1.0 INTRODUCTION

The Unified Lower Eagle River Chain of Lakes Commission (ULERCLC) has been the successful recipient of Wisconsin Department of Natural Resources (WDNR) Aquatic Invasive Species (AIS) Control Grants since 2007 as they conduct a project aimed at reducing the Eagle River Chain of Lake's Eurasian watermilfoil (*Myriophyllum spicatum*; EWM) population. This report specifically discusses the monitoring and control activities conducted during 2017. The chain-wide results will be presented first followed by results from each lake individually.

Additional information regarding the control actions completed from 2008-2016 can be found in their respective annual reports. Native aquatic vegetation inventories from whole-lake point-intercept surveys are conducted on the chain roughly every five years. Through funding from the Eagle River Chain of Lakes Association (ERCLA) and WDNR grant funds, whole-lake point-intercept surveys on all lakes were completed in 2017. These surveys were completed to reassess the EWM and native aquatic plant populations throughout the chain, and the data from these surveys were compared to data collected in 2005/06 and 2012 to determine if any significant changes have occurred over this time period. This report serves to present the 2017 EWM monitoring and control strategy assessment and the 2017 whole-lake point-intercept survey results.

2.0 2017 CHAIN-WIDE EWM CONTROL STRATEGY RESULTS

From 2007-2015, the ULERCLC has coordinated strategically targeted annual herbicide spot treatments and a few large-scale treatments targeting EWM throughout the Lower Eagle River Chain of Lakes. The lessons learned over this time period resulted in the ULERCLC developing a strategy where consideration for herbicide application would be given to areas of EWM if they met the following threshold (i.e. trigger): colonized areas of EWM with a density of *dominant* or greater where a sufficiently large treatment area can be constructed to maintain an adequate herbicide concentration and exposure time (CETs) to cause EWM mortality as opposed to injury.

Based upon this established herbicide treatment strategy, no areas of EWM in the Lower Eagle River Chain of Lakes have met this threshold since 2015 and no treatments occurred in 2016 or 2017. While herbicide treatments did not occur in 2016, experimental traditional hand-harvesting (non-mechanical) was implemented by professionals in Voyageur Lake in an effort to control small, low-density colonies of EWM. This initial hand-removal effort in 2016 was largely successful, and this effort was expanded in 2017. In 2017, traditional hand-harvesting was implemented in areas in Voyageur and Watersmeet lakes, while diver-assisted suction harvesting (DASH; mechanical) was implemented in two areas in Scattering Rice Lake.

The DASH system has been found to be effective at removing smaller, dense colonies of EWM. During this process, a scuba diver manually extracts the invasive plants (including the roots) and then feeds the removed plants into a vacuum tube that transports the plants to a bin or bag on a boat. They do not simply vacuum the area to remove the plants as that would result in the removal of sediment and non-target native plants which would be considered suction dredging (requires elaborate permitting). The DASH system is thought to be more efficient than manual removal alone as the diver does not have to go to the surface to deliver the pulled plants to someone on a boat. The DASH system also is theorized to cause less fragmentation, as the plants are immediately transported to the surface using the vacuum technology.

During the 2017 Early-Season AIS Survey (ESAIS), the mapping of the EWM within proposed hand-harvesting areas were refined and a final hand-harvesting strategy was derived. Onterra provided the hand-harvesting firm with the spatial data from the ESAIS Survey to coordinate the removal efforts. As is discussed specifically within the Voyageur, Scattering Rice, and Watersmeet lakes individual results sections, the hand-harvesting actions occurred over two days in June, two days in July, and three days in August.

The traditional hand-harvesting conducted in 2017 was met with mixed results. The traditional hand-harvesting implemented in Voyageur Lake was considered successful as it was able to maintain a low-density EWM population comprised primarily of single-plant occurrences within the hand-harvest areas. The traditional hand-harvesting implemented in one area of Watersmeet was considered unsuccessful as EWM within this area was found to have increased in density despite the implementation of hand-harvesting. The fact that EWM was not reduced in Watersmeet is not the result of deficient hand-harvesting methodology but is an indication that the rate of EWM expansion exceeded the pace of hand-removal efforts. In other words, more hand-harvesting effort (time) would have been needed to decrease EWM density in this area. In Scattering Rice Lake, the implementation of DASH was considered successful as the density of EWM was reduced in both harvested areas.

The EWM mapping completed in the late-summer of 2017 showed that at a chain-wide level, the EWM population remains small. Following the implementation of annual herbicide applications from 2008-2015, colonized acreage of EWM was reduced from 278 acres to 12 acres (Figure 1). Since 2015, EWM acreage has increased slightly to 20 acres in 2016 and 36 acres in 2017. However, 74% of the acreage mapped in 2017 was comprised of low-density EWM with density ratings of *scattered* and *highly scattered*, densities which do not meet the pre-defined threshold for consideration of herbicide treatment. Please note that Figure 1 only represents the acreage of mapped EWM polygons, not EWM mapped within point-based methodologies (*single or few plants, clumps of plants,* or *small plant colonies*). Taken out of context, this figure can be misleading as large increases in EWM colonial acreage may be the results of low-density point-based data increasing to levels that now are best delineated with EWM colonies.

Like in past years, the majority of the EWM acreage mapped in 2017 (92%) was located in Cranberry and Watersmeet lakes (Figure 2). The EWM within these lakes is largely located in channelized areas where water flow is higher. Past herbicide treatments conducted in these areas revealed it is difficult to achieve the needed concentration and exposure time to achieve EWM mortality. While the 2015 herbicide treatment in the Cranberry Channel achieved control beyond one year, assessments in 2017 revealed EWM is beginning to rebound within this area. Similarly, the EWM in Watersmeet, primarily within the Wisconsin River portion of the lake, has been increasing in density. A preliminary EWM control strategy for 2018 is outlined within the *2018 Preliminary Chain-Wide EWM Control Strategy* section (Section 4.0).

