Comprehensive Lake Management Planning

For

Pioneer Lake

Vilas County, WI

Funded by: Pioneer Lake Association, Inc. and WDNR Surface Water Grants (LPL168719). Technical assistance and field data provided by the Vilas County Land and Water Conservation Department.

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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 management alternatives and options.
- Including strategies to monitor for progress towards goals and objectives.

The goal for this project is to gather a baseline of ecological information of Pioneer Lake and provide actions that support aesthetic qualities and ecosystem health over time. Supporting goals include identifying ecological threats and formulating responses to them; engaging and educating the lake community; and developing actions that support mindful management of invasive species while conserving native species and their habitats. Likewise, this plan seeks to meet NR 198.43 requirements, allowing the Pioneer Lake Association to be eligible for further Wisconsin DNR Surface Water Grants. The plan has a five-year scope; however, periodic review is recommended to ensure content is relevant to the current situation.

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)[1]**.** 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 Pioneer Lake. This establishes baseline information to detect change that might identify and guide the need for future action.

This planning project dove-tailed a Directed Lakes project through Vilas County Land and Water Conservation District. Directed Lakes is Wisconsin Department of Natural Resources (WDNR) program that surveys lakes and collects information on the physical, chemical, and biological condition. The purpose of Directed Lakes is to create a state-wide comprehensive data set useful to WDNR, lake residents, and local units of government to address issues of concern and make informed management decisions. Specifically, this Directed Lakes project filled in data gaps, helped identify negative lake health issues, and provided most of the key data to develop a comprehensive lake management plan. Excerpts from Directed Lake's report for Pioneer can be found in **Appendix A**.

[1] In 2012, the EPA reported updated data based on the most recent sampling. Overall, a comparison of 2007 to 2012 data indicated very little change to the percentage of lakes with degraded biological, chemical and physical condition of lakes at the national level.

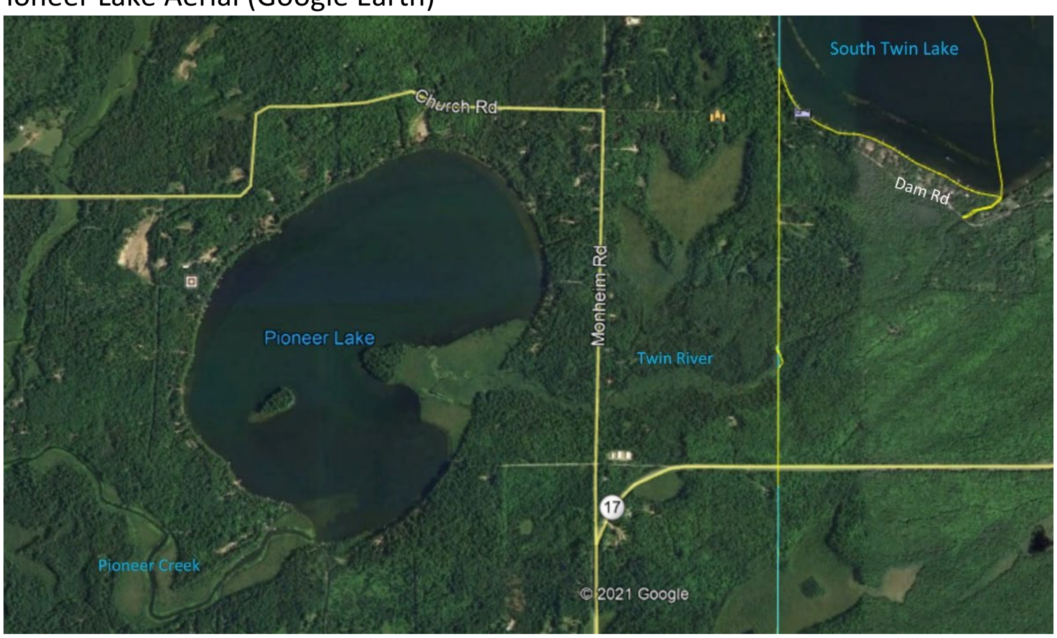
INTRODUCTION

Pioneer Lake, located in Vilas County, is a 429-acre shallow lowland drainage lake with a mean depth of 12 feet and a maximum depth of 27 feet. The WDNR considers Pioneer Lake to be in good health, meeting all state water quality standards. Pioneer is moderately clear and supports a diverse fish and aquatic plant population. Current invasive species include Chinese Mystery Snail, and newly identified Narrow Leaf Cattail and Banded Mystery Snail. While not yet in the lake, an isolated population of Eurasian Watermilfoil was identified upstream in the Twin River.

Located within the Tamarack Pioneer Watershed, land cover consists of forests (69%), wetlands (18%), mixed open (10%) and other uses (2%). Overall, this watershed is ranked low for runoff impacts to streams and groundwater and medium impact runoff for lakes, giving it an overall low runoff impact ranking. Of significant importance to Pioneer Lake is the flow contributed by the Twin River, originating at a dam-controlled outlet from South Twin Lake and flowing to Pioneer Lake, entering Pioneer Lake along the eastern shore. The connected North and South Twin Lakes act as a natural reservoir in a system of similar reservoirs operated by the Wisconsin Valley Improvement Company (WVIC) to help regulate flow across the Wisconsin River system. Water levels in the Twin Lake Project are regulated by a manually operated dam located along the southern shore of South Twin Lake. Recent flooding on Pioneer Lake has caused a concerted effort to understand and mitigate the problem, which likely has a complex of both natural and man-made causes. Pioneer Creek drains from Pioneer Lake along the far southern shore, flowing mostly unimpeded north and west for approximately 10 miles before entering the Wisconsin River just west of Conover, WI. Because of its unique location in the watershed and the larger Wisconsin River Valley system, lake management in the case of Pioneer Lake may need to be especially in tune with climate resiliency science and practices.

Pioneer Lake is accessed by one public boat launch at the southeast end of the lake. It is represented by the Pioneer Lake Association, which galvanized around flooding issues and concerns about invasive species. The Association is now a member of the new regional Conover Town Lakes Committee.

Map 1: Pioneer Lake Aerial (Google Earth)



1-SOCIAL AND HISTORICAL CONTEXT

Pioneer Lake is part of a region known as the northern highlands, which comprised of ancient and interesting geology. "The prominent mound in the center of northern Wisconsin is part of the Canadian Shield, which is made of the oldest rocks on the continent. The rocks were pushed up as ancient mountains were formed, eroded, and reformed. After the final uplift, about 200 million years ago, the northern highlands remained above water as an ancient sea covered the rest of the state. Today, the northern highlands area of Wisconsin is widely known for its forests, lakes, and wetlands. Most of these lakes and wetlands occupy kettles in broad plains deposited by rivers carrying meltwater and sediment, called outwash, from the Langlade, Wisconsin Valley, and Chippewa Lobes of the Laurentide Ice Sheet as it receded from its maximum extent about 18,000 years ago."[2] (***Photo 1***)

Photo 1: Wisconsin's Glacial History

From an anthropology standpoint, the area surrounding Pioneer Lake has rich tribal heritage that predates European settlement by thousands of years. As part of current day Vilas County, Pioneer Lake shares about three centuries of history with the Chippewa Ojibwe tribe[3], who were known to utilize its rich woodlands, abundant fishery, and forage- particularly berries and native wild rice. French missionaries and then fur traders traversed the region from 1650-1850. By 1850, the very lucrative fur trade industry was nearly exhausted and had left the area. What is now Vilas County was ceded to the United States by treaty with the Ojibwe in 1842. **(WDNR, 2015)** Of local and watershed importance, the Lac Du Flambeau Band of Lake Superior Chippewa Indians has inhabited the Lac du Flambeau area since 1745 when Chief Keeshkemun led the Band to the area. The Band acquired the name Lac du Flambeau from its gathering practice of harvesting fish at night by torchlight. The name Lac du Flambeau, or Lake of the Torches, refers to this practice and was given to the Band by the French traders and trappers who visited the area. The Lac du Flambeau Reservation was officially established by the Treaty of 1854.

Photo 2: Logging the giant white pine. *wisconsinhistory.org*

The area was continually logged in the following years, extracting nearly all its giant white pine by the late 1800's. This vast logging and subsequent railroads spurred settlement of the area.

[2] https://wgnhs.wisc.edu/wisconsin-geology/major-landscape-features/northern-highlands/

[3] https://www.wisconsinhistory.org/Records/Article/CS4380

Settlement History

Around 1900, the lake and resource rich Northwoods, including Pioneer Lake, became a tourist destination for families from southern Wisconsin and Illinois. The development of railways linking the Northwood's to cities such as Chicago, facilitated the travel of railroad executives and wealthy businessmen to the Northwoods to hunt and fish. Eventually the vast natural resources led to white settlement in the area.

According to George Dobbs' (1991) History-of-Conover[4] , Seth H. Conover, a prominent cheese buyer from Plymouth, WI, is credited with paving the way to the settlement that soon bore his name and to which Pioneer Lake has an entwined history. Friendly with the railroad executives, he was let off the train in one location near his favorite hunting and fishing grounds by Big Twin Lake so often that it became known as Conover's Place and then Conover. It was noted on railroad maps and had its own train station by the 1890s. After the railroad station was built, several logging camps were established and a tremendous effort to log off the giant white pine forests continued for the next twenty years. Seth Conover was first deeded land on Big Twin lake in 1891, but sold it within the year. Other businessmen saw opportunity here, and Conover had a brickyard, tavern, store and school by 1900. The Town of Conover, composed of 30 sections of land, was officially described in 1907, being split out of the Town of Eagle. Additional land that included lakes was annexed in 1914 and 1920. A Town Hall was built in 1935[5].

The History of Conover also notes that William Adams homesteaded the island on Pioneer Lake "when Teddy Roosevelt was president" (1901-1909). Not an easy feat as lumber was carried a mile to the lake, then via boat to the island. Railroads supplied a ready vehicle for sportsmen and summer tourists in the 1920s and many lake lots were purchased in the 1940s and 50s. The Von Hoffmans and the Jones families were recorded as the first summer people around Pioneer Lake. Today, Pioneer Lake is populated by approximately 80 lakefront landowners, with another 40 or so associated properties.

History of Water Regulation in the Wisconsin River System

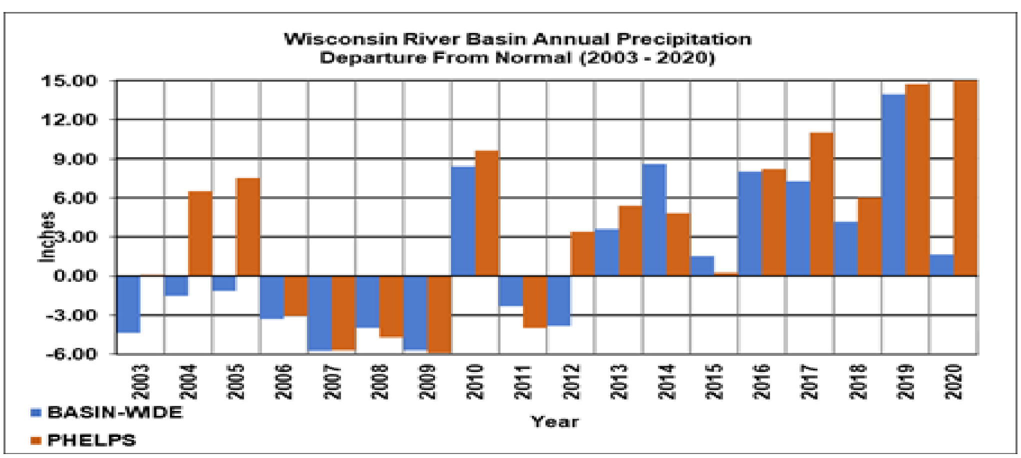
Another legacy of the logging era was a number of earthen dams at the outlets of natural lakes in the Wisconsin River Valley. These dams were used to accumulate winter's harvest of timber and release it in a controlled fashion during spring's high flow, facilitating transport of the logs to downstream industrial facilities. Historic mention of a dam at the outlet of Pioneer Lake could not be verified, but Pioneer Lake is associated with the flows of one such dam at the outlet of South Twin Lake, known as the Twin Lakes Development by the Wisconsin Valley Improvement Company (WVIC). The Twin Lakes Development is one of sixteen natural-lake reservoirs in the WVIC License that become part of a natural lake reservoir system whose purpose was to provide flow regulation in the Wisconsin River downstream. It is the source of the Twin River, which flows into Pioneer Lake, 2.1 river-miles downstream from the Twin Lakes Dam. Pioneer Creek then flows out of Pioneer Lake, 9.9 river-miles to its confluence with the Wisconsin River. The original dam was acquired from the Pioneer Improvement Company in July 1907. The dam was rebuilt in 1949 and consists of a concrete gated spillway and short earthen dikes on both sides of the spillway. The maximum head is 4.33 feet measured from the gate sill. Spillway capacity is provided by

[4] https://www.townofconover.com/community/about_us.php
[5] Wikipedia: Conover, WI

one 10-foot wide by 4-foot-4-inch high tainter gate and one 4-foot-wide stop log overflow section. The gate is manually operated by a damtender with a cable hoist. The dam is classified as low hazard and is exempt from FERC' s Emergency Action Plan and Part 12 Inspection Requirements. An additional five man-made reservoirs were also created as part of this system, and the twenty-one dams are still owned and operated by the WVIC to "maintain as uniform a flow as practicable in the Wisconsin River and a reasonable balance among the benefits the water resource provides including water conservation, flood control, low flow augmentation, hydroelectric generation, water quality, wildlife and recreation." The system has a licensed operating plan (describing its maximum and minimum flows) by the Federal Energy Regulation Commission. (FERC License No. 2113)[6]. The Twin Lakes Dam is the subject of much concern among Pioneer Lake residents, who have experienced significant flood damage following extreme rain events in recent years. Residents attribute the flooding and property damage on Pioneer Lake with dam operations that regulate the flow from the much larger volume of the Twin Lakes reservoir. WVIC states that operations of Twin Lakes Dam have reflected the hydrologic conditions of the watershed. In the corresponding report (Article 421- Operating Plan Status Report and Review) referencing this response, WVIC details that the last 8 years have been the wettest on record since data was kept starting in 1890. The report states that the 8-year (2013-2020) cumulative departure above normal precipitation within the entire operating system of WVIC is 50 inches. It is important to note that precipitation at Phelps, Wisconsin, where much of the subject drainage basin is located is more than 65 inches above normal during this same 8-year period and adding 2012 amounts into the data, the sub-basin is nearly 70 inches above normal. The following graphic shows the comparison.

***Photo 3**: Flooding damage on one Pioneer Lake Property (2017). Mary Finlay.*

Figure 1.1: Wisconsin River Basin Annual Precipitation Departure from Normal (2003-2020) (WVIC).



[6] http://www.wvic.com/

At the time of this writing, there are ongoing discussions between the Pioneer Lake Association and regulatory agencies to discern the relationship of this flooding with weather patterns, watershed topography, and dam operation. Questions concerning the efficacy of the maximum and minimum water levels at the Twin Falls Dam received the following answer: The original maximum and minimum operational elevations used at the Twin Lakes project were established by the Wisconsin State Board of Forestry and described in the following report: *Wisconsin State Board of Forestry, E.M. Griffith, State Forester, Preliminary Report on Storage Reservoirs at the Headwaters of the Wisconsin River and Their Relation to Stream Flow. By C.B. Stewart, Consulting Engineer, February 1911.* Based on observations made on a gage at the dam, high and low water limits were proposed for winter and summer seasons, as related to National Geodetic Vertical Datum of 1929 (NGVD29), where a 0'0" height on the gauge equals an elevation of 1680.24'. The original high and low water elevations proposed in 1911 were:

1. *High water, winter and summer seasons, +2'10" = 1683.07'*
2. *Low water, summer season, June 1-Oct. 1, +0'8" = 1680.91'*
3. *Low water, winter season, +0'4" = 1680.57'*

These levels stood until 1936, when the Wisconsin Public Service Commission, which assumed regulation of the reservoirs, investigated a petition for the establishment of a lower maximum and a higher minimum elevation for the headwater controlled by the dam at the outlet of Twin Lakes in Vilas County. The Wisconsin Public Service Commission, by order, fixed the maximum summer elevation at 2 feet 4 inches; the crest of the stop logs in the stop-log gate not to exceed 2 feet 2 inches on the gage during the summer season. Using this order, the elevations were established using the 1929 conversion datum as follows:

• High water, winter and summer seasons, +2'4" = 1682.57'
• Summer season target elevation, +2'2" = 1682.40'

The elevations established by the 1936 order have continued through the original 1959 WVIC FERC License and the current License issued in 1996.

Photo 4 : Twin Falls Dam, 2017. PLA.

Following discussions with the Pioneer Lake Association and their engineering consultant after recent high water, WVIC recommended installing a staff gage at a location on Pioneer Lake that would establish water levels tied to a NGVD benchmark. In 2020, WVIC staff established a benchmark and installed the staff gage (location chosen by the Association) in Pioneer Creek, at a location where the data would correlate to Pioneer Lake levels. WVIC agreed with the Association and their engineering consultant that the establishment of data on the same datum as the Twin Lakes Dam will show the rise and fall of water levels on Pioneer Lake in relation to the Twin Lake Dam. Pioneer Lake Association members will record daily water level information at the **calibrated staff gauge and provide it to WVIC over the period** 2021-2025. These four years of information will help inform all parties, help determine if any adjustments to the operations of the Twin Lakes Dam are warranted, and what types of adjustments may fall within the parameters guided by the restrictions established in Articles 403 and 404 of the WVIC FERC

License. This data will be presented with any recommendations at the next 5-Year review of the WVIC operating plan scheduled for 2026.

Changing environmental/climactic conditions in the Midwest resulting in more extreme rainfall events, integrity of the aging dams, inherent topographical features in the watershed, continued development, and attempts to regulate flows across the watershed will be ongoing concerns for the future.

Lake Stewardship

Lake residents have a history of lake stewardship and interest in the water quality. Volunteers have monitored water clarity with a secchi disc since 1995, as early participants in the Citizen Lake Monitoring Network. With the advent of concerns over aquatic invasive species in the 2000's and increasing emphasis on lake management planning in Wisconsin, a committee of landowners laid the groundwork for the formation of a lake association. The Pioneer Lake Association held its first meeting on September 17, 2016, attended by 40 people and describing its purpose as "to preserve and protect Pioneer Lake and its surroundings, and to enhance the water quality, fishery, boating safety, and aesthetic values of Pioneer Lake, as a public recreational facility for today and future generations."

By the first Annual Meeting in September 2017, the Pioneer Lake Association represented 71 households, had become a non-profit corporation, and had authorized the pledging of match toward a grant application to obtain a lake management plan. The Lake Association became the hub for the response to flood damage on Pioneer Lake caused by opening the Twin Falls Dam by the Wisconsin Valley Improvement Company (WVIC) following extreme rainfall events in 2017 and subsequent years. Reports on discussions/actions regarding property damages and regulation of water levels with WVIC has been a significant portion of subsequent meetings. The WVIC FERC License and the operational plan for their 21 dam system is up for renewal in 2021 and Pioneer Lake Association members are engaged in contributing input to this process.

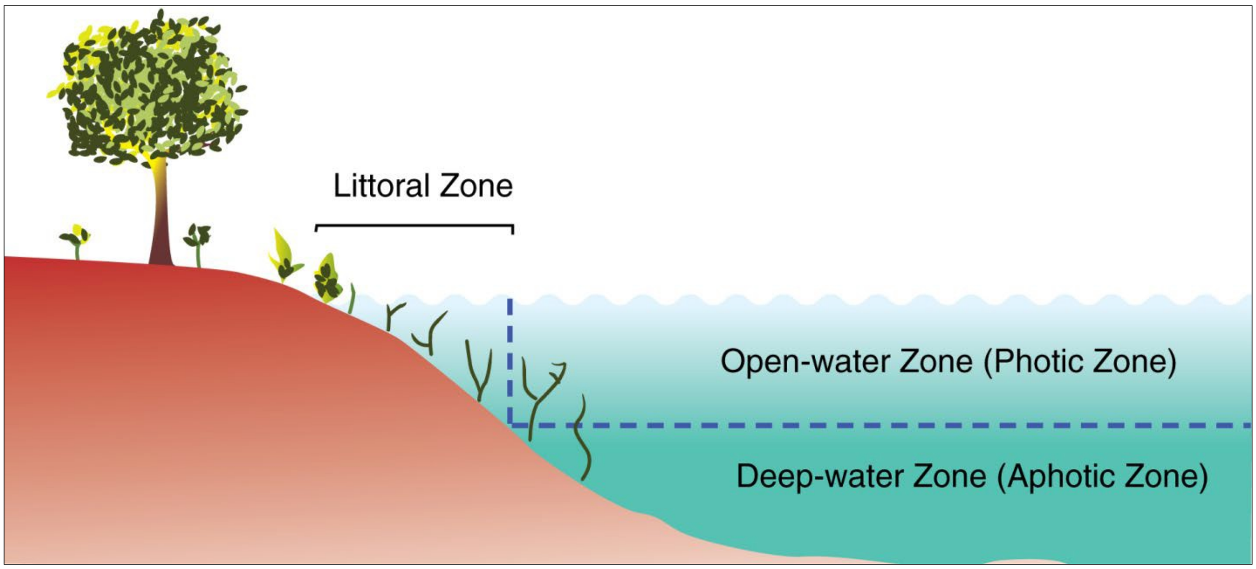
In 2018, Many Waters LLC was contracted to write a lake management planning grant application to the WI DNR. Mary and Jim Finlay attended a Clean Boats Clean Waters training session in 2018, to educate boaters about aquatic invasive species and the need for boater hygiene. Volunteers were recruited for the 2019 season. A WDNR Surface Waters Grant for comprehensive lake management planning was awarded in 2019 and included an aquatic invasive species survey, of significant interest to Association members. The Vilas County Land and Water Conservation Department also received grant funding to conduct a Directed Lake Assessment in 2019. Its 2020 report supplied most of the data for this comprehensive lake management plan, compiled by Many Waters LLC.

Recently, the Pioneer Lake Association joined the Conover Town Lakes Committee, which was formed in August 2019, joining the Town of Conover, riparian landowners, Lake Associations and Lake Districts in a concerted effort to protect lake health by addressing aquatic invasive species.

2- 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 2.1).** 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 2.1: *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.

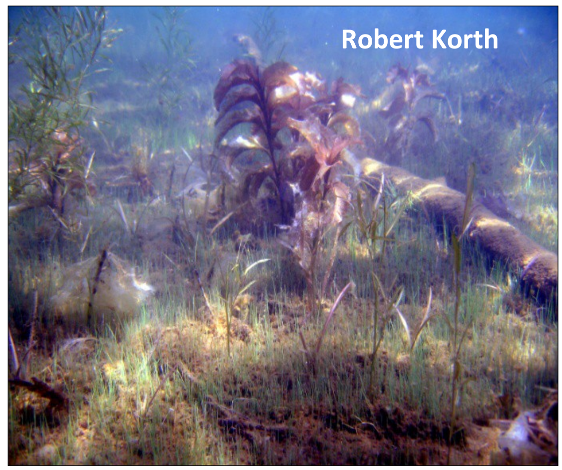
[2] Geoff Ruth [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

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 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.

