qualitative mapping from 2014 to 2015, the CLP population in Musser Lake still remains quite low.

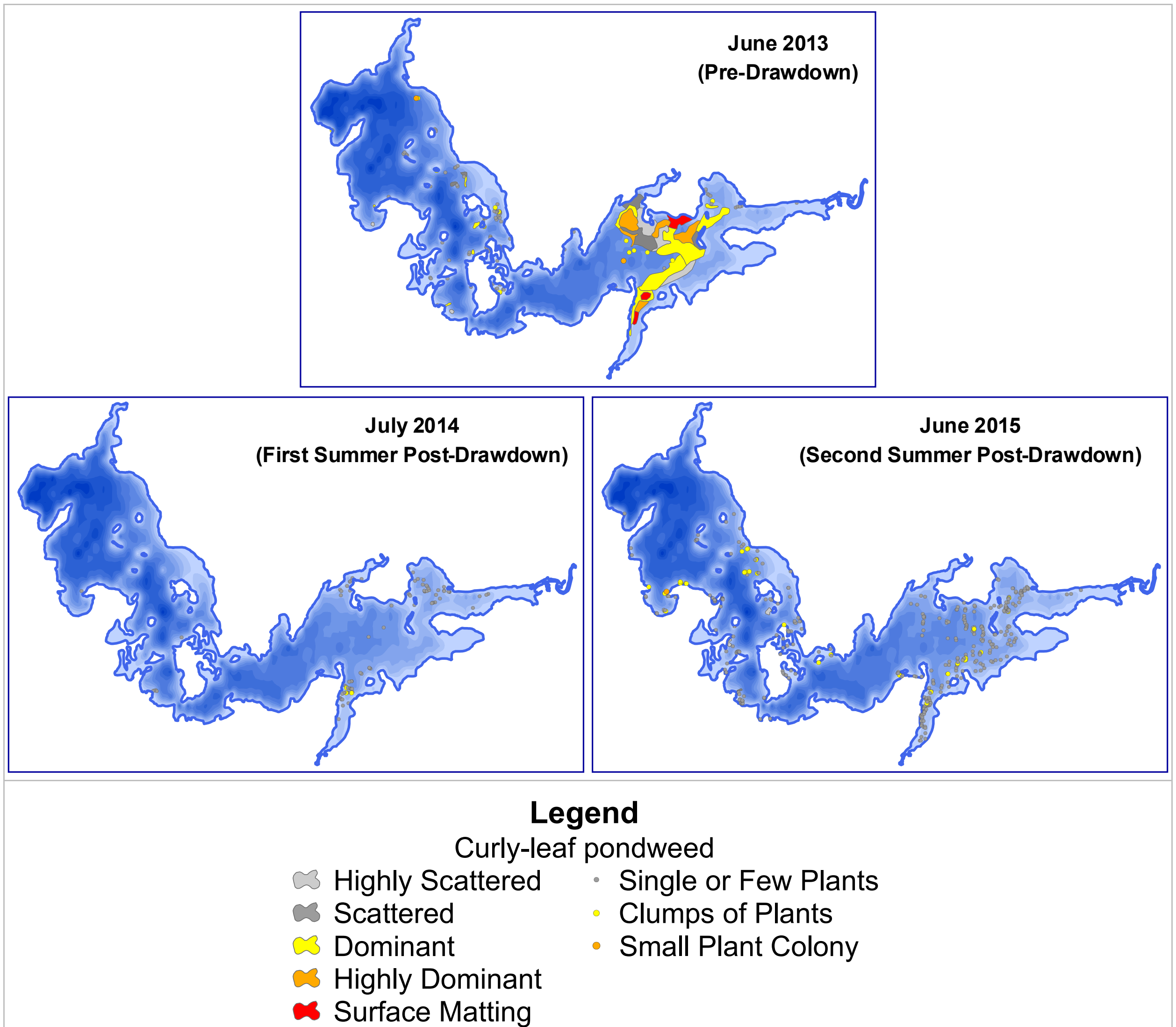


Figure 15. Musser Lake June 2013 pre- and June 2014 CLP locations determined from qualitative mapping surveys. Created using data from Onterra 2013 and 2014 mapping surveys.

Native Aquatic Plants

During the 2010, 2013, 2014, and 2015 whole-lake point-intercept surveys, data concerning the presence of native aquatic plants were also collected. Figure 16 illustrates the percentage of littoral sampling locations that contained native aquatic plants only, native plants and CLP, and CLP only during the 2010 and 2013 pre-drawdown and 2014 and 2015 post-drawdown whole-lake point-intercept surveys. Prior to the drawdown, approximately 39% and 29% of the littoral sampling locations in 2010 and 2013 contained native aquatic plants, respectively. In the first summer following the drawdown in 2014, the occurrence of native vegetation in Musser Lake was not statistically different from 2013 with an occurrence of 28%. However, in 2015, the second summer following the drawdown, the occurrence of native aquatic vegetation declined slightly to approximately 23%.

