Buckatabon Lakes

Vilas County, WI

Aquatic Invasive Species Prevention & Planning Project

Buckatabon Lakes Aquatic Invasive Species Prevention & Planning

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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 debate on alternatives/options
- Including strategies to monitor for progress
- Allowing adaptability in the process

The ultimate goal for this project is to understand the current ecological condition of Buckatabon Lakes and develop actions that support its aesthetic qualities and ecosystem health over time. Supporting goals include identifying ecological threats and formulating responses to them; maintaining high quality aesthetic and recreational opportunities; engaging and educating the lake community; and developing actions that conserve native species and their habitats. Likewise, this plan seeks to meet NR 198.43 requirements, allowing the Buckatabon Lakes Association (BLA) to be eligible for further Wisconsin DNR Surface Water Grants.

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

The vast majority of data collected for this project focused on in-lake and riparian habitat features. These features relate well to understanding and describing the health of a lake and its surrounding landscape. In addition to inventorying the ecological condition of Buckatabon Lake, an overview of the historical and social context is included incorporating early on accounts and remembrances from lake residents. Several lake residents provided insight. Thank you to Bruce Bickner, Gary Croisatiere, and Carla Hibbard for their contributions **(Appendix A).** The plan has a five year scope; however, periodic review is recommended to insure content is relevant to the current situation.

INTRODUCTION

Upper and Lower Buckatabon Lakes are connected water bodies located in Conover Township, Vilas County, WI with 493 and 378 surface water acres respectfully. Upper Buckatabon has a maximum depth of 47 feet and Lower Buckatabon has a maximum depth of 16 feet. Both lakes are drainage lakes and Two-Story Natural Communities. The WDNR defines two-story lakes as those that “are often more than 50 feet deep and are always stratified in the summer”. These lakes have the potential to support coldwater fish, such as cisco, in cooler deeper waters of the lake. Recently, the WDNR listed both Upper and Lower Bucktabon Lakes on the State’s impairment listing for exceeding phosphorous levels recommended for a two-story natural community.

Buckatabon Creek flows into Upper Buckatabon Lake from the north. This creek is a cool-cold headwater creek that supports a Class II trout stream. Located in the Tamarack Pioneer River Watershed, land cover is primarily forests (63%), wetlands (18%), and open water (10%). This watershed ranks medium for nonpoint sources affecting lakes. A dam owned and operated by Wisconsin Valley Improvement Company is located along the eastern end of Lower Buckatabon that drains Buckatabon Creek to the Wisconsin River. A public boat launch owned by Vilas County is located on Upper Buckatabon, whereas a channel between Upper Buckatabon and Lower Buckatabon provides public access to Lower Buckatabon. Private boat launches also provide access to Lower Buckatabon. Aquatic invasive species known to occur on the Buckatabon Lakes include banded mystery snails, Chinese mystery snails, Eurasian watermilfoil, and yellow iris.

Photo 1: Upper Buckatabon Lake, Aerial View, 2019

Photo by Ken Whyte

Photo 2: Upper Buckatabon Lake, Aerial View, 2019

Photo by Ken Whyte

1 - HISTORICAL AND SOCIAL CONTEXT

Glacial History

Buckatabon Lakes are 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 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 melt water 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" (Photo, right[1]).

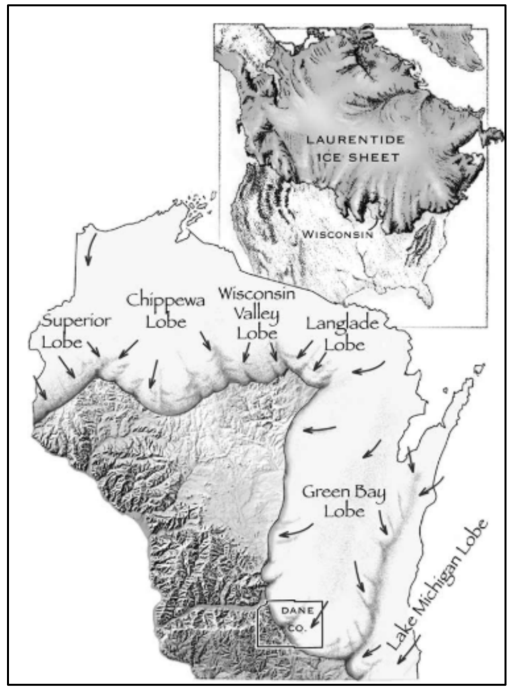


Photo 2: *Wisconsin's Glacial History*

Anthropology

From an anthropology standpoint, the area surrounding Buckatabon Lakes has rich tribal heritage that predates European settlement by thousands of years. As part of current day Vilas County, Buckatabon Lakes shares about three centuries of history with the Chippewa Ojibwe tribe[2], 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, 2011). 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.

Logging History and the Buckatahpon Dam

The area was continually logged in the years following the 1842 Treaty, extracting nearly all its giant white pine by the late 1800's. Another legacy of the logging era was an earthen dam, in the outflow channel from Lower Buckatabon Lake- used to raise the lake level several feet, containing

[1] https://wgnhs.wisc.edu/wisconsin-geology/major-landscape-features/northern-highlands/
[2] https://www.wisconsinhistory.org/Records/Article/CS4380

the winter's harvest of timber. The dam was released during spring's high water flows which sped the transport of logs to downstream markets. This dam was named Buckatahpon (said to be from the Ojibwe word for "hunger") (**Bright, 2004**). In 1908 this dam was acquired by Wisconsin Valley Improvement Company (WVIC), along with fifteen other existing logging dams to become natural lake reservoirs in the Wisconsin River Headwaters Reservoir System. An additional five man-made reservoirs were also enacted 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 dam was upgraded to a concrete structure in 1938 by WVIC, and has a licensed operating plan (describing its maximum and minimum flows) by the Federal Energy Regulation Commission. [3] See **Appendix B** for more information about Buckatahpon Dam.