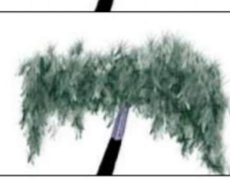


Pioneer Lake's Aquatic Vegetation

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

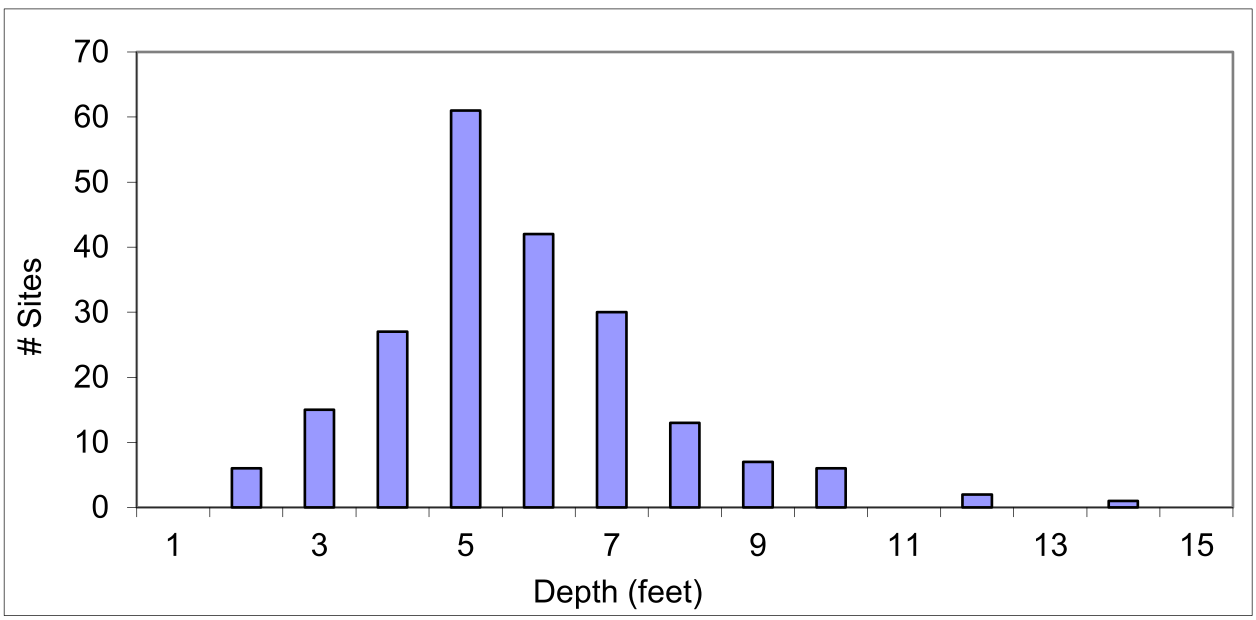
Figure 2.2: *Rake fullness description.*

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 B)** 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 2.2**[3]). At each sampling site, water depth and sediment type are also recorded. Point intercept surveys took place the week of August 1st and 5th 2019. Emergent/floating leaf community mapping took place on August 10th 2020. Emergent/floating leaf community surveys circumnavigated the entire lake identifying all observed emergent and floating leaf plant locations. **(Appendix C)**. Small locations (<1/10 acre) were geo referenced with a GPS point whereas the outer edges of larger locations were traced creating geo-spatially referenced beds.

Pioneer Lake's point intercept survey sampled 252 locations, identifying a total of 24 native aquatic plant species. Rake samples detected 21 native plants species, whereas the remaining species were visual observations. Maximum depth of plant colonization occurred at 14 feet, with most vegetation occurring between 4 to 7 feet **(Figure 2.3).** Most sites sampled consisted of soft or mucky sediments, followed by sand and rock **(Figure 2.4).** Total species detected per rake sample ranged from 1 to 8 with an average of 2.49 species per rake sample **(Table 2.1.)**

Figure 2.3: *Depth of aquatic plant colonization – Pioneer Lake, 2019.*



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[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 2.4: *Bottom substrate consistency – Pioneer Lake, 2019.*

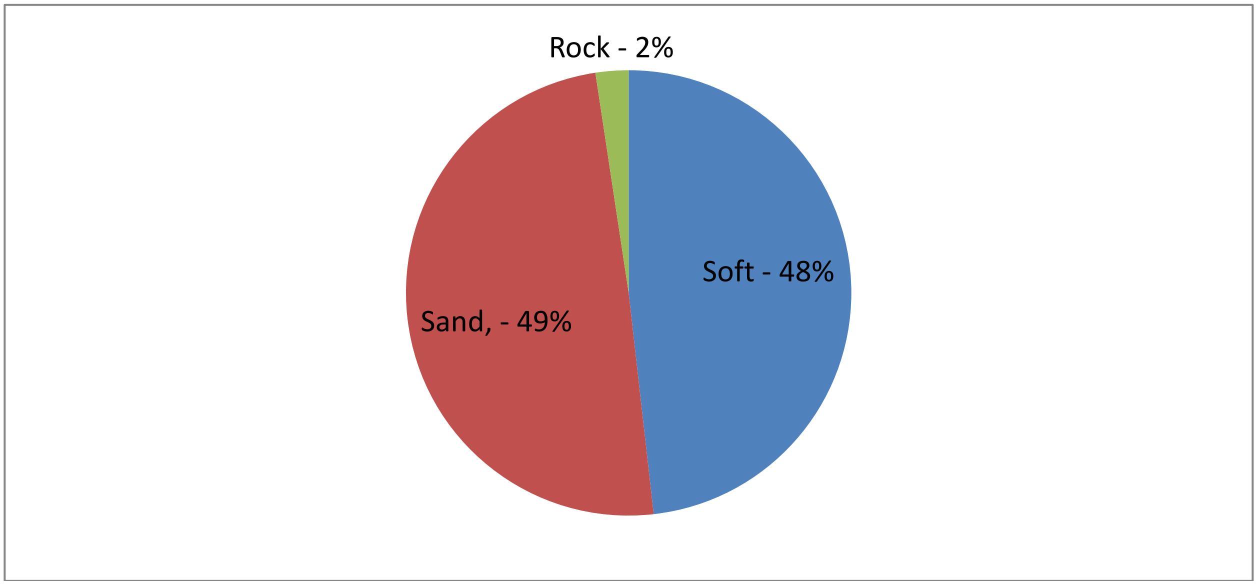
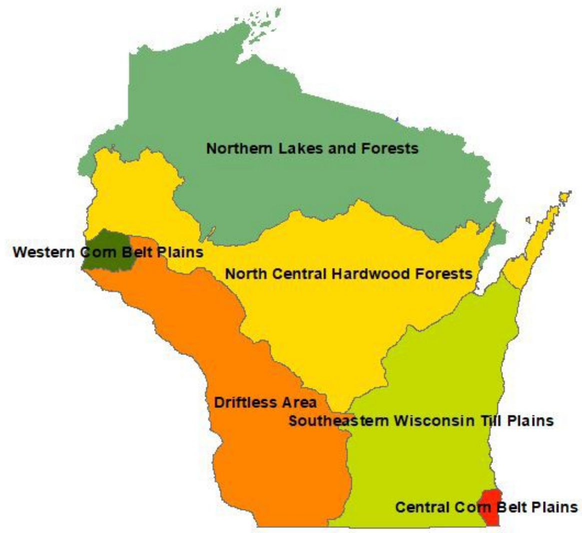


Table 2.1: *Point intercept survey summary – Pioneer Lake, 2019.*

Total number of sites visited	252
Total number of sites with vegetation	210
Total number of sites shallower than maximum depth of plants	242
Frequency of occurrence at sites shallower than maximum depth of plants	86.78
Simpson Diversity Index	0.90
Maximum depth of plants (ft)	14.00
Number of sites sampled using rake on Rope (R)	1
Number of sites sampled using rake on Pole (P)	251
Average number of all species per site (shallower than max depth)	2.49
Average number of all species per site (veg. sites only)	2.87
Average number of native species per site (shallower than max depth)	2.49
Average number of native species per site (veg. sites only)	2.87
Species Richness	21
Species Richness (including visuals)	24

Plant Analysis Primer

Figure 2.5: Wisconsin's Ecoregions.



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 tolerant some change or degradation 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.

Floristic quality assessments generally compare the floristic quality of lakes within a similar Ecoregion **(Figure 2.5).** An Ecoregion is a defined landscape that has similar characteristics including land-use, vegetation, soils, and landscape formations. Pioneer 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)**.**

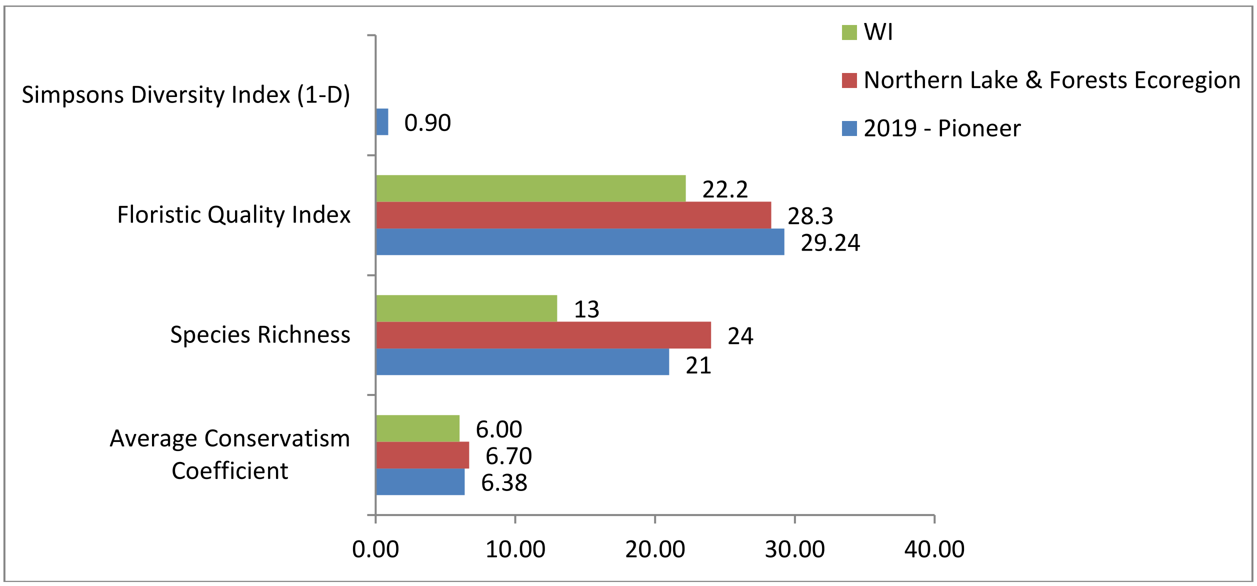
Aquatic Plant Analysis

Overall Pioneer' floristic quality ranks above the Statewide median[5] value for lakes in the Northern Lakes and Forests region and Wisconsin statewide **(Figure 2.6).** Species richness and average conservatism for Pioneer Lake are above the Statewide median value and just slightly below the Northern Lakes and Forest median value.

[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. Current Simpson Diversity Index value for Pioneer Lake is 0.90.

Figure 2.6: *Summary of Pioneer Lake's floristic quality and diversity, 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 Pioneer Lake based on the 2019 point-intercept survey include fern pondweed, wild celery, and flat-stem pondweed **(Figures 2.7 & 2.8).**

Figure 2.7: *Littoral frequency of occurrence of aquatic plants (>5% occurrence) – Pioneer Lake, 2019.*

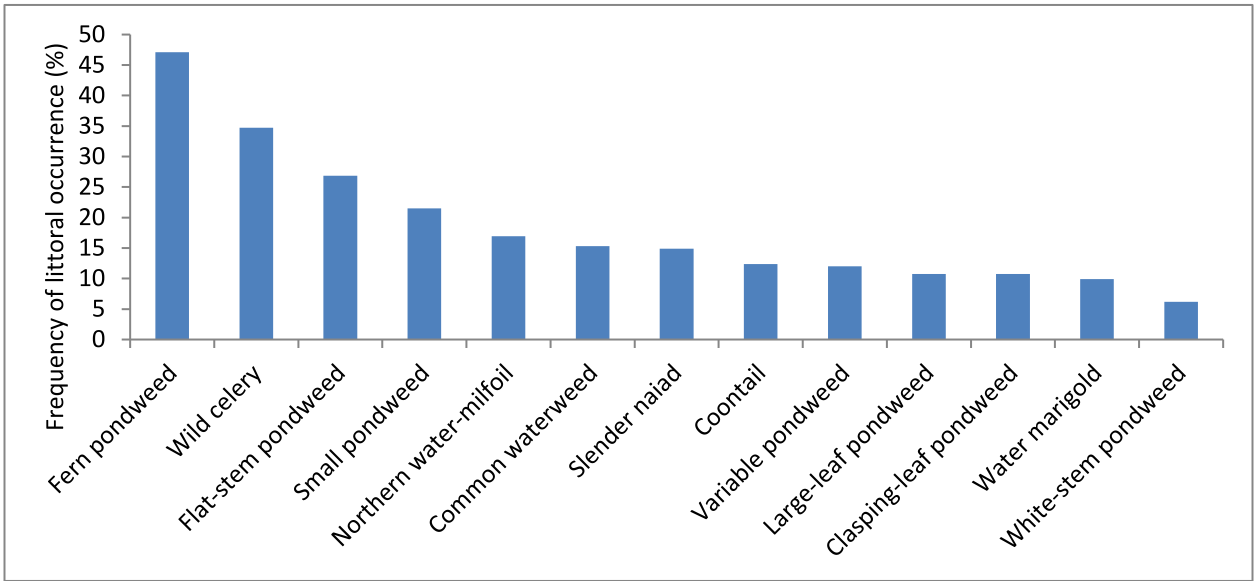
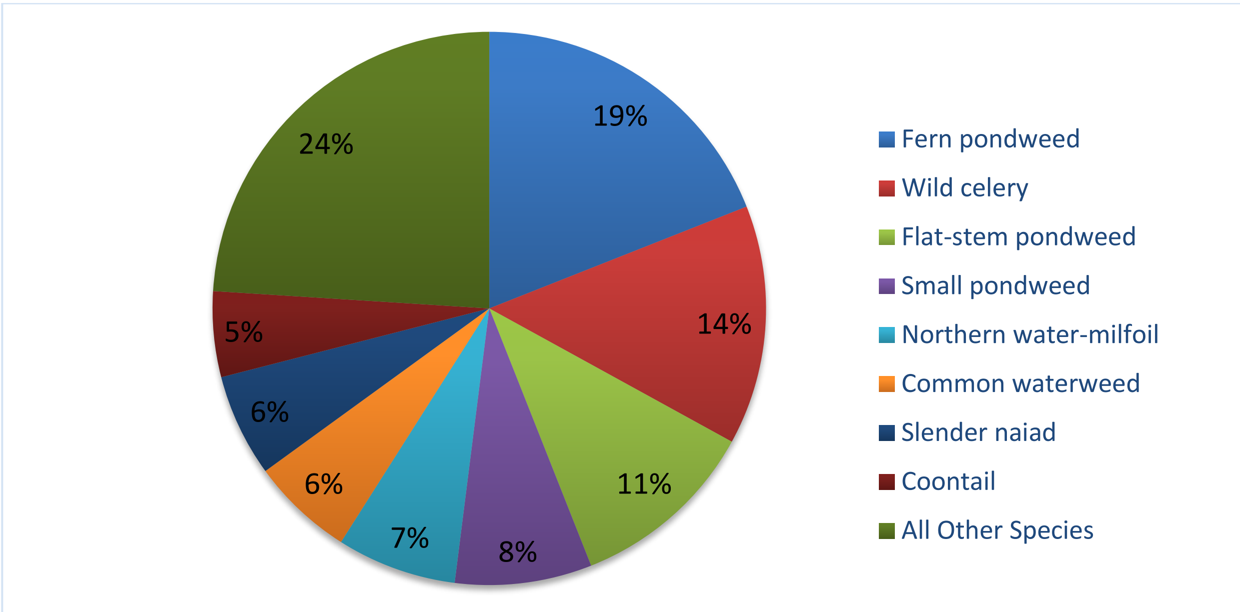


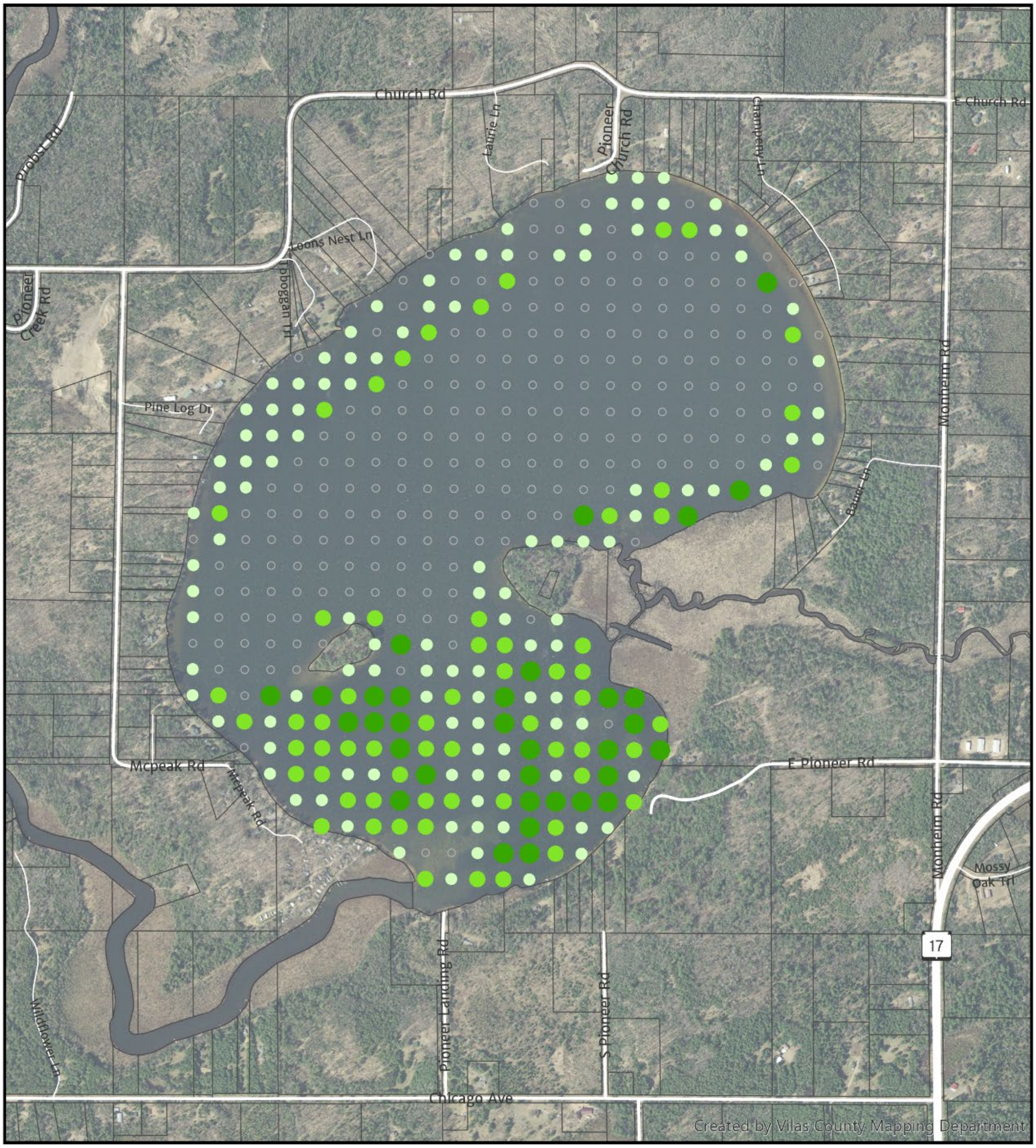
Figure 2.8: *Three most common plants detected on Pioneer Lake, 2019. In order left to right: Fern pondweed, wild celery, and flat-stem pondweed. (Photos courtesy of Vilas County Land and Water Conservation District)*

As mentioned above, frequency of littoral occurrence is the percentage of time a species is detected across the sampled littoral area. These values are 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 Pioneer Lake in 2019 based on relative frequency are again fern pondweed, wild celery, and flat-stem pondweed **(Figure 2.9).**

Figure 2.9: *Relative frequency of occurrence of aquatic plants – Pioneer Lake, 2019.*



Map 2 : 2019 Pioneer Lake Rakefullness Data (Vilas Co LWCD)



Number of Aquatic Plants on Rake

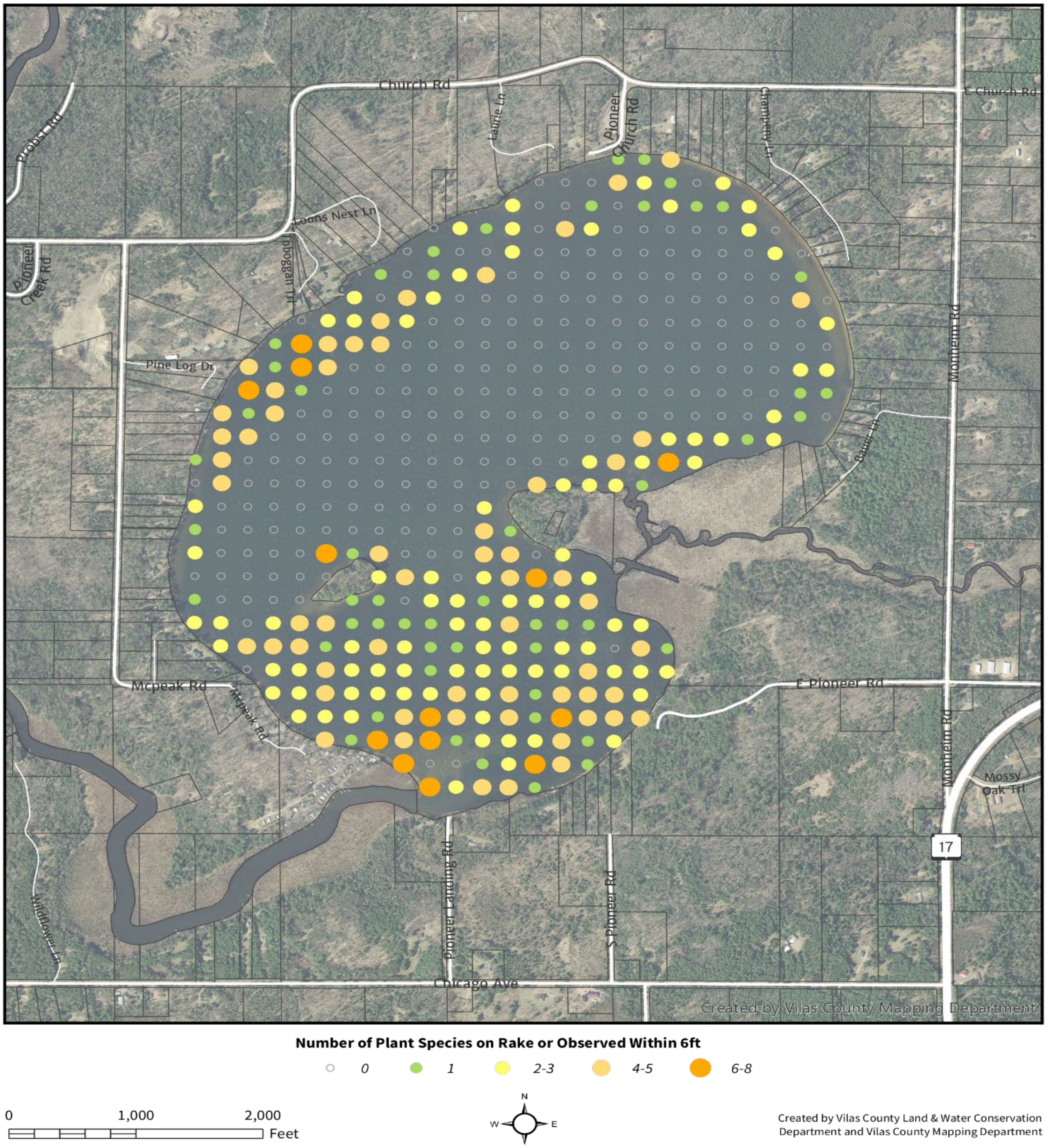
None *Few Plants* *Many Plants* *Overflowing Plants*

0 1,000 2,000 Feet

N W E S

Created by Vilas County Land & Water Conservation Department and Vilas County Mapping Department

Map 3: 2019 Pioneer Lake Species Richness Data (Vilas Co LWCD)



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. Pioneer Lake's emergent and floating leaf communities encompass approximately 4.41 surface acres.[7] This represents approximately 1% of the total surface water acres on Pioneer Lake.

[7] 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.

3-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 Pioneer Lake. However, a basic understanding of their applicability is important to understand the rationale for choosing methods specific to Pioneer 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 contribute to negative water quality include:</u>

- Mowing to the water's edge
- Lawn fertilization
- Removing down woody debris from the water
- Hard-scaping the shoreline with rip-rap and seawalls
- Raking rooted native vegetation out of the water

<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 establish, especially in drought years
- Animal browse may be an issue; fencing may be required until plants are established
- Check with WDNR on regulatory requirements

Photo 5: *Before and After:* *Shoreline Restoration Example from the MI Natural Shoreline Partnership - Middle Lake, Oakland County, MI*

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.

Benthic Barriers

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.

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. Diver Assisted 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.

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 air. 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 at an 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 impact species that are unable to re-locate during water drawn down, such as mussels and small aquatic insects.
- Check 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 need annually stocking for several years, before seeing results.

Application Considerations for Biological Control

- 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
- *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 *and* 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 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, especially in warmer water. Treating in the early spring when water temperatures are cool can minimize degradation.

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. 2,4-D 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.

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 reported range 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).

[7] https://dnr.wi.gov/lakes/contacts/Contacts.aspx?role=AP_MNGT

[8] https://dnr.wi.gov/topic/eia/apmsa.html

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 caused by 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.

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.

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 Guiding Principles & Framework

When deciding to control aquatic invasive species, management shall take into consideration the following principles:

- Apply a early detection and rapid response framework to new invaders as appropriate
- Provide management aimed at reducing population (abundance and distribution)
- Provide recreational nuisance relief caused by invasive species
- Continue to monitor and collect baseline data to detect ecological change
- 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, such as monitoring the population and evaluating results of management. 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 the target invasive species found.

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 or other aquatic invasive plants 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.

