Memorandum

To: Valley Branch Watershed District (VBWD) Board of Managers
From: Meg Rattei, Senior Biologist
Subject: VBWD June 2015 Point-Intercept Plant Surveys
Date: October 1, 2015
Project: 23/82-0405
c: John Hanson, Ray Marshall, Ray Roemmich, Melissa Imse

This memorandum summarizes methods and results of the June 2015 point-intercept plant surveys at Long Lake, Lake DeMontreville, Lake Olson, Lake Jane, Eagle Point Lake, Lake Elmo, Horseshoe Lake, Lake Edith, McDonald Lake, and Sunfish Lake. All tables and figures follow the discussion.

Requested Manager Actions

1. Authorize the release of this memorandum to the following:
    A. Maynard Kelsey of McDonald Lake
    B. Brian Buchmayer of Friends of Long Lake and the VBWD Lake Citizen Advisory Committee
    C. Justin Bloyer of the Lake Jane Association and council member, City of Lake Elmo
    D. Roger Johnson of the Lake DeMontreville/Olson Association and the VBWD Citizen Advisory Committee
    E. Wendy Griffin of the Lake Elmo Association
    F. Jeff Berg of the Lake Elmo Association and the VBWD Citizen Advisory Committee
    G. Dale Dorschner of the Lake Elmo Association
    H. Keegan Lund, Chip Welling, and any other interested staff of the Minnesota Department of Natural Resources (MDNR).
2. Authorize the release of the eight reports submitted to Washington County to fulfill the VBWD Aquatic Invasive Species (AIS) Grant contractual obligation to Keegan Lund, Chip Welling, and any other interested MDNR staff.
3. Direct Barr to request a meeting with MDNR to discuss the results of the 2015 herbicide treatments for Long Lake, Lake DeMontreville, Lake Olson, and Lake Jane and ask for suggestions moving forward. The meeting could also include discussion of 2015 diver harvesting of Eurasian watermilfoil (EWM) in Lake Elmo and MDNR suggestions for moving forward.

5. Initiate a VBWD grant program to fund 50% of the cost (up to a maximum total amount set by the Managers) for herbicide treatments sponsored by lake associations to reduce aquatic invasive plants such as EWM in VBWD lakes. A VBWD grant program would provide the financial assistance lake associations need to manage aquatic invasive species (AIS), while reducing administrative costs. This would make the program less expensive than procuring funds from other programs such as the Washington County AIS grant program. In 2015, VBWD procured Washington County AIS grant funds and used the funds to reimburse lake associations for about half of the cost of herbicide treatment to manage EWM in VBWD lakes. The administrative costs required by the grant program exceeded the amount of the grant award. These efforts included preparing a proposal, an interview, preparing a contract, completing eight different reports, and providing presentations at two meetings. Initiating a VBWD grant program would provide the same level of funding to lake associations, but at a lower cost to the District.
6. Authorize technical support to lake associations that want to complete herbicide treatment to manage EWM in 2016. Barr anticipates that support will be needed for Friends of Long Lake, Lake DeMontreville/Olson Association, and the Lake Jane Association. Technical support would include:
   - Two point-intercept plant surveys, one in spring before treatment and one in June after treatment. Both are permit requirements.
   - Permitting.
   - Treatment.
   - Reporting required by the MDNR treatment permit.
7. Authorize technical support to Friends of Long Lake to update the Long Lake Lake Vegetation Management Plan (LVMP) prior to the 2016 herbicide treatment season. The Long Lake LVMP will expire on April 15, 2016.

2014 Sample Methods

Matt Berg of Endangered Resource Services, LLC conducted point-intercept plant surveys in 10 VBWD lakes from June 21 through June 24, 2015. He located equally spaced preset points in the field with GPS and took measurements at each point. His measurements included the following:

1. Individual species present
2. Overall density of plants, as measured by rake method
3. Density of individual species, as measured by rake method

Endangered Resource Services used a rake (pictured above) to collect plants for the plant surveys. Rake fullness is a measure of plant density.

4. Water depth
5. Dominant sediment type

Results

A discussion of survey results for the 10 individual lakes follows. VBWD provided technical assistance for herbicide management of EWM in Long Lake, Lake DeMontreville, Lake Olson, and Lake Jane in 2015. A discussion of the results of these management efforts is also included the following paragraphs.

EWM was only observed at two locations in Long Lake during 2015. Pictured above is the single barely surviving EWM plant collected in 19 feet of water.

Long Lake—Long Lake has been treated with herbicide almost annually since 2011 to reduce the extent of EWM in the lake. In 2015, 5.5 acres of EWM were observed in the lake during the May pre-treatment plant survey; all EWM observed in the lake was treated with 2,4-D in May (Figures 1 and 2). The average 2,4-D concentration measured in the lake 3 days after treatment was lethal to EWM (Figure 3).

The Long Lake treatment goal of reducing EWM by at least half was met. EWM area was reduced by 93 percent (Figures 4 and 5) and frequency was reduced by 91 percent between May and June of 2015 (Figure 6). In addition, EWM density was reduced (Figure 7). In June 2010, prior to the start of herbicide treatment, EWM extent was 52 acres, which was 97 percent of the plant growth area of the lake (Table 3). After treatment in 2015, EWM extent was 0.4 acres—0.73 percent of the plant growth area of the lake (Table 3). Since herbicide treatment began in 2011, the frequency of EWM occurrence has been reduced from 92 percent to 1 percent (Figure 6).

No significant changes in the frequency of individual native plant species were observed in Long Lake between May and June of 2015, verifying that the herbicide treatment had no impact on the frequency of individual native plant species[1]. Common waterweed significantly increased in frequency between June of 2014 and June of 2015, a positive change for the Long Lake plant community (Figure 8).

Reduction of EWM in Long Lake during 2015 improved the overall frequency of native plants in the lake, but had no impact on the number of native species. The frequency of occurrence of natives increased

[1] Margaret Rattei, letter to June Mathiowetz regarding VBWD AIS Grant Project: Deliverable 7 – Report on Native Plant and Eurasian Watermilfoil (EWM) Presence in Post-Treatment Plant Surveys, 8 Sept. 2015. TS.

from 33 percent in June of 2014 to 47 percent in June of 2015, while the number of native species (10) remained the same (Table 8).

Since treatment began in 2011, the quality of the Long Lake plant community, measured by the Floristic Quality Index (FQI), has improved. FQI considers both the quality of the individual native species in the lake and the number of species collected on the rake. The 2010 pre-treatment FQI value was 14.1, compared with the 2011 post-treatment value of 15.7 (Figure 9). All FQI values since 2011 have been greater than 14.1, including the 2015 value of 16.8 (Figure 9). This indicates that EWM reduction has improved the quality of the lake's plant community.

Reduction of EWM in 2015 improved the frequency of native plants, including *Chara*, pictured above. *Chara* increased in frequency from 20 to 26 percent of sample locations.

The diversity of the Long Lake plant community approximately doubled after the first herbicide treatment in 2011. This is reflected by Simpson Diversity Index values, which indicate the probability that two individual plants randomly selected from a lake will belong to different species. The 2010 pre-treatment Simpson Diversity Index value was 0.4, compared with values of 0.77 to 0.85 from 2011 through 2015 (Figure 10). This indicates that reduction of EWM has improved plant diversity; i.e., the probability that two individual plants randomly selected from Long Lake will belong to different species has increased from 40 percent to 77–85 percent.

Curly-leaf pondweed (CLP), an invasive species, is present in Long Lake but not problematic. In 2015, CLP was found in 6 percent of the sample locations in the plant growth area of the lake, the same frequency observed in 2010 (Figure 11).

Lake DeMontreville—In 2015, the MDNR did not permit herbicide treatment of all EWM-infested areas within Lake DeMontreville. The total permitted treatment area of 14 acres was only 24 percent of the 58 acres infested (Figures 2 and 12). Because the treatment area was small and shallow, the quantity of herbicide allowed for the treatment was insufficient to attain a lethal, lake-wide 2,4-D concentration and exposure time. Results of research conducted by the Wisconsin Department of Natural Resources indicate the average 2,4-D concentration of 0.185 parts per million (ppm) measured 3 days after treatment (Figure 3) would result in seasonal control of EWM if sustained for 7 days, but would not attain long-term EWM control.[2]

EWM was severely knocked back, but a few plants, especially along deep-water margins, continue to survive. Pictured above is a deep water EWM fragment found mid-lake in the central basin of Lake DeMontreville.

Although the EWM area treated in 2015 was only 24 percent of the infested area, the Lake DeMontreville goal of reducing EWM by at least half was met. Between May and June of 2015, the EWM area was reduced by 64 percent (Figures 4 and 13) and frequency was reduced by 51 percent (Figure 14). In addition, EWM density was reduced (Figure 15). The 2015 treatment mitigated the EWM increase that occurred between June of 2014 and spring of 2015 and provided some reduction in EWM area, frequency, and density (Figures 13 through 15).

Significant changes in six native species were observed in Lake DeMontreville between May and June of 2015 (a significant decrease in northern watermilfoil and significant increases in five other species). The herbicide treatment could have caused the decline in northern watermilfoil frequency. However, rapid increases and decreases are common for northern watermilfoil. An untreated VBWD lake, Lake Edith, observed a rapid increase in northern watermilfoil in 2014 and a rapid decrease in 2015 (Figure 40). Hence, the significant decline in northern watermilfoil in Lake DeMontreville during 2015 could have been due to natural fluctuations. Nonetheless, the significant increase in five native species resulted in a net increase in native plant frequency following the 2015 herbicide treatment.[1]

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[2] Heath, Eddie, Tim Hoyman, Michelle Nault, and John Skogerboe. 2014. *Field Research of Early-Season Whole-Lake Herbicide Strategies for Control of Hybrid EWM*. Presentation at UMISC – October 22, 2014 in Duluth, Minnesota.

During a one-year period (June of 2014 to June of 2015) significant changes were observed in three native plant species in Lake DeMontreville—again, a significant decrease in northern watermilfoil and significant increases in filamentous algae and southern naiad (Figure 16). [1]

Pictured above, yellow iris plants shortly before they were removed from Lake DeMontreville in June of 2014. In 2015, yellow iris plants were common on the southern shoreline of the lake, with residents mowing around the plants and maintaining them along their shoreline.

Reduction of EWM in Lake DeMontreville during 2015 improved the frequency of native plants in the lake, but had no impact on the number of native species. The frequency of occurrence of native plants increased from 89 percent in June of 2014 to 94 percent in June of 2015, while the number of native species (19) remained the same (Table 9).

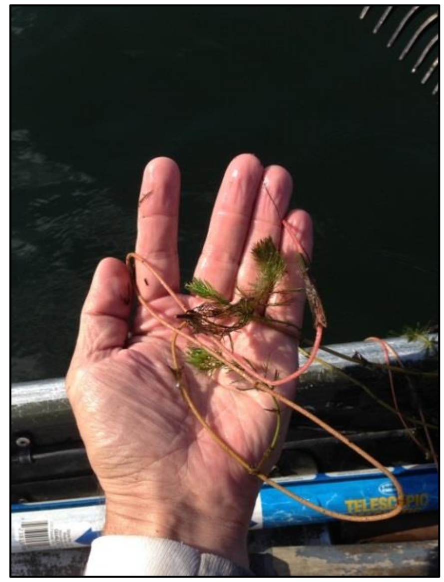
Since treatment began in 2014, the quality of the Lake DeMontreville plant community, measured by the FQI, has improved. FQI considers both the quality of the individual native species in the lake and the number of species collected on the rake. The 2012 and 2013 pre-treatment FQI values ranged from 25.0 to 26.2, compared with post-treatment values of 26.9 during 2014 and 2015 (Figure 17). This indicates that EWM reduction improved the quality of the lake's plant community.

The diversity of the Lake DeMontreville plant community remained stable after treatment. This is reflected by Simpson Diversity Index values, which indicate the probability that two individual plants randomly selected from a lake will belong to different species. The 2014 and 2015 post-treatment Simpson Diversity Index values of 0.90 were within the range of 2012 and 2013 pre-treatment values (0.89 to 0.90) (Figure 18). This suggests that EWM treatment had no impact on native plant diversity; i.e., the probability that two individual plants randomly selected from Lake DeMontreville will belong to different species has remained at about 90 percent.

Yellow iris, an invasive species, was common on the southern shorelines in 2015. It appears that residents are unaware it is a non-native, invasive plant—mowing around and maintaining the plants along their shorelines. In June of 2014, VBWD directed Barr staff to remove yellow iris plants growing near the boat (30 plants). We recommend that residents remove the yellow iris plants from their shoreline to prevent the spread and proliferation of this invasive species.

CLP frequency in Lake DeMontreville has fluctuated widely during the past few years (49-percent frequency in 2012, 42 percent in 2013, 10 percent in 2014, and 31 percent in 2015) (Figure 19). The 2015 frequency of 31 percent was within the 10 to 49 percent range observed from 2012 through 2014 (Figure 19). CLP density was low in 2015 and not problematic.

Lake Olson—In 2015, the MDNR did not permit herbicide treatment of all EWM-infested areas within Lake Olson. The total permitted treatment area of 7 acres was only 22 percent of the 32 EWM-infested acres (Figures 2 and 20). Because the treatment area was small and shallow, the quantity of herbicide allowed for treatment was insufficient to attain a lethal, lake-wide 2,4-D concentration and exposure time. Results of research conducted by the Wisconsin Department of Natural Resources indicate the average 2,4-D concentration of 0.156 ppm measured 3 days after treatment (Figure 3) would result in seasonal control of EWM if sustained for 7 days, but would not attain long-term control.[2]



EWM was burned and knocked back by the herbicide treatment, but it appeared the majority of the plants (not necessarily the stems) survived. Pictured above is a surviving EWM plant and pictured below is the typical density of surviving EWM in Lake Olson.

The project goal of a 50% reduction in EWM was not attained. EWM area was reduced by 11 percent (Figures 4 and 21) and density was also reduced (Figure 23); however, frequency increased by 4 percent (Figure 22) between May and June of 2015. The 2015 treatment partially mitigated the EWM increase that occurred from June of 2014 to spring of 2015 and provided some reduction in EWM area and density (Figures 21 and 23). Although the EWM management goal was not attained, lake residents have expressed satisfaction in the EWM reduction after the 2015 herbicide treatment.

The 2015 EWM reduction goal was not met because only 22 percent of the EWM area was treated (as restricted by the MDNR). The treatment area was a single location at the south end of the lake near the outlet (Figure 20). Lake flow is toward the outlet, reducing the likelihood of herbicide mixing to the north and central areas of the lake. The average 2,4-D concentration measured in the lake 3 days after treatment was less than one-third of the lethal dose (Figure 3). The area with the densest EWM was treated, but the concentration of herbicide was too low. Hence, the June 2015 EWM area was 17 percent greater than the June 2014 EWM area (Figure 21).

Significant changes in five native plant species were observed between May and June of 2015, but none were due to the herbicide treatment. There was a significant decrease in filamentous algae (algae are not impacted by 2,4-D) and significant increases in four native plant species. The result was a net increase in native plant frequency after the herbicide treatment.[2]

Between June of 2014 and June of 2015, significant changes in seven native plant species were observed, but none were due to the herbicide treatment. The changes included significant decreases in coontail, filamentous algae, water stargrass, northern watermilfoil, and small pondweed (Figure 24). Significant increases in fern pondweed and muskgrasses also occurred (Figure 24). Of the declining native species, coontail and northern watermilfoil are the only species potentially impacted by 2,4-D; however, neither species declined significantly between May and June of 2015. This indicates that declines between June of 2014 and June of 2015 were not caused by the herbicide treatment. Expanding EWM and subsequent displacement of natives during 2014 could have been a factor in the declines. EWM expanded from 28 acres in June of 2014 to 32 acres by May of 2015 (Figure 21).

Although both native plant frequency and number of species declined in 2015, the declines are not likely due to the herbicide treatment. The frequency of native species in Lake Olson decreased from 91 percent in June of 2014 to 82 percent in June of 2015. The number of native species decreased from 20 in June of 2014 to 19 in June of 2015 (Table 10). Based on historic natural variation of plants affected and locations of the changes, the native plant changes do not appear to be caused by the herbicide treatment.[1]

Since treatment began in 2014, the quality of the Lake Olson plant community, measured by the FQI, has improved. FQI considers both the quality of the individual native species in the lake and the number of species collected on the rake. The 2012 and 2013 pre-treatment FQI values ranged from 25.2 to 25.9, compared with post-treatment values in 2014 and 2015 of 26.6 to 28.0 (Figure 25).

The diversity of the Lake Olson plant community remained stable after treatment. This is reflected by Simpson Diversity Index values, which indicate the probability that two individual plants randomly selected from a lake will belong to different species. The 2012 and 2013 pre-treatment Simpson Diversity Index values ranged from 0.91 to 0.92. The post-treatment value from 2014 through 2015 is 0.90 (Figure 26); i.e., the probability that two plants selected at random from Lake Olson will belong to different species has stayed in the range of 90–92 percent.

CLP was present at a few locations, but was not problematic in 2015. CLP was found at 5 percent of sample locations in 2015, compared with 3 percent in 2014 (Figure 27).

Lake Jane—In 2015, the MDNR did not permit herbicide treatment of all EWM-infested areas within Lake Jane. The total permitted treatment area of 7.9 acres was only 18 percent of the 44 EWM-infested acres (Figures 2 and 28). Because the treatment area was small and shallow, the quantity of herbicide allowed for the treatment was insufficient to attain a lethal, lake-wide 2,4-D concentration and exposure time.

Results of research conducted by the Wisconsin Department of Natural Resources indicate the average 2,4-D concentration of 0.081 ppm measured 3 days after treatment (Figure 3) may have no effect on EWM.[2]

EWM in Lake Jane was seriously burned by the herbicide treatment, but many plants survived. Many small fragments of EWM were re-growing from axils. Pictured above, surviving EWM on Lake Jane.

The project goal of reducing EWM by at least half was not attained in Lake Jane. Between May and June of 2015 EWM area was reduced by 30 percent (Figures 4 and 29) and frequency was reduced by 28 percent (Figure 30); EWM density was also reduced (Figure 31). The 2015 treatment partially mitigated the EWM increase that occurred from June of 2014 to spring of 2015 and provided some reduction in EWM area, frequency, and density (Figures 29 through 31).

Although the EWM reduction goal was not attained, lake residents have expressed satisfaction in the EWM reduction occurring after the 2015 herbicide treatment.

Pictured above, typical Lake Jane EWM that was damaged but not killed.

The 2015 herbicide treatment did not attain the EWM reduction goal because only 18 percent of the EWM area was treated (as restricted by the MDNR). The average 2,4-D concentration measured in the lake 3 days after treatment was less than 20 percent of the EWM lethal dose (Figure 3). While the area with the densest EWM was treated, the concentration of herbicide was too low (Figure 29). Hence, the June 2015 EWM area was 29 percent greater than the June 2014 EWM area (Figure 29).

Significant changes in seven native plant species were observed between May and June of 2015, but none of the changes were due to the herbicide treatment. The changes included a significant decrease in water stargrass, which is not impacted by 2,4-D. Significant increases in six native plant species resulted in a net increase after the herbicide treatment.[1]

Between June of 2014 and June of 2015 significant changes were observed in three native plant species, but none of the changes were due to the herbicide treatment. The changes included an increase in filamentous algae and decreases in water stargrass (not impacted by 2,4-D) and northern watermilfoil

(Figure 32). Northern watermilfoil did not decline significantly between May and June of 2015, indicating its decline between June of 2014 and June of 2015 was not caused by the herbicide treatment. Expanding EWM and subsequent displacement of natives during 2014 could have been a factor in the decline. EWM expanded from 24 acres in June of 2014 to 44 acres in May of 2015 (Figure 29).

Although both native plant frequency and number of species declined in 2015, the declines are not likely due to the herbicide treatment. The frequency of native species in Lake Jane decreased from 99 percent in June of 2014 to 96 percent in June of 2015. The number of native species decreased from 28 in June of 2014 to 24 in June of 2015 (Table 11). Based on historic natural variation and plants affected, the native plant changes do not appear to be caused by the herbicide treatment.[1]

The quality of the Lake Jane plant community, measured by the FQI, remained stable after the 2015 herbicide treatment. FQI considers both the quality of the individual native species in the lake and the number of species collected on the rake. The 2012 through 2014 pre-treatment FQI values ranged from 31.0 to 32.7, compared with the 2015 post-treatment value of 31.4 (Figure 33).

After the 2015 treatment, the diversity of the Lake Jane plant community did not change. This is reflected by Simpson Diversity Index values, which indicate the probability that two individual plants randomly selected from a lake will belong to different species. The 2012 through 2014 pre-treatment Simpson Diversity Index values ranged from 0.91 to 0.92, compared with a 2015 post-treatment value of 0.92 (Figure 34); i.e., the probability that two plants selected at random from Lake Jane will belong to different species has stayed in the range of 91–92 percent.

CLP was present in 2015, but not problematic; the plant was observed in 11 percent of sample locations within the plant growth area of the lake, which was within the 8- to 16-percent frequency documented from 2012 through 2014 (Figure 35).

Eagle Point Lake—Problematic growths of the invasive CLP were observed in Eagle Point Lake from 2012 through 2015 (Figure 36). However, CLP was stable in 2015 with the density and distribution similar to 2014 levels.

Problematic growths of CLP (pictured above) were observed in Eagle Point Lake from 2012 through 2015.

The frequency of occurrence of filamentous algae in Eagle Point Lake (pictured above) increased from 4 percent of sample locations in 2014 to 55 percent in 2015.

Two additional invasive species were observed in Eagle Point Lake in 2015; however, both were stable and not problematic. Reed canary grass was abundant along the lakeshore and in surrounding wetland areas—a distribution similar to 2014. The distribution of narrow-leaved cattail was also similar to distributions from 2012 through 2014. Narrow-leaved cattail was observed in 29 percent of sample points in 2015 (Table 2) compared to 24 to 30 percent from 2012 through 2014[3].

The greatest change in the Eagle Point Lake plant community in 2015 was a significant increase in the extent of filamentous algae. The frequency of occurrence of filamentous algae increased from 4 percent of sample locations in 2014 to 55 percent in 2015 (Figure 37). The increased extent of filamentous algae and associated shading reduced the growth of other plants, likely causing the significant 2015 declines in frequency observed for common waterweed, small pondweed, small duckweed, and river bulrush (Figure 37). In addition, the increased algae reduced the maximum depth at which plants were growing by over half—from 8.5 feet in 2014 to 4 feet in 2015.

Despite the increased extent of algae and significant declines in frequency of four native plant species in 2015, the quality of the plant community, measured by FQI, was stable. FQI considers both the quality of the individual native species in the lake and the number of species collected on the rake. The 2015 FQI value of 19.2 was within the 2012 through 2014 range of 18.7 to 22.6 (Figure 38).

Plant diversity was also stable in 2015. This is reflected by Simpson Diversity Index values, which indicate the probability that two individual plants randomly selected from a lake will belong to different species. The 2015 value of 0.84 was within the 2012 through 2014 range of 0.84 through 0.88 (Figure 39); i.e., the

[3] Margaret R. Rattei to Valley Branch Watershed District (VBWD) Board of Managers, October 3, 2014. *VBWD June 2015 Point-Intercept Macrophyte Surveys*.

probability that two individual plants selected randomly from Eagle Point Lake will belong to different species has stayed in the range of 84 to 88 percent.

Lake Edith—Carp were observed throughout the lake in 2015, explaining some of the limitations in the Lake Edith plant community. Carp can severely reduce submersed aquatic vegetation through direct uprooting of vegetation or herbivory (eating the vegetation).[4] Aquatic plant growth in the lake is also limited by the lake's poor growing substrate for plants (marly clay and thin muck over sand). This poor substrate protects the lake from problematic growth by invasive species.

The native plant community in Lake Edith remained stable in 2015 including the continued presence of Illinois pondweed at the south end of the lake (pictured above) and hardstem bulrush at the lake's outlet (pictured below).

Three invasive species were present in Lake Edith in 2015, but none were problematic. All three species were observed at a low frequency, similar to previous years. Curly-leaf pondweed was observed at a frequency of 4 percent annually from 2013 through 2015 (Figures 40 and 43). Reed canary grass was visually observed in the lake in 2013 and observed at a frequency of 1 percent during 2014 and 2015 (Figure 40). Hybrid cattail was observed at a frequency of 3 percent in 2013, 1 percent in 2014, and 4 percent in 2015 (Figure 40). Although the frequency of hybrid cattail has fluctuated since 2013, the differences are not significant.

The native plant community has remained relatively stable from 2013 through 2015. Northern watermilfoil significantly increased in frequency in 2014 and significantly decreased in frequency in 2015; its 2015 frequency was relatively similar to its 2013 frequency (Figure 40). Rapid increases and decreases are common for northern watermilfoil.

There were two positive changes to the plant community in 2015:

- A significant increase in small pondweed—observed at a frequency of 1 percent in 2013, not observed in 2014, and observed at a frequency of 11 percent in 2015 (Figure 40).

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[4] Bajer, P.G., G. Sullivan, P.W. Sorenson. 2009. *Effects of Rapidly Increasing Population of Common Carp on Vegetative Cover and Waterfowl in a Recently Restored Midwestern Shallow Lake*. Hydrobiologia. Doi: 10.1007/s 10750-009-9844-3.

- Presence of water stargrass—observed for the first time in 2015 (Figure 40).

The quality of the lake's plant community, measured by FQI, and its diversity, measured by Simpson's Diversity Index, both improved in 2015. FQI considers both the quality of the individual native species in the lake and the number of species collected on the rake. The 2015 FQI value of 22.1 was higher than values of 19.1 through 21.8 observed in 2013 and 2014 (Figure 41). The 2015 Simpson's Diversity Index value of 0.92 was higher than values of 0.88 and 0.89 observed in 2013 and 2014 (Figure 42); i.e., the probability that two individual plants randomly selected from the lake will belong to different species increased from 88 and 89 percent in 2013 and 2014 to 92 percent in 2015.

EWM was problematic in Lake Elmo during 2015. Canopied EWM was observed in 7 to 10 feet of water along the north western shoreline (pictured above) and canopied EWM was mixed with floating-leaf pondweed in 3 to 4 feet of water on the western shoreline (pictured immediately below).

Lake Elmo— Problematic levels of EWM were observed in Lake Elmo from 2012 through 2015. In 2015, as in previous years, EWM was the dominant plant in the north and south bays; overall, the plant increased in total area, frequency of occurrence, and the percent of the plant growth area occupied. From 2014 to 2015, EWM area increased from 51 acres to 68 acres (Table 7), frequency increased from 34 percent to 45 percent (Figure 44), and percent of the lake's plant growth area occupied increased from 45 percent to 59 percent (Table 7). As shown in Figure 45, dense canopied beds of EWM (beds that have reached the lake surface) were prevalent in 2015; however, despite the increased extent and frequency, EWM levels were within the 2012 through 2013 range (Table 7).

EWM density in canopied beds was typically the maximum rake fullness of 4.

Because Lake Elmo is classified as a "natural environment" lake, the use of herbicides is not allowed without obtaining a variance to the Minnesota rule. The MDNR did not provide this variance. In September, the Lake Elmo Lake Association hired divers to hand remove EWM from an area that was less than an acre. The EWM hand removal area was about 1 percent of the 68 acres infested with EWM (Table 7).

Although four invasive species are present in Lake Elmo; EWM is the only problematic invasive species. A single floating CLP plant was observed in Lake Elmo during the 2015 plant survey. CLP frequency in Lake Elmo was 0 percent from 2013 through 2015 because it was not collected on the rake during plant surveys (Figure 46). The frequency of reed canary grass declined steadily from 2012 through 2014 and was not observed in Lake Elmo during 2015 (Figure 47). Narrow-leaved cattails were present but not problematic. Their 2015 frequency of 17 percent was within the 2012 through 2014 range of 15 to 17 percent (Figure 47).

The Lake Elmo native plant community was stable in 2015 and no significant changes in native plant frequency were observed (Figure 47).

In addition, 2015 plant community quality (measured by FQI) and diversity (measured by Simpson's Diversity Index) were stable. FQI considers both the quality of the individual native species in the lake and the number of species collected on the rake. The 2015 FQI value of 23.5 was within the 20.4 to 26.1 range observed from 2012 through 2014 (Figure 48). The 2015 Simpson's Diversity Index value of 0.88 was within the 0.88 to 0.91 range of values observed from 2012 through 2014 (Figure 49); i.e., the probability that two individual plants randomly selected from the lake will belong to different species has remained in the range of 88 to 91 percent.

Horseshoe Lake—EWM was the dominant plant in Horseshoe Lake in 2015 and was canopied (reached the lake's surface) in the majority of the littoral zone (plant growth area). EWM frequency in Horseshoe Lake is higher than any other VBWD lake (Table 2) and has significantly increased: from 10 percent in 2013, to 40 percent in 2015, to 62 percent in 2015 (Figure 50). There has also been an annual increase in density: from a rake fullness of 1.4 in 2013, to 2.4 in 2014, to 2.6 in 2015.

EWM was the only problematic invasive species in Horseshoe Lake during 2015. CLP, reed canary grass, and narrow-leaved cattail frequency have fluctuated at low levels from 2013 through 2015. The 2015 CLP frequency of 6 percent was within the 4- to 7-percent frequency observed from 2013 through 2014 (Figure 51), and the 2015 reed canary grass frequency of 6 percent was within the 6- to 7-percent frequency observed during 2013 and 2014 (Figure 51). The 2015 narrow-leaf cattail frequency of 12 percent was only slightly higher than the 8- to 11-percent frequency observed from 2013 through 2014 (Figure 52).

The Horseshoe Lake native plant community was stable in 2015 and no significant changes in native plant frequency were observed (Figure 52).

Pictured above, panorama of canopied EWM in the northwest bay of Horseshoe Lake, just west of the golf course.

The 2015 plant community quality, measured by FQI, was stable. FQI considers both the quality of the individual native species in the lake and the number of species collected on the rake. The 2015 FQI value of 11 was within the range of values (9 to 12) observed from 2013 through 2014 (Figure 53). Plant community quality in Horseshoe Lake is poorer than any other VBWD lake.

The annual increase in EWM extent has reduced diversity in Horseshoe Lake, as measured by the Simpsons Diversity Index. Index values decreased from 0.80 in 2013, to 0.76 in 2014, to 0.71 in 2015 (Figure 54); i.e., the probability that two individual plants randomly selected from the Horseshoe Lake will belong to different species has decreased from 80 percent in 2013 to 71 percent in 2015. Plant diversity in Horseshoe Lake is poorer than any other VBWD lake.

McDonald Lake—In 2015, the McDonald Lake plant community showed signs of recovery from the presumed 2014 illegal herbicide treatment. Plant density, frequency, quality, and diversity improved in 2015—after the 2014 decline (Table 12 and Figures 55 through 57). The frequency of occurrence of plants in the lake declined from 95 percent in 2013 to 79 percent in 2014 and then increased to 88 percent in 2015 (Table 12). Plant density, measured by average rake fullness, declined from 3.12 in 2013 to 1.92 in 2014 and then increased to 2.39 in 2015 (Table 12). The quality of the plant community, measured by FQI, declined from 22.3 in 2013 to 19.0 in 2014 and then increased to 19.8 in 2015 (Table 12 and Figure 56). FQI considers both the quality of the individual native species in the lake and the number of species collected on the rake. The diversity of the

Water quality during the 2015 plant survey was poor, due to an algal bloom (pictured above).

plant community, measured by Simpson's Diversity Index, declined from 0.85 in 2013 to 0.80 in 2014 and then increased to 0.83 in 2015 (Table 12 and Figure 57); i.e., the probability that two individual plants randomly selected from McDonald Lake will belong to different species increased from 80 percent in 2014 to 83 percent in 2015.

In 2015, the frequency of plant species in McDonald Lake was relatively stable. However, four plant species (common waterweed, nitella, bald spikerush, and large-leaf pondweed) significantly increased in frequency, while one species (small duckweed) significantly decreased in frequency (Figure 55).

Although three invasive species were present in McDonald Lake during 2015, they were not problematic. At a frequency of 1 percent, CLP was rare—a few scattered plants were observed growing among the waterlilies in the south basin (Figures 55 and 58). Narrow-leaved cattails were also rare (frequency of 1 percent), occurring at only a couple of sample locations along the northeastern shoreline (Figure 55). Reed canary grass frequency in 2015 was 10 percent, which is at the low end of the 2013 to 2014 range of 10 to 15 percent (Figure 55).

Sunfish Lake—Neither invasive nor native plant species were problematic in Sunfish Lake during 2015. Two invasive species were present in 2015, but at a low frequency. CLP occurred at a slightly lower frequency in 2015 (3 percent) than previous years (4 to 6 percent) (Figure 59). Reed canary grass occurred at a slightly higher frequency in 2015 (10 percent) than previous years (4 to 9 percent) (Figure 59).

Of the 10 VBWD lakes surveyed in 2015, Sunfish Lake (pictured above) had the highest number of native species.

Of the 10 VBWD lakes surveyed in 2015, Sunfish Lake had the highest number of native species (31 native species, Table 1). The native plants were relatively stable in 2015, although significant frequency changes were observed for three species: muskgrasses, slender naiad, and leafy pondweed. The unusually late ice-out in 2014 caused delayed growth for some species and was the cause of the significant decline in muskgrasses. With a return to normal ice-out and a normal growing season in 2015, muskgrasses significantly increased in frequency (Figure 60)—returning to 2013 levels. Both slender naiad and leafy pondweed increased in frequency in 2014, then significantly decreased in 2015, returning to 2013 levels (Figure 60).