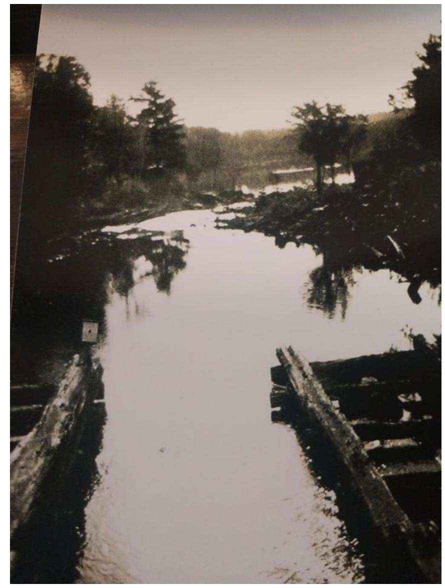


Photo 3: *Buckatahpon Dam, 1930's. Source: Bauer's Dam*

Settlement History

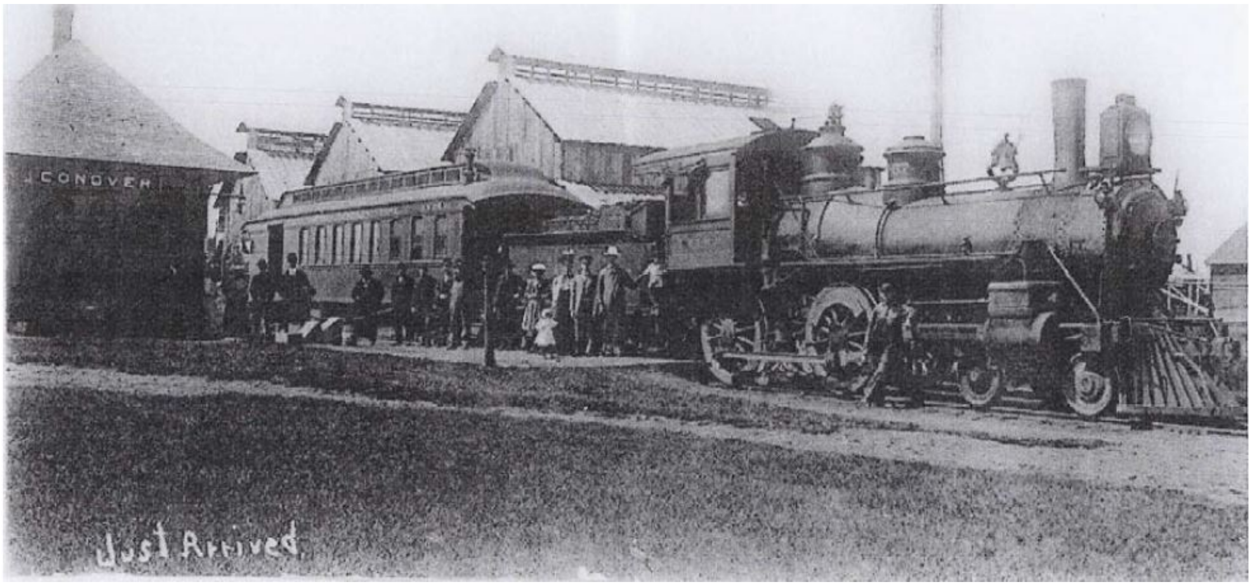
Around 1900, the lake and resource-rich Northwood's, including the Buckatabon Lakes, became a tourist destination for families from southern Wisconsin and Illinois. The development of railways linking the Northwood's to cities such as Chicago, facilitated the travel of railroad executives and wealthy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

According to the History of Conover **(Dobbs, 1991**), 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 Buckatabon Lakes 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[4].

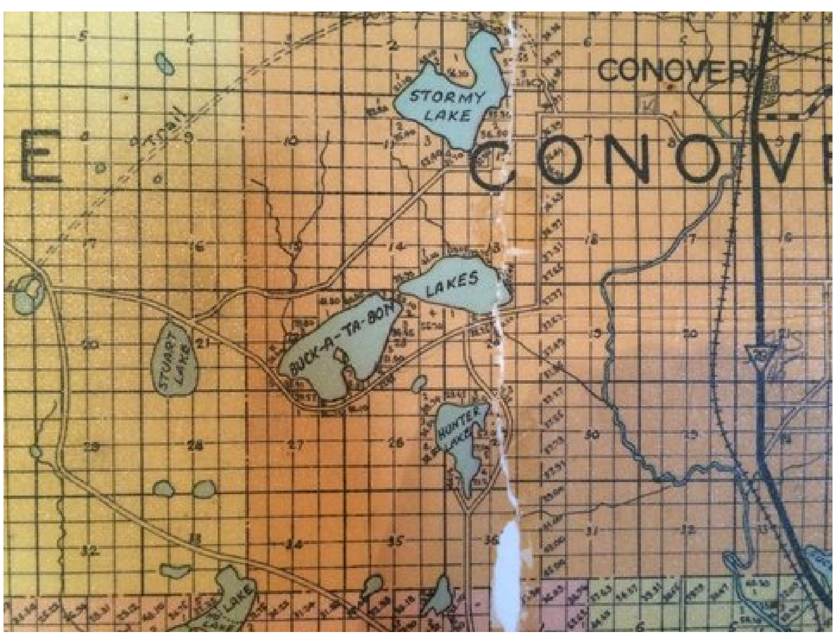
[3] http://www.wvic.com/

[4] Wikipedia: Conover, WI

Photo 4 : *Conover Railroad Station, circa 1920-30. Source: History of Conover*



The History of Conover **(Dobbs, 1991)** notes that in the early 1900's Native Americans from all over Wisconsin congregated in the area, camping along the Wisconsin River, to pick thousands of quarts of blueberries, and staying on for wild rice and cranberries in the fall. The early 1900's saw the homesteaders claiming logged land as farms, attempted businesses and early deeding of lake properties as well. Some of the first resorts on Upper and Lower Buckatabon and other lakes were established in this time frame. In the 1920s, railroads continued to bring sportsmen and seasonal visitors, especially those from Chicago, enjoying early resorts such as the Lakeview Resort (originally the LaMason property and later owned by Fred and Friedel Mueller), according to collected family notes of Bruce Bickner. The Bickner notes also report that Carl and Margaret Gesell had inherited much of the land around Upper Buckatabon by the 1930's. To satisfy debts, they were forced to sell off much of their lake frontage in the 1940s, at a cost of around $2 per frontage foot. This decade appears to have been the one in which much of the lake frontage was divided and developed with modest cottages, in keeping with post war building material rationing.



Map 1 : *Historic Survey Map of several Conover area lakes.*

Conover Recreation Association

The enthusiasm of those who frequented the Buckatabon Lakes was infectious- and they often drew friends northward to purchase lake lots. Census records from the 1940's lack information about seasonal residents at the lake, but the anecdotal notes compiled by Bickner told the story of his parents and a series of acquaintances (teachers) from the Chicago area that purchased neighboring lakefront properties. The roots of Conover area lake organizations can be traced back to 1946 and a meeting of a handful of people to discuss ways to care for and improve local lakes, specifically Upper and Lower Buckatabon, Stormy, and Hunter Lakes. This led to a larger meeting of interested lake owners at the Conover Town Hall that appointed officers and directed the development of bylaws and included 87 members by the end of 1946. In 1947 the organization expanded its base to include residents of Pioneer and Twin Lakes, as well as Conover business owners. The members chose "Conover Recreation Association" as the association's name, reflecting the inclusion of both lake residents and town business owners. (Conover Recreation Association, unpublished history compiled by Bruce Bickner.) Since many of the members were Chicago natives, they enjoyed the camaraderie of meeting in the winter months in the Chicago region. At first, meetings were among about 35 early members' homes and later moved to public places as membership grew. The Conover Recreation Association stayed very active through the 1950s-60s and celebrated its 25th Anniversary on July 22, 1971.

Over its thirty years, the Association served as a lakes association, local chamber of commerce, and the host of much local entertainment. Beside its many social events, the Conover Recreation Association was a driving force in local infrastructure such as postal routes around the lakes, road improvements, the first town dump, the first public telephone, dam management and water levels on Buckatabon lakes and doing the legwork necessary to bring electricity to Buckatabon and Stormy Lakes in the 1950s.

Another piece of lake history is Larson's Resort in a bay at the southeast end of Upper Buckatabon, started in the late 1800s by Andrew Leard. It was a rough, old-fashioned lumber camp when purchased by timberman Robert Thurston (b 1861 in Ontario Canada) in 1902. Hadley B. Larson, a Chicago native in the printing business, and Seward Grinde, a dentist from DeForest, WI who practiced in Chicago until 1916, bought what became Larson's Resort in 1913. In their tenure, the resort had twelve cottages, accommodating up to sixty people who dined in a communal log dining room. Publicity for the resort enticed guests with abundant fish, deer, and game birds, access to nine large area lakes and experienced guides. The resort thrived for many years before being sold to the Jewish Theological Seminary to form the first Ramah Camp, a Jewish summer camp, in 1947. Multi-purpose buildings were quickly

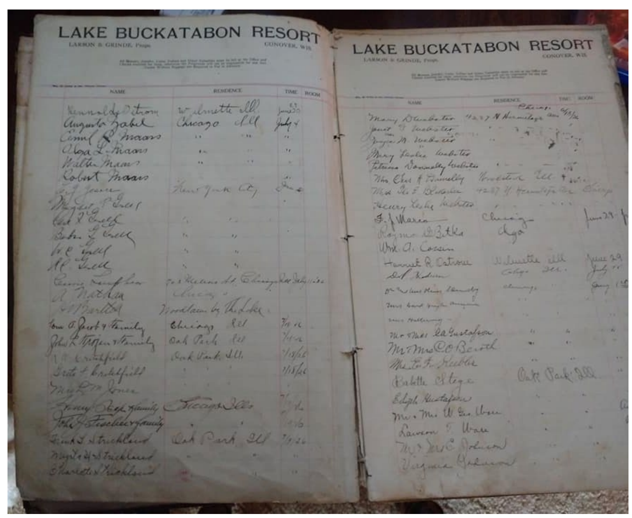


Photo 5 : *Guest Log from Lake Buckatabon Resort, Source: Bauer's Dam Resort Facebook* erected, and the first campers, nearly 100, arrived by train on the Flambeau Express line. It still draws campers from across the Midwest, primarily Chicago and the Twin Cities. The 150 acre camp has been renovated and improved over the years and hosts over 2000 youth annually in grades 3 through 11 (Dobbs, 1991 & Wikipedia).