Current Status of Aquatic Invasive Species in Pioneer Lake – *Information and language taken from Pioneer Lake 2019 Lake Assessment Report, prepared by Vilas County Land and Water Conservation*

On July 8, 2019, Vilas County surveyed Pioneer Lake for aquatic invasive species. Prior to this survey, only Chinese mystery snails were known to occur in Pioneer Lake. Since very few invasive species were known to occur on Pioneer Lake, a comprehensive survey targeting multiple types of species including invasive plants, animals and zooplankton (microscopic animals) took place. Surveys followed WDNR early detection protocols. These protocols generally target several regions of the lake where AIS are suspect to first colonize based on habitat, access sites, high traffic sites, and other unique lake features. Specifically this survey targeted the public boat landing, the outlet to Pioneer Creek, Maple View Resort shoreline; the north side of the island; the shoreline near the church; and both the north and south inlets from the Twin River. In addition to the targeted surveys, a survey meandering around the perimeter of the lake was completed.

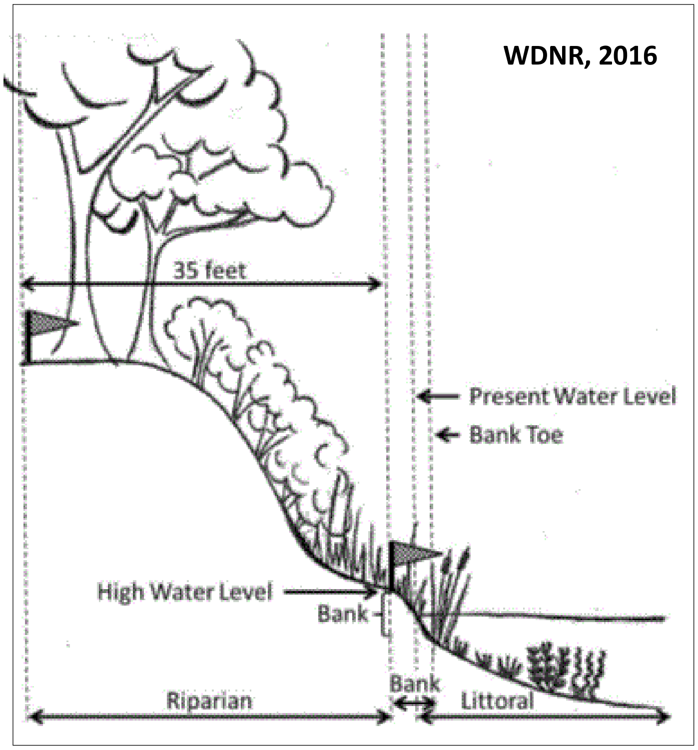
New aquatic invasive species detected include narrow leaf cattail (*Typha angustifolia*) and banded mystery snails (*Viviparus georgianus*). Previously verified Chinese mystery snails were also found during the survey. Yellow iris is suspected on the northeast shoreline just north of Bauer Lane, but cannot be verified because it was not flowering at the time of the survey – native blue flag iris can look quite similar. Several crayfish were found living in the rocky substrate near the island. A sample was collected, and verified as a native Northern Clearwater Crayfish (*Orconectes propinquus*). Invasive Eurasian watermilfoil (*Myriophyllum spicatum*) was found and verified on the downstream side of the Twin River – Monheim Rd crossing.

Figure 3.1 : *Invasive species found on Pioneer Lake and the Twin River between South Twin and Pioneer Lake. Clockwise from top left: narrow leaf cattail; narrow-leaf cattail flower; Chinese mystery snail; Banded mystery snail; and Eurasian water- milfoil found on the Twin River-Monheim Rd. crossing. (Chinese mystery snail photo credit – Amy Benson (USGS) remaining photos courtesy of Vilas County Land and Water Conservation District)*

4 - SHORELAND ASSESSMENTS

Shoreland Habitat Overview

Figure 4.1: *Lakeshore habitat area definitions*



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 Assessment Methods

Shoreland assessments conducted by Vilas County Land and Water Conservation District in 2019 used the WDNR Lake Shoreland and Shallows Habitat Monitoring Field Protocol. 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.

This protocol emphasizes habitat features key to lake health and focus on the riparian buffer, bank, and littoral zones **(Figure 4.1).** 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 80 individual parcels.

Riparian features documented include:

- Percent vegetation coverage
- Impervious surface coverage
- Listing and description of human structures
- Run off concerns
- Evidence of point[8] 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.

[8] Point source runoff or pollution has a definable source, such as a pipe

All assessed properties had a some degree of a canopy (tree layer) and shrub/herbaceous layer **(Figure 4.2).** Fifty-eight percent of assessed properties had some degree of manicured lawn, covering 13% of the total lake riparian area. Eighty-six percent of assessed parcels had some degree of impervious surface, covering 6% of the total lake riparian area. Sloping soils observed on 45% of parcels followed by trails or pathways to the lake observed on 43% of parcels represented the highest observed potential runoff issues recorded. Other observed potential runoff concerns include point sources on 3% of parcels assessed and bare soils observed on 29% of parcels (**Figure 4.3**).

Figure 4.2: *Breakdown of total "ground-layer" riparian buffer by riparian coverage type, Pioneer Lake – 2019. Note: This breakdown does not include canopy- total canopy cover for Pioneer Lake buffer zone was 61%.*

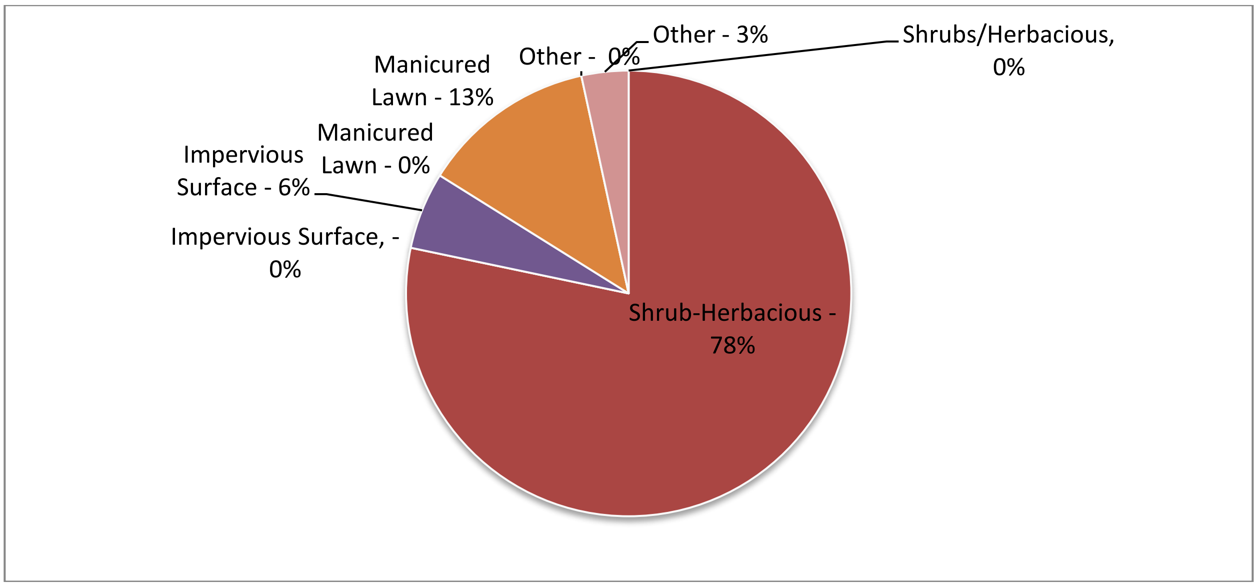
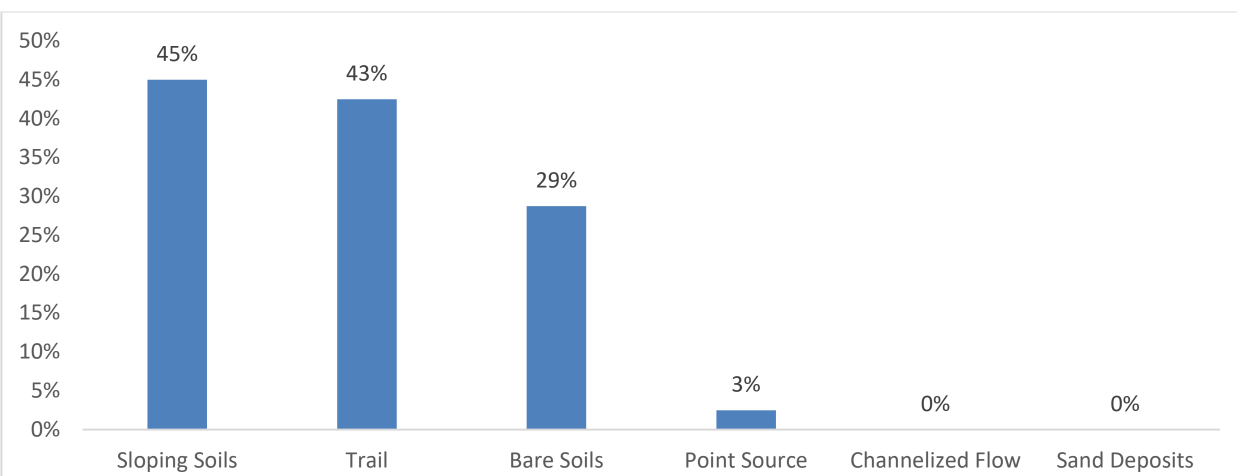


Figure 4.3: *Percent of total properties contributing potential runoff to the lake by runoff type, Pioneer Lake – 2019.*



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 38% of all assessed parcels covering 12% of the total shoreline of Pioneer Lake **(Figure 4.4).** Average length of riprap on Pioneer Lake is 35 feet, and roughly 6% of all parcels having this bank zone feature across the entire length of their property. Erosion greater than one foot in height within the bank zone was observed on 6% of parcels with an average length of 19 feet. Erosion less than one foot in height was not observed **(Figure 4.5).**

Figure 4.4: *Percent of properties with observed bank zone modifications by type – Pioneer Lake, 2019.*

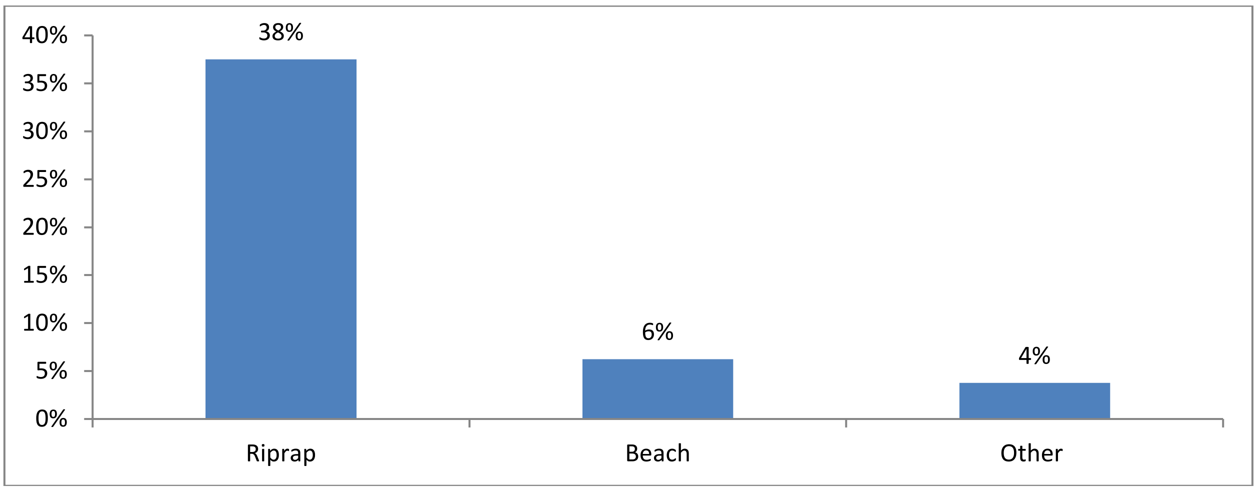
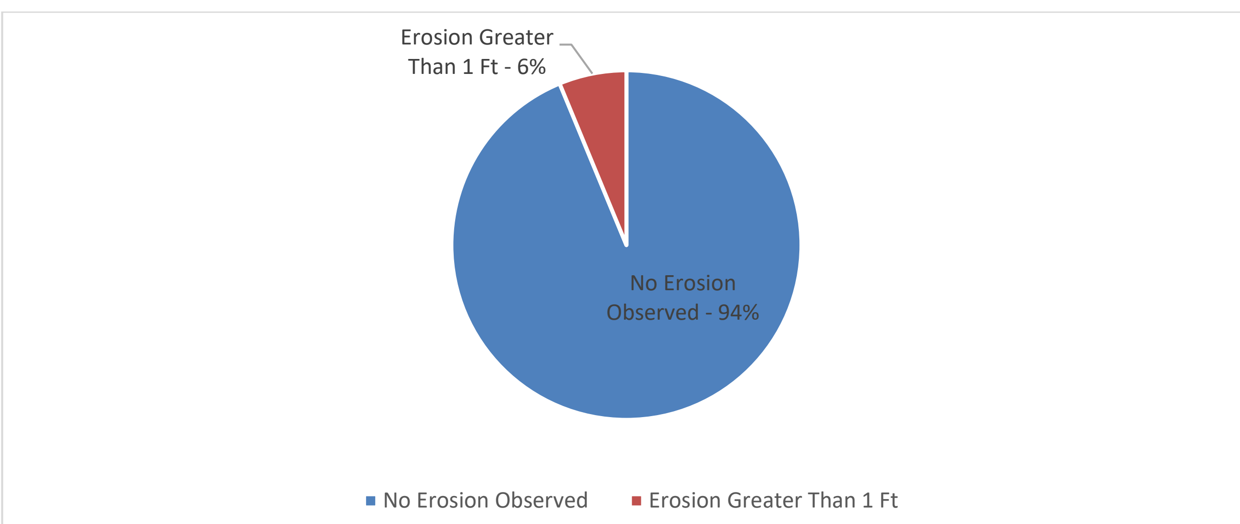


Figure 4.5: *Percent of parcels with observed erosion – Pioneer Lake, 2019.*



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. Sixty-eight percent of parcels on Pioneer Lake have piers, with an average of 1.9 piers per property. **(Figure 4.6).** Overall pier densities averaged 25.20 piers per mile of shoreline. Emergent leaf and floating leaf aquatic vegetation was observed along 16% and 8% of parcels respectfully. Evidence of emergent and floating leaf plant removal was observed not observed **(Figure 4.7).**

Figure 4.6*: Percent of properties with observed littoral zone features – Pioneer Lake, 2019.*

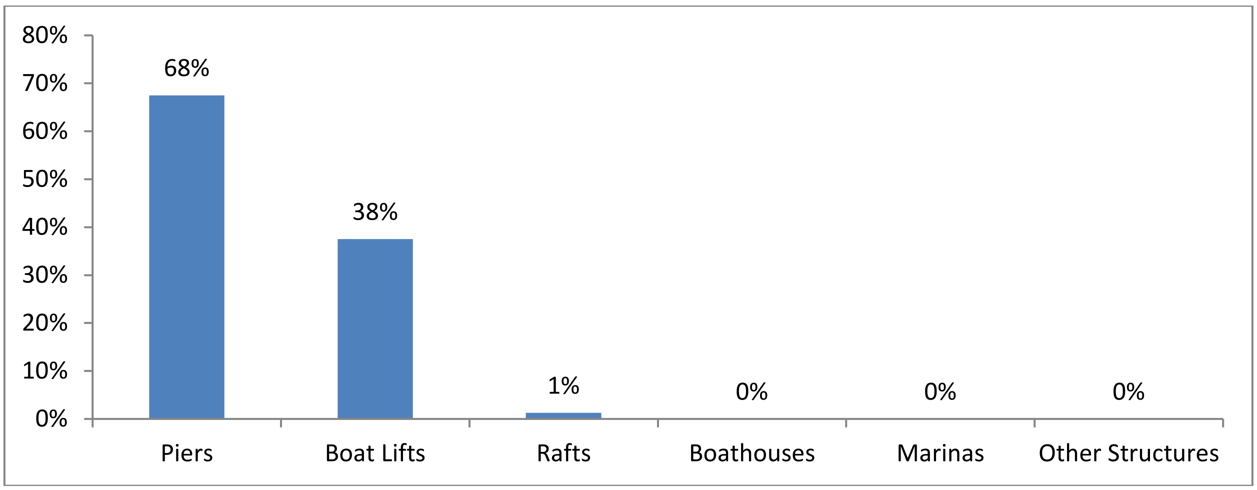
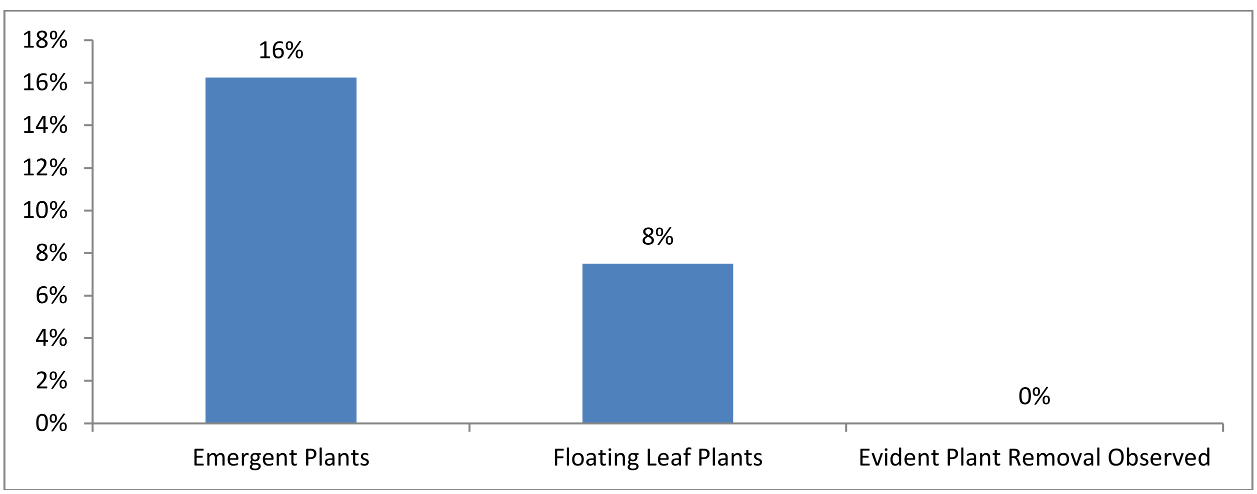


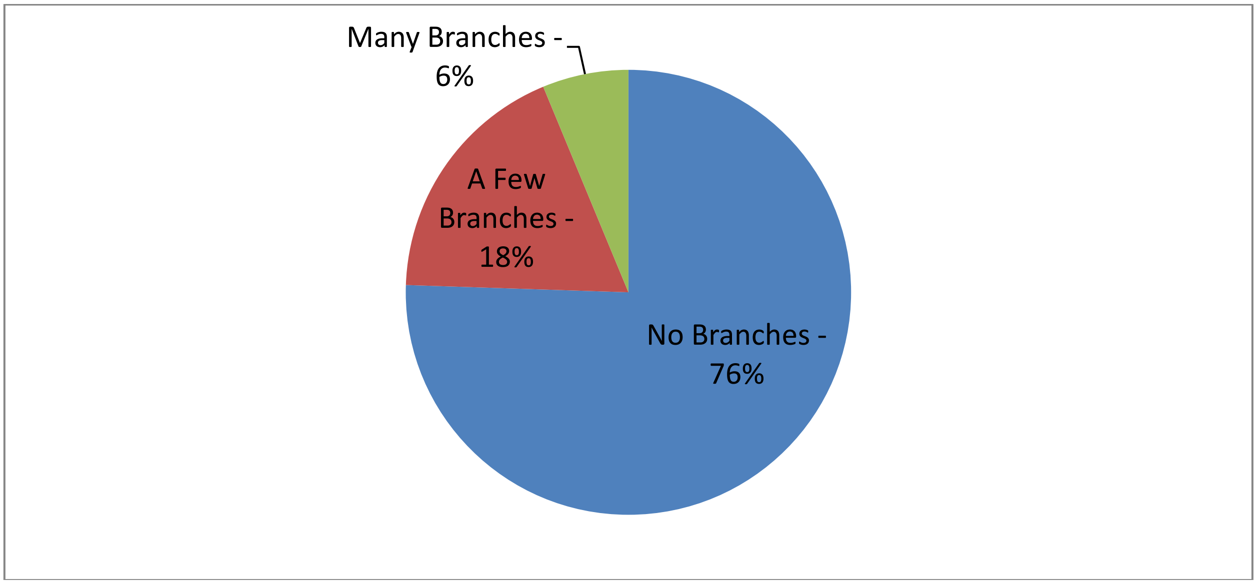
Figure 4.7: *Percent of properties with emergent and floating leaf vegetation– Pioneer Lake, 2019.*



Coarse Woody Debris – Results

One hundred and ninety-two (192) pieces of wood that fit the pre-determined categories were recorded on Pioneer Lake. Seventy-six percent of wood observed had "no branches", followed by 18% with "a few branches" and 6% with "many branches" **(Figure 4.8).** Forty percent of the wood observed crossed the observed high-water level whereas 60% did not. All (100%) identified pieces of wood had at lead 5 feet under water.

Figure 4.8: *Percent of coarse wood debris by branching type – Pioneer Lake, 2019.*



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.

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[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 16 piers/ 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.

[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.

Shoreland Habitat Considerations for Pioneer Lake

Pier density on Pioneer Lake averaged 1.3 piers across all properties, with an average of 25.2 piers/mile. The highest pier density observed on any individual parcel was 33 piers. Pier densities considerably exceed the described "threshold" of 16 piers/mile.

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. Pioneer Lake's estimated density of CWD is ~28 pieces per kilometer of shoreline (46.49 pieces/mile). It is important to note that the survey methods from the example study and the data collected on Pioneer Lake vary, and should not be a direct comparison, but rather provides an illustration on the overall importance of CWD to a lake.

Near shore trees provide the future "investment" for continued supply of wood to a lake. Over time as tree fall into a lake, they decompose, loosing limbs and simplifying in branchiness or structure. Of note for Pioneer Lake, most woody debris documents has little to no limbs present, whereas very little debris consisted of more complex branching or remnants of tree crowns. This lack of structure diversity, may suggest limited "investment" or recruitment of wood to Pioneer Lake over time. Possible reasons a lack of structural complexity is landowners "cleaning" up their shorelines by removing recently fallen trees and branches to the lake.

As mentioned above, the most common bank zone modification observed was riprap, observed on 38% of all assessed parcels covering a total of 12% of Pioneer Lakes total bank zone. Rip-rap, a type of hardscape armoring of the bank zone, uses rocks of various sizes stacked along the water's edge. Hardscaping creates 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. Shorelines where rip-rap is present may cause waves to bounce back off the rip-rap with greater energy, stirring up the nearshore sediment, affecting action and increasing erosion along their shorelines due to displaced wave energy. This may partially explain a domino phenomenon on lakes where rip-rap may be common along a series of adjacent properties.

Of particular concern at Pioneer Lake in recent years (2017-2020) is the amount of flooding in the shoreland area. Sediment, nutrients, petroleum products from swamped boats, and various other residue has entered the lake as floodwaters submerged the shoreland area. Effects of these inputs may not be fully realized until years later. These flooding events may be part of a complex of long-term climatic changes and watershed issues and signal a need for building resiliency into shoreline development.

Photo 6: A sampling of shoreland flooding on Pioneer Lake following 2017 extreme rain events. M. Finlay.

5 - 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.

