Crescent Lake

Oneida County, WI

Aquatic Invasive Species Prevention
&
Planning Project

Photo by Sue Binder

Date:

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PREFACE

Planning is an important aspect of lake management. Planning is an active, thoughtful process that inventories the physical, social, and ecological environment, evaluates lake community perceptions, values, and concerns. The process provides clear direction, articulates the needs and concerns of the lake community, and provides a framework to accomplish goals.

This plan is designed to be read by a wide range of audiences involved in lake management and is intended to represent a model to help the lake community by:

- Summarizing information to support decision-making
- Providing a template to allow discussion on alternatives/options
- Including strategies to monitor for progress

The ultimate goal for this project is to update data on the ecological condition of Crescent Lake and develop actions that support aesthetic qualities and ecosystem health over time. Supporting goals include identifying ecological threats and formulating responses to them; maintaining recreational opportunities; engaging and educating the lake community; and developing actions that provides mindful management of invasive species while conserving native species and their habitats. Likewise, this plan seeks to meet NR 198.43 requirements, allowing the Crescent Lake Association (CLA) to be eligible for further Wisconsin DNR Surface Water Grants.

According to the Environmental Protection Agency (EPA), fifty-four percent of lakes sampled within the Upper Midwest show moderate to high levels of lakeshore human disturbances. Subsequently, lakes with poor lakeshore habitats in general have poor overall biological conditions and are three times more likely to be impaired (USEPA, 2009)**.** Over time, an accumulation of subtle ecological changes may result in irreversible ecosystem degradation, species loss and advance the spread and establishment of invasive species. Characterizing riparian and in-lake habitats provides information on the types and qualities of habitats on and surrounding Crescent Lake. This establishes baseline information to detect change that might identify and guide the need for future action.

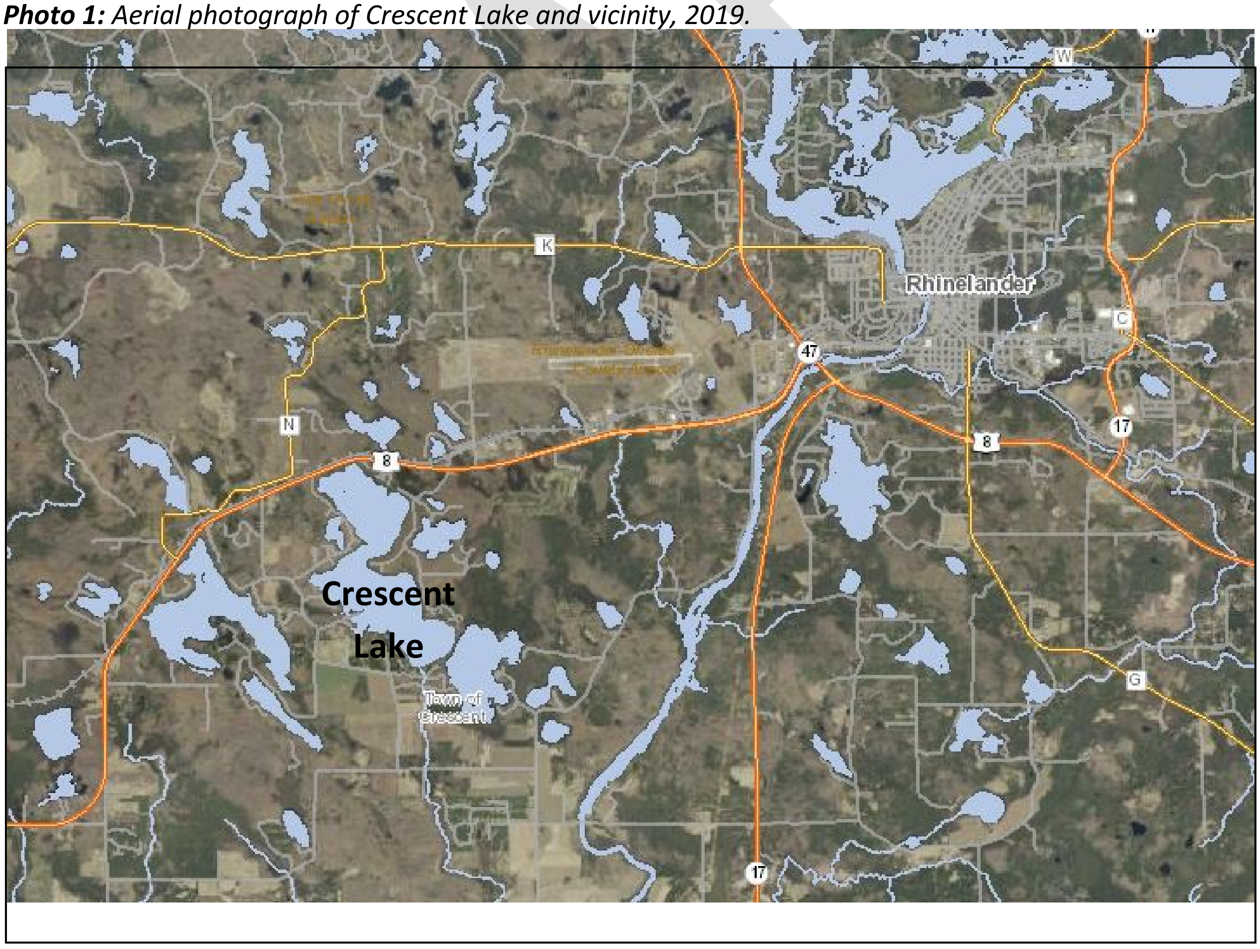
The vast majority of data collected for this project focused on in-lake and riparian habitat features. These features relate well to understanding and describing the health of a lake and its surrounding landscape. The plan has a five year scope; however, periodic review is recommended to ensure content is relevant to the current situation.

INTRODUCTION

Crescent Lake, Oneida County, is a 616-acre deep lowland lake with a mean depth of 17 feet and a maximum depth of 32 feet. Crescent Lake, assessed in 2020, is below impairment thresholds for phosphorous and chlorophyll *a*, with a general water quality condition ranking of excellent. Located within the Lake Mohawkin-Wisconsin River Watershed, land cover consists primarily of forests and wetlands. The most recent calculated floristic quality index for Crescent Lake is 39.86 (2019). Floristic Quality measures the natural quality of a lake's aquatic plant community or nearness of the lake's aquatic plants to those seen in undisturbed conditions. More on the floristic quality of Crescent Lake can be found under the aquatic plant section of this document. Invasive species known to occur in Crescent Lake include Eurasian watermilfoil (EWM), purple loosestrife, rusty crayfish, and yellow iris.[1] Though rusty crayfish have known to occur on Crescent, they have not been prevalent on Crescent for many years.

Located just west of Rhinelander, WI (the largest city in Oneida County), Crescent Lake is easily accessed by locals and visitors alike. A WDNR boat launch located at the north end of the lake supports 10 vehicle-trailers, a vaulted toilet, and a picnic area with grills. Crescent Lake has approximately 240-property owners including the Bible Camp.

Photo 1: *Aerial photograph of Crescent Lake and vicinity, 2019.*



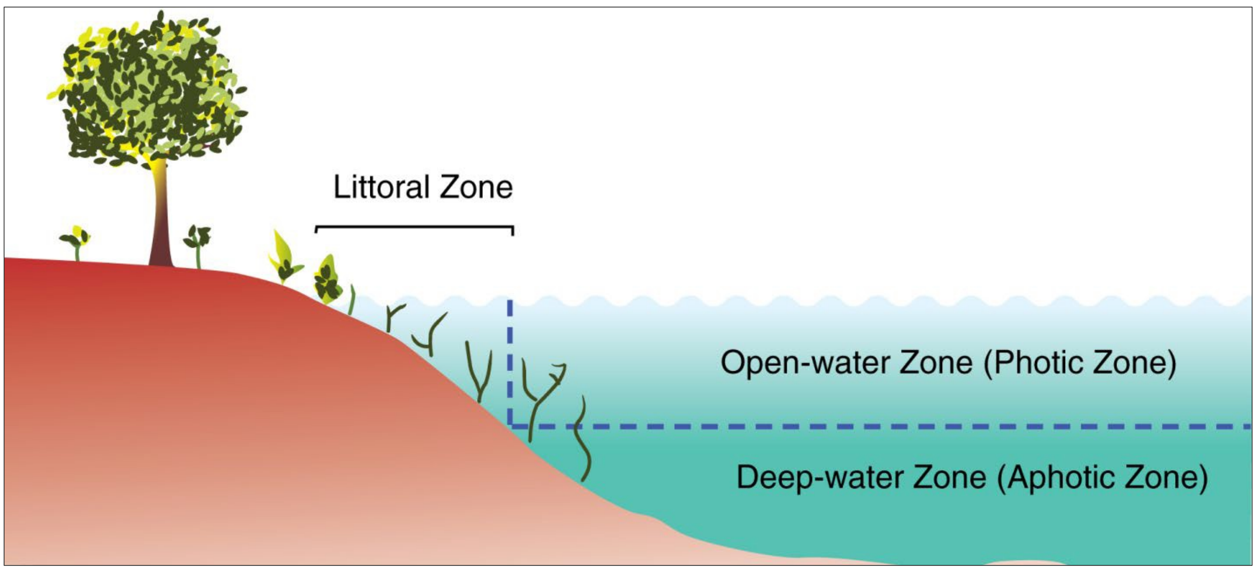
[1] WDNR Accessed 3/2020.

1 - AQUATIC PLANTS

Introduction

Aquatic plants provide habitat, refuge and food sources for fish, mammals, birds, insects, and amphibians. In addition, aquatic plants replenish lakes with oxygen, stabilize sediments, minimize erosion, and filter water. Aquatic plants are limited to areas of a lake where light can penetrate to the bottom; this area, commonly referred to as the littoral zone, is where most aquatic life lives **(Figure 1.1).** Additional factors that affect the distribution, abundance, and types of aquatic plants present in a lake include water levels, water temperature, sediment type, wave action, and nutrients.

Figure 1.1: *Littoral Zone*[2]



Categories of Aquatic Plants

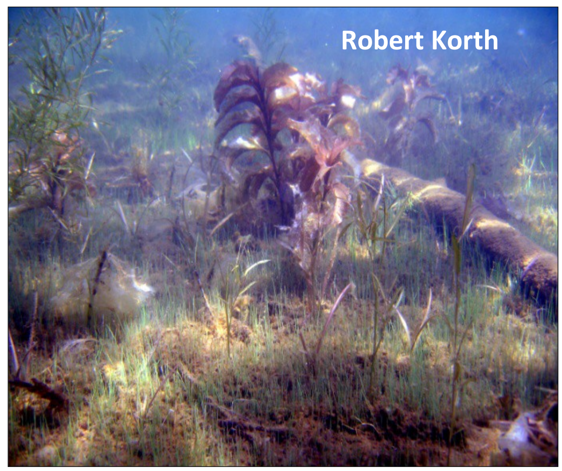
Emergent Plants

Emergent plants are typically associated with the shallowest portion of the littoral zone. They tolerate fluctuating water levels, and usually root along the shoreline. They naturally protect shorelines from erosion by reducing wave action, and their roots create a woven barrier that stabilizes sediments. In many cases, these plants are the most impacted by shoreline development. Examples of emergent plants include cattails, bulrushes, irises, and wild rice.

[2] Geoff Ruth [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

Floating Leaf Plants
Floating leaf plants gradually replace emergent plants with increasing water depth. Floating leaf plants common to Northern Wisconsin often have circular, heart-shaped, or elliptical shaped leaves with a leathery texture to resist tearing from waves and wind, making them ideal to dissipate wave energy reaching shore. Exceptions include some bur-reeds, northern and American manna grass, which have linear floating leaves. Common floating leaf plants include white water lilies, watershield, and the American lotus. Floating leaf plants includes free-floating plants. Like their name suggests, free-floating plants are not rooted in the lakebed and easily transported around a lake. These plants include duckweeds and some bladderworts. Duckweed is an important food resource to waterfowl, particularly dabbling ducks. The smallest known flowering plant in the world is the free-floating aquatic plant, watermeal (*Wolffia* spp.).

Submersed Plants
Submersed plants are a very diverse group of plants found in both shallow and deeper portions of the littoral zone. Light often limits the depth to which these plants can grow. The leaves of these plants are thin and many times highly divided. This trait increases the surface area-to-volume ratio allowing these plants to live in areas of the lake that receive less light. Specialized cells trap gasses allowing these plants to remain buoyant. These plants provide spawning structure for many species of fish and provide refuge for juvenile fish and aquatic insects.



Crescent Lake's Aquatic Vegetation

Assessing a lake's aquatic plants provides detailed information on the types and distribution of aquatic plants in a lake, useful to understanding habitat characteristics, ecosystem stability, and identify high quality sites. Furthermore, repeating this assessment provides comparisons of these data over time.

Aquatic plant assessments included a point intercept survey and emergent/floating leaf plant community mapping. Point intercept (PI) surveys follow the WDNR Monitoring of Aquatic Plants in Wisconsin (2010) protocol, which uses a grid of predetermined points

Figure 1.2: Rake fullness description.

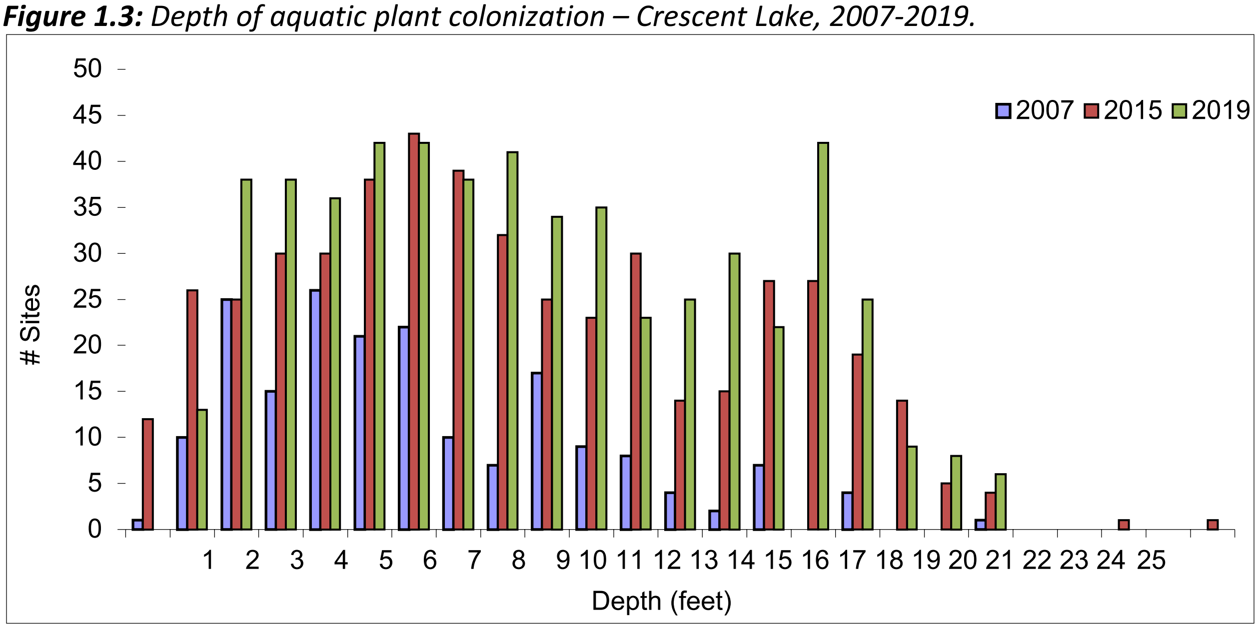
Fullness Rating	Coverage	Description
1		Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer.
2		There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines.
3		The rake is completely covered and tines are not visible.

evenly spaced across the lake **(Appendix A.)** These points are up-loaded into a GPS for field navigation. At each site, a double-sided rake lowered over the side of the boat collects a sample of aquatic vegetation. Each plant species on the rake is identified and the abundance or rake-fullness for the rake and each species is estimated (**Figure 1.2**[3]). At each sampling site, water depth and sediment type are also recorded. Emergent/floating leaf community surveys circumnavigated the entire lake identifying all observed emergent and floating leaf plant locations. Emergent/floating leaf community mapping used a combination of visually identified species documented during the point intercept survey combined with geo-spatially mapped beds **(Appendix B).** Small locations (<1/10 acre) were geo referenced with a GPS point whereas the outer edges of larger locations were traced to create geo-spatially referenced beds.

Point intercept surveys took place the week of August 5th, 2019. Additional point intercept surveys completed by Ayers Associates and WDNR[4] took place in 2007 and 2015. Emergent/floating leaf community mapping took place on September 16th, 2019.

Crescent Lake's survey sampled 1482 locations, identifying a total of 34 native aquatic plant species and one invasive plant species. Rake samples detected 33 native plants species and one invasive plant species, whereas the remaining species were visual observations. Maximum depth of plant colonization occurred at 20 feet, with the majority of vegetated sites occurring between 4 to 16 feet **(Figure 1.3).** Most sites sampled consisted of soft or mucky sediments (60%), followed by sand (25%) and rock (15%) **(Figure 1.4).** Total species detected per rake sample ranged from 1 to 10 with an average of 2.35 species per rake sample.

Figure 1.3: *Depth of aquatic plant colonization – Crescent Lake, 2007-2019.*



[3] Taken from Recommended Baseline Monitoring of Aquatic Plants in Wisconsin, (Hauxwell et al, 2010).
[4] 2010 surveys completed with assistance from the Vilas County Land and Water Conservation Department. 2015 surveys completed with assistance from Wisconsin Valley Improvement Company.

Figure 1.4: *Lake-wide percentage of substrate consistency – Crescent Lake, 2019.*

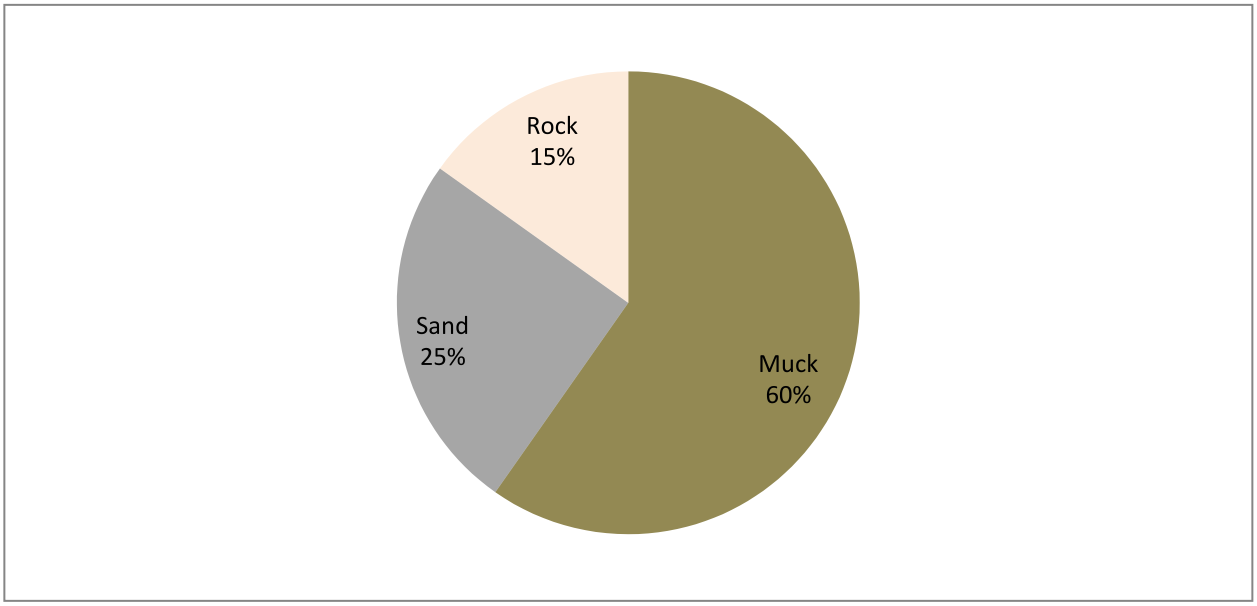


Table 1.1: Point intercept survey summary statistics from 2007-2019, Crescent Lake.

	2007	2015	2019	2007-2015 Change	2015-2019 Change
Total number of sites visited	576	815	1482	+29%	+45%
Total number of sites with vegetation	189	480	548	+60%	12%
Total number of sites shallower than maximum depth of plants	549	815	793	+32%	-2%
Frequency of occurrence at sites shallower than maximum depth of plants	34.43	58.90	69.10	+42%	+15%
Simpson Diversity Index	0.87	0.91	0.90	+4%	-1%
Maximum depth of plants (ft)	20	25	20	5 feet	5 feet
Number of sites sampled using rake on Rope (R)	437	266	355	-64%	+25%
Number of sites sampled using rake on Pole (P)	58	549	517	89%	-6%
Average number of all species per site (shallower than max depth)	0.62	1.47	2.35	+58%	+37%
Average number of all species per site (veg. sites only)	1.80	2.50	3.40	+28%	+26%
Average number of native species per site (shallower than max depth)	0.55	1.47	2.30	+63%	+36%
Average number of native species per site (veg. sites only)	1.80	2.50	3.34	+28%	25%
Average Rake fullness	1.0	2.41	2.48	+58%	+3%
Species Richness	14	29	34	52%	18%
Species Richness (including visuals)	17	35	35	51%	0%

Plant Analysis Primer

Floristic Quality Index (FQI) measures the natural quality of a lake's aquatic plant community or nearness of the lake's aquatic plants to those seen in undisturbed conditions. This value specifically uses a combination of species richness and coefficients of conservatism to calculate a value useful to monitor changes to plant communities over time (Nichols, 1999). Species richness can often be confused with species diversity. Species richness refers to the total number of different species, whereas species diversity considers how evenly within the lake species occur. A lake with 15 species may not be as diverse as a lake with ten species based on how evenly those ten species are distributed. The second value used in a floristic quality index is a coefficient of conservatism. This is an integer value ranging from zero and ten assigned to each native plant species that relates to its tolerance to degradation and the degree to which it is faithful to remnant natural habitats. For example, a plant that inhabits a broad range of natural communities and disturbed sites may have a value of one or two, whereas a plant that is usually restricted to a high quality natural habitat might have a value of nine or ten. Most plants are tolerant of some community changes or degradations and have values that fall between these two extremes. By definition non-native plants species do not have an affinity to any high-quality natural habitats and are assigned a value of zero.

Figure 1.5: *Wisconsin's Ecoregions.*

Floristic quality assessments generally compare the floristic quality of lakes within a similar Ecoregion **(Figure 1.5).** An Ecoregion is a defined landscape that has similar characteristics including land-use, vegetation, soils, and landscape formations. Crescent Lake is located within the Northern Lakes and Forests Ecoregion, which consists of conifer and northern hardwood forests, with numerous wetlands, lakes, and perennial streams. This ecoregion has poor agricultural potential (Omernic, 1998)**.**

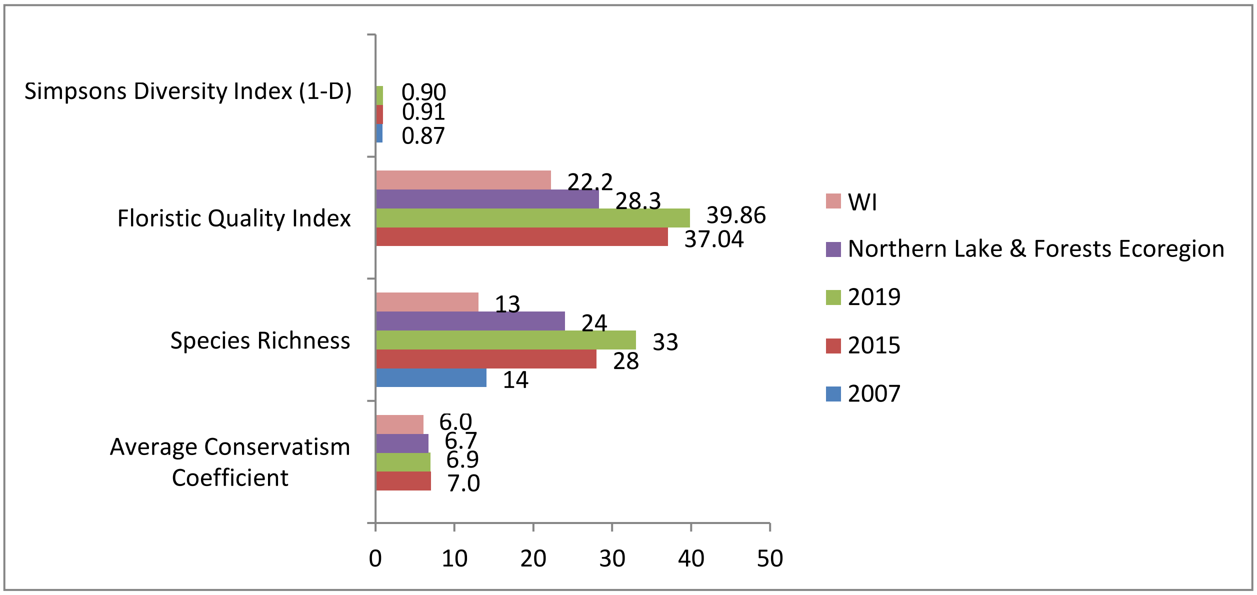
Aquatic Plant Analysis

Crescent Lake's FQI rose slightly in 2019 compared to 2015, but considerably from 2007 to 2019. Overall Crescent ranks above the median[5] value for lakes in the Northern Lakes and Forests region and Wisconsin statewide **(Figure 1.6).** Average species of conservatism for Crescent Lake in 2015 and 2019 was 6.7, and sits at the average for Northern Lakes, and above average for lakes across the state.

[5] Median values represent the middle of the total set of numbers used, whereas the average looks at the general trend of a data set. These values may be different, depending on the statistical distribution of the data being analyzed.

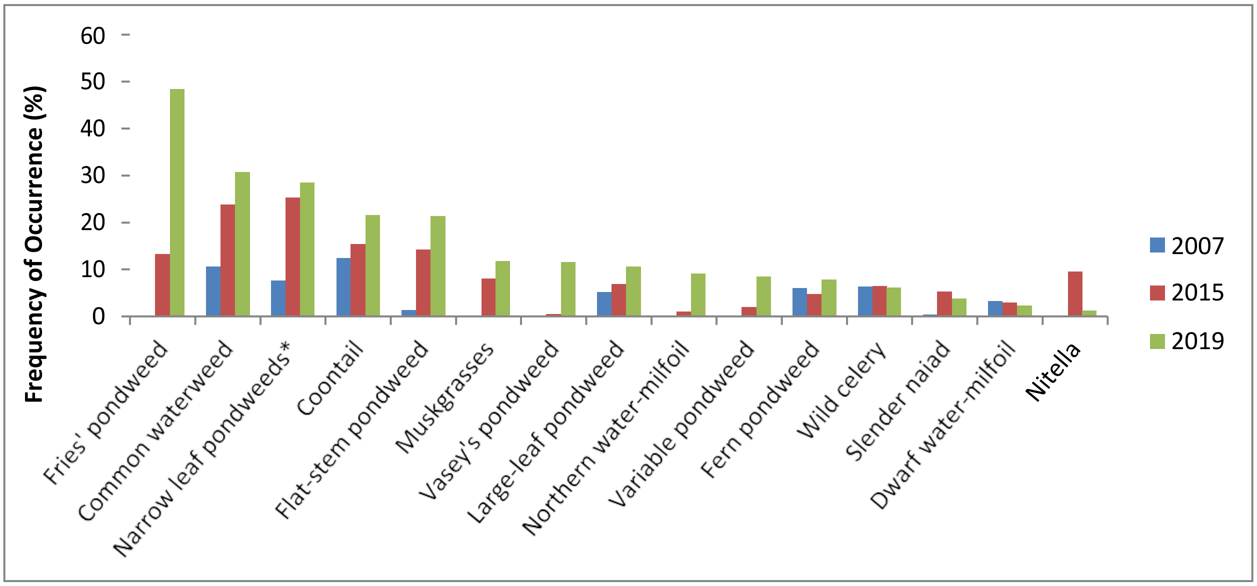
In addition to floristic quality, the Simpson's Diversity Index, is one of many indices useful in measuring ecological diversity. Diversity simply looks at the variability amongst living organisms and ecosystems, including genetic diversity to ecosystem diversity. Understanding diversity is important because diversity in a lake may protect or buffer a lake from change over time and improve its resilience to outside "stressors" and other vulnerabilities. A Simpson's Diversity Index measures species diversity and takes into account both richness and abundance of each species. This index is different from floristic quality that uses species richness and species conservatism. Simpson's Diversity Index values range from zero to one. The closer the value is to one, the more diverse the measured population is considered to be. Simpson Diversity Index values for Crescent Lake Lakes rose slightly from 0.87 in 2007 to 0.90 in 2019.