Buckatabon Lakes Association, Inc.

Galvanized by the official identification of a lake specimen as invasive Eurasian watermilfoil, a large group of lake residents first met on August 10th, 2015 at the Conover Community Center. By the end of this meeting, it was agreed that a lake association would be required to seek state assistance and coordinate the lake residents' response to EWM and general lake health. A slate of officers was elected at that meeting and bylaws developed in short order so that by August 20th, 2015, Buckatabon Lakes Association, Inc. (BLA) was incorporated. There were 17 paid members by September 2015 and grew to 115 members within a year. The group sought early counsel from Wisconsin Dept of Natural Resources (WDNR) and lake management professionals. Initial surveys were conducted, and a road map for understanding lake health and how to better position themselves for state grant assistance was developed. The goals included managing and educating about EWM. BLA realized early on the importance of documenting volunteer time for use as potential match for these grants.

By spring 2016, BLA members had conducted fundraising efforts, developed a newsletter, organized and begun training Clean Boats Clean Waters Volunteers and committed to their first WDNR Rapid Response Grant. The Town of Conover was the first sponsor for this grant. Many Waters LLC was hired to conduct surveys and manage EWM in 2016, training a core of volunteers to help. In 2018, an Aquatic Invasive Species Education, Prevention and Planning Grant was awarded by the WDNR. This plan is a product of that grant and includes exhaustive surveys of the lake, its vegetation, and shoreline with an emphasis on assessing invasive species and their management. BLA members continue to be engaged and active in EWM management as well as fisheries, lake development, and general lake health.

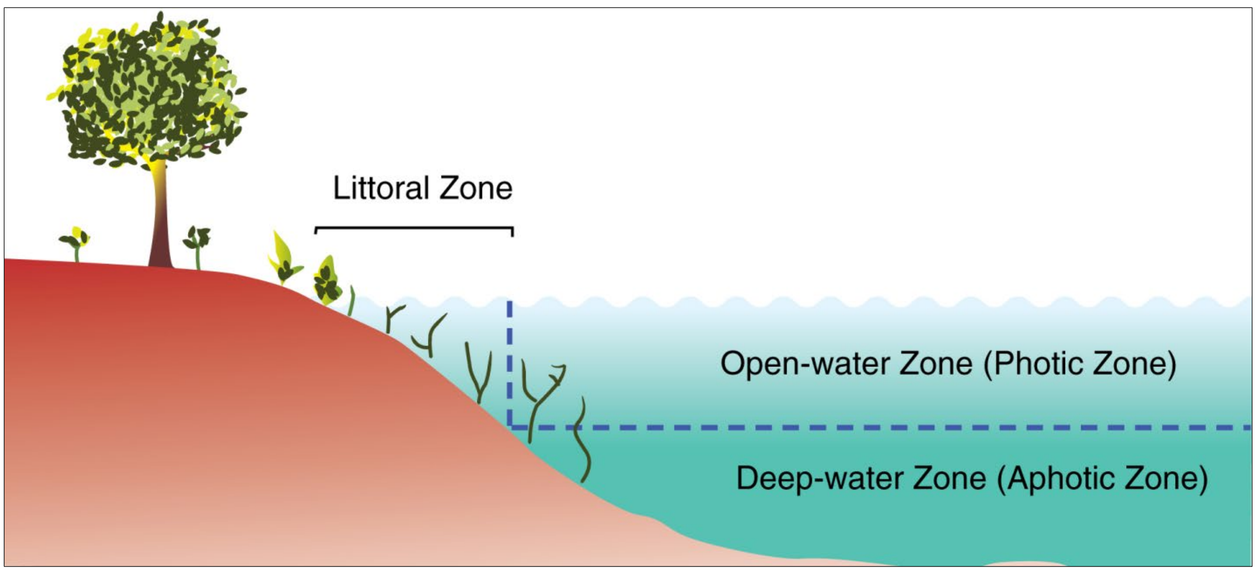
Photo 6 : *BLA members promote their Clean Boats, Clean Water Campaign during a 4th of July parade.*

2 - AQUATIC PLANTS

Introduction

Some lake users may consider aquatic plants a nuisance and aesthetically displeasing. Others may recognize that aquatic plants are important to lake health, but may not be familiar with the specific roles that plants have within a lake's ecosystem. 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*[5]



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.

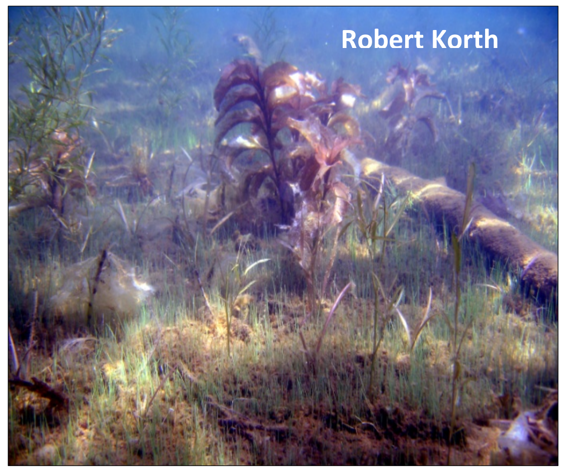
[5] Geoff Ruth [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

Floating Leaf Plants

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

Submersed Plants

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



Buckatabon 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 evenly spaced across the lake. These 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.

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[6]). At each sampling site, water depth and sediment type are also recorded. Emergent/floating leaf community surveys circumnavigated the entire lake identifying all observed emergent and floating leaf plant locations. Emergent/floating leaf community mapping used a combination of visually identified species documented during the point intercept survey combined with geo-spatially mapped beds **(Appendix C).** Small locations (<1/10 acre) were geo referenced with a GPS point whereas the outer edges of larger locations were traced to create geo-spatially referenced beds.

Point intercept surveys took place the week of July 20 , 2019 on Upper Buckatabon and the week of July 27, 2019 on Lower Buckatabon. Additional point intercept surveys completed by the WDNR[7] on Upper and Lower Buckatabon Lakes took place in 2010 and 2015. Emergent/floating leaf community mapping on both lakes took place on July 22, 2019.

Upper Buckatabon's survey sampled 742 locations, identifying a total of 42 native aquatic plant species and one invasive plant species. Rake samples detected 32 native plants species and one invasive plant species, whereas the remaining species were visual observations **(Appendix D).** Maximum depth of plant colonization occurred at 14 feet, with the majority of vegetated sites occurring between 5 to 8 feet **(Figure 2.3).** Most sites sampled consisted of soft or mucky sediments (48%) and sand (47%) followed by rock (5%) **(Figure 2.5).** Total species detected per rake sample ranged from 1 to 9 with an average of 2.93 species per rake sample.

Lower Buckatabon's survey sampled 452 locations, identifying a total of 31 native aquatic plant species and one invasive plant species. Rake samples detected 28 native plants species, whereas the remaining species were visual observations **(Appendix D).** Maximum depth of plant colonization occurred at 15 feet, with the majority of vegetated sites occurring between 5 to 9 feet **(Figure 2.4).** Most sites sampled consisted of soft or mucky sediments (87%), followed by sand (13%) and rock (1%) **(Figure 2.5).** Total species detected per rake sample ranged from 1 to 11 with an average of 2.00 species per rake sample.

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[6] Taken from Recommended Baseline Monitoring of Aquatic Plants in Wisconsin, (Hauxwell et al, 2010).

[7] 2010 surveys completed with assistance from the Vilas County Land and Water Conservation Department. 2015 surveys completed with assistance from Wisconsin Valley Improvement Company.

Table 2.1: Point intercept survey summary statistics for 2015 and 2019 – Upper Buckatabon.