[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. Pioneer Lake is considered a shallow lowland lake. Shallow lowland lakes have an outlet and may or may not 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 Pioneer Lake a mesotrophic lake **(Figure 5.1).**

Figure 5.1: *Pioneer Lake's trophic status based on water transparency, total phosphorous, and chlorophyll a.*[16]

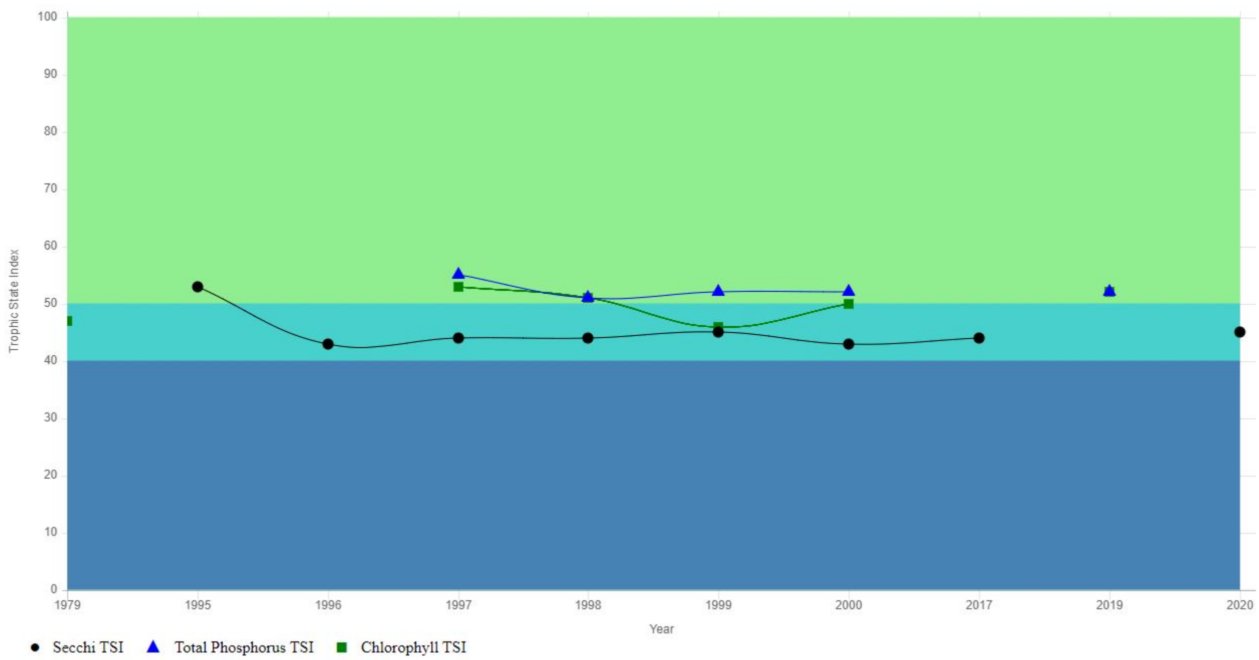


Figure 5.2: *General condition assessment for designated lake use – Pioneer Lake 2021.*

Comparing TSI values to Pioneer Lake's natural community type, Pioneer Lake's general condition is considered good, meaning water quality parameters are at or below designated thresholds assigned to that lake for fish and aquatic life and fish consumption **(Figure 5.2).** General condition assessment for recreational use is currently unknown. Pioneer Lake had been listed as impaired for fish consumption due to mercury contaminated fish tissue. This impairment listing has since been removed during the 2020 assessment process due to changes in the State assessment process.

Water Quality Trends

Water quality records on Pioneer Lake date back to 1979, with limited data early in the record and annual reporting to WDNR starting in 2017. Though, total phosphorous and chlorophyll *a* appear to trend upward for chlorophyll *a* and downward for total phosphorous, there is not enough data to support either trends seen **(Figures 5.3-5.5).**

[16] https://dnr.wi.gov/lakes/clmn/reports/tsigraph.aspx?stationid=643094 (Accessed 4/21)

Figure 5.3: *July 15th - September 15th average total phosphorus concentrations (ug/l) from 1997 to 2019 – Pioneer Lake.*

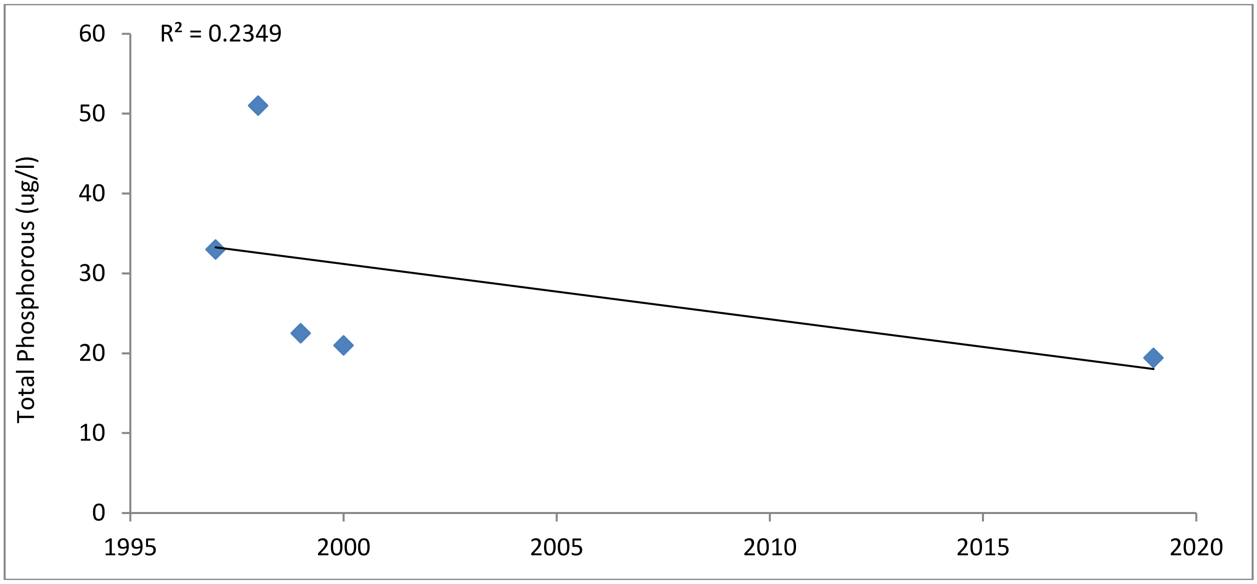
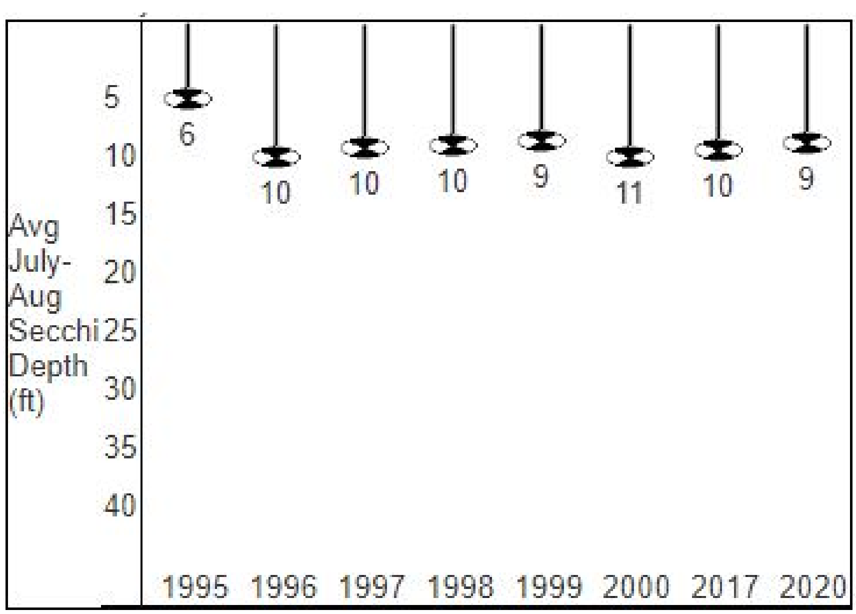
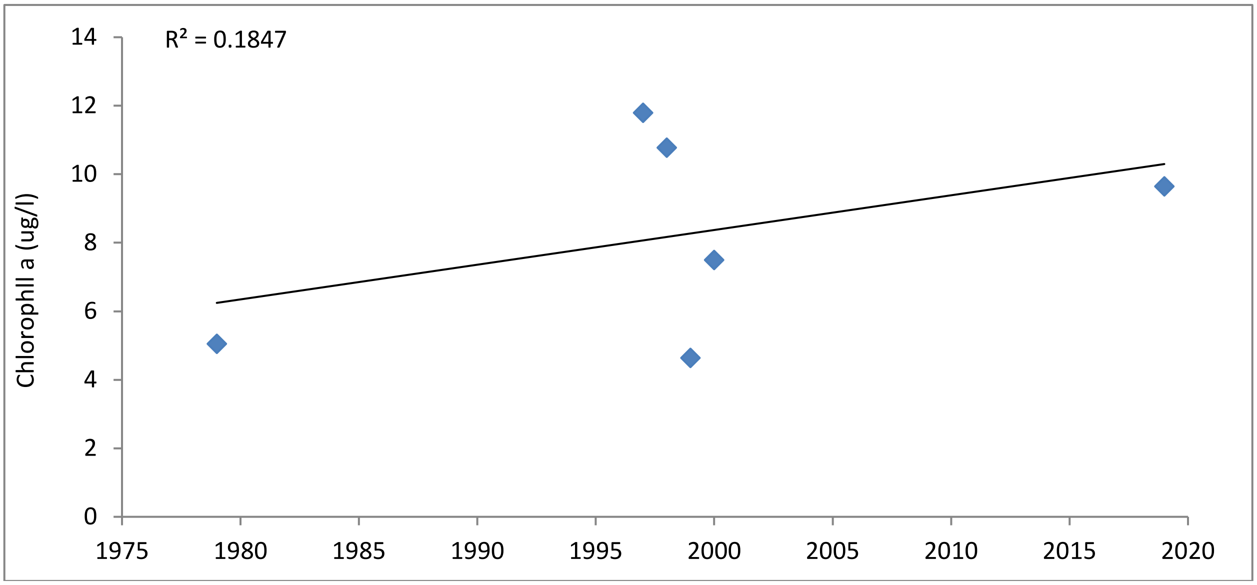


Figure 5.4: *July 15th- September 15th average secchi (ft) from 1995 to 2019 – Pioneer Lake.*[9]



[9] https://dnr.wi.gov/lakes/waterquality/Station.aspx?id=643094 (Accessed 4/21)

Figure 5.5: *July 15th -September 15th average chlorophyll a concentrations (ug/l) from 1979 to 2019 – Pioneer 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 (2019) Pioneer Lake is phosphorous limited with a ratio of 24:1.

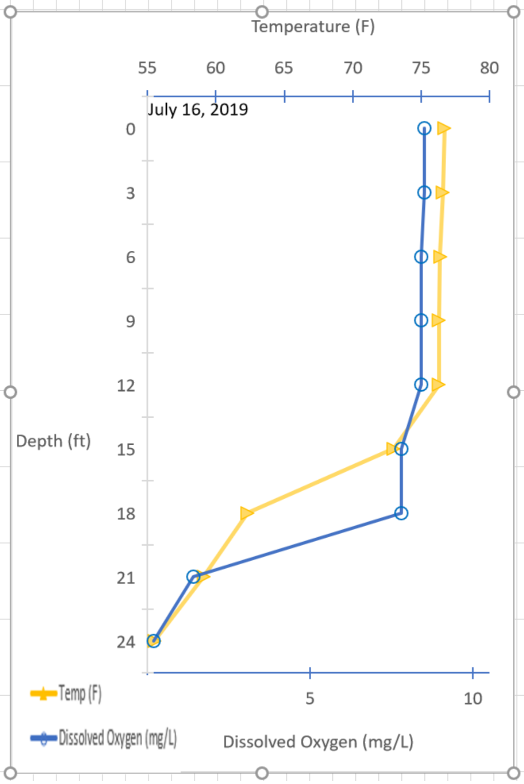
Dissolved Oxygen
Most aquatic life depends on oxygen, making it one of the most important dissolved gases in a lake. The amount of dissolved oxygen present in a lake is influenced by winds (which mix lake water - exposing it to the atmosphere), groundwater, amount of surface water entering a lake, and 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 Pioneer Lake stratified during the open water season. **(Figures 5.6-5.9)**

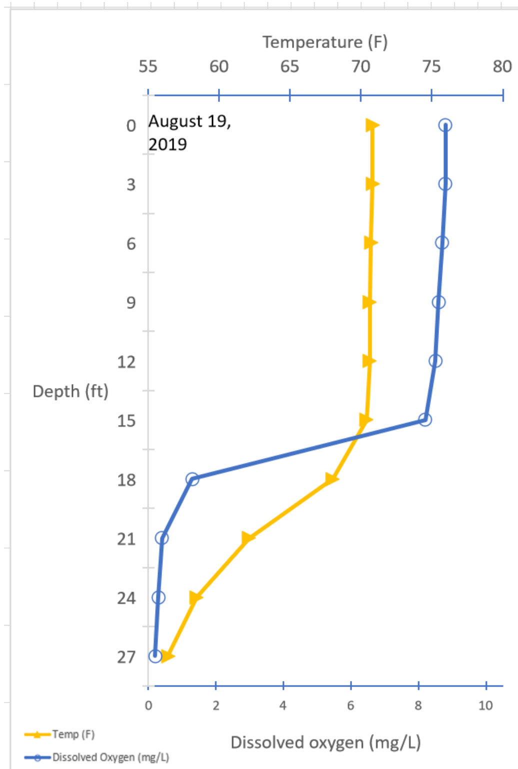
pH – Lake Acidity
pH measures the acidity of water. Values range from 0 - 14, where "0" would indicate high acidity, "14" would indicate high alkalinity and "7" would be considered neutral. Natural lakes in Wisconsin range in pH from 4.5 in acidic boggy lakes to above 8.4 in hard water/marl lakes (Shaw B. M., 2004). Average pH on Pioneer Lake (2019) measured 8.22 This is within the normal range for natural lakes (Horne, 1994).

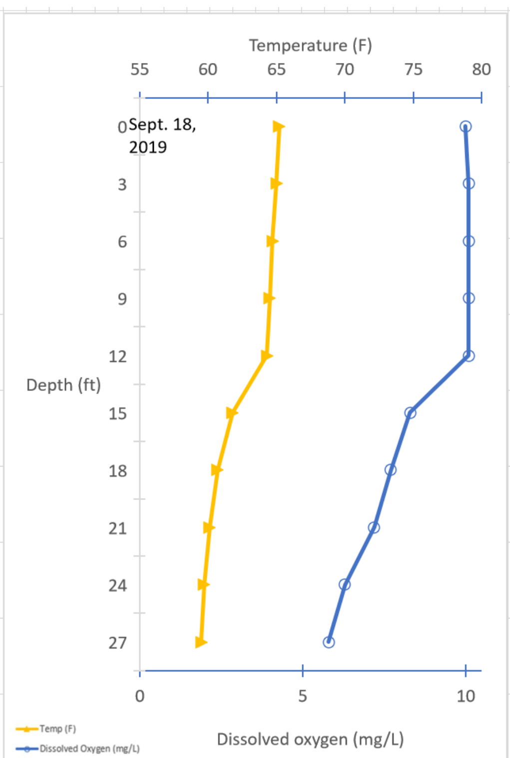
Lake water acidity is an important part of a lake's carbonate system. Simply put, a lake's carbonate system has a variety of naturally occurring chemical reactions that affect a lake's ability to buffer acid rain, regulate the solubility of many toxic compounds, and affect basic biological processes. Most rainwater in Northeastern Wisconsin ranges in pH from 4.8 to 5.1.[10] 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.

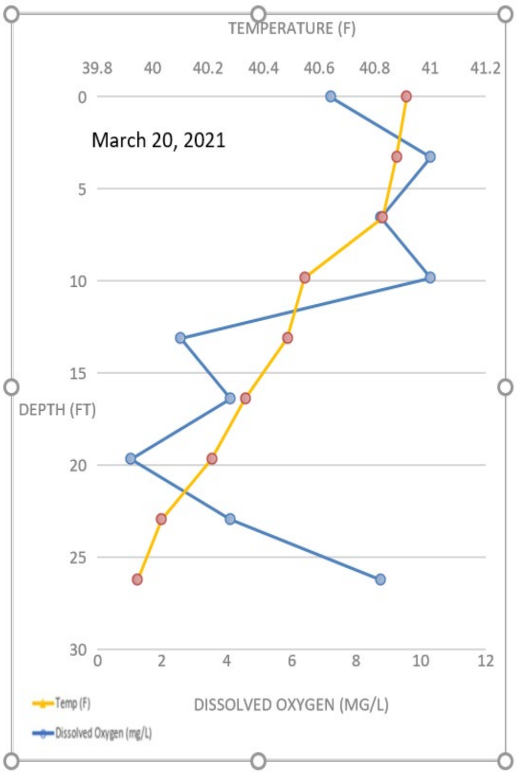
[10] Taken from https://water.usgs.gov/edu/ph.html

Figures 5.6-5.9: *Dissolved oxygen and temperature profiles July, August & September 2019, and March 2021 –Pioneer Lake. 2019 data collected by VCLWCD, 2021 data collected by Many Waters.*









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. Pioneer Lake's (2019) alkalinity levels measured 39.7 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). 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 levels for Pioneer Lake (2019) measured 10.3 mg/l. 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, Pioneer Lake is considered borderline suitable for zebra mussels (Papes, 2011)**.**

6 - 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.

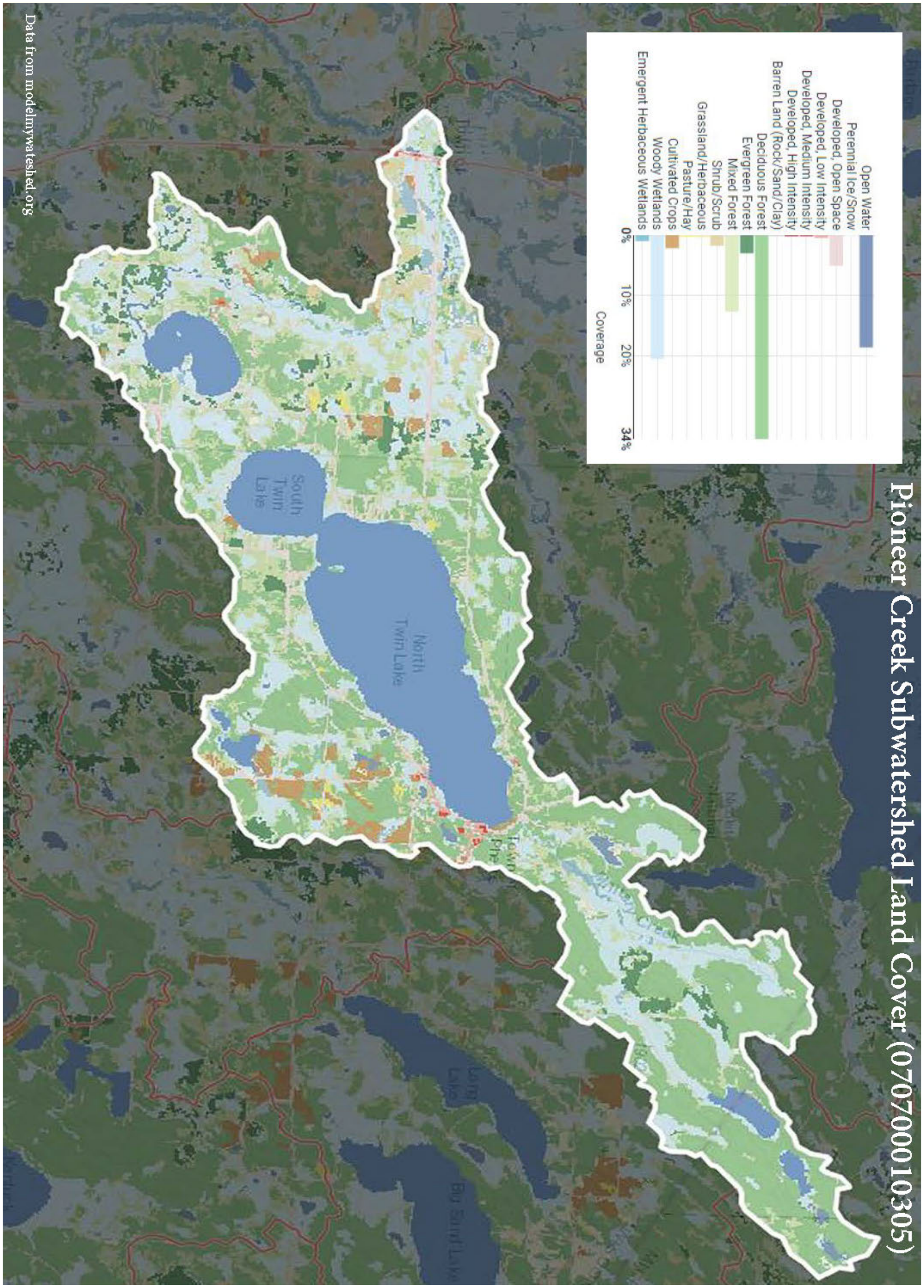
A lake's hydraulic residence time is the time required to refill a lake with its natural water inflow. At its simplest, this figure is the result of dividing the lake volume by the flow in or out of the lake. It roughly expresses the amount of time taken for a substance introduced into a lake to flow out of it again. The retention time is especially important where pollutants are concerned. (Wikipedia) 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 (more than 365 days) allow nutrients from runoff and other pollutants to accumulate in a lake, versus short residence times, which flushes lakes of nutrients and pollutants. Pioneer Lake's residence time will range between 84 to 290 days. Total annual average phosphorous loads from the watershed to Pioneer Lake range from 761 to 3,238 pounds/yr.[11]

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 **(Map 4.)** 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 acre of water) typically have more inflow of nutrients and pollutants than lakes with smaller ratios (Holdren, 2001)**.** In addition, lakes with large ratios many times have shorter residence times, allowing nutrients and other pollutants to flush out, compared to lakes with small ratios where residence times maybe longer, holding pollutants, and other nutrients in the lake longer. In these cases, land practices 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. Pioneer Lake's drainage area to lake area ratio is ~41:1, which is quite large compared to some other regional lakes. For example, Lac Vieux Desert's (Phelps) drainage area to lake ration is ~4:1, Long Lake (Phelps) is 15:1, South Twin Lake is ~25:1 and North Twin Lake is ~4:1. As mentioned above, Pioneer Lake's drainage area to lake ratio is quite large compared to other lakes within the watershed, meaning Pioneer Lake is the receiving end of water quite a bit of water draining through the Pioneer Creek Subwatershed.

[11] WILakeData03292016 excel workbook

Map 4: Pioneer Creek Subwatershed Land Use



Germaine to flooding issues currently experienced on Pioneer Lake is an understanding of how extreme rainfall events affect the ratio of water stored (infiltration) versus how much runs off over the landscape picking up pollutants and nutrients (**Figure 6.1**). Using the Pioneer Creek Subwatershed as an example, water quality impacts from non-point source pollutants such as suspended solids and the amount of nitrogen and phosphorus increase as rainfall amounts increase (**Figures 6.2 & 6.3**). Though the current water quality condition on Pioneer Lake is considered good, continuing to monitor key parameters of water quality will be important to detect long-term changes.