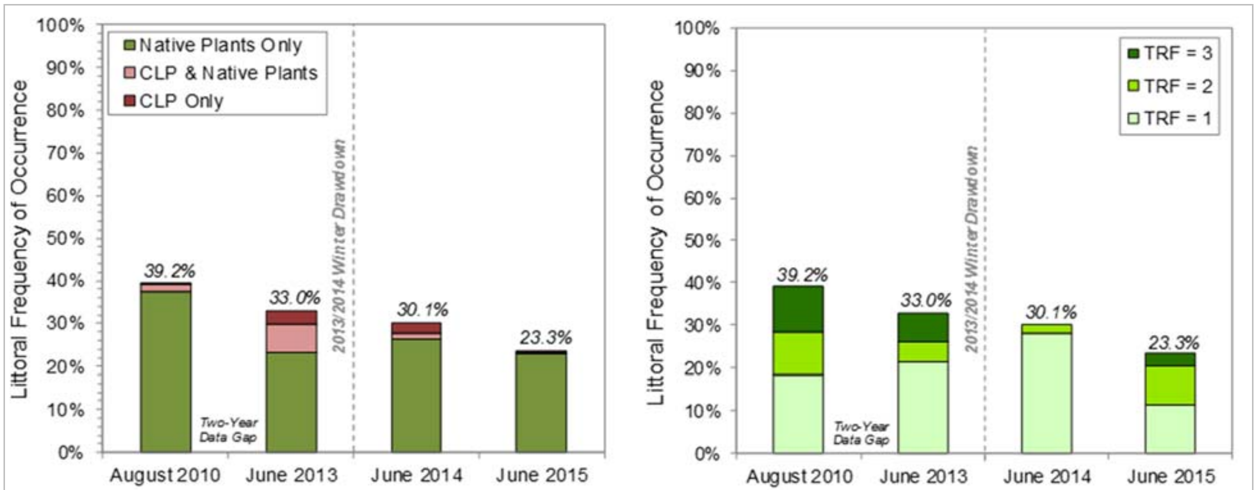


Figure 16. Musser Lake littoral frequency of occurrence of native and non-native aquatic vegetation (left) and aquatic vegetation total rake fullness ratings (right) from 2010 and 2013 pre- and 2014 and 2015 post-drawdown whole-lake point-intercept surveys. Created using data from Onterra 2010 and WDNR 2013, 2014, and 2015 whole-lake point-intercept surveys.

The point-intercept data show that the lake-wide occurrence of native vegetation did not decline significantly in the first two summers (2014 and 2015) following the drawdown. However, it is believed that the biomass of aquatic vegetation likely declined in the first summer following the drawdown. While the biomass of aquatic plants was not directly measured, the decline in biomass is indicated by the reduction in aquatic plant total rake fullness ratings of 2 and 3 in the first summer following the drawdown. Prior to the drawdown in 2010 and 2013, approximately 34% and 17% of littoral sampling locations had total rake fullness ratings of 2 or 3 recorded, respectively (Figure 16 and 17). In 2014, the number of littoral sampling locations with total rake fullness ratings of 2 or 3 declined to 3%. However, total rake fullness data collected in 2015 indicates that the biomass of aquatic plants in Musser Lake has increased in the second summer following the drawdown with approximately 51% of littoral sampling locations containing rake fullness ratings of 2 or 3.