In 2015, plant community quality, measured by FQI, improved slightly. FQI considers both the quality of the individual native species in the lake and the number of species collected on the rake. FQI has increased annually since 2013: from 19.5 in 2013, to 24.5 in 2014, to 24.8 in 2015 (Figure 61). The 2015 increase in FQI was accompanied by first-time sightings of four native plant species: hardstem bulrush, common rush, common bladderwort, and large duckweed. Diversity, measured by Simpson's Diversity Index, was stable in 2015. The 2015 Simpson's Diversity Index value of 0.89 compares with 0.90 during 2013 and 2014; i.e., the probability that two individual plants randomly selected from Sunfish Lake will belong to different species has ranged from 89 to 90 percent.

Summary

The majority of VBWD lakes had a diverse and high-quality plant community during 2015. Of the 10 lakes surveyed, Sunfish Lake had the highest number of native species. Lake Jane had the highest quality plant community, as measured by FQI. Lake Edith and Lake Jane had the most diverse plant communities, as measured by Simpson's Diversity Index. The Horseshoe Lake plant community had the fewest native species, was less diverse, and was of poorer quality than all other VBWD lakes. Rapidly expanding EWM is the apparent cause of the low number and quality of native species in the lake and the lack of diversity in the plant community.

Six of the 10 surveyed VBWD lakes are infested with EWM and four were treated with herbicide: Long Lake, Lake DeMontreville, Lake Olson, and Lake Jane. EWM frequency is highest in Horseshoe Lake (where it has not been managed), followed by Lake Elmo. Divers removed some EWM from Lake Elmo by hand in September of 2015.

Long Lake has been treated with herbicide nearly annually since 2011 to reduce EWM extent. All EWM-infested areas in Long Lake were treated with herbicide in 2015. The average 2,4-D concentration measured in the lake 3 days after treatment was lethal to EWM. The 2015 treatment reduced EWM area by 93 percent. In June 2010, prior to the start of herbicide treatment, EWM extent was 52 acres, which was 97 percent of the lake's plant growth area. After treatment in 2015, EWM extent was 0.4 acres, 0.73 percent of the lake's plant growth area.

In 2015, the MDNR did not permit herbicide treatment of all EWM-infested areas within Lake DeMontreville. The total permitted area of 14 acres was only 24 percent of the 58 infested acres. The average 2,4-D concentration measured in the lake 3 days after treatment was not lethal to EWM, but attained seasonal control. The herbicide killed EWM plants, but not their root crowns, resulting in regrowth of EWM later in the season. After treatment, the EWM-infested area of the lake was reduced by 64 percent. The 2015 treatment mitigated the EWM increase that occurred from June of 2014 to spring of 2015.

In 2015, the MDNR also did not permit herbicide treatment of all EWM-infested areas within Lake Olson. The total permitted treatment area of 7 acres was only 22 percent of the 32 infested acres. Because the treatment area was small and shallow, the quantity of herbicide allowed for the treatment was insufficient to attain a lethal, lake-wide 2,4-D concentration and exposure time. The average 2,4-D concentration measured in the lake 3 days after treatment was less than one-third of the EWM lethal dose. The treatment reduced EWM area by 11 percent, but EWM frequency increased by 4 percent. The 2015 treatment partially mitigated the EWM increase that occurred from June of 2014 to spring of 2015 and provided some reduction in EWM area and density; however, the concentration of herbicide in the lake was too low to reduce the EWM-infested area below 2014 levels.

The MDNR also declined to permit herbicide treatment of all EWM-infested areas within Lake Jane during 2015. The total permitted treatment area of 7.9 acres was only 18 percent of the 44 infested acres. The average 2,4-D concentration measured 3 days after treatment was less than 20 percent of the lethal EWM dose. The treatment reduced EWM area by 30 percent, only partially mitigating the EWM increase that occurred from June of 2014 to spring of 2015. Hence, after treatment, the June 2015 EWM area was 29 percent greater than the June 2014 EWM area.

Herbicide treatment of EWM-infested areas within Lake Elmo was not permitted by the MDNR. In September, the Lake Elmo Lake Association hired divers to remove EWM by hand from an area that was less than an acre. This was about 1 percent of the 68 EWM-infested acres.

All 10 surveyed VBWD lakes are infested with CLP. However, Eagle Point Lake is the only lake with problematic infestation. CLP was stable in Eagle Point Lake in 2015 with a density and distribution similar to 2014 levels.

Yellow iris, an invasive species, was common on the southern shorelines of Lake DeMontreville. It appears that residents are unaware that this is an invasive, non-native plant and are maintaining it along their shorelines. Residents are advised to remove the yellow iris plants from their shoreline to prevent the spread and proliferation of this invasive species.

Description of Tables

Table 1 summarizes the results of the 2015 aquatic plant surveys of 10 VBWD lakes. The following data are presented:

- **Number of species**—the number of different plant species that were either collected on the rake or observed in the lake (e.g., water lilies or cattail beds not collected on the rake but observed). This number includes both invasive and native species.

- **Number of native species**—the number of native plant species that were either collected on the rake or observed in the lake.

- **Number of native species collected on rake—**only native plants collected on the rake were used for this statistic.

- **Number of invasive species—**the number of invasive plant species that were either collected on the rake or observed in the lake.

- **Maximum depth of plant growth**—the maximum depth that plants were found in the lake.

- **Frequency of occurrence—**the frequency with which plants were found in water shallower than the maximum depth of plant growth.

- **Average rake fullness—**the density of plant growth, as measured by rake fullness on a scale of 1 to 4, where:

  1 = less than 1/3 of the rake head full of plants.

  2 = from 1/3 to 2/3 of the rake head full of plants.

  3 = more than 2/3 of the rake head full of plants.

  4 = rake head is full, with plants overtopping the rake head.

- **Simpson Diversity Index Value**—index used to measure plant diversity, which assesses the overall health of the lake's plant communities. The index, with scores ranging from 0 to 1, considers both the number of species present and the evenness of species distribution. The scores represent the probability that two individual plants randomly selected from the lake will belong to different species. A high score indicates a more diverse plant community—a higher probability that two randomly selected plants will represent different species.

- **C value—**scale of values used to measure the average tolerance of the plant community to degraded conditions. Plant species are assigned C values on a scale of 0 to 10, with increasing values indicating plants are less tolerant of degraded conditions and of better quality. An average of the C values for individual species within a lake's plant community indicates the average tolerance of the community to degraded conditions.

- **Floristic Quality Index (FQI) value—**FQI was used to assess the quality of the plant communities in VBWD lakes. FQI considers both the quality of the individual native species found in the lake (C value) and the number of native species collected on the rake. Although Minnesota has not kept a record of FQI values, recorded Wisconsin FQI values range from 3 (degraded plant communities) to 49 (diverse native plant communities). The median FQI for Wisconsin is 22.

Table 2 summarizes invasive species data from the 10 VBWD lakes surveyed in 2015. The table shows the frequency of occurrence of species collected on the rake and mentions species that were observed but not collected on the rake.

Tables 3 through 7 summarize Eurasian watermilfoil (EWM) extent during the period of record for Long Lake, Lake DeMontreville, Lake Olson, Lake Jane, and Lake Elmo. EWM extent is shown as acres of EWM in the lake and also as a percent of the plant growth area.

Tables 8 through 11 compare frequency of native species for 2014 and 2015, number of native species collected on the rake, and both the frequency and area of EWM in Long Lake, Lake DeMontreville, Lake Olson, and Lake Jane.

Table 12 summarizes the McDonald Lake plant community, including data on frequency of occurrence, density, diversity, and plant community quality.

Table 1 2015 Valley Branch Watershed District Lake Plant Survey Summary Statistics

Lake	Number of Species	Number of Native Species	Number of Native Species Collected on Rake*	Number of Invasive Species	Maximum Depth of Plant Growth (feet)	Frequency of Occurrence (%)	Average Rake Fullness	Simpson Diversity Index Value	C Value	FQI Value
Jane	30	25	24	5	23.0	96	2.37	0.92	6.4	31.4
Elmo	30	26	18	4	20.5	99	2.85	0.88	5.3	23.5
Sunfish	34	31	22	3	11.0	76	1.89	0.89	5.7	24.8
Olson	28	24	19	4	18.5	85	1.76	0.90	6.1	26.6
DeMontreville	28	23	19	5	26.5	94	1.76	0.90	6.0	26.8
McDonald	22	19	16	3	11.0	88	2.39	0.83	4.9	19.8
Eagle Point	17	14	12	3	4.0	100	3.24	0.84	5.1	19.2
Edith	22	19	16	3	12.0	91	1.51	0.92	5.4	22.1
Horseshoe	14	10	7	4	11.0	79	2.71	0.71	3.9	11.0
Long	18	14	12	4	27.0	49	1.73	0.77	5.3	16.8
Average	**24**	**21**	**17**	**4**	**16.5**	**86**	**2.22**	**0.86**	**5.4**	**22.2**

Table 2 2015 Valley Branch Watershed District Invasive Species Summary: Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth (Percent or Observed)

Lake	**Myriophyllum spicatum** (Eurasian watermilfoil)	**Potamogeton crispus** (curly-leaf pondweed)	**Phalaris arundinacea** (reed canary grass)	**Lythrum salicaria** (purple loosestrife)	**Typha angustifolia** (narrowleaf cattail)	**Typha glauca** (hybrid cattail)	**Iris pseudacorus** (yellow iris)
Horseshoe	62	6	6	--	12	--	--
Elmo	45	Observed*	Observed*	--	17	--	--
Olson	28	5	Observed*	--	Observed*	--	--
DeMontreville	17	31	Observed*	--	--	1	Observed*
Jane	23	11	Observed*	Observed*	Observed*	--	--
Long	1	6	Observed*	--	--	Observed*	--
Eagle Point	--	59	Observed*	--	29	--	--
Sunfish	--	3	10	--	Observed*	--	--
Edith	--	4	1	--	--	4	--
McDonald	--	1	10	--	1	--	--

*Observed in the lake but not collected on the rake.

Table 3 Long Lake Acres of EWM, Acres of Plant Growth, and EWM Extent as a Percent of Plant Growth Area with EWM

Lake	Sample Date	EWM Extent: Acres of EWM	Acres of Plant Growth Area	EWM Extent: % of Plant Growth Area with EWM
Long Lake	6/15/2010	52.31	53.71	97.39%
Long Lake	8/1/2011	4.89	22.67	21.56%
Long Lake	4/29/2012	2.44	31.47	7.74%
Long Lake	6/18/2012	7.24	21.06	34.39%
Long Lake (Partial Survey)	5/16/2013	14.28	--	--
Long Lake	6/24/2013	7.88	50.43	15.62%
Long Lake	5/24/2014	9.75	39.94	24.41%
Long Lake	6/25/2014	4.77	47.68	10.00%
Long Lake	5/9/2015	5.5	52.81	10.41%
Long Lake	6/22/2015	0.4	54.72	0.73%

Table 4 Lake DeMontreville Acres of EWM, Acres of Plant Growth, and EWM Extent as a Percent of Plant Growth Area with EWM

Lake	Sample Date	EWM Extent: Acres of EWM	Acres of Plant Growth Area	EWM Extent: % of Plant Growth Area with EWM
Lake DeMontreville	6/18/2012	5.39	137.07	3.93%
Lake DeMontreville	6/24/2013	50.88	144.45	35.22%
Lake DeMontreville	5/24/2014	53.08	143.93	36.88%
Lake DeMontreville	6/28/2014	26.75	146.94	18.20%
Lake DeMontreville	5/10/2015	58.01	149.40	38.83%
Lake DeMontreville	6/21/2015	20.60	157.29	13.10%

Table 5 Lake Olson Acres of EWM, Acres of Plant Growth, and EWM Extent as a Percent of Plant Growth Area with EWM

Lake	Sample Date	EWM Extent: Acres of EWM	Acres of Plant Growth Area	EWM Extent: % of Plant Growth Area with EWM
Lake Olson	6/18/2012	2.17	88.03	2.46%
Lake Olson	6/24/2013	3.55	89.01	3.99%
Lake Olson	5/24/2014	22.96	87.11	26.36%
Lake Olson	6/28/2014	23.96	89.02	26.92%
Lake Olson	5/9/2015	31.77	89.26	35.59%
Lake Olson	6/21/2015	28.13	87.02	32.33%

Table 6 Lake Jane Acres of EWM, Acres of Plant Growth, and EWM Extent as a Percent of Plant Growth Area with EWM

Lake	Sample Date	EWM Extent: Acres of EWM	Acres of Plant Growth Area	EWM Extent: % of Plant Growth Area with EWM
Lake Jane	6/18/2012	0.10	118.54	0.08%
Lake Jane	6/28/2013	1.68	121.82	1.38%
Lake Jane	6/27/2014	24.08	112.61	21.38%
Lake Jane	5/9/2015	44.16	125.08	35.31%
Lake Jane	6/21/2015	31.01	126.77	24.46%

Table 7 2015 Lake Elmo Acres of EWM, Acres of Plant Growth, and EWM Extent as a Percent of Plant Growth Area with EWM

Lake	Sample Date	EWM Extent: Acres of EWM	Acres of Plant Growth Area	EWM Extent: % of Plant Growth Area with EWM
Elmo	6/18-19/2012	71.09	112.68	63.09
Elmo	6/28/2013	52.69	109.61	48.07
Elmo	6/27/2014	50.58	112.42	44.99
Elmo	6/21/2015	67.52	113.53	59.47

Table 8 Long Lake Results: Pre-Treatment and Post-Treatment EWM and Native Species—June 2014 and June 2015

Parameter	June 2014	June 2015
Frequency of EWM (%)	10	1
Area of EWM (acres)	4.77	0.4
Frequency of Native Species (%)	33	47
# of Native Species Collected on the Rake	10	10

Table 9 Lake DeMontreville Results: Pre-Treatment and Post-Treatment EWM and Native Species—June 2014 and June 2015

Parameter	June 2014	June 2015
Frequency of EWM (%)	19	17
Area of EWM (acres)	27	21
Frequency of Native Species (%)	89	94
# of Native Species Collected on the Rake	19	19

Table 10 Lake Olson Results: Pre-Treatment and Post-Treatment EWM and Native Species—June 2014 and June 2015

Parameter	June 2014	June 2015
Frequency of EWM (%)	28	28
Area of EWM (acres)	24	28
Frequency of Native Species (%)	91	82
# of Native Species Collected on the Rake	20	19

Table 11 Lake Jane Results: Pre-Treatment and Post-Treatment EWM and Native Species—June 2014 and June 2015

Parameter	June 2014	June 2015
Frequency of EWM (%)	19	23
Area of EWM (acres)	24	31
Frequency of Native Species (%)	99	96
# of Native Species Collected on the Rake	28	24

Table 12 2013–2015 McDonald Lake Frequency, Density, Diversity, and Quality of Plant Community

Sample Date	Frequency of Occurrence* (%)*	Density (Average Rake Fullness)	Simpson Diversity Index	Plant Community Quality (FQI)
6/27/2013	95	3.12	0.85	22.3
6/26/2014	79	1.92	0.80	19.0
6/23/2015	88	2.39	0.83	19.8

***Frequency of occurrence at sites shallower than maximum depth of plant growth

Description of Figures

- Figures 1, 12, 20, and 28 show the 2015 herbicide treatment areas for Long Lake, Lake DeMontreville, Lake Olson, and Lake Jane.

- Figure 2 shows the percent of EWM-infested area treated with herbicide in Long Lake, Lake DeMontreville, Lake Olson, and Lake Jane.

- Figure 3 compares the 2,4-D concentrations measured in the treated lakes with the 2,4-D dose that is lethal to EWM.

- Figure 4 compares the May 2015 (pre-treatment) EWM area with the June 2015 (post-treatment) EWM area in the treated lakes and notes the percent reduction in EWM area for each lake.

- Figures 5, 13, 21, and 29 summarize EWM area in treated lakes for the period of record.

- Figures 6, 14, 22, and 30 summarize EWM frequency in treated lakes for the period of record.

- Figures 7, 15, 23, and 31 compare pre- and post-treatment EWM rake fullness in lakes treated in 2015.

- Figure 45 shows EWM extent in Lake Elmo during 2015.

- Figure 50 summarizes the EWM frequency in Horseshoe Lake for 2013 through 2015.

- Figures 11, 19, 27, 35, 36, 43, 46, 51, 58 and 59 summarize the curly-leaf pondweed frequency for the period of record in the 10 VBWD lakes surveyed in 2015.

- Figures 8, 16, 24, 32, 37, 40, 47, 52, 55, and 60 summarize the frequency of occurrence of individual plant species observed in the 10 VBWD lakes that were surveyed in 2015. The figures show species frequency for the entire period of record. The figures denote significant changes in frequency between years with asterisks. The number of asterisks denotes the degree of confidence that the change is not due to chance. One asterisk indicates a 95 percent confidence, two asterisks indicate a 99 percent confidence, and three asterisks indicate a 99.9-percent confidence.

- Figures 9, 17, 25, 33, 38, 41, 48, 53, 56, and 61 summarize the FQI values during the period of record for the 10 VBWD lakes surveyed in 2015.

- Figures 10, 18, 26, 34, 39, 42, 49, 54, 57, and 62 summarize Simpson's Diversity Index values during the period of record for the 10 VBWD lakes surveyed in 2015.

EWM Survey Results

- Not Observed
- Visual Only
- Density = 1
- Density = 2
- Treatment Area

Herbicide Residue Monitoring Location

N

Feet

0 125 250 500

Prepared by Margaret Rattei and Kelly Wild, Barr Engineering, for Valley Branch Watershed District based on results of a survey done by Matt Berg on May 9, 2015.
The Valley Branch Watershed District prepared this map to assist the Friends of Long Lake.

Figure 1

EURASIAN WATERMILFOIL TREATMENT AREAS, MAY 2015 PLANT SURVEY RESULTS AND HERBICIDE RESIDUE MONITORING LOCATIONS
Long Lake (82011800)
Washington County
Valley Branch Watershed District

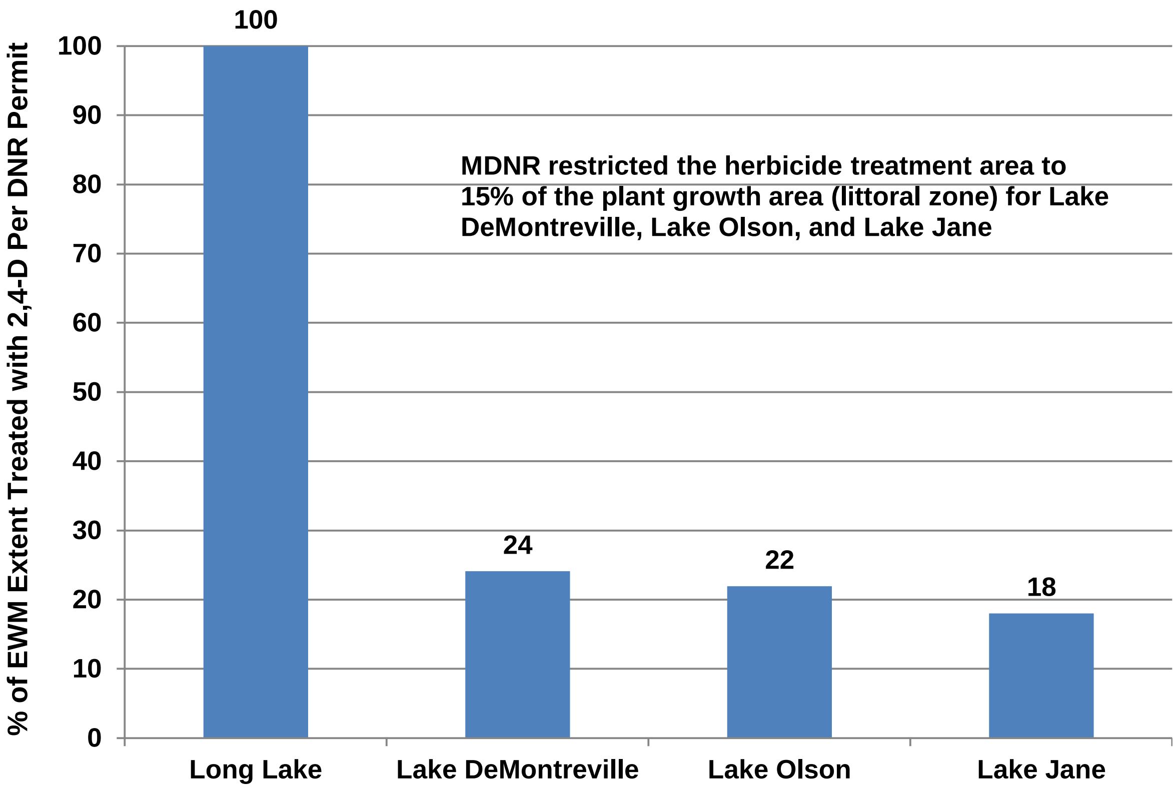


Figure 2 Percentage of EWM Area Treated with 2,4-D in 2015 per MDNR Permit

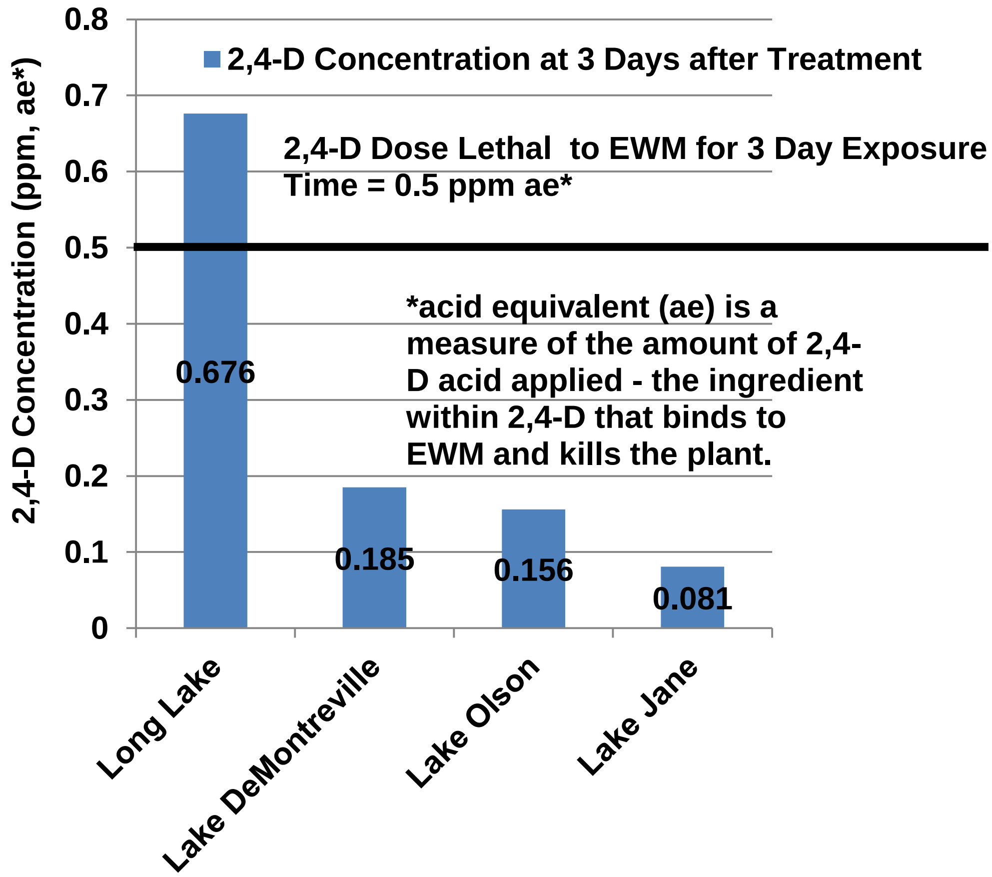


Figure 3 **Comparison of Lethal 2,4-D Dose with Herbicide Residue Data (3 Days after Treatment)**

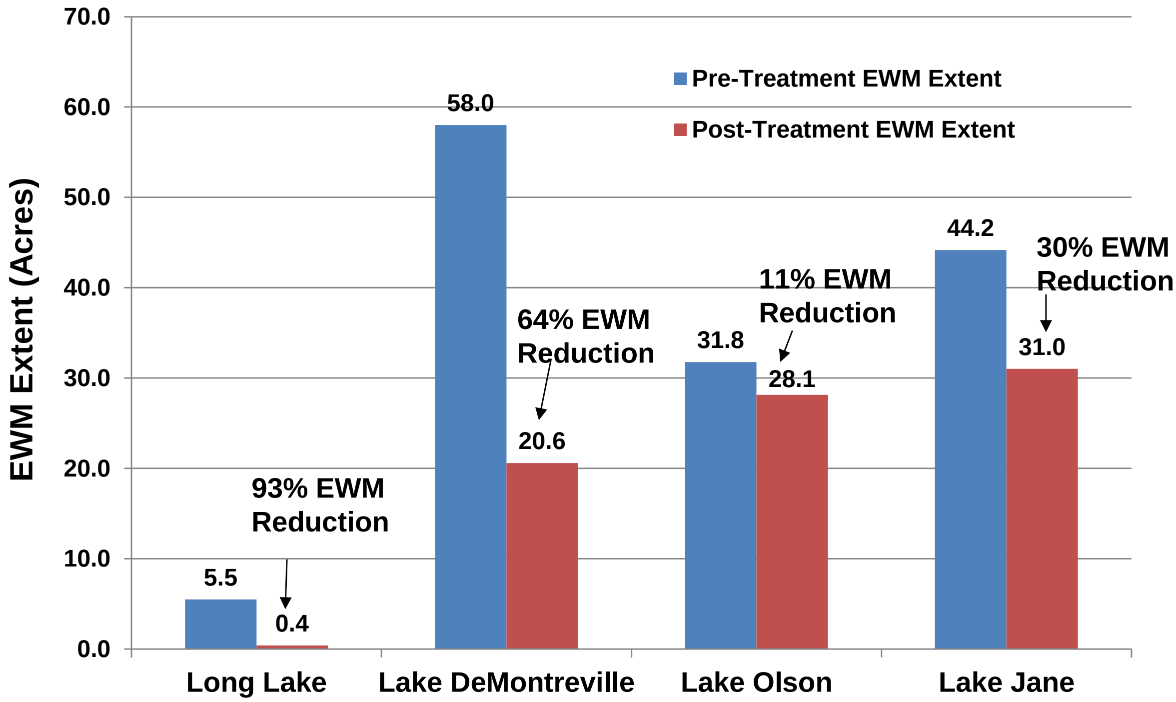


Figure 4 May 2015 Pre-Treatment and June 2015 Post-Treatment EWM Extent

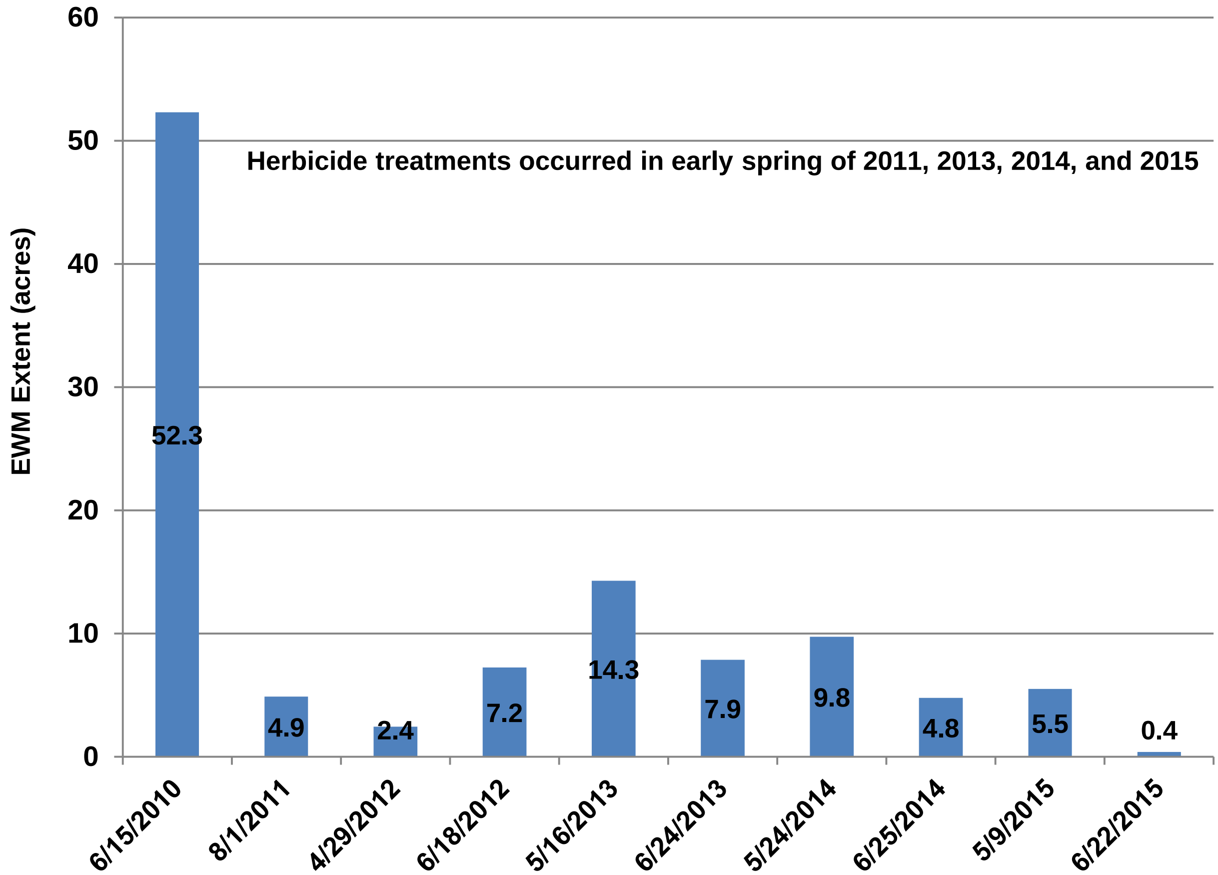


Figure 5 2010–2015 Long Lake Eurasian Watermilfoil Extent

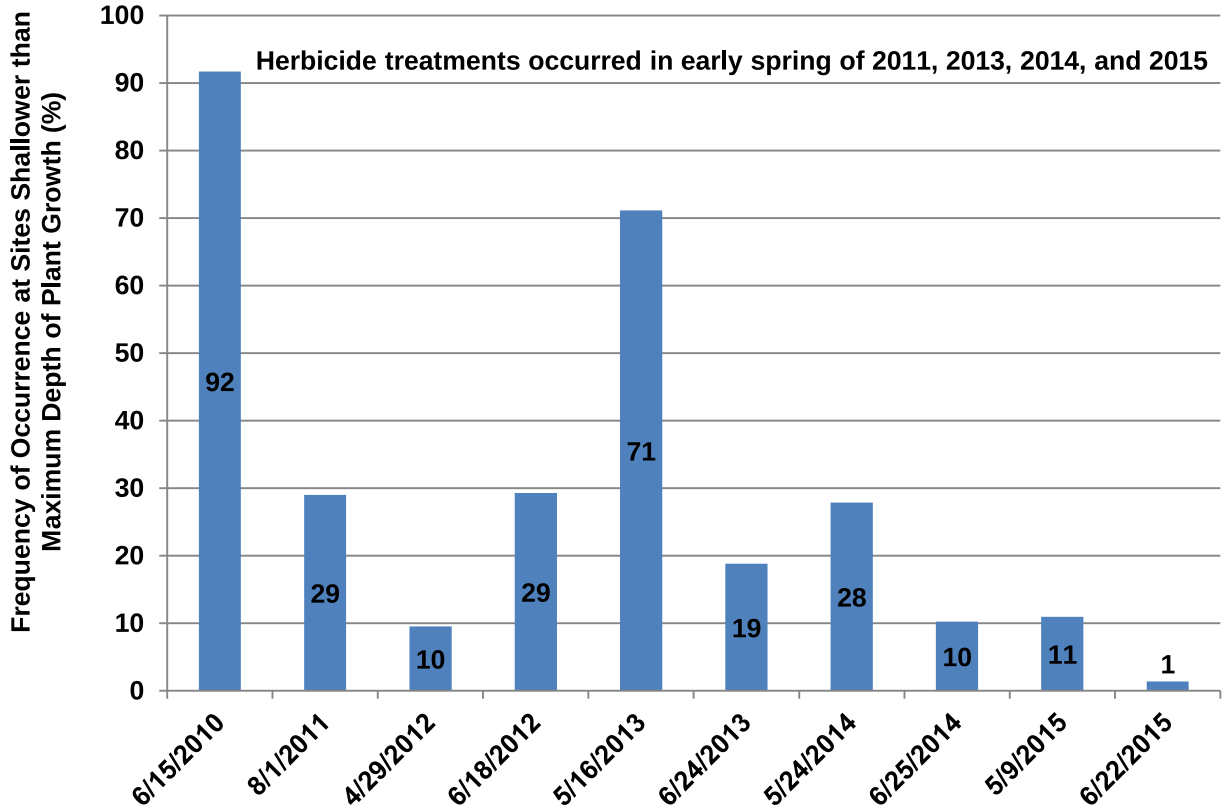


Figure 6 20102015 Long Lake Eurasian Watermilfoil Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth

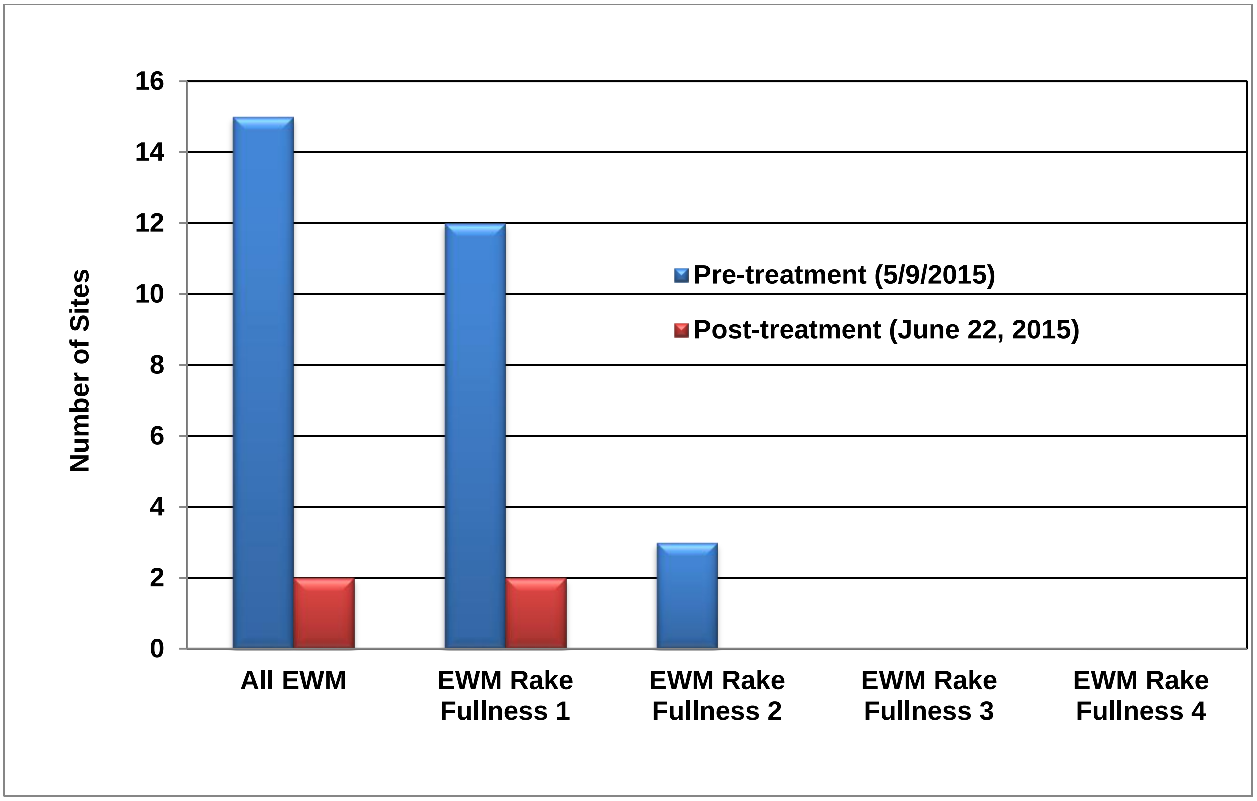
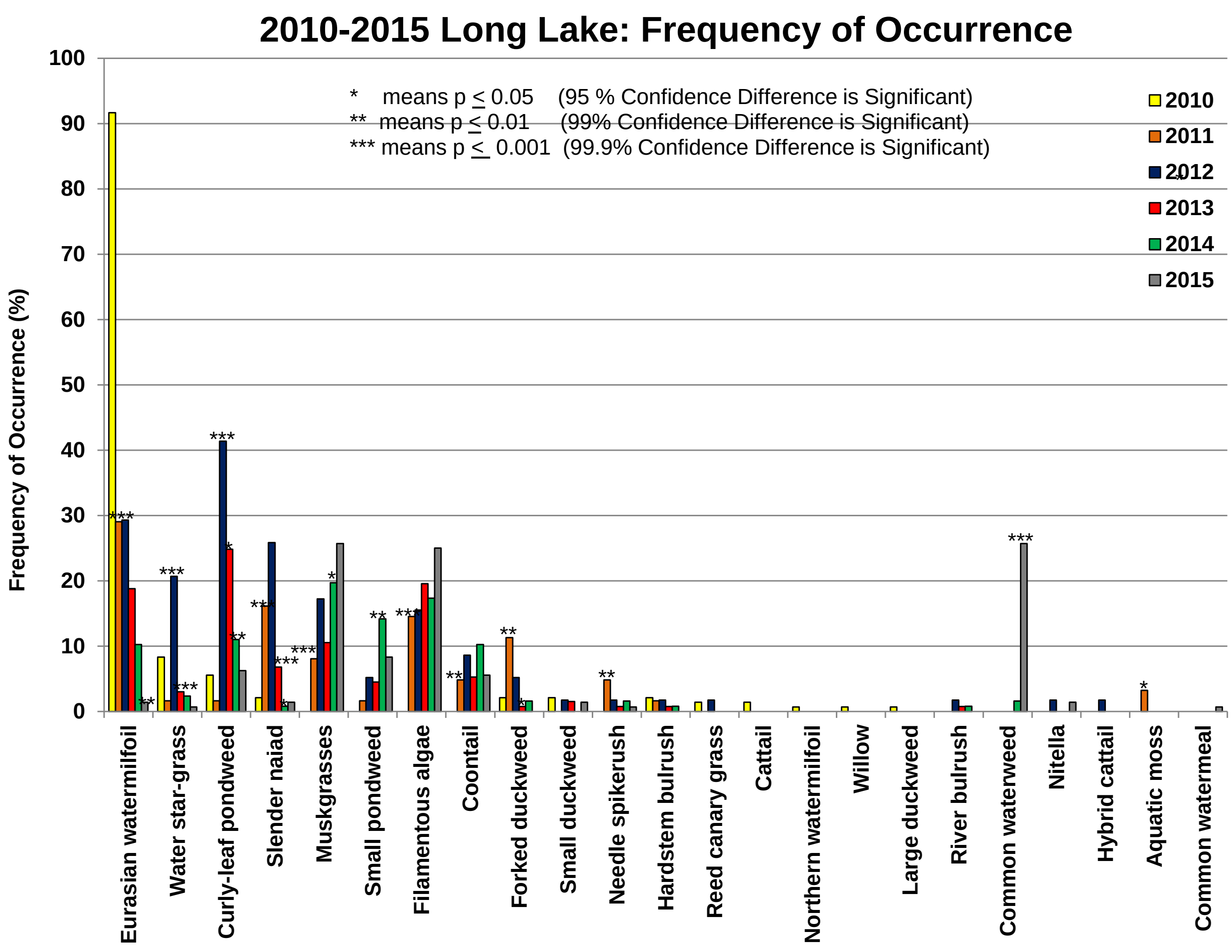


Figure 7 Long Lake: 2015 Pre- and Post-Treatment EWM Rake Fullness



Note: * indicates a significant change in frequency of occurrence between years

Figure 8 2010–2015 Long Lake Frequency of Occurrence in Plant Growth Area of the Lake

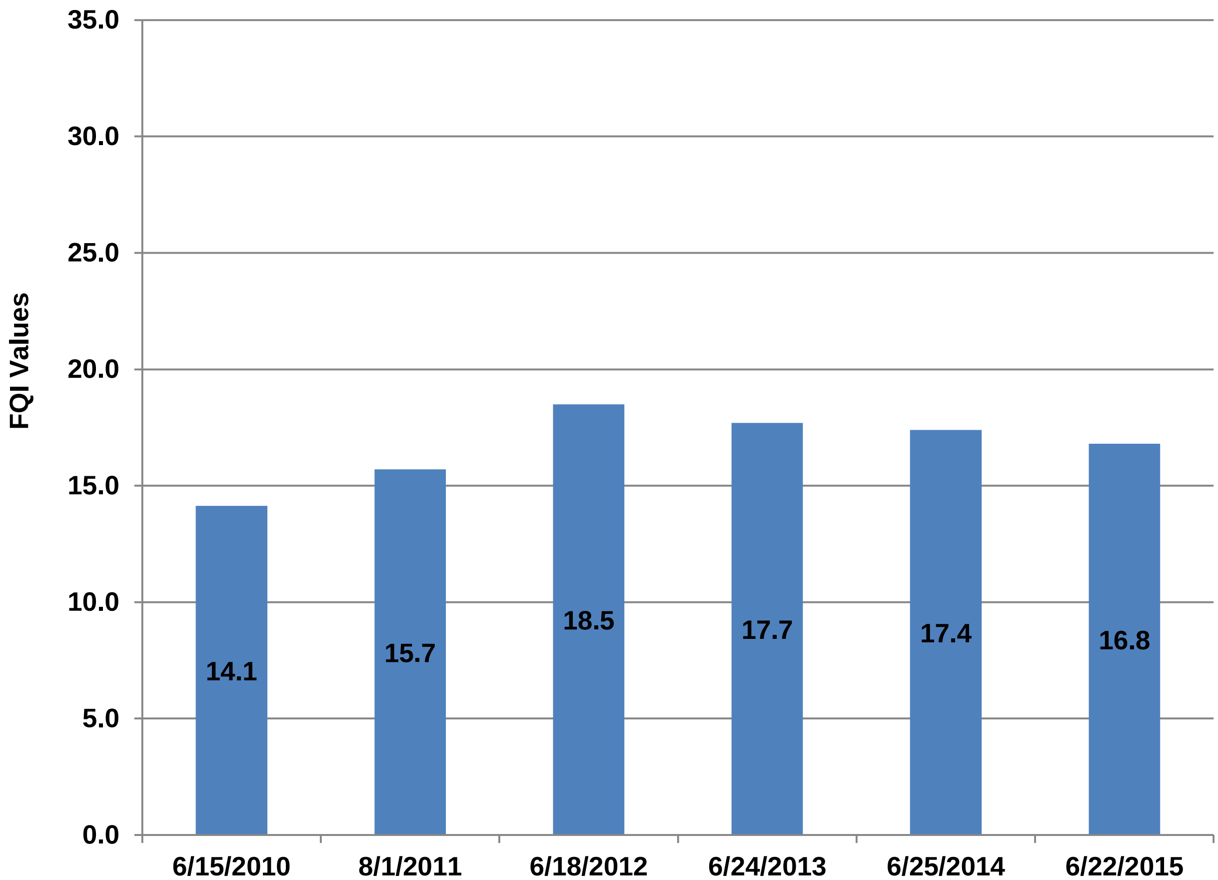


Figure 9 **2010–2015 Long Lake Floristic Quality Index (FQI) Values**

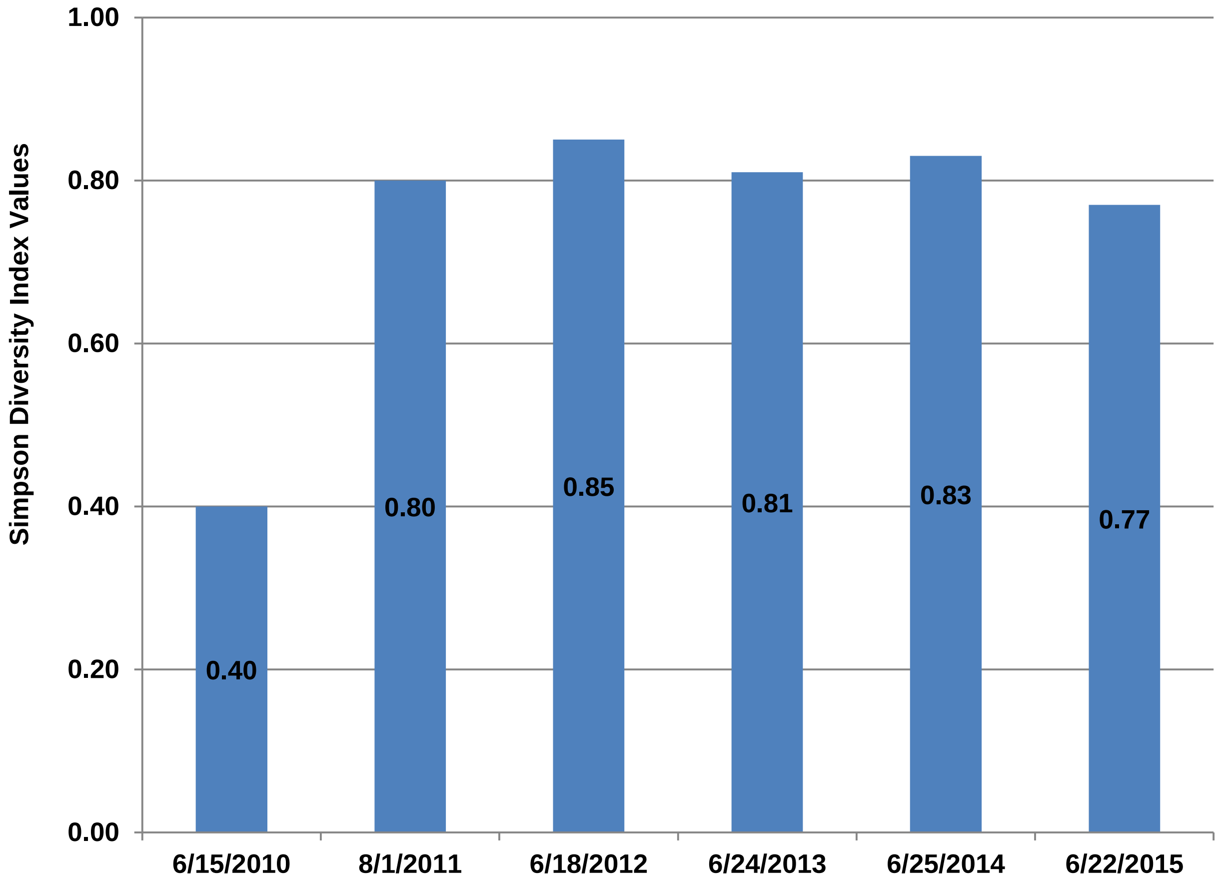


Figure 10 2010–2015 Long Lake Simpson Diversity Index Values

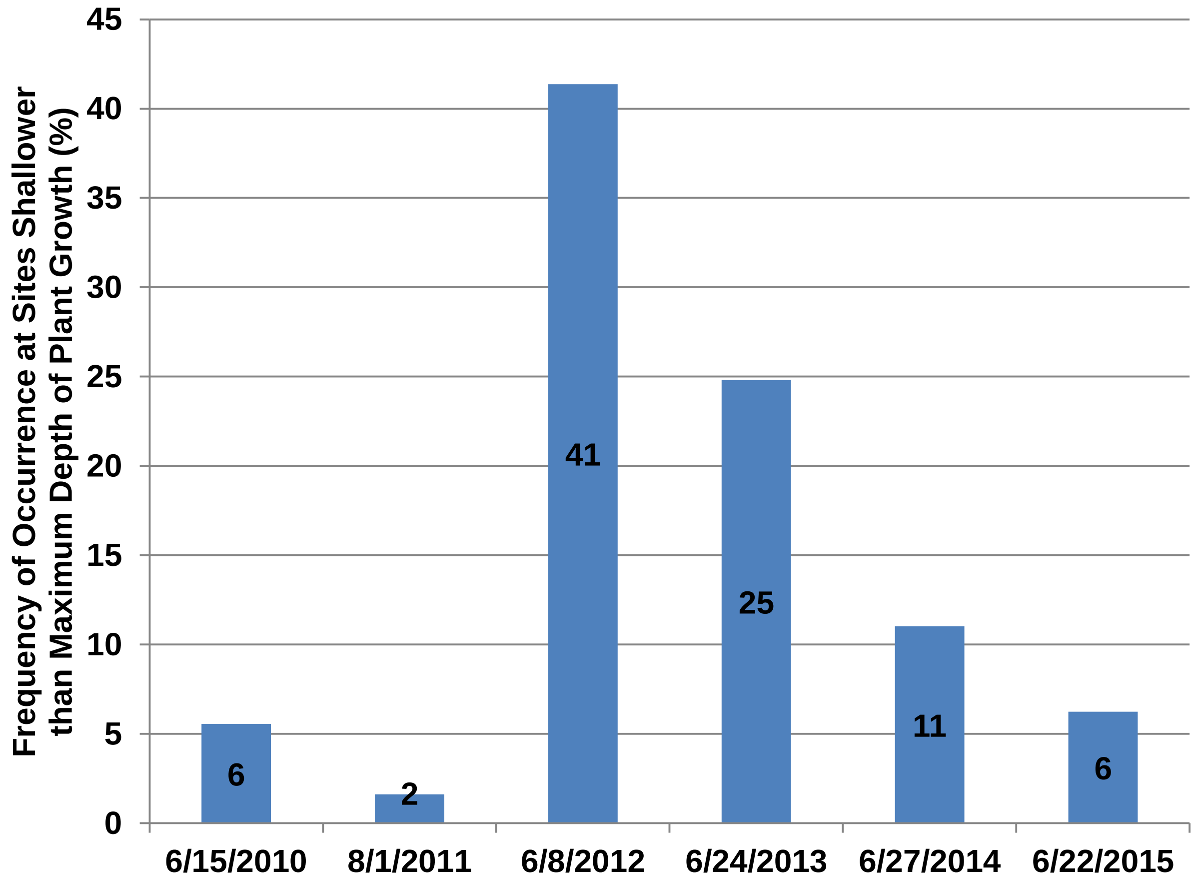
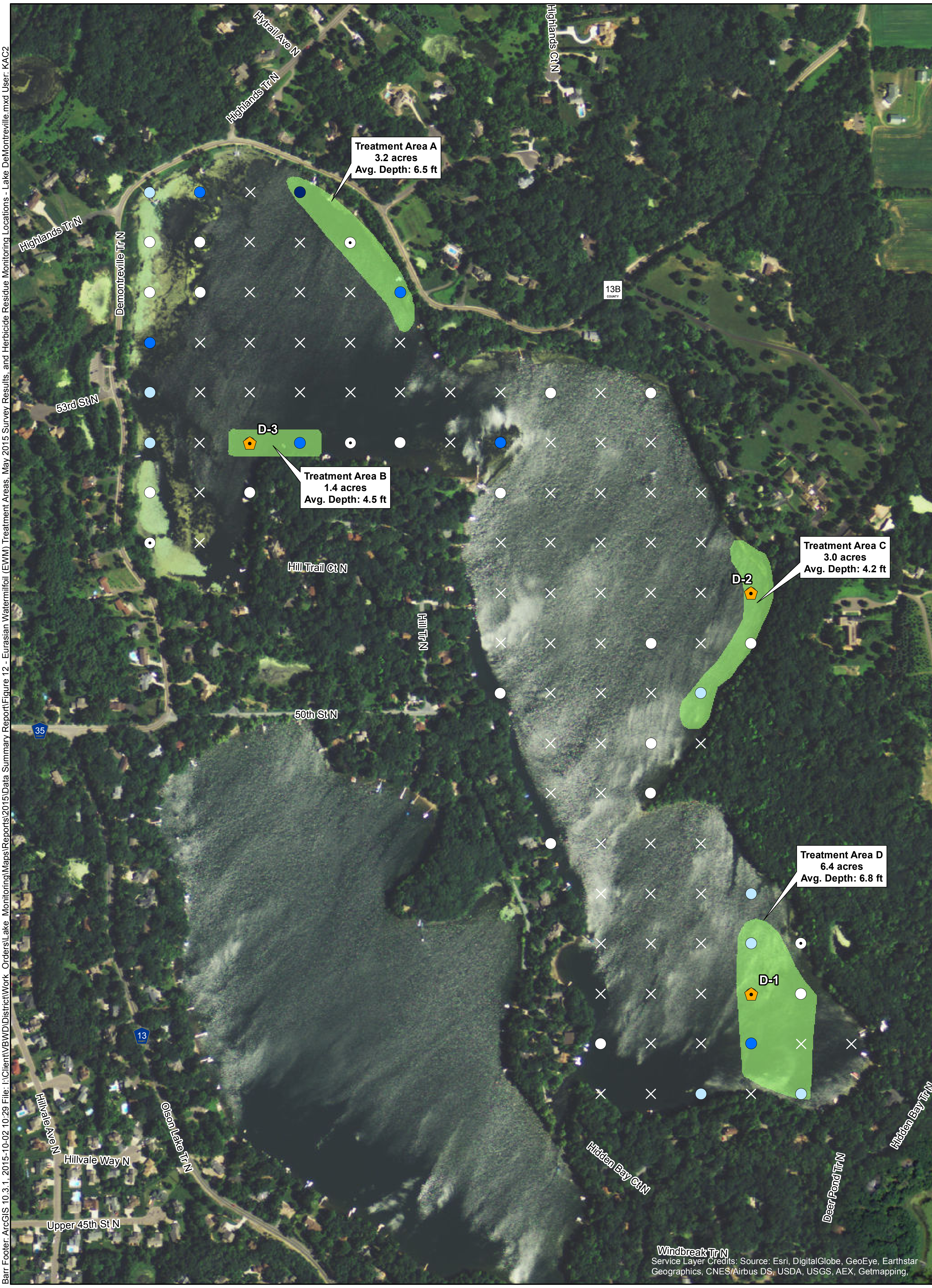


Figure 11 **2010–2015 Long Lake Curly-leaf Pondweed Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth**



Barr Footer: ArcGIS 10.3.1, 2015-10-02 10:29 File: I:\Client\VBWD\District\Work_Orders\Lake_Monitoring\Maps\Reports\2015\Data Summary Report\Figure 12 - Eurasian Watermilfoil (EWM) Treatment Areas, May 2015 Survey Results, and Herbicide Residue Monitoring Locations - Lake DeMontreville.mxd User: KAC2

EWM Survey Results

- × Not Observed
- ⊙ Visual Only
- ○ Density = 1
- ● Density = 2
- ● Density = 3
- ● Density = 4
- Treatment Area
- Herbicide Residue Monitoring Location

N

Feet

0 225 450 900

Prepared by Margaret Rattei and Kelly Wild, Barr Engineering, for Valley Branch Watershed District based on results of a survey done by Matt Berg on May 9, 2015.
The Valley Branch Watershed District prepared this map to assist the Lake DeMontreville/Olson Association.

Figure 12

EURASIAN WATERMILFOIL TREATMENT AREAS, MAY 2015 PLANT SURVEY RESULTS AND HERBICIDE RESIDUE MONITORING LOCATIONS
Lake DeMontreville (82010100)
Washington County
Valley Branch Watershed District

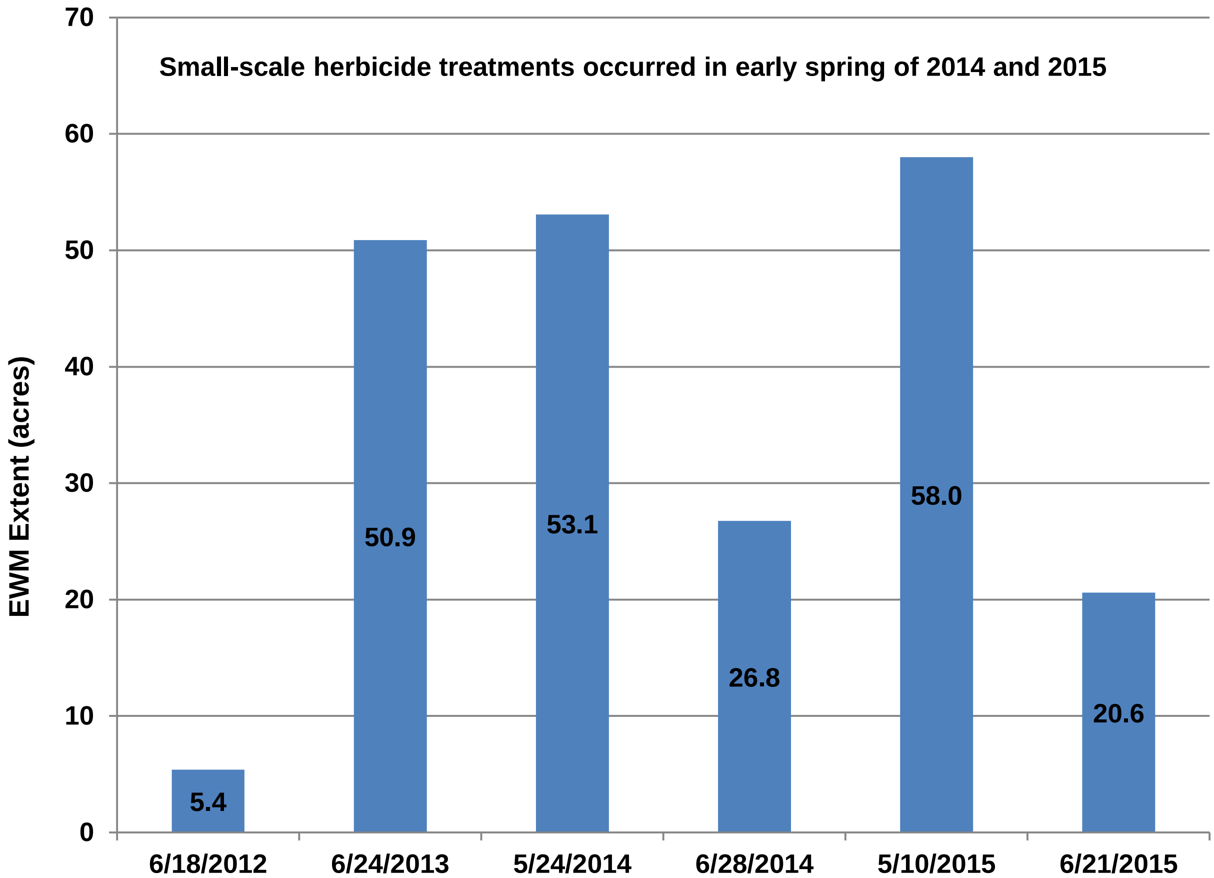


Figure 13 2012–2015 Lake DeMontreville Eurasian Watermilfoil Extent

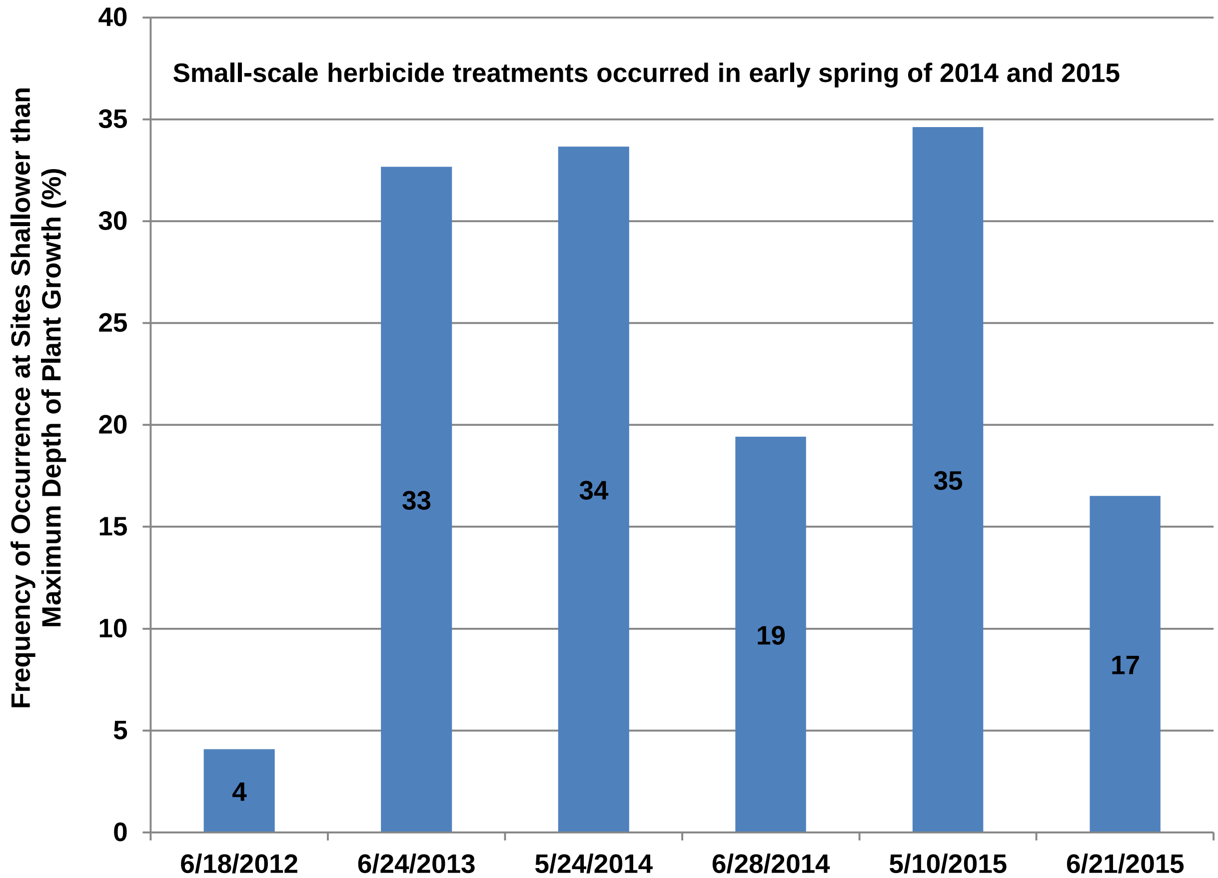

Small-scale herbicide treatments occurred in early spring of 2014 and 2015
Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth (%)
40
35
30
25
20
15
10
5
0
4
33
34
19
35
17
6/18/2012
6/24/2013
5/24/2014
6/28/2014
5/10/2015
6/21/2015

Figure 14 2012–2015 Lake DeMontreville Eurasian Watermilfoil Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth

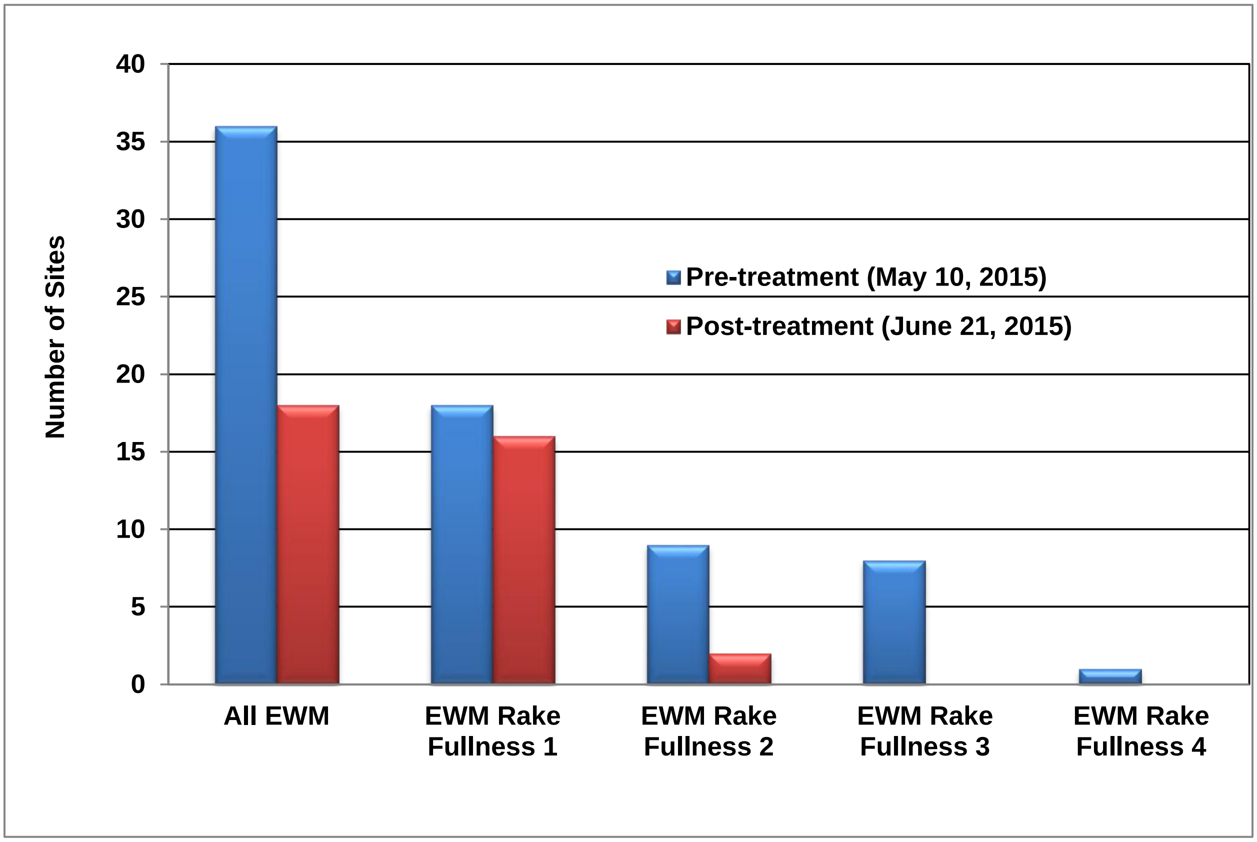
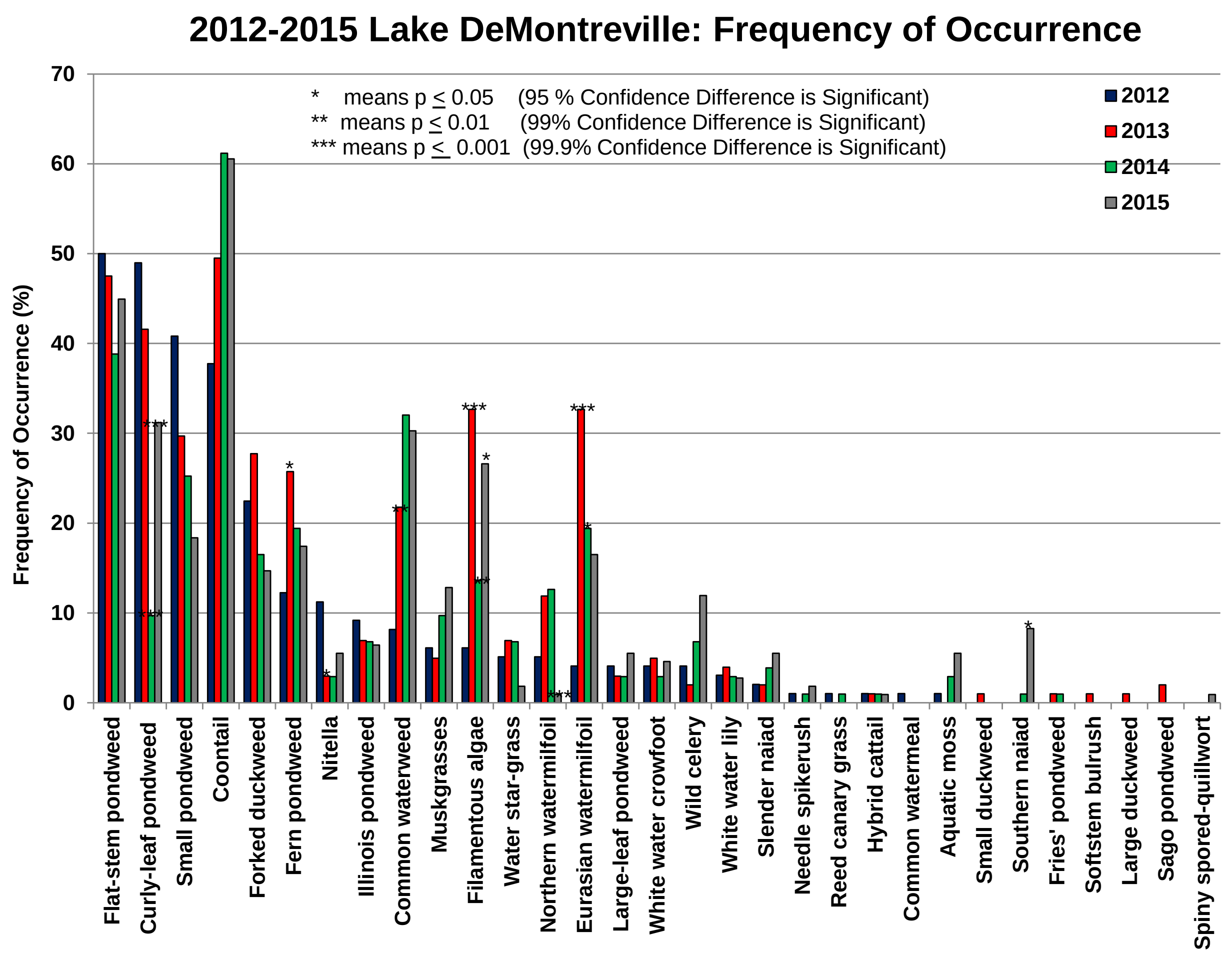