Figure 6.1 : Comparing potential volume of runoff, evapotranspiration and infiltration to different rainfall events within the Pioneer Creek Subwatershed. (Model My Watershed- https://runoff.modelmywatershed.org/)

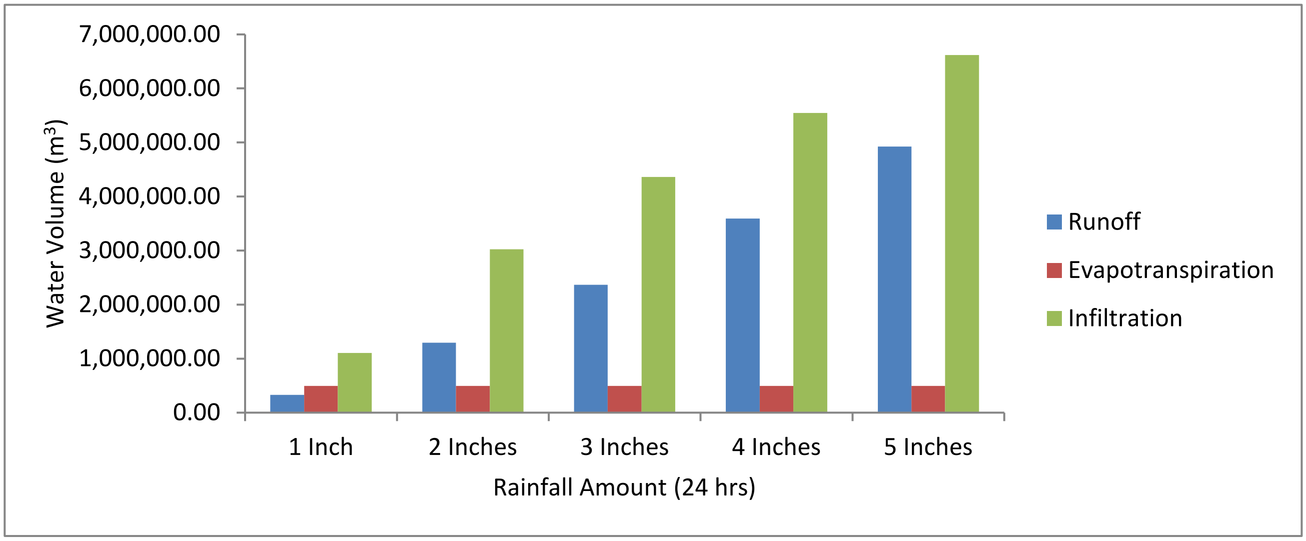


Figure 6.2: Comparing potential amount of total suspended solids loaded to different rainfall events within the Pioneer Creek Subwatershed. (Model My Watershed https://runoff.modelmywatershed.org/)

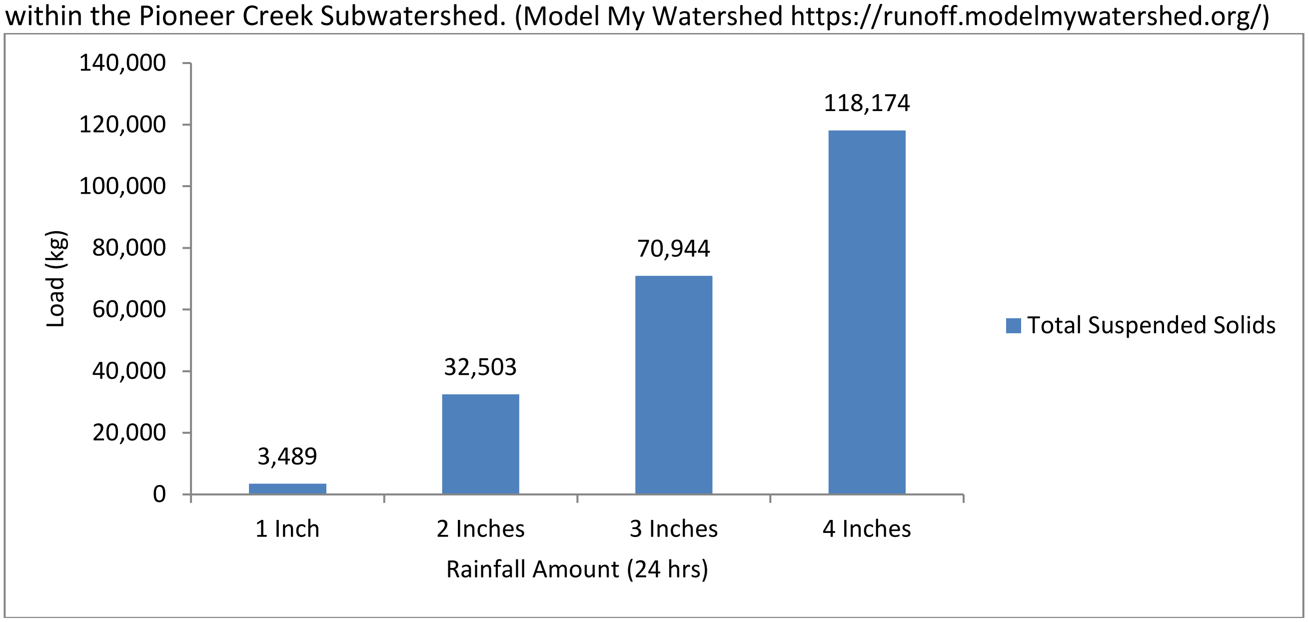
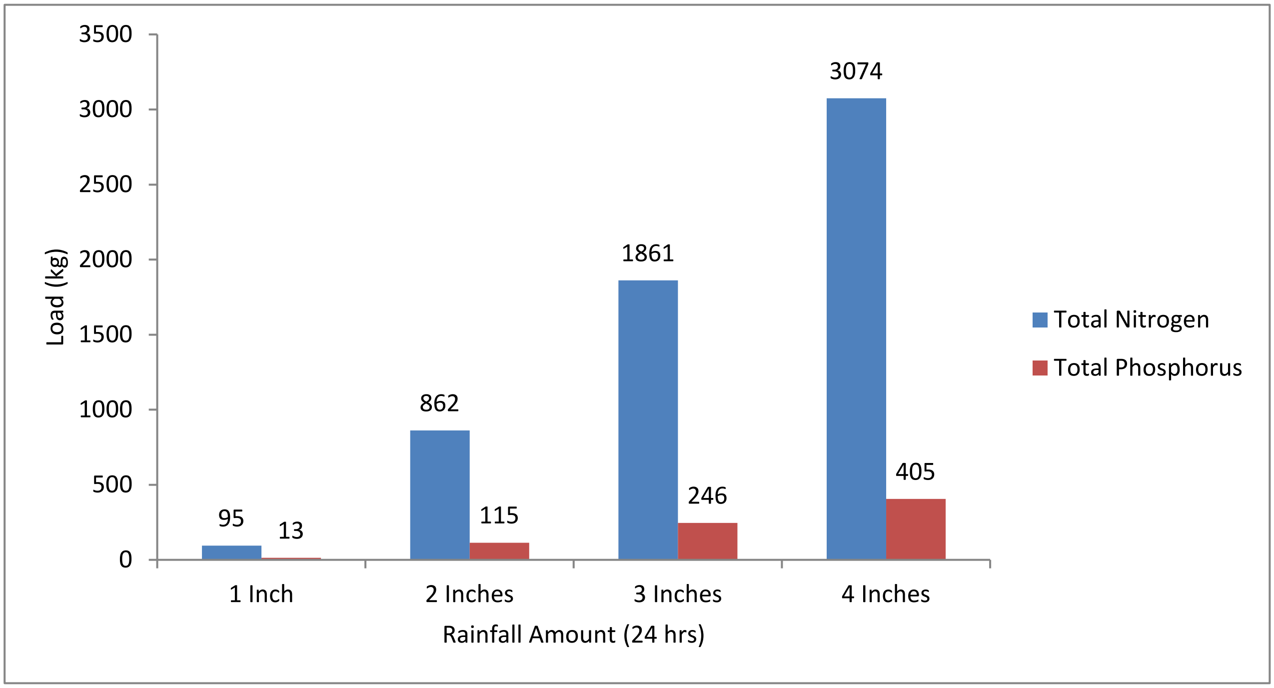


Figure 6.3: Comparing potential amount of nitrogen and phosphorous loads to different rainfall events within the Pioneer Creek Subwatershed. (Model My Watershed-https://runoff.modelmywatershed.org/)



7 - FISHERIES

Pioneer Lake is described as having a diverse fishery, which relies on the natural features and characteristics of the lake. The Wisconsin DNR describes Pioneer as a Shallow Lowland Drainage Lake. Drainage lakes have both an inlet and outlet where the main water source is stream drainage, in this case the Twin River flowing in the east side from South Twin Lake and exiting via Pioneer Creek on the west on its way to the Wisconsin River. Most major rivers in Wisconsin, including the Wisconsin River, have drainage lakes along their course that feed and regulate their flow. Drainage lakes support fish populations which are not necessarily identical to the streams connected to them. Drainage lakes usually have higher nutrient levels than many natural seepage or spring lakes. Analyses for this plan and the Directed Lakes Report (2020) mentions that Pioneer Lake nutrient levels are somewhat lower than other lakes of its type.

To identify themes that drive fisheries management decisions, lakes are given a classification. The WDNR has recently spent a great deal of time revising its lake classification system used for fisheries conservation and management (Rypel, 2019). Previous classification systems were based on static characteristics such as lake size, depth, and position in the landscape, which did not allow the classification to change. Wisconsin's new model uses water temperature and clarity as defining features, both of which can change over time with climate change or human influences on the lake. Under this system, Pioneer Lake is classified as a "complex" "warm-clear" lake. "Complex" refers to a lake that has four or more game species: walleye, muskellunge, largemouth bass, northern pike in the case of Pioneer. Warm references the average annual thermal conditions in the lake and clear references the relative water clarity.

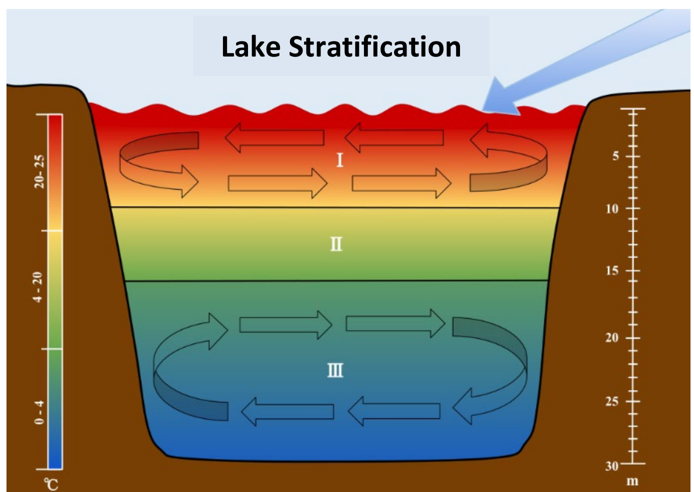


Figure 7.1: Lakes are stratified into three separate sections: Ⅰ. The *Epilimnion* Ⅱ. *Metalimnion* and Ⅲ. *Hypolimnion*. The scales are used to associate each section of the stratification to their corresponding depths and temperatures. The arrow is used to show the movement of wind over the surface of the water which initiates the turnover in the epilimnion and the hypolimnion. (MBrookings19)

One of the defining parameters that influences the presence of various fish species is dissolved oxygen. Stratification of lakes relates closely to the amount of dissolved oxygen available to fish and other aquatic life. Lake stratification[12] **(Figure 7.1)** is the tendency of lakes to form separate and distinct thermal layers during warm weather. Typically stratified lakes show three distinct layers, the Epilimnion comprising the top warm layer, the Metalimnion or Thermocline: the middle layer, which may change depth throughout the day, and the colder Hypolimnion extending to the floor of the lake. Temperature and dissolved oxygen monitoring for the recent Directed Lakes Report (**APPENDIX A**) showed that Pioneer Lake was stratified in July and August, and mixed in September. "Warm water" fish need dissolved

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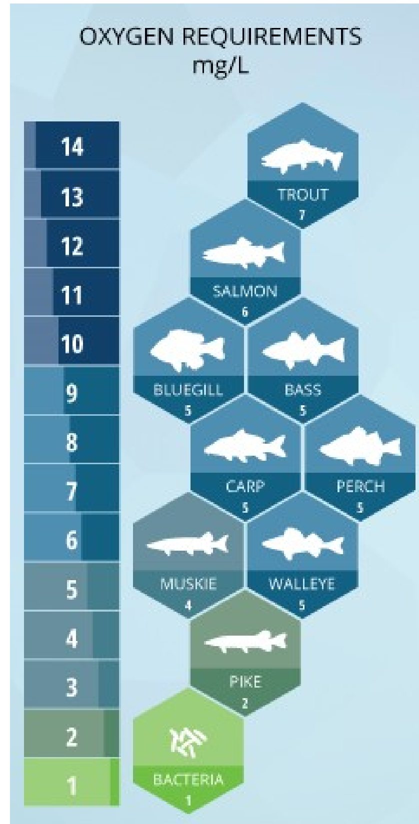
oxygen levels of at least 5 mg/L (Shaw et.al.). More than 5 mg/L dissolved oxygen was found in the epilimnion in July (18 ft) & August (15 ft), and in September when the lake was not stratified the entire water column had more than 5 mg/L.

Habitat

Another important fish consideration is habitat. Bottom habitat such as cobble, gravel, or large woody debris have a direct effect on the protection of developing eggs and young plus adult feeding success and protection from predators for survival. Aquatic plant structure is also an important part of habitat and this lake received above average marks for species diversity, richness, ***Figure 7.2:*** Minimum dissolved oxygen requirements for freshwater fish (Fondriest)**[13]** and density. The Pioneer Lake bottom is 30% sand, 10% gravel, 5% rock, and 55% muck. The lack of cobble and gravel on the lake bottom affects fish like walleye dramatically as they scatter their eggs over gravel where they will harden and remain hidden as they develop. Large woody debris on the lake bottom poses another fisheries challenge. The rate of 46.49 logs/mile is considered low but has potential for improvement with human assistance. The recommendation of the Pioneer Lake Directed Lake Report **(Appendix A)** is for preservation and WDNR permitted introduction of more coarse woody debris to enhance the fishery and aquatic life in general. Readers might find the WDNR Best Management Practices Manual on "Fish Sticks"[14] interesting.

Figure 7.2: Minimum dissolved oxygen requirements for freshwater fish (Fondriest)



Habitat changes can be natural, such as the gradual filling in of shallow bays. However, it is most often accelerated, or made more severe, by human activities and climatic extremes. Loss of habitat can occur in many forms. The filling in of marsh areas bordering lakes and streams destroys critical spawning habitat and diminishes the filtering capacity of the wetland, resulting in poorer water quality. Extreme rain events in the past eight years in the Phelps area have resulted in a cumulative 70 inches of rainfall above normal (WVIC, Article 421- Twin Lakes Operating Plan Status Report and Review.)

Changes to the littoral zone (near shore areas) caused by human development or climactic extremes impact fish populations as they are important for egg deposition, nursery and hiding areas for newly hatched fish, and as food production areas for juvenile fish and their prey items. Ten docks or less per kilometer (16 docks/mile) of shoreline, as a reflection of shoreline development, has been shown to be a threshold of maintaining high quality fish diversity in Minnesota (Jacobsen et. al). Pioneer Lake's pier density was 25.20 docks/mile of shoreline, much more than the suggested threshold. Various recreational activities can have a direct negative effect on habitat quality, particularly on water clarity and on aquatic plants in near-shore areas that provide habitat for young fish. Vilas County Ordinance No 1-76 restricts water skiing within 200' of the shoreline as one means of protecting water quality and property, while also

[13] https://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/
[14] https://p.widencdn.net/jcv7ac/Outreach_FishSticksBestPractices

protecting public safety. Finally, one of the most difficult problems affecting fish populations, directly and indirectly, is the problem of non-point source pollution. Non-point source pollution includes runoff from paved surfaces and lawn fertilizer. The variety of factors affecting habitat loss can act synergistically to negatively impact aquatic communities and compromise its long-term ability to adapt to changes (Hewett, 1998).

Management

Fisheries management, which includes studying population dynamics, manipulating fish populations by stocking, amending and improving habitat, and protecting water quality, is a complex art and science, whose philosophies vary over time with emerging science, watershed and climate changes, angler preferences, agency budgets, and even politics. In addition, on many lakes in the Ceded Territory of northern Wisconsin, harvest of fish is divided between sport anglers and the six Chippewa tribes who harvest fish under rights granted by federal treaties. The tribes harvest fish mostly using a highly efficient method, spearing, during a relatively short time period in the spring. Walleye is one of the primary tribal target species, as well as heavily sought by anglers, and resulted in tensions, especially in the 1980s-90s. According to the WDNR the impacts of tribal harvests compared to angler harvest under current regulations for walleye are not completely understood, but believed to be less than anticipated (Hewett, 1998). WDNR continues to monitor and learn about population dynamics of game fish, including walleye tribal harvests and angler catches with harvest censuses, creel surveys, and lake surveys.

WDNR describes the following species as being found in Pioneer Lake:

- Muskellunge (Common)- pictured at right,
- Panfish (Common),
- Largemouth Bass (Common),
- Northern Pike (Present),
- Walleye (Present)

During research for this Lake Management Plan, local DNR fisheries biologist Eric Wegleitner (Woodruff Service Center) mined the historical files for Pioneer Lake and provided this information:
Like many lakes in this area, Pioneer Lake has been stocked since the 1930's, with varying frequency, depending on current fish management theories and available stock. Fish stocking is often considered by the public to be synonymous with fish management. Although not true, it is often the measure by which many view the value of their lake. The years 1937-1940 were some of the most intense years, with walleye, largemouth bass, northern pike, and perch being stocked. Stocking became infrequent in the 1960s and early 1970s, then picked up again in the early 1990’s (**Figure 7.2.**) Although it is possible that both walleye and musky may have been naturally occurring, it is believed that their current presence is due to stocking. While young muskies are rarely captured during fall fish surveys and therefore difficult to assess, more data exists for walleye. An extensive WDNR fish survey (2003) yielded less than 1 adult walleye per acre (.8/ac), indicating that stocking has not created a sustaining population and they are not naturally reproducing in Pioneer Lake. A similar situation is suspected for musky.

Figure 7.3: Stocking Data, Pioneer Lake 1991-2020. (WDNR)

Year	Stocked Waterbody Name	Location	Species	Age Class	Number Fish Stocked	Avg Fish Length (IN)
2020	PIONEER LAKE	41N-10E-26	WALLEYE	LARGE FINGERLING	4,269	7
2019	PIONEER LAKE	41N-10E-26	MUSKELLUNGE	LARGE FINGERLING	118	11.2
2018	PIONEER LAKE	41N-10E-26	WALLEYE	LARGE FINGERLING	4,294	6.6
2017	PIONEER LAKE	41N-10E-26	MUSKELLUNGE	LARGE FINGERLING	67	10.8
2015	PIONEER LAKE	41N-10E-26	MUSKELLUNGE	LARGE FINGERLING	425	11.4
2014	PIONEER LAKE	41N-10E-26	WALLEYE	LARGE FINGERLING	4,293	7.3
2008	PIONEER LAKE	41N-10E-26	WALLEYE	SMALL FINGERLING	14,945	1.7
2006	PIONEER LAKE	41N-10E-26	WALLEYE	SMALL FINGERLING	14,945	1.4
2004	PIONEER LAKE	41N-10E-26	WALLEYE	SMALL FINGERLING	21,350	1.3
2002	PIONEER LAKE	41N-10E-26	WALLEYE	SMALL FINGERLING	21,350	1.4
2000	PIONEER LAKE	41N-10E-26	WALLEYE	SMALL FINGERLING	42,000	1.8
1998	PIONEER LAKE	41N-10E-26	WALLEYE	SMALL FINGERLING	42,000	1.45
1994	PIONEER LAKE	41N-10E-26	WALLEYE	FINGERLING	10,080	3
1992	PIONEER LAKE	41N-10E-26	WALLEYE	FINGERLING	5,112	3
1991	PIONEER LAKE	41N-10E-26	WALLEYE	FINGERLING	9,890	3

As part of the Wisconsin Walleye Initiative (2013), developed by the WDNR and governor's office to increase the number of walleye in public waterbodies across the state by expanding hatchery production of large (6-8") fingerling walleyes, Pioneer has received these extended growth walleye fingerlings since 2015, when a combo stocking pattern of alternating year walleye and musky stocking has occurred. Mr. Wegleitner indicated that this pattern is likely to continue.

An interesting discussion on the issues and evolving knowledge about walleye stocking as a management tool, is contained in the WI Walleye Management Plan, 1998 [15], which is currently under review for

[15] https://dnr.wi.gov/TOPIC/FISHING/documents/ceded/WIWalleyeMgmtPlan.pdf (Accessed 5/2020)

revision. Walleye population dynamics is a challenging situation overall- age class and spawning success can be highly variable from year to year and is still the subject of much study. It has been learned that spawning success depends heavily on favorable water temperatures and access to gravel bottom during spawning. This is compounded by the fact that walleye is a long-lived species that reach reproductive age later than most species—walleye generally do not start spawning until they are of catchable size (15”). Female walleyes reach maturity in four to five years when they are about 15 to 17 inches long. Because of the long history of walleye propagation in the state, understanding the effects of the stocking program on native walleye populations has been difficult.

It was also noted in our conversation that in the 2003 survey, largemouth bass numbered 3.3/acre, indicative of a "good", sustaining population and that in reality, Pioneer Lake might be better thought of as a bass/panfish lake at present.

One of Pioneer Lake’s notable fish is Muskellunge (Musky), which occurs in 667 Wisconsin lakes (588,852 acres) and 100 segments on 48 rivers (2,085 miles) (Simonson, 2012) Not all waters containing muskellunge are necessarily classified as "musky waters". Pioneer Lake lies in what the WDNR describes as part of the natural historic breeding range of Musky. Wisconsin musky waters are divided into 3 *classes* of angling quality, based on the relative abundance and size-structure of the muskellunge population (Simonson 2012), as well as their reproductive status *category.* Pioneer Lake was listed as a Class A2, Category 1 in the Simonson 2012 publication. Class A2 are best known for providing the most consistent angling action, and they may have the potential to produce some larger fish, as well. They generally have the best overall numbers of muskellunge, but big fish make up a small percent of the total, compared to the Class A1 waters. About 316 (47%) of the 667 classified muskellunge lakes in Wisconsin are Class A waters, while the rest are either Class B or C.

Although Pioneer was listed as a Category 1 for reproductive status, meaning the population is self-sustaining and wouldn’t typically be stocked, WDNR does not have current evidence of a self-sustaining musky population in Pioneer Lake and it has been stocked with musky in three of the past ten years. Approximately 45% of muskellunge waters in Wisconsin do receive some stocking. Class A lakes that are also category 1 tend to be relatively small in size, averaging about 456 acres (Simonson 2012). Pioneer is consistent with this trend.

Another tool in fisheries management are fishing regulations. For a complete list of annual regulations, visit the WDNR website or regulations received while purchasing a license.

8 - LAKE USER SURVEY

A lake-user survey is designed to collect information on stakeholder demographics, knowledge, and interest on a variety of lake topics and issues. This data helps understand what is important to the lake group including environmental and social concerns and assist in outlining planning goals, objectives and actions. Information collected includes property ownership and use, recreational use of the lake, and awareness and interest on water quality, fisheries, aquatic habitats, and invasive species.

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 Pioneer Lake and all property owners within a certain radius of the lake. The committee concluded the stakeholder group for this survey of interest to learn from would be property owners of Pioneer Lake, Pioneer Creek and those with ties to Pioneer Lake that are Association members but may not have adjacent property. Conclusions from this planning project may identify other stakeholder groups, not initially identified, to learn from to meet project goals and objectives.

Representatives of the planning task force reviewed a series of broad survey questions covering a number of lake topics, keeping and adapting questions most relevant to Pioneer Lake and Pioneer Creek. A draft of the survey was reviewed and approved by WDNR prior to mailing. A series of mailings occurred in July 2020. The initial mailing included a cover letter, a copy of the survey and specific instructions. One hundred and seventeen surveys were mailed. One week after the initial mailing a follow-up postcard reminder to all recipients was sent. Of the 117 surveys delivered, 79 were returned with a return rate of 67%.