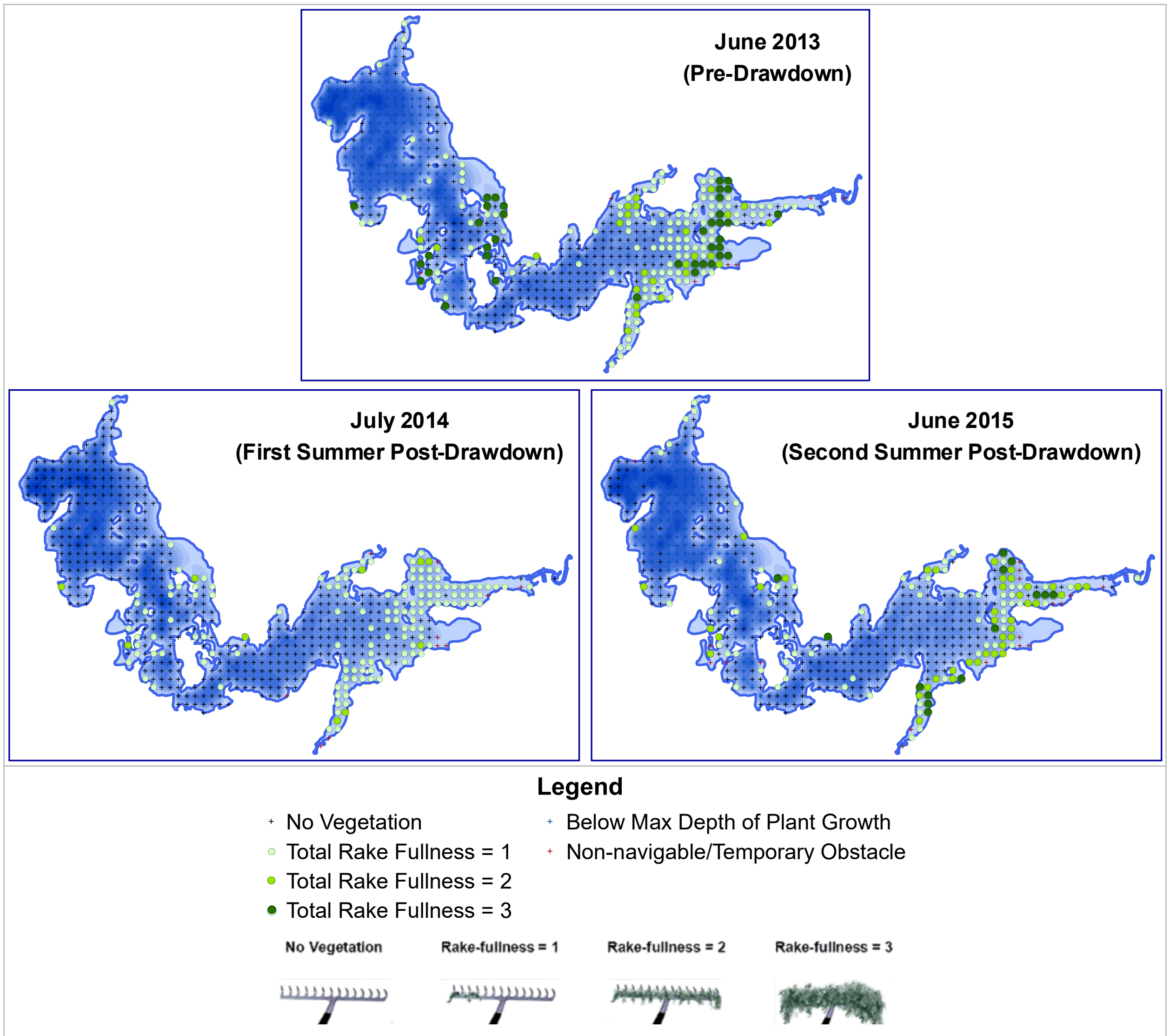


Figure 17. Musser Lake 2013 pre- and 2014 and 2015 post-drawdown point-intercept locations containing aquatic vegetation and their respective total rake fullness rating. Created using data from Onterra 2010 and WDNR 2013 and 2014 whole-lake point-intercept survey data.

Chi-square analysis (α = 0.05) was used to compare individual aquatic plant species occurrences from pre- and post-drawdown. The aquatic plant species that had a littoral frequency of occurrence of at least 5% in one of three surveys is applicable for analysis (Figure 18). For this analysis, *hornwort* refers to the combined occurrence of coontail and spiny hornwort (*C. demersum* and *C. echinatum*) and *waterweed* refers to the combined occurrence of common waterweed and slender waterweed (*E. canadensis* and *E. nuttallii*). The occurrences of these plants were combined due to their morphological similarity and often difficult identification. In addition, whorled water milfoil (*M. verticillatum*) as recorded in the 2013 and 2014 point-intercept survey data was changed to various-leaved water milfoil (*M. heterophyllum*) as these plants were positively identified as the latter by the UW-Stevens Point Herbarium in 2010.

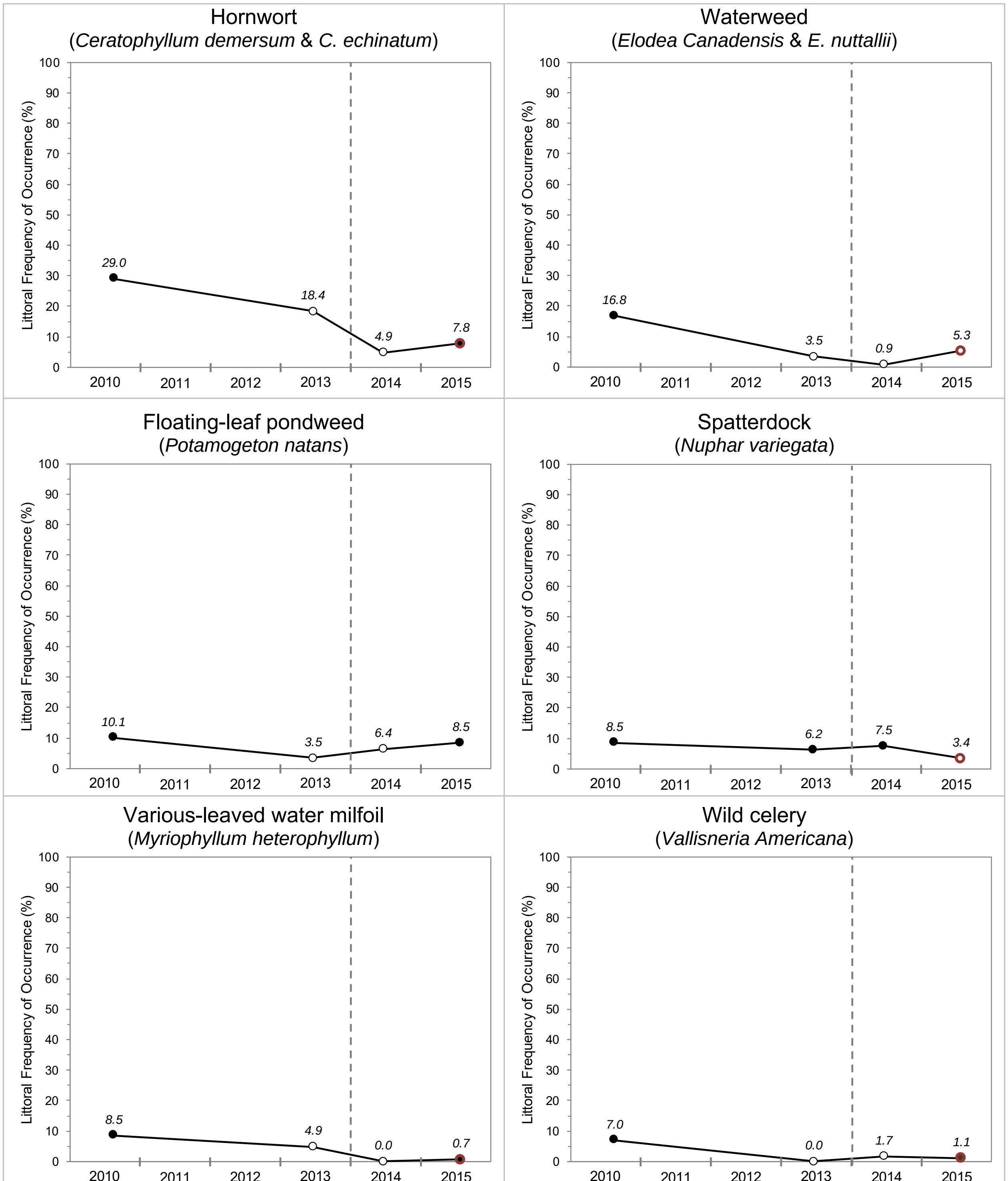


Figure 18. Musser Lake 2010 and 2013 pre- and 2014 and 2015 post-drawdown littoral frequency of occurrence of select native aquatic plant species. Dashed line represents 2013/2014 5.0-foot winter water level drawdown. Open circle indicates statistically valid change in occurrence from previous survey. Circle with red outline indicates statistically valid change in occurrence from 2010 to 2015.