	2010	2015	2019
Total number of sites visited	562	288	742
Total number of sites with vegetation	234	207	212
Total number of sites shallower than maximum depth of plants	452	281	273
Frequency of occurrence at sites shallower than maximum depth of plants	51.77	73.67	77.66
Simpson Diversity Index	0.91	0.91	0.92
Maximum depth of plants (ft)	25	20	17
Number of sites sampled using rake on Rope (R)	229	65	23
Number of sites sampled using rake on Pole (P)	230	215	227
Average number of all species per site (shallower than max depth)	1.4	2.1	3.7
Average number of all species per site (veg. sites only)	2.7	2.9	4.7
Average number of native species per site (shallower than max depth)	1.4	2.1	3.6
Average number of native species per site (veg. sites only)	2.7	2.9	4.7
Species Richness	33	24	33
Species Richness (including visuals)	35	31	33

Table 2.2: Point intercept survey summary statistics for 2015 and 2019 – Lower Buckatabon.

	2010	2015	2019
Total number of sites visited	457	454	452
Total number of sites with vegetation	421	394	380
Total number of sites shallower than maximum depth of plants	454	448	433
Frequency of occurrence at sites shallower than maximum depth of plants	92.73	87.95	87.76
Simpson Diversity Index	0.80	0.77	0.82
Maximum depth of plants (ft)**	16	15	15
Number of sites sampled using rake on Rope (R)	0	9	0
Number of sites sampled using rake on Pole (P)	457	445	452
Average number of all species per site (shallower than max depth)	1.9	1.6	2.0
Average number of all species per site (veg. sites only)	2.1	1.8	2.2
Average number of native species per site (shallower than max depth)	1.9	1.6	2.0
Average number of native species per site (veg. sites only)	2.1	1.8	2.2
Species Richness	29	25	28
Species Richness (including visuals)	34	33	29

Figure 2.3: *Depth of aquatic plant colonization – Upper Buckatabon, 2019.*

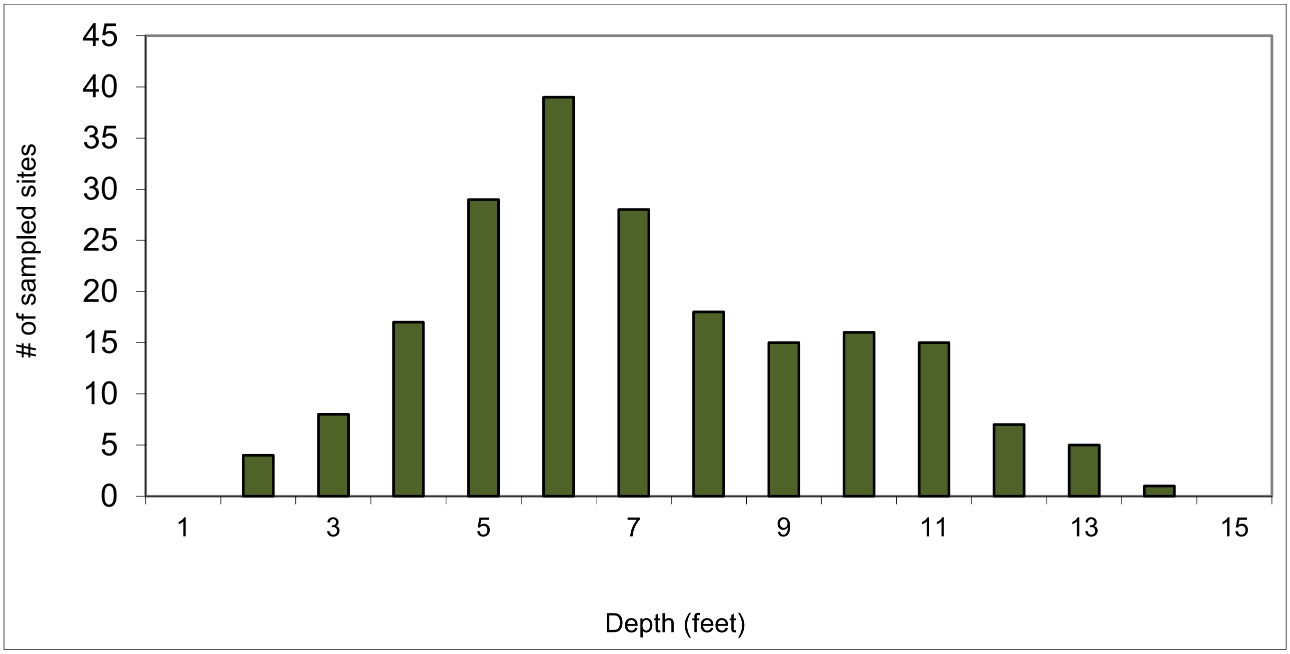
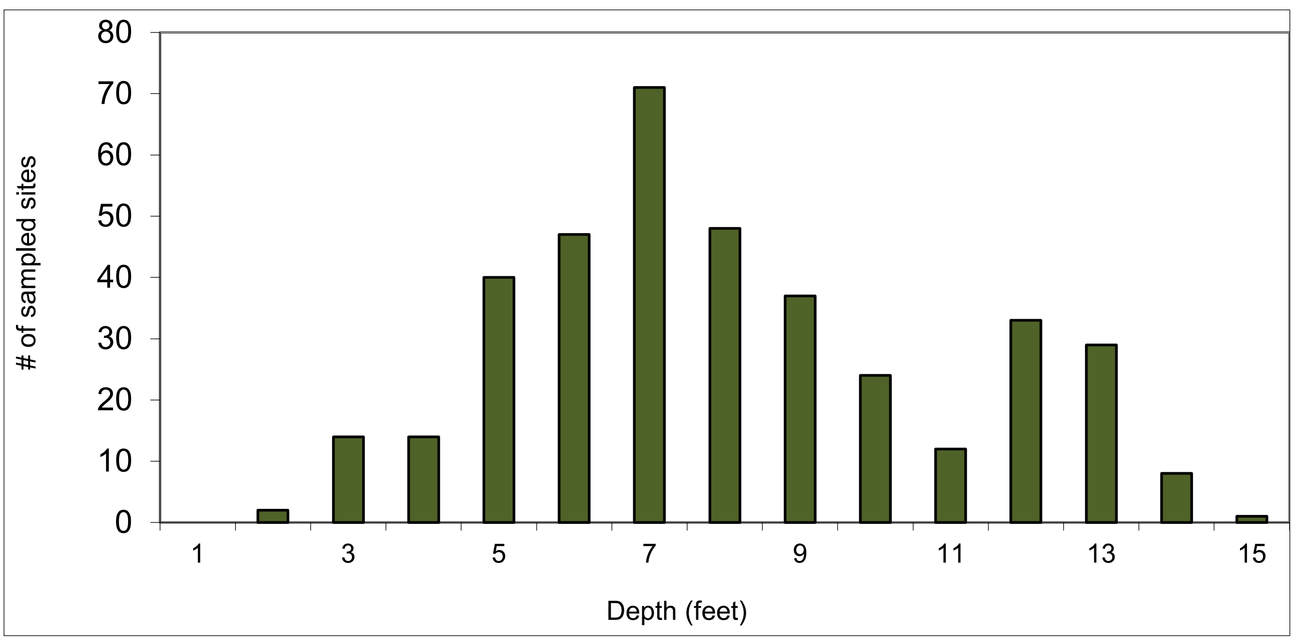
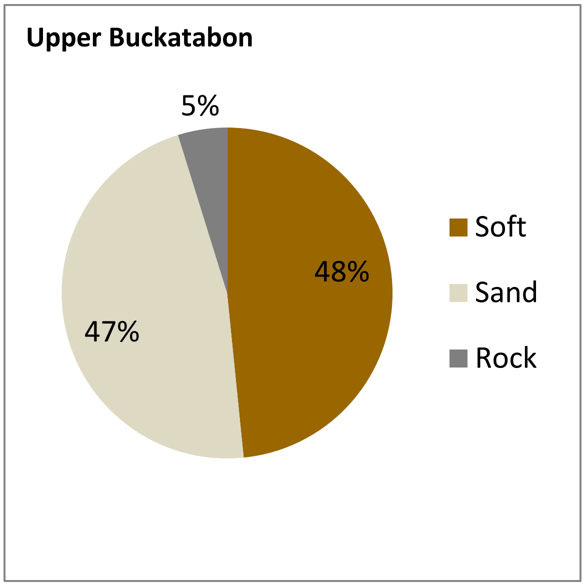
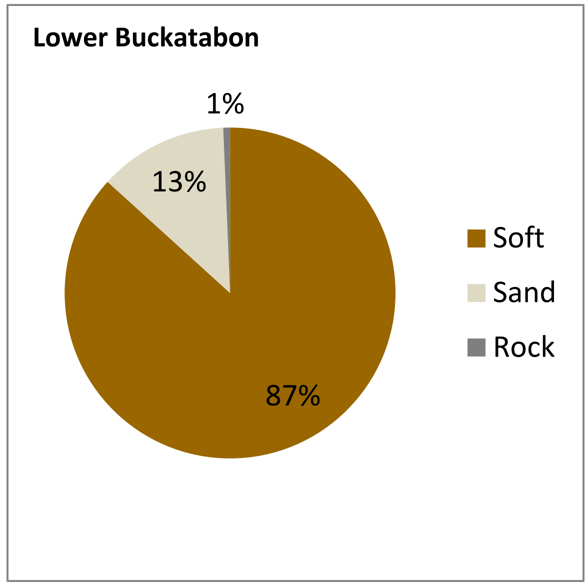