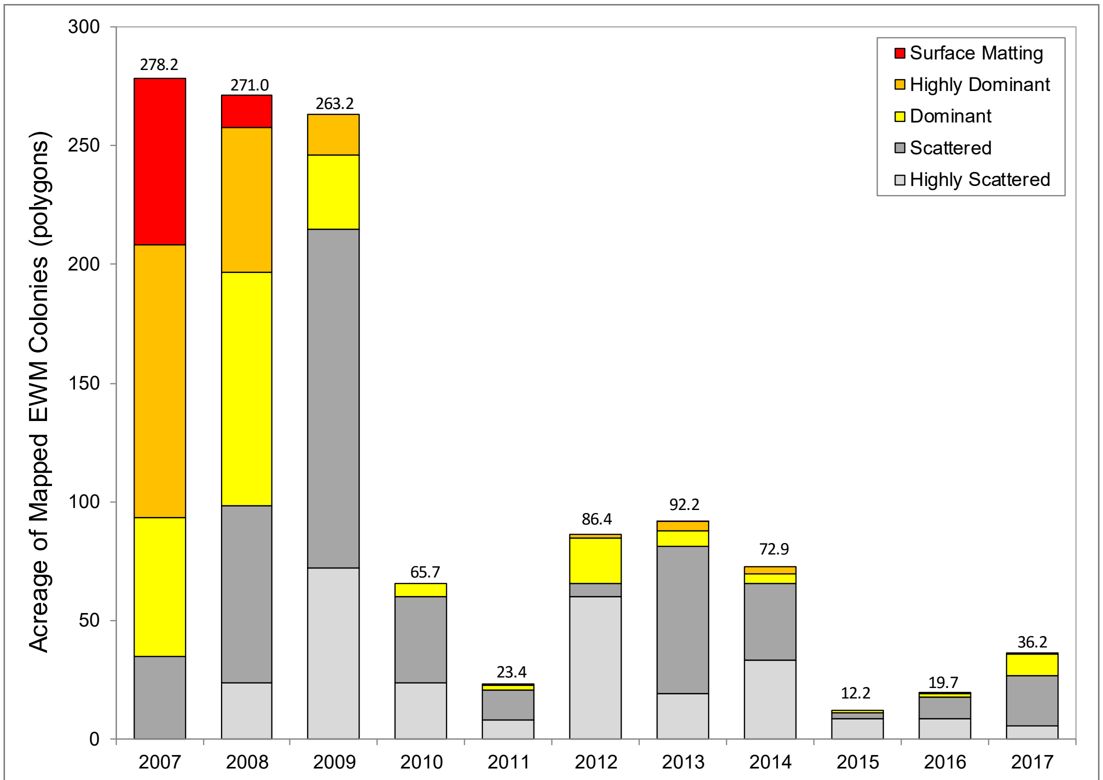


Figure 1. Chain-wide acreage of mapped EWM colonies on the Lower Eagle River Chain of Lakes from 2007-2016.

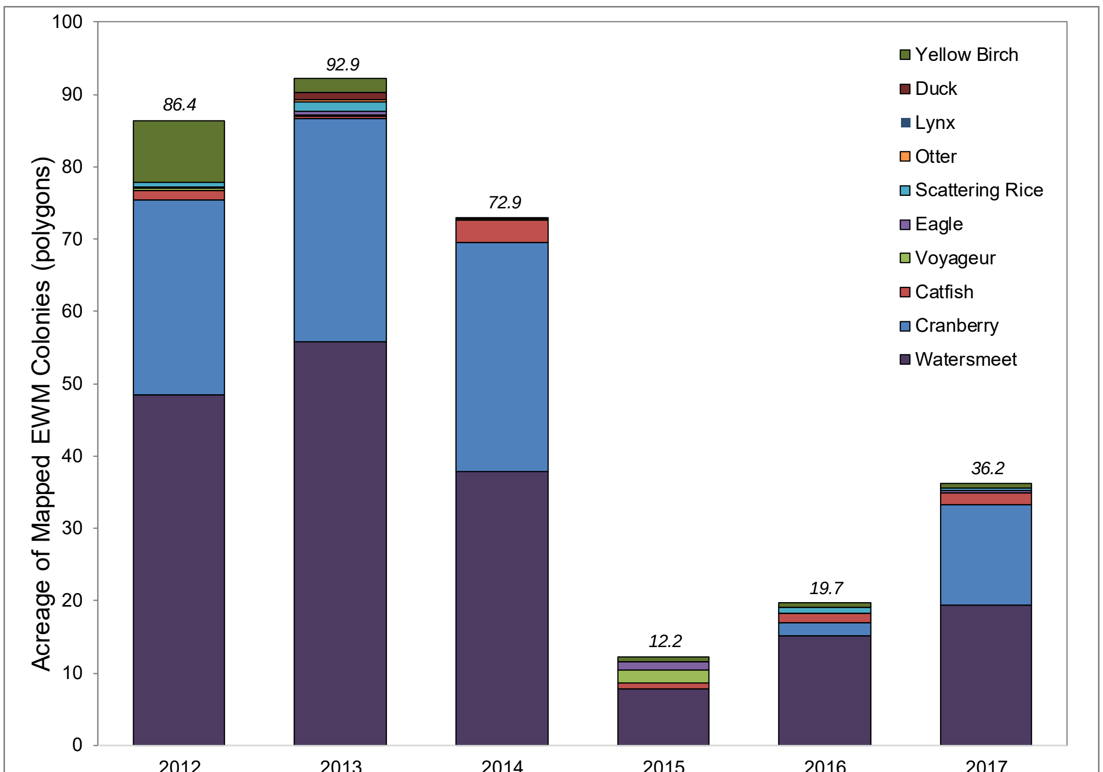


Figure 2. Acreage of mapped EWM colonies within each lake of the Lower Eagle River Chain of Lakes from 2012-2017.

3.0 2017 AQUATIC VEGETATION POINT-INTERCEPT SURVEY RESULTS

The whole-lake point-intercept surveys were conducted on the Eagle River Chain of Lakes on August 14-16, 2017. The results of these surveys can be compared to the results from the 2005/06 and 2012 point-intercept surveys to determine if any significant changes in the abundance of plants or species composition have occurred over this period. In 2005/06, of the 3,669 point-intercept sampling locations on the Lower Eagle River Chain, 34% contained aquatic vegetation (frequency of occurrence), and approximately 6% contained EWM (Figure 3). In 2012, the frequency of occurrence of aquatic plants decreased to 27% and the number of sampling locations containing EWM declined to <1%. In 2017, the frequency of occurrence of vegetation was found to have declined further to 20%, with 1% of the sampling locations containing EWM. Overall, the frequency of occurrence of native aquatic vegetation in the chain declined by 39% between the 2005/06 and 2017.

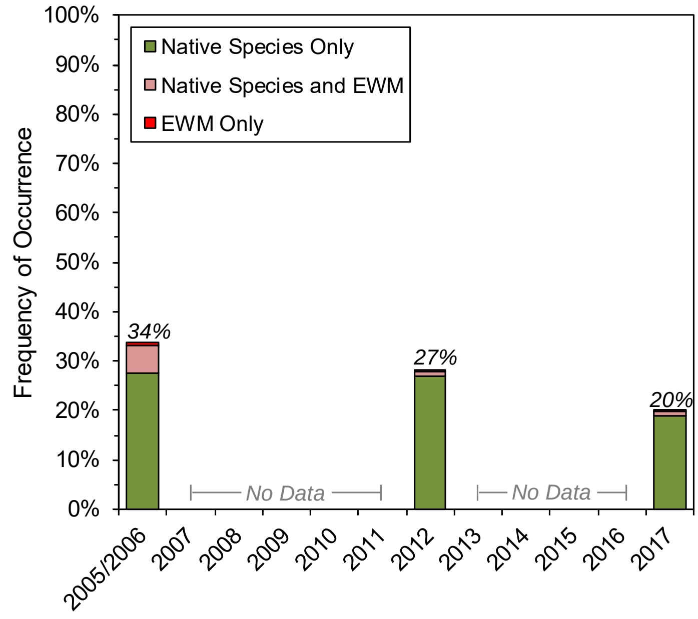


Figure 3. Frequency of occurrence of aquatic vegetation, native and non-native Eurasian watermilfoil (EWM), in the Lower Eagle River Chain of Lakes from 2005-2017. N = 3,669. Decline in native vegetation is believed to be due to decline in chain-wide water clarity.