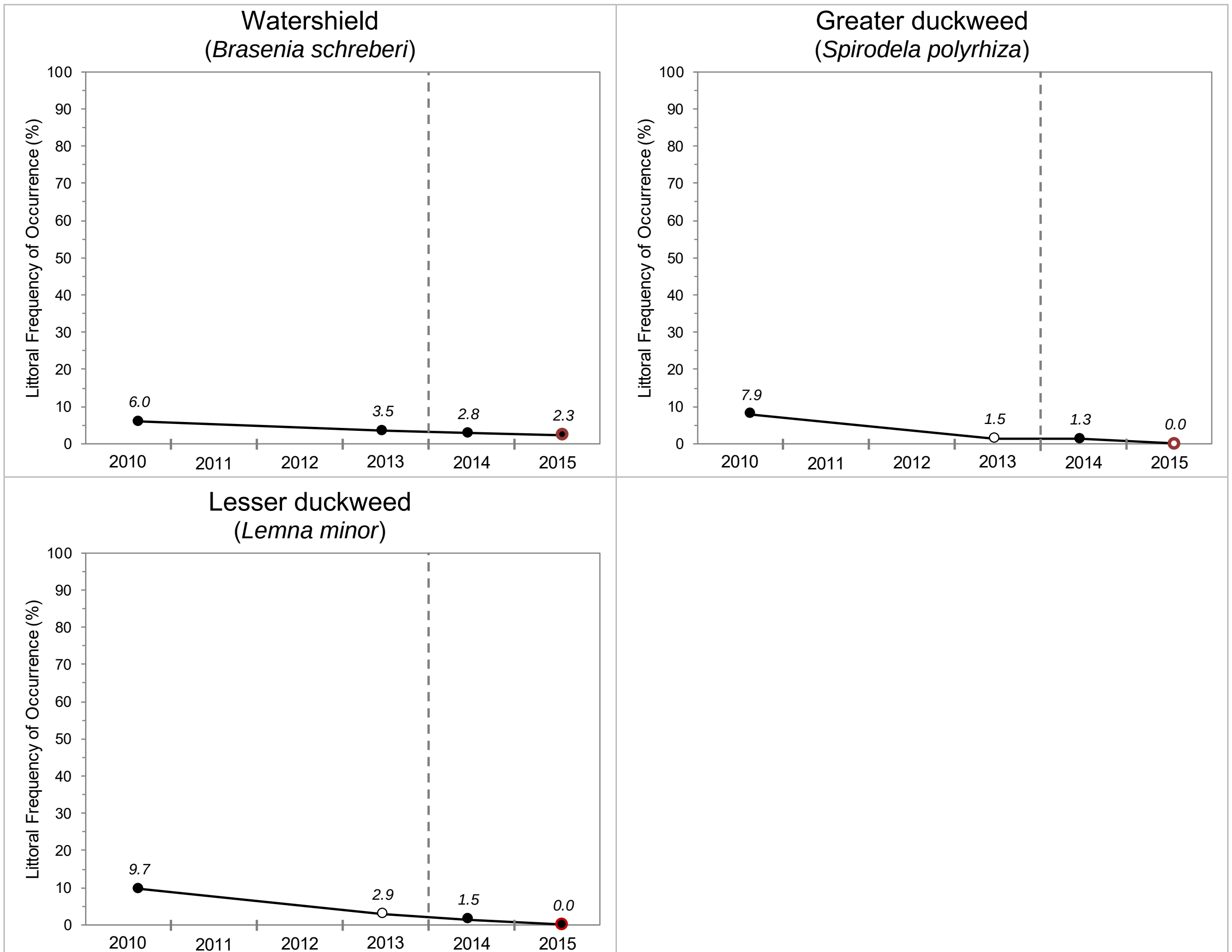


Figure 18 continued. Musser Lake 2010 and 2013 pre- and 2014 and 2015 post-drawdown littoral frequency of occurrence of select native aquatic plant species. Dashed line represents 2013/2014 5.0-foot winter water level drawdown. Open circle indicates statistically valid change in occurrence from previous survey. Circle with red outline indicates statistically valid change in occurrence from 2010 to 2015.

Five native aquatic plants exhibited statistically valid changes in their occurrence in the first summer following the 2013/2014 water level drawdown (Figure 18). Hornwort, waterweed, and various-leaved water milfoil exhibited reductions in their occurrence following the drawdown, decreasing in occurrence by 73%, 75%, and 100%, respectively. In downstream Lac Sault Dore, coontail and various-leaved water milfoil exhibited similar levels of decline in occurrence following the 2010/2011 winter drawdown. Unlike many other aquatic plants which overwinter via turions, seeds, and/or underground rhizomes; hornwort, various-leaved water milfoil, and waterweed all maintain some level of above-ground biomass through the winter making their tissues susceptible to desiccation and/or freezing during water level drawdowns.

Two species, floating-leaf pondweed and wild celery, exhibited statistically valid increases in their occurrence following the drawdown, increasing in occurrence by 85% and 100%, respectively (Figure 18). Both of these species overwinter via rhizomes buried in the sediment, and their increase in occurrence in 2014 may be a result of reduced competition from the previously discussed species that declined. The occurrences of spatterdock, lesser duckweed, greater duckweed, and watershield were not statistically different from pre- and post-drawdown (Figure 18).

In 2015, the second summer post-drawdown, the occurrences of hornwort and various-leaved water milfoil were not statistically different from 2014 indicating the populations of these plants have not yet returned to pre-drawdown levels (Figure 18). However, the waterweed population was found to have increased from 2014-2015 by a statistically valid 516%, exceeding pre-drawdown levels.