Figure 2.4: *Depth of aquatic plant colonization – Lower Buckatabon, 2019.*



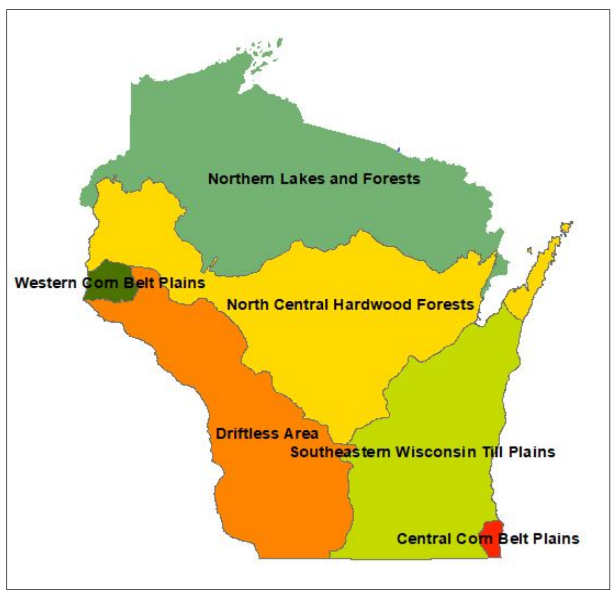
Figures 2.5: *Lake-wide percentage of substrate consistency – Upper and Lower Buckatabon Lakes, 2019.*





Plant Analysis Primer

Figure 2.6: *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 are tolerant of some community changes or degradations and have values that fall between these two extremes. By definition non-native plants species do not have an affinity to any high-quality natural habitats, and are assigned a value of zero.

Floristic quality assessments generally compare the floristic quality of lakes within a similar Ecoregion **(Figure 2.6).** An Ecoregion is a defined landscape that has similar characteristics including land-use, vegetation, soils, and landscape formations. Buckatabon Lakes 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

Upper and Lower Buckatabon's FQI rose in 2019 compared to 2015, and both lakes have an overall ranking above the median[8] value for the Northern Lakes and Forests region and Wisconsin statewide values **(Figures 2.7 & 2.8).** Average species conservatism for Upper Buckatabon ranged from 6.4 in 2015 to 6.7 in 2019, and sits at the average value for Northern Lakes, and above average for lakes across the state. Average species of conservatism for Lower Buckatabon in 2015 and 2019 was 6.7, and sits at the average for Northern Lakes, and above average for lakes across the state.

In addition to floristic quality, the Simpson's Diversity Index, is one of many indices useful in measuring ecological diversity. Diversity simply looks at the variability amongst living organisms and ecosystems, including genetic diversity to ecosystem diversity. Understanding diversity is important because diversity in a lake may protect or buffer a lake from change over time, and improve its resilience to outside "stressors" and other vulnerabilities. A Simpson's Diversity Index measures species diversity and takes into account both richness and abundance of each species. This index is different from floristic quality that uses species richness and species conservatism. Simpson's Diversity Index values range from zero to one. The closer the value is to one, the more diverse the measured population is considered to be. Simpson Diversity Index values for Upper and Lower Buckatabon Lakes rose slightly from 0.91 in 2015 to 0.92 in 2019 and 0.77 in 2015 to 0.82 in 2019 respectfully.

[8] 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.

Figure 2.7: *Summary of Upper Buckatabon's floristic quality and diversity, 2010, 2015 & 2019.*

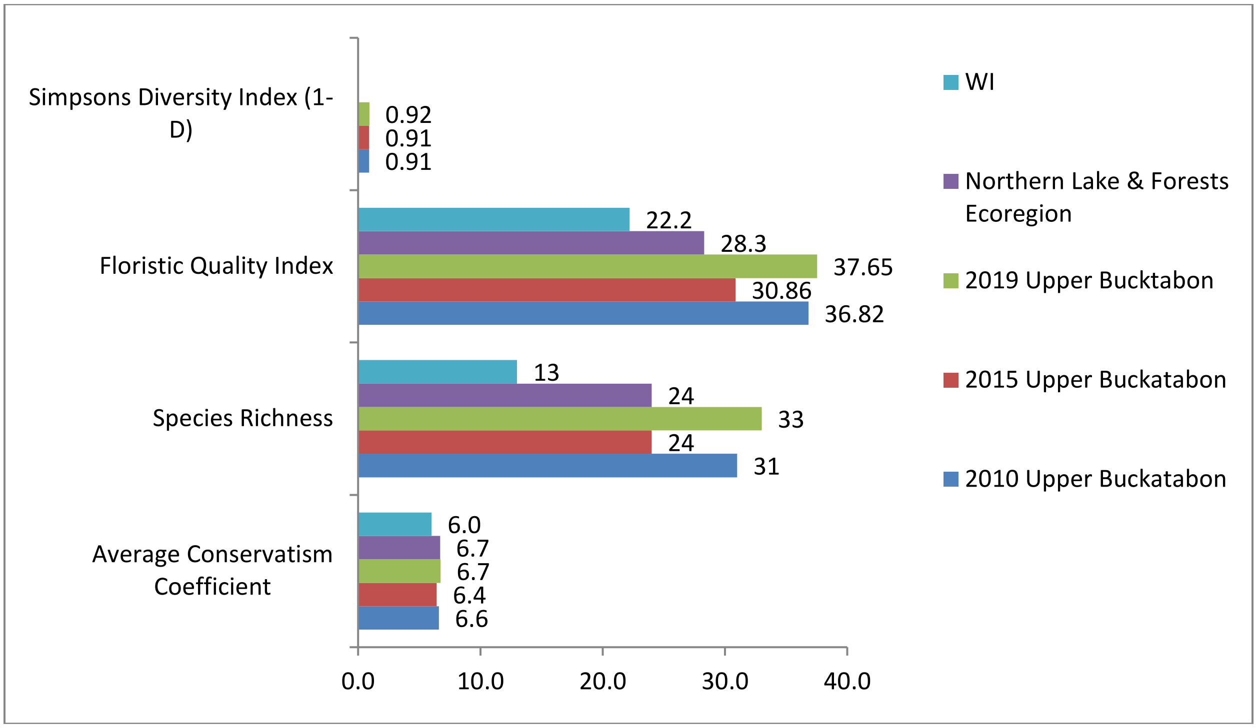
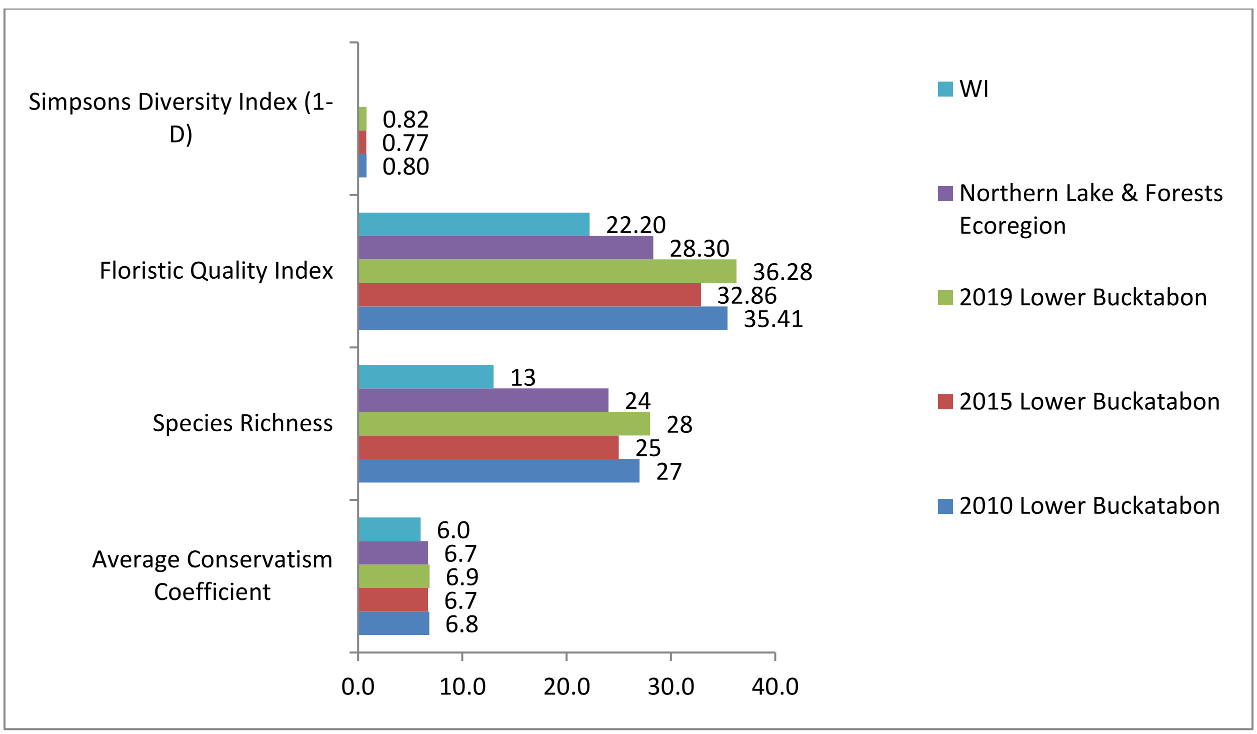