Property

Most respondents own property on Pioneer Lake (62%) and are either year-round residents (29%) or use their property mainly in the summer time (27%) **(Figures 8.1 & 8.2).** On average respondents have owned their property for 25 years and spend 155 days each year at their property**.** About 70% of respondents indicated they are current Lake Association members and 48% indicated they do not attend Association meetings or gatherings **(Figures 8.3 & 8.4).**

Figure 8.1: *Do you own property on Pioneer Lake or Pioneer Creek?*

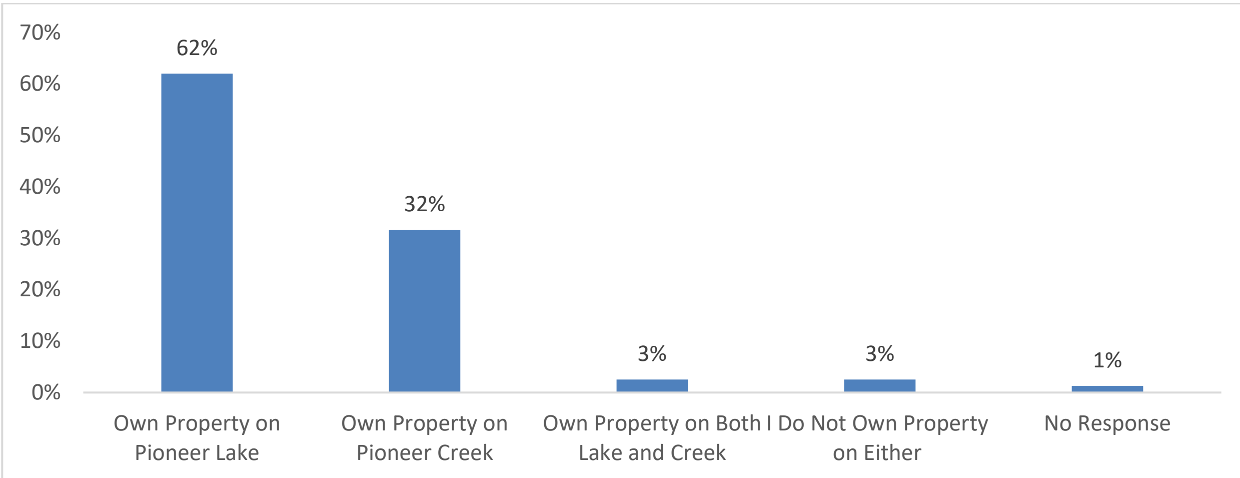


Figure 8.2: *How is your property used?*

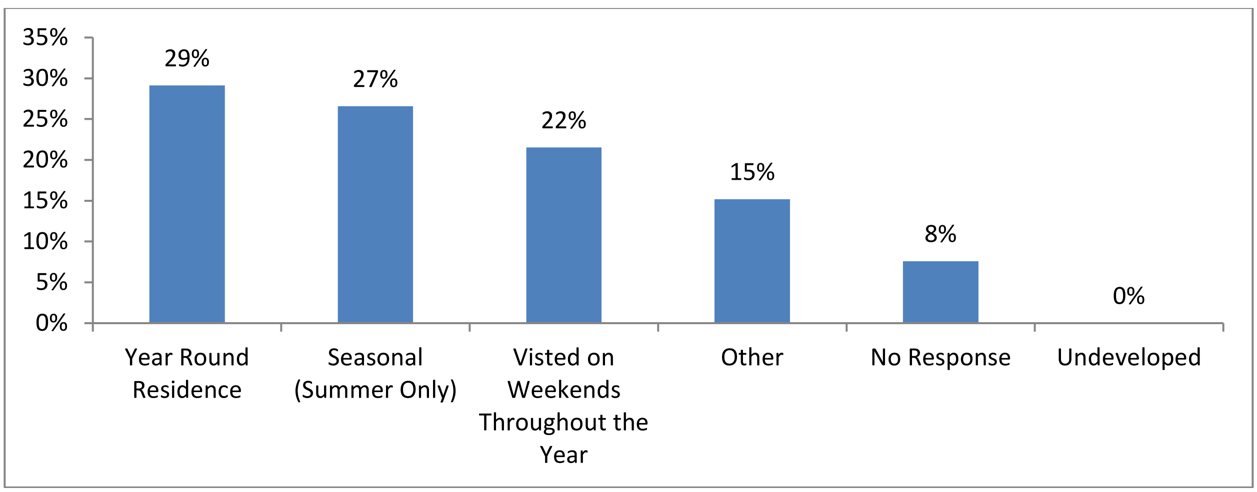


Figure 8.3: *Are you a member of the Lake Association?*

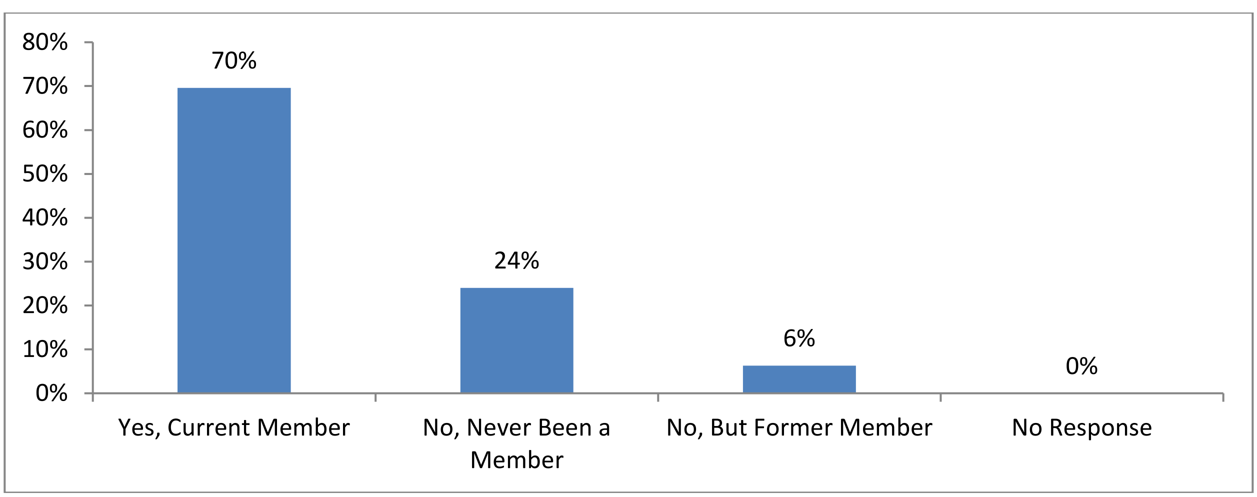
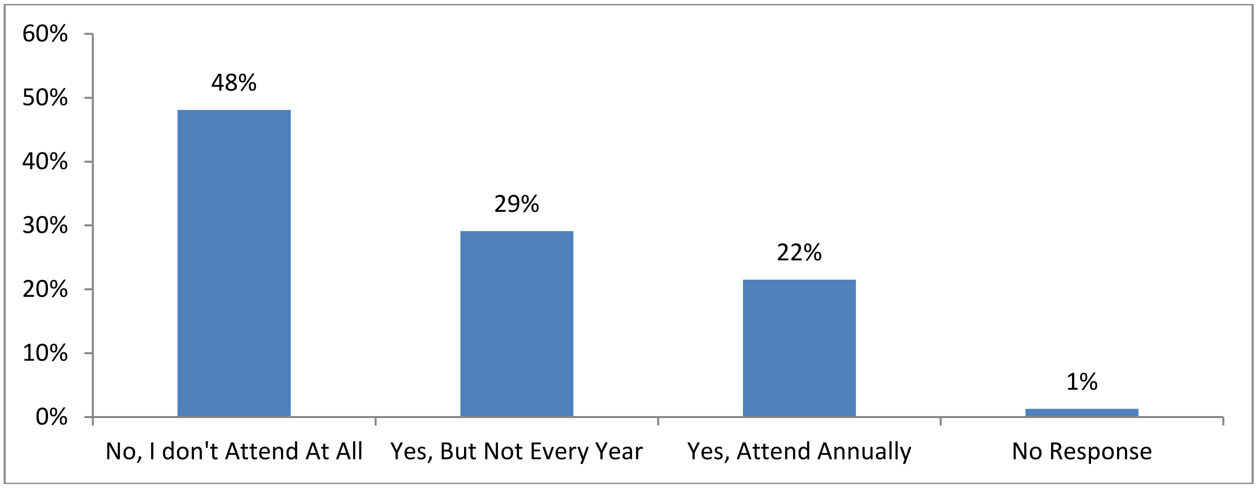


Figure 8.4: *Do you attend Lake Association meetings/events?*



Fishing

Approximately 76% of respondents reported fishing Pioneer Lake in the past three years and have been fishing the lake on average for 33 years **(Figure 8.5).** This survey did not include fishing experiences on Pioneer Creek, and one respondent did indicate that they fish Pioneer Creek and not Pioneer Lake. Fishing mainly occurs during the open water season **(Figures 8.6 & 8.7).** The top three species caught include Small and Largemouth Bass, Bluegill/Sunfish and Northern Pike. Species reported caught the least include Walleye and Musky **(Figure 8.8.)** Half of respondents (53%) indicate that the current quality of fishing is good and just under half (43%) feel the fishing has remained the same since they began fishing Pioneer Lake **(Figures 8.9 & 8.10.)**

Figure 8.5: *Have you fished Pioneer Lake in the last 3 years?*

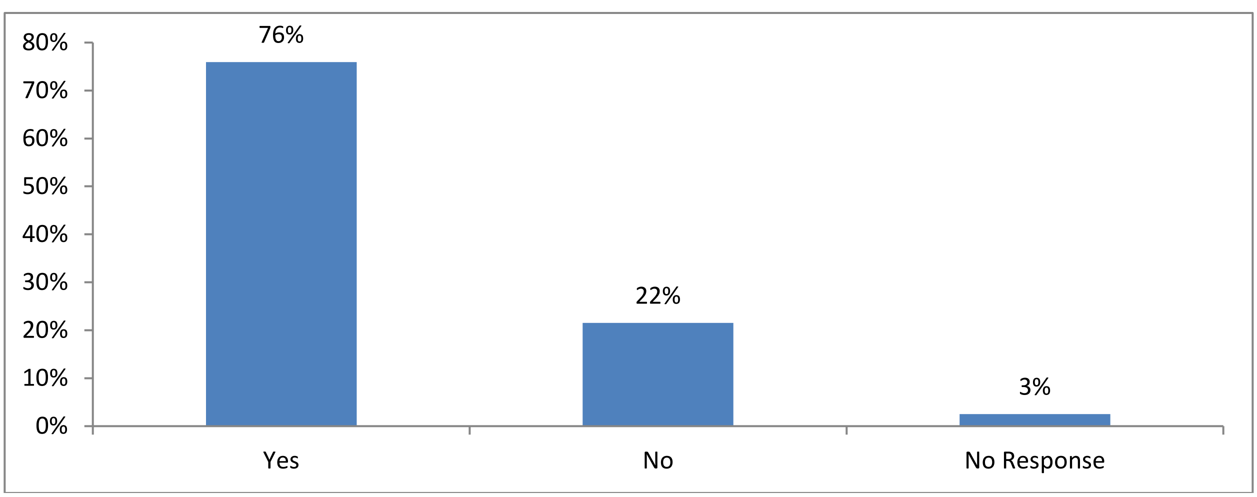


Figure 8.6: *In a typical year, how often do you fish Pioneer Lake during the open water season?*

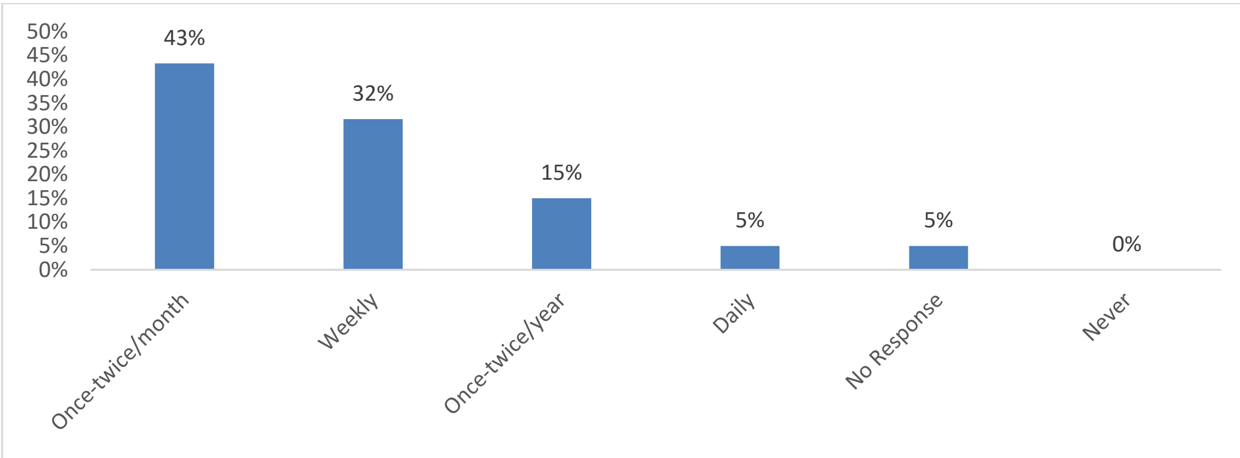


Figure 8.7: *In a typical year, how often do you fish Pioneer Lake during the ice-fishing season?*

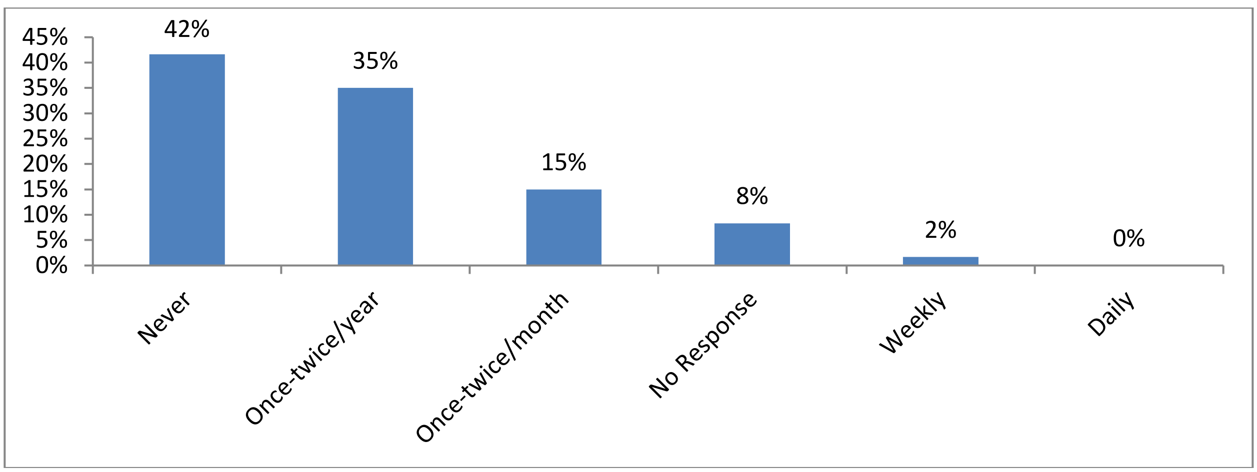


Figure 8.8: *What fish species do you catch when fishing Pioneer Lake?*

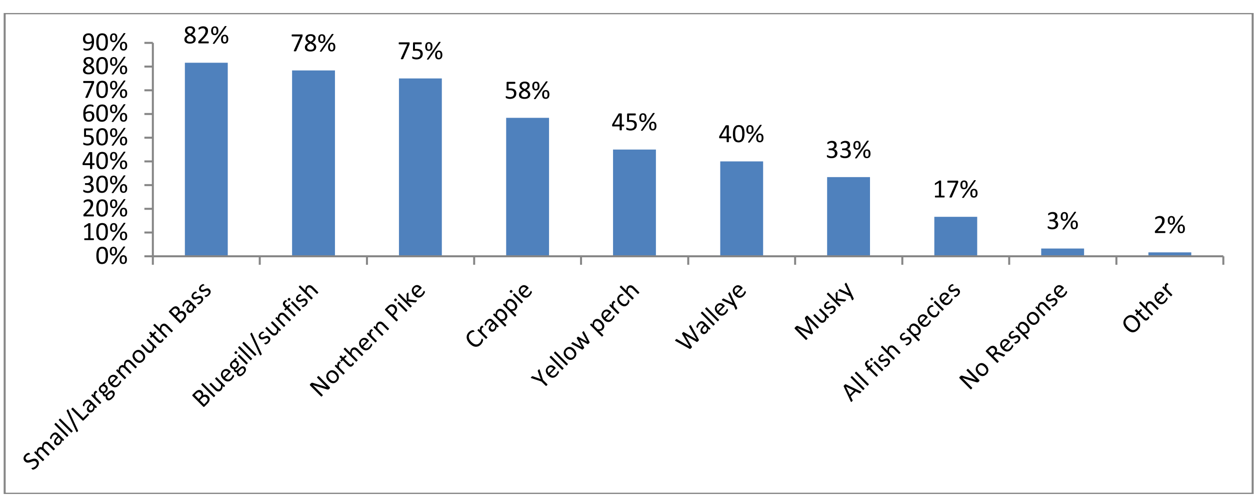


Figure 8.9: *How would you describe the current quality of fishing on Pioneer Lake?*

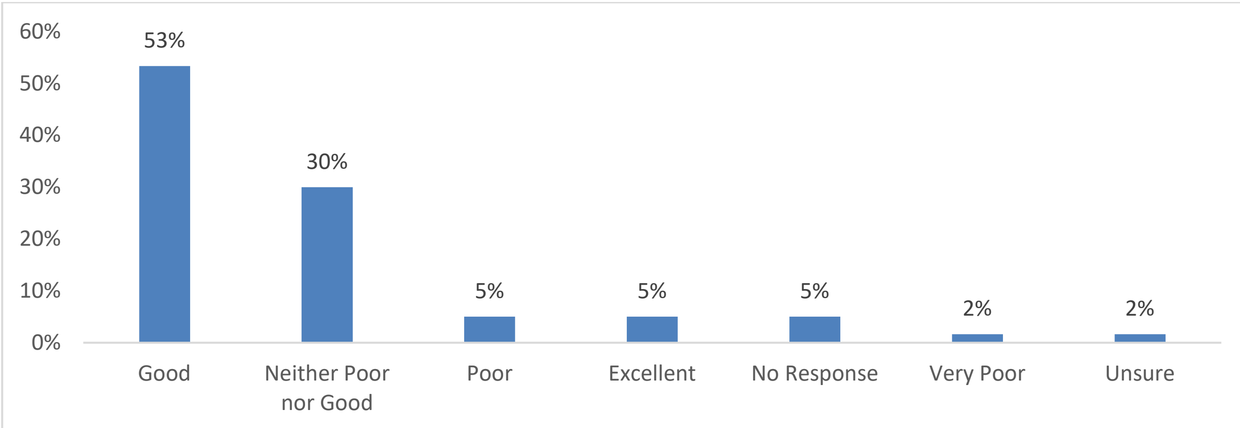
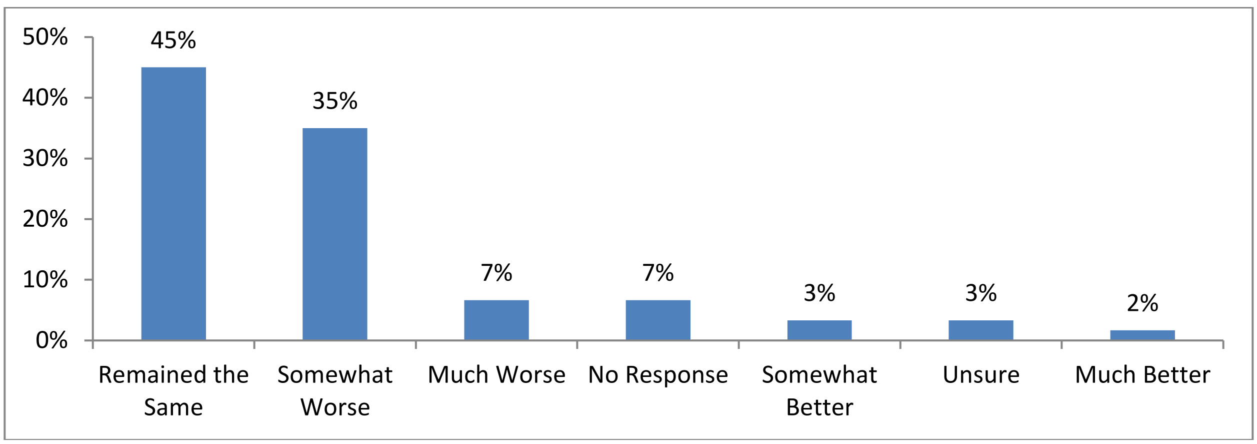


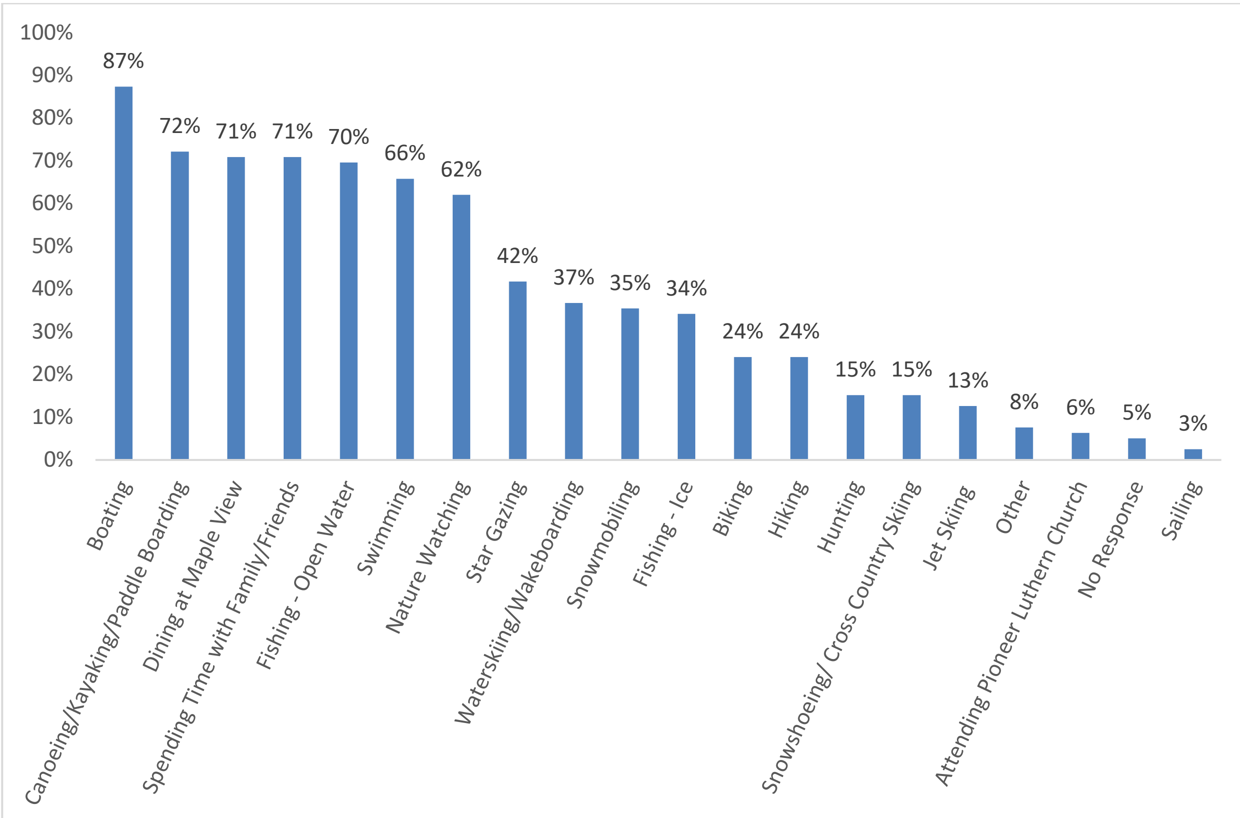
Figure 8.10: *How has the quality of fishing changed since you first started fishing Pioneer Lake?*



Lake Use - General

When asked which activities you enjoy on and adjacent to Pioneer Lake, the top responses included boating, canoeing/kayaking/paddle boarding, dining at Maple View, and spending time with family/friends **(Figure 8.11).**

Figure 8.11: *What activities do you enjoy on or adjacent to Pioneer Lake?*



Watercraft Use

Most respondents own and recreate with watercraft on Pioneer Lake, with motor boats (> 30 hp), kayaks, and canoes being most common (**Figure 8.12).** Respondents indicate between 0 to 8 watercraft used with an average of 3 different types of watercraft used per property. Respondents primarily keep their watercraft on Pioneer Lake (62%) whereas 33% did indicate they do use their watercraft on other waters **(Figure 8.13).** Those that do use their watercraft on other water bodies generally do some routine cleaning before putting their watercraft back onto Pioneer Lake **(Figure 8.14).** Seventy-seven percent of respondents reported removing visual material from the boat and trailer, 54% drain the bilge and 38% drain the live well. Eight percent indicated they do not clean their watercraft. On average respondents do three of the eight items listed to choose from.