Figure 15 Lake DeMontreville: 2015 Pre- and Post-Treatment Rake Fullness



Note: * indicates a significant change in frequency of occurrence between years

Figure 16 2012–2015 Lake DeMontreville Frequency of Occurrence in Plant Growth Area of the Lake

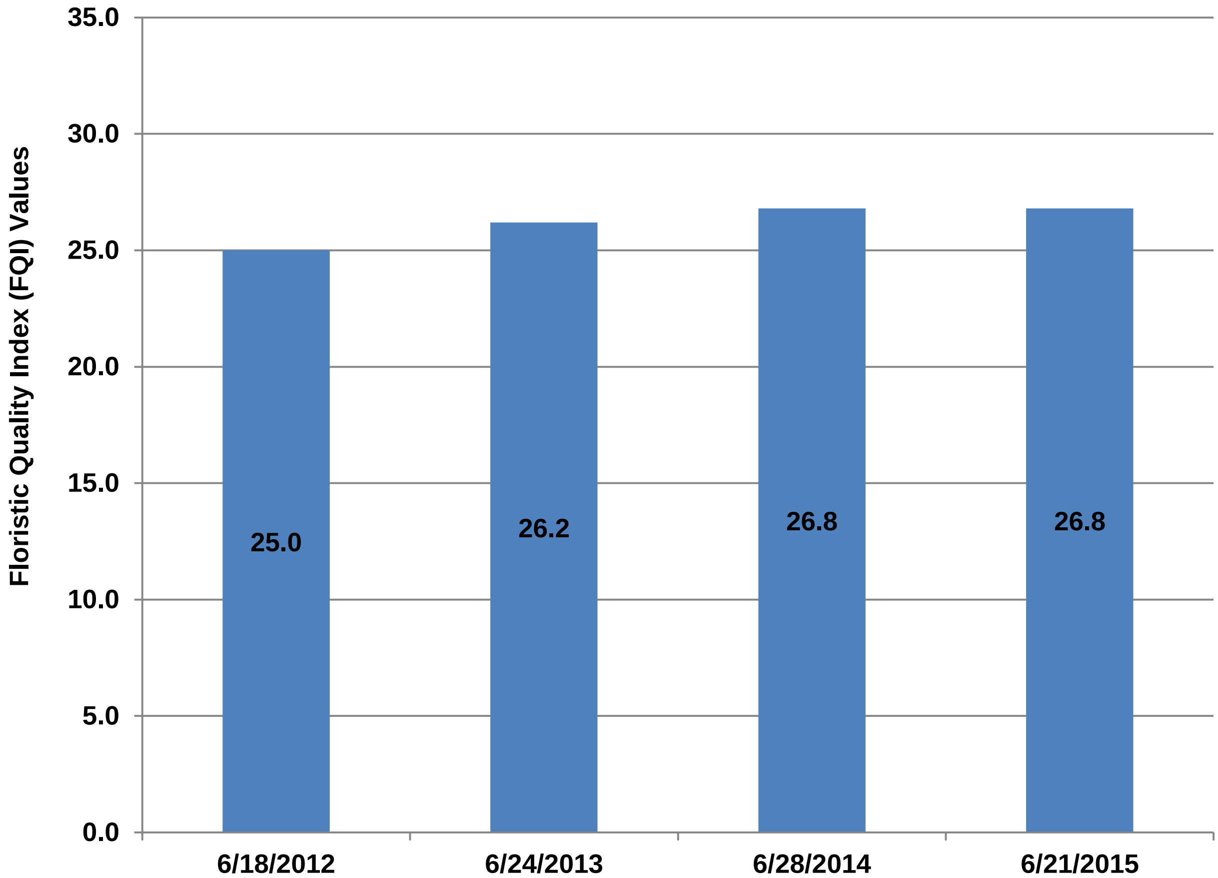


Figure 17 2012–2015 Lake DeMontreville Floristic Quality Index (FQI) Values

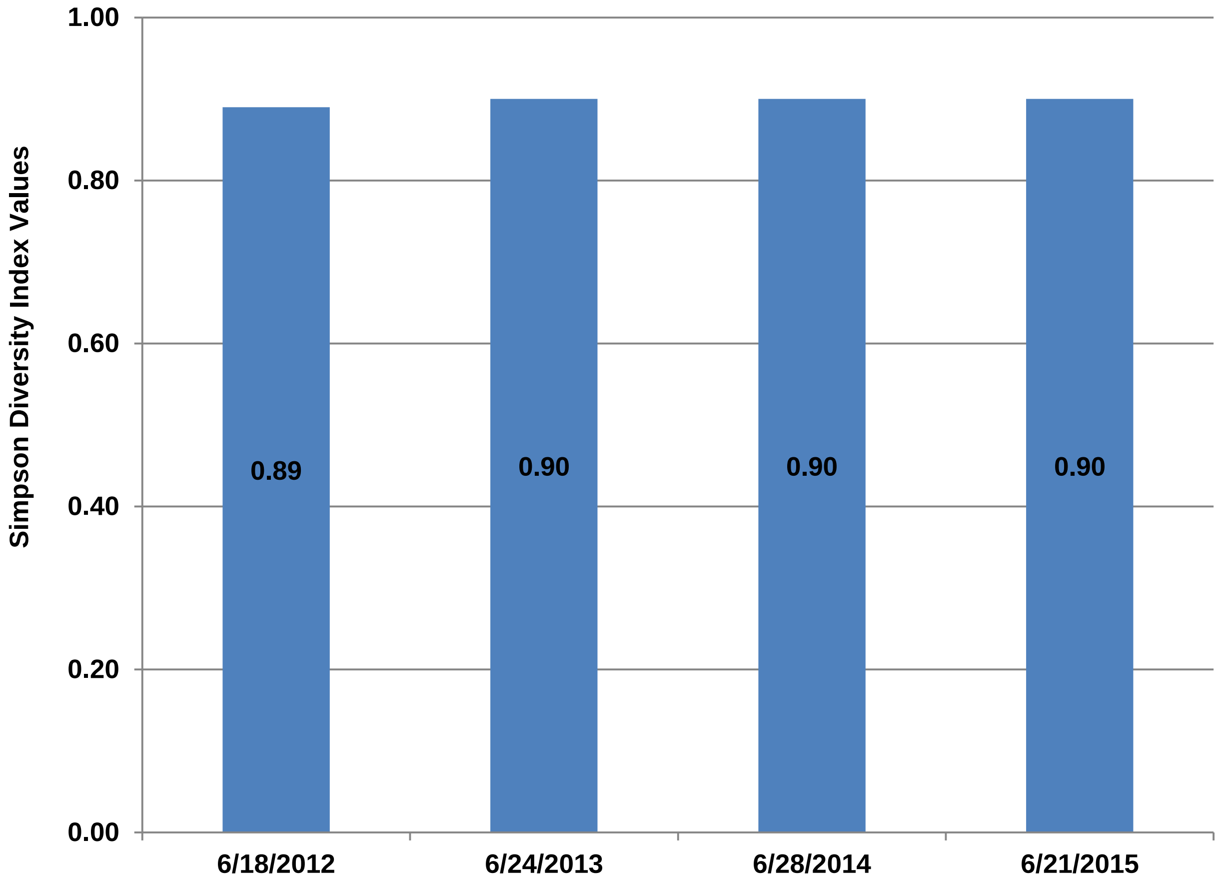


Figure 18 2012–2015 Lake DeMontreville Simpson Diversity Index Values

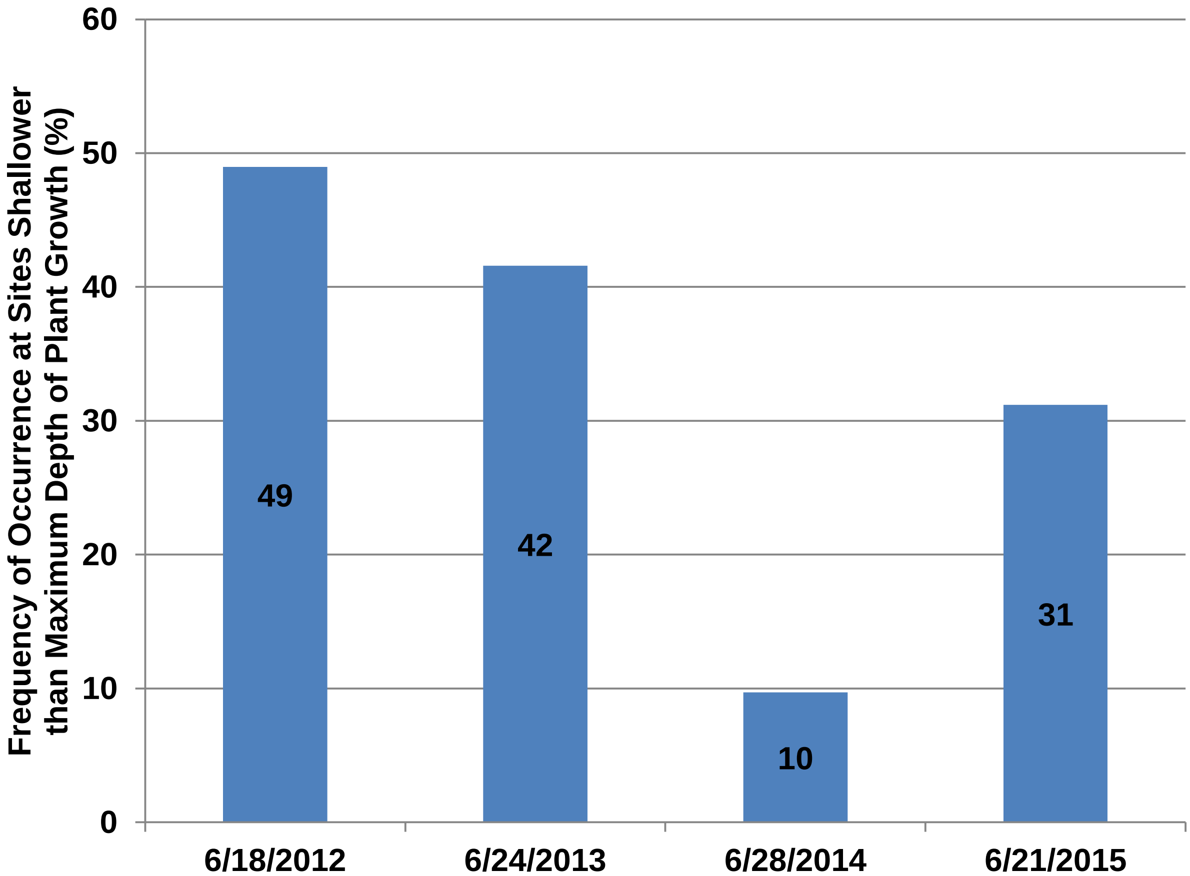
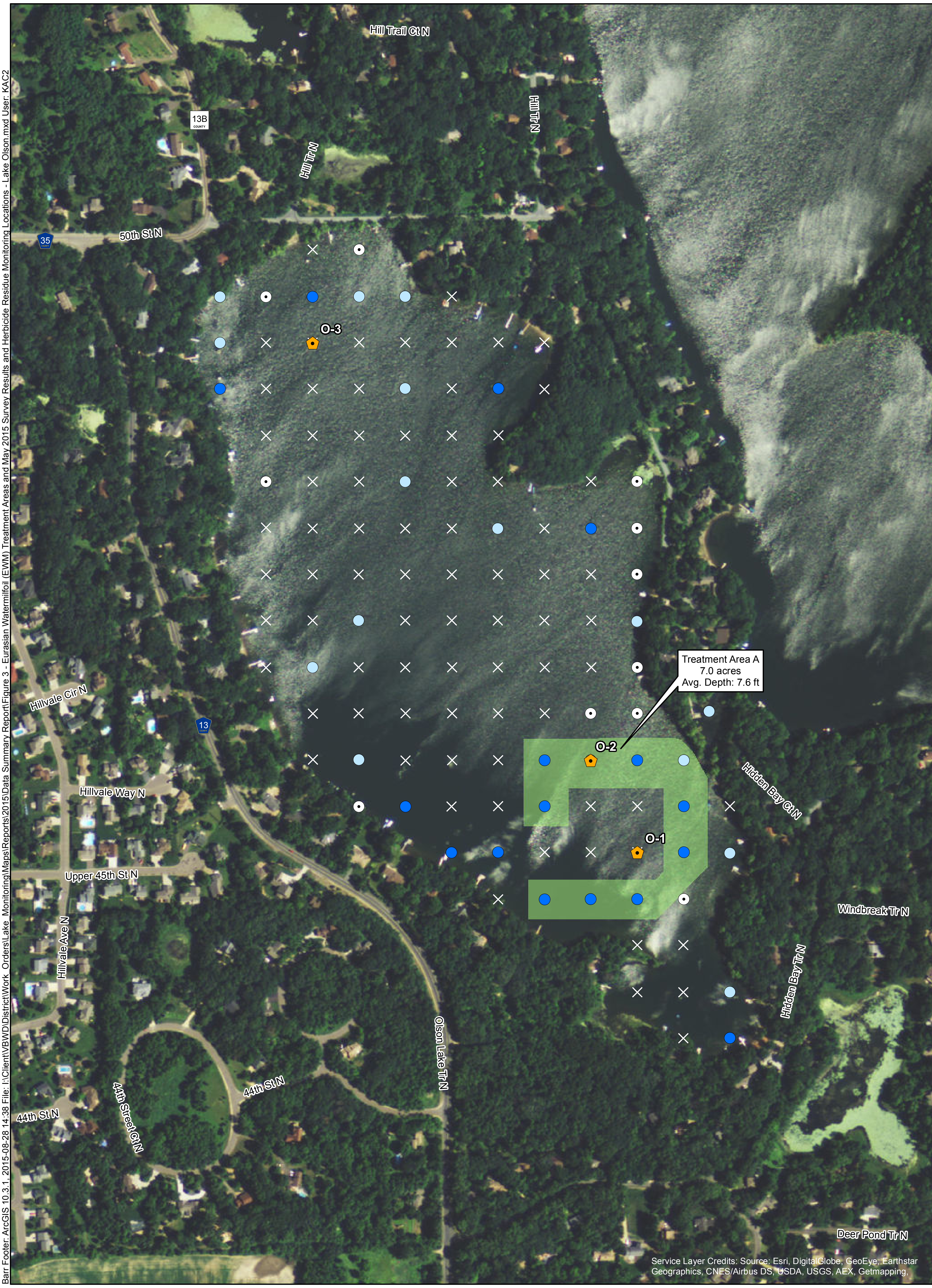


Figure 19 2012–2015 Lake DeMontreville Curly-leaf Pondweed Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth



EWM Survey Results

- Not Observed
- Visual Only
- Density = 1
- Density = 2
- Treatment Area

Herbicide Residue Monitoring Location

N

Feet

0 175 350 700

Figure 20

EURASIAN WATERMILFOIL TREATMENT AREAS, MAY 2015 PLANT SURVEY RESULTS AND HERBICIDE RESIDUE MONITORING LOCATIONS

Lake Olson (82010300)

Washington County

Valley Branch Watershed District

Prepared by Margaret Rattei and Kelly Wild, Barr Engineering, for Valley Branch Watershed District based on results of a survey done by Matt Berg on May 9, 2015.
The Valley Branch Watershed District prepared this map to assist the Lake DeMontreville/Olson Association.

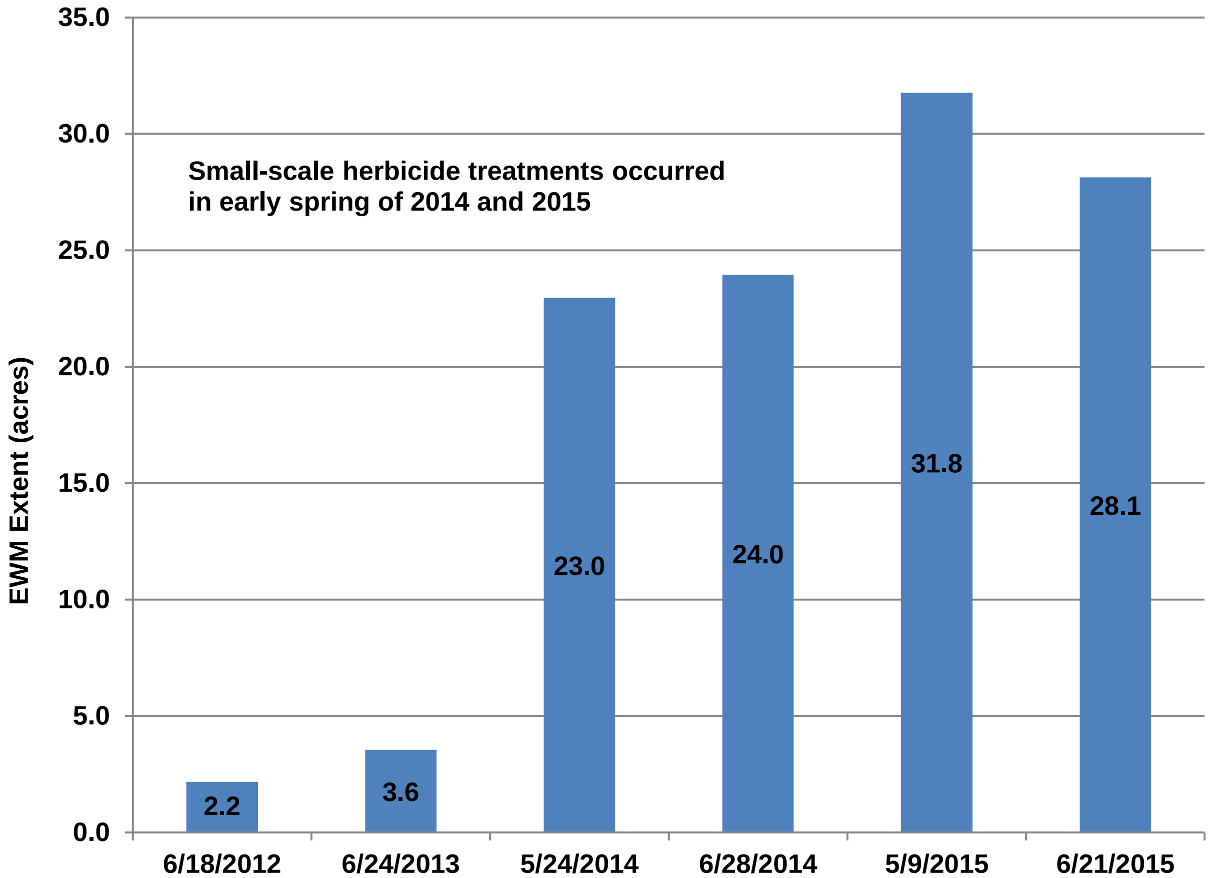


Figure 21 2012–2015 Lake Olson Eurasian Watermilfoil Extent

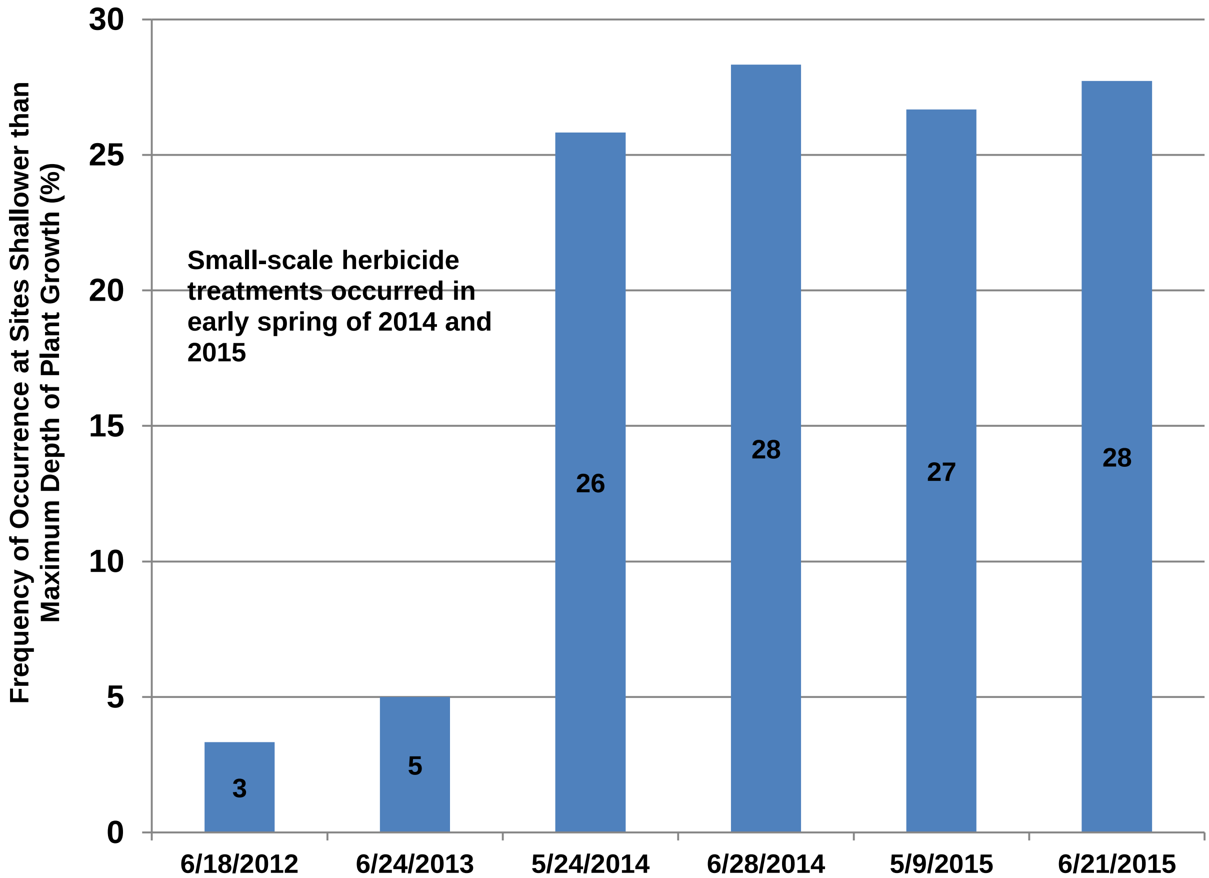


Figure 22 2012–2015 Lake Olson Eurasian Watermilfoil Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth

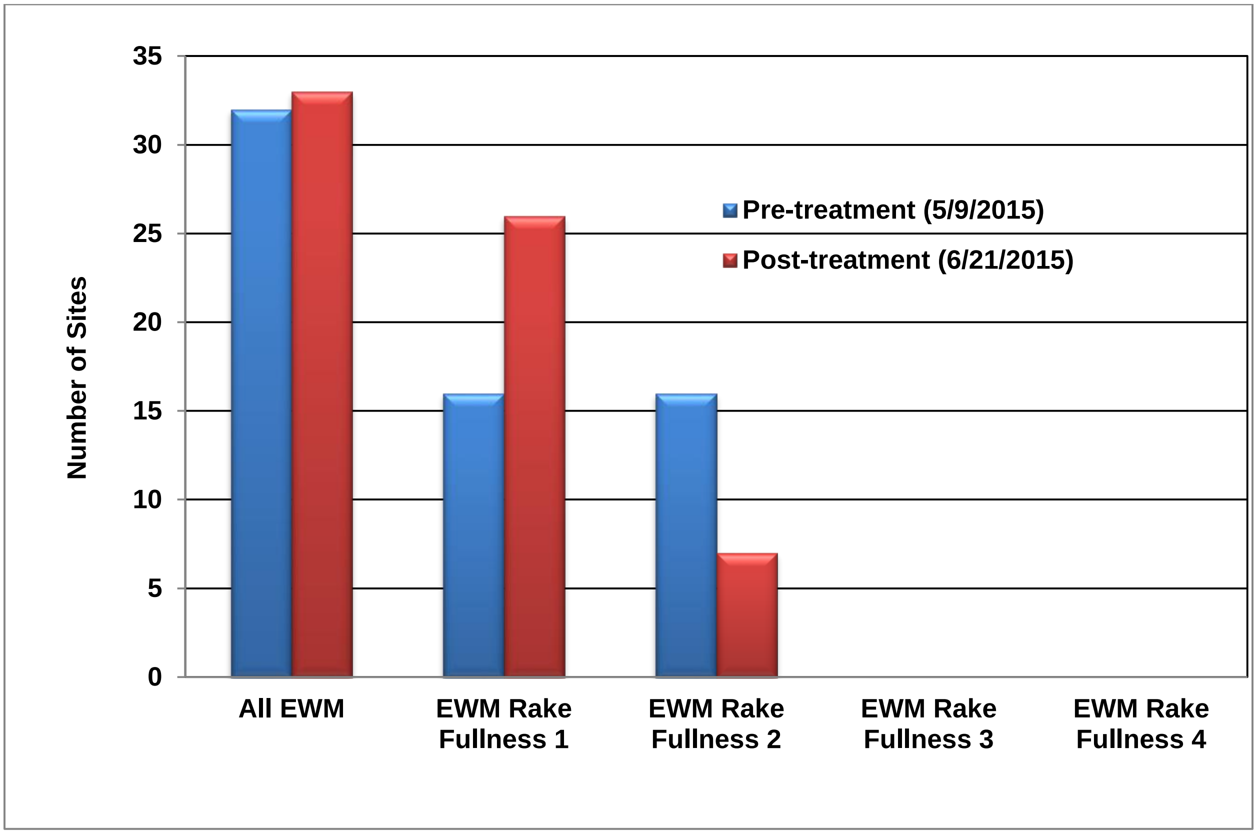
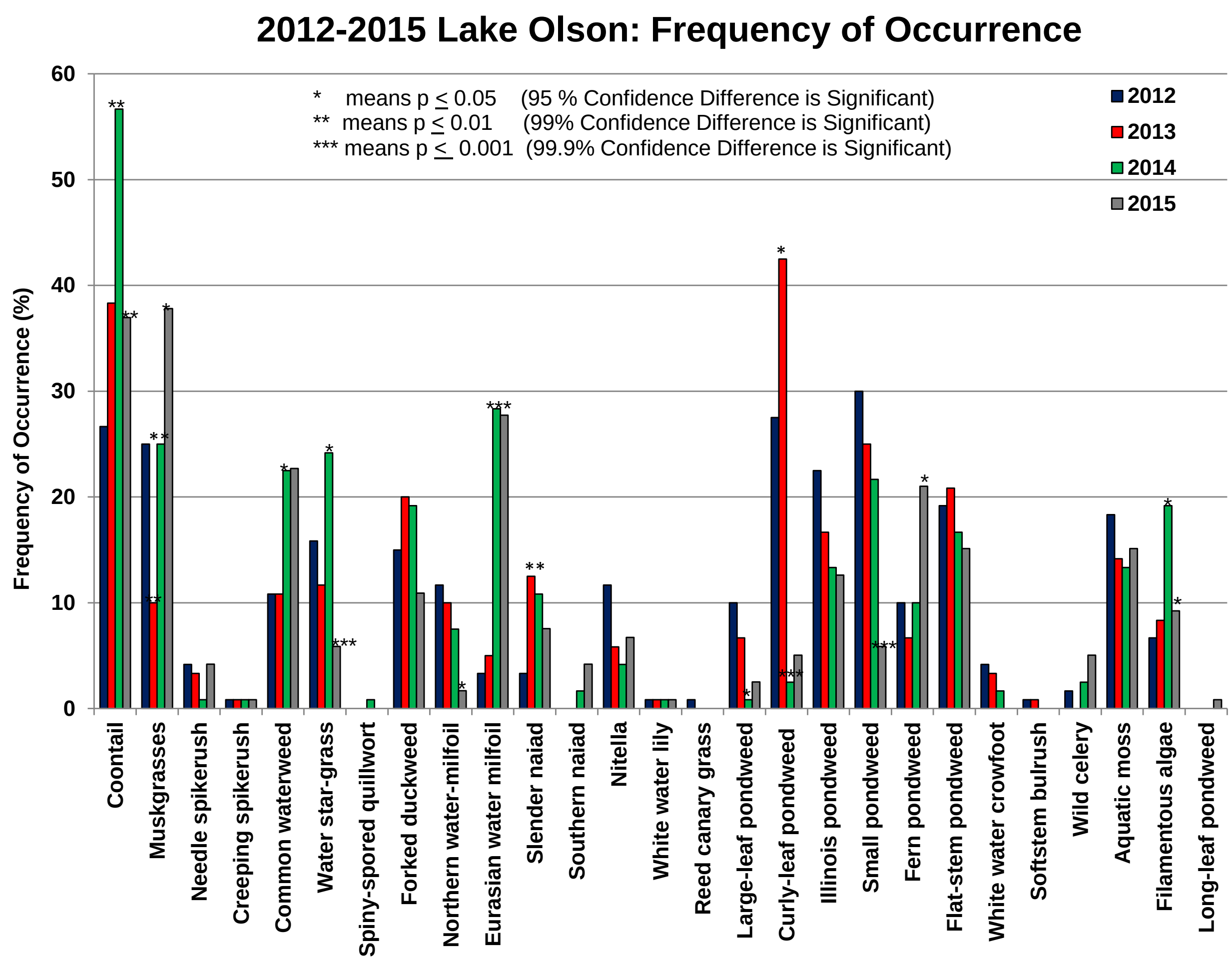


Figure 23 Lake Olson: 2015 Pre- and Post-Treatment Rake Fullness



Note: * indicates a significant change in frequency of occurrence between years

Figure 24 2012–2015 Lake Olson Frequency of Occurrence in Plant Growth Area of the Lake