Figure 1.6: *Summary of Crescent Lake's floristic quality and diversity, 2007, 2015 & 2019.*



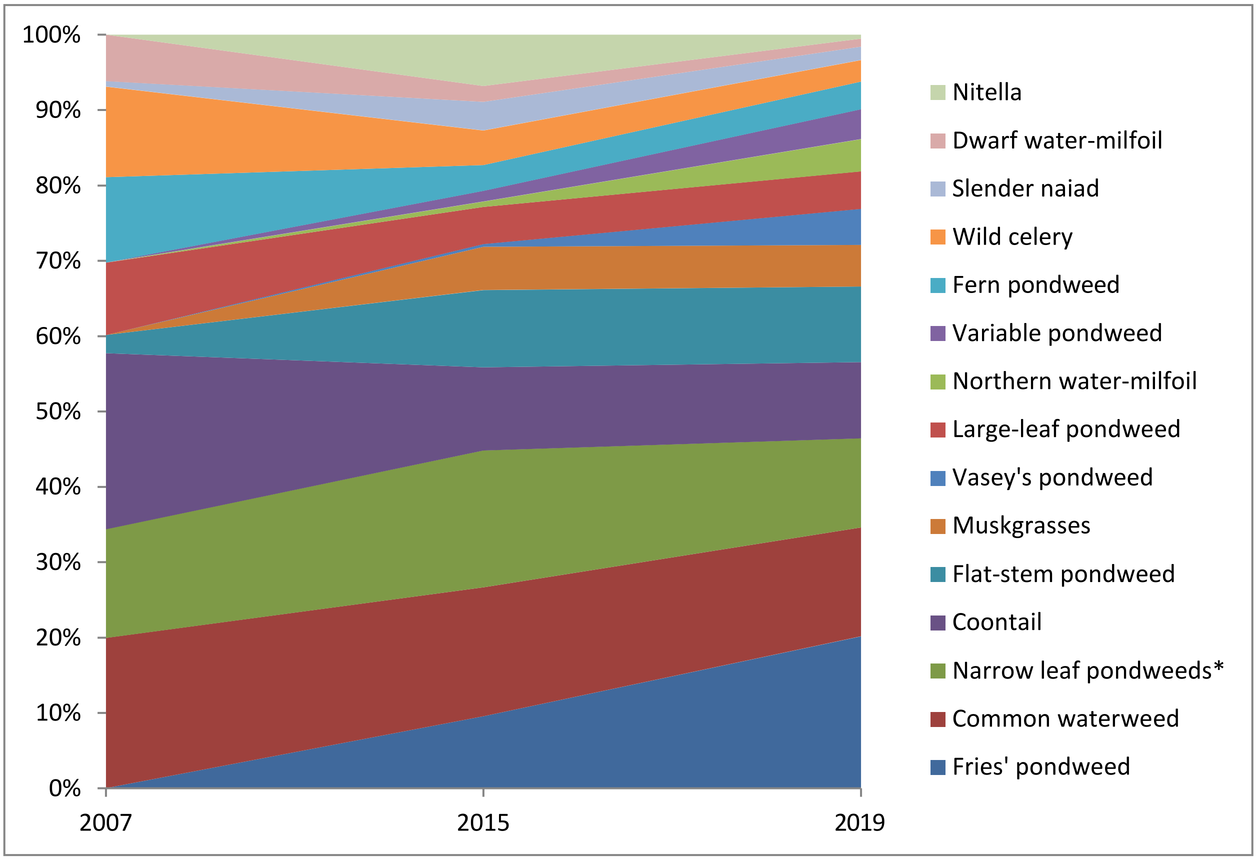
Frequency of littoral occurrence of a species is the percentage of the total surveyed points that a species was present on a rake sample divided by the total number of points sampled within the littoral zone**.** Over time, these values can provide evidence of change at the species level. This level of detail is important for several reasons. Shifts or change to aquatic plant communities may indicate changes within the watershed, shoreland and aquatic plant management practices, water levels, climate change or other disturbances. Species with the highest frequency of occurrence on Crescent Lake based on the 2019 point-intercept survey include Fries' pondweed, common waterweed, and narrow leaf pondweeds **(Figure 1.7).**

Figure 1.7: *Littoral frequency of occurrence of aquatic plants (>5% occurrence) – Crescent Lake 2007, 2015 & 2019.* Narrow leaf pondweeds include small pondweed and leafy pondweed combined.*



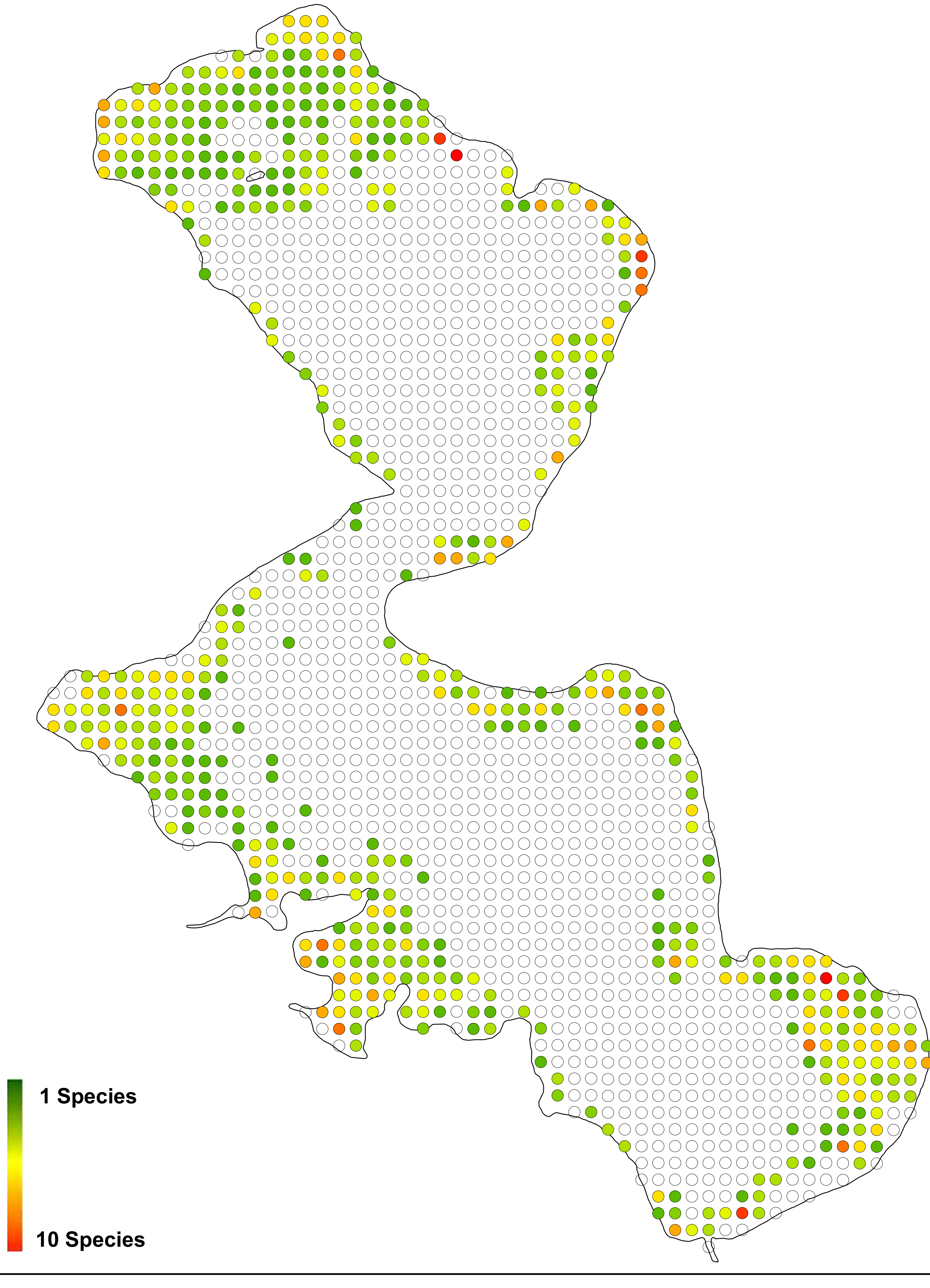
As mentioned above, frequency of littoral occurrence is the percentage of time a species is detected across the sampled littoral area. These values are sampling event dependent, meaning this value represents how often each plant is detected for that survey. You could not assume that 45% frequency of littoral occurrence for a particular species means that each time you sample there is a 45% chance of sampling that species. To look at the number of times a species is likely to occur (or be sampled), relative frequency of occurrence is calculated. Relative frequency of occurrence is the proportion of times that a species is sampled relative to the total population. The three most common species on Crescent Lake in 2019 based on relative frequency are again Fries' pondweed, common waterweed and small pondweed **(Figure 1.8).**

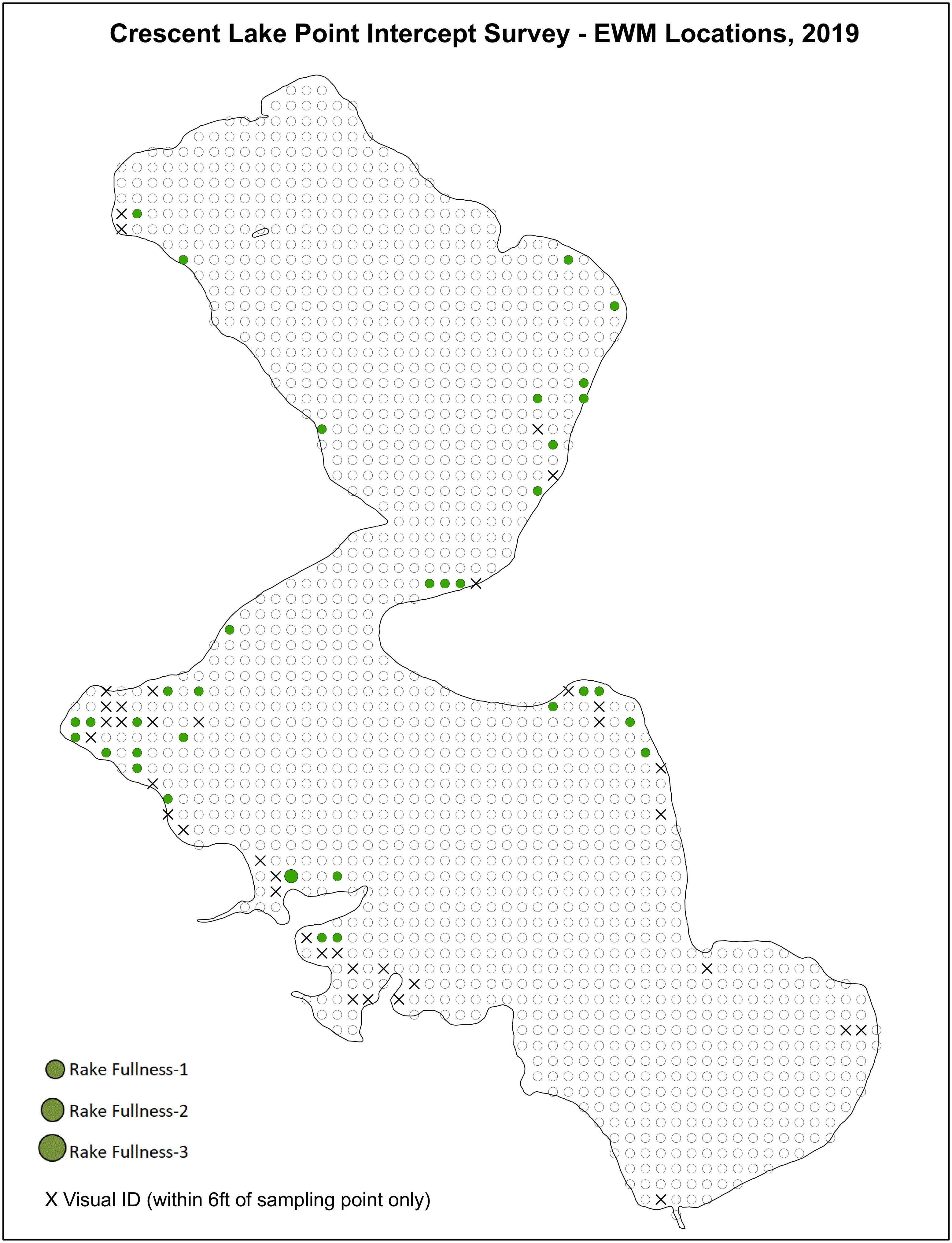
Figure 1.8: *Relative frequency of occurrence of aquatic plants (>5% occurrence) – Crescent Lake 2007, 2015 & 2019. * Narrow leaf pondweeds include small pondweed and leafy pondweed combined.*




Crescent Lake Point Intercept Survey - Vegetation Rake Fullness, 2019
Rake Fullness-1
Rake Fullness-2
Rake Fullness-3

Crescent Lake Point Intercept Survey - Species Richness, 2019




Crescent Lake Point Intercept Survey - EWM Locations, 2019
Rake Fullness-1
Rake Fullness-2
Rake Fullness-3
X Visual ID (within 6ft of sampling point only)

Emergent and Floating Leaf Community Mapping

Emergent plants are typically associated with the shallowest portion of the littoral zone**.** They tolerate fluctuating water levels, and usually root along the shoreline. They naturally protect shorelines from erosion by reducing wave action, and their roots create a woven barrier that stabilizes sediments. In many cases, these plants are the most impacted by shoreline development. Examples of emergent plants include cattails, bulrushes, irises, and wild rice.

Mapping of emergent and floating leaf plant communities on Crescent Lake estimates 4.21 acres of mixed emergent and floating leaf plant beds, less than one acre of emergent plant beds, and zero acres of floating leaf plant beds.[6] Emergent and floating leaf plants represent approximately 1% of the total surface water acres on Crescent Lake.

[6] Locations of emergent and floating leaf plants less than 1/10 of an acre in size where documented, but not included in these bed mapping estimates.

2 - AQUATIC PLANT MANAGEMENT

The goals of aquatic plant management will vary. One individual may prefer less aquatic plants to minimize interference with swimming or boating, while another may prefer more aquatic plants to improve fishing habitat. Aquatic plants are an important component of a healthy functioning ecosystem. However, they can become problematic, interfering with lake access and use. Invasive plants, species not native and introduced to new habitats, are capable of causing ecological and economic harm, and can disrupt the balance of natural ecosystems. Invasive plants may grow excessively, forming dense mats that out-compete native plants thereby reducing diversity and limiting recreational and navigational use of a water body. Native plant species can also display nuisance like characteristics including forming dense mats and dominating certain portions of a lake.

The non-native watermilfoils, Eurasian watermilfoil (EWM) and hybrid watermilfoil (HWM), are highly invasive aquatic plant species. They colonize a variety of habitats including reservoirs, lakes, ponds, low-energy streams and rivers, and brackish waters of estuaries and bays. Rapid growth rates allow this species to form thick mats on the surface of the water. Transport on boating equipment plays the largest role in introducing these species to new water bodies. Because the negative impacts these species pose, EWM and HWM are frequently targeted for management. Below is a description of commonly used aquatic plant control methods. Not all methods may be suitable options for Crescent Lake. However, a basic understanding of their applicability is important to understand the rationale for choosing methods specific to Crescent Lake.

Shoreland Protection & Restoration

Minimizing shoreline disturbance by protecting native vegetation may increase nature's ability to ward off colonization of invasive species. More important, intact shorelines reduce nutrients entering a lake that feed aquatic plant growth. When lakefront property owners develop their shorelines by removing what is naturally occurring, negative affects to a lake's ecosystem follow. Animals, birds, and amphibians depend on the habitat that natural shorelines provide. Removing this sustaining habitat ultimately can reduce the diversity of life that naturally exists in these ecosystems. For example, research has shown a direct negative correlation between higher levels of human disturbance on lakes and the presence of adult green frogs, versus undeveloped lakes (Woodford, 2003)**.** Removal of shoreline vegetation increases the susceptibility of erosion, leading to excessive sediments and nutrients running into a lake. Loose sediments can affect water clarity and nutrients can fuel excessive aquatic plant and algae growth.

<u>Examples of shoreline development that can lead to negative ecological impacts include:</u>

- Mowing to the water's edge
- Fertilization
- Removing down woody debris from the water
- Rip-rap and seawalls
- Raking rooted native vegetation out of the water

Shoreland protection and restoration can be as simple as not using fertilizers and not mowing to the water's edge or it could include installing plants and other bank stabilization materials.

Photo 2: ***Before and After:*** *Shoreline Restoration Example from the MI Natural Shoreline Partnership - Middle Lake, Oakland County, MI*

<u>Shoreland Restoration/Protection Considerations:</u>

- Provides an added barrier to minimize the establishment of invasive species
- Reduces wave action and erosion along shorelines
- Improves aquatic habitat and provides refuge for many species
- Low cost restoration sites using seed and small plant material will take several years to mature and see the benefits
- Will require maintenance until plants become established especially in drought situations
- Animal browse may be an issue, fencing may be required until plants are established
- Check with WDNR on permit requirements

Physical Control of Aquatic Plants

Physical control encompasses a variety of practices using manual or mechanical means including placement of benthic barriers (lake-bottom blankets), manual removal, mechanical cutting, and water level drawdown.

<u>Benthic Barriers</u>

Benthic barriers are used along the lakebed on a localized level to suppress aquatic plant growth by blocking sunlight. These barriers are typically made from high-grade materials and secured to the lake bottom with the use of scuba divers.

Application Considerations for Benthic Barriers

- Best suited for small areas including regions along shorelines or creating boating lanes
- Results typically seen within a couple weeks
- Requires seasonal maintenance
- Decomposing material under the barrier may create gas bubbles that need to be relieved
- No water use restrictions
- May not be cost effective for larger areas (>1 acre)
- Method is not selective, all organisms under the benthic barrier may be impacted
- Potential loss of aquatic habitat for fish and other organisms
- Installation and maintenance may be expensive
- May be difficult to re-use barriers because algae and plants may grow on top of the barrier
- Re-colonization of invasive plants may occur shortly after the barrier is removed
- Benthic organisms may be highly impacted depending on the type of barrier and the length of time the barrier remains in place (Engle, 1983).
- Check with WDNR on permit requirements

Manual Hand Removal

Manual removal mainly involves plants being removed by hand, typically with the use of snorkel or dive gear. In some cases, a rake may be used by an individual over the side of a boat to "pop" the roots of an individual plant free from the lake bed. However, in most cases divers will use their hands to physically remove the root of the plant from the lakebed. Suction harvesting or DASH is also a form of manual removal. Instead of a diver coming to the surface to dispose of invasive plants they hand removed, plants are hand fed into a hose and the entire plant is vacuumed from the diver's hands to the surface. Once the plants reach the surface, a series of bins or bags located on a boat collects the material. These bins/bags allow water to filter out, leaving the entire plant captured. Plants are then disposed of offsite in an upland location. This process improves efficiency allowing the diver to remain underwater for longer periods and minimizes potential for plants to fragment.

Application Considerations for Manual Removal

- Hand removal can be selective
- May minimize the need for herbicide management
- Can be effective when populations are at small scales
- There are no restrictions to water use
- Bottom substrate, under water obstacles and plant abundance affects efficiency
- Low water clarity or visibility affects efficiency
- May not be effective for lakes with very poor water clarity
- May require large economic investment
- Might not be practical for larger areas

- Labor intensive
- Volunteerism levels will vary and would mostly be appropriate for shallow waters only
- Plants can fragment when hand removed
- Check with WDNR on permit requirements

Water Drawdowns

Water level drawdowns intend to expose the targeted species to desiccation. This technique, primarily used in the northern climates, uses desiccation during the freezing cycle to kill the plant.

Application Considerations for Drawdowns

- Consolidates loose sediment
- Cost effective when a water level control structure (outlet) exists
- Submergent species that primarily reproduce through roots and vegetative means may be controlled well for several years
- Low water levels may provide protection to docks and offers an opportunity to complete dock or other shoreland structure repair work
- Some emergent invasive species are known to spread during drawdowns, including common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundianceae*)
- Is expensive if water has to be pumped or siphoned
- May have negative impacts to adjacent wetlands and water wells
- Is not selective and can have adverse impacts to fish and other aquatic life
- May be aesthetically displeasing
- May affect species that are unable to re-locate during water drawn down, including mussels and macro invertebrates.
- Check with MDEQ and WDNR on permit requirements

Mechanical Harvesting

Manual removal with cutters may include dragging a cutting apparatus across the lake bottom or the use of machine-powered pieces of equipment to cut aquatic plant material. The size and cutting depths vary depending on the type of equipment used. There are several types of mechanical harvesting boats, adapted to fit different types of aquatic plants from floating leaf plants along the surface to submergent plants in deeper water. Groups that utilize mechanical harvesters typically either purchase the harvester and staff the boat themselves, or will contract with a harvesting company.

Application Considerations for Cutting and Mechanical Harvesting

- Aquatic habitats are maintained because plants are typically not harvested to the lake bottom
- There are no restrictions to water use
- Efforts are site specific, there is no risk of offsite impacts
- New technologies in harvesting are improving the ability to capture fragments

- Non-selective
- Small fish and other aquatic organisms may be accidentally harvested
- Generally an expensive approach given the size of the operation, accessibility and transport of material to disposal site
- Re-growth of harvested areas occur and may require several cuts
- Fragmentation may lead to the spread of the invasive plant when the overall footprint of the invasive plant is small
- Check with WDNR on permit requirements

Biological Control

Biological control is the use of insects, pathogens or other animals to suppress the growth of another organism. The *Galerucella* leaf beetle has proven successful at reducing purple loosestrife. Larvae feed on the purple loosestrife plants, defoliating the plant and killing it. The weevil *Eurychiopsis lecontei,* native to North America, is used to control Eurasian watermilfoil. Stocking programs typically require a large volume of weevils and will need to be stocked annually for several years, before seeing results.

<u>Application Considerations for Biological Control</u>

- Low risk of inadvertent environmental consequences
- *Galerucella* beetles are relatively easy to raise and stock with the use of volunteers
- *Galerucella* beetles have proven to be very successful in controlling purple loosestrife
- *Eurychiopsis* weevils are naturally occurring in Northern Wisconsin and the Peninsula of Michigan
- *Eurychiopsis* stocking costs are high because of the amount of weevils that need to be continuously stocked over several years
- *Eurychiopsis* stocking programs have been received with mixed results
- Check with WDNR on permit requirements

Chemical Control

All chemicals used to control aquatic plants in the US are approved and registered by the EPA <u>*and*</u> must be registered in the state of use. Of the 300 plus herbicides registered in the US to control plants, only a fraction are registered for use in aquatic environments. The EPA re- evaluates these herbicides every 15 years. Herbicides, chemicals use to control plants, are referred to by their trade name and their common name. A trade name is the name that the manufacturer will call their product, whereas the common name will be what the chemical is. For example, Sculpin and Navigate are two trade names for the herbicide 2, 4-D.

The Northern Region WDNR Aquatic Plant Management Strategy includes best management practices that limit chemical treatments to spring applications to protect native plant species (WDNR, 2007)**.** The thought with early season treatments is to target EWM when it is small and most “vulnerable” and presumed that most native plants species are still dormant. This strategy seeks to reduce impacts to native plants; however, early season treatments may overlap with spawning periods for some fish species. Recent research does suggest that some herbicides commonly used in aquatic plant management may affect the development of fish eggs and embryos (Dehnert, 2019). The use of herbicides can potentially be hazardous and only trained licensed professional applicators should apply aquatic herbicides. For information about aquatic plant control in Wisconsin, please contact the regional aquatic plant management coordinator[7].

Aquatic herbicides are generally grouped into two categories, contact herbicides, and systemic herbicides. Contact herbicides kill only the plant parts contacted by the chemical, where-as systemic herbicides are absorbed by the roots or foliage and translocated (moved) throughout the plant. Herbicide effectiveness is the results of two primary factors. One being the concentration of the herbicide applied and two, being the length of time the target plant is exposed to the herbicide. For herbicides to be effective, plants need to be exposed to a lethal concentration of the herbicide for a period of time. Generally, contact herbicides will require shorter exposure times than systemic herbicides.

Once an herbicide is applied to the water, degradation or the breakdown of the herbicide into carbon, hydrogen and other compounds begins to occur. Degradation pathways include photolysis from ultraviolet light from the sun, microbial degradation by microbes present in the lake and hydrolysis from the action of water breaking apart the herbicide molecules.

Below is a description of a few commonly used herbicides to control aquatic vegetation in Wisconsin. Further information on approved herbicides in Wisconsin can be found in the Aquatic Plant Management in Wisconsin: Strategic Analysis[8].

Diquat

Diquat is a fast-acting contact herbicide that disrupts plant cells and inhibits a plant's ability to photosynthesize. Commonly used diquat trade names in Wisconsin include Reward™ and Weedtrine-D™. Diquat is considered a broad-spectrum herbicide; however, different aquatic plants are susceptible to diquat over a range of concentrations, so some level of selectivity may be achieved. Diquat is generally used for small sites, when immediate results are desired and when dilution may influence the concentration and exposure time. Only partial treatments of bays or ponds should occur to avoid issues with oxygen depletion caused by decomposing vegetation. Effectiveness of diquat is decreased when water is turbid or muddy because suspended sediments inactivate the herbicide faster. Diquat may persist in sediments indefinably, due to its ability to bind to organic matter.

Endothall

Endothall is a broad-spectrum contact herbicide (varying opinions) that inhibits plant respiration and protein synthesis. Two types of endothall trade names include Aquathol® and Hydrothol 191. Endothall is highly degradable and becomes less active when water temperatures are warm. Treating in the early spring when water temperatures are cool can minimize degradation.

[7] https://dnr.wi.gov/lakes/contacts/Contacts.aspx?role=AP_MNGT
[8] https://dnr.wi.gov/topic/eia/apmsa.html

Endothall is typically used to treat small or spot locations; however, recent use has included large-scale early spring treatments and using endothall in combination with other herbicides to control hybrid watermilfoil.

2, 4-D

2, 4-D is a systemic herbicide that is used to control broadleaf plants including non-native watermilfoils. Some trade names for 2, 4-D include Aqua-Kleen, Weedar 64, Navigate, Sculpin and DMA® 4 IVM. This herbicide is a synthetic auxin that mimics a naturally occurring growth hormone in the plant and induces uncontrolled growth in the plant. There are two types of 2, 4-D used in aquatic applications, including dimethyl amine salt and butoxythly ester, and toxicity will vary between the two (WDNR, 2012). High pH in water may reduce weed control. Ester formulations are considered more toxic to fish and some invertebrates at recommended application rates, whereas the amine may be less toxic. It has not been shown to bioaccumulate over time in significant levels in fish tissue (WDNR, 2012). The WDNR, while conducting whole lake low dose applications of 2, 4-D, estimates half-lives, or the time it takes for the herbicide to reach half of its original concentration, between 4-76 days. Slower degradation or longer half-lives were observed on oligotrophic seepage lakes (Nault, 2018).

Triclopyr

Triclopyr is considered a selective systemic herbicide and is commonly used to control broadleaf plants including Eurasian watermilfoil. Like 2, 4-D, triclopyr simulates a naturally occurring growth hormone in the plant, affecting all portions of the plant, including the roots. In Michigan, triclopyr does not carry the same near-shore regulations for use as does 2, 4-D.

Fluridone

Fluridone can be considered both a broad spectrum and a selective systemic herbicide depending on the target concentration used. Fluridone prevents plants from producing pigments that protect the plant from sun damage. Fluridone requires long exposure times, a minimum of 45 days, and is most applicable to whole lake treatments or in situations where dilution can be controlled. The half-life of fluridone varies, however, depending on the lake type and application; half-lives have been reported from several hours to hundreds of days.

Flumioxazin

Flumioxazin is a broad-spectrum contact herbicide that works by interfering with the plant's production of chlorophyll. Flumioxazin is not recommended to be used in very hard-water lakes (pH over 8.5) (WDNR, 2012). It is available in granular form and used to control submerged and emergent floating leaf plants and filamentous algae.

Imazapyr

Imazapyr is a systemic herbicide that works by preventing the plant from producing ALS (acetolactate synthase) enzyme. Plants will stop growing shortly after treatment and develop reddish tints on the tips of the plant. The mode of action (how the herbicide affects/kills the plant) with imazapyr may lead to more resistant plants than other herbicides' modes of action (WDNR, 2012).

Florpyrauxifen-benzyl

A relatively recent registered herbicide, florpyrauxifen-benzyl (trade name ProcellaCPOR) is a new class of synthetic auxin mimics that have a different binding affinity compared to those currently registered. This herbicide is considered a systemic herbicide with reported rapid plant uptake, reducing exposure time requirements.