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 native aquatic plant species that were encountered on the rake during the point-intercept surveys. These native species and their conservatism values were used to calculate the FQI of Musser Lake's aquatic plant community in 2010, 2013, 2014, and 2015.

The number of native aquatic plant species detected, or species richness, declined from 25 in 2013 to 22 and 17 in 2014 and 2015, respectively. The native plant species richness of Musser Lake in 2015 falls below the median value for flowages in both the ecoregion and the state. Table 1 lists the aquatic plant species located during the point-intercept surveys conducted in 2010, 2013, 2014, and 2015. The lake-wide occurrence of vegetation was lower in Musser Lake in 2015 when compared to 2014, and the decline in the number of species recorded in 2015 is not necessarily a result of the 2013/2014 drawdown but may likely be due to differences in climatic conditions or other factors.

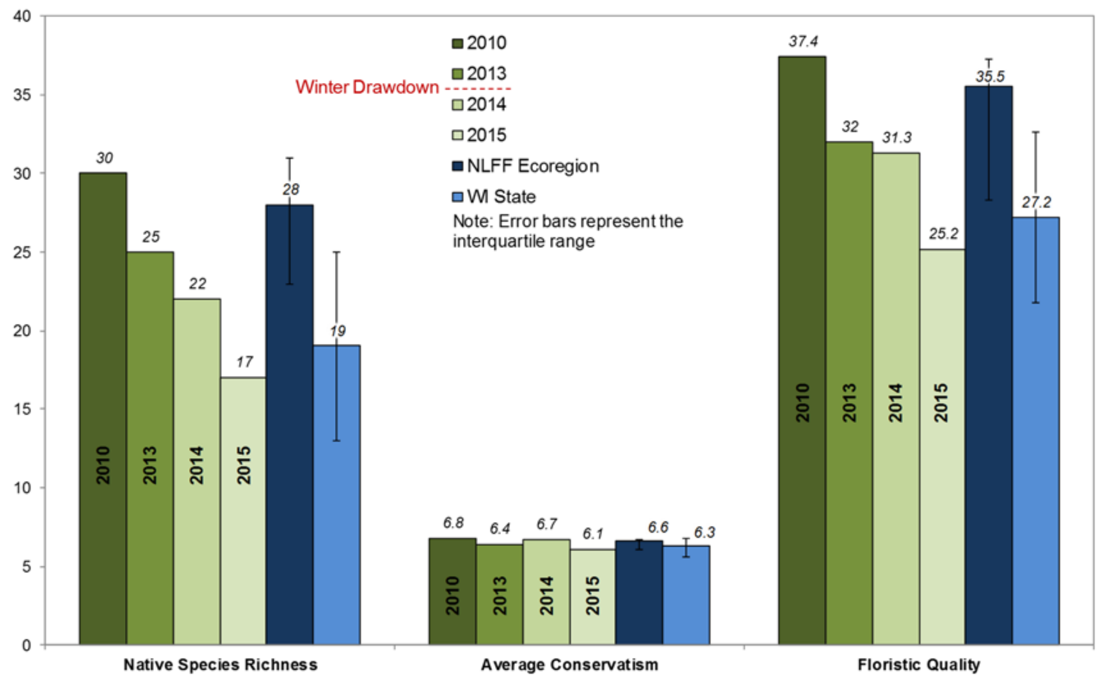


Figure 19. Musser Lake floristic quality assessment. Created using data from Onterra 2010 and WDNR 2013, 2014, and 2015 whole-lake point-intercept surveys. Analysis follows Nichols (1999) where NLFF = Northern Lakes and Forests-Flowages. Ecoregion and state data calculated from WDNR Bureau of Science Services and Onterra point-intercept data.

The average conservatism of Musser Lake's aquatic plant community fluctuated from 6.8 in 2010, 6.4 in 2013, 6.7 in 2014, and 6.1 in 2015, straddling the median values for flowages within the ecoregion and the state (Figure 19). The floristic quality values in 2013 and 2014 immediately before and after the drawdown are very similar, and indicate no detectable effects to the quality of Musser Lake's native aquatic plant community following the drawdown. However, Musser Lake's floristic quality declined significantly in 2015 as a result of the reduced species richness.

Table 1. Aquatic plant species located during the 2010 and 2013 pre- and 2014 and 2015 post-drawdown whole-lake point-intercept surveys on Musser Lake.