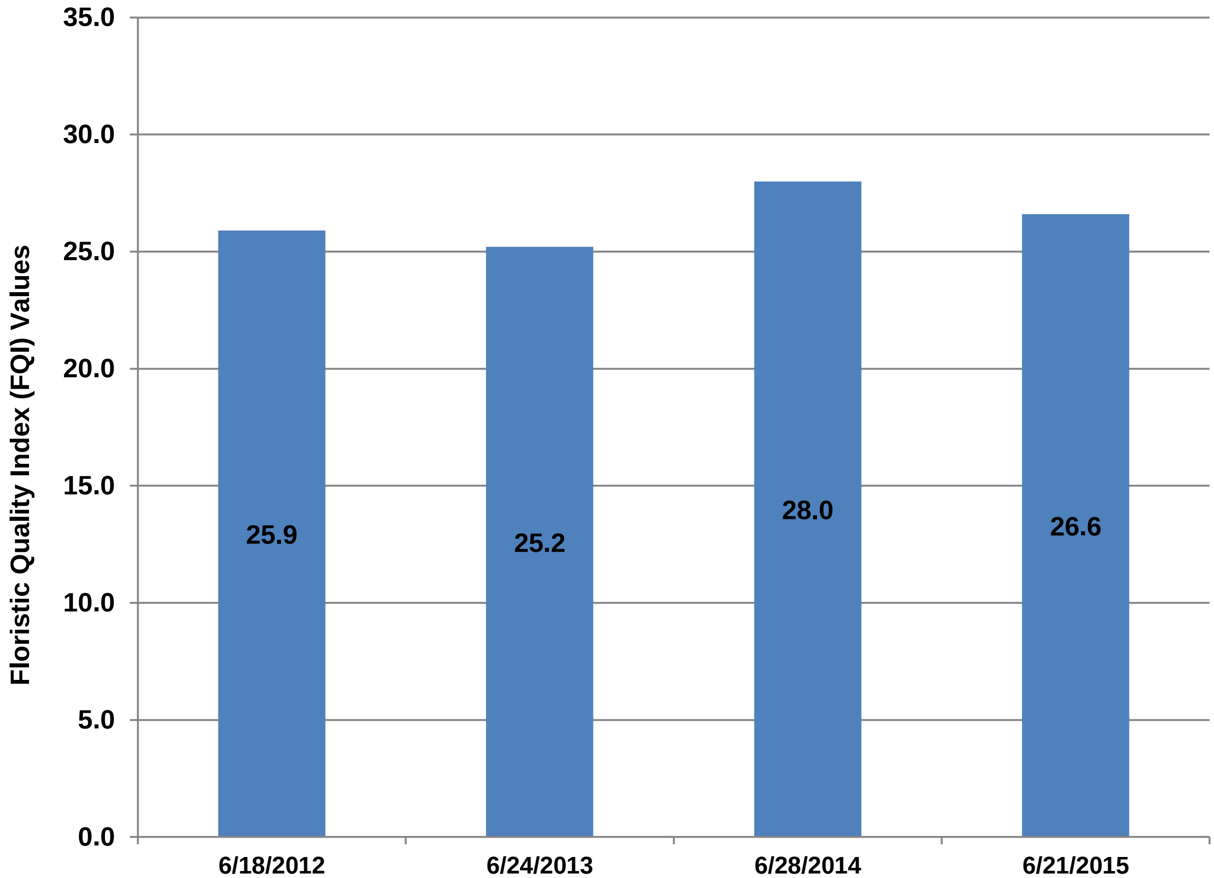


Figure 25 2012–2015 Lake Olson Floristic Quality Index (FQI) Values

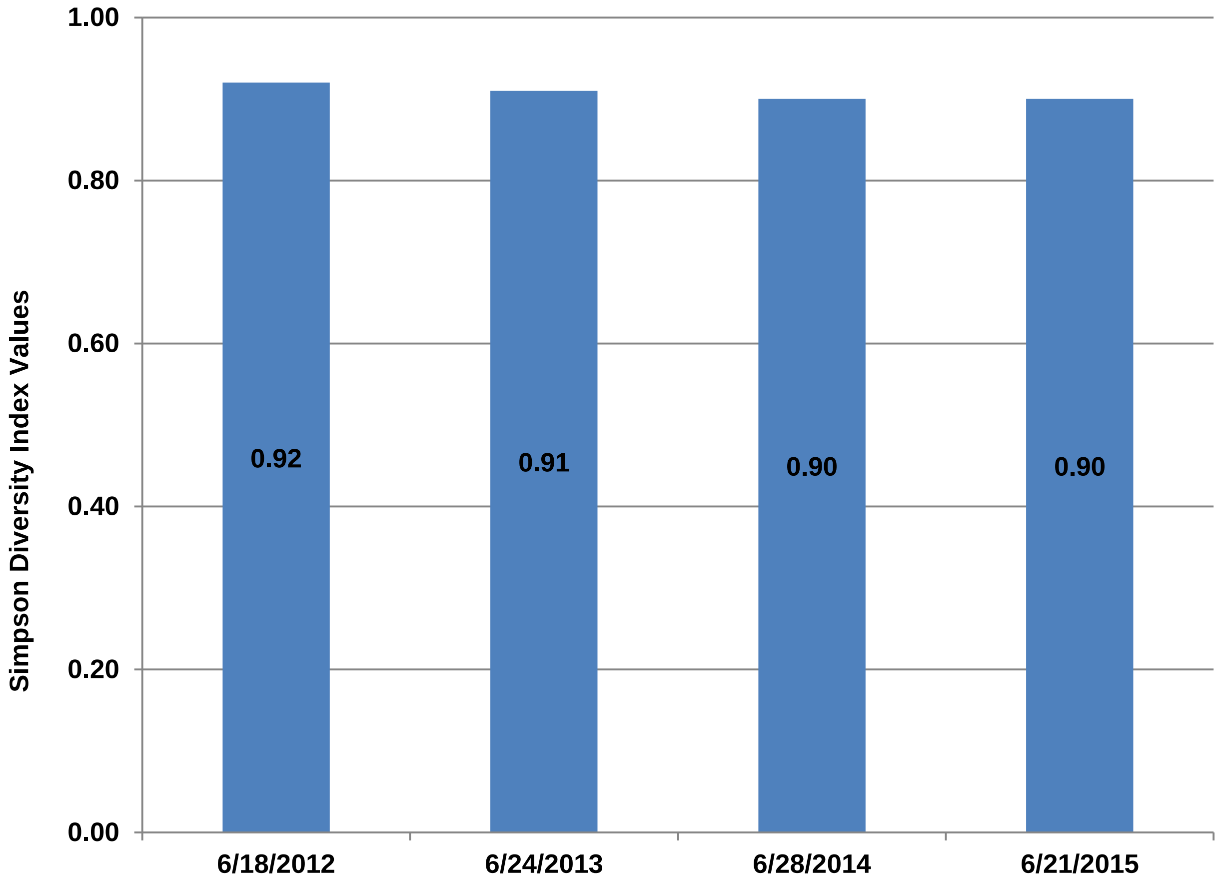


Figure 26 2012–2015 Lake Olson Simpson Diversity Index Values

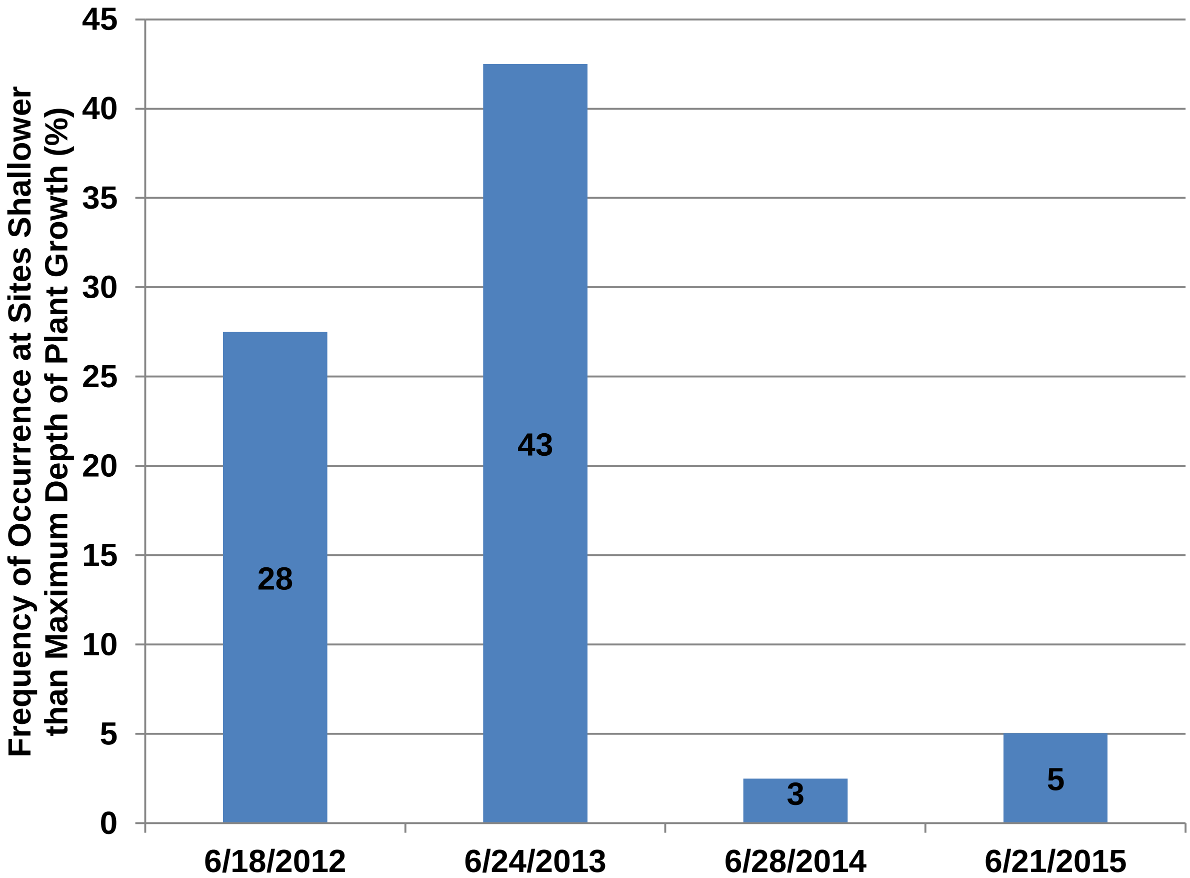
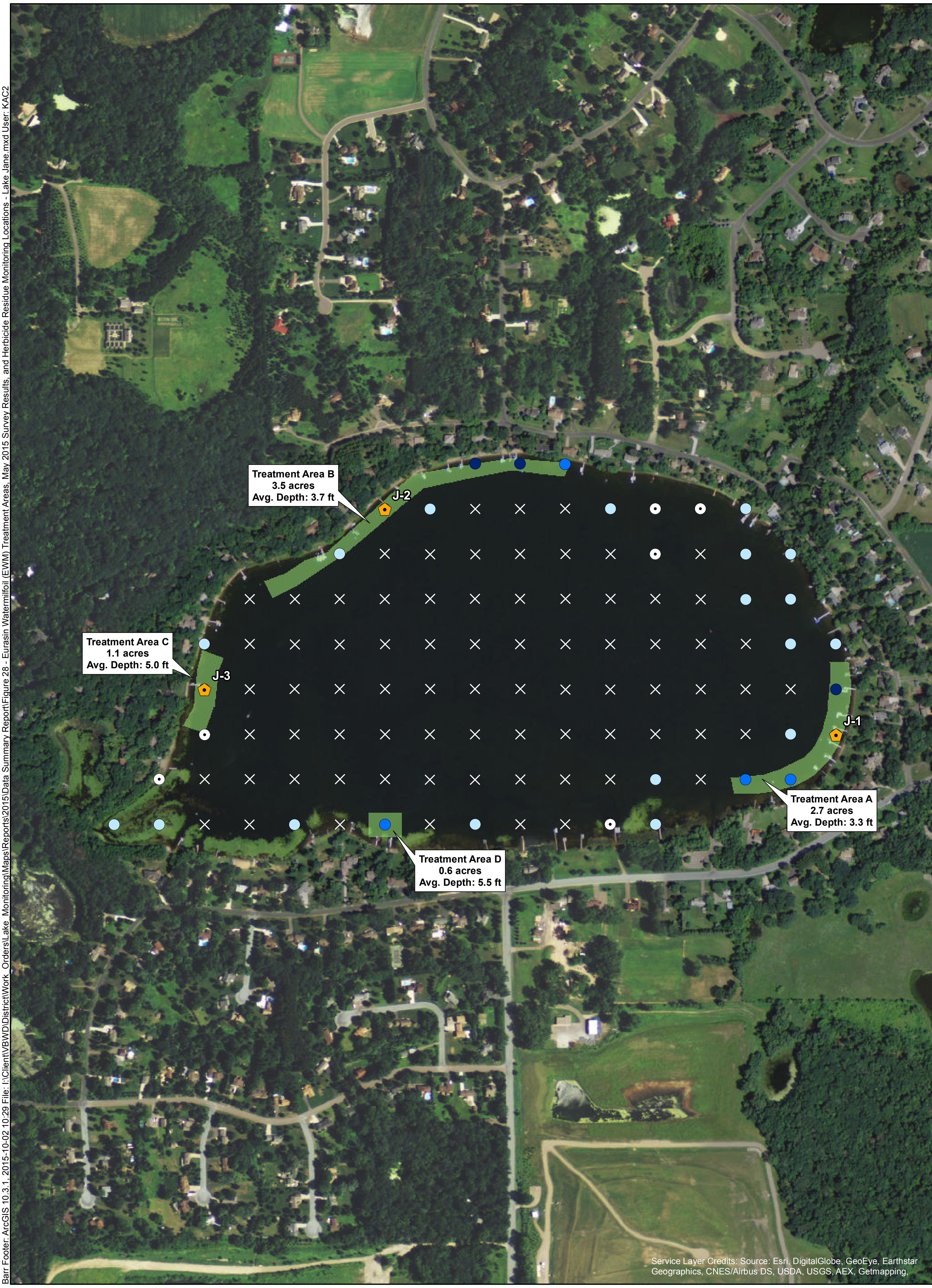


Figure 27 **2012–2015 Lake Olson Curly-leaf Pondweed Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth**



EWM Survey Results
- Not Observed
- Visual Only
- Density = 1
- Density = 2
- Density = 3

Treatment Area

Herbicide Residue Monitoring Location

N

Feet
0 250 500 1,000

Figure 28

EURASIAN WATERMILFOIL TREATMENT AREAS, MAY 2015 PLANT SURVEY RESULTS AND HERBICIDE RESIDUE MONITORING LOCATIONS
Lake Jane (82010400)
Washington County
Valley Branch Watershed District

Prepared by Margaret Rattei and Kelly Wild, Barr Engineering, for Valley Branch Watershed District based on results of a survey done by Matt Berg on May 9, 2015.
The Valley Branch Watershed District prepared this map to assist the Lake Jane Association.

Barr Footer: ArcGIS 10.3.1, 2015-10-02 10:29 File: I:\Client\VBWD\District\Work_Orders\Lake_Monitoring\Maps\Reports\2015\Data Summary Report\Figure 28 - Eurasin Watermilfoil (EWM) Treatment Areas, May 2015 Survey Results, and Herbicide Residue Monitoring Locations - Lake Jane.mxd User: KAC2

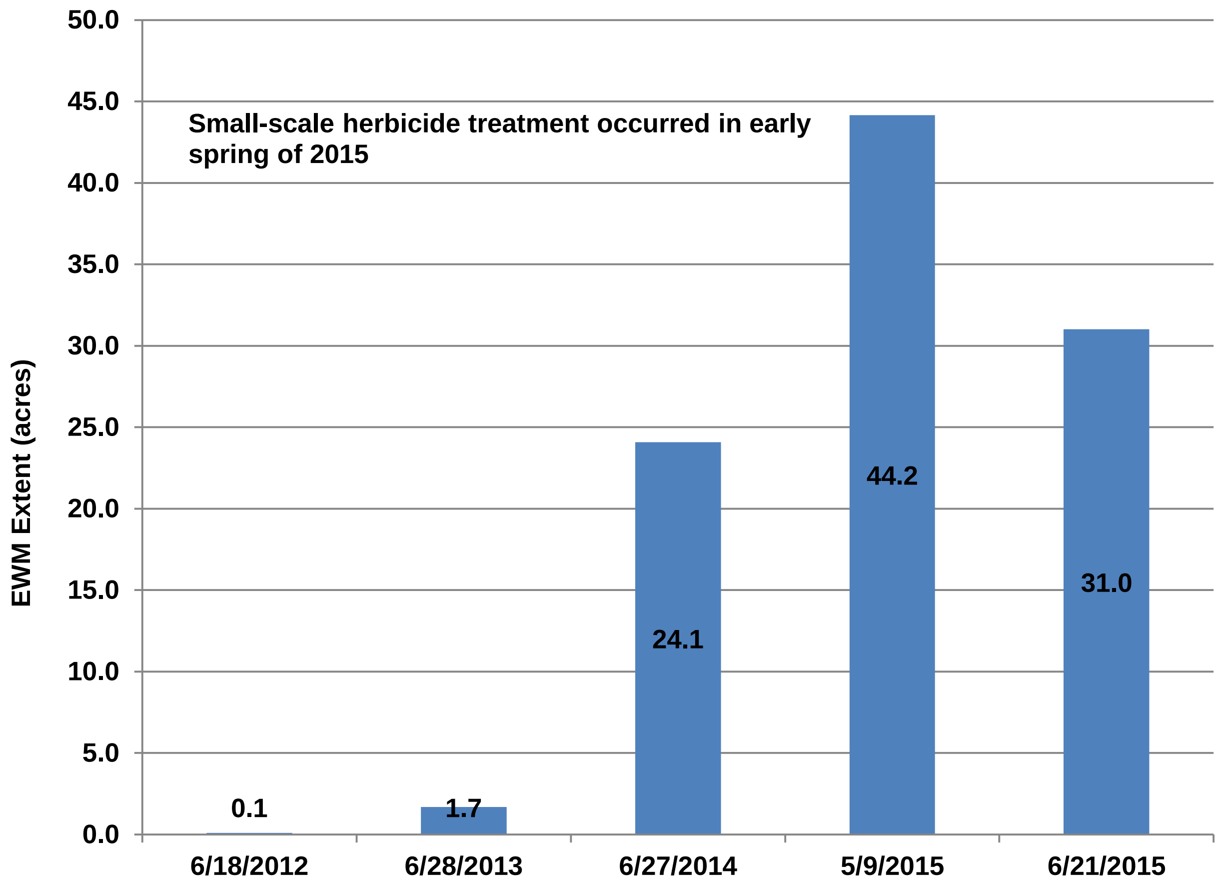


Figure 29 2012–2015 Lake Jane Eurasian Watermilfoil Extent

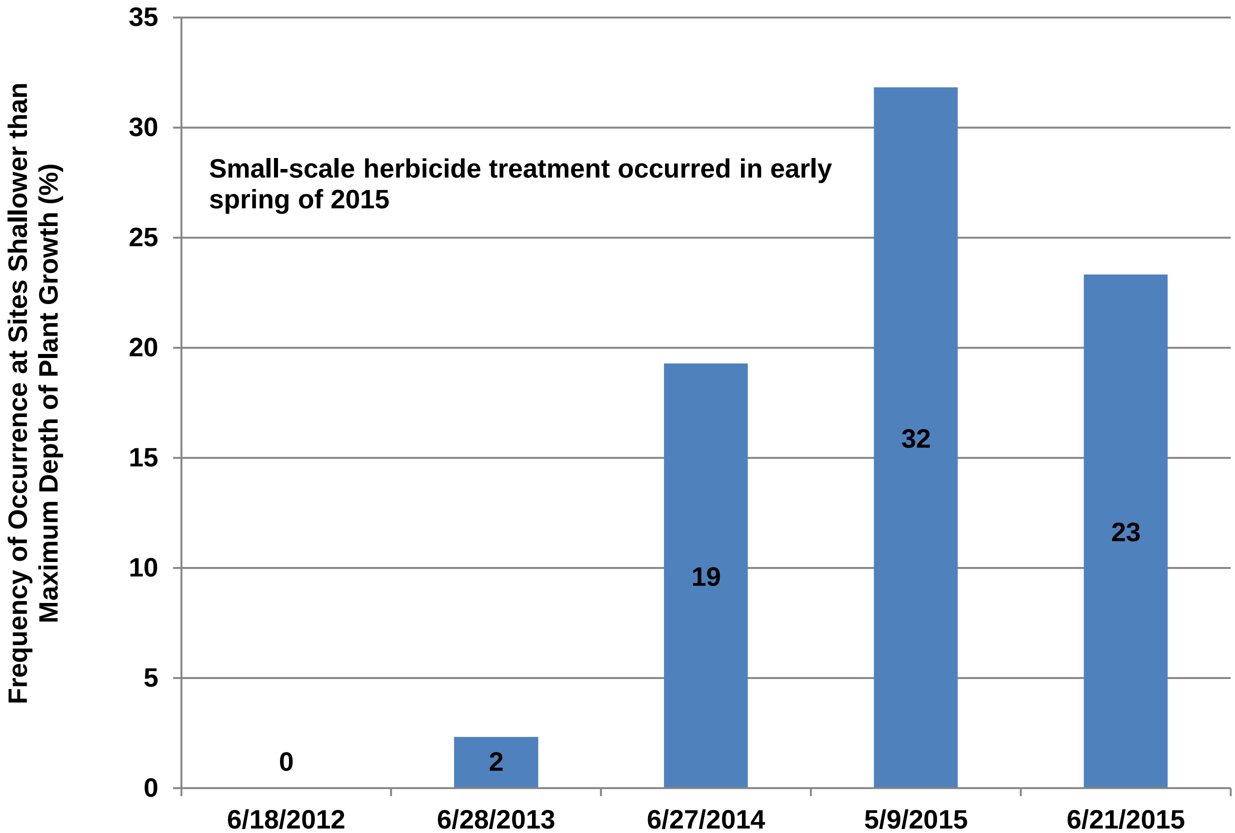


Figure 30 2012–2015 Lake Jane Eurasian Watermilfoil Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth

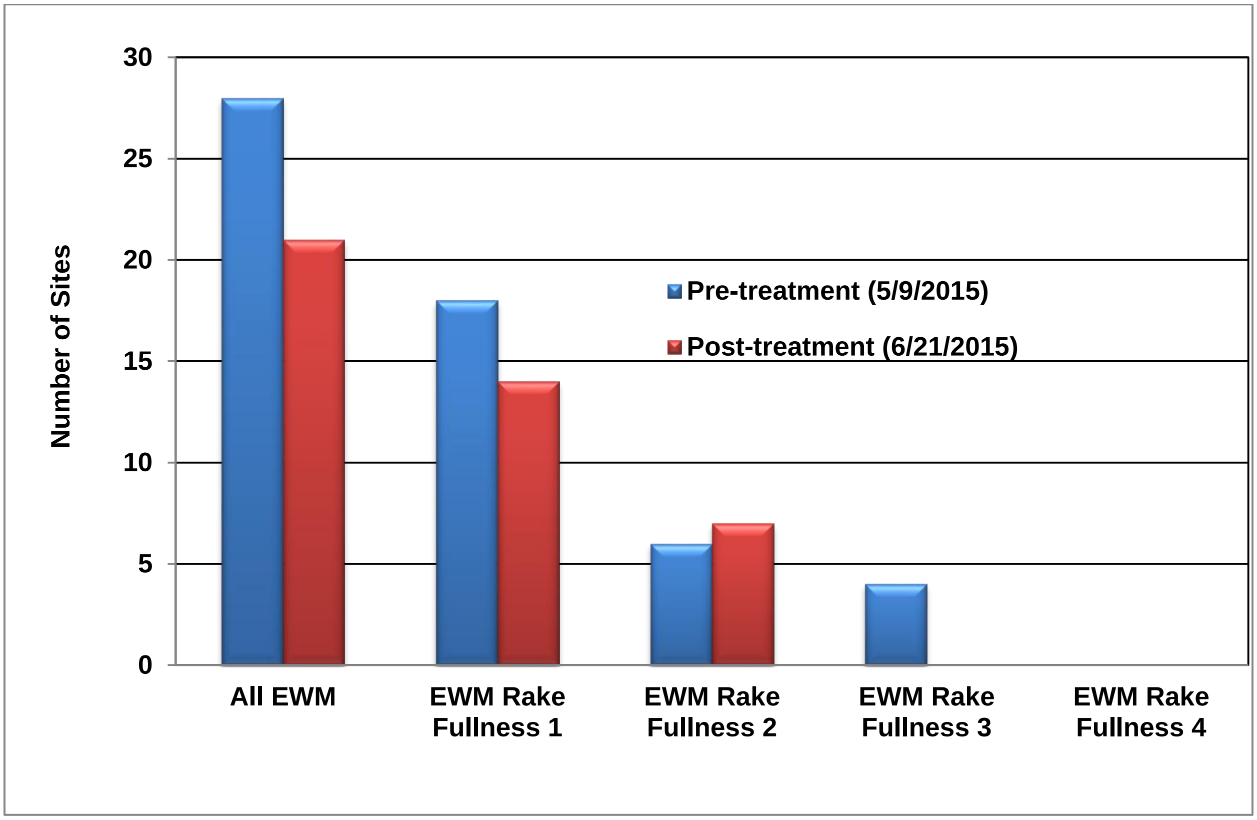
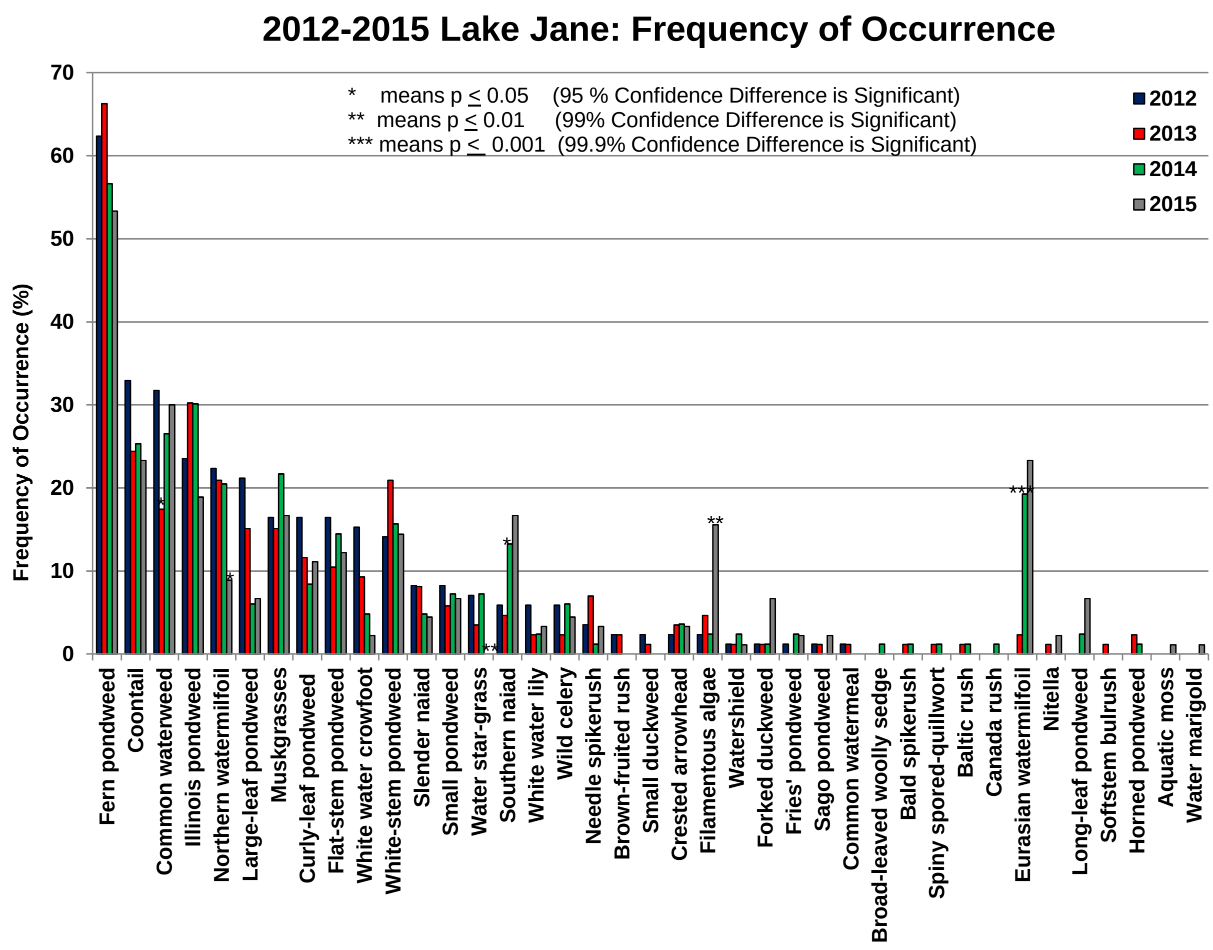


Figure 31 Lake Jane: 2015 Pre- and Post-Treatment Rake Fullness



Note: * indicates a significant change in frequency of occurrence between years

Figure 32 2012–2015 Lake Jane Frequency of Occurrence in Plant Growth Area of the Lake

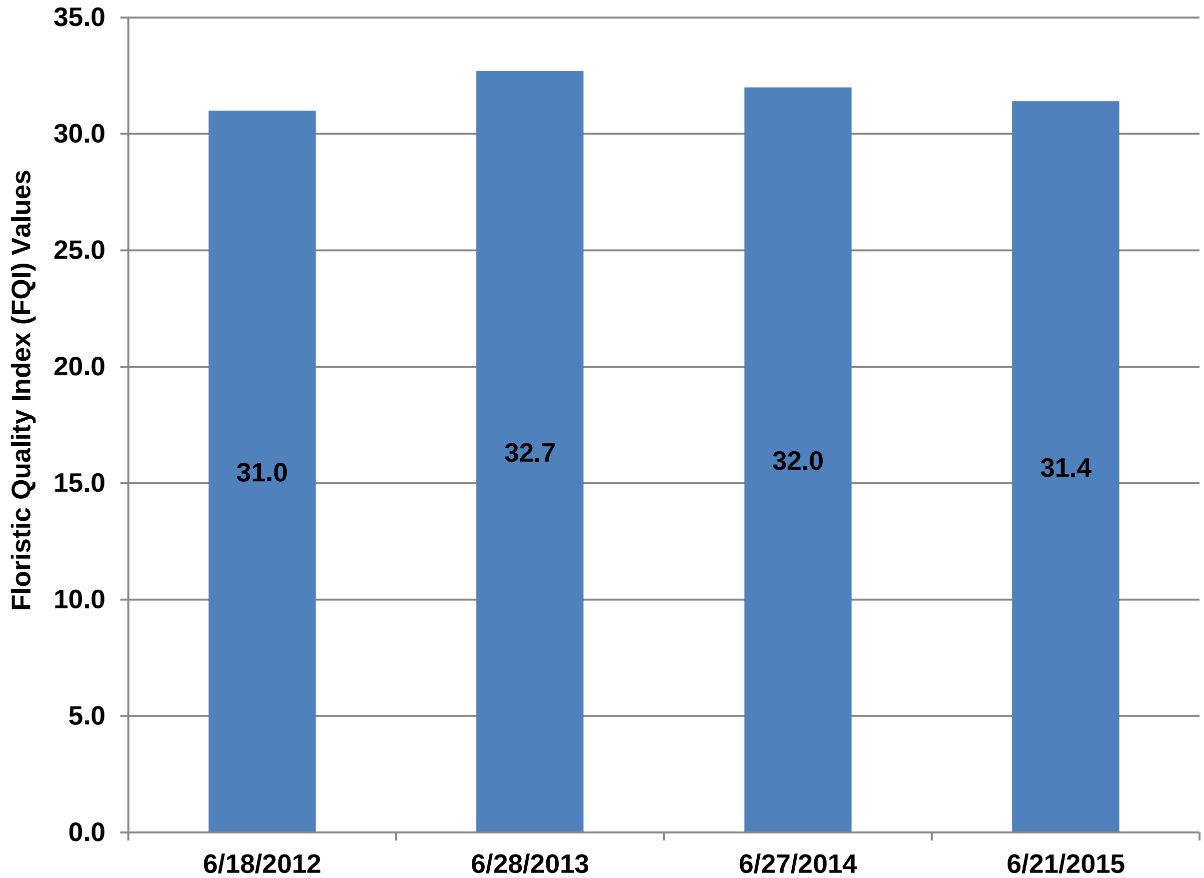


Figure 33 2012–2015 Lake Jane Floristic Quality Index (FQI) Values

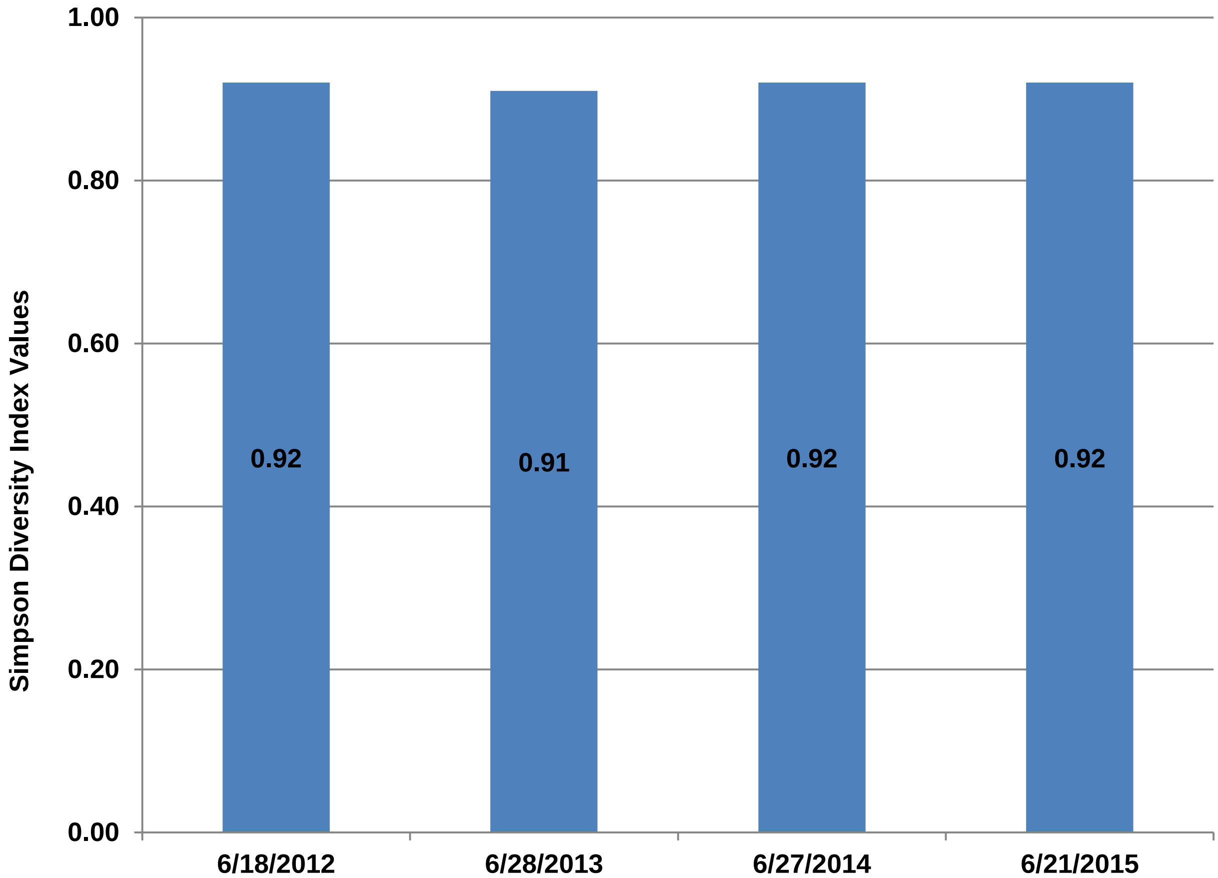


Figure 34 2012–2015 Lake Jane Simpson Diversity Index Values

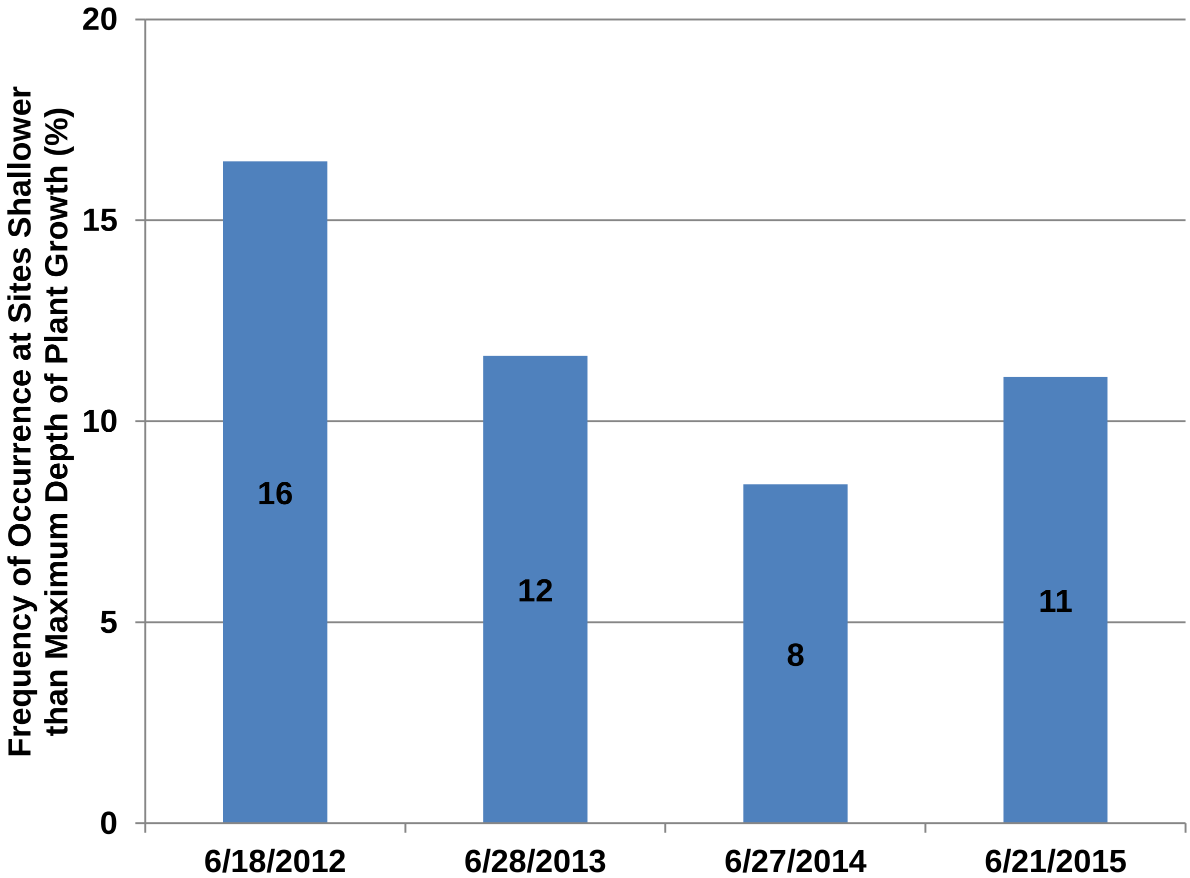


Figure 35 **2012–2015 Lake Jane Curly-leaf Pondweed Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth**