Since the herbicide (2,4-D amine and 2,4-D ester) used to control EWM on the chain has been shown to have potential adverse impacts to select native aquatic plant species, a link to the decline in the overall occurrence of aquatic vegetation from 2005 to 2017 in the chain was evaluated. The amount of acreage applied with herbicide in the chain was highest from 2008-2010, with an average of 257 acres applied with herbicide per year. The amount of acreage treated from 2011-2015 was lower with an annual average of 69 acres, and no herbicide applications took place in 2016 or 2017. Despite a decreased use of herbicide and less acreage treated in the chain since 2012, native aquatic plant occurrence still declined.

Within the *Comprehensive Management Planning Project*, the role of reduced water clarity caused by above-normal growing season precipitation was investigated in terms of the reduction in native aquatic vegetation over this period. Average chain-wide water clarity has declined by approximately 2.0 feet in recent years, coinciding with increases in precipitation (Figure 4). In 2017, average chain-wide Secchi disk depth was 3.5 feet, the lowest clarity recorded since record keeping began in 1992. Response of the aquatic plant community to the reduction in water clarity is evidenced by the recorded maximum depth of plant growth during the point-intercept surveys. In 2005/2006, the chain-wide average maximum depth of aquatic plant growth was 12 feet (Figure 5). In 2012, the chain-wide average maximum depth of aquatic plant growth declined to 11 feet, and in 2017 declined further to 8 feet. Due to a reduction in light availability with decreased water clarity, aquatic plant growth declined in deeper waters over this period. The reduction of the chain's littoral zone resulted in reduced occurrence of aquatic plant growth within the chain. The observed reduction in water clarity is believed to be the primary cause for the measured decline in aquatic plant occurrence over this period.

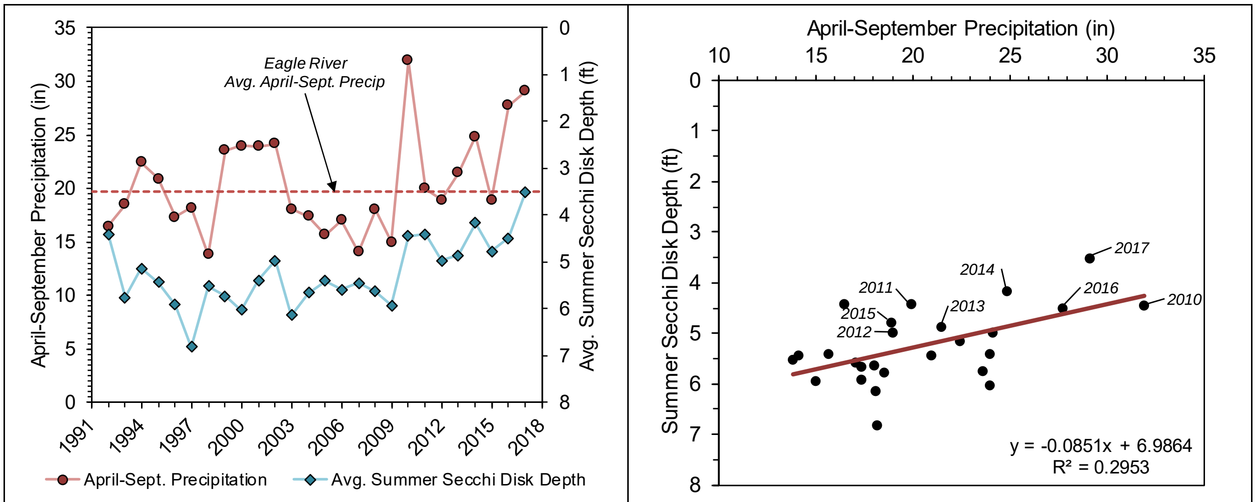


Figure 4. Eagle River total growing season (April-Sept.) precipitation and Lower Eagle River Chain of Lakes average summer (June-August) Secchi disk depth from 1992-2017 (left) and 1992-2017 summer Secchi disk depth plotted against growing season precipitation. Precipitation data obtained through Midwestern Regional Climate Center data portal from Eagle River station (ID 472314). Simple linear regression statistically significant (p-value = 0.004).

Chi-square analysis ($\alpha = 0.05$) was used to compare individual aquatic plant species chain-wide littoral frequencies of occurrence between the point-intercept surveys in 2005/06, 2012, and 2017 (Figure 6). The aquatic plant species that had a littoral frequency of occurrence of at least 5% in one of the three surveys are applicable for analysis. For this analysis, slender/small pondweed refers to the combined occurrence of slender pondweed (*Potamogeton berchtoldii*) and small pondweed (*P. pusillus*) due to their morphological similarity. Of the 10 native aquatic plant species that had a littoral occurrence of at least 5% in one of the three surveys, eight exhibited statistically valid changes in their littoral occurrence between the 2005/06 and 2017 surveys.

Of the eight native species which saw changes in their littoral frequency of occurrence, six saw statistically valid reductions in their occurrence over this time period (Figure 6). These species include small/slender pondweed (90% decline), common waterweed (27% decline), flat-stem pondweed (56% decline), northern wild rice (58% decline), northern watermilfoil (66% decline), and Vasey's pondweed (66% decline). The littoral occurrences of slender/small pondweed, common waterweed, and northern watermilfoil were not statistically different between the 2005/06 and 2012 surveys but exhibited declines in 2017. The littoral occurrence of flat-stem pondweed has declined in each survey since 2005/06, while the littoral occurrence of Vasey's pondweed increased from 2005/06 to 2012 and then declined in 2017. The littoral occurrence of northern wild rice declined between 2005/06 and 2012 but increased slightly in 2017. Being an annual plant, northern wild rice populations are known to be highly variable. On a four-year cycle, it can be expected that there will be one year with high abundance, two years with moderate abundance, and one year with low abundance, so changes in the occurrence of northern wild rice from year to year are expected.