Figure 2.8: *Summary of Lower Buckatabon's floristic quality and diversity, 2010, 2015 & 2019.*



Frequency of littoral occurrence of a species is the percentage of the total surveyed points that a species was present on a rake sample divided by the total number of points sampled within the littoral zone**. (Figures 2.13-2.16)** 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 Upper Buckatabon based on the both the 2015 and 2019 point-intercept survey include fern pondweed, wild celery, and small pondweed **(Figure 2.9).** Species with the highest frequency of occurrence on Lower Buckatabon based on both the 2015 and 2019 point-intercept survey include fern pondweed, coontail, and common waterweed **(Figure 2.10).**

Figure 2.9: *Comparisons of littoral frequency of occurrence in Upper Buckatabon in 2010, 2015 and 2019. Only species with a 5% or greater littoral frequency of occurrence are represented.*

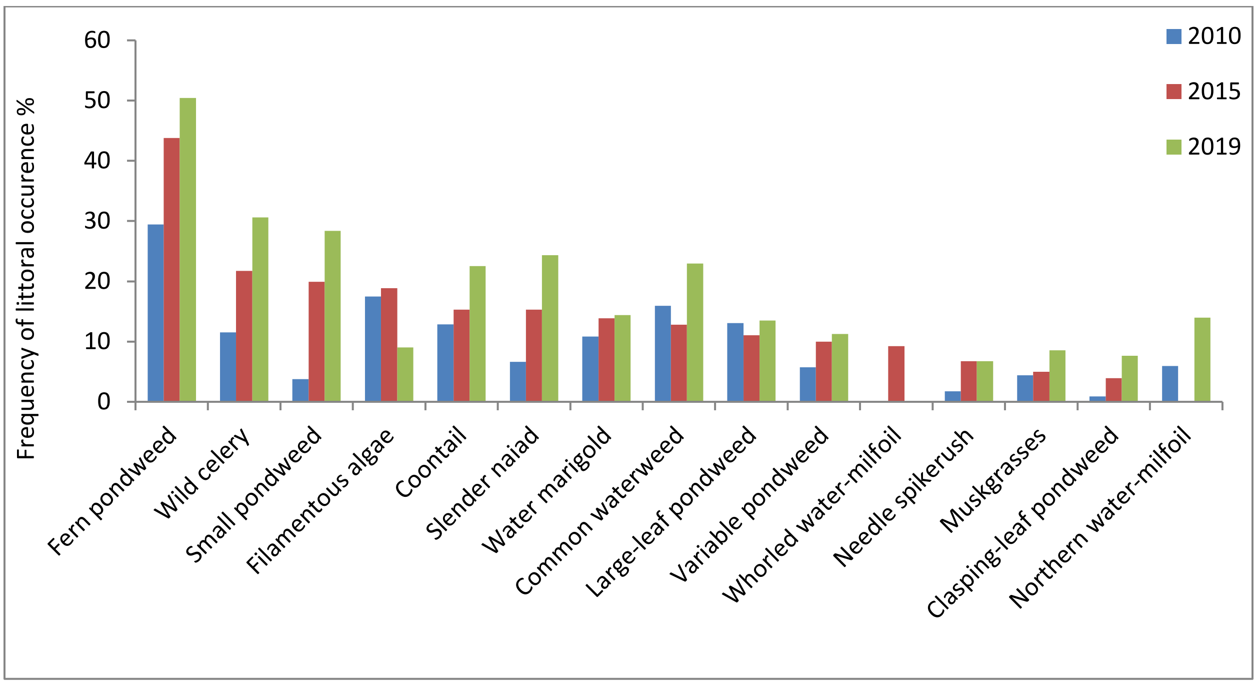
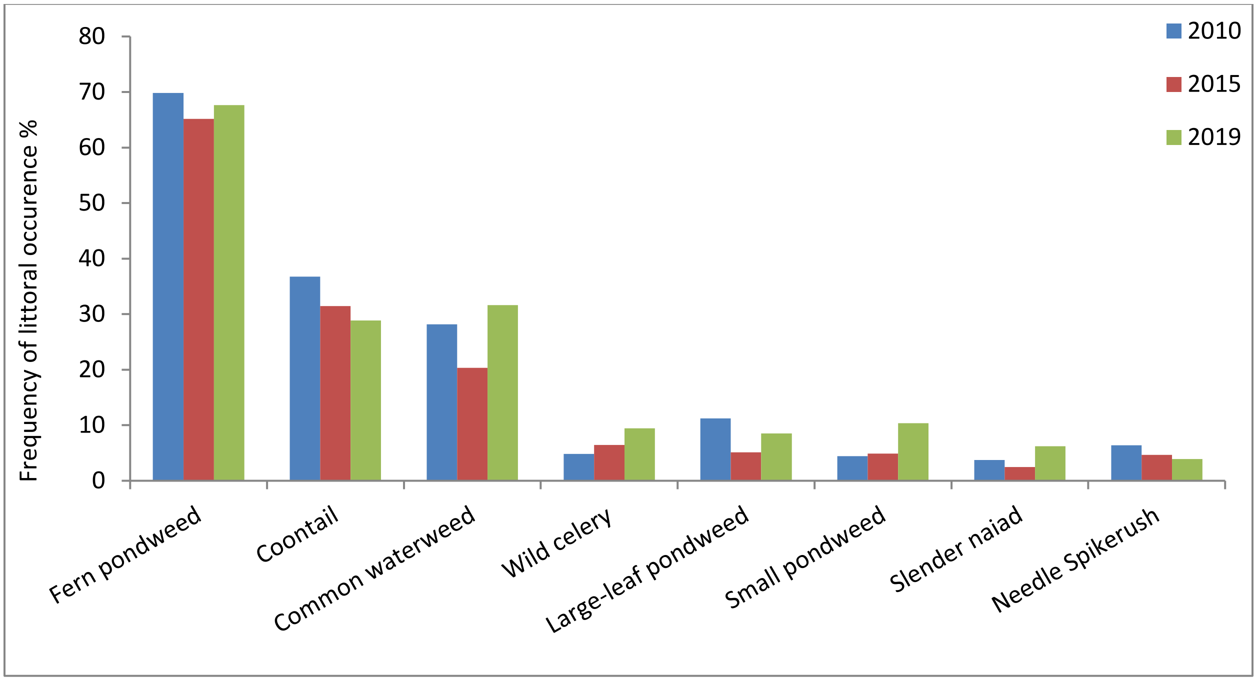