				Pre-Drawdown		Post-Drawdown	
Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	August 2010	June 2013	June 2014	July 2015
Emergent	*Acorus americanus*	Sweetflag	7			X	
	Carex sp.	Sedge sp.	N/A		X		
	Equisetum fluviatile	Water horsetail	7	X	X	X	
	Schoenoplectus tabernaemontani	Softstem bulrush	4	X			X
	Zizania palustris	Northern wild rice	8	X	X	X	
FL	*Brasenia schreberi*	Watershield	7	X	X	X	X
	Nuphar variegata	Spatterdock	6	X	X	X	X
FL/E	*Sparganium androcladum*	Shining bur-reed	8	X			
	Sparganium fluctuans	Floating-leaf bur-reed	10	X	X	X	X
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X	X	X
	Ceratophyllum echinatum	Spiny hornwort	10		X	X	
	Chara spp.	Muskgrasses	7			X	X
	Elodea canadensis	Common waterweed	3	X	X	X	X
	Elodea nuttallii	Slender waterweed	7		X	X	
	Myriophyllum farwellii	Farwell's water milfoil	9	X			
	Myriophyllum heterophyllum	Various-leaved water milfoil	7	X	X		X
	Najas flexilis	Slender naiad	6				X
	Nitella spp.	Stoneworts	7	X	X	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X		
	Potamogeton crispus	Curly-leaf pondweed	Exotic	X	X	X	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X	X	X	X
	Potamogeton foliosus	Leafy pondweed	6				X
	Potamogeton natans	Floating-leaf pondweed	5	X	X	X	X
	Potamogeton obtusifolius	Blunt-leaf pondweed	9	X			
	Potamogeton pusillus	Small pondweed	7	X	X	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X	X	X
	Potamogeton strictifolius	Stiff pondweed	8	X			
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X	X	
	Ranunculus aquatilis	White water-crowfoot	8	X		X	
	Utricularia intermedia	Flat-leaf bladderwort	9	X			
	Utricularia minor	Small bladderwort	10	X			
	Utricularia vulgaris	Common bladderwort	7	X	X	X	
	Vallisneria americana	Wild celery	6	X		X	X
S/E	*Schoenoplectus subterminalis*	Water bulrush	9		X		
FF	*Lemna minor*	Lesser duckweed	5	X	X	X	
	Lemna trisulca	Forked duckweed	6	X	X		
	Riccia fluitans	Slender riccia	7	X	X		
	Spirodela polyrhiza	Greater duckweed	5	X	X	X	X
	Wolffia columbiana	Common watermeal	5	X	X		

FL = Floating-leaf; FL/E = Floating-leaf & Emergent; S/E = Submergent & Emergent; FF = Free-floating
X = Located on rake during whole-lake point-intercept survey

As discussed in the primer section, northern wild rice populations in Musser Lake were mapped in 2013 prior to the drawdown by GLIFWC staff and in 2014 and 2015 following the drawdown by Onterra. In 2013, GLIFWC mapped approximately 15.6 acres of northern wild rice within the eastern basin of the lake in the mouths Popple Creek and Musser Creek, but not in the inlet area of the Elk River. (Figure 20).

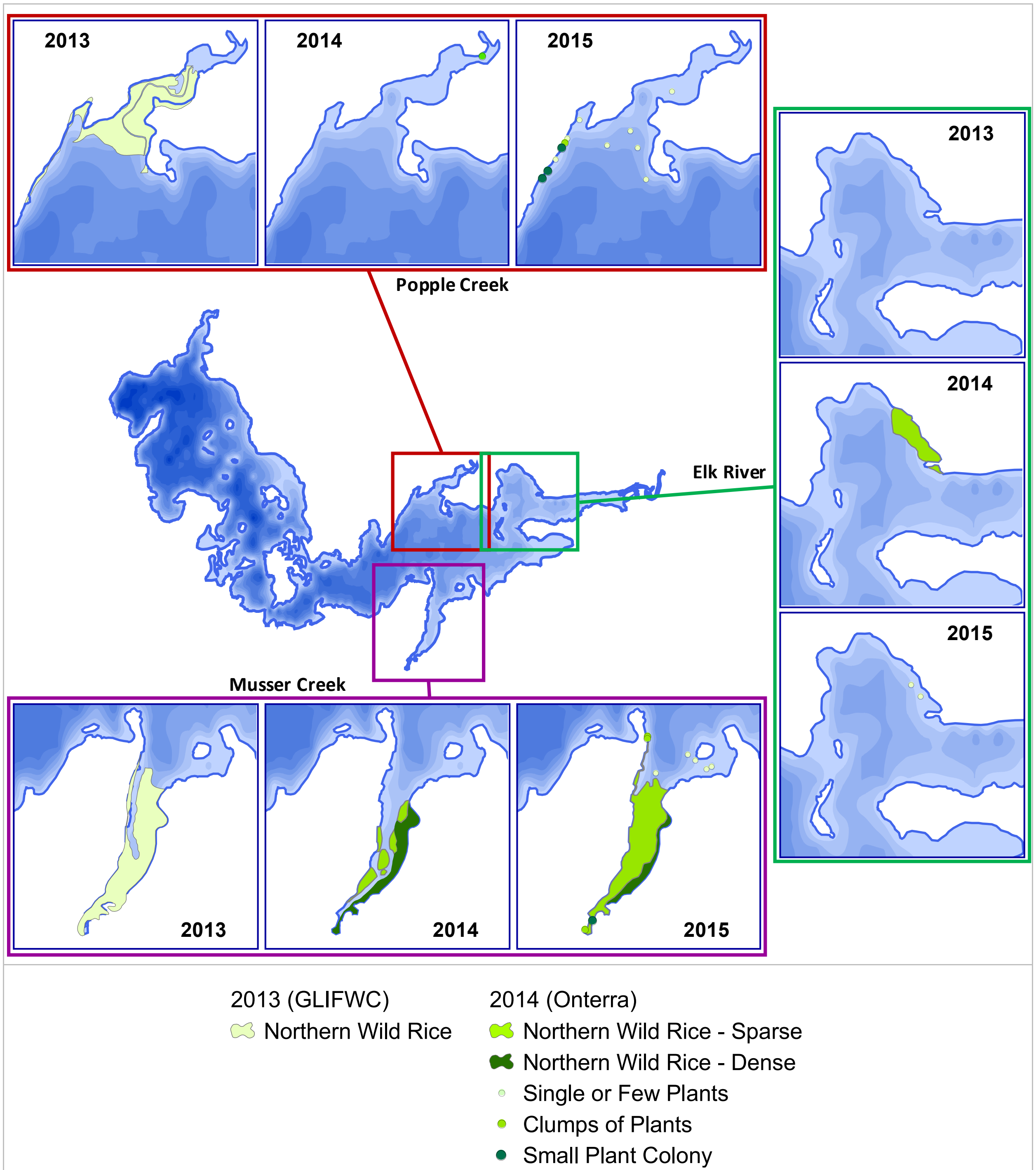


Figure 20. Musser Lake northern wild rice populations from 2013 pre- and 2014 and 2015 post-drawdown. Created using data from GLIFWC (2013) and Onterra (2014 & 2015).