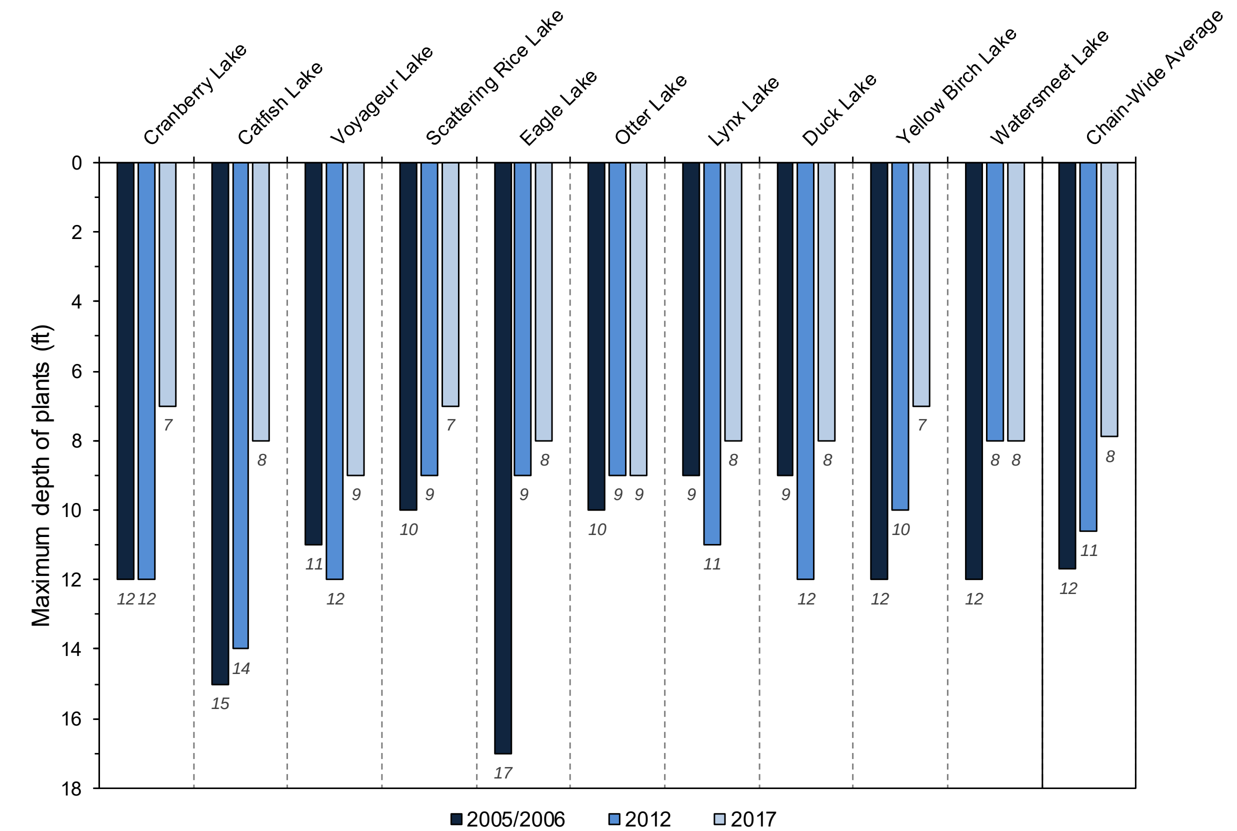


Figure 5. Recorded maximum depth of aquatic plant growth in the Lower Eagle River Chain of Lakes from 2005/06, 2012, and 2017. Decline in maximum depth of aquatic plant growth is due to reduction in chain-wide water clarity over this period.

The littoral occurrences of wild celery and slender naiad saw statistically valid increases over the period from 2005/06 to 2017, while the littoral occurrence of coontail was not statistically different between the three surveys (Figure 6). Some Eagle River Chain of Lakes riparians had expressed concerns to Onterra ecologists about observing less large-leaf pondweed (aka musky cabbage) within the chain. The littoral occurrence of large-leaf pondweed did exhibit a statistically valid decline in occurrence of 46% between 2005/06 and 2012 but increased to an occurrence in 2017 that was not statistically different from 2005/06. Onterra ecologists also noted increased observations of large-leaf pondweed colonies throughout the chain in recent years (Photo 1). Continued research is showing large-leaf pondweed is typically not susceptible to the herbicide used in the Lower Eagle River Chain, and it is likely naturally-driven environmental factors resulted in changes in this plant's occurrence over this period.

Aquatic plant communities are dynamic and the abundance of certain species from year to year can fluctuate depending on climatic conditions, herbivory, competition, disease, and management among other factors. Ongoing research on Wisconsin's lakes shows that native aquatic plant populations can fluctuate over short- and long-term periods, believed to be driven by natural variations in climate, growing season, water levels, etc. As discussed previously, the changes in native plant species occurrences in the Lower Eagle River Chain from 2005/06 to 2017 are believed to be largely due reductions in water clarity caused by higher precipitation in recent years. Aquatic plant species such as wild celery saw an increase in occurrence over this time period. This is likely due to the fact that wild celery is tolerant of lower light conditions, providing it with a competitive advantage over other plants which require higher levels of light. Other species which require higher light availability, such as northern watermilfoil, saw reductions in occurrence between 2012 and 2017.