General Application Considerations for Chemical Control

- May be effective tools in large scale or whole lake management
- Selectivity to control Eurasian watermilfoil may be achieved when certain herbicides are applied at the appropriate concentration and time of the year
- May be more cost effective than alternative management options
- Requires little to no volunteer efforts
- Stakeholder approval varies
- Many herbicides will have water use restrictions
- Many herbicides are not selective
- There are irrigation restrictions with certain herbicide products
- Repetitive use of herbicides may lead to plant resistance
- Large-scale herbicides applied during warm summer months may impact water quality including dissolved oxygen due to plant decomposition
- Dissipation or dispersal of herbicides can occur to offsite areas of the lake
- Non-target impacts to native species can occur. Some native plants are more susceptible to herbicides than others
- Variable results in control can occur with small-scale applications
- Subsequent applications may be necessary to achieve desired control
- Check with WDNR on permit requirements

Considerations for Herbicide Use

As stated above, herbicide effectiveness is the results of two primary factors: concentration of the herbicide applied and exposure of that plant to the herbicide. This concentration-exposure relationship, explored in laboratory research, provides specific concentration-exposure times necessary for adequate plant control. For example, plants would need to be in contact with 2, 4-D applied at 2pmm (ae) for about 24 hours to achieve adequate control (Green, 1990). In a laboratory scenario, the movement of the herbicide off the target treatment area is controlled, whereas in a lake setting controlling for this movement or dissipation is much more challenging. Factors affecting this movement in lakes include the treatment area relative to the lake area, wind, currents, and water depth.

In small scale or spot treatments, where the treatment area is relatively small compared to the total lake area, herbicide exposure time may be limited. In these cases, it is common to use a very high concentration of product to "off-set" low predicted exposure times. Even in these treatment scenarios (using high concentrations of herbicide), rarely is target concentration achieved, suggesting rapid dissipation of the herbicide off site (Nault M. K., 2015)**.** In the above example, laboratory results suggest that 2, 4-D applied at a target concentration of 2ppm (ae) would need 24 hours of contact time to achieve control. In field concentration monitoring during treatments by the WDNR found that not only is the target concentration not achieved; only a small fraction of the applied herbicide was detected after 24 hours.

For large scale or whole lake applications, lower herbicide concentrations may be used because the entire water body is being treated and dissipation of the herbicide off site is not an issue. In these cases, a longer exposure time is can be achieved, but with a lower concentration of herbicide used. A caveat to this is when applying herbicide to multiple spot treatments across a lake. This scenario may result in enough herbicide being dissipated to effectively cause a large scale or whole lake treatment.

Another consideration in the application of herbicides is the occurrence of hybrid watermilfoil—typically the invasive Eurasian watermilfoil hybridizing with one of the native watermilfoils and producing seedling hybrids. Recent research supports some hybrids being less sensitive to the herbicide 2, 4-D and tolerant to fluridone (LaRue, 2012) (Parks, 2016). Furthermore, not all hybrids may respond equally, meaning certain hybrid clones may have various responses to treatment (LaRue, 2012). Rotating the mode of action of the herbicide may reduce the potential of resistance issues. Laboratory analysis of milfoil samples from Crescent Lake confirmed pure strain Eurasian watermilfoil, and no hybrids (GVSU, 2015). This does not mean hybrids are not present on Crescent Lake just the samples analyzed are not hybrid watermilfoil.

Repetitive herbicide treatments that result in non-lethal killing of the target plant species may result in that target species to develop resistance or a reduced sensitivity to that herbicide (USEPA, 2016). Furthermore, these repetitive annual treatments may shift aquatic plant communities from diverse stable communities to low diversity more disturbance tolerant systems. Recent research by the WDNR looking at degradation patterns of commonly used herbicides are finding that on lakes with previous 2, 4-D use, microbial degradation of the herbicide occurs quicker than on lakes that do not have that history of herbicide use. This may suggest that microbial activity on lakes with historical 2, 4-D use have adapted to breakdown 2, 4-D more efficiently than lakes without historical 2, 4-D use. This may be true for other herbicides beside 2,4-D. The judicial use of herbicides should include practices that decrease risk of resistance including minimizing frequent or consecutive applications of herbicides with similar mechanism of action and apply integrated pest management.

Management Considerations-Crescent Lake

Several management techniques discussed above may be feasible on Crescent Lake, however, many would not be applicable at this time including drawdowns and mechanical harvesting. Water level drawdowns without a control structure would be costly and logistically challenging. Mechanical harvesting would be a somewhat costly operation considering the current low density. Benthic barriers would be feasible and appropriate for small-scale application.

The detection of an invasive species, such as EWM, may lead a lake group to respond with intentions of being as aggressive as possible, in hopes to prevent the spread of that invasive species within that waterbody. Many times these tactics create a habitual pattern of repeating management methods. These repetitive tactics may lead to unintended environmental consequences, some known, and some unknown. Continuous use of aquatic herbicides may alter plant communities from those that are species rich and diverse to less diverse dominated by fewer disturbance tolerant species. In addition, repetitive herbicide use with similar modes of action may lead to plant resistance issues. Over time, treatments become less and less effective and more and more herbicide or combinations of several herbicides and adjuvants are required to obtain the same desire in management. Using "cocktails" of herbicides in the management of aquatic invasive plants and the long-term environmental impacts of these "cocktails: in aquatic environment is not well known. These applications often described a positive "synergetic" response. However, many herbicides are not labeled or tested in combination by federal and state agencies, therefore their toxicological interactions are unknown. Meaning the described "synergetic" response may be a more-than-additive response where the effects of the two chemicals combined is greater than the effects of each chemical applied alone (Eg, 1+1 =4). This may provide a desired result in controlling the target species, but non-target effects to native plants and other lake dwelling organisms is unknown. Continuing to balance risk should be a long-term strategic goal for the management of invasive species on Crescent Lake.

Integrated pest management (IPM) is a useful framework when making decisions about invasive plant management. Pests include those organisms that are known to cause harm to the environment and humans. The EPA defines IPM as "an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. This approach uses comprehensive information on the life cycles of pests and their interactions with the environment. Using best available control means, IPM manages pest damage by the most economic means and with the least possible hazard to people, property, and the environment, including the judicious use of pesticides".

Permitting

Aquatic plant management and nuisance control activities require a permit issued by the Wisconsin Department of Natural Resources (WDNR). Depending on the criteria and the type of activity, (chemical vs. DASH) different permits will apply. Please contact the local aquatic plant management coordinator on details before any management activities take place.

Aquatic Plant Management Goals, Guiding Principles & Framework

Eurasian watermilfoil can potentially alter aquatic plant ecosystems and cause recreational use and impairment issues. However not all lakes may experience high populations of Eurasian watermilfoil, particularly in Northern Wisconsin (Nault M. , 2016). Recent WDNR research suggests that across the State of Wisconsin, many lakes do not reach lake-wide high densities, as previously once thought. Nonetheless, it is important to recognize that aquatic ecosystems are dynamic. Annual variation does occur, and further research is needed to understand how lake ecology and climate may play a role in EWM population variability.

Management of aquatic invasive species will provide benefit to the use and ecological function of the waterway and its adjacent watershed. It should include the use of control techniques that support the best use of resources, are best fit and adaptive to address the population at that time and follow well-accepted best management practices. This approach will recognize that current and potential future introductions of invasive species may need continued monitoring and/or management depending on the species, the degree of infestation and location within the water body.

Actions undertaken to manage aquatic invasive species will consider the following guiding principles:

- Provide management aimed at reducing population (abundance and distribution).
- Provide recreational nuisance relief caused by invasive species.
- Improve early detection and response to new aquatic invasive species.
- Continue to monitor and collect baseline data to detect ecological change.
- Improve upon and generate site-specific adaptive framework to manage for and control aquatic invasive species.
- Provide accountability for management actions – management evaluation.
- Reduce risk to non-target species.
- Continue to work towards long term strategies to reduce nutrient and other pollutants that may exacerbate aquatic plant growth.

Using a balance of social perspective, conservation, and acknowledgement of risk to non-target species, annual management objectives using these guiding principles should be adaptive: taking into account the current condition of the invasive population.

Regardless of the options adopted, management will follow well-accepted best management practices including monitoring and an evaluation component. Quantitative metrics are favored, however there are challenges posed with small-scale management, including sampling size (replicates), controls (which are used to verify effects), non-uniform treatments (varying treatment and monitoring dates) and pseudo-replication (sample units not being independent but rather subsamples of the same unit). The degree of statistically verified information regarding management will vary however, it is important to mention these limitations and thus reliance many times on more qualitative monitoring methods.

Specific monitoring recommendations by the WDNR regarding large-scale treatment scenarios in Wisconsin will be followed and may be adapted to smaller scale management based on site-specific ability to address sampling size using a point intercept method.

Generally, monitoring and management evaluations will use qualitative metrics, which collects information that describes the condition of target species rather than using measured or quantitatively calculated values. For example, information collected during monitoring or pre/post evaluation efforts may use a scale from very sparse to dense to describe the condition or abundance of EWM found. The distribution of EWM would be represented by spatially GPS collected information.

An integrative framework is suggested regardless of the management options chosen. This framework uses a combination of management techniques (described above) to manage the invasive species to an acceptable level. Eradication is not a feasible option and should not be the end goal of any management approach. Management of EWM using an integrated approach should look at judicious use of herbicides. Herbicide use will be consistent with applicable WDNR regulations and policy depending on the location within the waterbody.

History of Eurasian Watermilfoil and Association Efforts 2015-2019

<u>2015</u>

In July, a single EWM plant was discovered near the public boat launch. Further investigation by the Oneida County Land and Water Conservation Department found additional EWM locations all within the general proximity of the boat landing. These locations were snorkel pulled by the Oneida County AIS Team. A survey completed later in the summer detected seven colonies of EWM within the vicinity of the public boat launch **(Appendix C).** No other locations on the lake were detected. One sample of milfoil analyzed for genetics by Grand Valley State University confirmed Northern watermilfoil.

<u>2016</u>

All EWM locations detected were contained to the far northwest and northeast shores of Crescent Lake. These sites were targeted with both volunteer and professional hand removal efforts. A total of 41 hours between volunteer and professional efforts was spent hand removing EWM.

<u>2017</u>

EWM expanded to several regions along the north shore of Crescent and to three general regions within the southern basin mainly along the northwest and northeast shore. Volunteers reported over 100 hours of hand harvesting time and 48.5 hours of professional hand harvesting efforts.

<u>2018</u>

EWM continued to expand to several regions around Crescent Lake. The most notable expansion occurred along the far northwest end of the lake, near the boat launch. Late summer EWM mapping detected a total of 15.5 acres of EWM. Lake volunteers spent 451 hours hand removing EWM and contracted an additional 21 hours of professional lead efforts. The Association submitted an application to treat 15.2 acres along the northwest end using ProcellaCOR in 2019.

2019

Regions identified for proposed herbicide use included a 15.2 acre stretch of shoreline along the north end of the lake. Treatment occurred on June 26, 2019 and included an herbicide concentration monitoring component. Concentration monitoring detected Porcellacor™ between 2.3-5.2 ppb within the treatment area and <1 ppb adjacent to the treatment area three hours after treatment. Thereafter, most sampling detected very low herbicide concentrations (<1 ppb) in and adjacent to the treatment area, with a few exceptions. One sites within the treatment area had detectable concentrations (>1 ppb) at 9 and 12 hours after treatment. In addition, one location outside of the treatment area had detectable concentrations (florpyrauxifen-benzyl >1 ppb) at six hours after treatment. Detection at a sampling site outside of the treatment area may suggest movement or dissipation of the herbicide off site, however, to the extent that the herbicide may have dissipated is unclear.

Late summer EWM mapping detected a total of 21.1 acres of EWM. Very little EWM was detected within the 2019 treatment area. Point intercept results detected a littoral frequency of occurrence for EWM at 4.29%. Volunteers reported a total of 213 dive hours hand removing EWM and 11 days of DASH.

2020

The two primary regions of the southern basin treated with ProcellaCOR in 2020 included stretches along the southwest and northeast shorelines. In addition to the herbicide treatment, hand removal efforts included a total of 114.5 dive hours and 23 days of DASH boat operation. Early fall mapping detected 26.3 acres of EWM. In addition to a moderate dense bed, many sparse locations of EWM were detected within the 2019 treatment area.

Figure 2.1: *Change in EWM acreage (polygon and point data combined) from 2018-2020, Crescent Lake.*

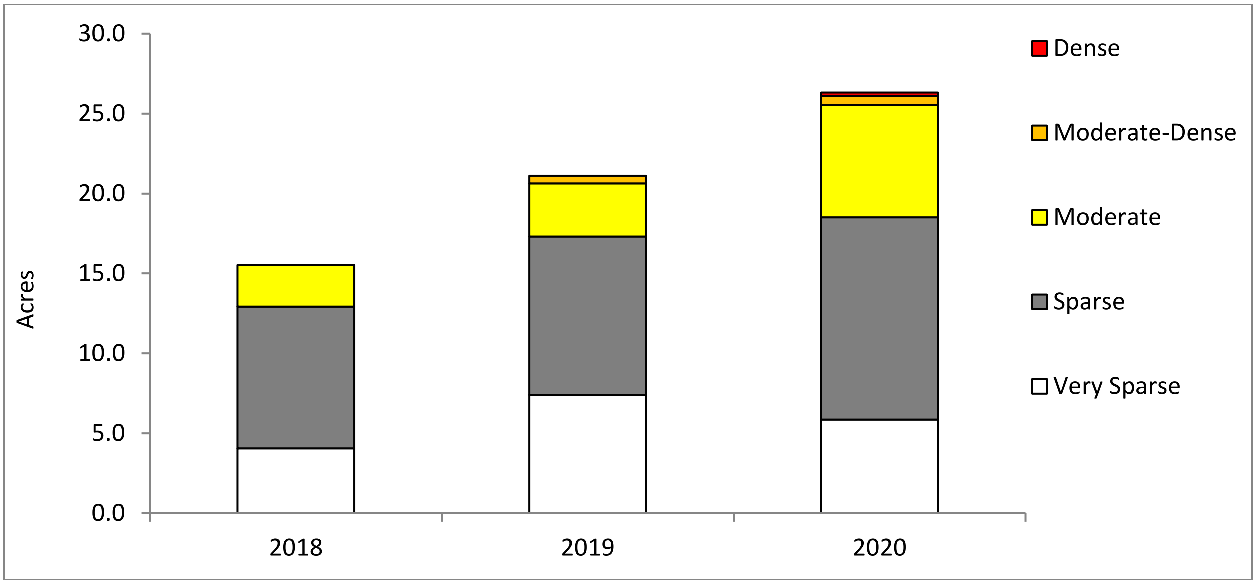


Table 2.1: *Change in EWM acreage (polygon and point data) from 2018-2020, Crescent Lake.*

TOTAL	**2018**	**2019**	**2020**
Very Sparse	4.1	7.4	5.9
Sparse	8.9	9.9	12.7
Moderate	2.6	3.3	7.0
Moderate-Dense	0.0	0.5	0.6
Dense	0.0	0.0	0.2
TOTAL	**15.5**	**21.1**	**26.3**

3 - Shoreland Assessments

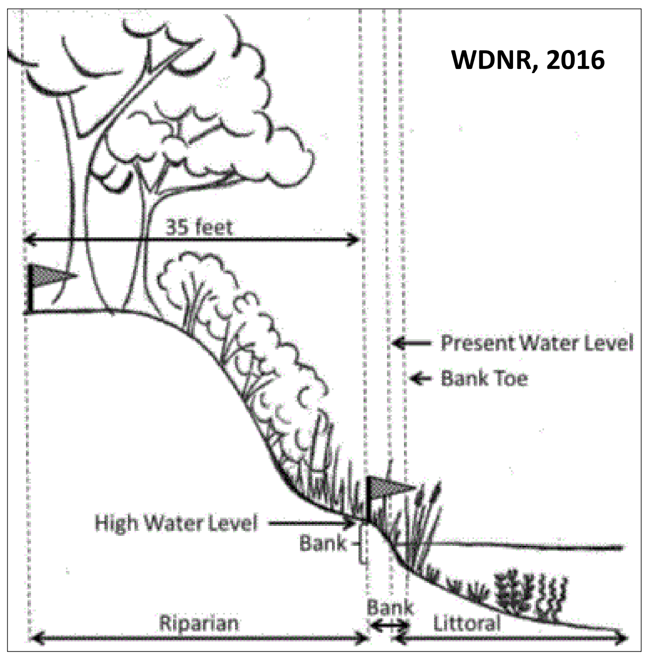
Shoreland Habitat Overview

As lakes become developed, piece-by-piece manipulations of natural landscapes result in fragmentation and loss of critical habitat that many species rely on. By themselves, each of the manipulations may seem insignificant. However, over time, the cumulative effects of these small habitat changes may result in irreversible ecosystem degradation and species loss. Based on the U.S. EPA National Lakes Assessment, lakeshore disturbance is increasing**.** Subsequently lakes with poor lakeshore habitats are three times more likely to have impaired biological conditions (U.S. Environmental Protection Agency, 2009)**.** These disturbances potentially affect water quality, in-lake habitat, and increase the likelihood of spreading aquatic invasive species. A substantial portion of aquatic life depends on shoreland areas to provide shelter, spawning and nursery grounds, and food sources. Understanding the role of shoreland habitats in maintaining lake health allows lakeshore owners to make informed and wise decisions on how to enjoy their place on a lake while continuing to provide a home, shelter, and food for the plants and animals that share this space.

Shoreland Survey Methods

Shoreland assessments conducted by Many Waters, LLC took place in September of 2018 and 2019 and used the WDNR Lake Shoreland and Shallows Habitat Monitoring Field Protocol (WDNR, 2016)**.** This protocol provides standard methodologies used across the State to survey, assess, and map habitat characteristics in the shoreland area. Information from these surveys is useful to stakeholder groups, allowing them to make informed decisions about habitat protection, prioritize restoration efforts, and address potential erosion concerns. In addition, this information may be used for aquatic plant management planning and to understand long-term trends in shoreland habitat and lake ecology.

Figure 3.1: *Lakeshore habitat area definitions.*



This protocol emphasizes habitat features key to lake health and focus on the riparian buffer, bank, and littoral zones **(Figure 3.1).** The riparian buffer zone measures from the observed high water level to 35 feet landward from shore. The bank zone starts where the riparian zone ends and extends lake-ward to the bank toe, which may or may not be underwater. Often piers are anchored to shore in the bank zone. The littoral zone generally starts at the water line and extends into the lake, including the lakebed where most aquatic plant life grows. Low water levels may expose the lakebed; exposed lakebeds are considered part of the littoral zone.

Habitat assessments included three loops around the lake. The first loop took geo-referenced photographs of the entire shoreline in spaced intervals. Photos were not taken when people were present to protect personal privacy. The second loop assessed the riparian buffer, bank, and littoral zones of individual parcels. In cases where multiple parcels are owned by the same entity, one assessment was conducted for each parcel separately. Parcels with condominiums were assessed as one parcel, even though there might be several owners. Spatial data for the Wisconsin parcels boundaries was obtained online from the Oneida County GIS mapping application.

Riparian features documented include:

- Percent vegetation coverage
- Impervious surface coverage
- Listing and description of human structures
- Run off concerns
- Evidence of point[9] and non-point runoff concerns
- Run off concerns present beyond the riparian area

Bank zone characteristics mainly focused on erosion and hardscape (rocks/concrete) armoring including seawalls and rock riprap. Littoral zone characteristics included human structures such as piers, boatlifts, swim rafts, and the presence of aquatic emergent and floating leaf vegetation.

The final loop included a coarse woody debris assessment. This assessment documented all woody habitat located in two of feet of water or less, at least 5 feet in length and 4 inches in diameter. A geo-referenced location was collected for each piece of wood that fit the criteria and a description of the wood was noted. This description includes “branchiness,” which involves ranking each piece of wood from no branches to multiple branches, if the piece of wood touched the shore, crossed the high water mark, or was fully submerged in the water.

Riparian Buffer Zone - Results

Percent cover for each individual parcel assessed included trees, shrubs, herbaceous vegetation, impervious surfaces, manicured lawns, agriculture, and duff. Impervious surfaces are surfaces that shed water rather than absorb water including but not limited to decking, stone, rooftops, and compacted soils. Duff is a layer of leaves, pine needles, twigs, and other natural organic materials. Generally, duff support little to no natural vegetation, but does allow water to infiltrate. No agriculture was observed.

Most assessed properties had a canopy (tree), shrub, and herbaceous layer **(Figure 3.2).** Ninety-two percent of assessed properties had some degree of manicured lawn, covering 26% of the total lake riparian area. Fifty-four percent of assessed parcels had some degree of impervious surface, covering 3% of the total lake riparian area. Compacted soils, mainly from pathways to the lake account for the majority of the impervious surfaces observed. Other observed riparian coverage features included sand and bare soils. Sloping soils followed by trails or pathways to

[9] Point source runoff or pollution is identified by a definable source, such as a pipe

the lake represented the highest observed potential runoff issues recorded. Other runoff issues include high traffic areas, beaches, and lawn fertilization (**Figure 3.2**).

Figure 3.2: *Breakdown of total riparian buffer by riparian coverage type, Crescent Lake – 2019.*

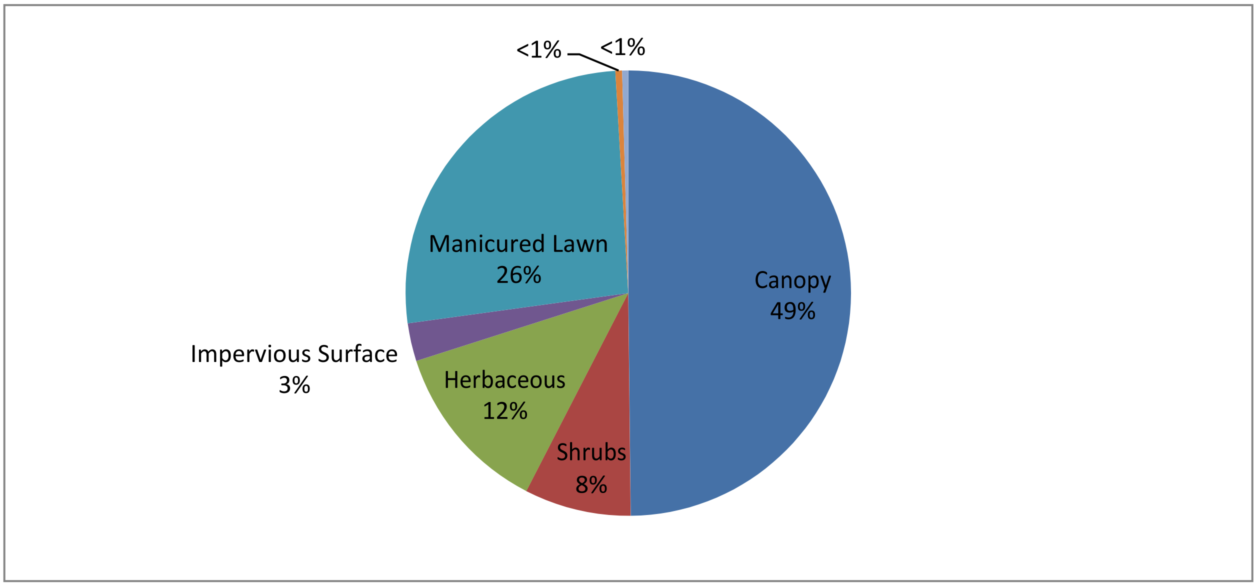
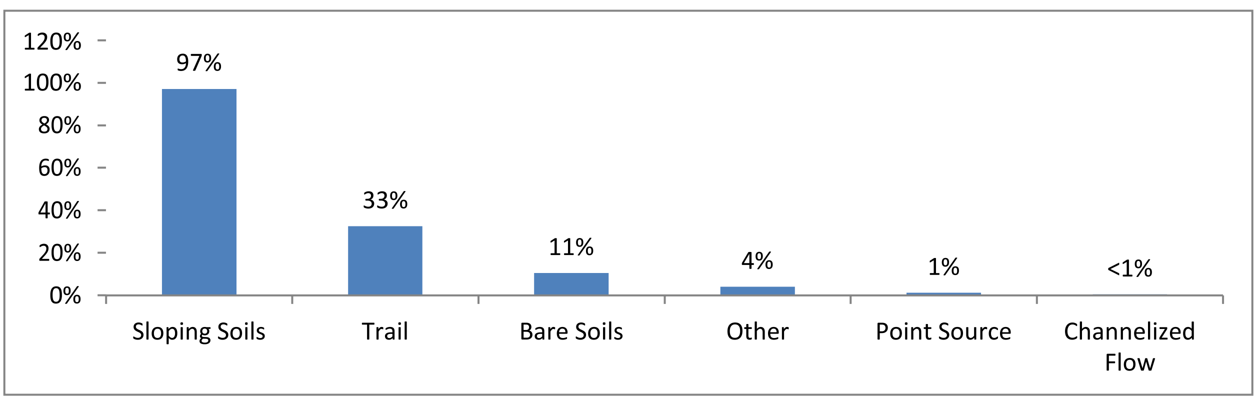


Figure 3.3: *Percent of total properties contributing runoff to the lake by runoff type, Crescent Lake – 2019.*



Bank Zone – Results

Hardscape armoring of bank zones may include the use of vertical sea walls made of concrete or other building materials and more commonly rip-rap or rocks of various sizes stacked along the water's edge. Hardscapes create impervious surfaces, allowing water to run directly into the lake. Hardscapes also disrupt the water-to-shore corridor or transitional areas that many organisms, both aquatic and terrestrial, rely on to live. The most common bank zone modification observed was riprap, observed on 32% of all assessed parcels **(Figure 3.4).** Average length of riprap on Crescent Lake is 61 feet. Of those parcels that had riprap, roughly 23% had this feature across the entire length of their property. Other observed bank zone modifications included bank stabilization using broken concrete, timbers, cement blocks, and railroad ties. Erosion greater than one foot in height within the bank zone was observed on 17% of parcels with an average length of 7 feet. Erosion less than one foot in height was observed on 15% of parcels with an average length of 6.5 feet **(Figure 3.5).**

Figure 3.4: *Percent of properties with observed bank zone modifications by type – Crescent Lake, 2019.*

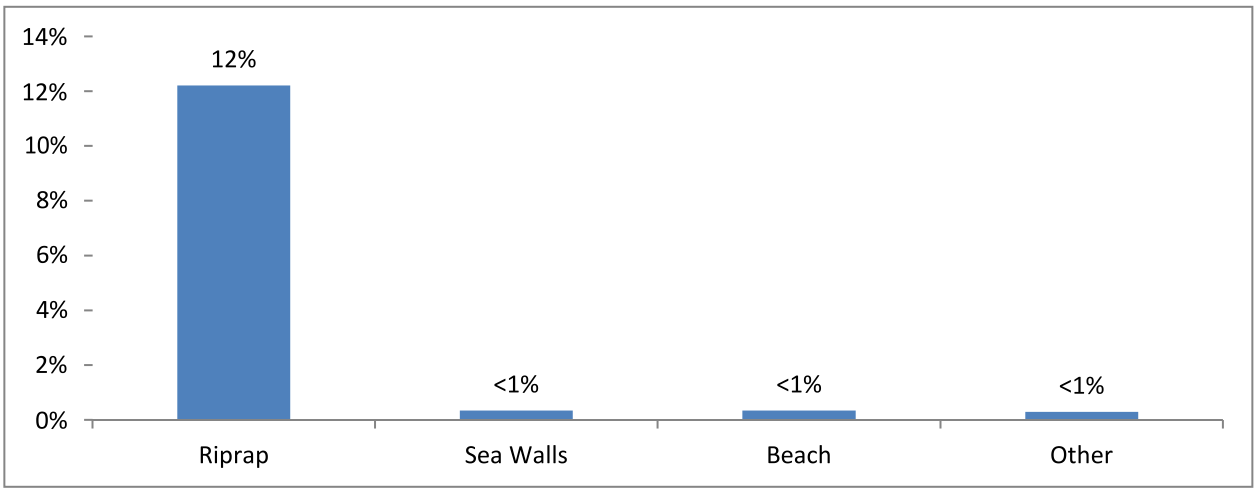
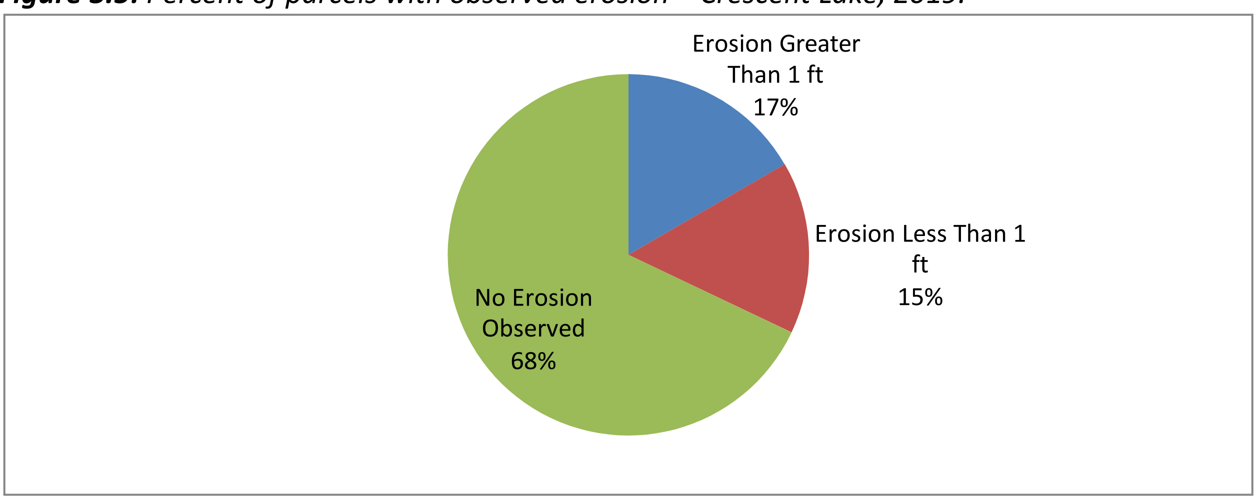