Figure 8.12: *What types of watercraft do you use on Pioneer Lake?*

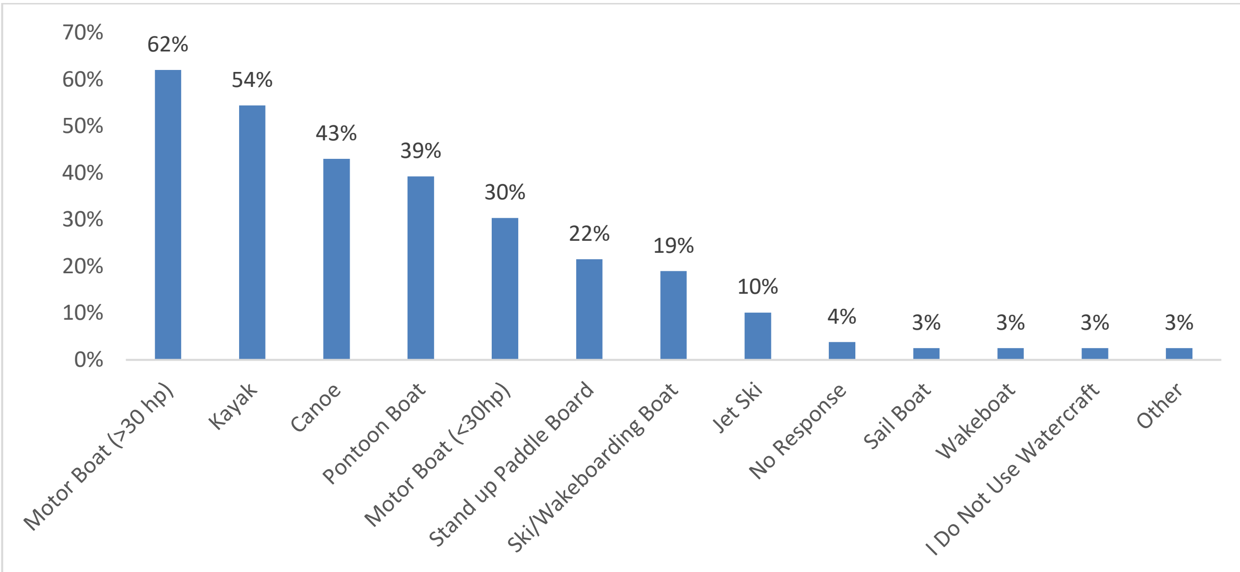


Figure 8.13: *Do you use your watercraft on other waters?*

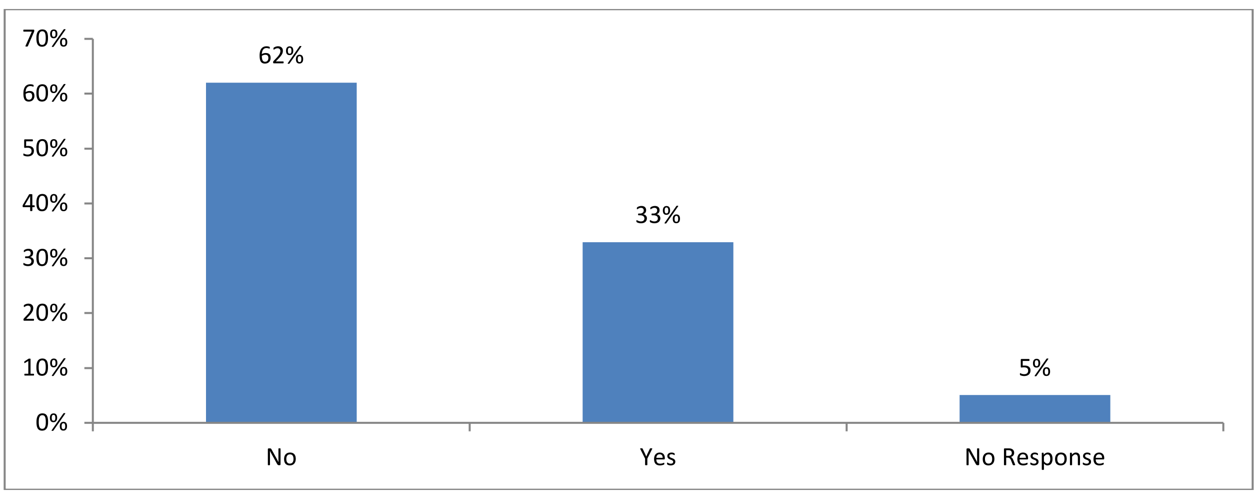
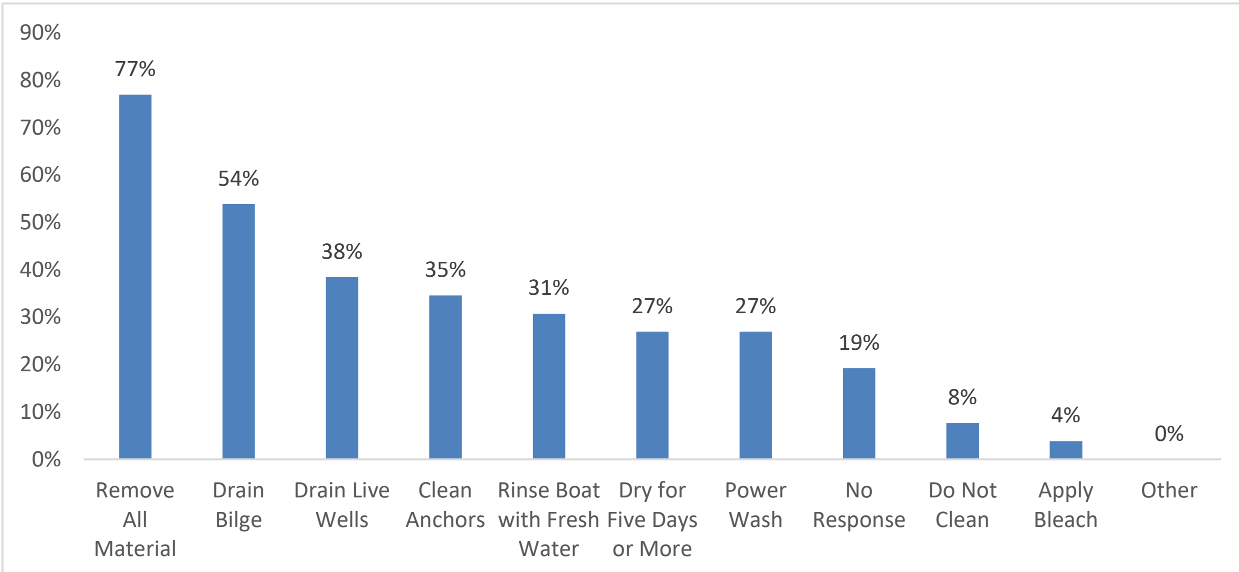


Figure 8.14: *If you use your watercraft on other waters, what is your typical cleaning routine after you visit another lake?*



Lake Health

A series of questions sought to gauge lake owners' perspectives on the current and past condition of Pioneer Lake and find out what they believe may be affecting lake health. Overall, 56% described Pioneer's current water quality as good and 41% feel the water quality has remained the same **(Figures 15 and 8.16).** When asked to describe water quality most respondents indicated water levels and water clarity **(Figure 8.17).** Of the aspects most important to water quality respondents indicated water levels (28%), followed by water clarity (24%) and aquatic plant growth (23%) **(Figure 8.18)**. The question on the most important aspect of water quality asked to circle one answer, all questionnaires with multiple answers circled were tallied as no response.

Figure 8.15: *How would you describe the current water quality of Pioneer Lake?*

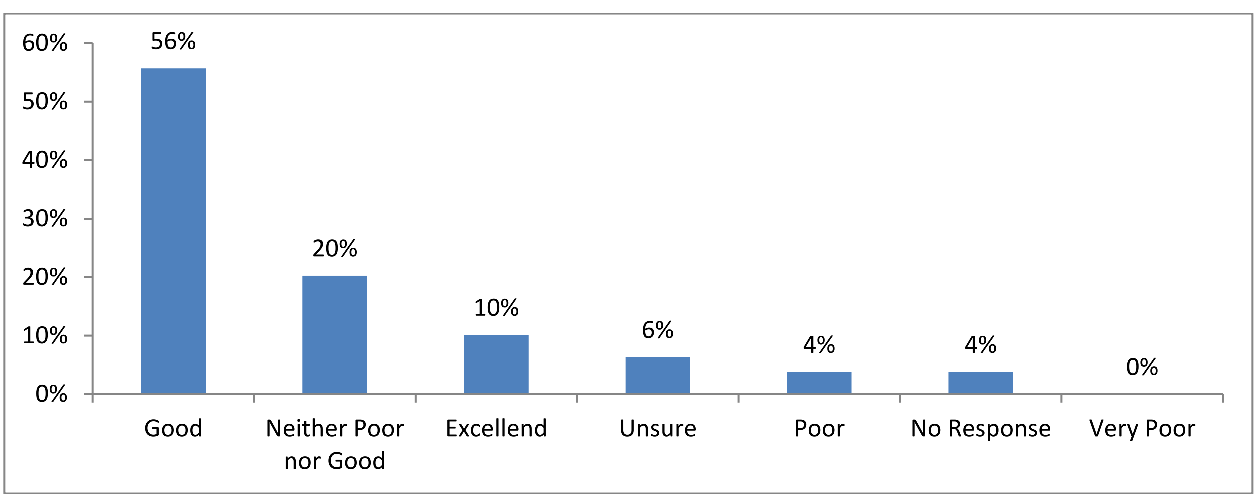


Figure 8.16: *Do you feel the water quality of Pioneer Lake has changed since you first started to visit Pioneer Lake?*

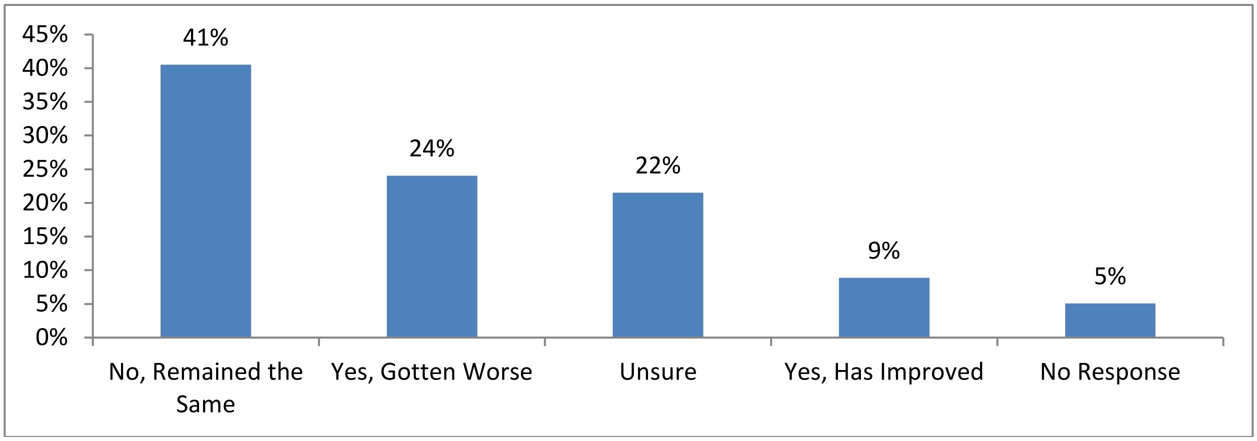


Figure 8.17: *What do you think of when you describe water quality?*

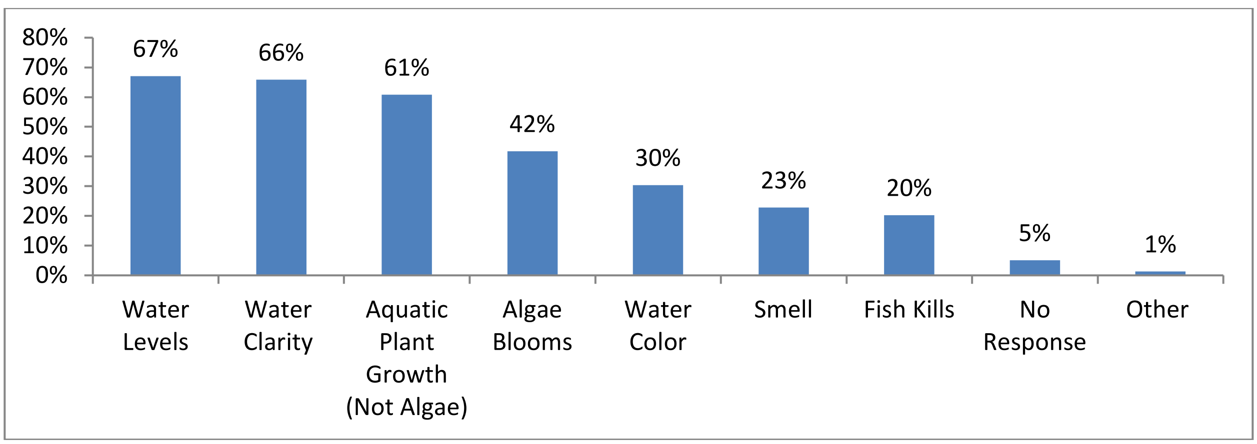
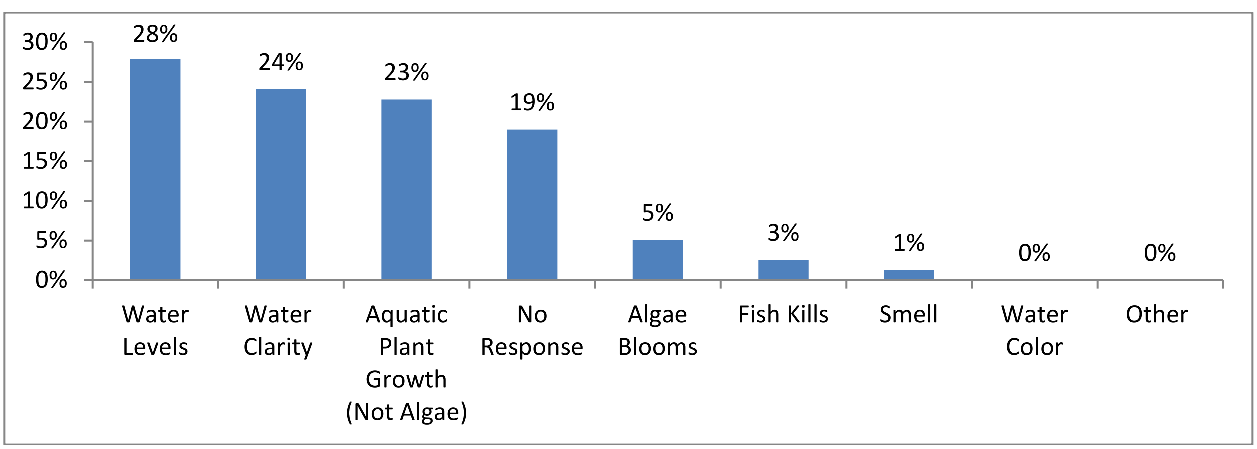


Figure 8.18: *What is the most important aspect when you think about water quality on Pioneer Lake.*



Most respondents (91%) had some knowledge of aquatic invasive species and 42% think there are aquatic invasive species in Pioneer Lake **(Figure 8.19).** Though most think that aquatic invasive species are present in Pioneer Lake, 46% are unsure which species may be present. The most indicated aquatic invasive species believed to be present in Pioneer Lake are Eurasian watermilfoil (EWM) and Chinese Mystery Snails. (**Figure 8.20**).

When asked if aquatic plants negatively impact enjoyment on Pioneer Lake, 34% answered sometimes, 30% indicated they rarely do, and 15% indicated often **(Figure 8.21).** A similar question was asked regarding algae negatively impacting enjoyment and most respondents indicated rarely (42%), sometimes (32%), and never (16%) **(Figure 8.22).** Forty-four percent of respondents indicated that were unsure if the control of *native* plants is needed on Pioneer Lake, 27% believe native plant control is needed and 25% believe native plant control is not needed **(Figure 8.23)**. Fifty-one percent are unsure that control of aquatic invasive plants is needed, while 33% indicated yes that control of invasive plants is needed **(Figure 8.24).**

Figure 8.19: *Do you believe aquatic invasive species are present in Pioneer Lake?*

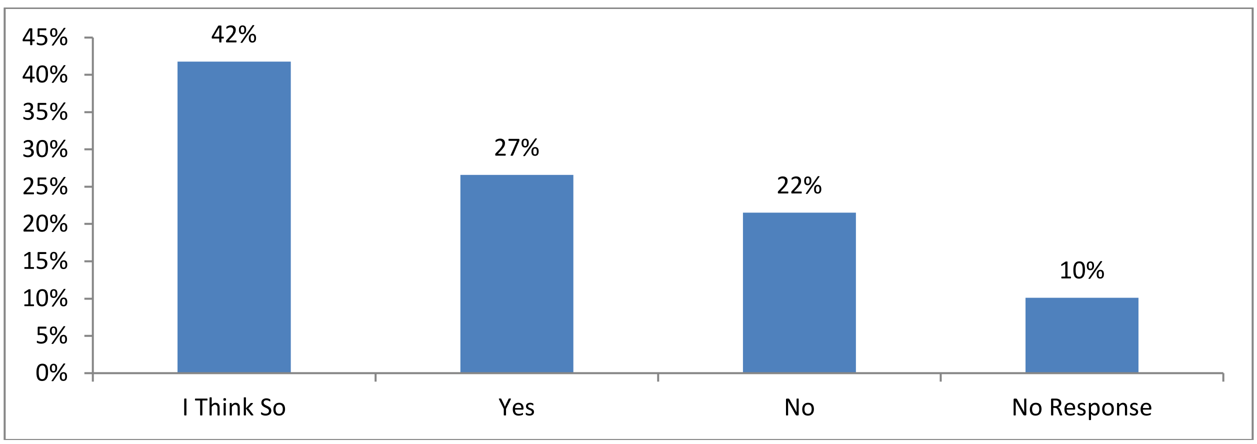


Figure 8.20: *Which aquatic invasive species do you believe are present in and adjacent to Pioneer Lake?*

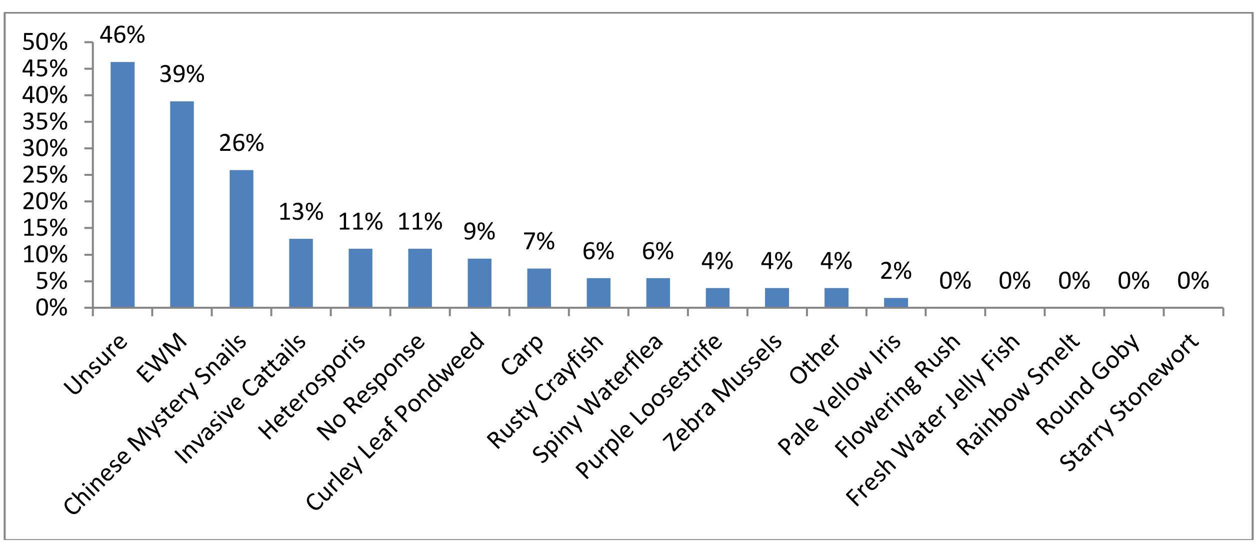


Figure 8.21: *During the open water season how often does aquatic plant growth (excluding algae) negatively impact your enjoyment of Pioneer Lake?*

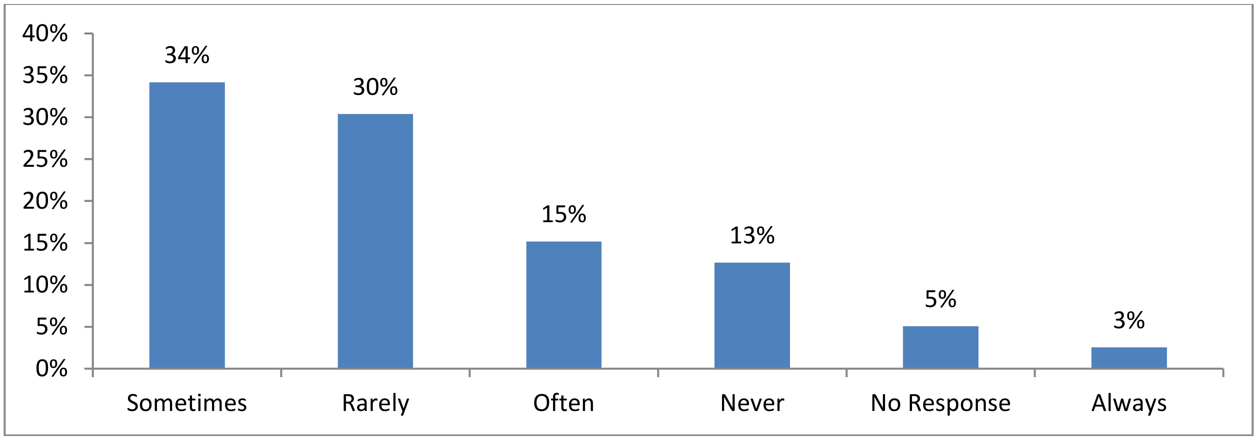


Figure 8.22: *During the open water season how often does aquatic algae negatively impact your enjoyment of Pioneer Lake?*

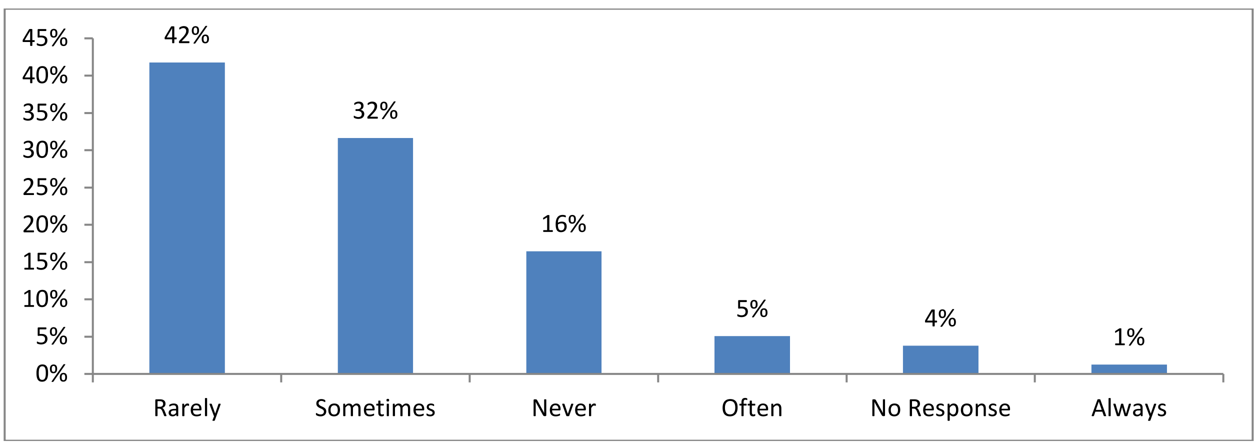


Figure 8.23: *Do you believe the control of native plants is needed in Pioneer Lake?*