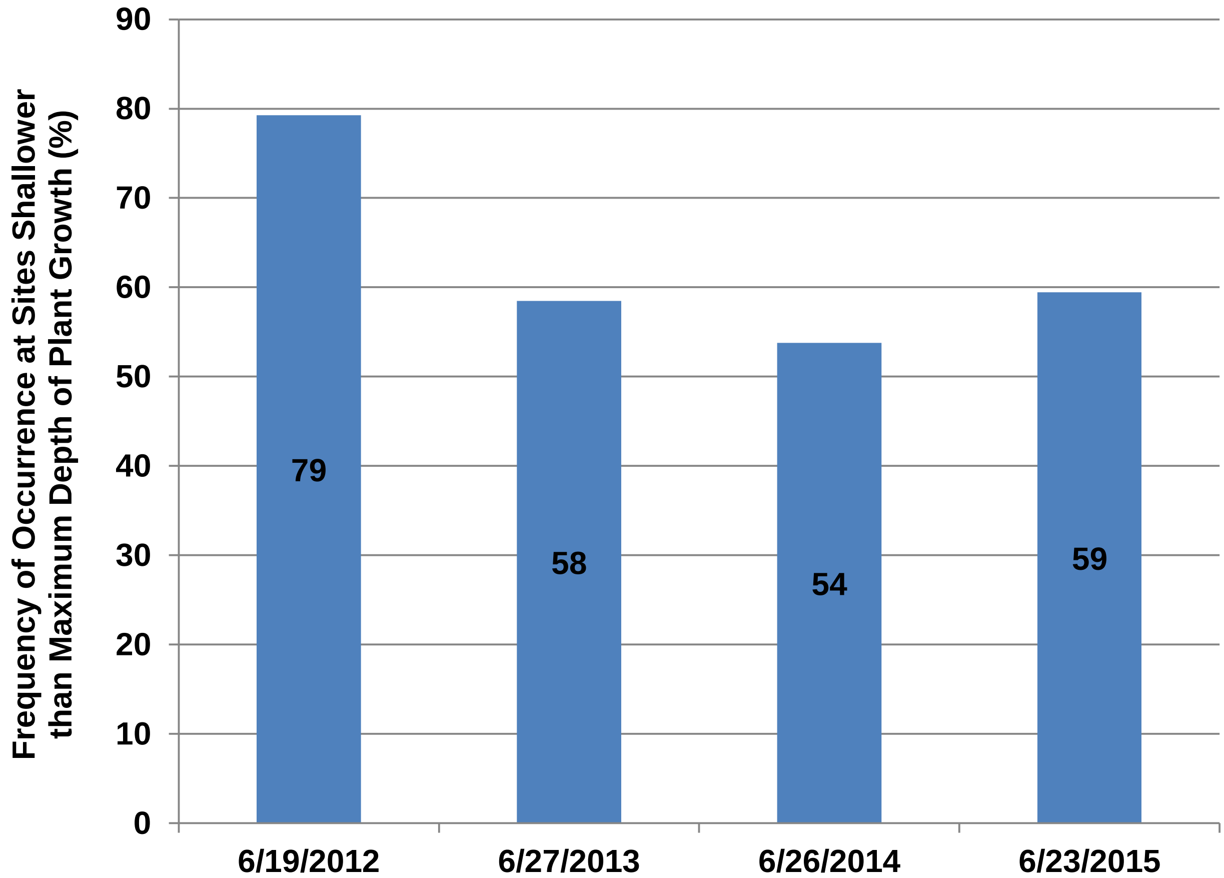
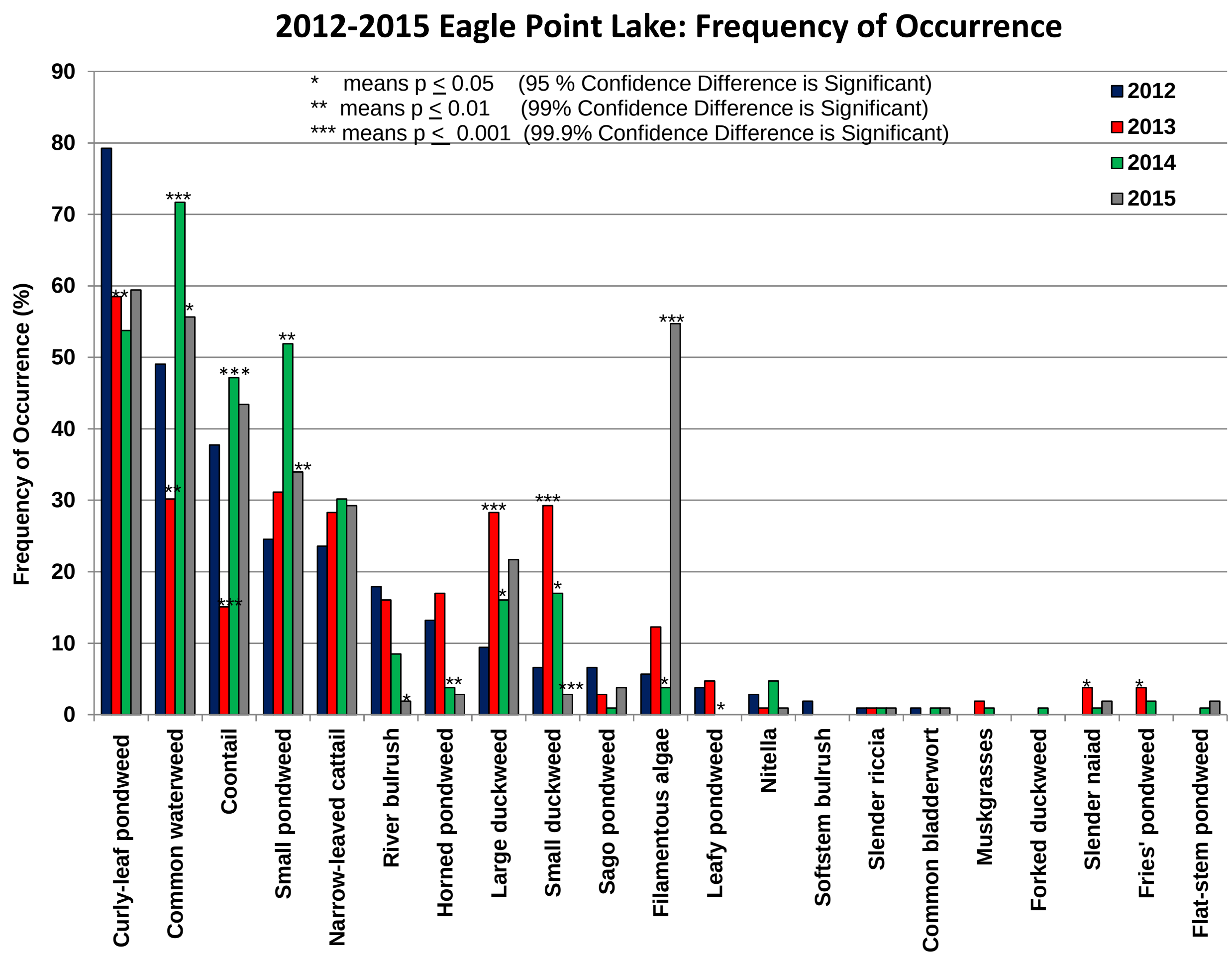


Figure 36 2012–2015 Eagle Point Lake Curly-leaf Pondweed Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth



Note: * indicates a significant change in frequency of occurrence between years

Figure 37 2012–2015 Eagle Point Lake Frequency of Occurrence in Plant Growth Area of the Lake

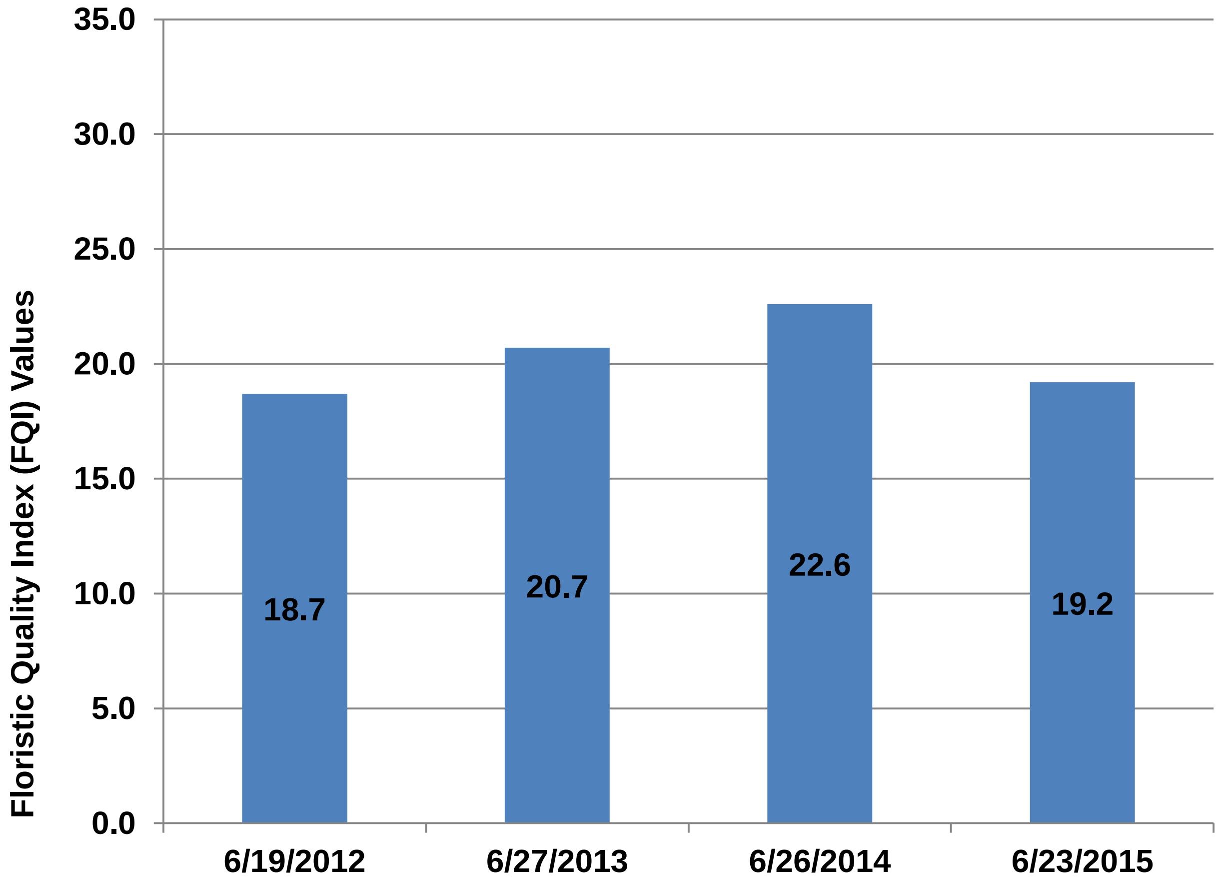


Figure 38 2012–2015 Eagle Point Lake Floristic Quality Index (FQI) Values

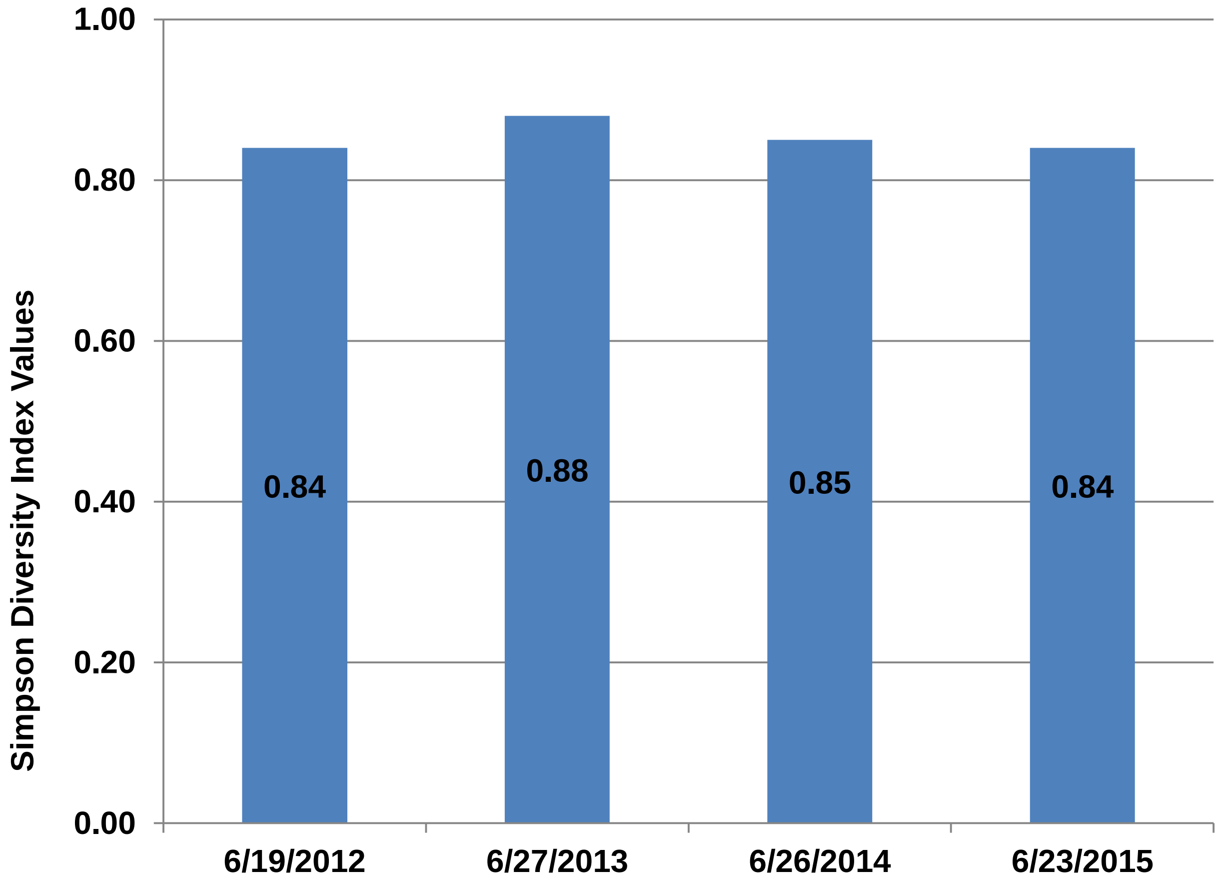
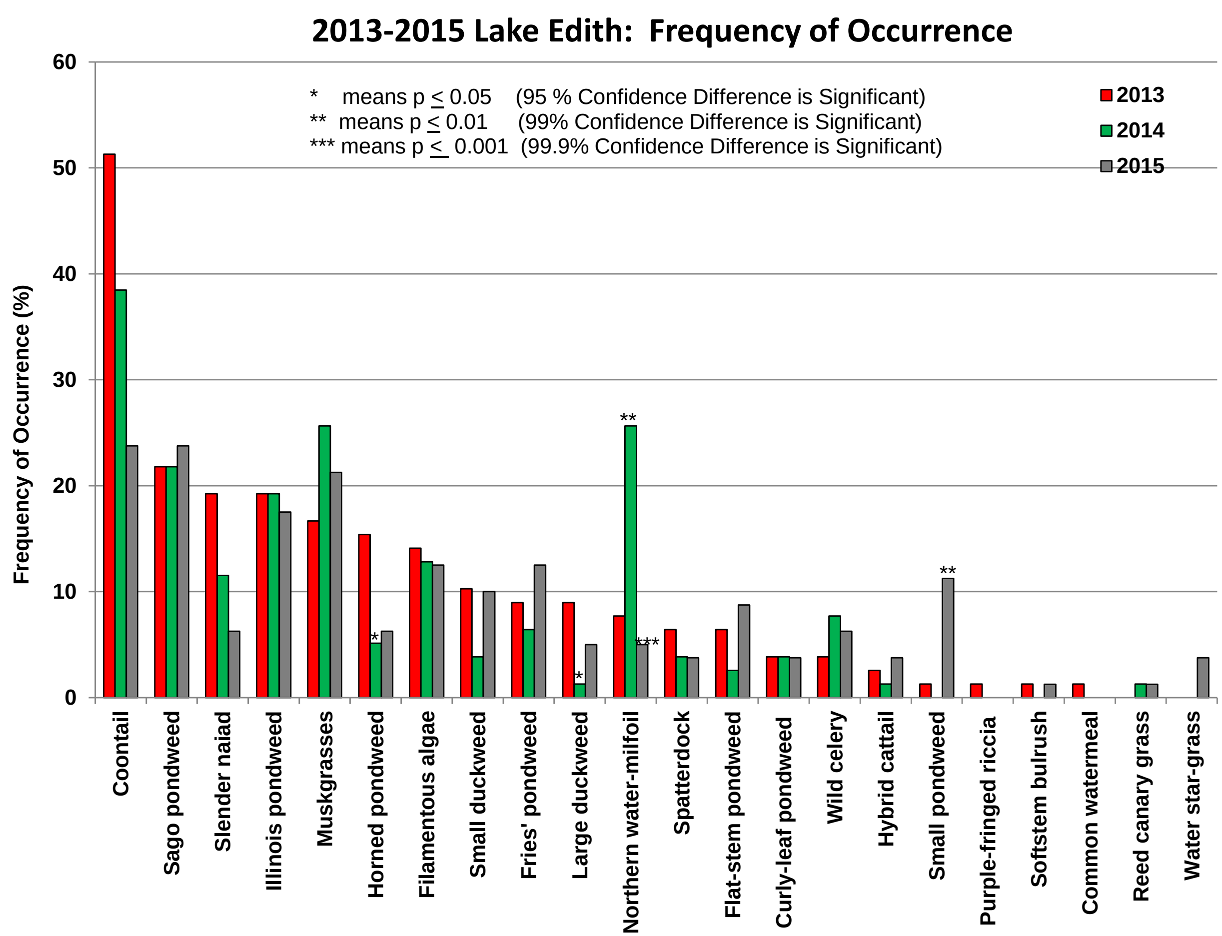


Figure 39 2012–2015 Eagle Point Lake Simpson Diversity Index Values



Note: * indicates a significant change in frequency of occurrence between years

Figure 40 2013–2015 Lake Edith Frequency of Occurrence in Plant Growth Area of the Lake

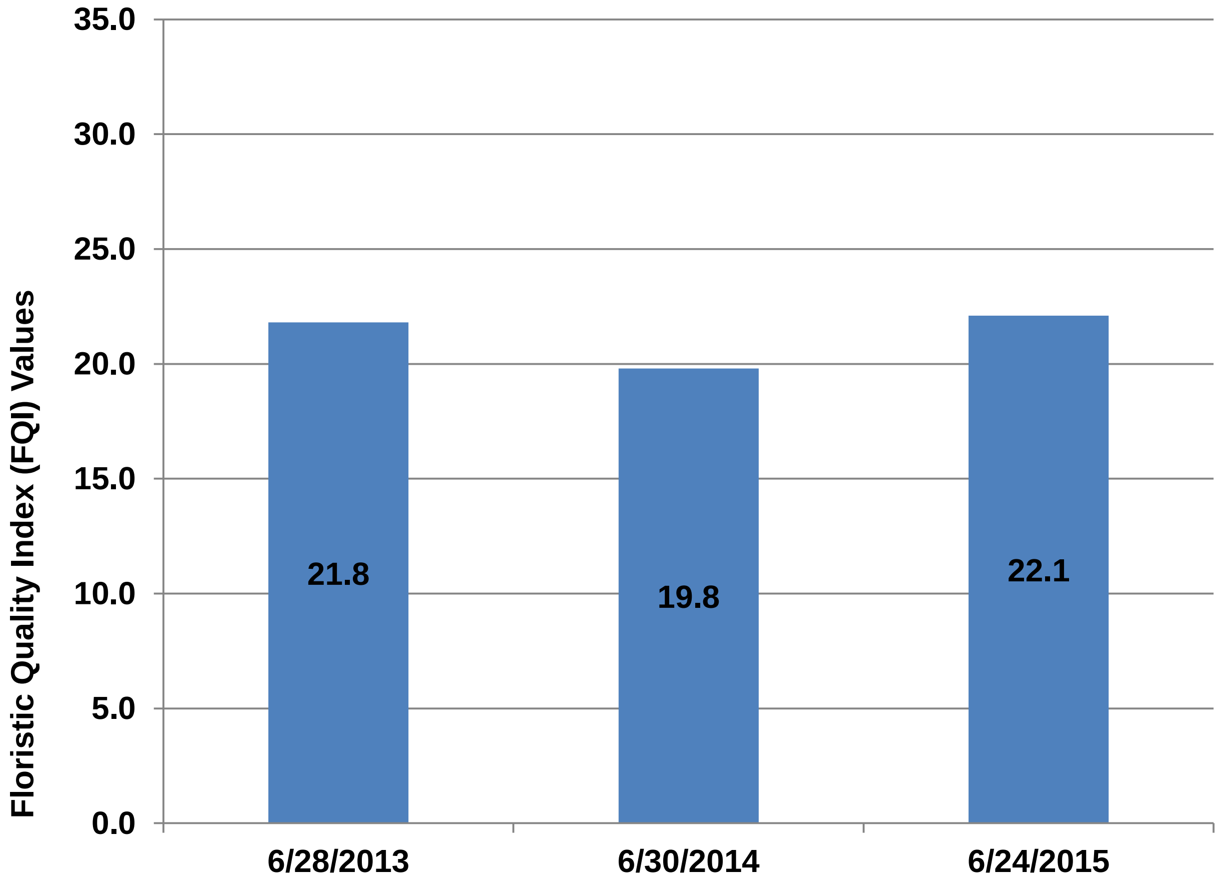


Figure 41 2013–2015 Lake Edith Floristic Quality Index (FQI) Values

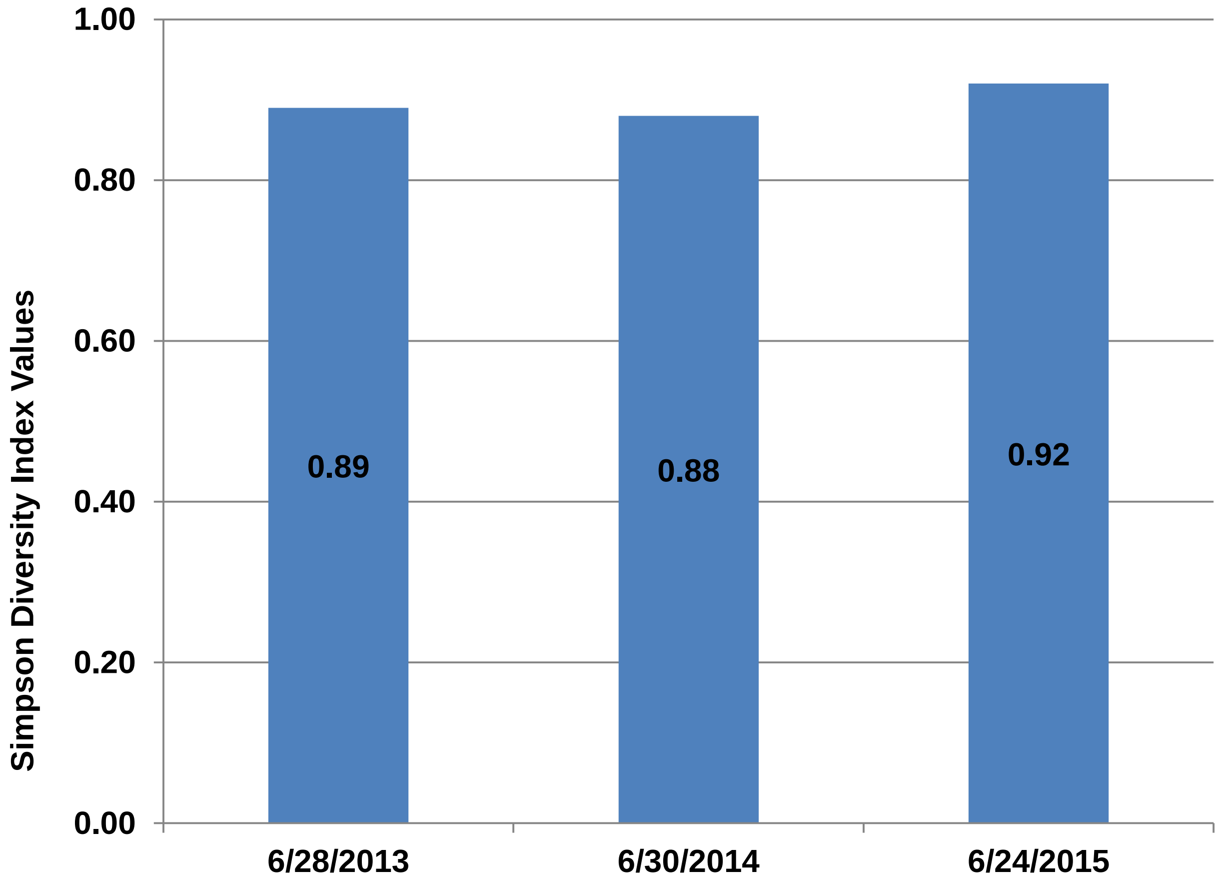


Figure 42 2013–2015 Lake Edith Simpson Diversity Index Values

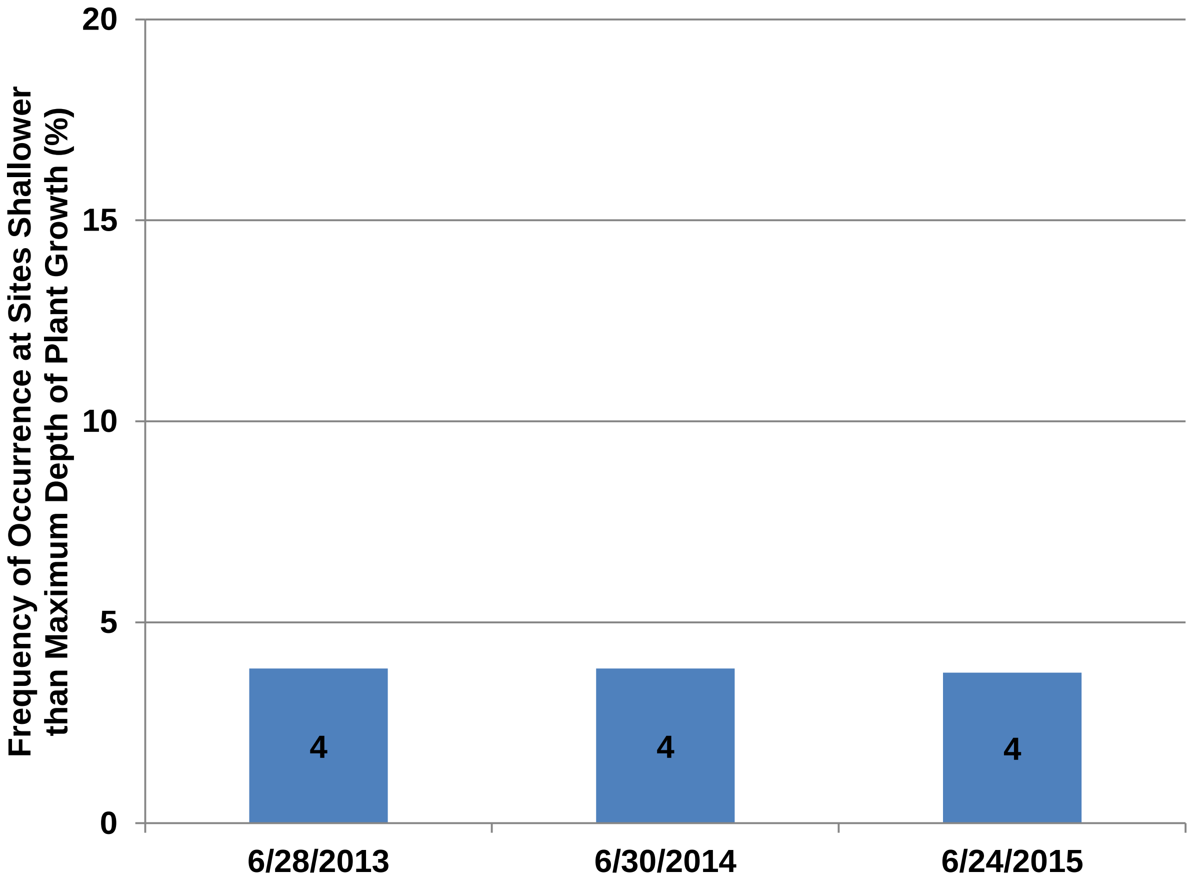


Figure 43 **2013–2015 Lake Edith Curly-leaf Pondweed Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth**