Figure 3.5: *Percent of parcels with observed erosion – Crescent Lake, 2019.*



Littoral Zone – Results

Littoral zone observations included noting the number of piers, boat lifts, swim rafts, and other near shore features. A pier was defined as a "structure leading out from shore into the waterbody." One pier was counted for each access to shore even if the pier split into two or more piers or had a more complex configuration. Ninety-one percent of parcels on Crescent Lake have piers **(Figure 3.6).** Of parcels that had piers, pier density averaged 1.2 piers per property and 36 piers per mile of shoreline (22.37 piers/kilometer of shoreline). Emergent leaf and floating leaf aquatic vegetation was observed along 13% and 7% of parcels respectfully. Emergent and floating leaf plant removal was observed on 31% of parcels where emergent or floating leaf vegetation was identified **(Figure 3.7).**

Figure 3.6*: Percent of properties with observed littoral zone features – Crescent Lake, 2019.*

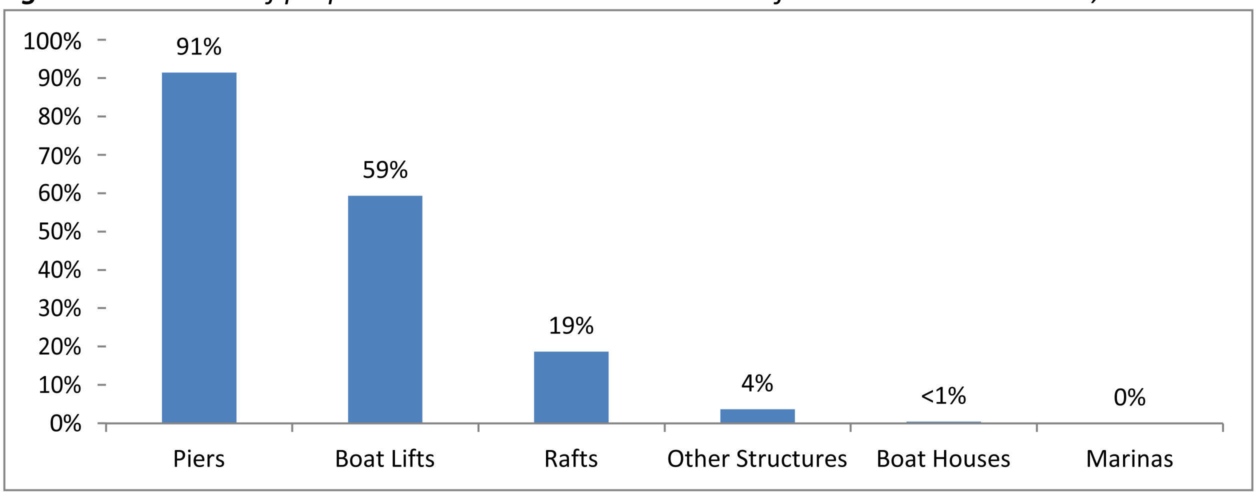
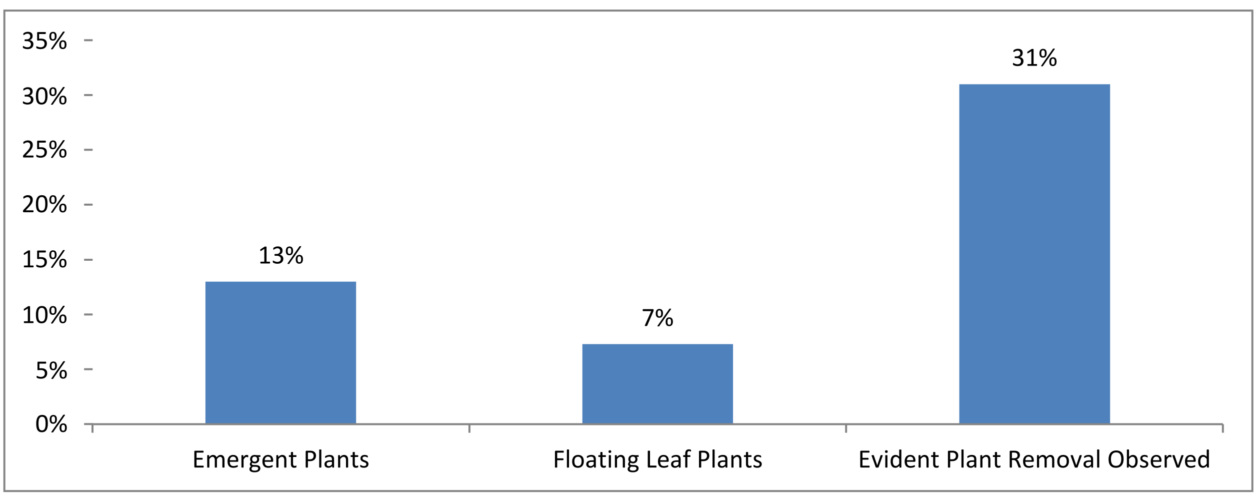


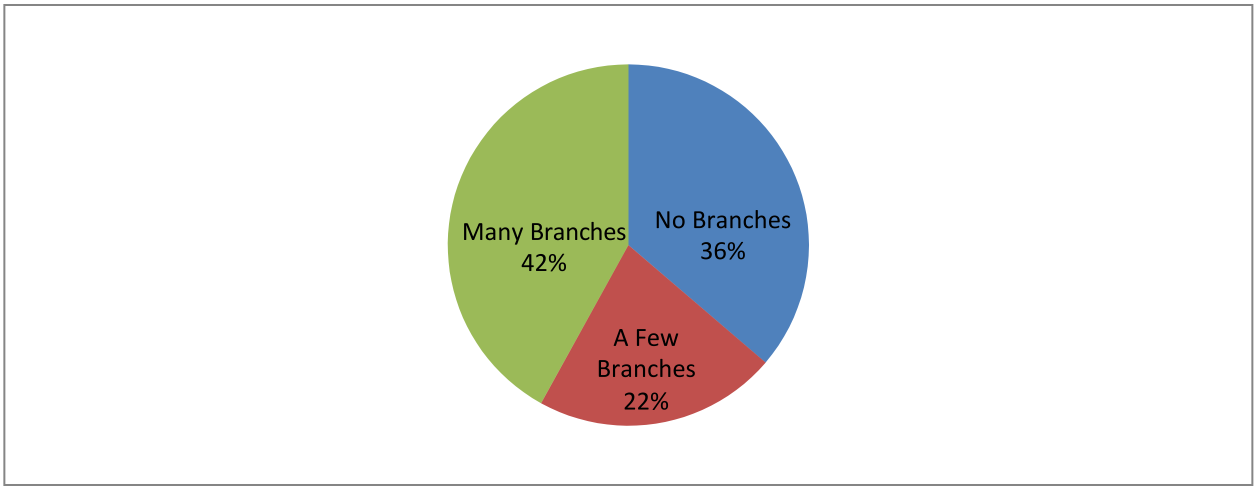
Figure 3.7: *Percent of properties with emergent and floating leaf vegetation– Crescent Lake, 2019.*



Coarse Woody Debris – Results

One hundred and ninety-six (196) pieces of wood that fit the pre-determined categories were recorded on Crescent Lake. Forty-one percent of wood observed had "many branches", followed by 36% with no branches and 21% with few branches **(Figure 3.8).** Forty-two percent of the wood observed crossed the observed high-water level whereas 58% did not. Fifty-one percent of the wood had at least five feet currently underwater, whereas the remaining 49% had less than five feet underwater.

Figure 3.8: *Percent of coarse wood debris by branching type – Crescent Lake, 2018.*



Shoreland Habitat Importance

As stated above, shoreland disturbances are rising on lakes within the Upper Midwest Region, translating to increases in water quality impairments and overall habitat degradation. Over the course of the past 50 years, home building along lakeshore areas in Northern Wisconsin increased. The WDNR estimates that from 1965 to 1995 alone, Wisconsin shoreland building increased on average by 216%.[10]

Shoreland development results in increased runoff, resulting in more phosphorous and sediment to a lake. For comparison, a 100 ft by 200 ft undeveloped lake lot located within an upland forest with sandy-loam soils will add approximately 1,000 cubic feet of runoff, transporting .03 pounds of phosphorus and 5 pounds of sediment to a lake annually. In contrast, the same lot that is developed with a large home, maintained lawn and a paved driveway will add 5,000 cubic feet of runoff, transporting .20 pounds of phosphorous and 90 pounds of sediment to a lake annually.[11] While this comparison is somewhat generalized, it illustrates the potential impact that lake-lot development can have on water quality.

[10] http://clean-water.uwex.edu/pubs/pdf/margin/sld013.htm

[11] http://clean-water.uwex.edu/pubs/pdf/margin/sld038.htm

Maintaining good water quality is important for overall lake health and protects the economic investment lake residents put into their properties. Work by economists at UW Eau Claire on local lakes in Vilas and Oneida Counties (WI) found that water clarity matters to home prices. This study found that a three-foot increase in water clarity translates to an $8,090.87 to $32,171.12 improvement in the market price for the average lake property.[12]

These shoreland assessments provide a wealth of information useful in educating lake residents on the importance of shoreland habitat protection and improvement. In addition, some of this information can be useful when looking at the quality and function of a lake's natural habitat. For example, does pier density or the removal of coarse woody debris affect certain lake organisms? Work completed by the Minnesota DNR found 10 piers per kilometer (or 6.25 piers per mile) of shoreline resulted in substantial shoreline disturbances that negatively affected habitat function and fish communities (Jacobson, 2016). Other work suggests shoreline disturbances began to disrupt habitat function at 5 piers per kilometer (Beck, 2013). Removal of coarse woody debris and alterations to riparian and littoral habitat affect many other organisms as well. Green frog populations are lower on lakes with shoreland development versus non- developed lakes (Woodford, 2003)**.**

The importance of coarse woody debris on fish populations has been studied extensively. A Wisconsin study found that when coarse woody debris was removed from a lake, predator-prey and growth relationships among largemouth bass and yellow perch were negatively affected compared to an unaltered reference lakes (Sass, 2006)**.** This study showed that in the absence of woody debris, bass initially consumed perch at high rates, because of the loss of shelter that coarse woody debris provided to the perch. Once perch availability diminished, bass relied more on terrestrial prey organisms to make up their food diet. The authors suggest that the shift in diet resulted in slower growth of bass in the study lake (coarse woody debris removed) versus bass from the reference lake. Perch populations from the study lake decreased in abundance and showed very little recruitment. (Recruitment refers to the number of young-of-the-year fish that survive to enter the fishery in future years.) Declines in perch resulted from the initial elevated consumption of perch by bass, and the possible reduction of food available to perch caused by the removal of woody habitat. This study is one of many examples that show the intricate relationships between fish and other aquatic organisms, and the links between lake organisms and nearshore habitat.

Shoreland Habitat Considerations for Crescent Lake

Roughly, 98% of the total parcels assessed on Crescent Lake exhibited some degree of human influence, ranging from just a pier or small footpath to highly manipulated shoreland areas. No development was observed on four parcels, of which two are in public ownership including WDNR and Wisconsin Board of Commissioners of Public Lands. Tree canopy, shrubs, and herbaceous coverage on undeveloped parcels ranked higher than on developed parcels **(Figure 3.9).** Other than bare soils observed on the state-owned island, all other observed erosion occurred on properties with dwellings.

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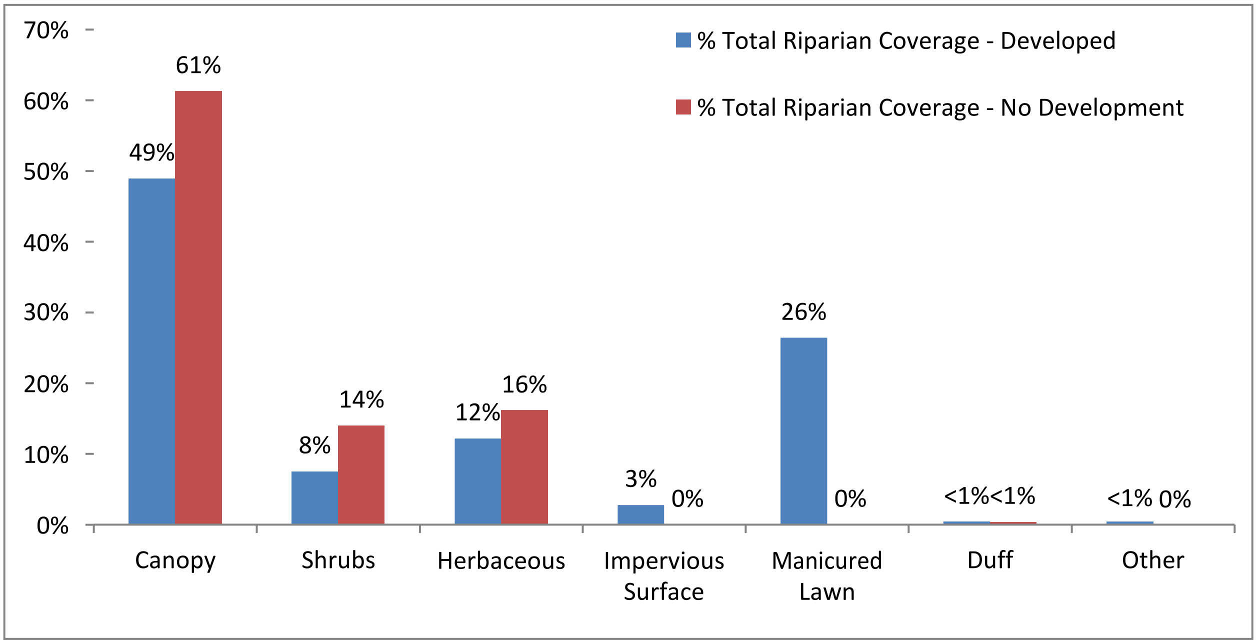
[12] Wisconsin Lakes Convention, 2019. Presentation - Economic Data on Oneida and Vilas County Waters. Thomas Kemp, Department Chair, and Professor of Economics, UW-Eau Claire.

Figure 3.9: *Comparison of average riparian coverage of undeveloped versus developed parcels – Crescent Lake, 2019.*



Pier density on Crescent Lake averaged 1.10 piers across all properties, with an average of 22.37 piers/km (36 piers/mile). The highest pier density observed on any individual parcel was 3 piers. Pier densities considerably exceed the described "threshold" of 10 piers per kilometer.

Coarse woody debris (CWD) provides a multitude of habitat functions to lakes. Coarse woody debris enters a lake from fallen snags, weather events, and logging activities. Generally, lakes with more trees along the riparian area have reserves and the potential to replace woody debris in a lake, once older wood decomposes. As dwelling density around a lake increases, the number of riparian trees and pieces of CWD in the lake decrease (Christensen, 1996). Studies on lakes within Northern Wisconsin and the Upper Peninsula, comparing coarse woody debris around undeveloped and developed lakes, show that as dwellings increase, the total amount of coarse woody debris in the littoral area diminishes. The amount of CWD per kilometer of lakeshore on undeveloped lakes in this study ranged from 338 to 965 pieces per kilometer of shoreline. On lakes with a mixture of properties with and without shoreland dwellings, CWD per kilometer varied from 48 to 637 pieces of wood per kilometer of shoreline. Crescent Lake's estimated density of CWD is ~16 pieces per kilometer of shoreline (26 pieces/mile). It is important to note that the survey methods from the example study and the data collected on Crescent Lake vary, and should not be a direct comparison, but rather provides an illustration on the overall importance of CWD to a lake.

The 2007 Crescent Lake Management Report (Ayres Associates, 2007) describes the shores of Crescent Lake as “fairly heavily developed,” with very little non-developed shorelines. This condition still exists today, as the most recent shoreland assessment supports observations of very few natural parcels. Most of the understory which consists of herbaceous and woody (shrub) plants have been removed and replaced by lawns. In the 2007 report, a survey of landowners included some questions regarding their shoreline practices and perceptions. Questions included topics lawn maintenance, degree of natural shoreland vegetation and dwelling density. Eighty-five percent of respondents indicated that they maintain some lawn and the majority (54%) do not fertilize. The recent shoreline assessments suggest that about 92% of parcels maintain some degree of lawn. Though not a direct relationship, this information may suggest an increase in the coverage of lawns within the riparian area. Over half (58%) described their shoreline best as an undeveloped natural landscape, followed by lawn (29%) and rock rip-rap (19%). The 2007 assessment estimated 8.8% of total shoreline (linear measurement) as either lightly developed or no developed. The recent shoreland assessment did not rank parcels on a scale of undeveloped to developed, but rather measured many aspects of shoreland health. Very few parcels would be considered undeveloped to “lightly developed.” Minus trees, which average about 44% of the total riparian coverage across all properties, a great degree of natural vegetation in the riparian area has been removed. The survey (2007) also found that the majority feel that shoreland housing is about right (54%), whereas 36% thought it was too much. Recent shoreland surveys estimate 128 structures within the riparian zone, averaging 10 structures/kilometer (17 structures/mile). Estimated structures observed across all parcels (riparian and non-riparian) totaled 456, averaging 38 structures/kilometer (61 structures/mile). Structures may include, storage lockers, homes, garages, outbuildings and are permanent, not easily moved.

4 - Water Quality

Overview and Importance

Why is it important to collect information on water quality? **Lille and Mason (1983)** describe three general reasons (1) assess water quality conditions for current/immediate management purposes, (2) document existing conditions to assess changes over time and (3) "gain a better understanding of the factors and interrelationships which affect water quality in lakes." Immediate management or actions may be needed for issues relating to health and human safely, for example blue-green algae blooms. Having a long-term record of specific water quality parameters also helps resource managers and lake stewards understand water quality trends and changes that may be occurring within the lake over time. For instance, to detect a 15% change in average phosphorous concentrations and 20% change in water clarity in a lake, 10 years of consecutive monitoring is required (National Park Service, 2008).

WDNR Water Quality Standards and Assessment Process

Three general elements guide water quality standards for Wisconsin waters, including designated waterbody uses, water quality criteria, and anti-degradation provisions. Designated uses define goals for that water body based on water body use and include fish and aquatic life, recreational use, public health and welfare and wildlife.[13] To determine if a waterway meets these goals, specific water quality criteria using numerical (quantitative) values or narrative (qualitative) criteria are used. Numerical data designates acceptable values whereas the narrative criteria[14] describes water conditions that are unacceptable such as nuisance algal blooms, floating solids, scum or conditions that interfere with public rights. Anti-degradation policies maintain and protect existing water quality condition, to prevent water quality degradation when reasonable control measures are available.[15]

Wisconsin uses a tiered approach to water quality monitoring. Beginning at Tier 1, baseline monitoring collects information across the State to establish water quality trends. Using this data, Tier 2 – site-specific monitoring follows up on specific water bodies that may have potential water quality issues. If specific water quality issues are identified, these water bodies may be place on the State Impaired Waters List. The final tier, Tier 3, includes following up on impaired waters that are making water quality improvement.

Using data from the tiered monitoring strategy, a waterbody is assessed to determine if the water quality condition meets the criteria for designated use. This assessment describes a continuum of water quality conditions from "excellent" to "poor." Excellent means the water body fully supports designated uses whereas poor would mean a waterbody is not meeting water quality standards for a designated use.

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[13] NR 102, Wis. Adm. Code

[14] NR 102.04(1) Wis. Adm. Code

[15] NR 102.05(1) Wis. Adm. Code

A lake's general condition is assessed by comparing the lake's natural community type to a tropic state index (TSI) or lake productivity. The WDNR recognizes 10 natural community types for Wisconsin Lakes. Crescent Lake is considered a deep lowland lake. Deep lowland lakes usually are drainage lakes that stratify. The **trophic state index** uses measurements for lake **water transparency**, **total phosphorous** and **chlorophyll *a*** to determine trophic status.

Water transparency, or clarity, is measured using a secchi disc, which is an 8-inch disk painted black and white and attached to a long rope. Measurements are taken by lowering the disk into the water until it just disappears out of sight and then slowly raising the disk until it barely becomes visible. The average of the two depths is recorded, typically in feet. Water transparency is affected by several factors including the abundance of algae, (which can vary throughout the growing season,) and suspended materials such as silt and other particulate matter dissolved in the water.

Phosphorous is the nutrient most responsible for excessive aquatic plant and algae growth. Some sources of phosphorous are natural but many are from human activities on the lake and in the surrounding watershed. Total phosphorous in natural waters is often expresses as a concentration, for example milligrams/liter.

Algae abundance is difficult to measure directly, so it is common to measure the green pigments or the **chlorophyll *a*** in algae, which is responsible for photosynthesis. Chlorophyll *a* values are also representation as a concentration, similar to phosphorous.

Using water transparency, total phosphorous, and chlorophyll *a* measurements, a trophic status value for each parameter can be calculated. Based on those values, lakes are divided into three general categories: oligotrophic, mesotrophic and eutrophic. Oligotrophic lakes are generally deep, clear lakes that are low in nutrients and have relatively few aquatic plants and algae. These lakes may support a desirable game fishery, but because they are low in nutrients, may not support a large fish population. Eutrophic lakes typically have high levels of nutrients, aquatic plants, and algae. Seasonal algae blooms and dense plant growth during certain times of the year are common. Moderate eutrophic lakes often support an abundant fish population, though winterkill can be a serious problem. Mesotrophic lakes fall in between oligotrophic and eutrophic lakes. The WDNR considers Crescent Lake to be a mesotrophic lake **(Figure 4.1).**

Figure 4.1: *Crescent Lake's trophic status based on water transparency, total phosphorous, and chlorophyll a.*[16]

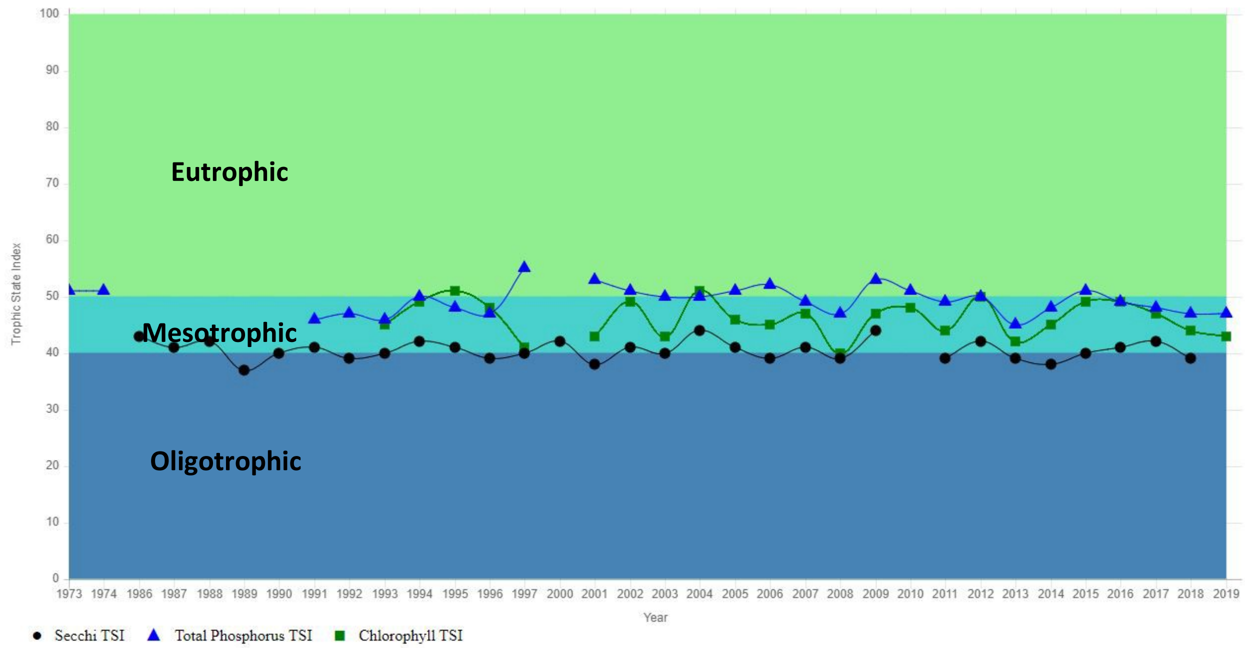


Figure 4.2: *General condition assessment for designated lake use – Crescent Lake 2019.*

Comparing TSI values to Crescent Lake's natural community type, Crescent Lake's general condition is considered excellent, meaning water quality parameters are at or below designated thresholds assigned to that lake **(Figure 4.2).**

Water Quality Trends

Water quality records on Crescent Lake date back to 1973, with varying degrees of data early in the record and annual reporting to WDNR starting in 2000. Over this time, total phosphorous has remained somewhat consistent **(Figure 4.3).** Whereas there is a general trend of increasing water transparency and decreasing chlorophyll *a* **(Figures 4.4-4.5)**. The exact reason for these trends is unknown. However, cyclic patterns in weather, ground water influence, presence of invasive mussels, such as zebra mussels may possible.