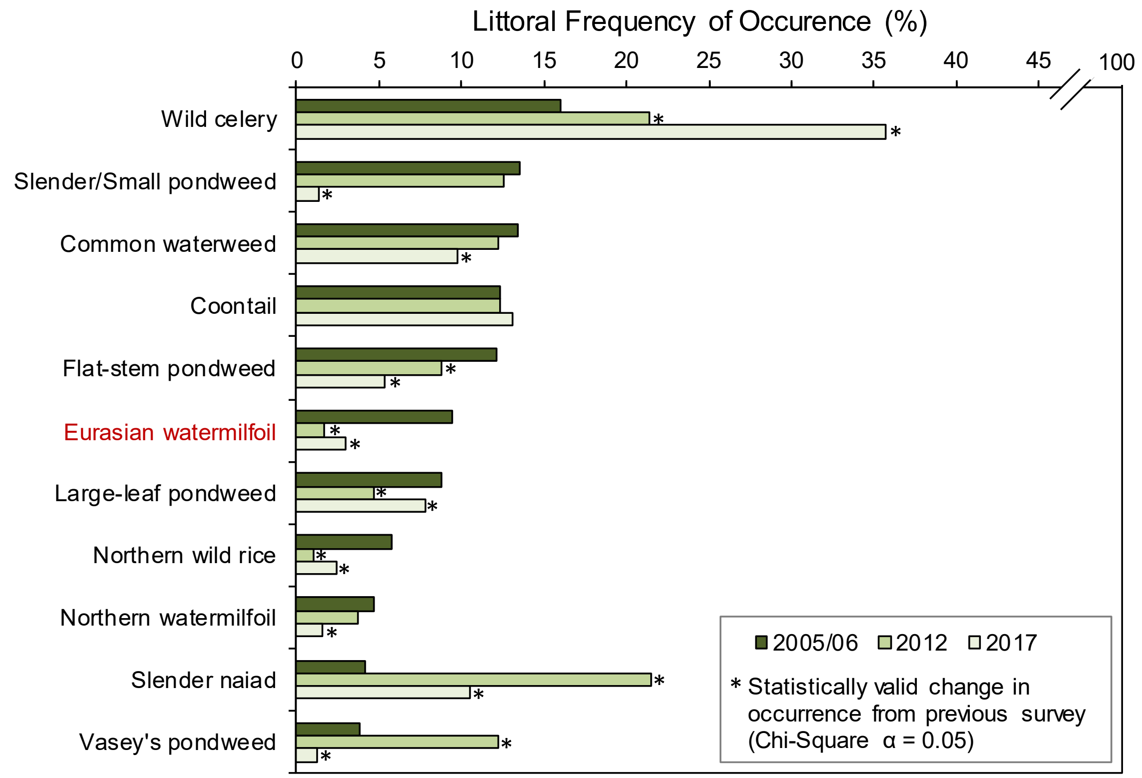


Figure 6. Eagle River Chain of Lakes littoral frequency of occurrence of select aquatic plant species from NEI 2005/06, Onterra 2012 and 2017 point-intercept surveys. Please note that only those species with an occurrence of at least 5% in one of the surveys are displayed. Created using data from 2006, 2012, and 2017 point-intercept surveys.

The chain-wide littoral frequency of occurrence of EWM in the Eagle River Chain of Lakes was found to have exhibited a statistically valid reduction in occurrence of 68% from 2006 to 2017 (Figure 6). While there was a slight increase in the littoral frequency of occurrence of EWM from 1.4% in 2012 to 3.0% in 2017, its littoral occurrence in 2017 is still considered low.

Figure 7 displays the individual littoral frequency of occurrence of EWM within each of the Eagle River Chain of Lakes from 2005/06, 2012, and 2017. In 2005/06, the littoral frequency of occurrence of EWM within each lake ranged from 1% in Cranberry Lake to 23% in Watersmeet (Figure 7). In 2012, the littoral frequency of occurrence of EWM within each lake ranged from 0% in Lynx Lake to 5% in Watersmeet. And in 2017, the littoral frequency of occurrence of EWM in each lake ranged from 0% in Voyageur, Eagle, Otter, Lynx, and Duck lakes to 7% in Watersmeet. As is discussed within the individual lake summary and conclusion sections, with the exception of Lynx Lake, Onterra ecologists still observed EWM in the lakes that had EWM littoral frequencies of occurrence of 0% in 2017 but the populations were at a level low enough to avoid detection during the point-intercept survey.

With the exception of Watersmeet, the lakes within the Lower Eagle River Chain of Lakes have maintained EWM littoral frequencies of occurrence of 3% or less between 2012 and 2017. The 2017 surveys indicate that overall the EWM population within the Lower Eagle River Chain of Lakes remains small and highlights the continued success of the control and monitoring program. However, areas still remain within the chain that have larger, localized populations of EWM. These areas primarily include the upstream channel in Cranberry Lake and the Wisconsin River branch of Watersmeet. As discussed earlier, these are areas of the chain that have a higher rate of water flow which makes it difficult for the herbicide to reach an adequate concentration-exposure time to achieve EWM mortality. A monitoring and control strategy for controlling EWM in these areas of higher flow along with continued strategies for monitoring EWM throughout the chain are discussed in the subsequent *2018 Preliminary Chain-Wide EWM Control Strategy* section (Section 4.0).

Photo 1. Colony of large-leaf pondweed (*Potamogeton amplifolius*; also known as musky cabbage) in Catfish Lake. Photo credit Onterra 2015.

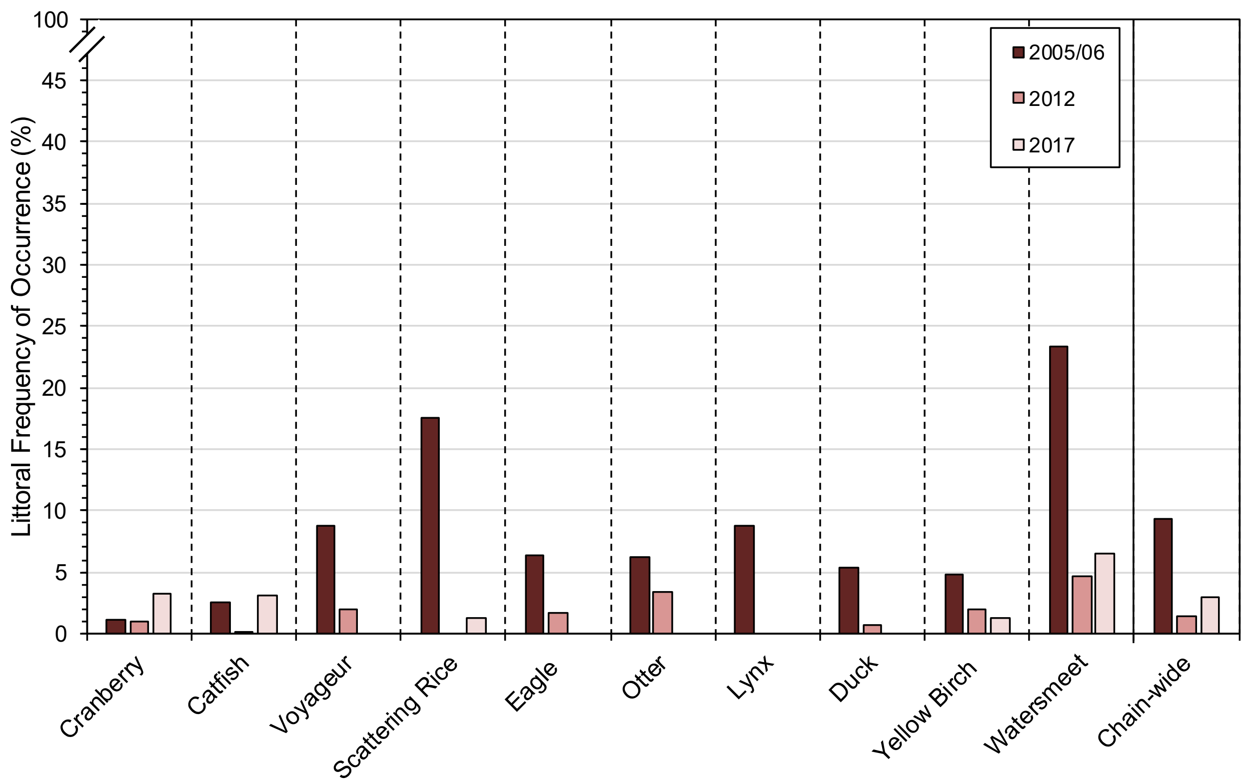


Figure 7. Lower Eagle River Chain of Lakes individual lake and chain-wide littoral frequency of occurrence of Eurasian watermilfoil from 2005/06, 2012, and 2017 point-intercept surveys.