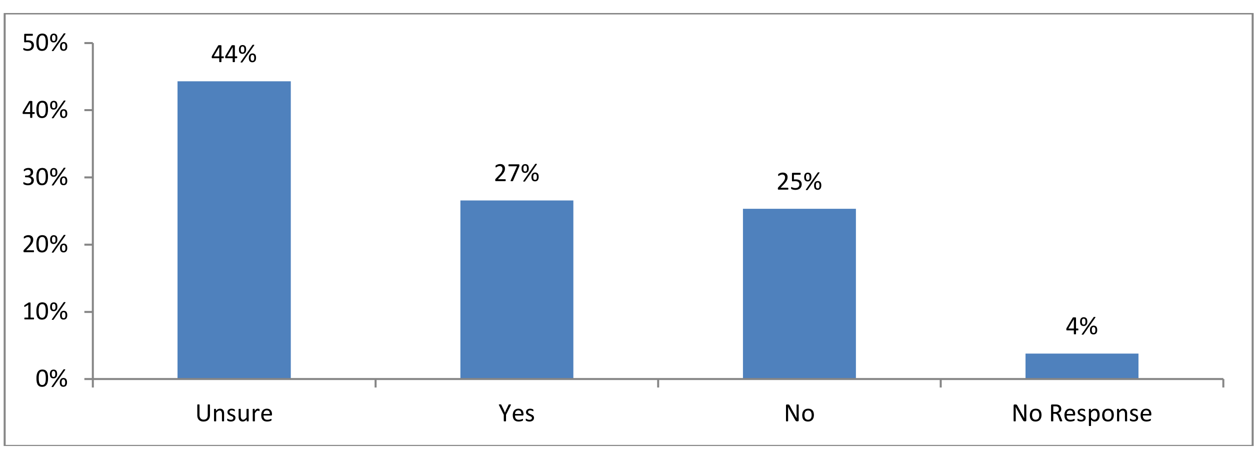
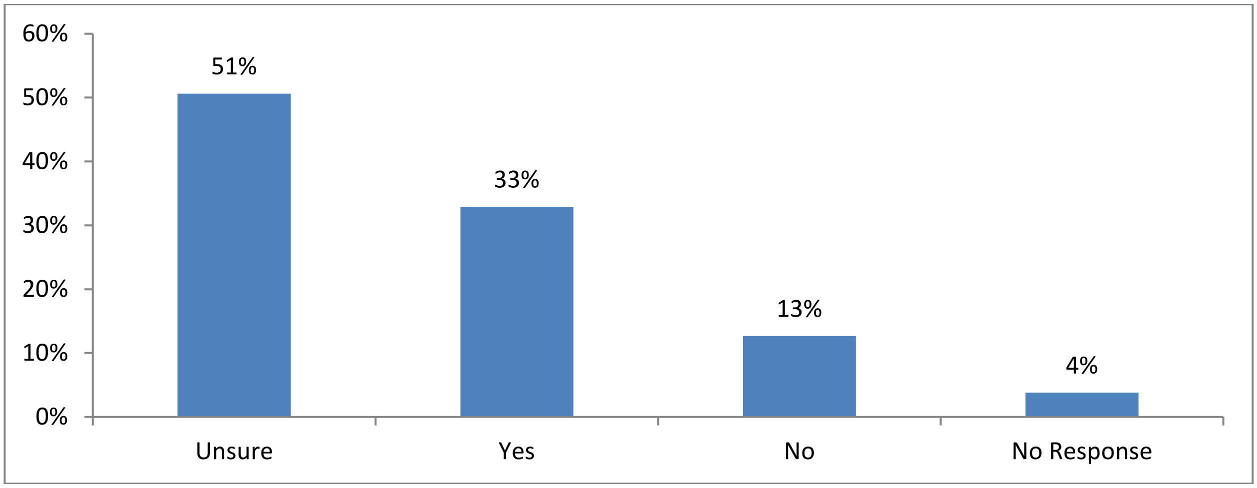
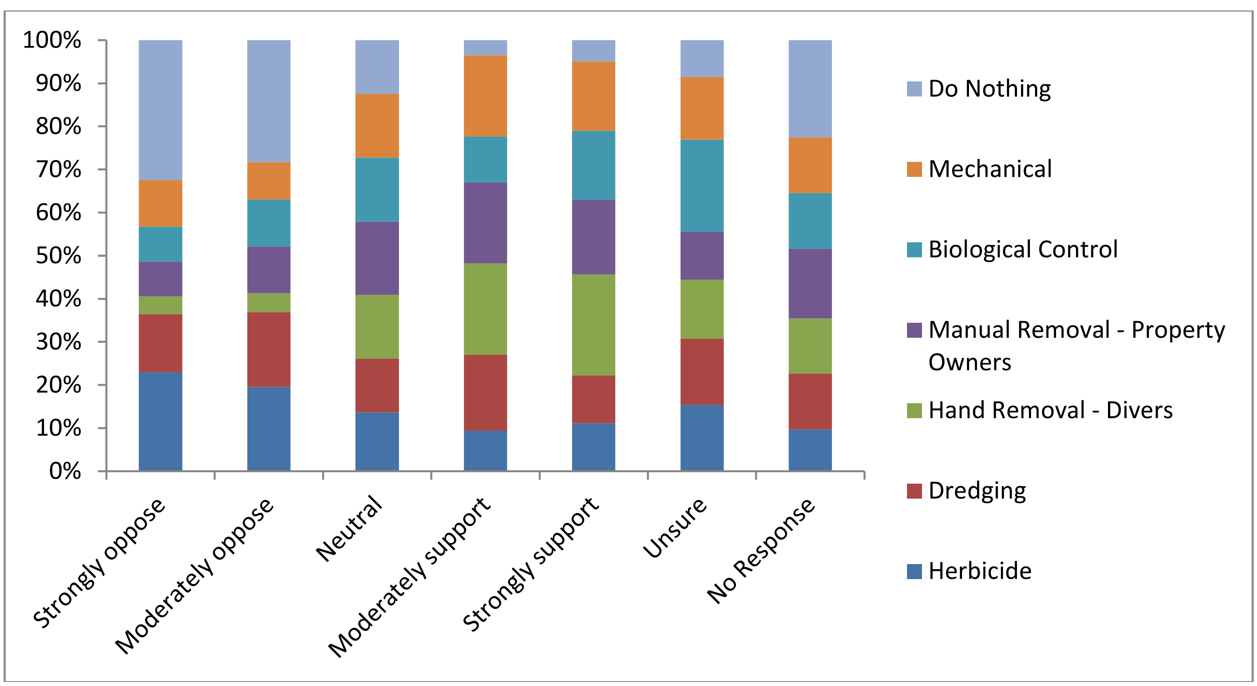


Figure 8.24: *Do you believe the control of invasive plants is needed in Pioneer Lake?*



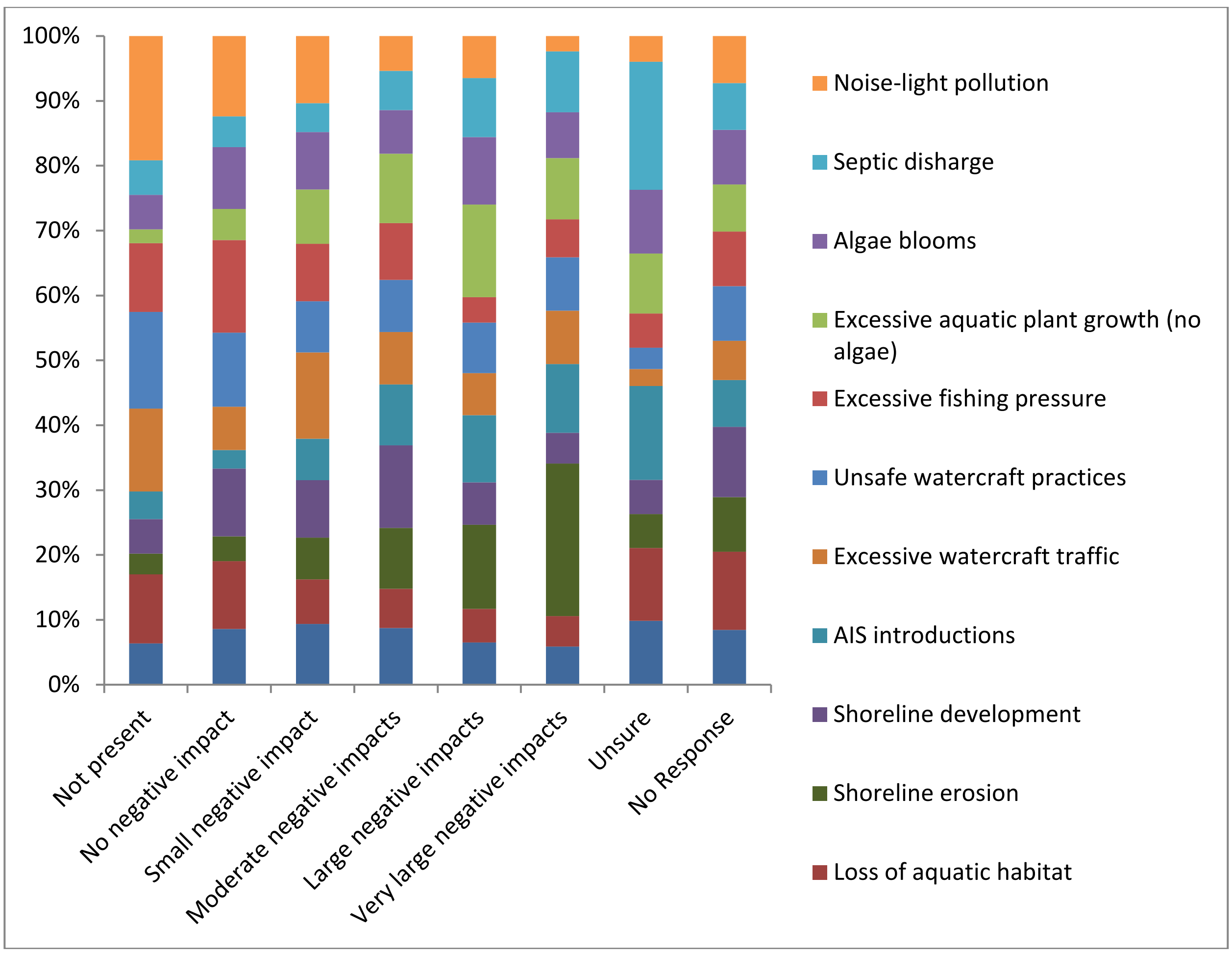
Respondents were asked to rank opposition or support for several aquatic plant management techniques **(Figure 8.25).** Thirty-one percent of respondents strongly oppose "doing nothing" as a management strategy for aquatic plants, followed by herbicide use (22%). Strongest support is for hand removal with divers (24%) hand removal by property owners (18%). The management technique with most uncertainty is biological control (32%) followed by herbicides (23%) and dredging (23%).

Figure 8.25: *Please tell us if you oppose or support the responsible use of the following aquatic plant management techniques for Pioneer Lake.*



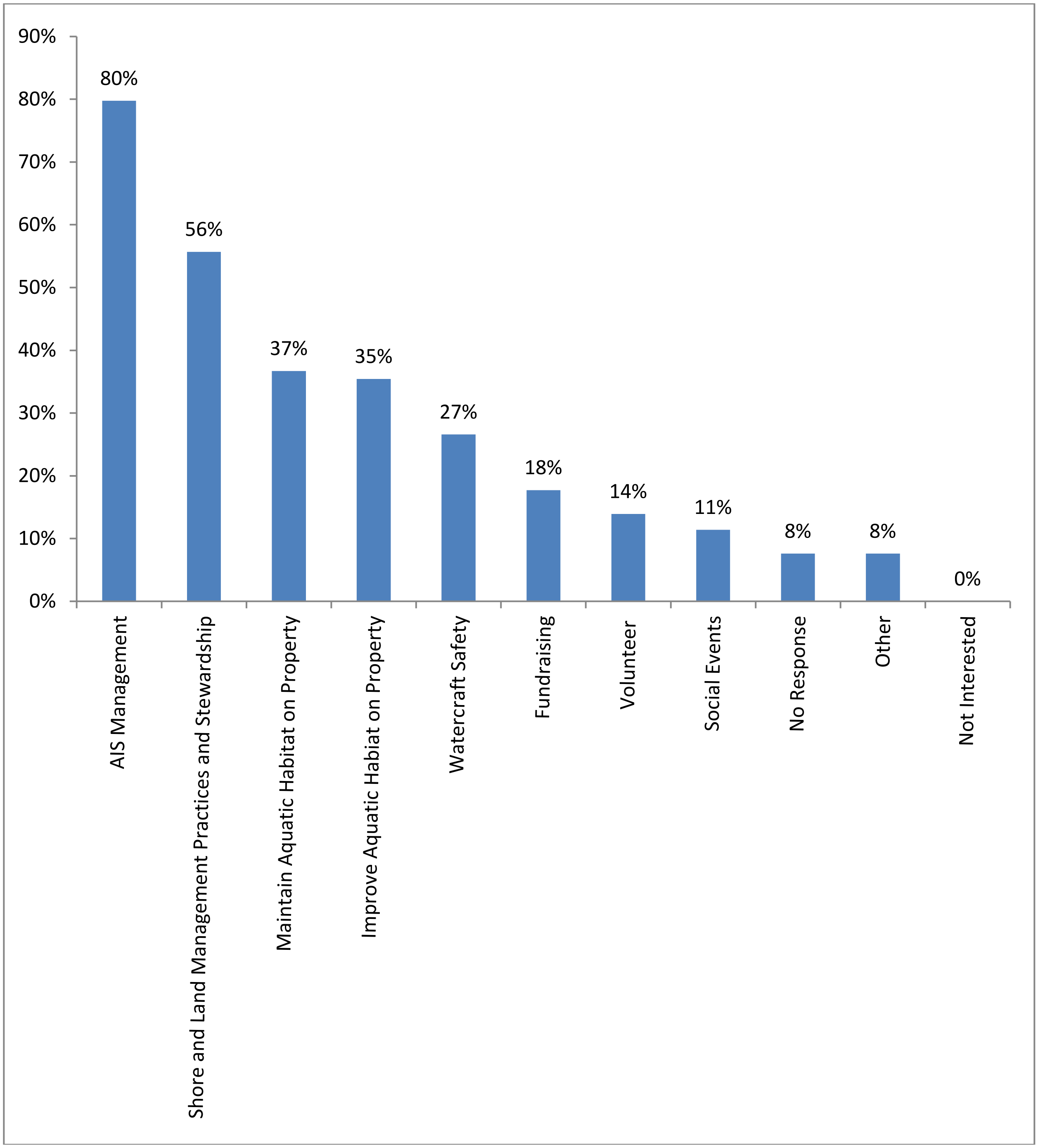
The next series of questions provide a list of possible impacts to Wisconsin lakes **(Figure 8.26).** Respondents were asked, "To what level do you believe each of the following factors may currently be negatively impacting Pioneer Lake?" Circling *not present* means the respondent perceives the issue as not existing on Pioneer Lake, whereas circling *no negative impact* means the issue may exist on Pioneer Lake but is not believed to be negatively affecting the lake. Respondents indicated that shoreline erosion (25%) and aquatic invasive species introductions (11%) are two very large negative impacts to Pioneer Lake. Respondents were unsure about septic discharge (38%) and loss of aquatic habitat (28%) and indicated that noise pollution (23%), unsafe watercraft practices (18%) and excessive fishing pressure (13%) are issues not currently present on Pioneer Lake.

Figure 8.26: *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 Pioneer 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 8.27).** The top three responses include aquatic invasive species management, shore and land management practices, and maintain aquatic habitat on property. Other topics to learn about includes water levels, improving fishery, and public boat landing road maintenance and signage.

Figure 8.27: *What educational topics would you like to learn more about?*



9 - PLANNING REVIEW

06/14/2019 Lake management grant organization meeting. This meeting reviewed the WDNR lake planning grant scope of work, timelines, local share responsibilities and committee involvement. Cathy Higley from Vilas County Land and Water Conservation Department provided the committee an overview of lake data that the County would be collecting as part of the planning project.

01/22/2019 Lake user survey development. The lake management task force reviewed a draft of the lake survey and discussed tentative timelines for the survey mailing. Once the survey draft was ready, Many Water's worked with WDNR to finalize the survey (04/08/2021 phone call with WDNR). Due to Covid -19, the initial mailing timing, which was to occur during the beginning of the summer, was postponed to July 2021.

04/20/2021 Directed Lakes Program-Lake Data Presentation. Members of the lake management task force met online to review the lake data, summary, and conclusions developed by Vilas County Land and Water Conservation Department's directed lakes work for Pioneer Lake. Cathy Higley of Vilas County lead the presentation and took questions. The presentation recorded and data shared is available through Cathy Higley.

06/25/2021 Lake management plan review. This meeting reviewed the current draft of the plan and discussed actionable items for the lake association to move forward with. Round table comments were received, outlying questions were answered, and a discussion on the next step of the review process was detailed. Using information from this meeting an action plan was developed and reviewed by the planning task force.

The intent will be to have the plan approved and ratified by the Pioneer Lake Association membership in 2022 during their annual meeting; however, given uncertainty of Covid and safety concerns for gathering in person, this may need to be reviewed.

10 - SUMMARY AND CONCLUSIONS

The ultimate goal for this project is to assess the ecological condition of Pioneer 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 Pioneer 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

Pioneer Lake supports a robust and diverse aquatic plant community. The overall floristic quality suggests that Pioneer Lake is above average for lakes in the State (WI) and within the Northern Lake and Forest Region. Very few aquatic invasive species currently occur on Pioneer Lake. Education to lake users on how to prevent the introduction of new aquatic invasive species from entering Pioneer Lake will be important to keep Pioneer Lake relatively invasive free. In addition to prevention, continuing early detection monitoring to “catch” new pioneering invasives, if they do arrive, tends to reduce overall management costs (both economic and environmental) and generally have considerable better containment and long-term success.

Long-Term Planning and Lake Management Considerations

Climate predictions for Wisconsin over the next few decades forecast a warmer and wetter climate with increasing number and intensity of precipitation events, most notably seen during the winter months.[16] Currently Wisconsin is experiencing above average precipitation and near historic groundwater level highs. As ground water levels rise, the relationship between the upper layers of ground water, commonly referred to as the water table, and the deeper layers become important. If the deeper layers of groundwater are saturated, meaning no more water can infiltrate from the water table down, the water table rises above the ground to the surface, causing higher surface water levels in lakes and streams. Saturated water tables coupled with more frequent and intense precipitation events may lead to increases in run-off, from the landscape (since the water has limited placed to be absorbed into the ground) carrying excessive nutrients, sediments and other pollutants. 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

[16] https://wicci.wisc.edu/wisconsin-climate-trends-and-projections (Accessed 4/21)

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 Pioneer 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.

Take away messages that highlight some special aspects of Pioneer Lake include:

- Pioneer Lake's floristic quality is above average for Wisconsin Lakes and above average for neighboring lakes in Northern Wisconsin. Meaning, Pioneer Lake has a diverse and healthy aquatic plant community.
- Overall, there are currently relatively few invasive species that currently cause dramatic harm to the lake. 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.
- Pioneer Lake's water quality is very good and supports healthy fish and aquatic life.
- Most of the nearshore vegetation on Pioneer Lake (81%) is natural.

Some identified challenges for Pioneer Lake include:

- Presence of lawns, 58% of parcels have lawn covering 13% of the total nearshore area. Lawns provide very little high-quality habitat for aquatic organisms and increase unnecessary run-off and pollutants such nutrients to a lake.
- High density of piers per shoreland mile. Piers affect fish and disrupt natural shoreline habitats.
- Thirty-eight percent of parcels have some degree of riprap along the water's edge. This riprap covers 12% of the total shoreline of Pioneer Lake. Think of the turtle test. If you were a turtle, could you get from shore to the water without being stuck between the rocks?
- Pioneer Lake provides 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, Pioneer Lake needs:

- Increase educational opportunities, among both riparian residents and public users, including a Clean Boats Clean Waters boat landing education program.
- Enroll in Wisconsin's Citizen Lake Monitoring Network and form a citizen group to monitor AIS, native vegetation, and basic water quality parameters.
- Protect existing natural shoreland habitats by leaving or restoring native, deep rooted plants in the 35' riparian buffer zone, minimizing erosion, and avoiding the use of rip rap

for bank stabilization.

- Improve marginal shoreland habitats for aquatic life and protecting water quality, including maintaining (leave down wood) and improving coarse woody debris (tree drops and adding Fish Sticks) in the lake. Contact Cathy Higley from Vilas County Land & Water Conservation 715-479-3738 or cahigl@vilascountywi.gov for assistance and funding coordination.

ACTION PLAN

This Action Plan identifies areas to strengthen conservation knowledge and practice. It provides a working framework that outlines the goals, actions, assigned responsibilities, timeframes[17], 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 surface water grant eligibility. This update would include updating lake studies, goals, objectives, re-prioritizing needs and review of accomplishments. This plan and the supporting Directed Lake Project provide a comprehensive understanding of the current and historical condition of Pioneer'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) new aquatic/wetland species.

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 education committee to oversee education and outreach aspects of this planning project.

Timeframe: Discussions on structure and process to take place within one year of plan adoption. Topics, programming, and communication materials within two years of plan adoption. This action will be ongoing.

Role/Responsibility: Board, with assistance from Lake Association volunteers.

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

- Education on water quality impacts, including the use of fertilizers, impervious surfaces, run-off abatement, periods of high water, and septic system maintenance.
- Raise awareness on planning efforts 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.
- Line up guest speakers to talk about lake health, and other lake related topics. Relay related events and opportunities happening in the area.
- Use newsletters and other social media to facilitate communication.

Objective (2) Continue to promote networking and collaboration.

Action (1) Continue networking and building connections with local like-minded

[17] Timeframes are contingent on the current status of Covid-19 and the ability to safely meeting and organize.

minded groups and organizations. Develop a working list of organizations and contacts.

Role/Responsibility: Designate liaisons and board members.

Timeframe: Ongoing

- **Expected output/outcome:** The list will serve as a networking directory to identify resources and contacts for more information. List will have periodic review for inclusiveness and usefulness.

Goal (2) Initiate efforts to monitoring water quality and ecosystem health.

Objective (1) Monitor water quality

Action (1) Enroll in the 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 build long-term water quality data for Pioneer 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 and/or 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 improve detection of new species.

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

Timeframe: Every two years

Role/Responsibility: Volunteer lake monitors/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, with invited professional speakers

Expected output/outcome: Board with input from the Lake Association will propose priorities, strategies, and oversight to meet objective. 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
- Share success stories
- Hands on learning
- Installing loon nesting structures

Objective (2) Prevent the spread of aquatic invasive species to Pioneer Lake

Action (2) Participate in Clean Boats Clean Waters and other AIS prevention educational activities, such as Landing Blitz.

Timeframe: Ongoing

Role/Responsibility: Board/Volunteers/Paid staff

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

Action (3) Work with Vilas County to 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.

WORK CITED

Beck, M. W. (2013). Between and within lake responses of macrophyte richness metrics to shore-line development. *Lake and Reservoir Management, 29*, 179-193.

Christensen, D. H. (1996). Impacts of Lakeshore Residential Development on Coarse Woody Debris in Northern Temperate Lakes. *Ecological Applications 6(4)*, 1143-1149.

Dehnert, G. (2019). Effects of Low, Subchronic Exposure of Commercial 2,4-D Formulations on Early Stages of Native Wisconsin Game Fish Species. *Presented at the UWEX Lakes Convention*. Stevens Point, Wisconsin.

Engle, S. (1983). Evaluating Stationary Blankets and Removable Screens for Macrophyte Control in Lakes. *Journal of Aquatic Plant Management*, 21:73-77.

Green, W. a. (1990). Response of Eurasian Watermilfoil to 2,4-D Concentration and Exposure Times. . *Journal of Aquatic Plant Management*, 28:27-32.

Hewett, S. &. (1998). *Wisconsin's Walleye Mangement Plan: Moving Management into the 21st Century.* Madison, WI: Wisconsin Department of Natural Resources.

Holdren, C. J. (2001). *Managing Lakes and Reservoirs.* Madison, WI: North American Lake Management Society and Terrene Inst., in coop. with Off. Water Assess. Watershed Prot. Div. USEPA.

Jacobson, P. C. (2016). A Fish Habitat Conservation Framework for Minnesota Lakes. *Fisheries, 41:6*, 302-317.

LaRue, E. Z. (2012). Hybrid watermilfoil lineages are more invasive and less sensitive to commonly used herbicide than their exotic parent (Eurasian watermilfoil). *Evolutionary Applications*, 6:462-471.

Lille, R.A., & J.W. Mason. 1983. Limnological characteristics of Wisconsin lakes. Technical Bulletin No. 138. Wisconsin Department of Natural Resources. 2008/109.

National Park Service. (2008). *Water Quality Monitoring Protocol for Inland Lakes.* Great Lakes Resource and Monitoring Network. Natural Resources Report NPS/GLKN/NRTR.

Nault, M. B. (2018). Evaluation of large-scale low concentration 2,4-D treatments for Eurasian and hybrid watermilfoil control across multiple Wisconsin Lakes. *Lake and Reservoir Management*, 34 (2): 115-129.

Nault, M. K. (2015). Control of Invasive Aquatic Plants on a Small Scale. *Lakeline-North American Lake Management Society*, 35-39.

Nichols, S. (1999). Floristic quality assessment of Wisconsin lake plant communities with example applications. *Journal of Lake and Reservoir Management 15(2)*, 133-141.

Omernic, J. &. (1998). *Ecoregions of the Upper Midwest States.* U.S. Environmental Protection Agency Region 5, Library (PL-12J).

Papes, M. S. (2011). Invasive Species Research to Meet the Needs of Resource Management and Planning. *Conservation Biology 25(5)*, 867-872.

Parks, S. M. (2016). Divergent responses of cryptic invasive watermilfoil to treatment with auxin herbicides in a large Michigan lake. *Lake and Reservoir Management*, 32:4.

Rypel, A. S. (2019). Flexible Classification of Wisconsin Lakes for Improved Fisheries Conservation and Management. *Fisheries*, 44:5 (225-238).

Sass, G. K. (2006). Fish Community and Food Web Responses to a Whole-lake Removal of Coarse Woody Habitat. *Fisheries 31:7*, 321-330.

Shaw, B. M. (2004). *Understanding Lake Data.* University of Wisconsin Extension Publication G3582 RP-03/2004.

Simonson, T. ed (2012). Wisconsin Muskellunge Waters. Wisconsin Dept of Natural Resources. Pub FH-515. (2012)

U.S. Environmental Protection Agency. (2009). *National Lakes Assessment: A Collaborative Survey of the Nation's Lakes. EPA 841-R-09-001.* Washington, D.C.: U.S. Environmental Protection Agency, Office of Water, and Office of Research and Development.

USEPA. (2009). *National Lakes Assessment: A Collaborative Survey of the Nation's Lakes. EPA 841-R-09-001.* Washington, D.C.: U.S. Environmental Protection Agency, Office of Water, and Office of Research and Development.

USEPA. (2016). *Draft Herbicide Resistance PRN 2016-XX for Public Comment.* USEPA.

WDNR. (2007). *Aquatic Plant Management Strategy. Northern Region WDNR.* Wisconsin Department of Natural Resources.

WDNR. (2012). *2,4-D Chemical Fact Sheet.* Wisconsin Department of Natural Resources.

WDNR. (2015). *The Ecological Landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management.* Wisconsin Department of Natural Resources, PUB-SS-1131 2015, Madison.

Woodford, J. a. (2003). Impact of lakeshore development on green frog abundance. *Biological Conservation*, 110:227-284.

WDNR. (2012). *Flumioxazin Chemical Fact Sheet.* Wisconsin Department of Natural Resources.

WDNR. (2012). *Imazapyr Chemical Fact Sheet.* Wisconsin Department of Natural Resources.

Woodford, J. &. (2003). Impact of lakeshore development on green from abundance. *Biological Conservation 110*, 277-284.