[16] https://dnr.wi.gov/lakes/clmn/reports (Accessed 1.30.20)

Figure 4.3: *June 1st - September 15th average total phosphorus concentrations (ug/l) from 1973 to 2019 – Crescent Lake.*

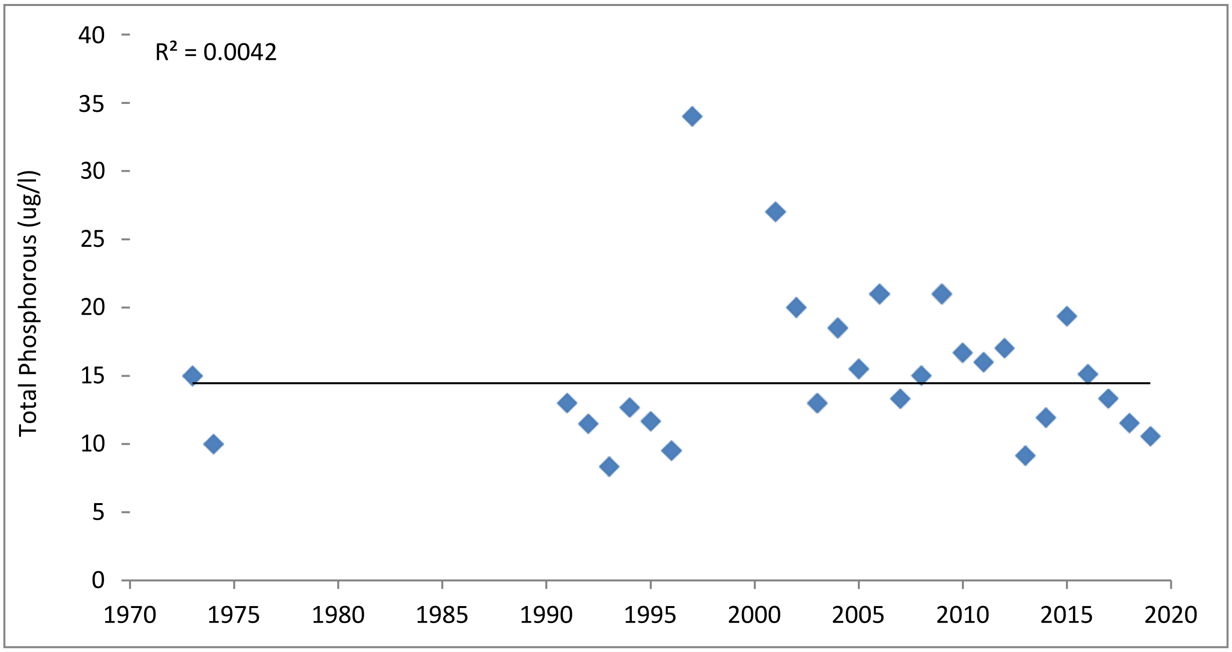


Figure 4.4: *July 15th- September 15th average secchi (ft) from 1993 to 2019 – Crescent Lake.*

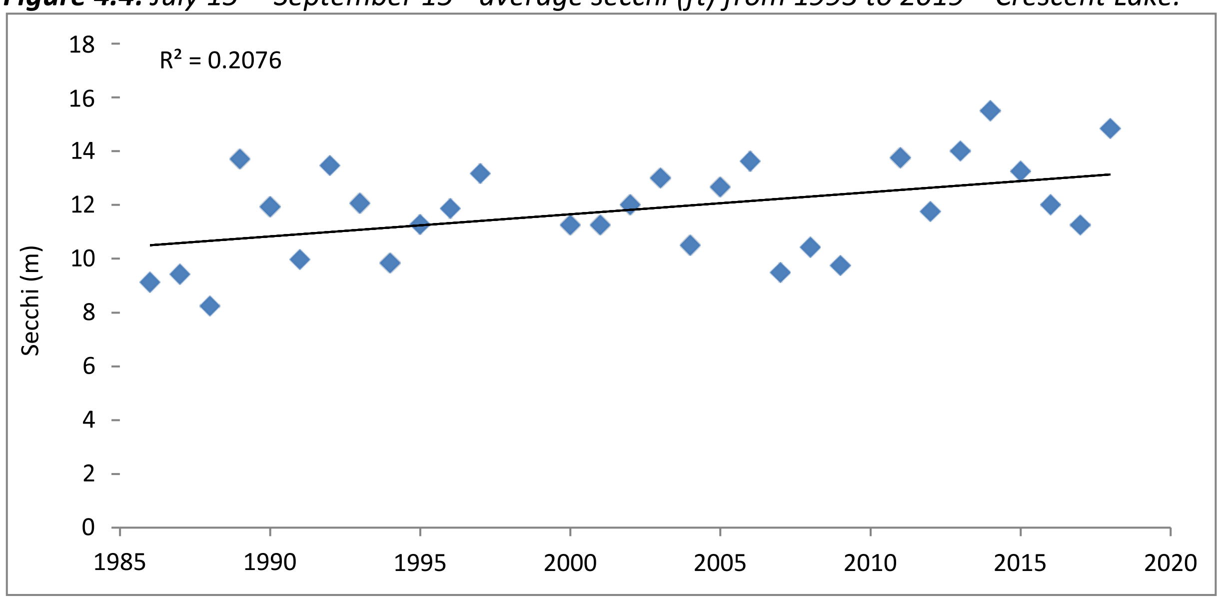
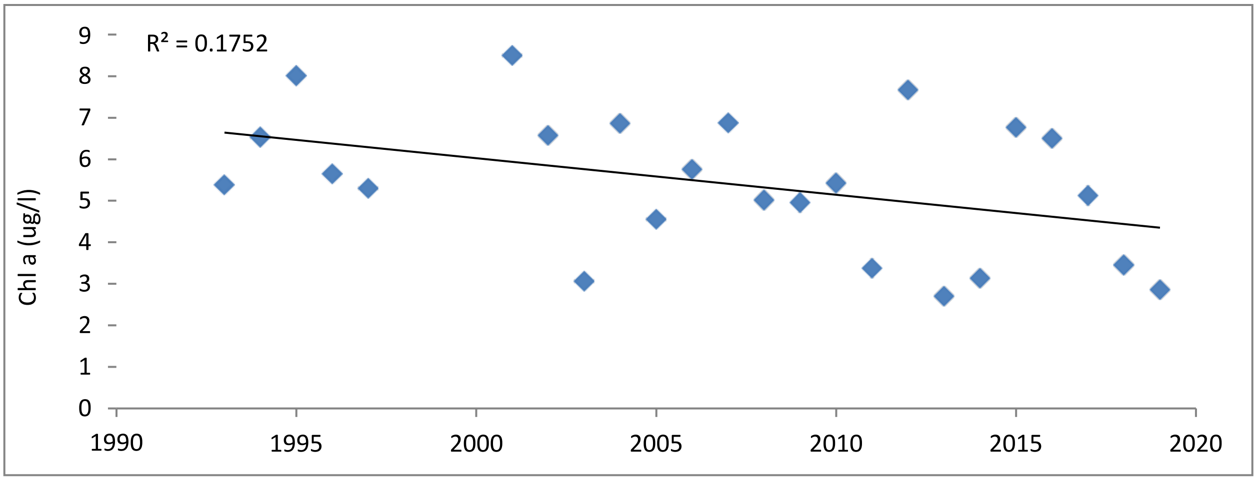


Figure 4.5: *July 15th -September 15th average chlorophyll a concentrations (ug/l) from 1993 to 2019 – Crescent Lake.*



Phosphorous and Nitrogen Relationship

In most Wisconsin Lakes, phosphorous is the key nutrient for plant and algae growth. Excessive phosphorous in lakes may allow plants and algae to grow excessively. Phosphorous in lakes comes from a variety of sources, most of which are results of human activity. These include soil erosion from poor land practices, runoff from the surrounding landscape, septic systems, and detergents.

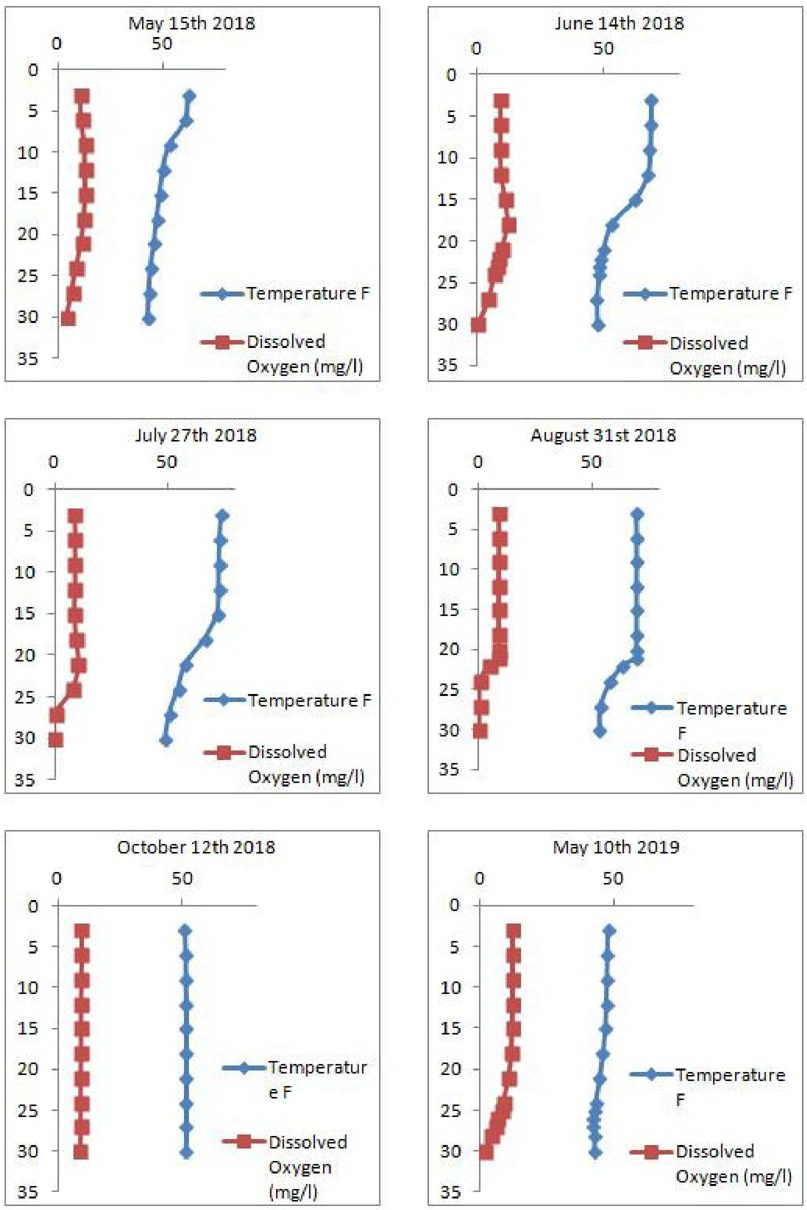
After phosphorous, nitrogen is the second most important nutrient for plants and algae. Sources of nitrogen in a lake vary and include atmospheric inputs from rain and ground water and surface water runoff from the surrounding watershed. Mineral soils, created by weathered rocks, do not naturally contain nitrogen. However, organic soils, created by decomposing plants and animal materials do. This is important because the amount of nitrogen in a lake may be directly related to the types of human activities within the watershed. Watershed sources of nitrogen include fertilizers, animal waste from agricultural practices, and human waste from sewage treatment plants and septic systems.

The nutrient in the shortest supply to algae in a lake is considered the limiting nutrient because it limits growth of algae in a lake. For most lakes in Wisconsin, phosphorous is the limiting nutrient. To determine if a lake is nitrogen limited or phosphorous limited, the ratio of nitrogen to phosphorous is used. Nitrogen limited lakes have a N/P ratio of less than 10:1, whereas phosphorous limited lakes have a N/P ratio of greater than 15:1. Lakes that fall in between these two ratios are considered transitional. Based on recent water quality data (2018) Crescent lake is phosphorous limited with a ratio of 29:1.

Dissolved Oxygen

Most aquatic life depends on oxygen, making it one of the most important dissolved gases in a lake. The amount of dissolved oxygen present in a lake is influenced by winds (which mix lake water - exposing it to the atmosphere), groundwater, amount of surface water entering a lake, and biological activity. Lake stratification, or thermal separation of warmer surface waters from deeper cooler waters, affects dissolved oxygen. In lakes that strongly stratify, the water above the thermocline remains oxygenated due to continued mixing with the atmosphere and oxygen production by plants and algae. Below the thermocline, the waters are cooler, and oxygen levels will decline throughout the summer months due to lack of atmospheric input and respiration from organisms that consume oxygen. In lakes that continuously mix, dissolved oxygen and temperature will remain similar from top to bottom, depending on the time of year. Dissolved oxygen and temperature monitoring suggests that Crescent Lake stratified during the open water season.

Figures 4.6- 4.11: *Dissolved oxygen and temperature profiles 2018-2019 – Crescent Lake.*



pH – Lake Acidity
pH measures the acidity of water. Values range from 0 - 14, where “0” would indicate high acidity, “14” would indicate high alkalinity and “7” would be considered neutral. Natural lakes in Wisconsin range in pH from 4.5 in acidic boggy lakes to above 8.4 in hard water/marl lakes (Shaw B. M., 2004). pH on Crescent Lake (2018) measured 7.8 This is within the normal range for natural lakes (Horne, 1994).

Lake water acidity is an important part of a lake’s carbonate system. Simply put, a lake’s carbonate system has a variety of naturally occurring chemical reactions that affect a lake’s ability to buffer acid rain, regulate the solubility of many toxic compounds, and affect basic biological processes. Most rainwater in Northeastern Wisconsin ranges in pH from 4.8 to 5.1.[17] Without a lake’s carbonate system, helping raise pH levels from (buffering) water sources to a lake, biological processes in a lake would be affected. Lower pH levels in water allow metals such as aluminum, mercury, and zinc if present in the lake sediment or watershed soils to become soluble. High levels of mercury and aluminum are toxic to fish and may be harmful if consumed by humans and other animals such as loons, eagles, and ospreys. Acidic pH levels (<7) may inhibit fish spawning in some species, including walleye and lake trout and at very low pH levels many fish species just cannot survive.

Lake Alkalinity – Hardness
Alkalinity measured as $CaCO_3$, measures water’s ability to resist changes in pH and predicts a lake’s overall sensitivity to acid rain. Like pH, it is an important component of a lake’s carbonate system. Hardness is simply the amount of dissolved calcium and magnesium in the water. Minerals in the soil and bedrock influence lake alkalinity, and hardness. Soft water lakes, which are lakes with hardness values of less than 60 mg/l of $CaCO_3$, are common in Northern Wisconsin, due to types of glacial deposits and minerals present. Crescent Lake’s (2018) alkalinity levels measured 38.1 indicating a soft water lake with low sensitivity to acid rain (Shaw B. M., 2004).

Other water quality parameters
The underlying bedrock of a region directly influences the amount of calcium and magnesium in a lake. Lakes with limestone and dolomite bedrock layers, mainly in southeastern Wisconsin, account for the highest calcium and magnesium lakes in Wisconsin, with values 40 mg/l or greater for both calcium and magnesium (Lille & Mason, 1983). Similar limestone and dolomite bedrock exist in the eastern portion of the Upper Peninsula of Michigan, from Dickinson County eastward. Fifty five percent of Wisconsin Lakes have calcium levels of less than 10 mg/l whereas 77% of Wisconsin lakes have 20 mg/l or less. Most Wisconsin Lakes (77%) have magnesium levels below 10 mg/l (Lille & Mason, 1983).

Calcium and magnesium levels for Crescent Lake (2018) measured 10.9 mg/l and 3.69 mg/l respectfully. Lake suitability research suggests that calcium may predict the ability for zebra mussels (a major invasive species) to colonize a lake. Based on calcium levels of less than 10 mg/l, Crescent Lake is considered borderline suitable for zebra mussels (Papes, 2011).

[17] Taken from https://water.usgs.gov/edu/ph.html

5 - WATERSHED

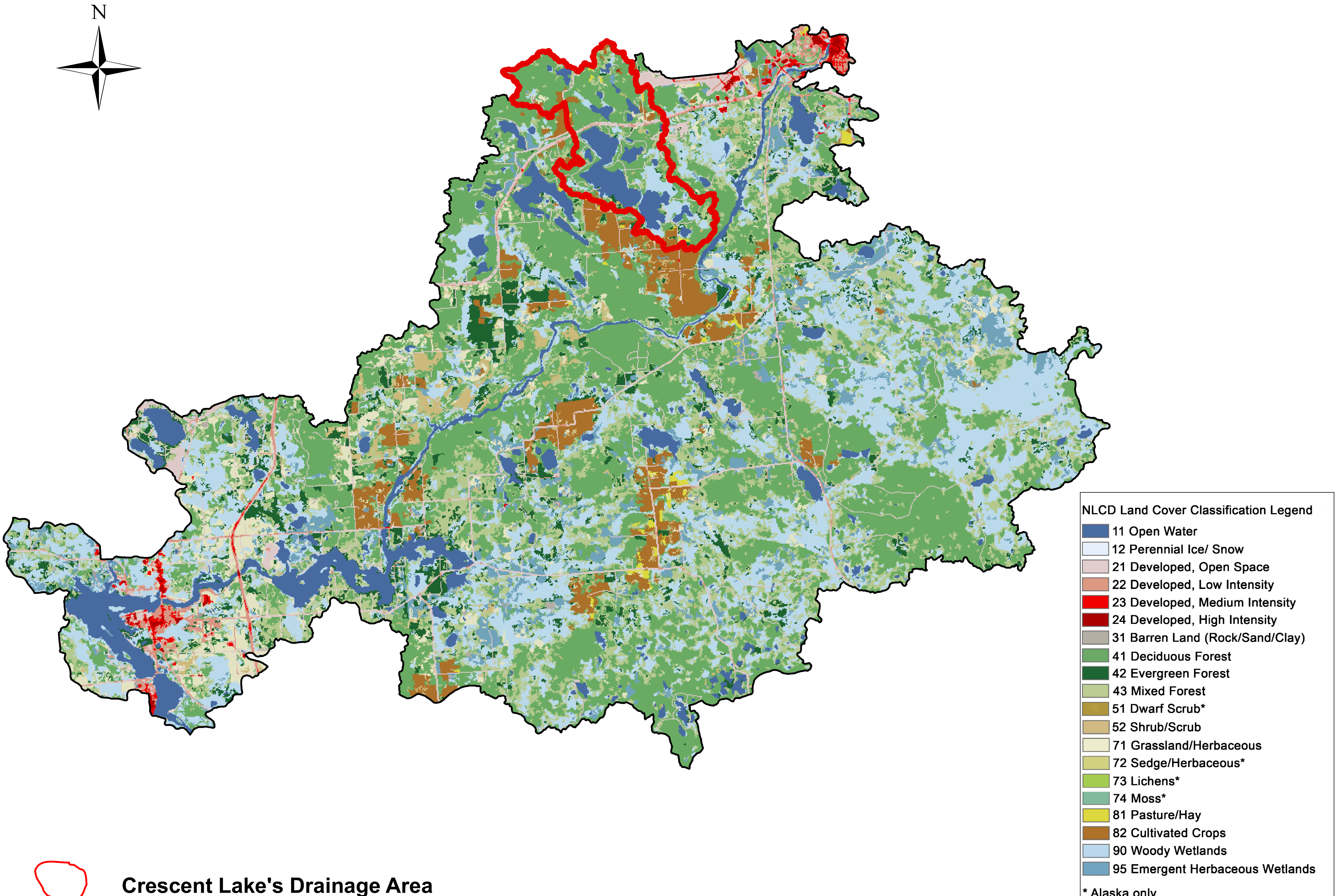
A watershed is an area of land where all water drains and collects at a central location, to a river or lake at a lower elevation. Land use in the surrounding watershed is important to lake health because water flowing across the land picks up pollutants such as nutrients and sediment that may run off into a stream or lake. Pollutants are broadly categorized as point sources and non-point sources. Point sources originate from a distinct location, such as a wastewater treatment plants; they are traceable to the source. Point sources are often monitored with state and federal permit requirements. Non-point sources do not originate from a distinct location. Thesesources typically come from precipitation and run-off, but can come from groundwater. Examples of non-point pollution sources include water running down a driveway or across a lawn.

A lake's hydraulic residence time is the time required to refill a lake with its natural water inflow. The size of the lake, watershed, and sources of water to a lake affect residence time. If a lake is relatively shallow, with a high inflow of water, residence time may be short. Whereas in deep lakes with low to minimal water inflow, residence time may be very long. Longer residence times allow nutrients from runoff and other pollutants to accumulate in a lake, versus short residence times, which flushes lakes of nutrients and pollutants. Crescent Lake's residence time will range between 530 to 2,200 days.[18]

Factors that contribute to the amount of nutrients and other pollutants that enter a lake include the size of the watershed and land cover/land use within the watershed. The drainage area to lake area ratio (DA/LA) looks at the how many acres of land drains to each surface water acre of a lake. Lakes with large ratios (7-10 acres of land drainage per acres of water) typically have more inflow of nutrients and pollutants than lakes with relatively small ratios (Holdren, 2001)**.** In addition, lakes with large ratios will typically have shorter residence times, allowing nutrients and other pollutants to flush out. Lakes with small ratios typically have a much longer residence times, holding pollutants, and other nutrients longer. In these cases, land practice improvements to mitigate water quality issues may take many years to see any change in water quality. In very large drainage area to lake area ratios (>10/1), land cover plays a role, but the sheer amount of land contributing run-off to a lake may drive characteristics of a lake regardless of land cover. For example, lakes with largely forested watersheds may have higher nutrient levels, even though most of the watershed remains undeveloped. Crescent Lake's drainage area to lake area ratio is ~8/1**.** Total annual phosphorous loads to Crescent Lake's drainage area based on WDNR estimation tools ranged from 323 to 1,503 pounds/yr (WDNR PRESTO, 2013) **(Appendix D)**.

[18] WILakeData03292016 excel workbook

Lake Mohawkin-Wisconsin River Watershed



6 - LAKE USER SURVEY

A lake-user survey gains a better understanding of stakeholder demographics, knowledge, and interest on a variety of lake topics and issues. General information collected includes property ownership and use, recreational use of the lake, and knowledge about water quality, fisheries, aquatic habitats, and invasive species. Data helps lake owners understand what is important to the lake group including environmental and social concerns and assist in defining plan goals and objectives. Furthermore, these results assist in creating a well-rounded action plan catered to the needs and issues of Crescent Lake.

When deciding which lake-user groups to learn from, members of the lake planning steering committee considered both demographic and geographical scopes including daily lake users, non-riparian owners with specific interest or connection to Crescent Lake and all property owners within a certain radius of the lake. The committee concluded the stakeholder group for this survey most beneficial to learn would be immediate lake property owners. Additional surveys to reach out to a larger lake community were considered and included attendants of the Crescent Lake Bible Camp and boaters using the public boat launch. Learning from these and other stakeholders may be priorities for plan updates, especially for proposed changes to resource management and land use. In addition, conclusions from this planning project may identify other stakeholder groups, not initially identified, to learn from to meet project goals and objectives.

Survey development began with a draft of broad questions covering a number of lake topics. Committee members reviewed each question, keeping those most relevant to Crescent Lake and added questions specific to Crescent Lake. With guidance from the WDNR, a series of mailings to each property owner on Crescent Lake occurred May 2019. The initial mailing included a cover letter, a copy of the survey and specific instructions. In addition to the mail in survey, an on line option to fill out the survey was included. Two hundred and fifty eight surveys were mailed. One week after the initial mailing a follow-up postcard reminder to all recipients was sent. Two-weeks after the initial mailing, a final mailing to those whose surveys had not been returned was sent with an additional copy of the survey. Of the 258 surveys delivered, 179 were returned. Several surveys were undeliverable or sent to a previous owner. With these corrections, a total of 211 surveys were correctly mailed and 146 surveys were returned. Two surveys were returned completely blank and were not included in this analysis. Return rate was 68%. Several questions under property ownership and lake health, respondents circled multiple answers. In these cases, the total returned responses exceed 144. In the case of lake health, those that circled multiple responses generally circled unsure in addition to another response.

Property

Most property owners (49%) are year-round residents, whereas 32% indicated seasonal use of their property **(Figure 6.1).** Roughly 25% indicated between 26-40 and 0-5 years of property ownership **(Figure 6.2).** Days spent at each property ranged from 1 to 365 days, with most respondents indicating 351-365 days **(Figure 6.3).** On average 1-2 people are present when the property is in use. About 90% of respondents indicated they are current Lake Association members and 49% indicated they do not attend Association meetings or gatherings **(Figures 6.4-**

6.5). Most properties (76%) use a conventional septic system and have their system pumped every 2-4 years **(Figures 6.6-6.7).**