Figure 2.10: *Comparisons of littoral frequency of occurrence in Lower Buckatabon in 2010, 2015, & 2019. Only species with a 5% or greater littoral frequency of occurrence are represented.*



As mentioned above, frequency of littoral occurrence is the percentage of time a species is detected across the sampled littoral area. These values are sampling event dependent, meaning this value represents how often each plant is detected for that survey. You could not assume that 45% frequency of littoral occurrence for a particular species means that each time you sample there is a 45% chance of sampling that species. To look at the number of times a species is likely to occur (or be sampled), relative frequency of occurrence is calculated. Relative frequency of occurrence is the proportion of times that a species is sampled relative to the total population. The three most common species on Upper Buckatabon in both 2015 and 2019 based on relative frequency are fern pondweed, wild celery, and small pondweed **(Figure 2.11).** The three most common species on Lower Buckatabon in both 2015 and 2019 based on relative frequency are fern pondweed, coontail, and common waterweed **(Figure 2.12).**

Figure 2.11: *Relative frequency of occurrence of aquatic plants (~5% occurrence or greater) – Upper Buckatabon 2010, 2015 & 2019.*

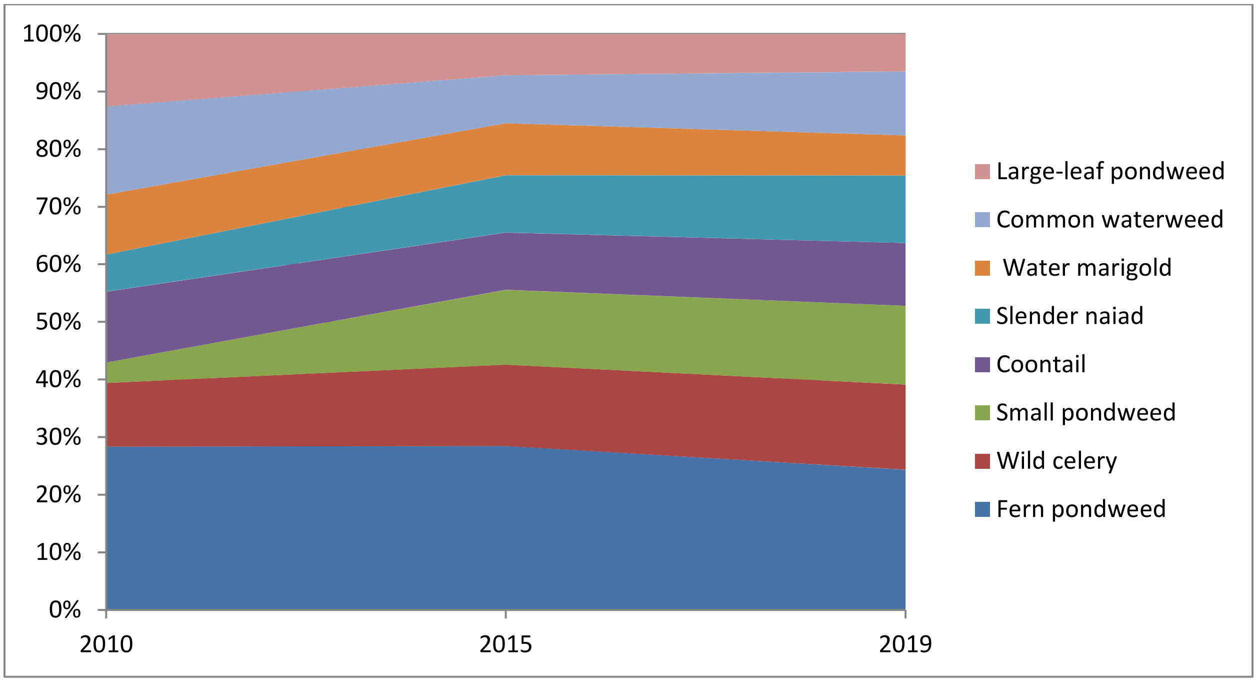


Figure 2.12: *Relative frequency of occurrence of aquatic plants (5% occurrence or greater) – Lower Buckatabon 2010, 2015, & 2019.*