In the first summer following the drawdown, Onterra ecologists found that the colony of wild rice near the mouth of Popple Creek had declined from approximately 6.7 colonized acres in 2013 to 0.0 colonized acres in 2014 and 2015 with only a few wild rice occurrences mapped with point-based methods in 2015 (Figure 22). The colonies mapped in 2013 near the mouth of Musser Creek also declined from approximately 8.8 acres in 2013 to 4.6 acres in 2014, but rebounded to 8.6 acres in 2015 (Figure 20).

Onterra ecologists mapped an additional 1.7-acre colony of wild rice near the mouth of the Elk River in 2014 that was not part of GLIFWC's 2013 survey. In 2015, this colony was found to have reduced to a couple of *single or few plants* occurrences.

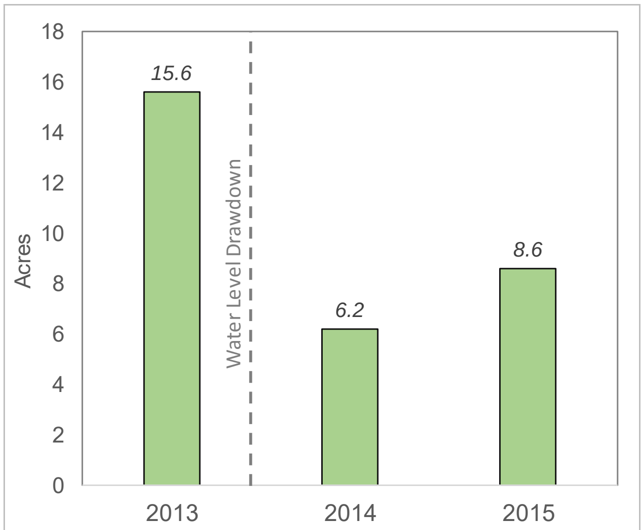


Figure 22. Musser Lake 2013 pre- and 2013 and 2015 post-drawdown acreage of northern wild rice. Created using data from GLIFWC (2013) and Onterra (2014 & 2015).

Because wild rice is an annual plant and relies solely on seed for population sustenance, variations in seed production in a given year will impact the size of rice bed in subsequent years. Other factors, such as spring temperatures and water levels, also impact rice populations by affecting seed germination. According to Aiken et al. (1988), over the course of four years it is likely that there will be a boom year, a bust year, and a couple of average years. However, it has been documented that in systems with higher rates of water flow, rice production and population dynamics are more consistent over time.

The acreage of wild rice at the mouth of Musser Creek increased in 2015 to similar acreage that was mapped prior to the drawdown in 2013. However, wild rice was still very sparse at the mouth of Popple Creek and was not yet at pre-drawdown abundance. It is not clear if the changes in wild rice abundance from 2013-2015 are the results of the water level drawdown or natural inter-annual variation of this species. Continued monitoring of the wild rice population in Musser Lake will bring a better understanding of the population's annual dynamics.

SUMMARY & CONCLUSIONS

The 2013/2014 5.0-foot winter water level drawdown on Musser Lake was executed as designed due to great efforts by the Price County Dam Tender. Water level data provided by the Price County Dams Tender indicates that the 5.0-foot water level drawdown was maintained from early-September 2013 through late-April 2014. Quantitative and qualitative assessments conducted by Onterra and the WDNR indicate that Musser Lake's CLP population was adversely impacted and reduced by the water level drawdown, and the lake's CLP population remains low two summers after the winter drawdown took place.

The whole-lake point-intercept data show that the lake-wide occurrence of CLP declined by 63% from 2013-2014, while the sub-sample point-intercept data indicate that in areas where CLP was most abundant prior to the drawdown, its occurrence was reduced by 75% from 2013 vs 2014 and 90% from 2013 vs 2015. Qualitative mapping surveys conducted by Onterra pre- and post-drawdown revealed that CLP colonial acreage decreased from approximately 52 acres in 2013 to zero acres in 2014 and 0.6 acres in 2015.