Figure 6.1: *How is your property used?*

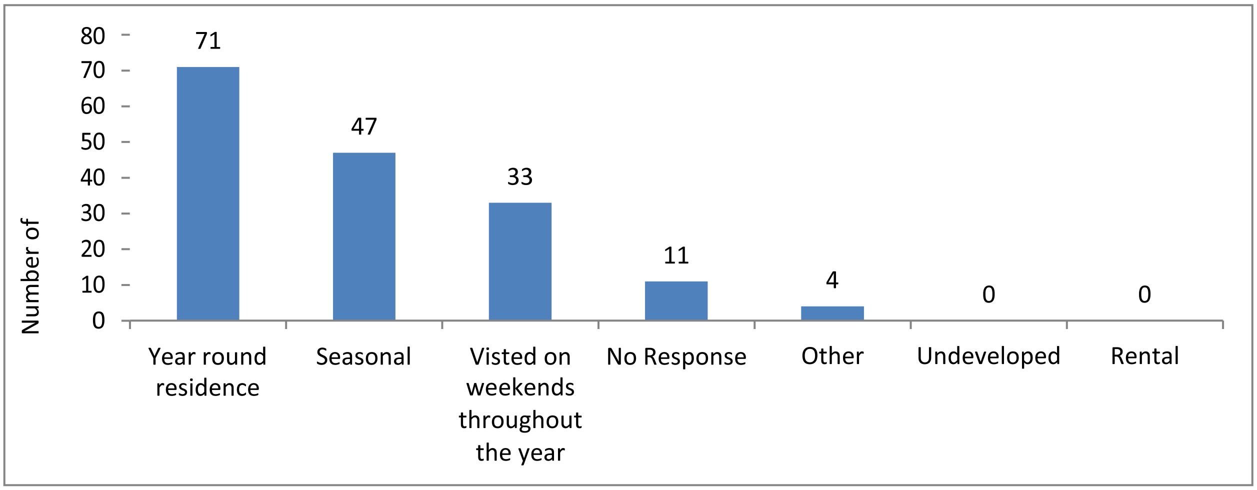


Figure 6.2: *How long have you owned property on Crescent Lake?*

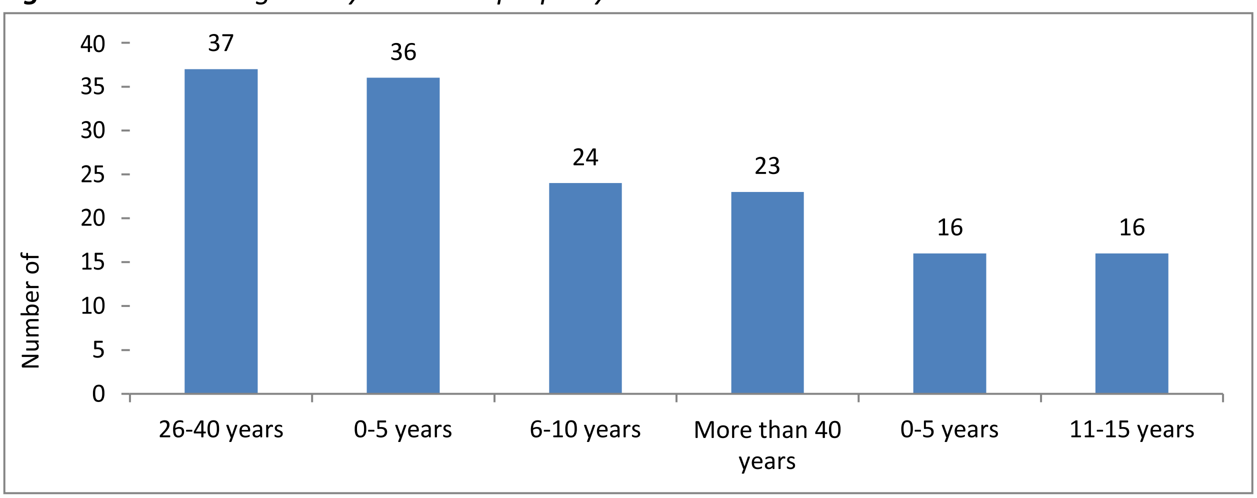


Figure 6.3: *How many days a year is your property used?*

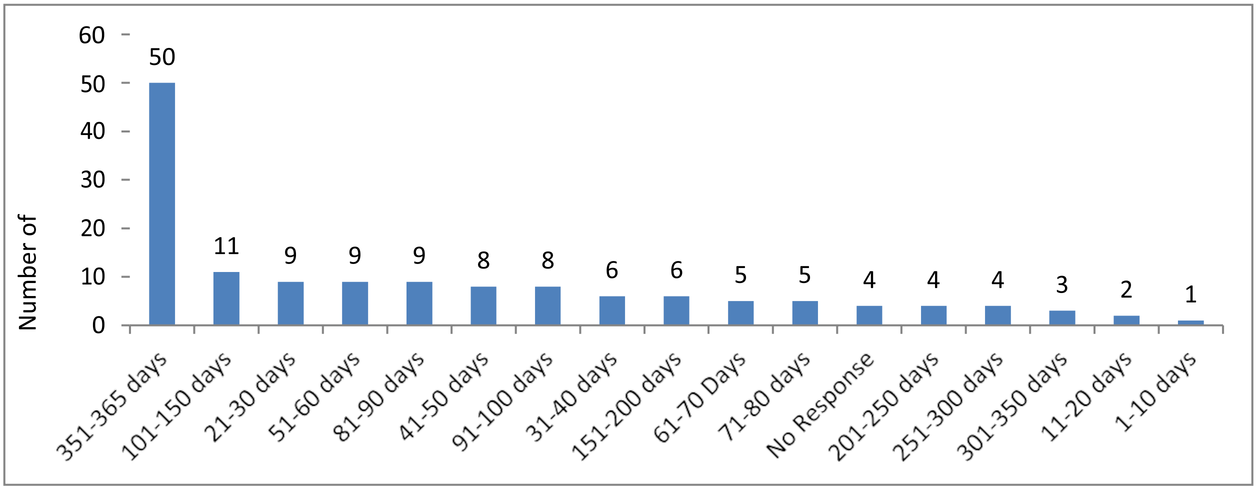


Figure 6.4: *Are you a member of the Lake Association?*

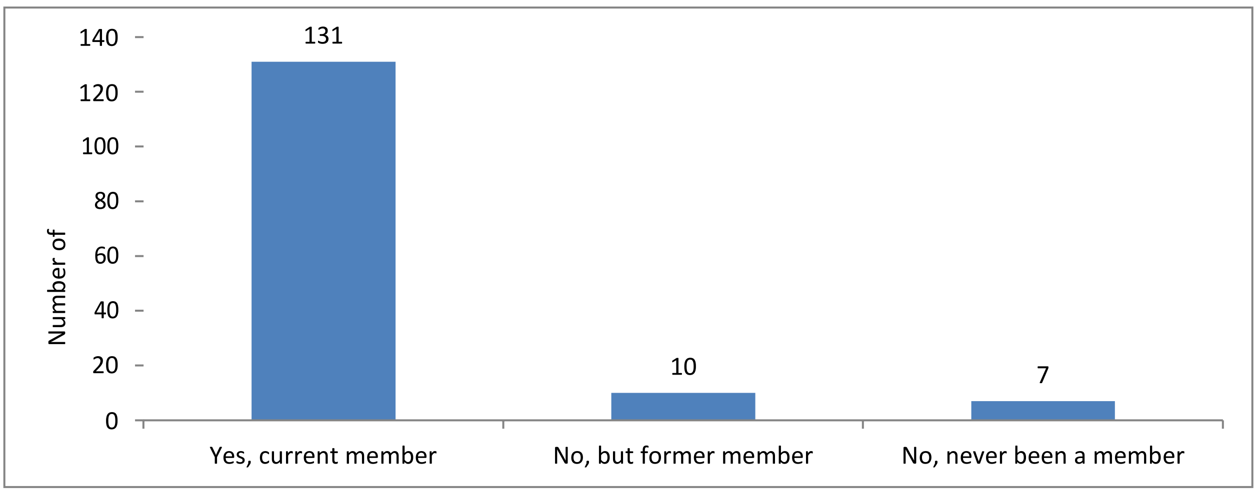


Figure 6.5: *Do you attend Lake Association meetings/events?*

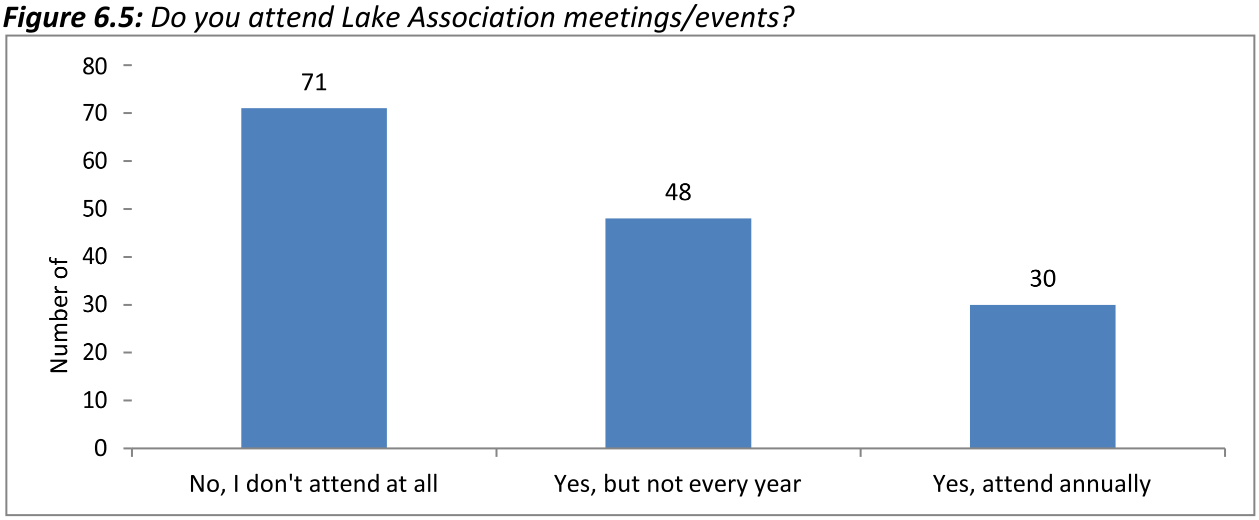


Figure 6.6: *What type of septic system does your property utilize?*

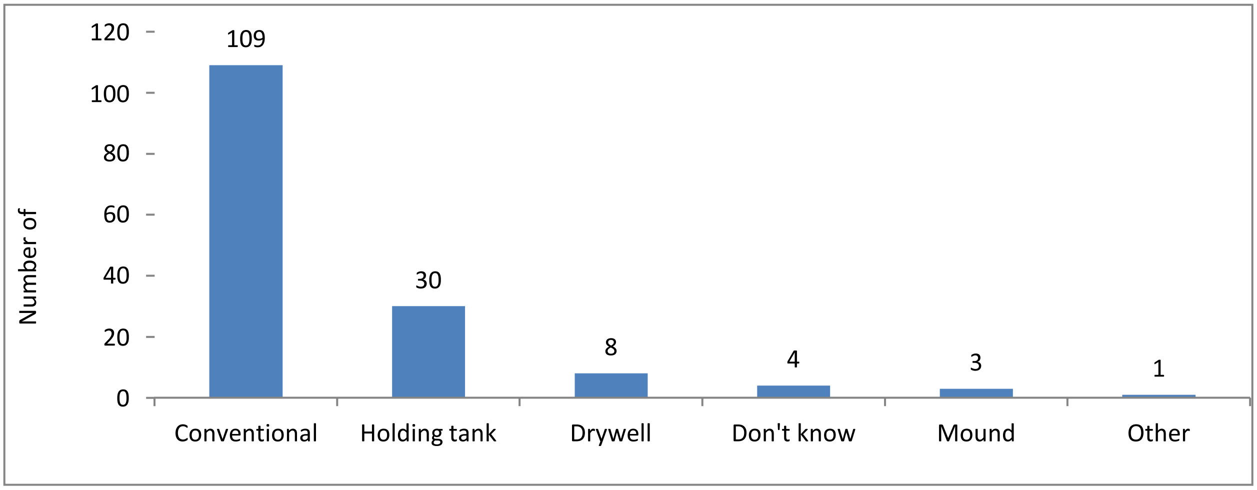
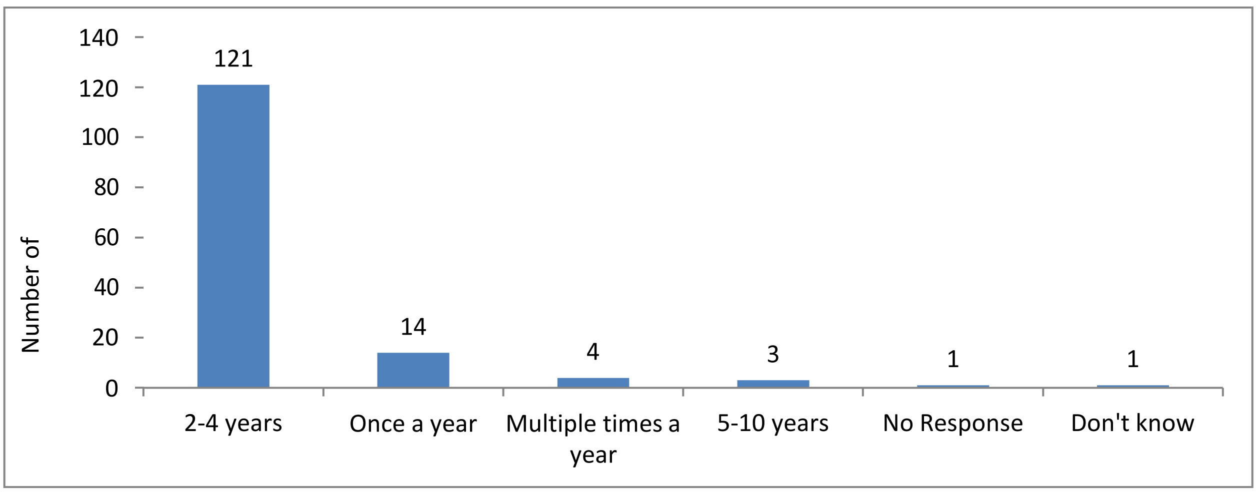


Figure 6.7: *How often is your septic system pumped?*



Fishing

Approximately 69% of respondents reported fishing Crescent Lake and have been fishing the lake for 11-30 years **(Figures 6.8-6.9).** Fishing occurs during the open water season **(Figures 6.10-6.11).** The top three species caught include bluegill/sunfish, smallmouth bass, and largemouth bass. Species reported caught the least include crappie and musky **(Figure 6.12).** Most indicate that they use both live and artificial bait. Most indicated that the current quality of fishing is fair to good and most agree that the quality of fishing on Crescent Lake has gotten somewhat to much worse over time **(Figures 6.13-6.14).**

Figure 6.8: *Have you fished Crescent Lake in the last 3 years?*

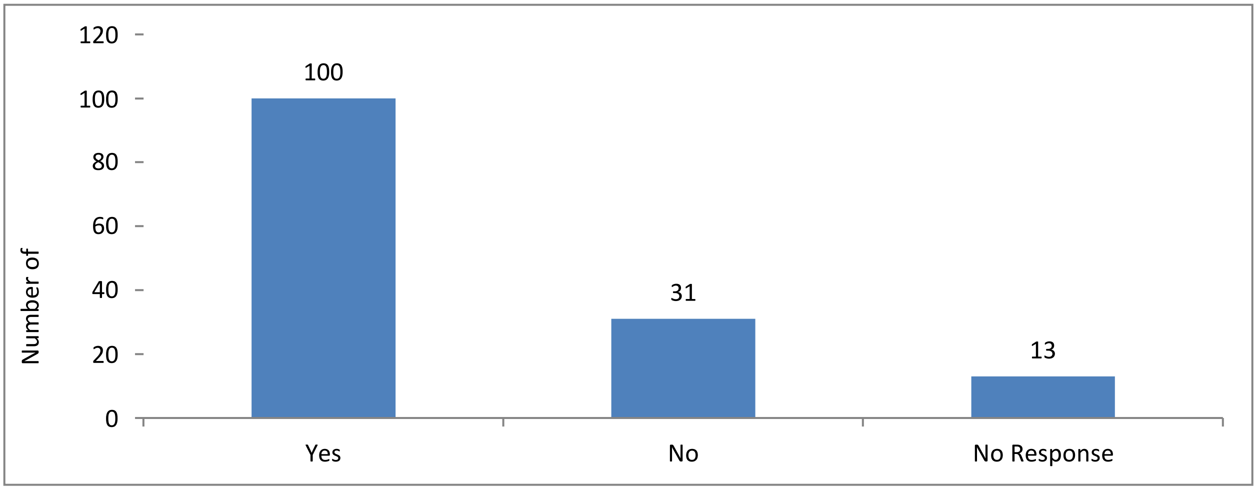


Figure 6.9: *How many years have you been fishing Crescent Lake?*

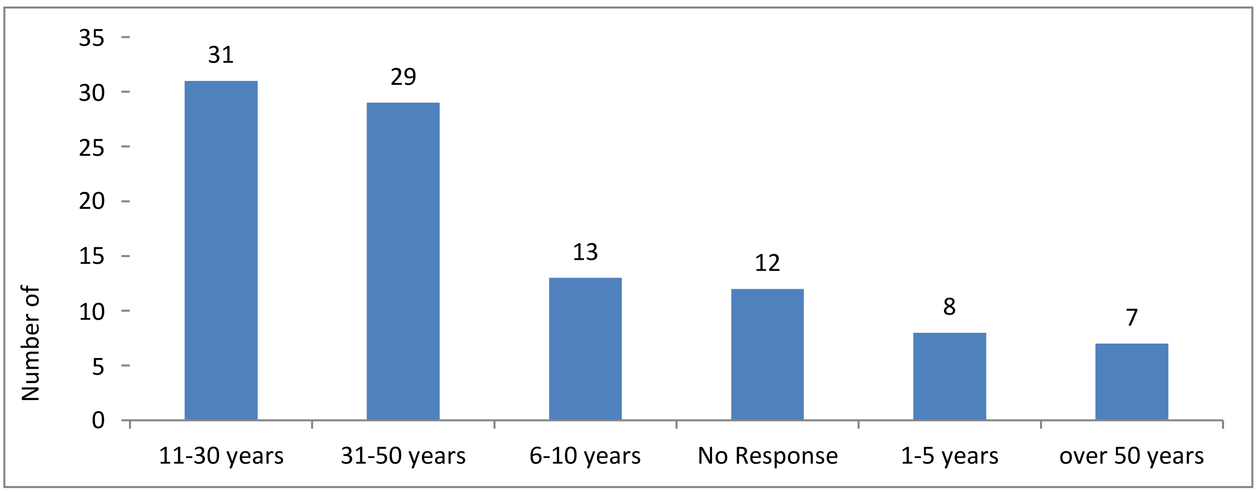


Figure 6.10: *In a typical year, how often do you fish Crescent Lake during the open water season?*

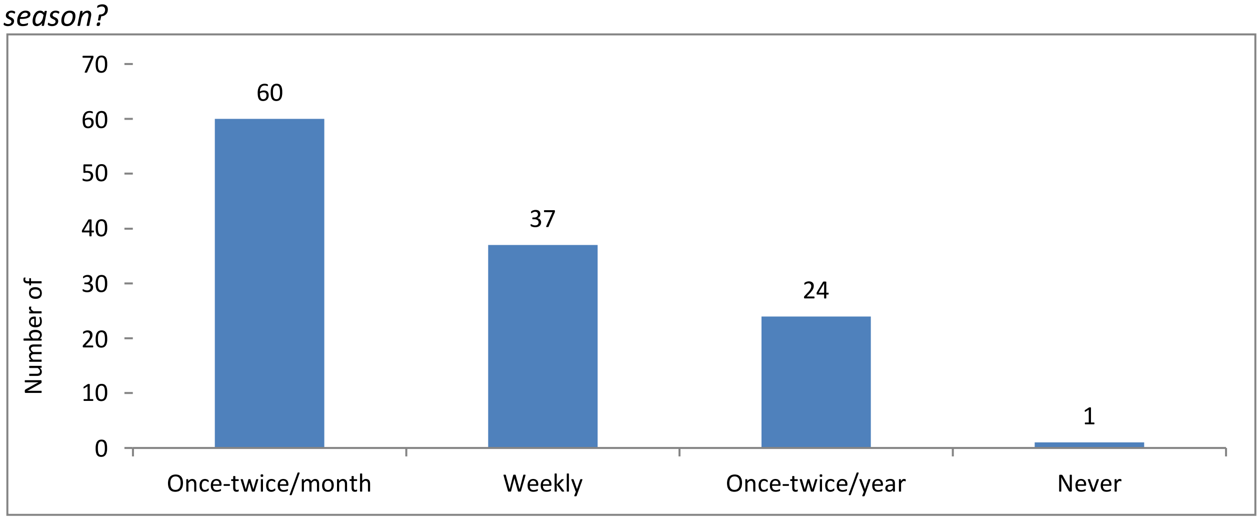


Figure 6.11: *In a typical year, how often do you fish Crescent Lake during the ice-fishing season?*

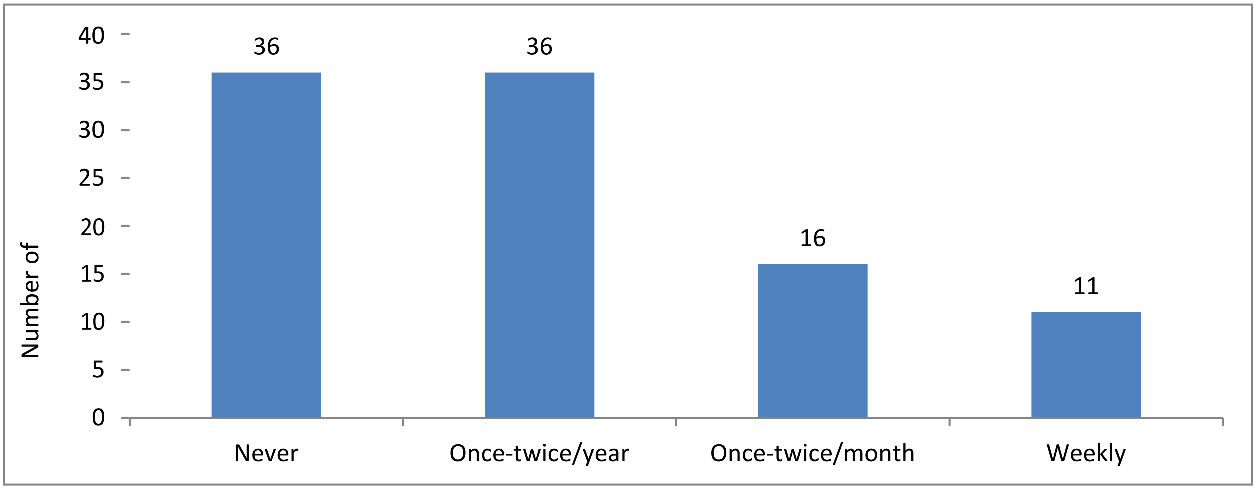


Figure 6.12: *What fish species do you catch when fishing Crescent Lake?*

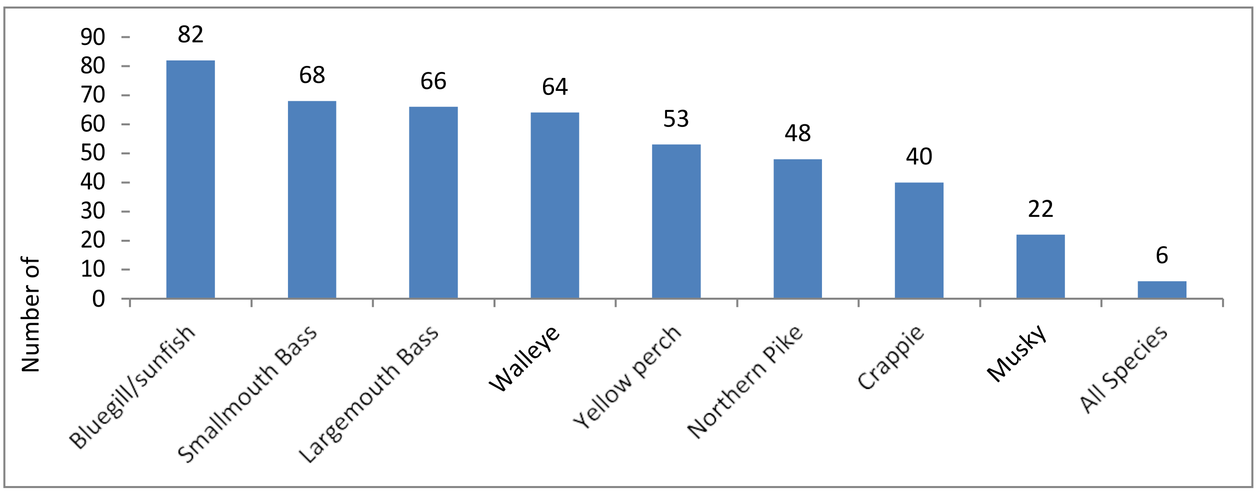


Figure 6.13: *How would you describe the current quality of fishing on Crescent Lake?*

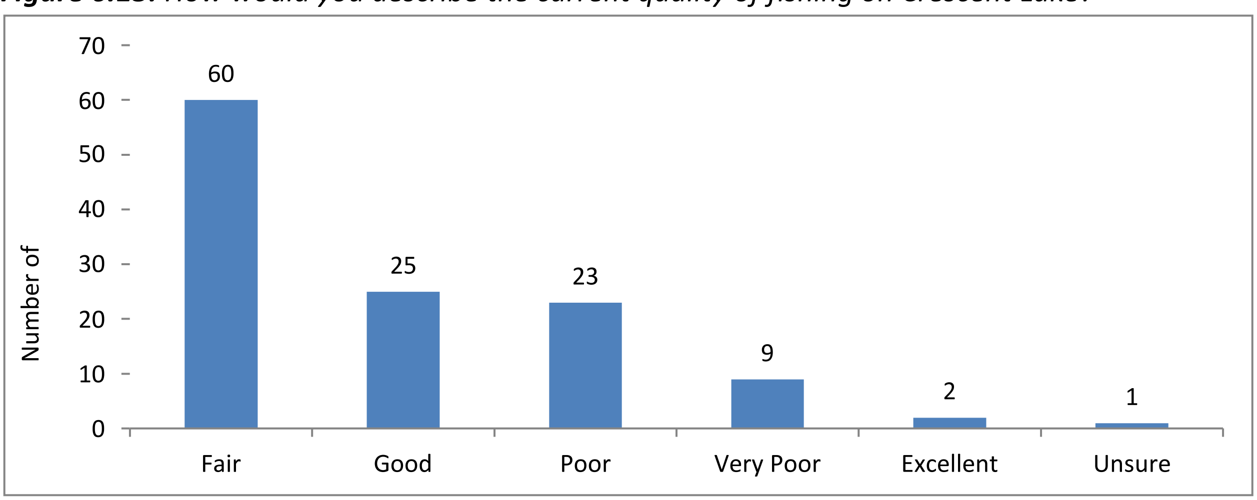
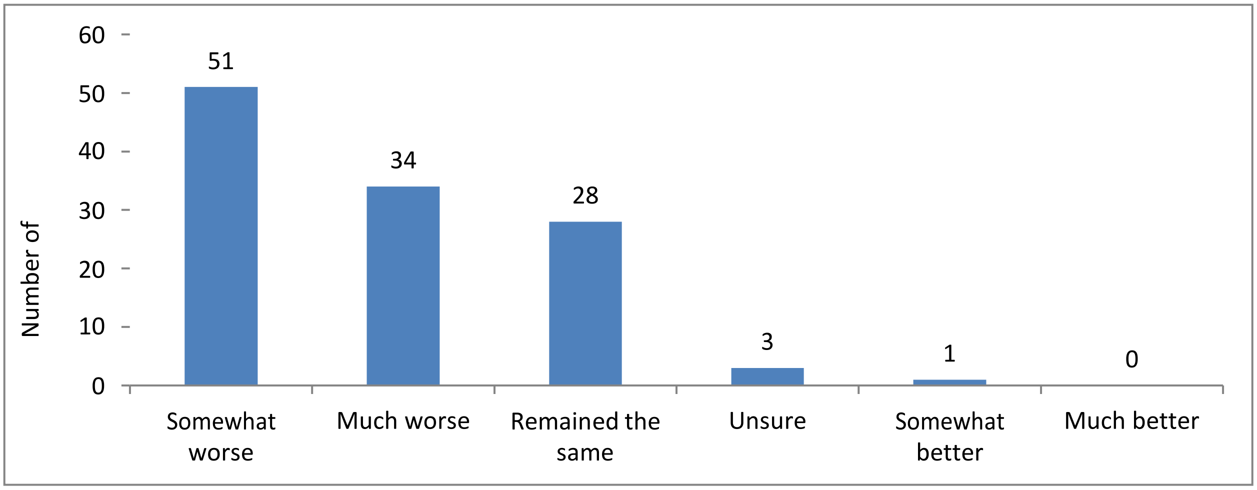


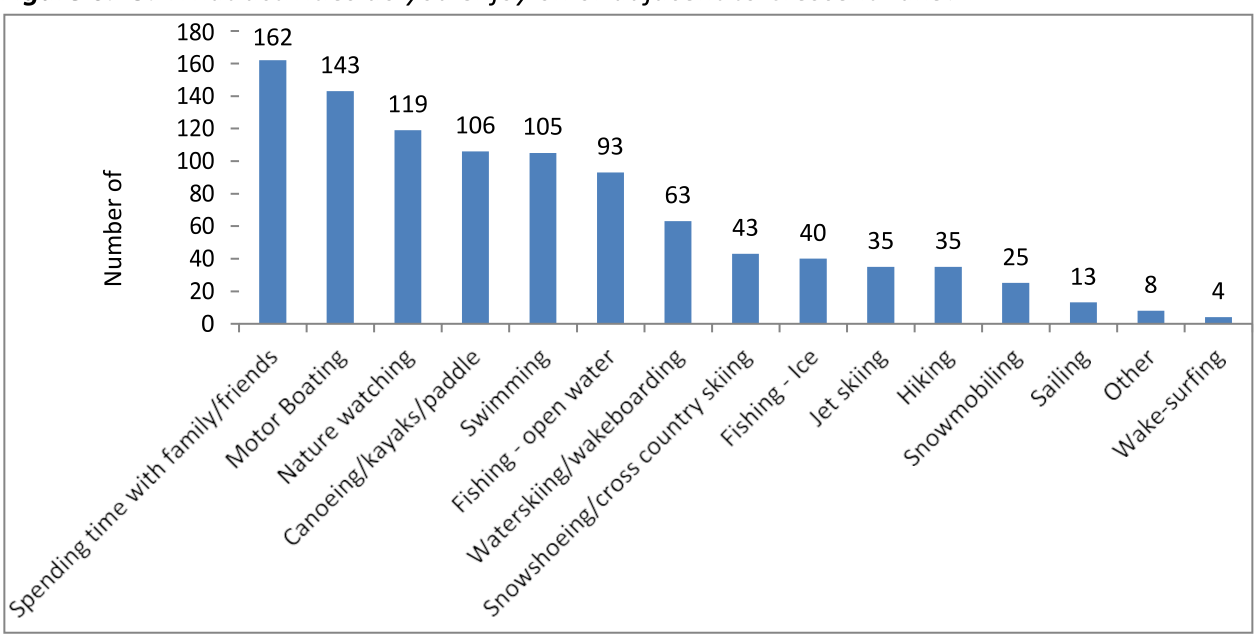
Figure 6.14: *How has the quality of fishing changed since you first started fishing Crescent Lake?*



Lake Use - General

When asked which activities you enjoy on and adjacent to Crescent Lake, the top responses included spending time with family and friends, motor boating, and nature watching **(Figure 6.15).** Sixty percent indicate they do not visit Emma Lake, whereas 20% indicated they do visit Emma Lake and bring a watercraft. Most (90%) are aware that there is a State-owned island on Crescent Lake and 54% indicated they do not recreate on the island.

Figure 6.15: *What activities do you enjoy on or adjacent to Crescent Lake?*



Watercraft Use

Most respondents own a watercraft, with pontoon boats, kayaks, and motor boats (> 30 hp) being most common (**Figure 6.16).** Residents primarily keep their watercraft on Crescent Lake (65%) whereas 34% did indicate they do use their watercraft on other waters **(Figure 6.17).** Those that do use their watercraft on other water bodies generally do some routine cleaning before putting their watercraft back onto Crescent Lake **(Figure 6.18).** Ninety-five percent of respondents reported removing visual material from the boat and trailer, 68% drain the bilge and 53% drain the live well. Five percent indicated they do not clean their watercraft. On average respondents do three of the eight items listed.

Figure 6.16: *What types of watercraft do you use on Crescent Lake?*

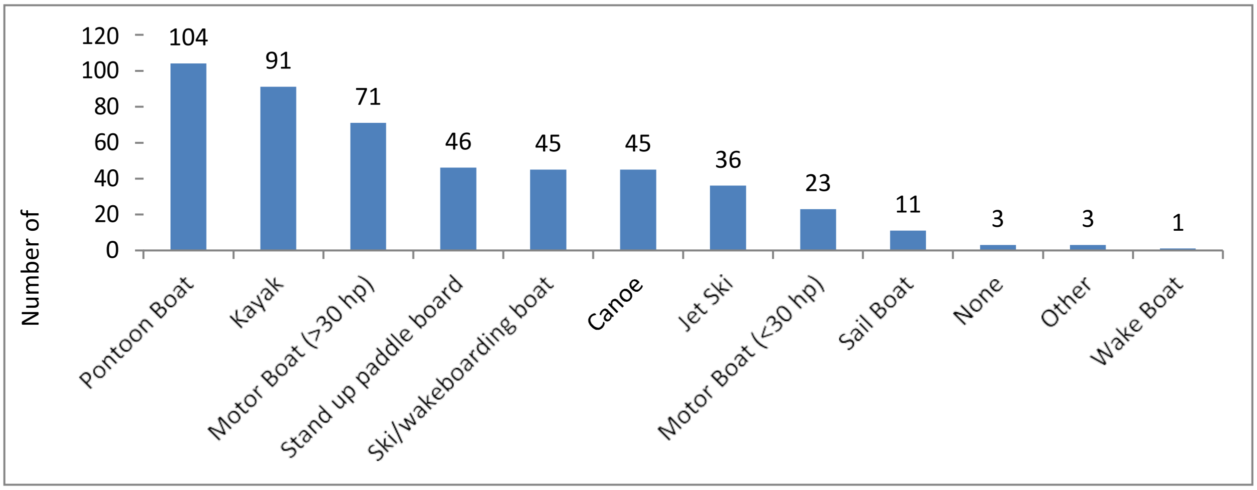


Figure 6.17: *Do you use your watercraft on other waters?*

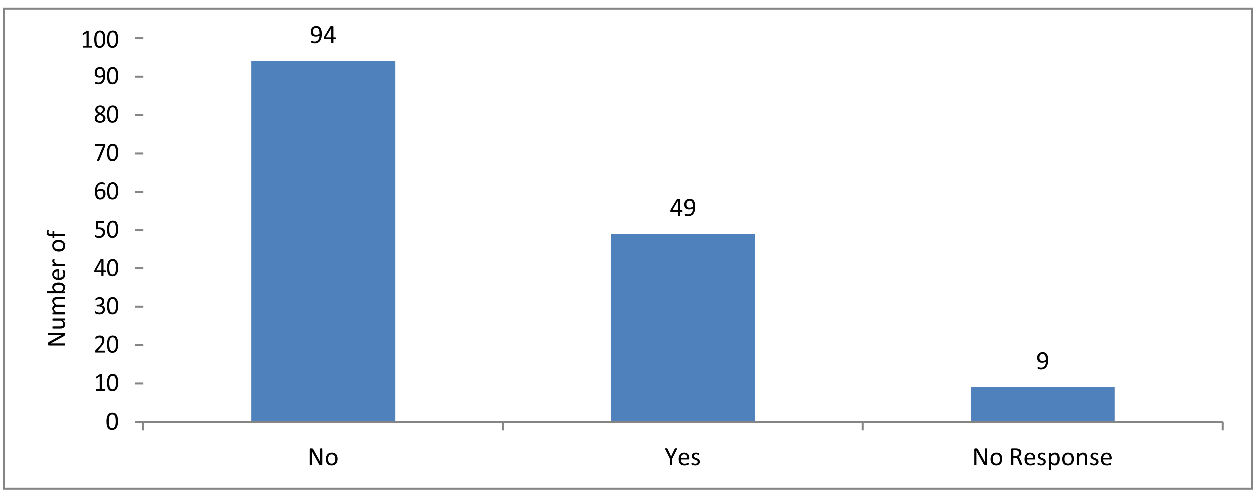
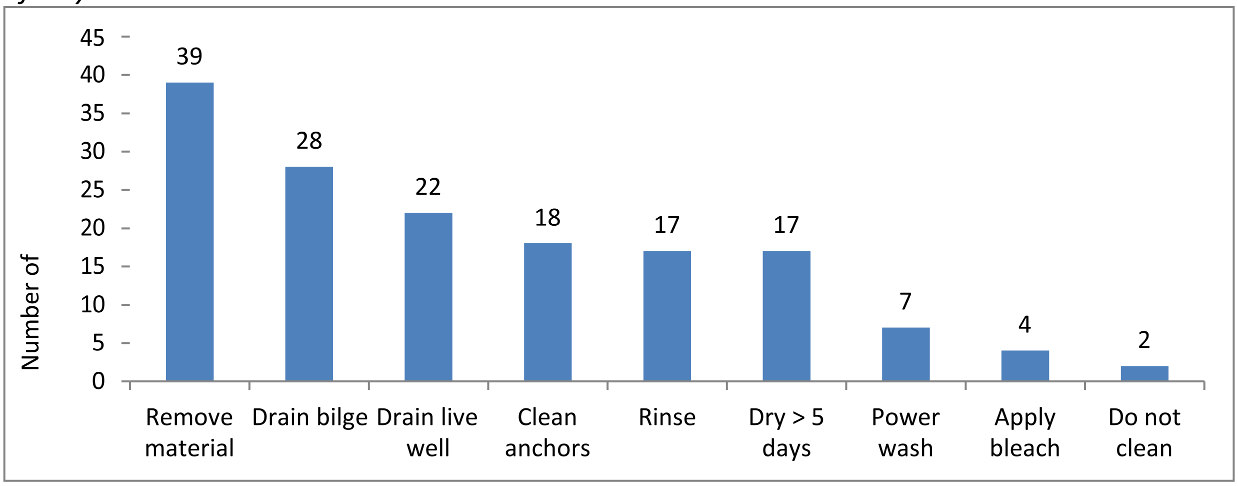


Figure 6.18: *If you use your watercraft on other waters, what is your typical cleaning routine after you visit another lake?*



Lake Health

A series of questions sought to gauge lake owners' perspectives on the current and past condition of Crescent Lake and find out what they believe may be affecting lake health. Overall, 45% described Crescent's current water quality as good and 49% felt the water quality has gotten worse **(Figures 6.19-6.20).** When asked to describe water quality most respondents indicated water clarity and aquatic plant growth **(Figure 6.21).** Of the aspects most important to water quality respondents indicated aquatic plant growth (35%) and water clarity (34%).