4.0 2018 PRELIMINARY CHAIN-WIDE EWM CONTROL STRATEGY

While the population of EWM remains widespread throughout the Lower Eagle River Chain of Lakes, as discussed in the previous section, the population is small with the majority of occurrences consisting of single plants or low-density colonies. Based on the EWM mapped in 2017, no areas of EWM within the chain meet or exceed the threshold previously developed for implementing herbicide control actions in 2018. The threshold for consideration of an herbicide treatment is met when an area of EWM has a density rating of *dominant* or greater and is of a size where sufficient concentration and exposure time of the herbicide is likely to be achieved to cause EWM mortality.

There are isolated areas in the chain, primarily in Cranberry Lake and Watersmeet, where colonies of EWM are approaching levels that will likely meet the predefined threshold in one or two years if they continue to expand. These EWM colonies are in areas of high flow where past spot-treatments have produced only short-term successes. Large-scale herbicide efforts have had longer-term results in these areas, but the current level of EWM within Watersmeet is below levels that would justify this herbicide use pattern. The upstream Cranberry Channel is also beginning to see an increase in the EWM population since the spring 2015 treatment, and the plants are once again beginning to form larger colonies.

Based on the results of the 2017 professional hand-harvesting program, the ULERCLC would like to build upon the positive strides gained in 2017 through increasing the amount of professional hand-harvesting effort devoted to EWM control during the 2018 growing season. A preliminary hand-harvesting EWM control strategy for 2018 includes both DASH and traditional hand-harvesting methods. The ULERCLC plans to target areas of EWM in Scattering Rice and Yellow Birch lakes with DASH harvesting. Specific areas and acreages of these areas are discussed in the subsequent individual lake sections. An area of EWM in Watersmeet will also be targeted with DASH if feasible given the shallow water. However, if DASH is not feasible in this area, traditional hand-harvesting will be implemented. Diver-assisted suction harvesting requires a mechanical harvesting permit that will need to be acquired before any harvesting can be completed.

As in past years, an Early-Season AIS Survey will be conducted in 2018 from which a final hand-harvesting strategy would be created. Onterra will provide the hand-harvesting firm with the spatial data from the early-July survey to aid the removal efforts. Following the hand removal efforts, a Late-Season EWM Peak Biomass Survey will qualitatively assess the hand harvesting efforts (Figure 8).

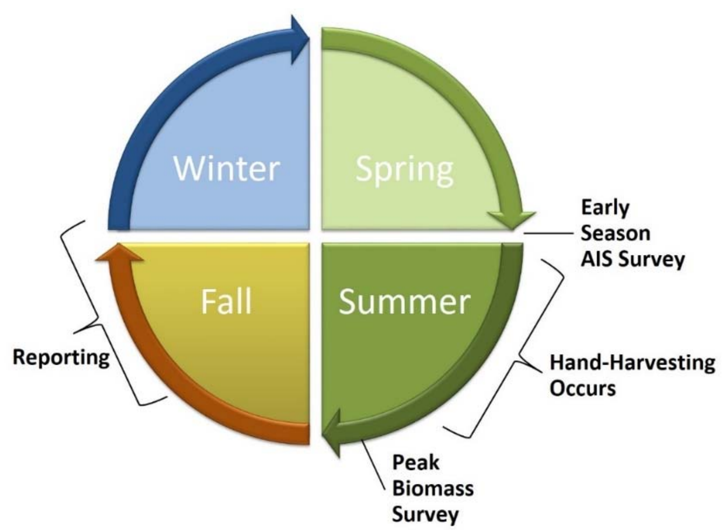


Figure 8. Hand-harvesting project timeline diagram.

5.0 INDIVIDUAL LAKE SECTIONS

The remainder of this report will focus on 2017 EWM monitoring and control strategy assessments (if applicable) on a lake-by-lake basis. Some of the text may seem redundant if one reads each lake section. However, this is intentional to ensure the information is portrayed to those that just read the chain-wide sections and their individual lake-specific section.

5.2 Catfish Lake Summary and Conclusions

The EWM population in Catfish Lake in 2015 and 2016 was relatively small and no control actions were implemented in the lake during 2017 (Figure 11). In 2017, the EWM in Catfish Lake was mapped professionally during Onterra's Early-Season AIS (ESAIS) and Late-Season EWM Peak-Biomass surveys. During the ESAIS survey, the entire littoral zone of the Lower Eagle River Chain of Lakes was searched for EWM by Onterra field staff. Completion of an ESAIS survey presents numerous advantages. Typically, the water is clearer during the early summer allowing for more effective viewing of submersed plants. While not at their peak growth stage (peak biomass), EWM plants are higher in the water column than most native plants during this time of year which increases the chances that even low-density and isolated EWM occurrences would be located.

The results from the ESAIS survey were loaded onto specific ULERCLC GPS units, and trained volunteers were tasked with searching and mapping EWM in areas where Onterra did not locate it during the ESAIS survey. Prior to the Late-Season EWM Peak-Biomass Survey, the volunteer mapping data were provided to Onterra. During the Late-Season EWM Peak-Biomass Survey, Onterra ecologists revisited and refined areas of EWM mapped during the ESAIS survey as well as any areas marked by volunteers.

During the ESAIS survey, two *dominant* colonies and two *scattered* colonies of EWM were mapped in Catfish Lake totaling 0.9 acres. Scattered *single or few plants*, *clumps of plants,* and *small plant colonies* were located within littoral areas in the northern and southern portions of the lake. During the 2017 Late-Season EWM Peak-Biomass Survey, Onterra field crews mapped four *highly scattered*, two *scattered*, and two *dominant* EWM colonies totaling 1.7 acres (Figure 11 and Catfish – Map 1). In addition, scattered *single or few plants*, *clumps of plants*, and *small plant colonies* were located in similar locations that were mapped during the ESAIS survey. With the small, low-density EWM population present in Catfish Lake in 2017, none of the colonized areas met the predefined threshold for the consideration of an herbicide treatment in 2018. No control actions for EWM are proposed to occur in Catfish Lake in 2018.

The whole-lake point-intercept survey was conducted in Catfish Lake on August 14-15, 2017 and 22 aquatic plant species were recorded. Similar to the chain-wide results of the point-intercept survey, wild celery, slender naiad, common waterweed, and fern-leaf pondweed were the most frequently encountered species. Eurasian watermilfoil was found to have a low littoral frequency of occurrence of just 0.2% in 2017.

A chi-square analysis ($\alpha = 0.05$) was used to compare individual aquatic plant species littoral frequencies of occurrence in Catfish Lake between the point-intercept surveys in 2006, 2012, and 2017 (Figure 12). The aquatic plant species that had a littoral frequency of occurrence of at least 5% in one of the three surveys are applicable for analysis. Of the 13 native aquatic plant species that had a littoral occurrence of at least 5% in one of the three surveys, six exhibited statistically valid changes in their littoral occurrence between the 2006 and 2017 surveys.