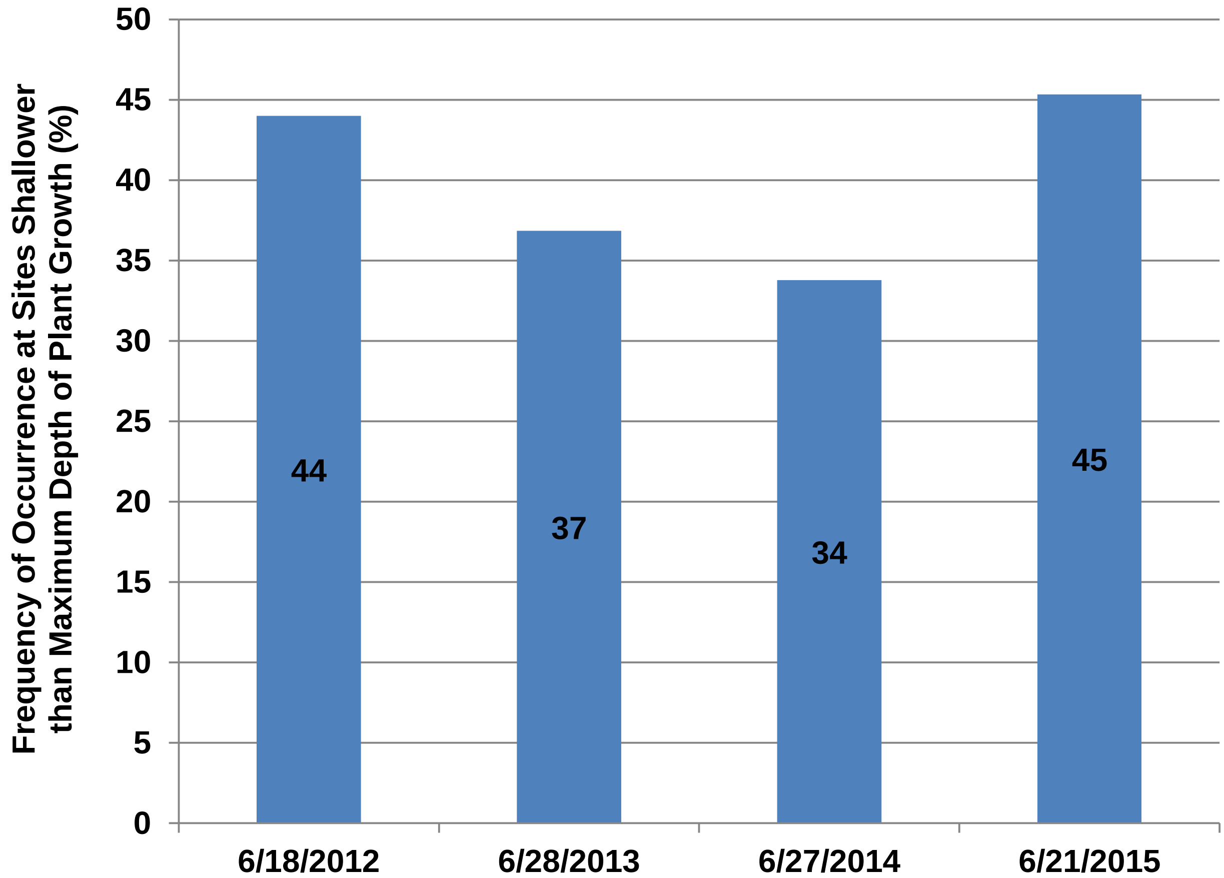
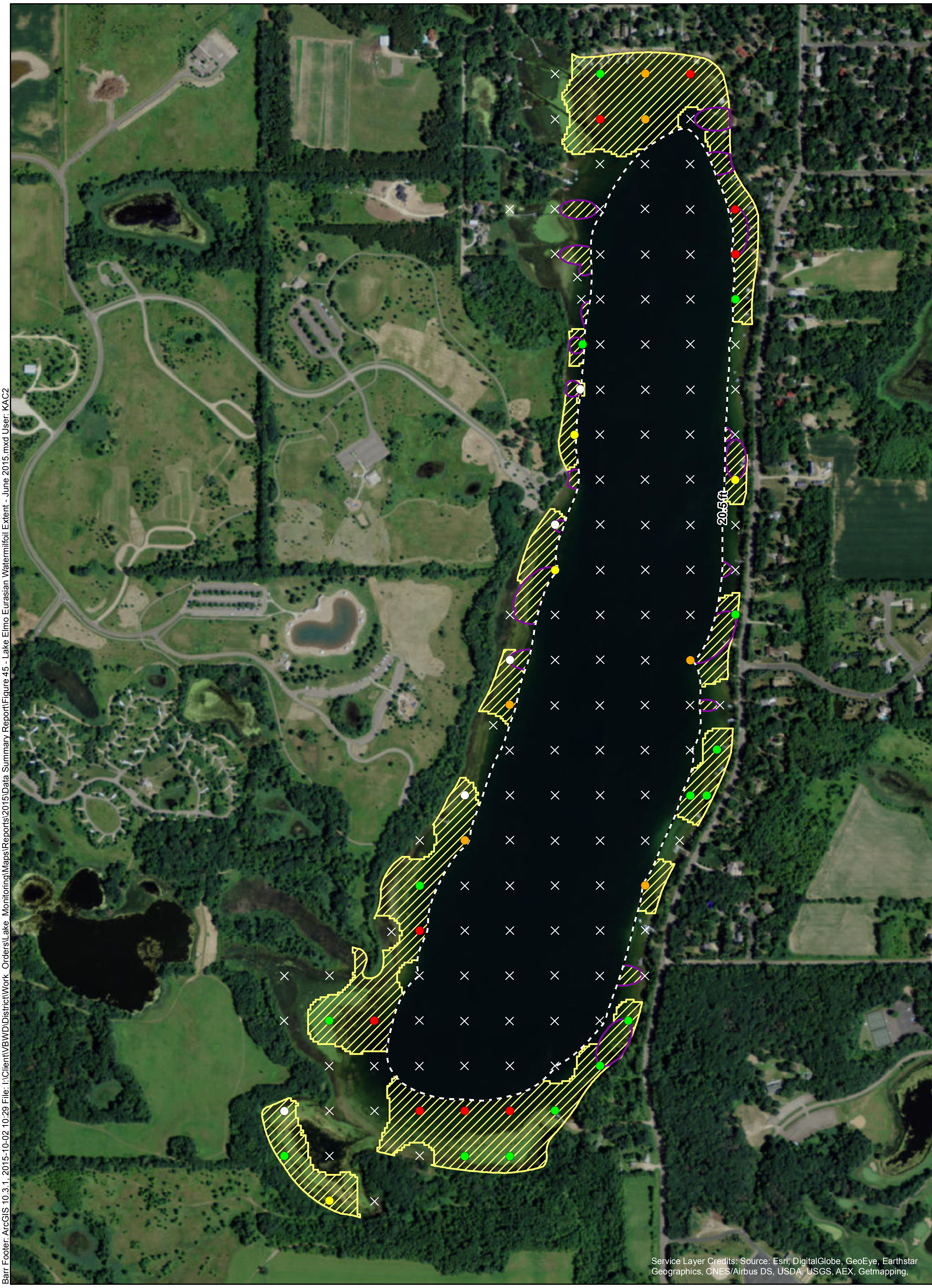


Figure 44 **2012–2015 Lake Elmo Eurasian Watermilfoil Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth**



EWM Sample Locations (June 2015)

- Not Observed
- Visual but not on rake
- Density = 1
- Density = 2
- Density = 3
- Density = 4
- Additional Canopied EWM Beds
- Maximum Depth of Plant Growth
- Approximate Extent of EWM

Feet

0 300 600 1,200

Figure 45

LAKE ELMO EURASIAN WATERMILFOIL EXTENT, JUNE 2015

Lake Elmo (82010600)

Washington County

Valley Branch Watershed District

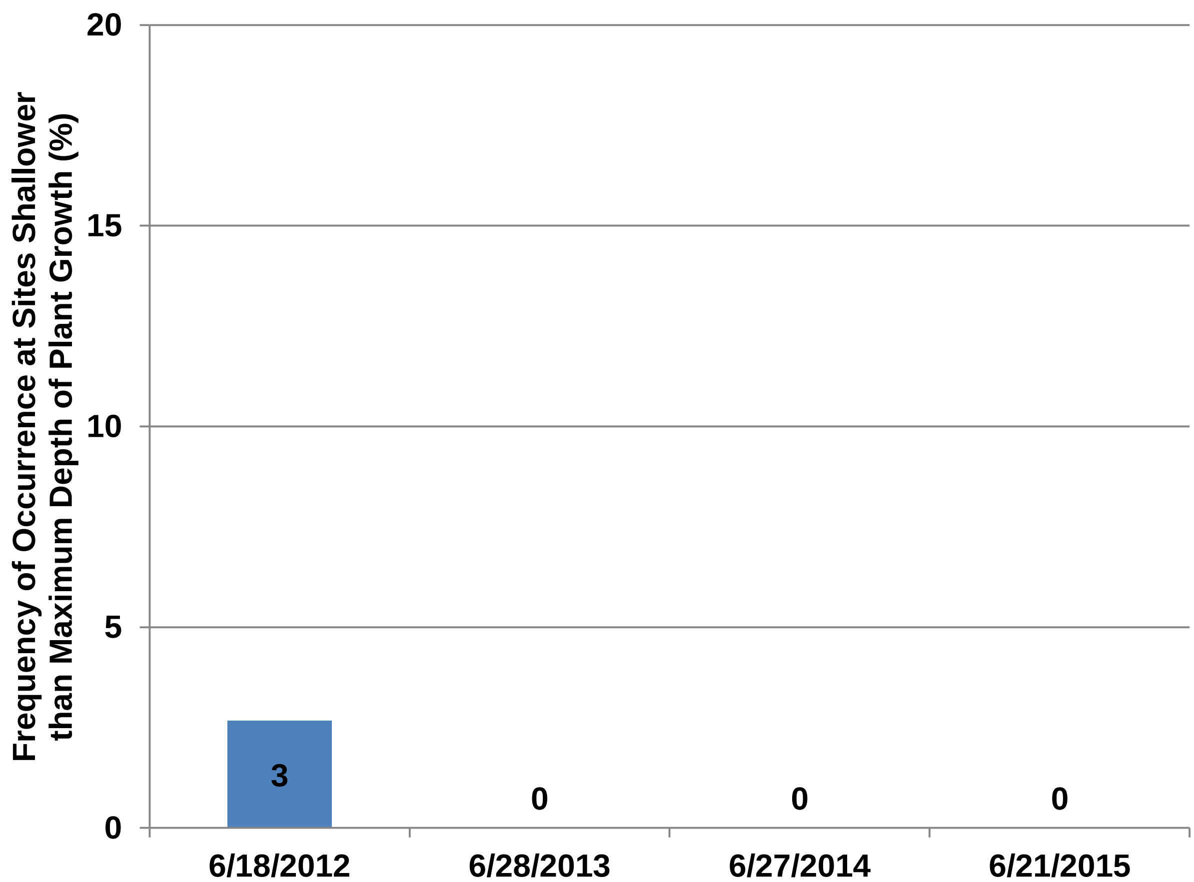
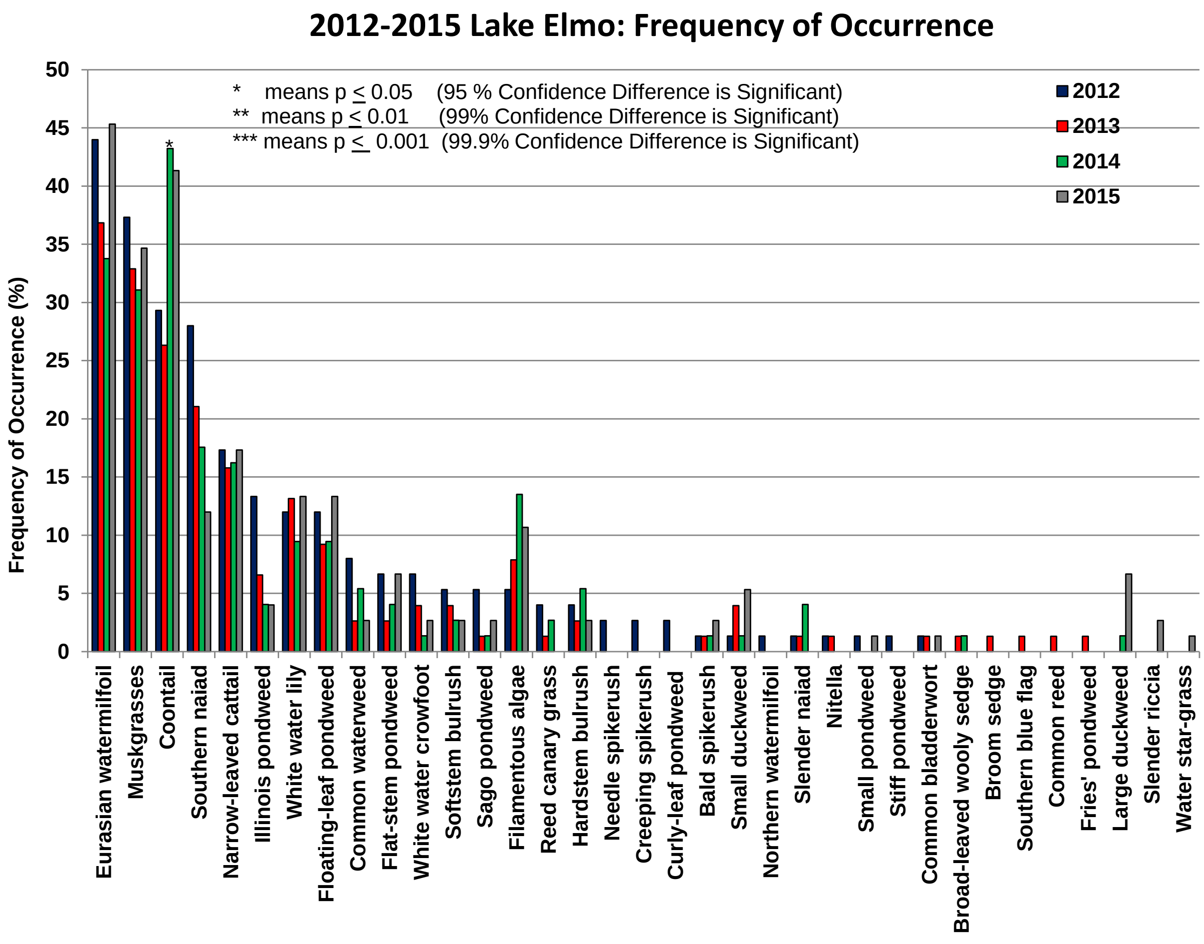


Figure 46 2013–2015 Lake Elmo Curly-leaf Pondweed Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth



Note: * indicates a significant change in frequency of occurrence between years

Figure 47 2012–2015 Lake Elmo Frequency of Occurrence in Plant Growth Area of the Lake

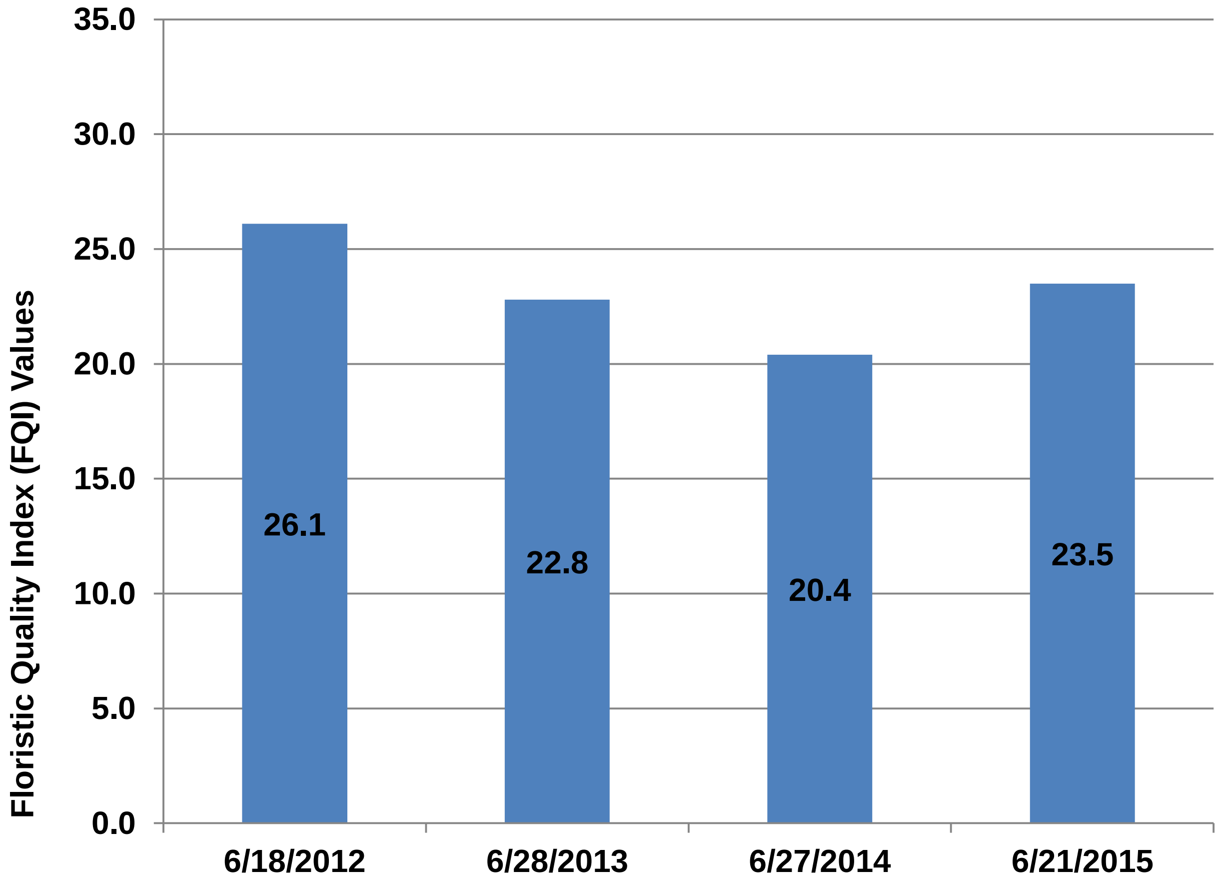


Figure 48 **2012–2015 Lake Elmo Floristic Quality Index (FQI) Values**

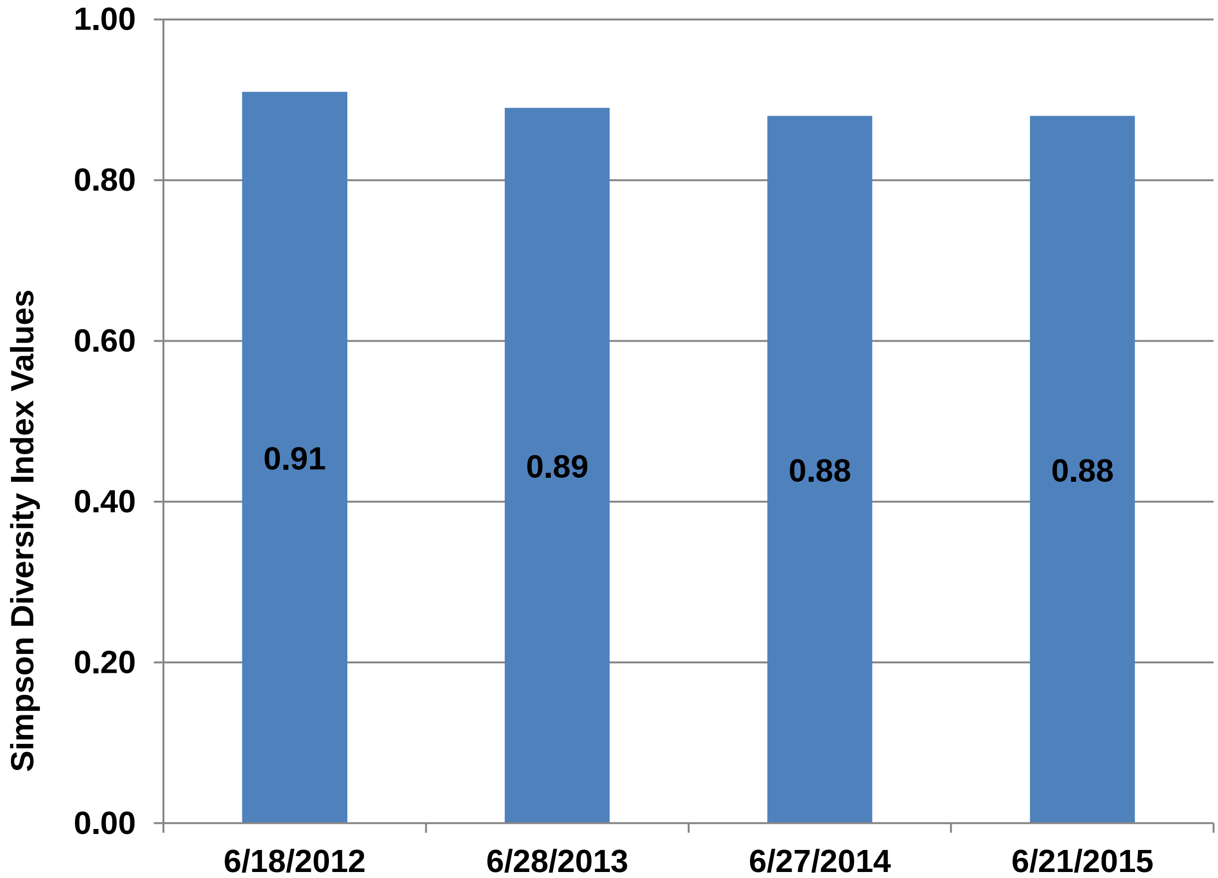


Figure 49 2012–2015 Lake Elmo Simpson Diversity Index Values

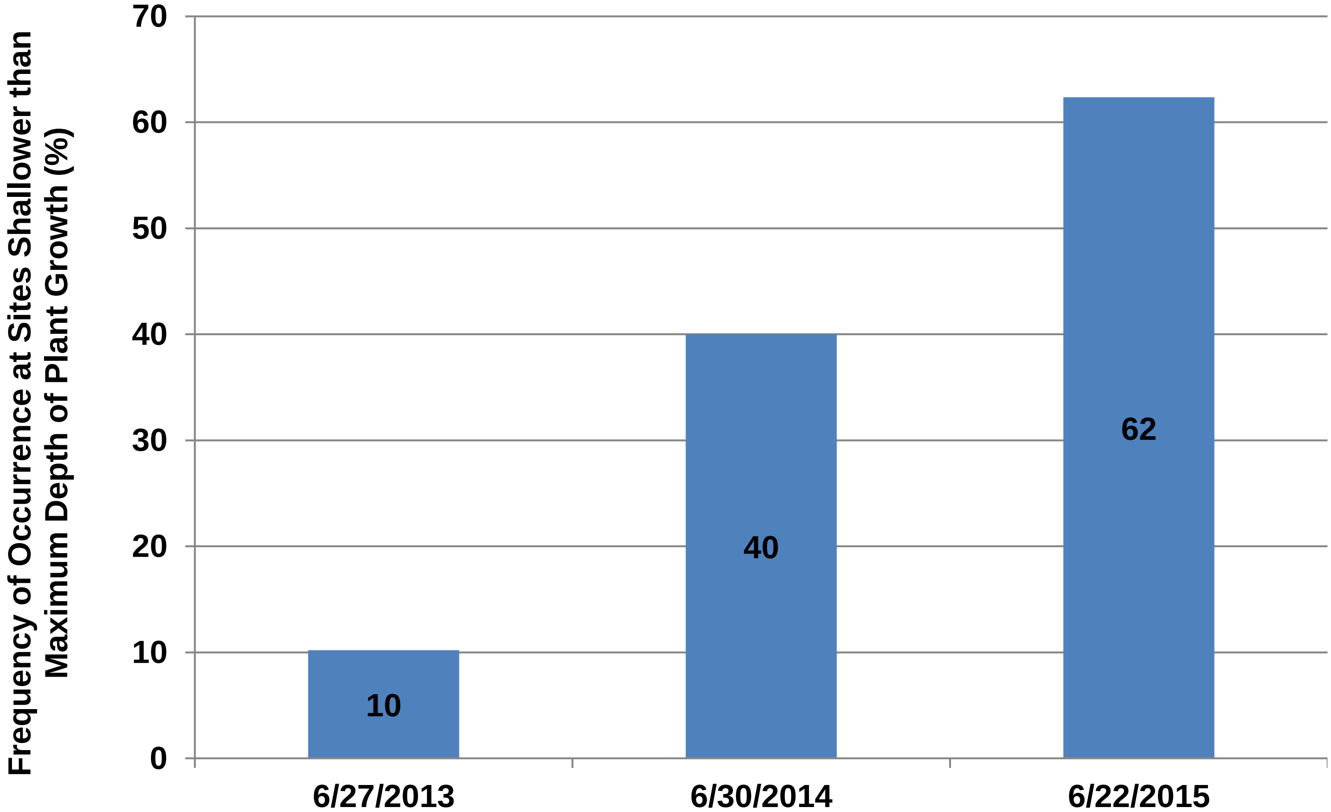


Figure 50 2013–2015 Horseshoe Lake Eurasian Watermilfoil Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth

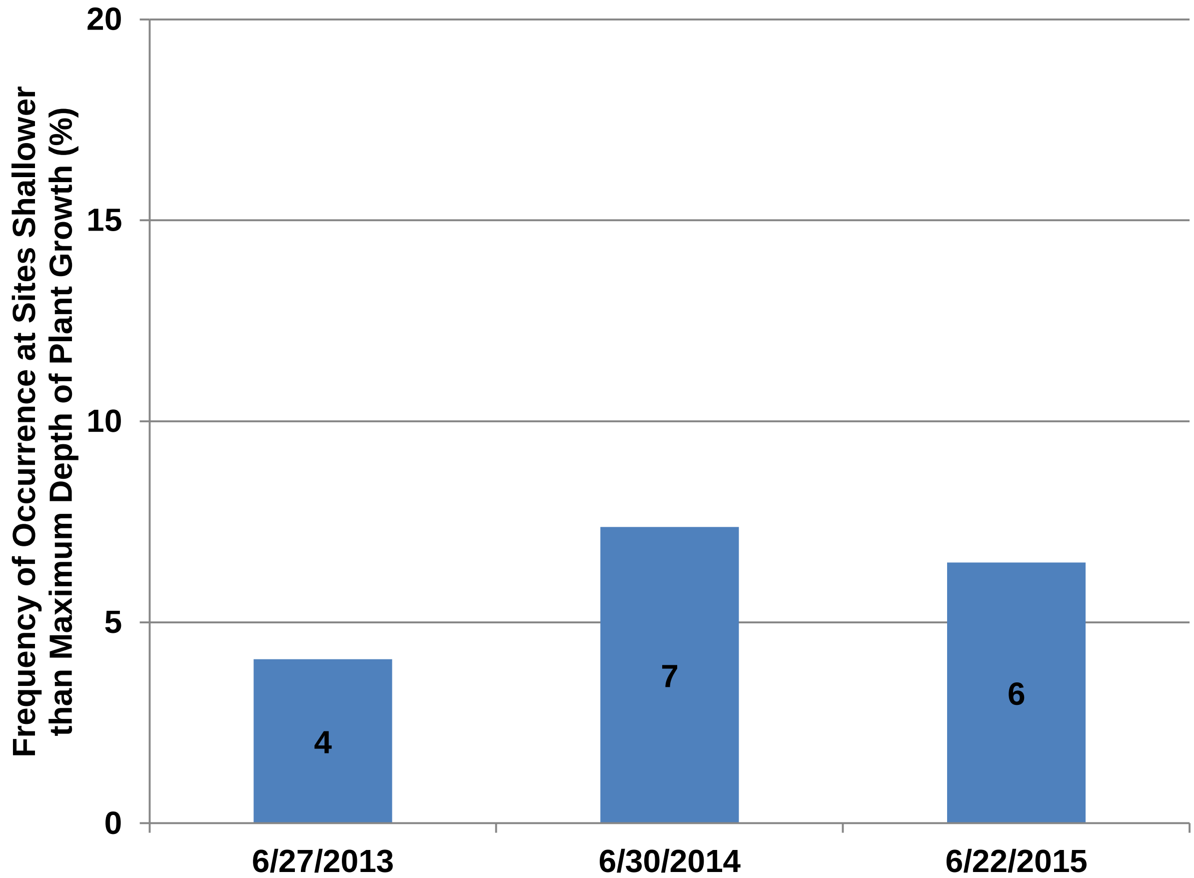
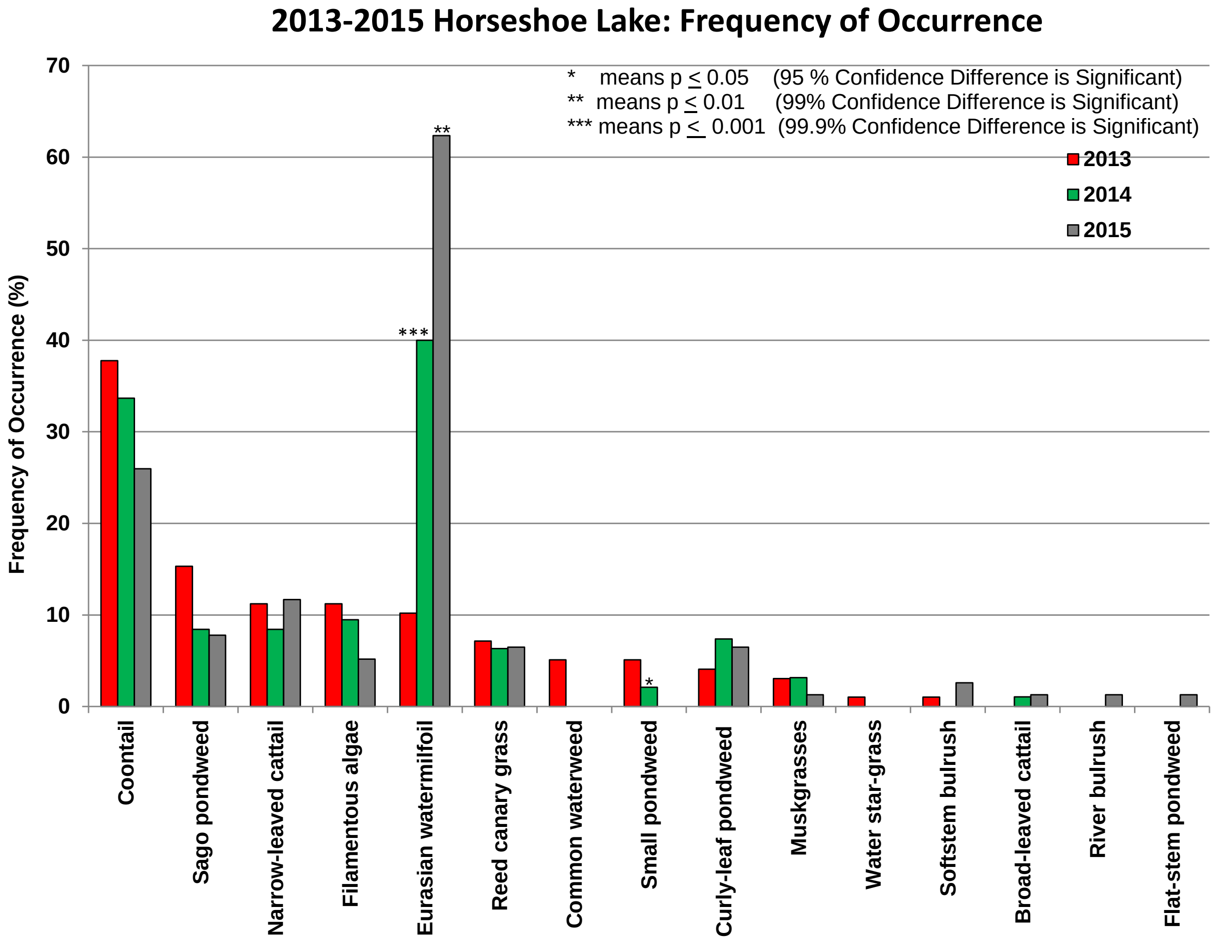


Figure 51 2013–2015 Horseshoe Lake Curly-leaf Pondweed Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth



Note: * indicates a significant change in frequency of occurrence between years

Figure 52 2013–2015 Horseshoe Lake Frequency of Occurrence in Plant Growth Area of the Lake