Figure 6.19: *How would you describe the current water quality of Crescent Lake?*

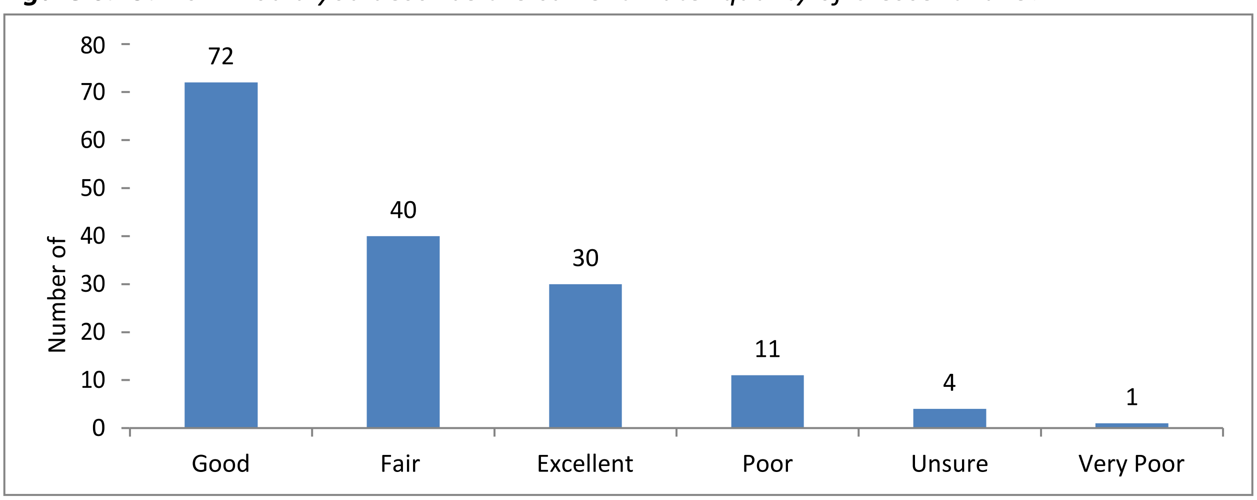


Figure 6.20: *Do you feel the water quality of Crescent Lake has changed since you first started to visit Crescent Lake?*

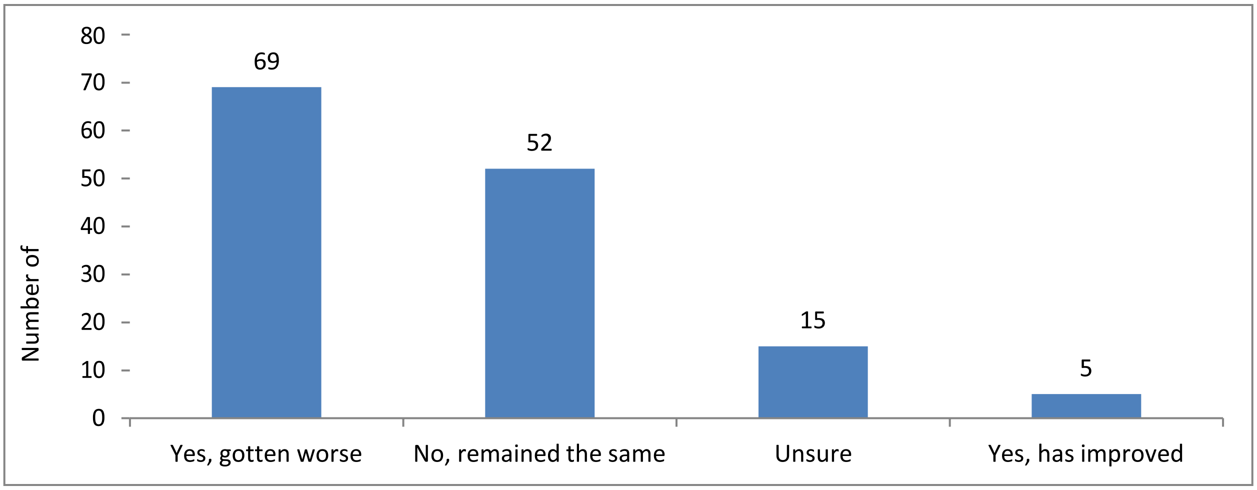
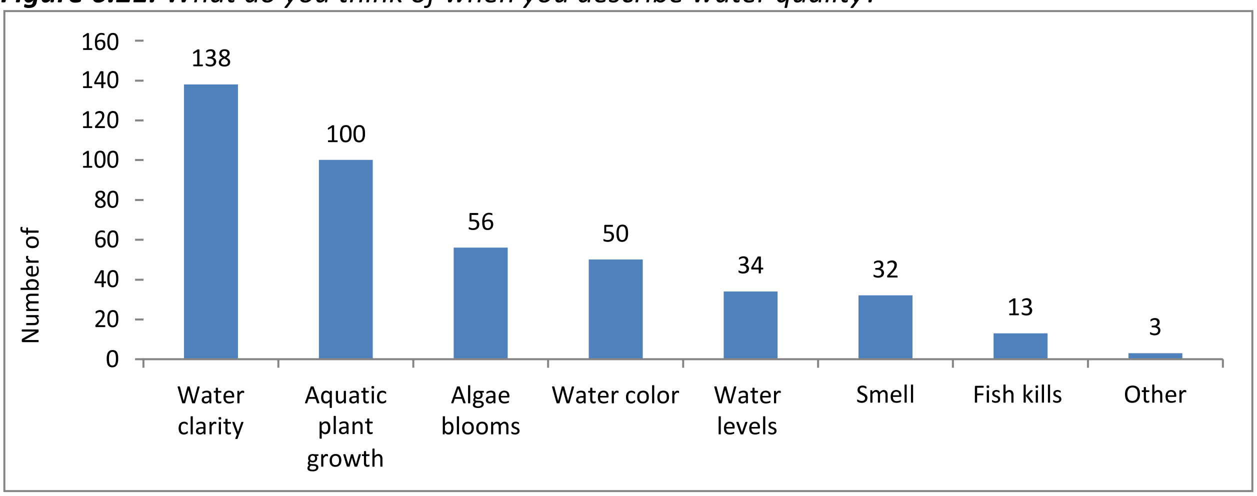


Figure 6.21: *What do you think of when you describe water quality?*



Most respondents (97%) had some knowledge of aquatic invasive species. Most (94%) believed aquatic invasive species are present in Crescent Lake. Five percent of respondents do not believe aquatic invasive species are present in Crescent Lake. The three top invasive species believed to be present in Crescent Lake include Eurasian watermilfoil, rusty crayfish, and curly leaf pondweed (**Figure 6.22).** When asked about wetland and terrestrial invasive species, 46% indicated those present adjacent to Crescent Lake, 43% were uncertain, 8% do not think these species are present. The top three terrestrial/wetland invasive species believed to be present include purple loosestrife (40%), unsure, but presume to be present (29%) and pale yellow iris (21%)(**Figure 6.23**). When asked if aquatic plants negatively impact enjoyment on Crescent Lake, 39% answered sometimes, 28% indicated they rarely do and 19% indicated often **(Figure 6.24).** A similar question was asked regarding algae negatively impacting enjoyment and most respondents again indicated rarely (44%), sometimes (34%) and often (8%) **(Figure 6.25).** Thirty-six percent of respondents agree that aquatic control of *native* plants is needed on Crescent Lake, 25% are unsure and 28% believe native plant control is not needed **(Figure 6.26)**. Eighty-eight percent agree that control of aquatic *invasive* plants is needed while 9% indicated unsure (**Figure 6.27**).

Figure 6.22: *Which aquatic invasive species do you believe are present in and adjacent to Crescent Lake?*

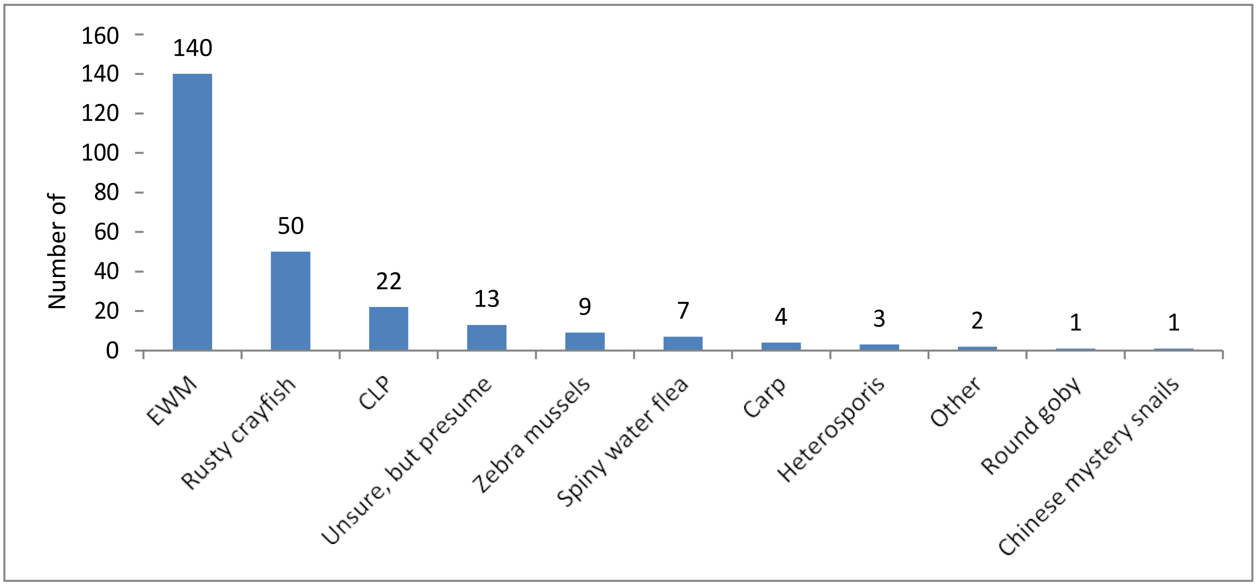


Figure 6.23: *Which terrestrial/wetland invasive species do you believe to be present adjacent to Crescent Lake?*

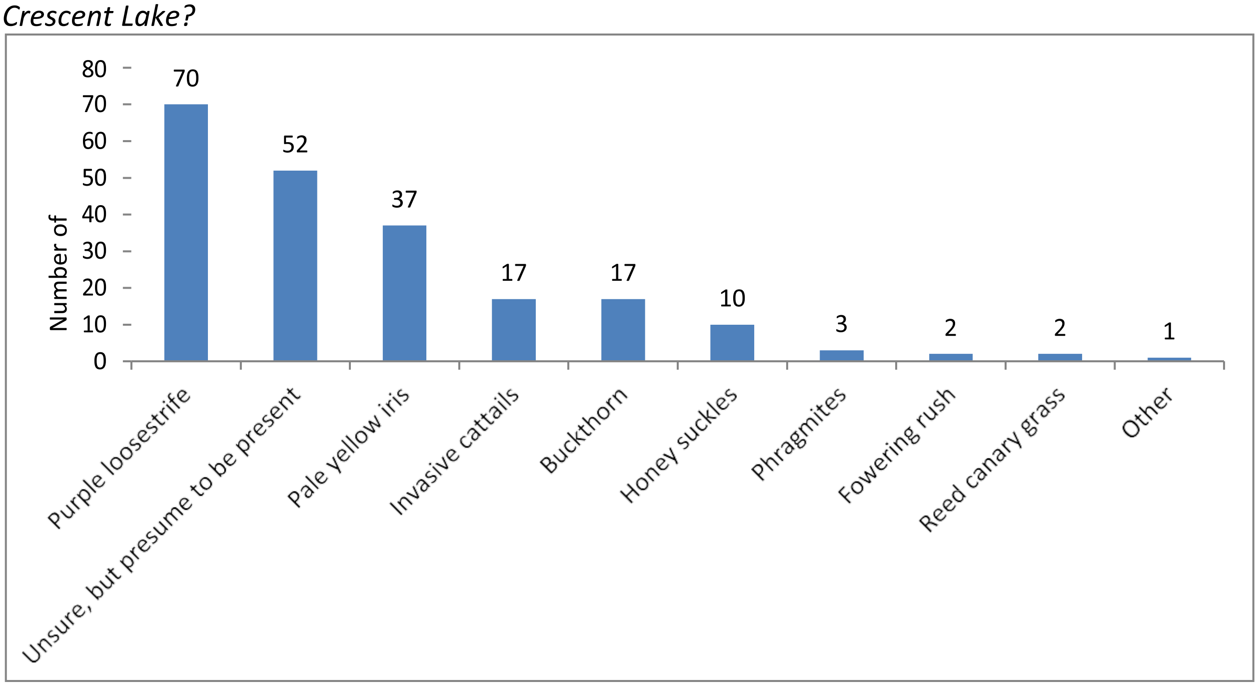


Figure 6.24: *During the open water season how often does aquatic plant growth (excluding algae) negatively impact your enjoyment of Crescent Lake?*

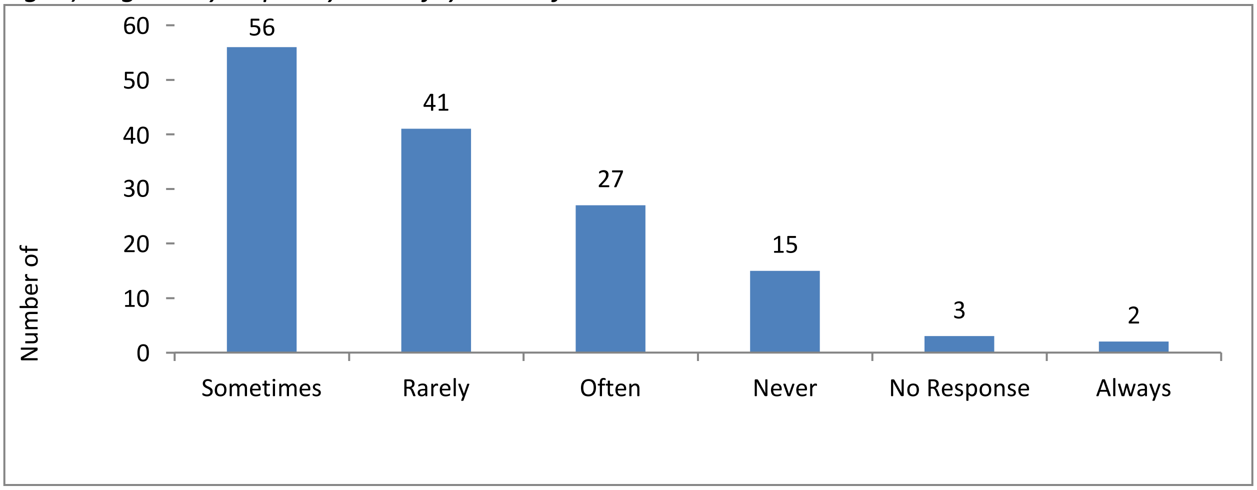


Figure 6.25: *During the open water season how often does aquatic algae negatively impact your enjoyment of Crescent Lake?*

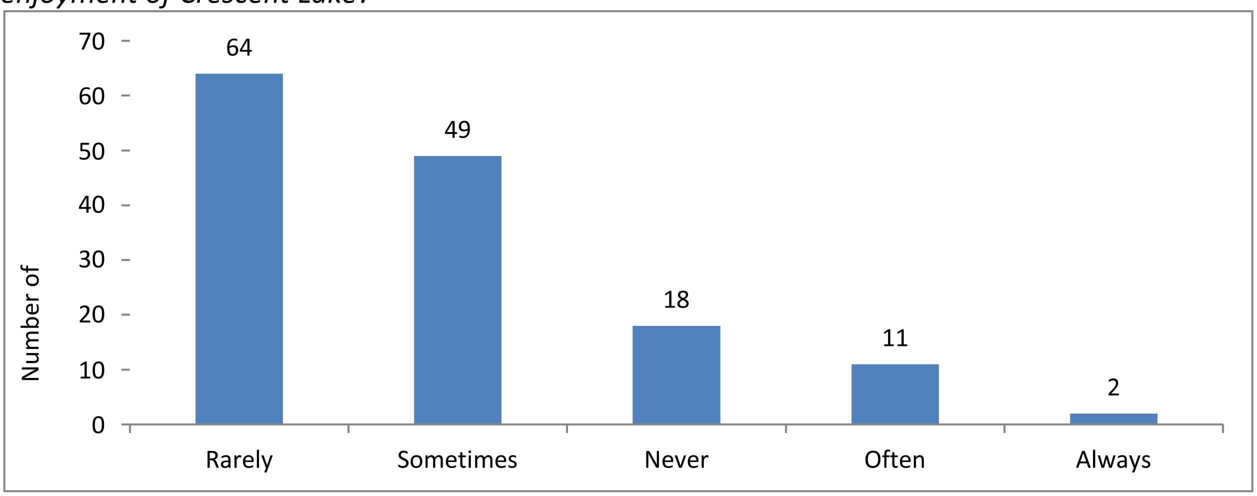


Figure 6.26: *Do you believe the control of native plants is needed in Crescent Lake?*

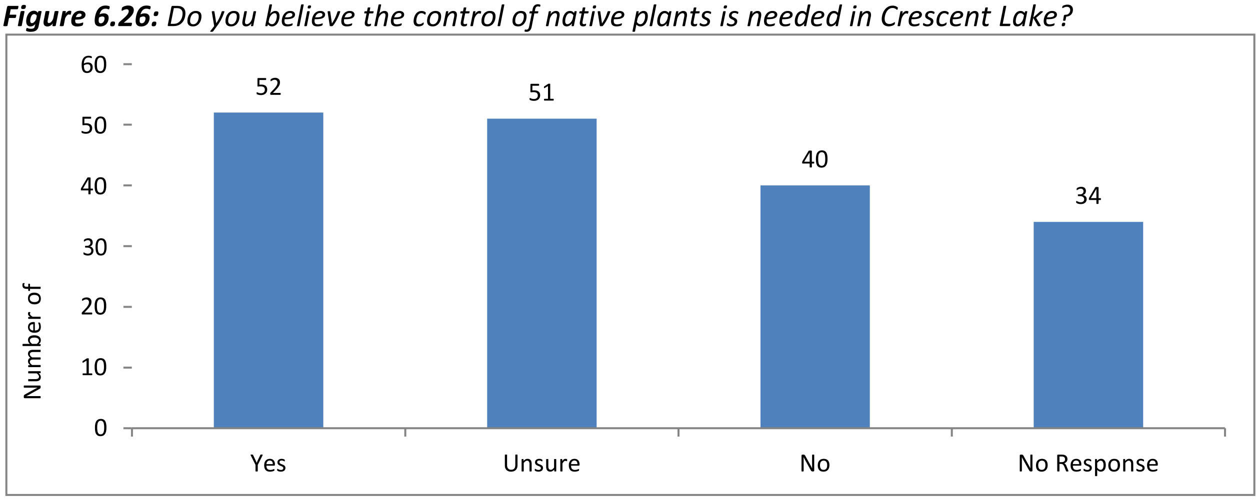
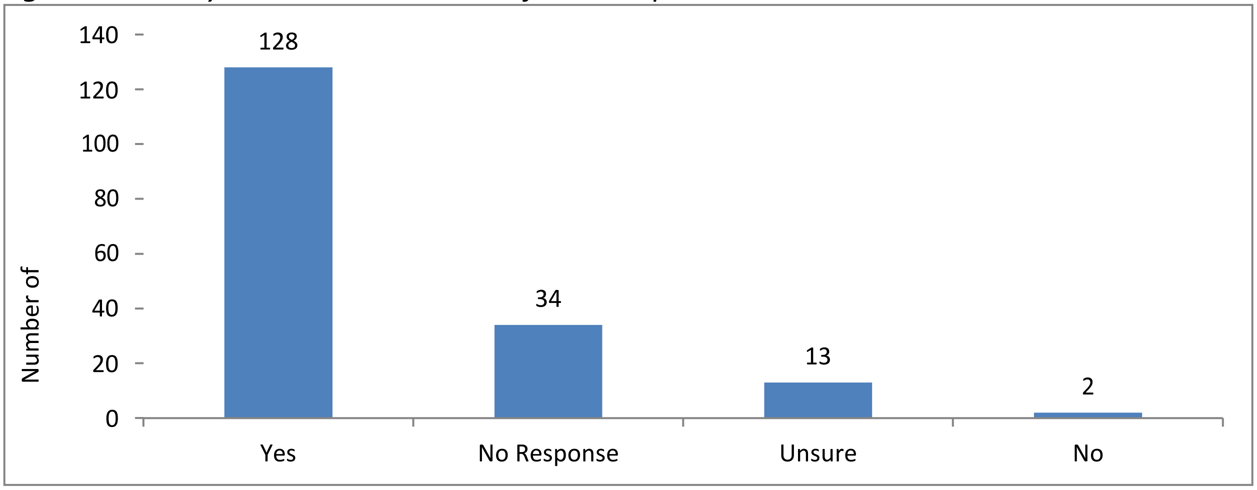
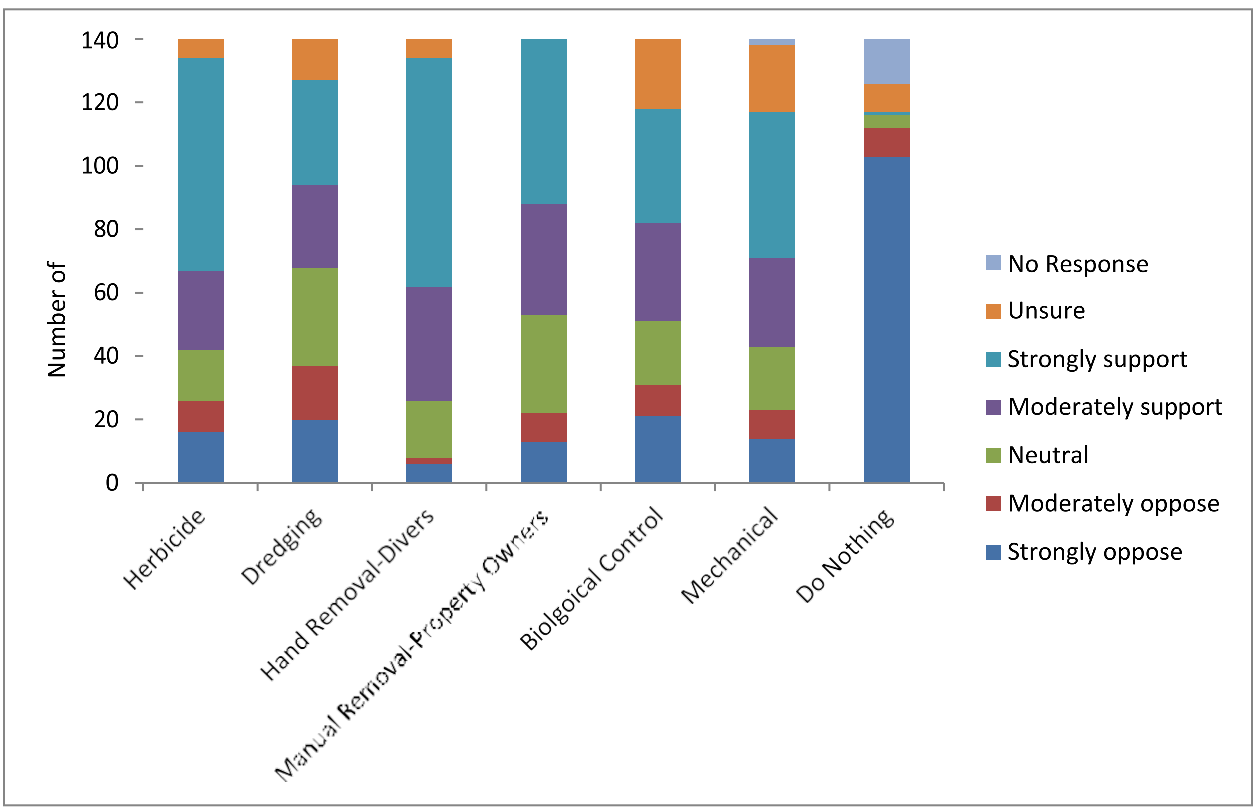


Figure 6.27: *Do you believe the control of invasive plants is needed in Crescent Lake?*



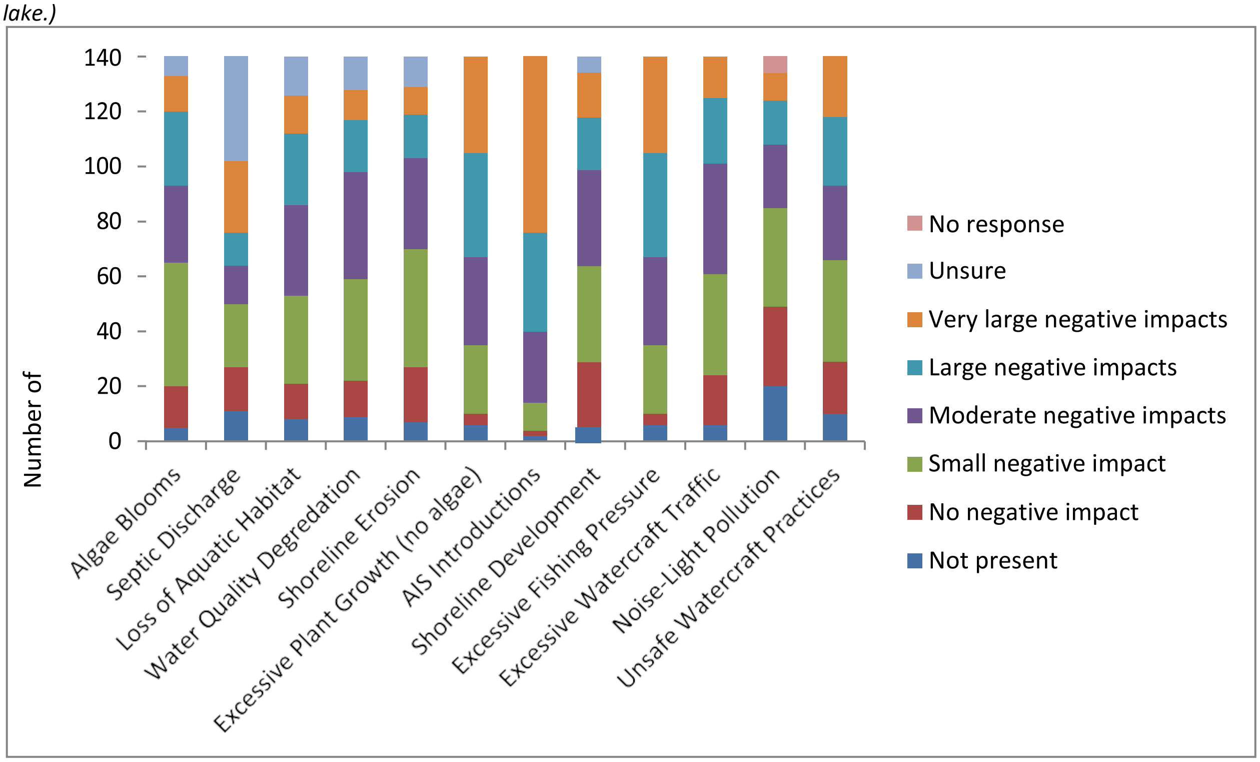
Respondents were asked to rank opposition or support for several aquatic plant management techniques **(Figure 6.28).** Eighty-one percent of respondents strongly oppose "doing nothing" as a management strategy for aquatic plants, and 14% did not respond to this question. Strongest support is for hand removal with divers (50%) followed by herbicides (47%). The management technique most uncertain about is biological control (26%) and 22% did not respond to ranking mechanical harvesting.