Of the six native species which saw changes in their occurrence, two species saw a statistically valid reduction in its occurrence over this time period: small pondweed (92% decline) and Vasey's pondweed (100% decline). The littoral occurrences of slender naiad, spiral-fruited pondweed, and stoneworts displayed statistically valid increases from 2006 to 2012 and then statistically valid decreases from 2012 to 2017. Of these species, slender naiad and spiral-fruited pondweed maintained higher frequencies of occurrence in 2017 when compared to 2006.

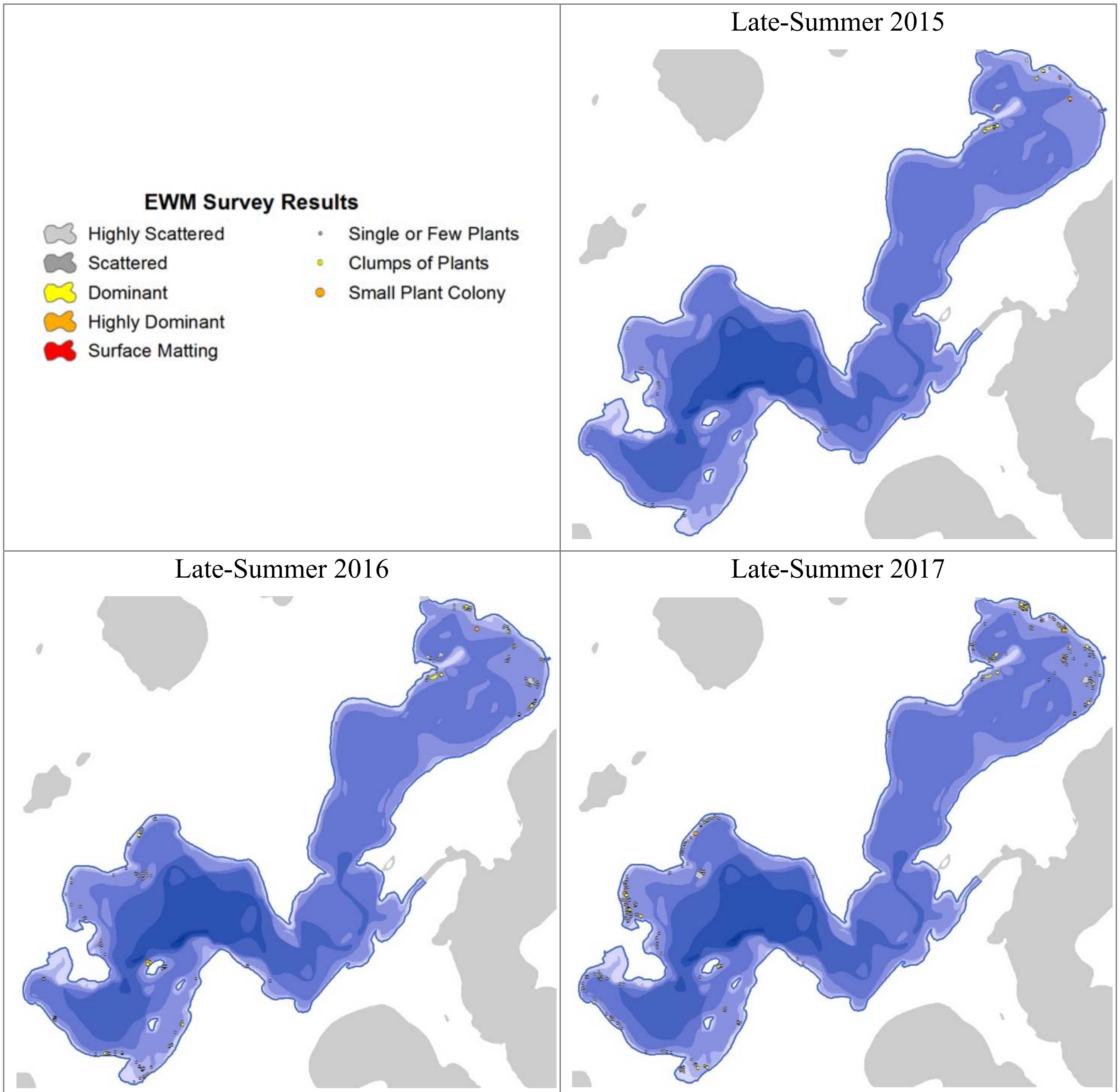


Figure 11. Catfish Lake EWM Population from Late-Summer 2015 to Late-Summer 2017.

Wild celery and fern-leaf pondweed both saw statistically valid increases in occurrence from 2006 to 2017. As discussed in the chain-wide section, an increase in wild celery is likely due to the fact that wild celery is tolerant of reduced light availability, providing it with a competitive advantage over other plants in low-light conditions. Fern-leaf pondweed is generally a low-lying plant also tolerant of lower light conditions. An increase in fern-leaf pondweed occurrence may also be in response to reduced water clarity in the chain in recent years.

The littoral occurrences of Eurasian watermilfoil, coontail, northern watermilfoil, common waterweed, large-leaf pondweed, and flat-stem pondweed have remained relatively stable over the course of the three surveys.

Aquatic plant communities are dynamic and the abundance of certain species from year to year can fluctuate depending on climatic conditions, herbivory, competition, disease, and management among other factors. Ongoing research on Wisconsin's lakes shows that native aquatic plant populations can fluctuate over short- and long-term periods, believed to be driven by natural variations in climate, growing season, water levels, etc. As discussed previously, the changes in native plant species occurrences in the Lower Eagle River Chain from 2006 to 2017 are believed to be largely due reductions in water clarity caused by higher precipitation in recent years.