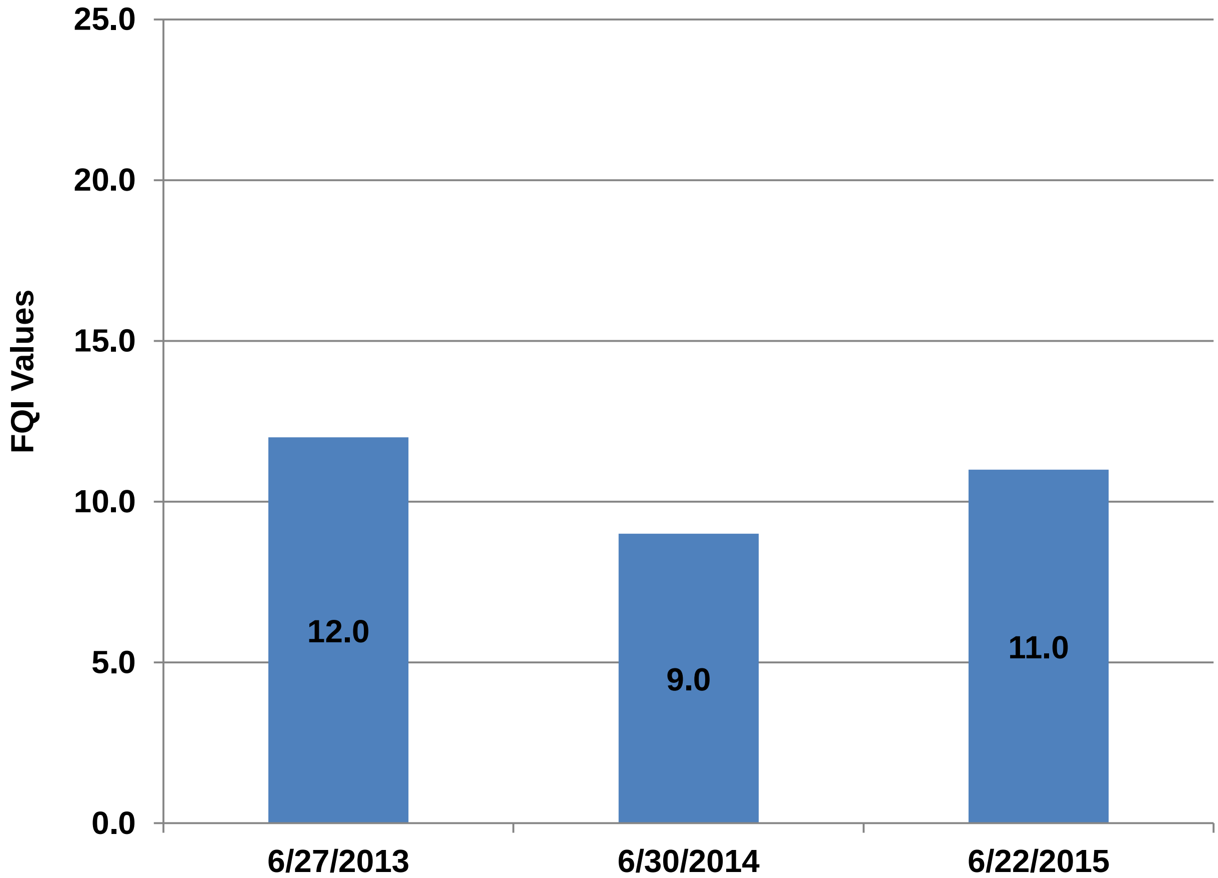


Figure 53 2013–2015 Horseshoe Lake Floristic Quality Index (FQI) Values

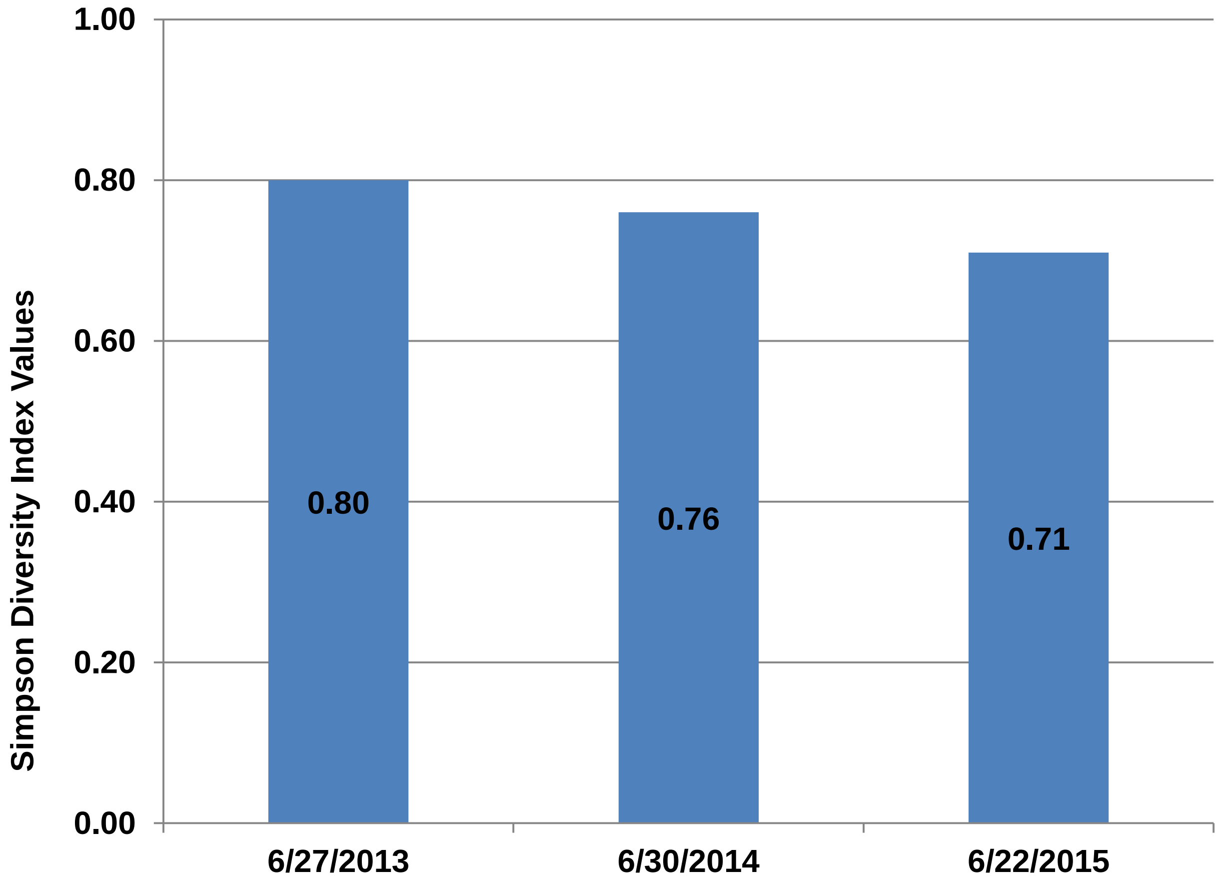
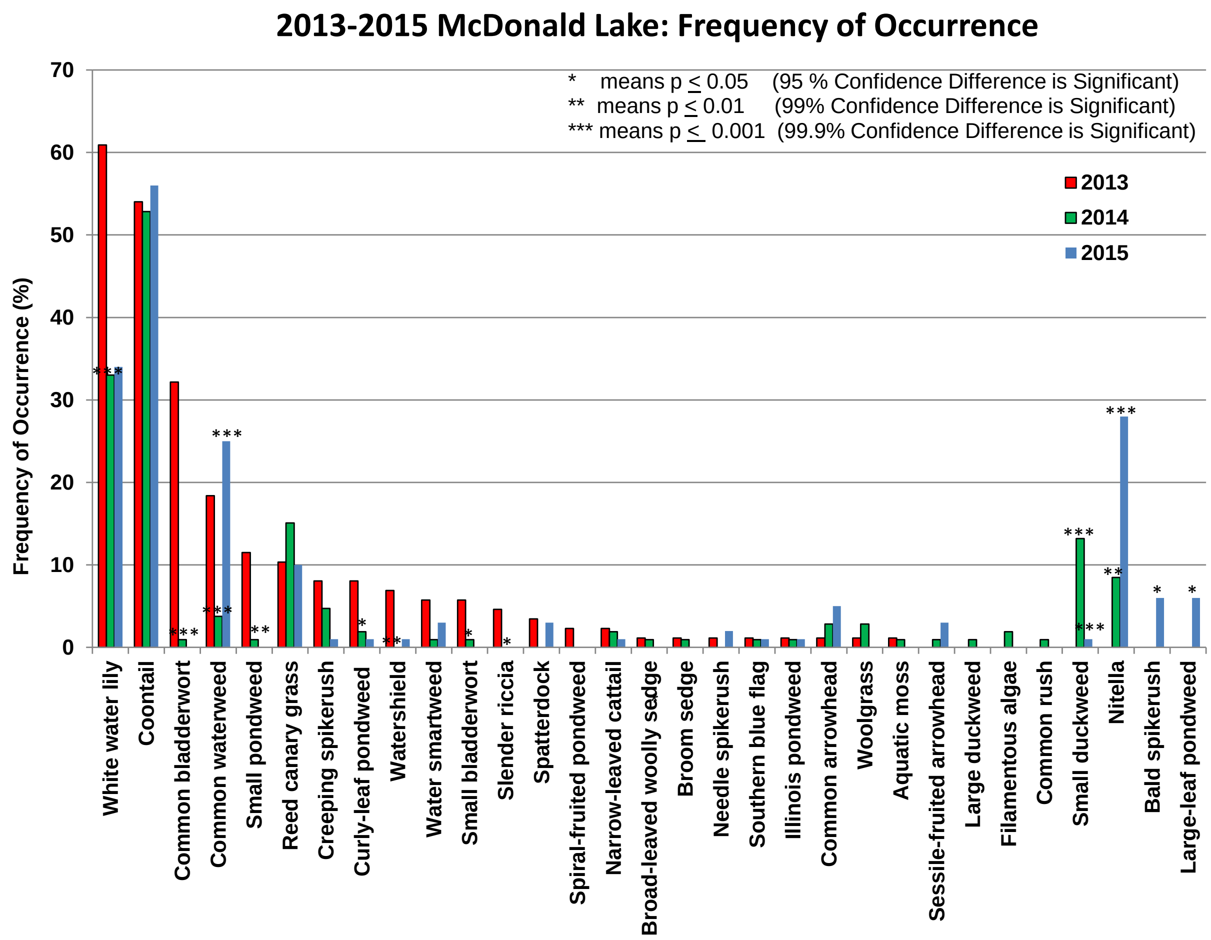


Figure 54 2013–2015 Horseshoe Lake Simpson Diversity Index Values



Note: * indicates a significant change in frequency of occurrence between years

Figure 55 2013–2015 McDonald Lake Frequency of Occurrence in Plant Growth Area of the Lake

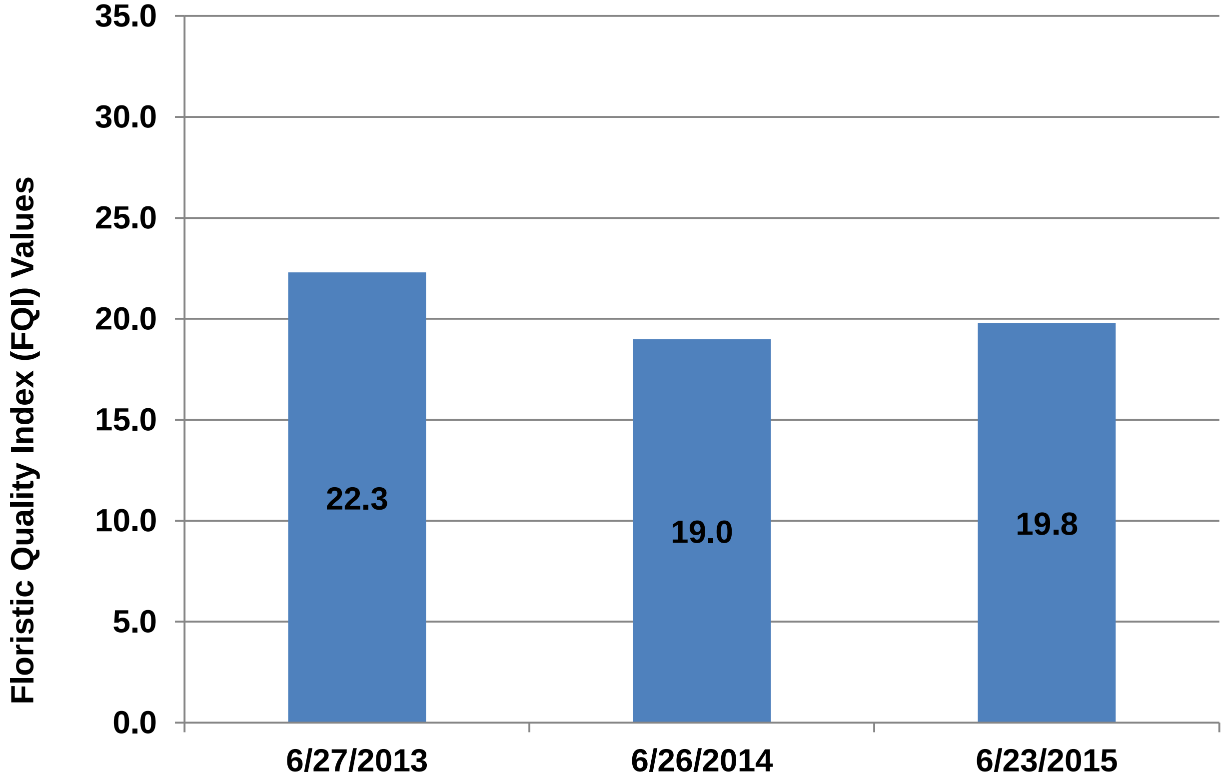


Figure 56 2013–2015 McDonald Lake Floristic Quality Index (FQI) Values

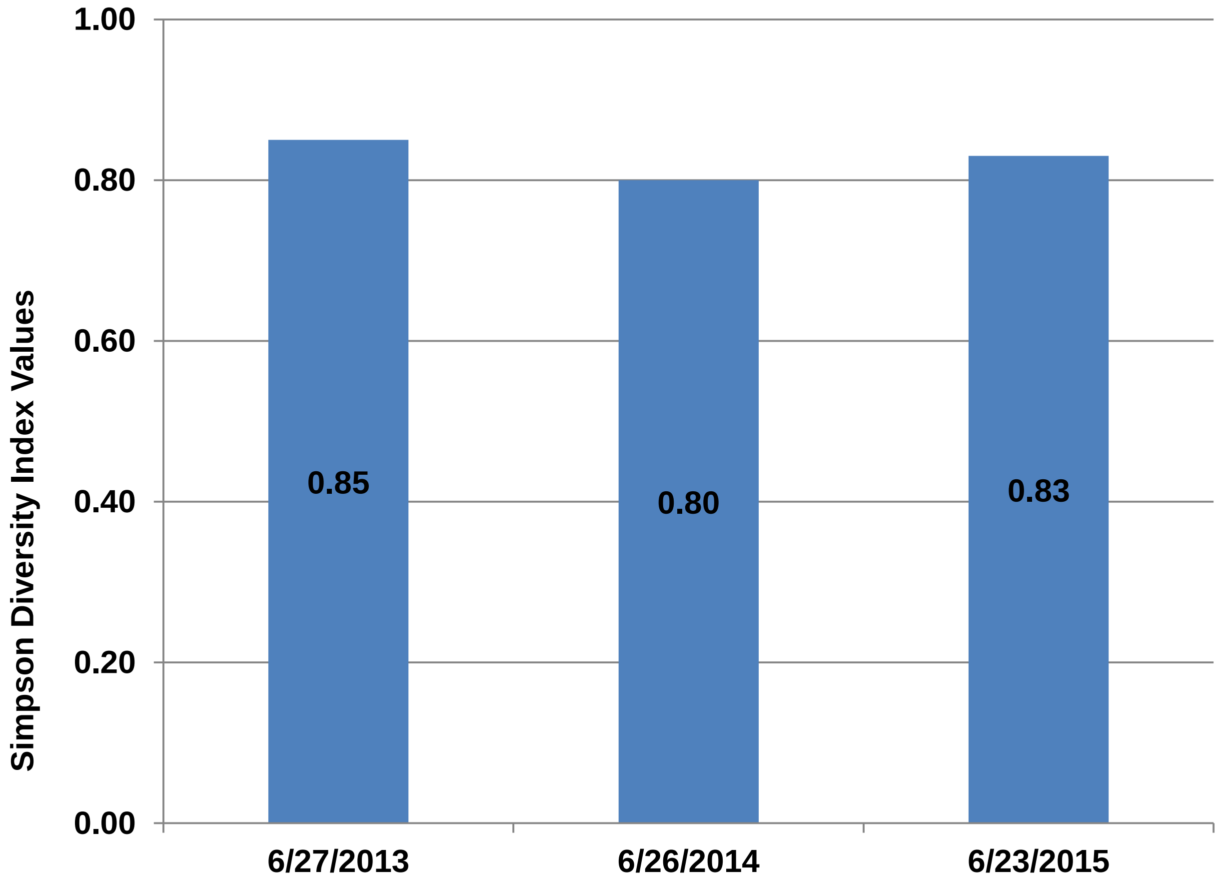


Figure 57 2013–2015 McDonald Lake Simpson Diversity Index Values

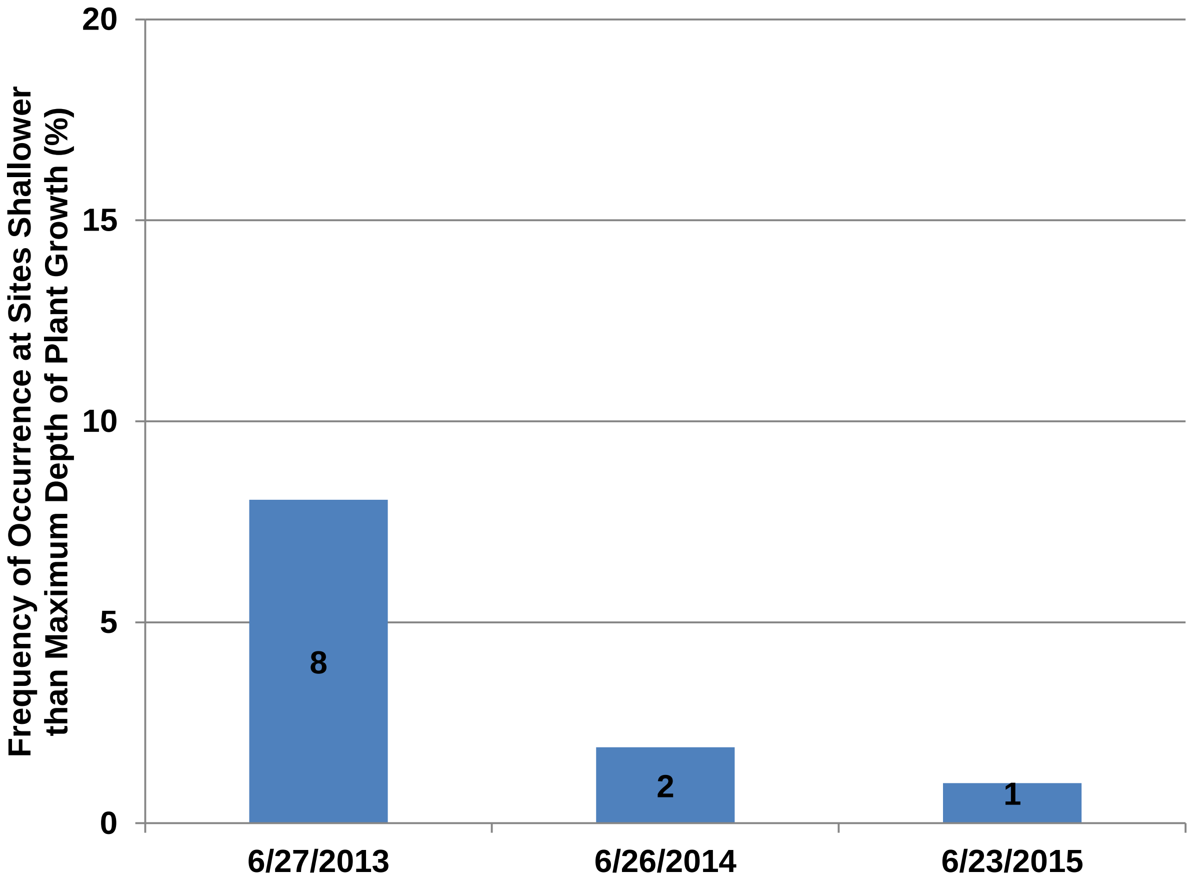


Figure 58 2013–2015 McDonald Lake Curly-leaf Pondweed Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth

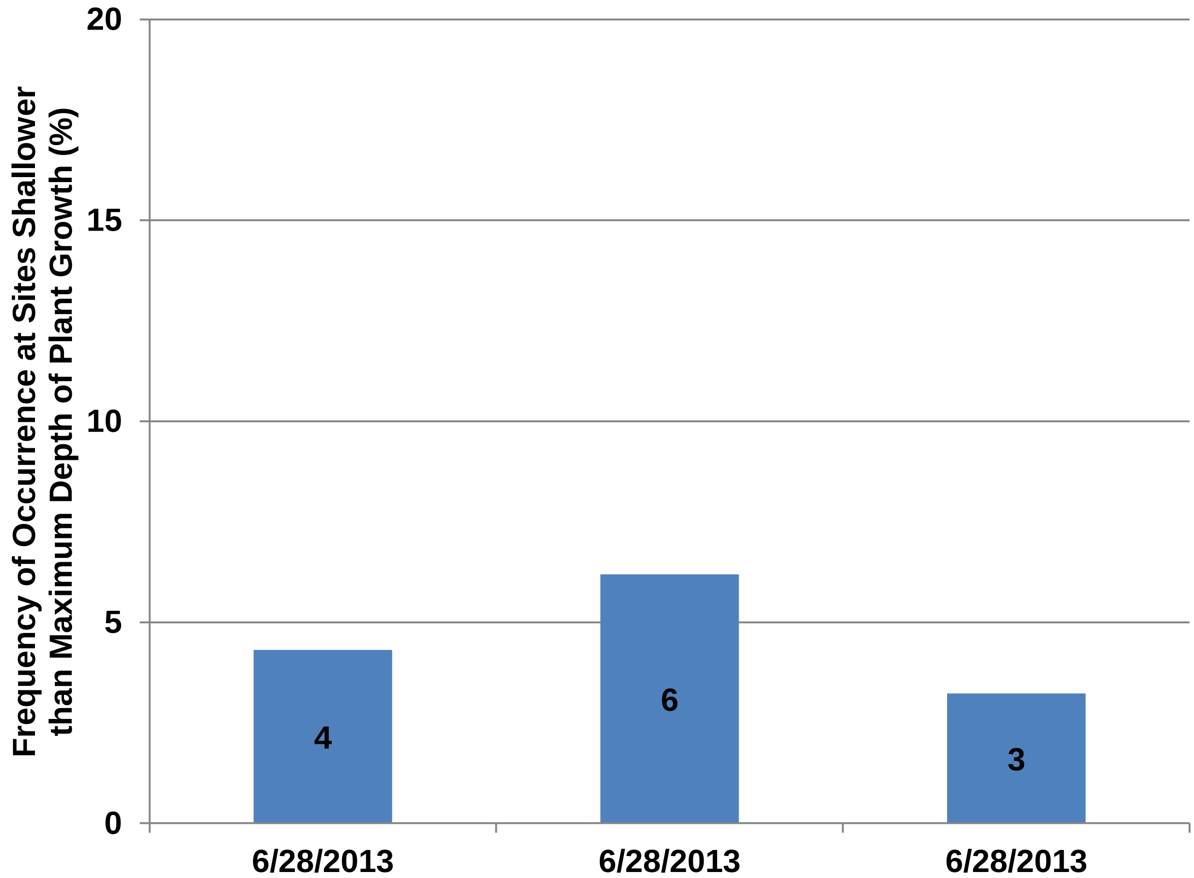
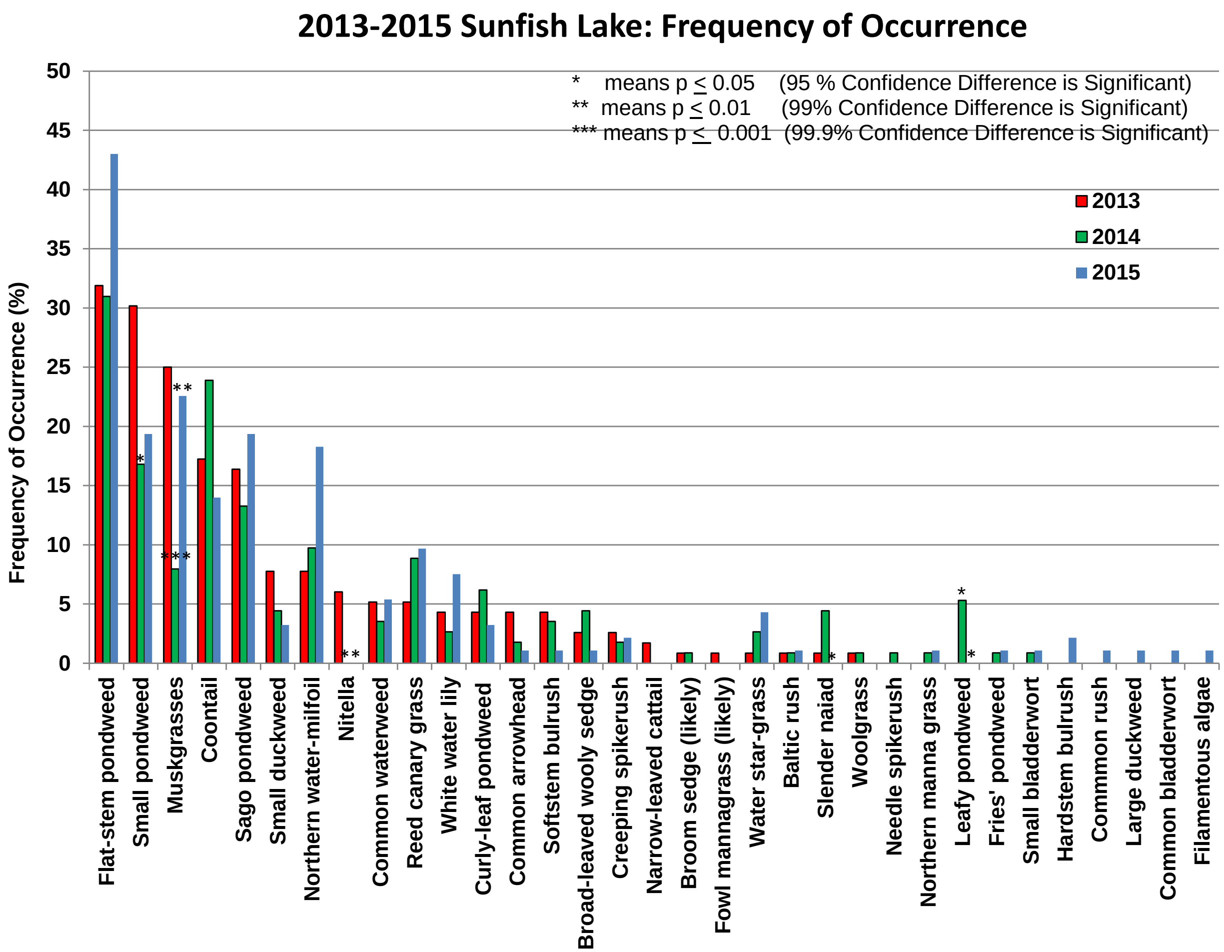


Figure 59 2013–2015 Sunfish Lake Curly-leaf Pondweed Frequency of Occurrence at Sites Shallower than Maximum Depth of Plant Growth



Note: * indicates a significant change in frequency of occurrence between years

Figure 60 2013–2015 Sunfish Lake Frequency of Occurrence in Plant Growth Area of the Lake

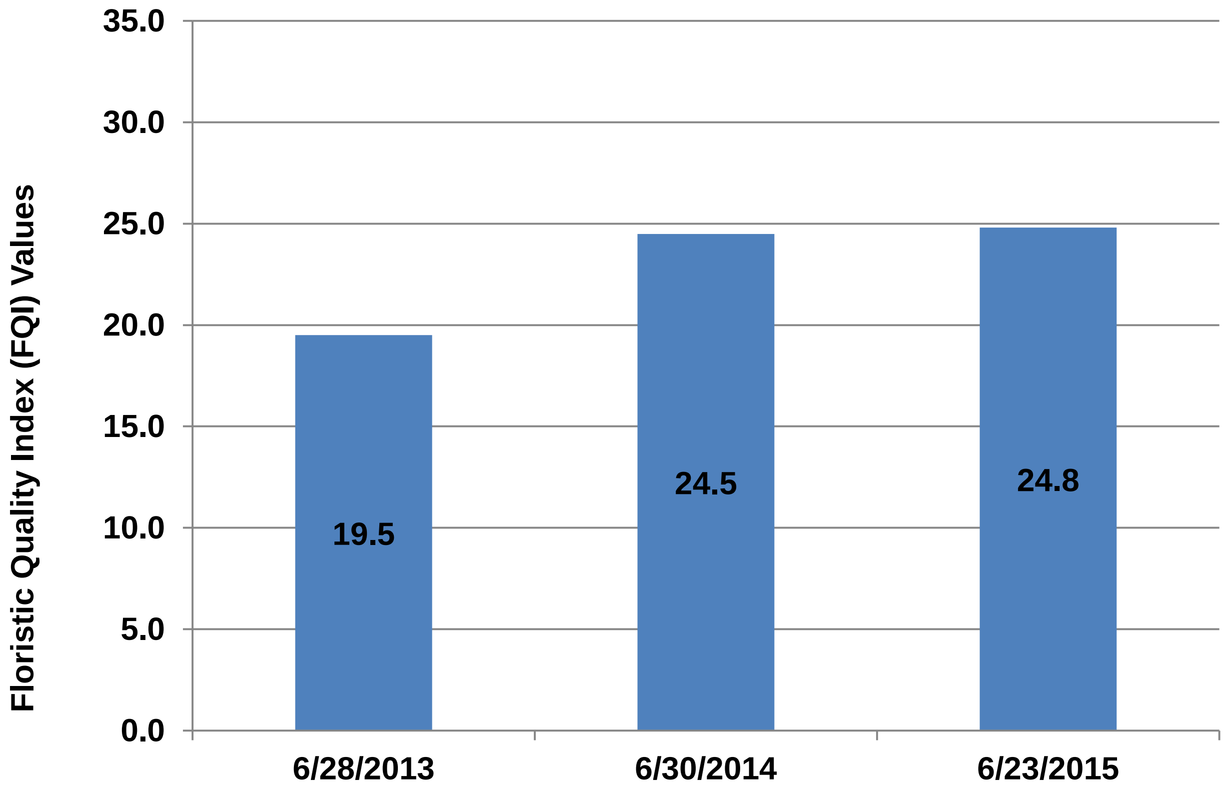


Figure 61 2013–2015 Sunfish Lake Floristic Quality Index (FQI) Values

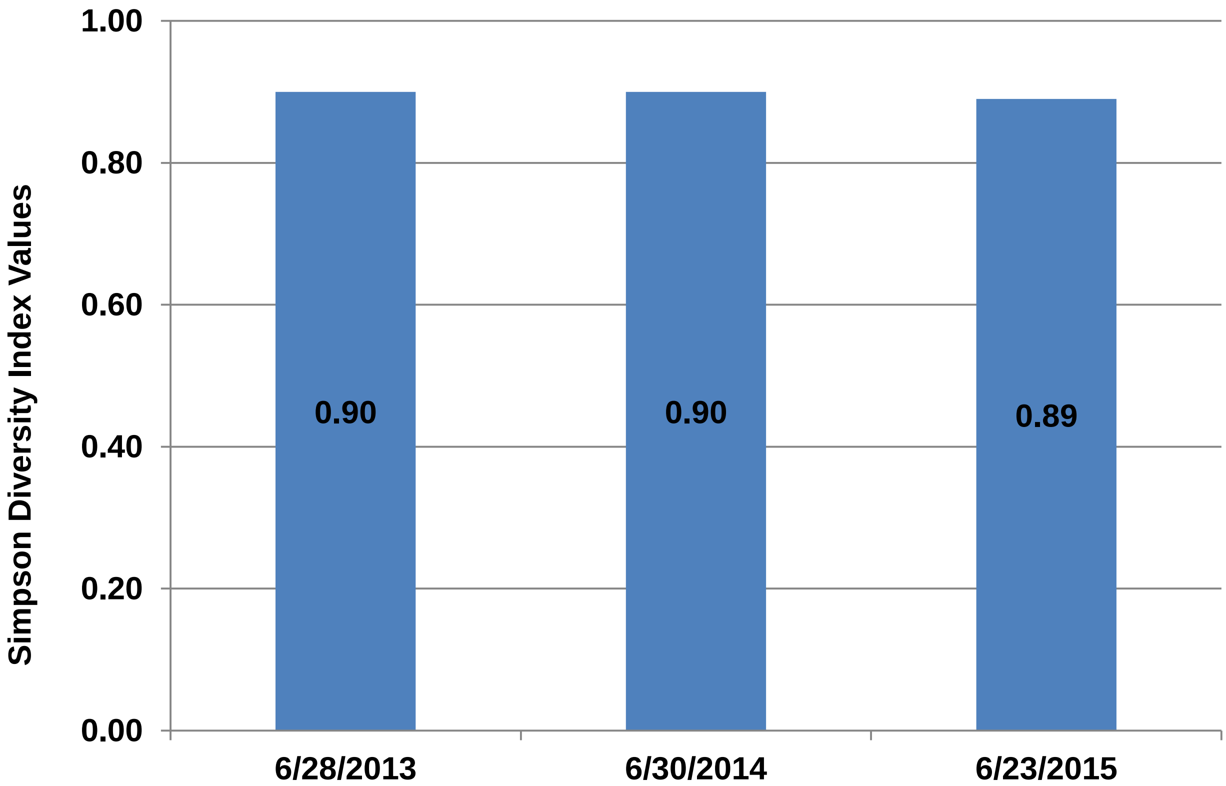


Figure 62 2013–2015 Sunfish Lake Simpson Diversity Index Values