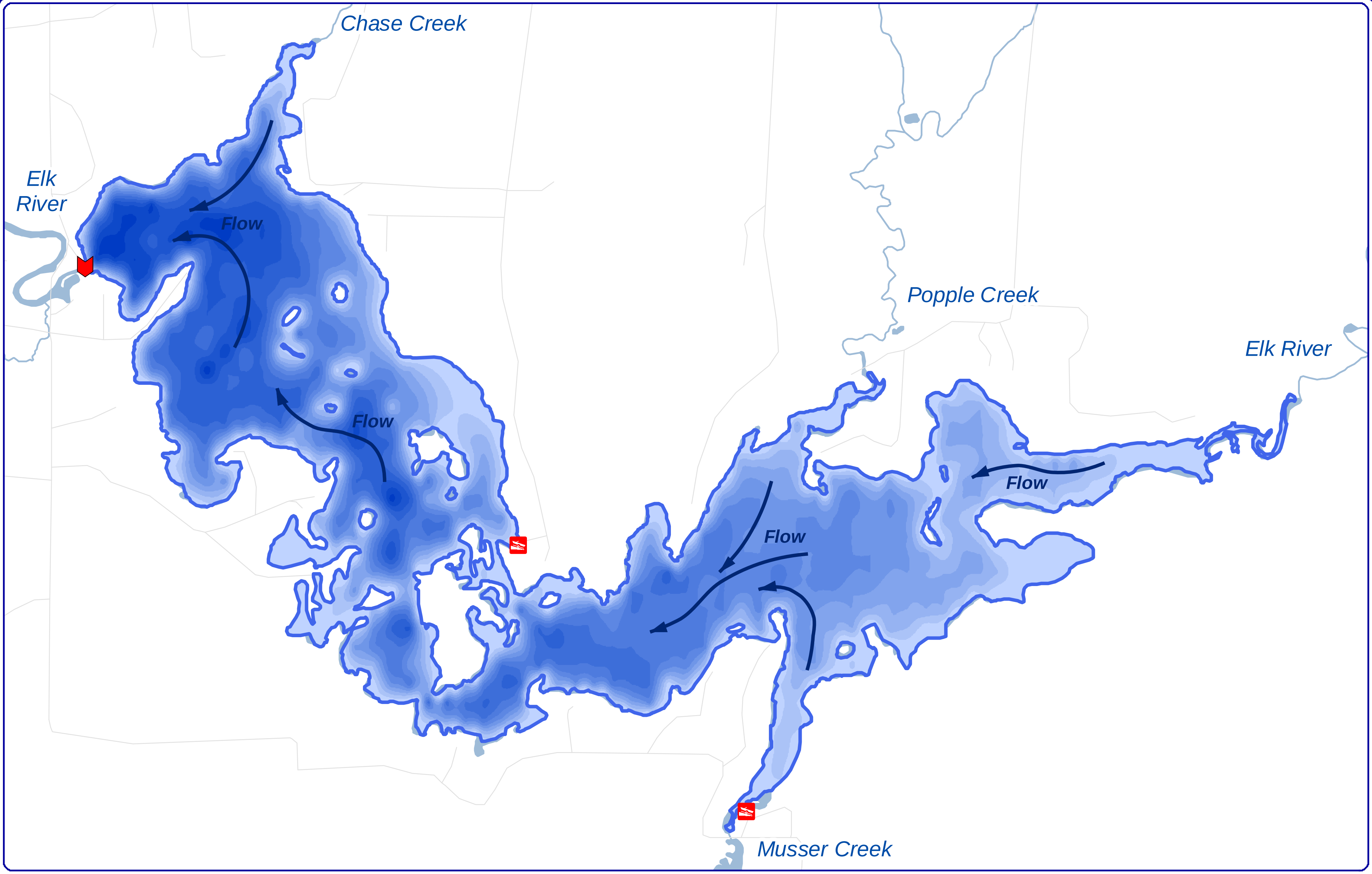
The WDNR's turion study found a statistically valid reduction in the number of viable turions following the drawdown, and the percentage of viable turions sprouting in laboratory conditions from before and after the drawdown decreased from 73% to 25%, respectively. These data indicate that the majority of turions present within Musser Lake's sediments were exposed to desiccation and freezing during the drawdown, which may equate to decreases in the CLP population beyond the year following the drawdown. The 2015 assessments indicate that a 5.0-foot water level drawdown in Musser Lake has the capacity to reduce and maintain a small CLP population for at least two growing seasons following the drawdown. Because this is the first study to look at the response of CLP to a winter drawdown in Musser Lake, and because few studies have been conducted elsewhere, there is uncertainty has to how quickly the CLP population will rebound following the drawdown.

Monitoring of Musser Lake's native aquatic plant community indicated that a few species which maintain above-ground biomass over the winter exhibited statistically valid reductions in their occurrence following the drawdown. A couple species were found to have increased in their occurrence following the drawdown, while the occurrences of the majority of the plants in the lake were not statistically different from before and after drawdown. While the total number of whole-lake point-intercept sampling locations containing vegetation was not markedly different from before and after drawdown, total rake fullness ratings declined after the drawdown indicating aquatic plant biomass was reduced. However, surveys in 2015 indicated that the biomass of aquatic plants had increased compared to 2014.

In addition, mapping of wild rice indicates that it has declined in abundance lake-wide since 2013; however, the 2015 data indicate abundance was similar to that observed in 2013 in the mouth of Musser Creek. The abundance of wild rice at the mouth of Popple Creek in 2015 was still lower than what was mapped prior to drawdown in 2013. As discussed, wild rice populations tend to fluctuate naturally between years, and it is not clear if the decline in wild rice abundance was due to the water level drawdown or natural causes. Overall, wild rice has declined by approximately 7.0 acres from 2013 to 2015.

Overall, a 5.0-foot winter water level drawdown appears to be an effective management tool for controlling the CLP population in Musser Lake for at least two growing seasons while minimizing impacts to valuable native aquatic plant species. No areas of CLP were located within the lake in 2015 that warrant herbicide control in 2016; however, it is recommended that some of these areas comprised of single plants be targeted for hand-removal in 2015. During the Musser Lake management planning process, MLA members received training that included identification of non-native plants and native look-a-likes, proper use of a GPS for recording and locating plant occurrence, note taking, and transfer of data utilizing a grant-funded GPS unit. The MLA has also learned several hand-removal techniques to be used for varying conditions of water depth and clarity.

This report marks the final deliverable for the LMA's two-phased WDNR Grant-Funded Project (ACEI-118-12 and AEPP-386-13). With remaining funds from not conducting an herbicide treatment in 2015, the MLA may decide to continue specific monitoring components in 2016. The WDNR would like to conduct another point-intercept survey of Musser Lake in 2016 if their staffing resources allow.



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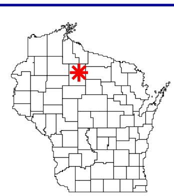
Sources:
Roads & Hydro: WDNR
Bathymetry: WDNR 2013, digitized by Onterra
Map date: February 5, 2015
Filename: *Map1_Musser_Location.mxd*



Project Location in Wisconsin

Legend

Musser Lake ~ 533 acres

Musser Dam

Public Access Location

Map 1

Musser Lake

Price County, Wisconsin

Project Location & Lake Boundaries