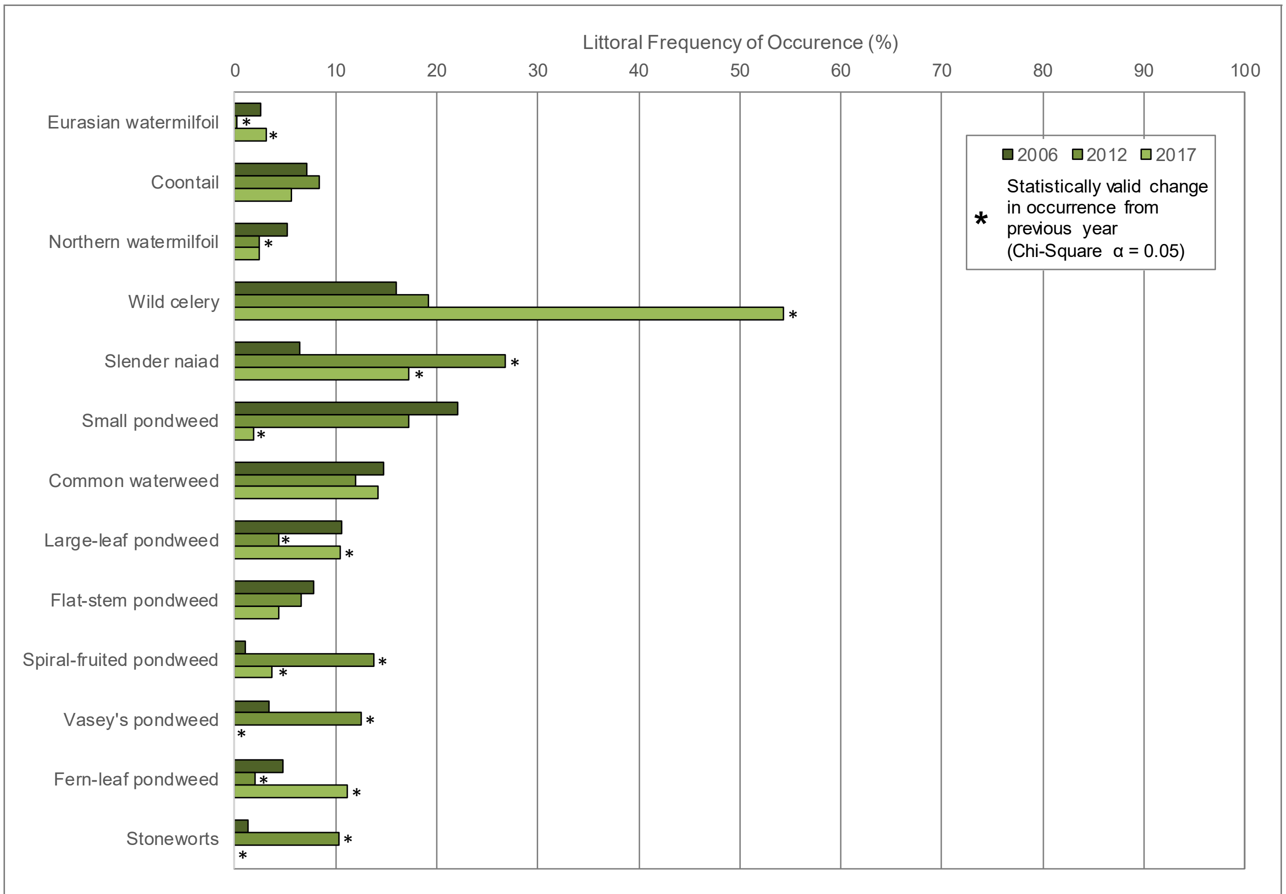
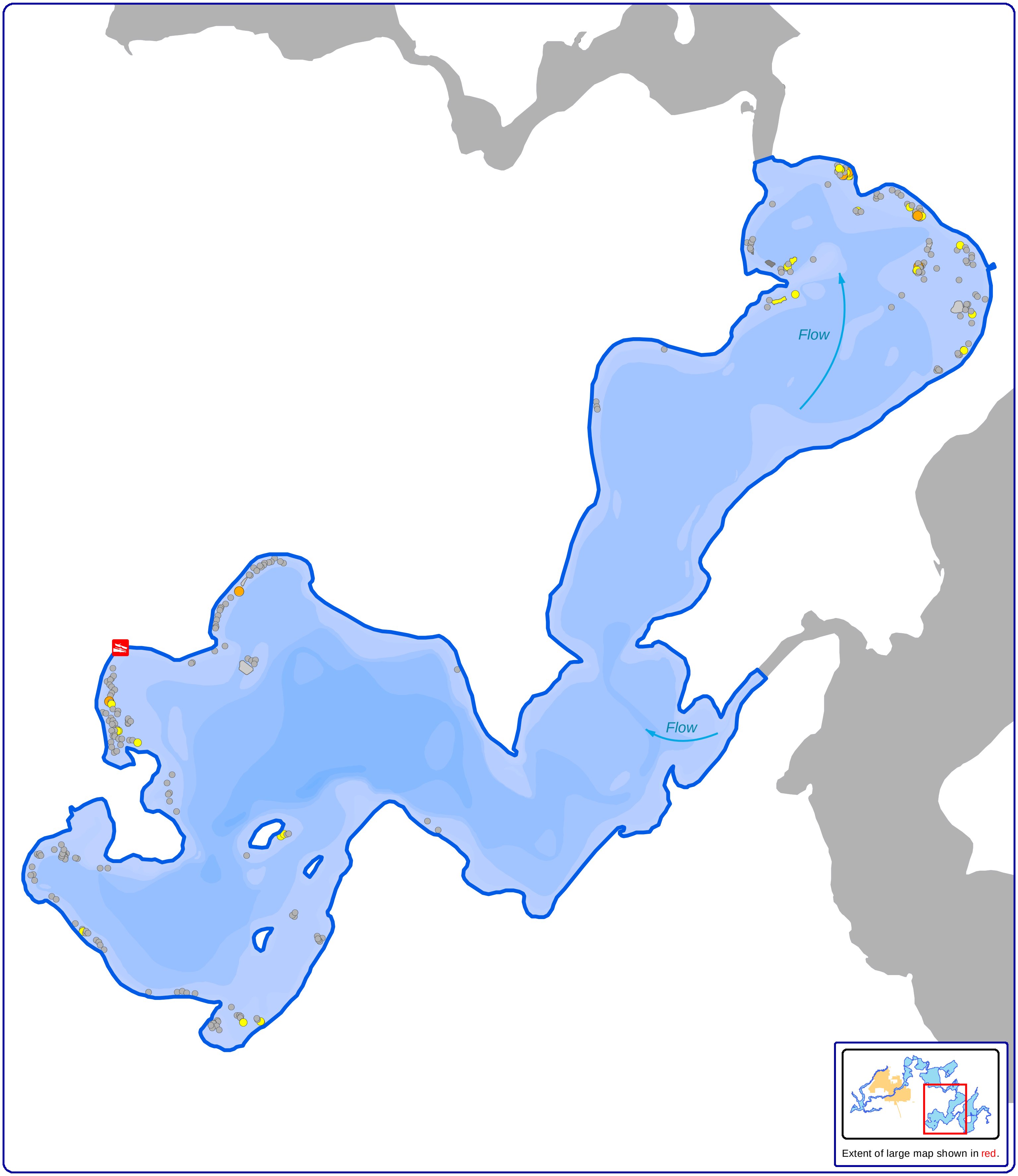


Figure 12. Catfish Lake littoral frequency of occurrence of select aquatic plant species from NEI 2006, Onterra 2012, and 2017 point-intercept surveys. Please note that only those native species with an occurrence of at least 5% in one of the three surveys are displayed. Created using data from 2006, 2012 and 2017 point-intercept surveys.



N
W E
S

1,600
Feet

Legend

2017 EWM PB Survey (September 2017)

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant *(None found)*
- Surface Matting *(None found)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

Catfish Lake - Map 1

Vilas County, Wisconsin

2017 EWM PB Survey Results

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Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR, Onterra digitized
Aquatic Plants: Onterra, 2017
Map Date: September 19, 2017
Filename: *Catfish_EWMPB_Sept17.mxd*