Figure 6.28: *Aquatic plants can be managed using many techniques. Please tell us if you oppose or support the responsible use of the following on Crescent Lake.*



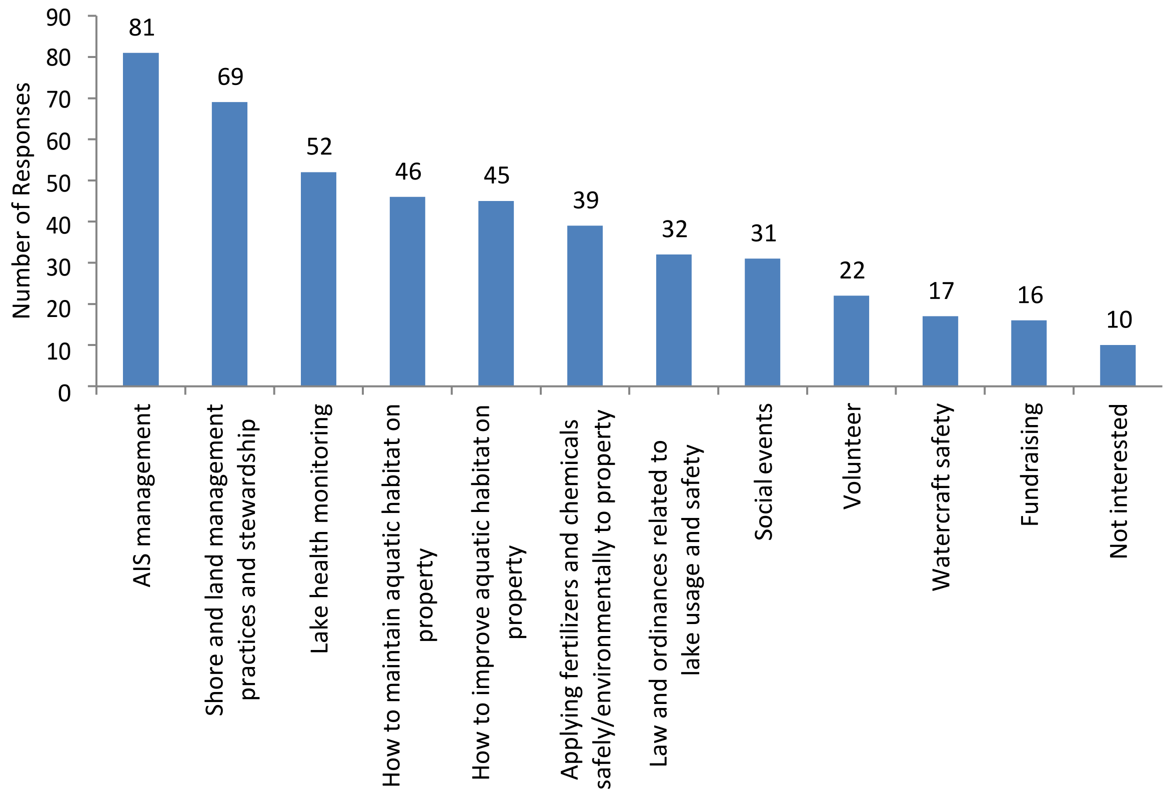
The next series of questions provide a list of possible impacts to Wisconsin lakes **(Figure 6.29).** Respondents were asked, "To what level do you believe each of the following factors may currently be negatively impacting Crescent Lake?" Circling *not present* means the respondent perceives the issue as not existing on Crescent Lake, whereas circling *no negative impact* means the issue may exist on Crescent Lake but is not perceived to be negatively impacting the lake. As mentioned above, several respondents circled more than one response. Respondents indicated that aquatic invasive species introductions and excessive fishing pressure are two very large negative impacts to Crescent Lake. Issues that many respondents were unsure about include septic discharge, loss of aquatic habitat, and algal blooms. Respondents indicated that noise pollution, shoreline development, and shoreline erosion are the three issues present on Crescent Lake however are not believed to be negatively impacting the lake.

Figure 6.29: *Below is a list of possible impacts to Wisconsin lakes. To what level do you believe each of the following factors may currently be negatively impacting Crescent Lake? (Not present means that you believe the issue does not exist. No negative impact means that the issue may exist but is not negatively impacting the lake.)*



The final question addresses education and what topics lake residents are interested in learning about **(Figure 6.30).** The top three responses include AIS management, shore and land management practices, and lake health monitoring. Eight respondents indicated that they are not interested.

Figure 6.30: *What educational topics would you like to learn more about?*



7 - PLANNING REVIEW

10/10/2018 Lake management grant organization meeting. This meeting reviewed the lake planning grant scope of work and timelines and organized the steering committee to oversee the project development. The meeting mainly covered local share responsibilities, committee involvement, grant paperwork, and initiating a working group to be responsible for the distribution of the lake user survey.

11/26/2018 Lake user survey development. The steering committee reviewed the proposed survey scope and discussed possible user groups that they may want to include in the survey. Groups initially identified included: lake residents, Crescent Lake Bible Camp guests and boat landing users. Lake residents would provide information on population demographics, interests, concerns, and knowledge on different lake topics. The Crescent Lake Bible Camp filters many youth and families through their doors throughout the year, many of which have been coming to Crescent Lake for decades. These folks would add information on concerns and lake knowledge. After through consideration, the extended commitment to fully engage camp goers and learn from them would require more resources and time than available. This group may be a good group to include in future surveys. The final user group considered included those that use the public launch. Of interest to learn from this group would be fishing, types of watercraft, perception of water quality, AIS precautions, watercraft ownership versus rental and island usage. A preliminary draft of a short survey was developed and reviewed by DNR. The initial thought was to have it handed out at the same time Clean Boats Clean Waters inspectors staffed the boat landing. Given Clean Boats Clean Waters is a well established program, before any survey information would be distributed contacts were made to both the County and the State regarding acceptance of this additional task for Clean Boats Clean Waters inspectors. The committee did not receive clarification from either the County nor the State, so this option was tabled. The final survey participants include all lake lot owners of Crescent Lake.

1/2/2019 EWM management strategy meeting. This was a joint meeting with the steering committee and the AIS response team. This meeting sought to initiate discussions on what short and long-term management of Eurasian watermilfoil may look like for Crescent lake and start to strategize EWM management goals and objectives. To begin the discussion a short presentation by Scott Van Egeren and Ty Krajewski from WDNR gave information on WDNR perspective to AIS management including recent science, management tools and how to begin framing short and long-term goals, objectives, and expectations. This was followed by an overview of the EWM response to date given by representatives of the AIS Response Team. A document presented at a previous meeting the Response Team had with WDNR on December 4th 2018 was circulated (Appendix D). The remaining of the meeting circled past attempts at actions and the growing concern of the abundance of EWM on Crescent Lake.

3/1/2019 EWM management strategy meeting. This was a joint meeting with the steering committee and the AIS response team. This meeting again sought to discuss short and long-term management of Eurasian watermilfoil may look like for Crescent lake and to strategize EWM management goals and objectives. The meeting mainly focused on identifying regions on the lake to manage EWM in 2019. Using a large poster of the lake that had the EWM areas identified, participants' highlighted area on the lake they sought to manage, why, and the types of techniques to be considered.

11/21/2019 Lake planning meeting to review survey results. This was a joint meeting with the steering committee and the AIS response team. Agenda included reviewing survey results and discussion of highlight, topics of interest and how to use these results in the planning document. Some actionable items for consideration in the lake management plan included more educational events discussion a variety of topics beyond AIS and how to engage more of the Association. Discussion turned to growing concern of the expanding EWM issue, and what needed to be done in regards to 2020 management.

8/21/2020 Lake management planning review meeting. Steering committee members met via Zoom to discuss the draft of the lake management plan. Meeting began with every committee member providing general comments and feedback followed by a lengthy discussion on what the short and long-term aquatic plant management goals and objectives would be for Crescent Lake. Using information from this meeting, the first draft of the Action Plan was developed.

9/1/2020 Action Plan Review. The steering committee met via Zoom to discuss the first draft of the Action Plan. The committee reviewed in detail each proposed goal, objective and task. This information was incorporated into a revised version of the Action Plan. The final portion of the meeting was dedicated to review accomplishments from recommendations made in the 2007 Lake Management Plan. These items are detailed per topic below.

Water Quality

- Recommendation: Continue participation in the WDNR citizen lake monitoring program.
  - Accomplishment: Water quality monitoring under this program is ongoing.
- Recommendation: Determine sources of chemicals that may be in the lake due to water treatment system discharge including sodium, calcium, potassium, and iron.
  - Accomplishment: The committee is not aware of any additional testing that may have taken place.
- Recommendation: Investigate water treatment systems in watershed to determine number and type of systems discharging into Crescent Lake.
  - Accomplishments: The committee is not aware of any movement on this topic. There was some recollection that the Township of Crescent may have done a septic workshop about four years ago.

Watershed-reduce pollutant loading

- Recommendations: Reduce pollutant loads to Crescent Lake by not fertilizing lawns, or using very little phosphorous-free fertilizer if necessary, create natural buffer strips along the shoreline edge, seed and mulch open/bare soil areas, perform a sanitary survey to identify leaking and/or failing septic systems and promote best management practices in the watershed.
    - Accomplishments: The committee was not aware of any pursuit by the Association to work with lake owners to reduce the use of lawn fertilization, promote and install buffer strips, seed/mulch bare soils or perform any sanitary surveys to identify leaking and failing septic systems. The Association did work with neighboring lakes to develop a brochure on how lake owners can protect water quality by maintaining or installing natural buffer zones along the water's edge.

Prevent/Control invasive species

- Recommendation: Continue to monitor aquatic plants visually several times a year.
    - Accomplishment: The Association has an active group of volunteers that monitors for invasive species annually.
- Recommendation: Perform detailed aquatic plant surveys every five years following WDNR methods.
    - Accomplishments: Detailed plant surveys occurred on Crescent Lake in 2007, 2015, and 2019.
- Recommendation: Monitor for other aquatic invasive species such as zebra mussels, spiny water fleas, and rusty crayfish.
    - Accomplishment: Local entities such as the Oneida County Land and Water Conservation Department have worked with Crescent Lake to monitor for these additional species.
- Recommendation: Continue Clean Boats Clean Waters watercraft inspections.
    - Accomplishment: The Association has an active group of volunteers that participate annually in this program.
- Recommendations: Seek grants to help pay and sustain AIS, Lake Management Planning and Lake Protection work.
    - Accomplishment: The Association has procured WDNR AIS grants to help with their AIS prevention, monitoring, and management programs.

Education

- Recommendation: Publish a Lake Association newsletter to keep lake residents informed.
    - Accomplishment: The newsletter has been discontinued; all lake information is now housed on a Lake Association website.

- <u>Recommendation:</u> Use local WDNR and County resources to learn more about publications and programs to educate the public.
    - <u>Accomplishments:</u> The Association regularly communicates with local WDNR and County staff on lake issues.
- <u>Recommendation:</u> Conduct a lake fair for the Association or partner with surrounding lake associations to conduct a larger fair on lake topics such as shoreland protection/restoration and invasive species.
    - <u>Accomplishments:</u> The steering committee is not aware of any previous lake fair events undertaken by the Association.
- <u>Recommendation:</u> Educate on the importance of shoreland buffers.
    - <u>Accomplishments:</u> The committee feels this recommendation has fallen short since the plan writing in 2007 and agrees that more attention to this topic needs to be addressed in the current plan.

<u>AIS Response Team, Volunteer Leaders, and Board Review</u> Upon planning committee review, a draft of the plan was distributed to the AIS Response Team, volunteer leaders and the Crescent Lake Board. Overall, the feedback received was positive, with some minor corrections and suggestions for additional details. Of note, is the identification of Northern watermilfoil in 2014, by volunteers and the continued observation of this species increasing annually. Historically, there is little evidence of this species presence on Crescent Lake and some members of the lake community are concerned of its increasing presence and how this may upset the balance of the native plant community on Crescent Lake. Though not an invasive species, lake residents are observing this species displaying nuisance like characteristics. Northern watermilfoil can cross breed with Eurasian watermilfoil and create a hybrid. However, all genetic testing to date has not detected any hybrid watermilfoil plants in Crescent Lake.

8 - SUMMARY AND CONCLUSIONS

The ultimate goal for this project is to update data on the ecological condition of Crescent Lake and develop actions that support its aesthetic qualities and ecosystem health over time. The vast majority of data collected for this project focused on in-lake and riparian habitat features commonly measured to monitor health and possible impairments to a waterbody. Specific monitoring standards collected a wealth of ecological data on Crescent Lake including water quality, aquatic plants, and shoreline habitat. These features relate well to understanding and describing the health of a lake and its surrounding landscape.

Short-Term Planning and Lake Management Considerations

Crescent Lake supports a robust and diverse aquatic plant community. The overall floristic quality suggests that Crescent Lake is above average for lakes in the State (WI) and within the Northern Lake and Forest Region. Over the course of the last decade, three full lake plant surveys have been completed on Crescent Lake. These surveys used the same methods, making the data comparable over time. The first survey took place in 2007, with 189 sampling points detecting vegetation. In comparison, the 2019 survey found 547 points with vegetation. Both surveys detected a maximum rooted depth of vegetation at 20 feet. Though the lake-wide littoral presence of EWM in Crescent Lake rose from 0% in 2015 (0%) to 4.29% in 2019, the increase in sites with vegetation are mainly attributed to increases in native vegetation.

Many lake residents are reporting more vegetation now than in previous years, and the plant data does suggest that to be the case. Anecdotal accounts of high and low periods of vegetation have been reported on about a 10-year cycle. Though, the reason for this cyclical pattern in plants cannot be fully explained, water quality data suggests Crescent Lake has become “clearer” over the past ten years, which may allow more light penetration into the lake allowing aquatic plants to capitalize on the access to light and growing conditions. What is causing the lake to become clearer is unknown, however, underlying factors such as changes in groundwater influx may be partially at play. Knowing these boom and bust cycles may be occurring with the aquatic plant community, expectations of invasive species management is important. For example in 2019, the lake association spent several hundred hours diving and hand pulling EWM and treated 15.2 acres with an aquatic herbicide. Though the first year of treatment appears to be successful, these management activities combined, did not reduce the total population of EWM in Crescent Lake from 2018 to 2019. Total acres of EWM rose 5.6 acres in this time. If a similar effort in management took place during a low period of aquatic vegetation, possibly different outcomes in controlling the lake wide population of EWM may have occurred.

Repetitive long-term management of invasive species with the use of herbicides may lead to shifts in the aquatic plant community from a diverse community to a community with fewer more disturbance tolerant species. Furthermore, repetitive management does increase the probability of herbicide resistance, which may result in treatments not being as affected as they once were.

Long-Term Planning and Lake Management Considerations

Future predictions for Wisconsin estimate that by 2050 average temperatures will increase by 3-9˚F, more days will exceed 90˚F and winters will be warmer (WICCI, 2019). Increasing temperatures affect the duration that lakes remain stratified. Lakes will remain stratified longer and oxygen concentrations will have more time to decline during this period. This will reduce optimal oxythermal habitat for some native fish. Higher precipitation predicted during the winter and spring months will raise ground water levels. High intensity rain events will lead to increases in run-off and nutrients entering a lake, reducing water quality and possibly affecting spring fish spawning habitat. Building climate resilience in lakes through conservation practices such as protecting habitat and minimizing run-off, improves the capacity that lakes will have to buffer against future stressors that climate change will bring.

The social perception of water quality is often complex, but defining what impacts water quality is well known. Land cover and land use play an important role in the amount of sediment and nutrients entering a lake, affecting water quality. Natural vegetation and duff absorb rain and runoff coming from the surrounding landscape better than shallow rooted lawns. Diverting runoff from impervious surfaces such as rooftops and driveways to areas where water can infiltrate into the soil will also minimize runoff to the lake. Most land cover within the watershed consists of forests and wetlands that allow water to infiltrate rather than run over the landscape and picking up pollutants that may enter the lake.

Shoreland development continues to increase on lakes within the Upper Midwest Region, which trends towards poor water quality and overall nearshore habitat degradation. Watershed land use and cover may attribute a large portion of Crescent Lake's long-term water quality. However, the quality of nearshore habitat is something riparian owners can directly engage in. Encouraging natural buffers along shorelines, remediating active erosion, and leaving downed wood in place along the water's edge will provide critical habitat and refuge for most aquatic life.

ACTION PLAN

This Action Plan blends current lake data with steering committee's discussions, identifying areas to strengthen conservation knowledge and practice. It provides a working framework that outlines the goals, actions, assigned responsibilities, timeframes, and expected outcomes. This document is intended to be adaptive, requiring periodic review to be responsive to new information, priorities, and needs. According to the WDNR, a formal plan update is required every five years to maintain grant eligibility for AIS control projects. This update would include updating lake studies, goals, objectives, re-prioritizing needs and review of accomplishments.

Being a aquatic plant management plan, much detail was given to understanding the current and historical condition of Crescent Lake's aquatic plants, water quality, and surrounding shoreland habitats; all which play a role in the health of a lake and its aquatic plant community. This information provides the backdrop to formulate short and long term goals, objectives and strategies to manage (when appropriate) existing and new aquatic/wetland species while keeping to the ecological expectations of a lake. Meaning, a lake is the sum of all its parts, including plants, water quality, shoreland habitats, and other features within the watershed.

A take away message from this plan is to highlight the many aspects of Crescent Lake that are special from its *natural habitat* to its *dedicated lake leaders*.

- Crescent Lake's floristic quality is above average for Wisconsin Lakes and specifically above average for neighboring lakes in Northern Wisconsin. Meaning, Crescent Lake has a diverse and healthy aquatic plant community.
- Crescent Lake is also home to valuable aquatic plants, including those considered special concern[19] by WDNR.
- Overall, there are relatively few invasive species, most of which have management options. Some lakes have invasive species, such as zebra mussels or spiny water fleas, which there relatively few solutions for. These species cause dramatic shifts and irreversible changes to ecosystem food webs including loss of microscopic organisms to top predator fish.
- Crescent Lake's water quality is excellent and supports healthy fish and aquatic life.
- Crescent Lake is a stopping ground for migrating waterfowl. Residents have identified over 15 species of waterfowl using Crescent Lake during the spring and fall migrations.
- Crescent Lake landowners have been getting together to discuss lake issues since the 1970s, with a formal Association known to be in existence since 1981.
- Crescent Lake has a healthy group of advocates, who have a long history of participation in many activities such as Clean Boats Clean Waters (16 years), AIS and aquatic plant monitoring (11 years), water quality monitoring **(34 years),** and serve on committees and fill board positions. Those dedicated lake residents have facilitated a knowledgeable, active, and caring lake community.

[19] Special concern species are those which the distribution and abundance may not be fully known. These species are given attention or note before they may become threatened or endangered.

Besides invasive species, other challenges for Crescent Lake include:

- Large presence of lawn, 92% of parcels have lawn. Lawns provide very little high quality habitat for aquatic organisms and increase unnecessary run-off and pollutants such nutrients to a lake, which may fuel aquatic plant growth.
- High density of piers per shoreland mile. Piers affect fish and disrupt natural shoreline habitats.
- A third of parcels have some degree of hard-scape, such as rip-rap along the water's edge. Think of the turtle test. If you were a turtle, could you get from shore to the water without getting stuck between the rocks.
- Crescent Lake provides only limited coarse woody habitat for fish and other aquatic organisms.
- Shoreland conservation will become more important as more frequency high intensity rain events flush more run-off water and nutrients from the landscape into the lake.

To protect water quality and habitat, Crescent Lake needs:

- Increase educational opportunities.
- Protect existing natural shoreland habitats.
- Improve marginal shoreland habitats for aquatic life and protecting water quality.
- Continue mindful management of invasive species using an adaptive and integrated pest management framework.

The overarching aquatic plant management goal for Crescent Lake is to balance the diversity of lake use through sound management practices that address both short and long-term lake health. Objectives will use the guiding AIS management principles detailed earlier in this plan (pg 21). Additional goals that support the short and long-term management of aquatic plants include:

(1) Build lake community capacity to support project goals and objectives

(2) Continue monitoring water quality and ecosystem health

(3) Promote conservation of native species, their habitats, and water quality protection

Goal (1) Build lake community capacity to support project goals, and objectives.

Objective (1) Promote programming and communication within the Lake Association to achieve Action Plan objectives.

Action (1) Create an educational committee to oversee education and outreach aspects of this planning project.

Timeframe: Committee structure discussion and formulation to take place within one year of plan adoption.

Role/Responsibility: Board, with assistance from Lake Association volunteers may facilitate development and committee recruitment. Board member to serve as a liaison between the committee and the board.

Expected output/outcome: The education committee, with input from the board and Lake Association membership, will propose ways, strategies, and oversight to inform lake community to meet Action Plan objectives. Priority topics identified through the planning process for the committee's consideration include:

- Provide education on water quality impacts including the use of fertilizers, impervious surfaces, run-off abatement and septic system maintenance.
- Review of best management practices and policy of the use of pesticides/fertilizers in lakeshore environments.
- Providing resources and education for on site design and near shore habitat improvements.
- Raise awareness within the lake community about the lake management plan and current lake issues.
- Inform and engage new property owners to bring them up to speed on Association business, lake health, volunteer opportunities, and current lake concerns.
- Engage realtors and those marketing properties on Crescent Lake on lake stewardship and shoreland habitat conservation.
- Line up guest speakers at association events to talk about lake health and other lake related topics.
- Promote and connect lake residents to citizen science and other monitoring for other aspects of lake health.
- Boating and wake regulations.

Action (2) Advance communication and connection amongst our lake community residents.

Timeframe: Ongoing

Role/Responsibility: Education committee with liaison representation from the board.

Expected output/outcome: Review how information is shared to the lake community on current lake issues. Including revisiting effectiveness of current avenues of communication:

- Revisit the idea of a newsletter
- Social media
- Current website

Objective (2) Promote networking and collaboration with other lake associations and similar organizations.

Action (1) Continue building networking and collaboration list. Identify and expand relationships with local/State/Federal management agencies and like-minded environmental organizations.

Role/Responsibility: Lake planning committee to create document with periodic review from lake association representatives. Housing of current master document to be determined.

Timeframe: First master list to be completed by the planning committee (Appendix E). Review of document to occur as new information becomes available.

Expected output/outcome: Develop a working list of organizations and contacts with periodic review for inclusiveness and usefulness. This list will serve as a directory to identify resources and contacts for more information. Continue to build connections with local like minded environmental groups.

Goal (2) Continue monitoring water quality and ecosystem health.

Objective (1) Monitor water quality

Action (1) Use WDNR Citizen Lake Monitoring Program to monitor water quality including water transparency, total phosphorus, chlorophyll *a,* dissolved oxygen, and temperature.

Timeframe: Ongoing

Role/Responsibility: Volunteer

Expected output/outcome: Volunteers are responsible for collection and submission of water quality samples to the State of Wisconsin and sharing information with association committees and membership.

Report findings to SWIMS. Participation in this program will continue to build long-term water quality data for Crescent Lake.

Objective (2) Monitor for new aquatic invasive species

Action (1) Conduct annual monitoring for new aquatic invasive species.

Timeframe: Ongoing

Role/Responsibility: Volunteer Lake Monitors/AIS Response Team/AIS Coordinator/Other Resource Professionals

Expected output/outcome: Provide annual summaries of volunteer efforts and report new findings to the WDNR, SWIMS and other appropriate databases. Monitoring data will track EWM and other AIS populations over time and improve detection of new species.

Action (2) Train volunteers on AIS identification and early detection monitoring.

Timeframe: Everyone to two years

Role/Responsibility: Volunteer Lake Monitors/AIS Response Team/AIS Coordinator/Other Resource Professionals

Expected output/outcome: Recruit new volunteers and refresh existing volunteers on AIS identification and early detection monitoring protocols.

Goal (3) Promote conservation of native species, their habitats, and water quality protection

Objective (1) Conserve native species and improve habitat quality along the lakeshore.

Action (1) Educate lake residents on the importance of near-shore habitat and measures they can take to improve and protect habitat.

Timeframe: Ongoing

Role/Responsibility: Board and Education Committee, with invited professional speakers

Expected output/outcome: The Education Committee will propose priorities, strategies, and oversight to meet objective. Committee will be given opportunity to circulate educational materials and/or articles of interest to lake membership and to suggest items for website. Use current shoreline habitat data and water quality data as a baseline to compare and to detect changes to shoreland habitats, coarse woody debris, and water quality over time. Projects include:

- Healthy Lakes projects
- Grant opportunities
- Invited presentations or articles where possible
- Communication capacity
- Share success stories
- Hands on learning

Objective (2) Manage invasive species

Action (1) Continue management of EWM.

Timeframe: Ongoing

Role/Responsibility: Board/AIS Response Team/AIS Coordinator/Other Resource Professionals

Expected output/outcome: Using an adaptive management framework, develop annual strategies that best fit the current condition of the situation including discussions on:

- Balancing recreational needs and ecological health.
- Revisit acceptance of EWM levels at different lake locations.
- Annually inform lake residents of proposed annual management strategies and provide information on management accomplishments.
- Annually invite input from lake residents on management and decisions.

As described in the aquatic plant management portion of this plan management of Eurasian watermilfoil (or other AIS) shall:

- Use integrated pest management. Integrated pest management is a framework that relies on a combination of management practices *(Page 21).*
- *Develop annual monitoring and evaluation strategies based on the annual strategies deployed. These will vary depending on scale (Page 22).*
- Continue to track volunteer and paid management efforts, such as dive time and DASH work.

Action (2) Track/monitor EWM population and management actions.

Timeframe: Ongoing

Role/Responsibility: Volunteers/AIS Response Team/AIS Coordinator/Resource Professionals

Expected output/outcome: Continue to monitor EWM management including the effectiveness of the control techniques used and when appropriate impacts to non-target species *(Page 22).* Continue to ask advice and guidance from local professional to ensure Crescent Lake is benefitting from the latest research in the field.

Action (3) Continue exploring other applicable EWM management techniques.

Timeframe: Ongoing

Role/Responsibility: Board/ AIS Response Team/AIS Coordinator

Expected output/outcome: Stay up to date on current management techniques and applicability and keep informed of new techniques as they become available. Visit at least once annually with local professional (such as but not limited to DNR staff) to ask questions and hear updates on ongoing successes or challenges in other lakes.

Action (4) Include annual management strategies for wetland invasive species.

Timeframe: Ongoing

Role/Responsibility: Volunteer/AIS Response Team/AIS Coordinator

Expected output/outcome: Monitor and track efforts to address wetland invasive species such as purple loosestrife present on Crescent Lake. Ask county invasive species coordinator annually about any new reports in the area.

Objective (3) Prevent the spread of aquatic invasive species to and from Crescent Lake.

Action (1) Participate in Clean Boats Clean Waters and other AIS prevention educational activities, such as Landing Blitz.

Timeframe: Ongoing

Role/Responsibility: AIS Coordinator/Volunteers

Expected output/outcome: Provide outreach and education to launch users on AIS prevention to reduce the likelihood of transporting invasive species to and from Crescent Lake. Report educational efforts to SWIMS.

Action (2) Review and replace signage at boat landing regarding AIS prevention.

Timeframe: Every other year

Role/Responsibility: Board

Expected output/outcome: Signage that is up to date with current policy and standard AIS prevention messaging.

Action (3) Strengthen boater etiquette regarding boating actions that impact the internal EWM spread on Crescent Lake.

Timeframe: On going

Role/Responsibility: AIS Coordinator/AIS Response Team/Board

Expected output/outcome: Better messaging/education to lake users on boating etiquette to minimize impacts of internal EWM. Minimize boater disturbance through dense colonies of EWM.

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