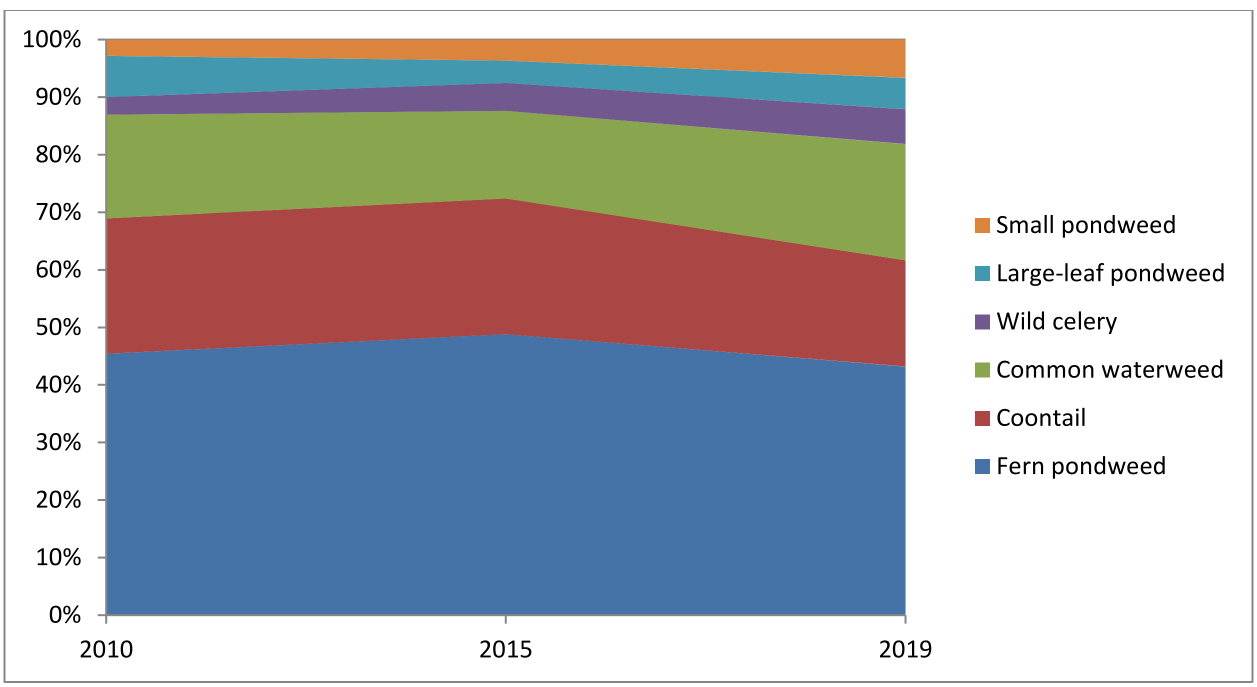


Figure 2.13 : *Upper Buckatabon Vegetation Rake Fullness, 2019.*

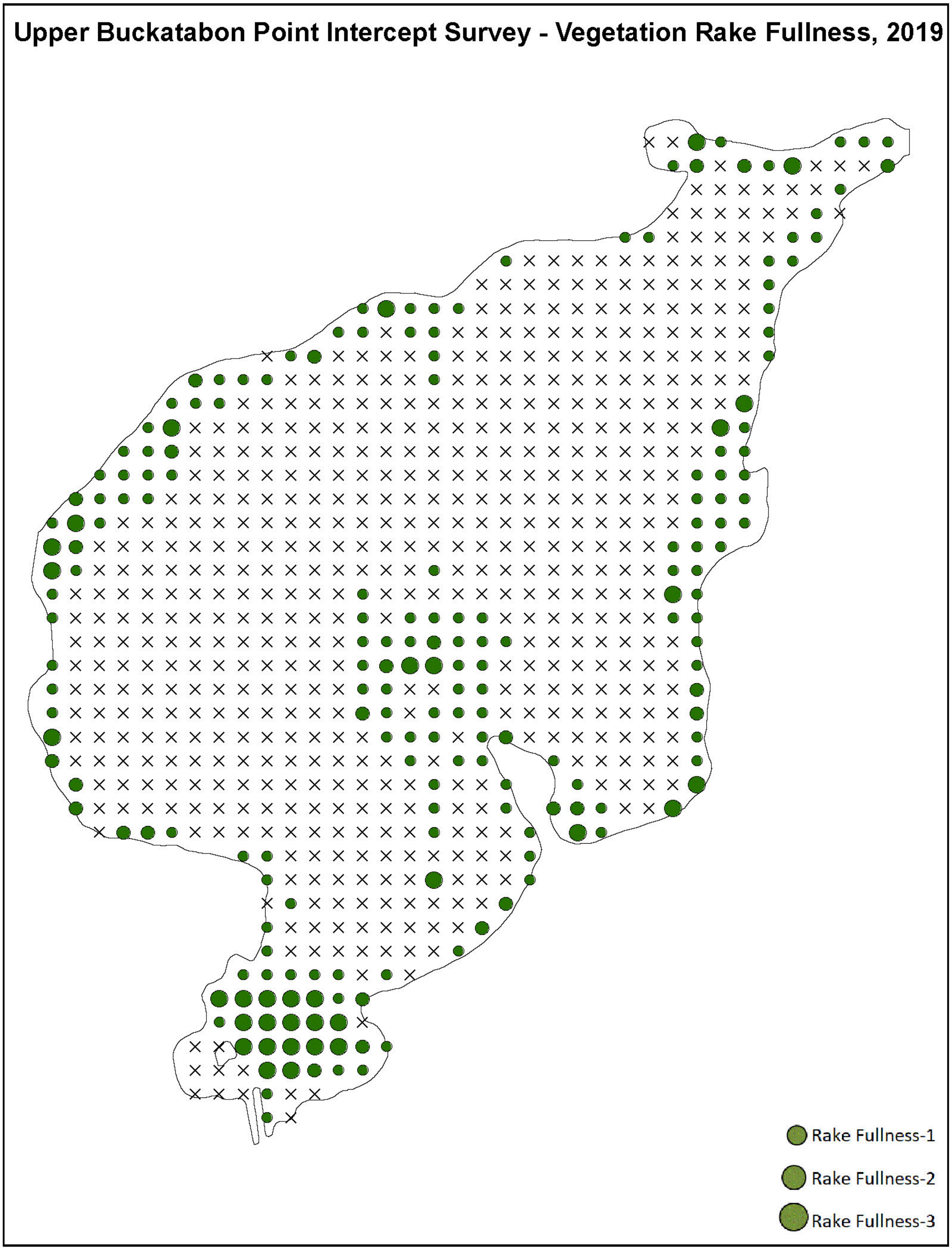


Figure 2.14 **:** *Lower Buckatabon Lake Rakefullness Map, 2019.*

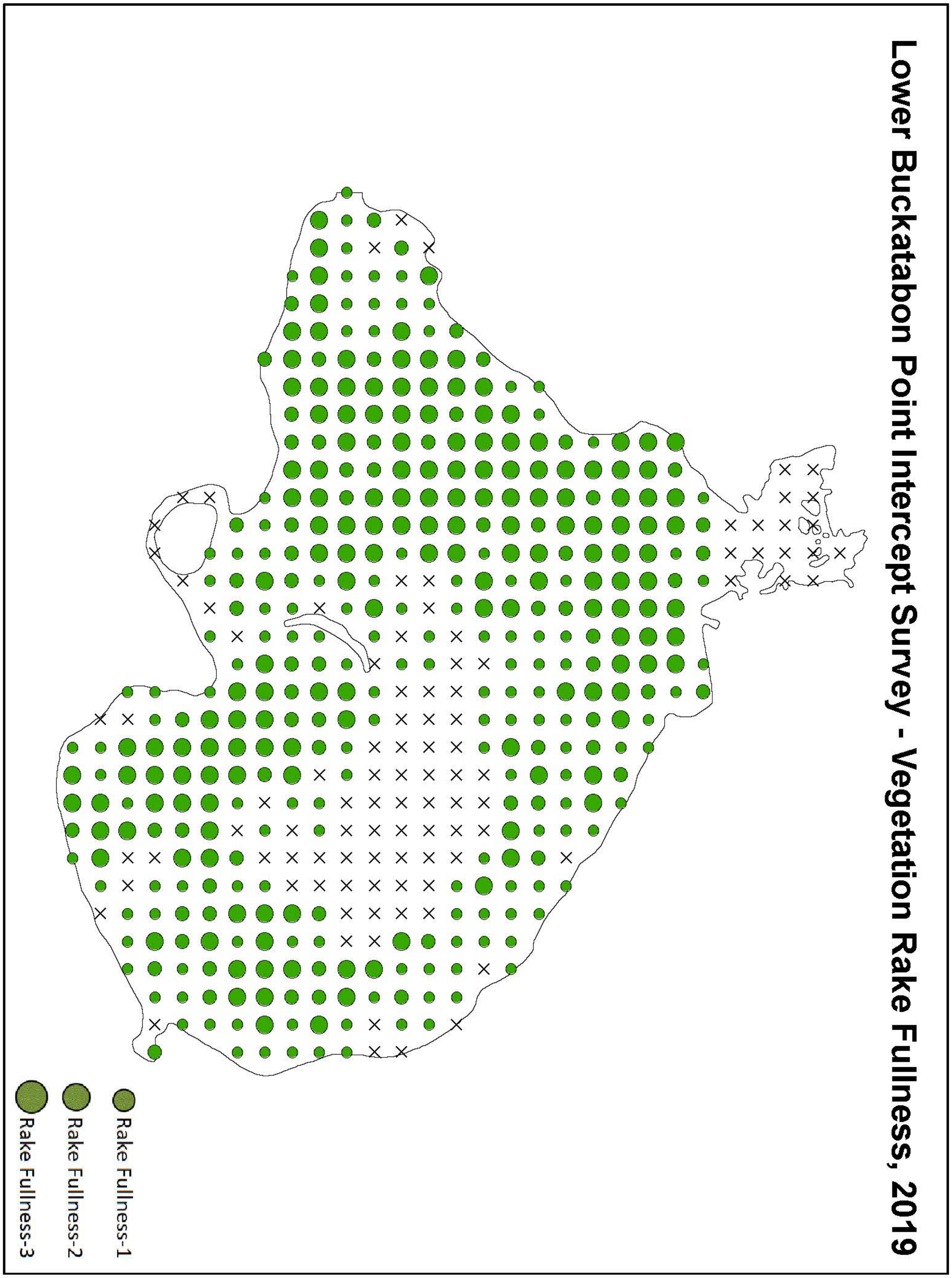


Figure 2.15 : *Upper Buckatabon Species Richness Map, 2019*

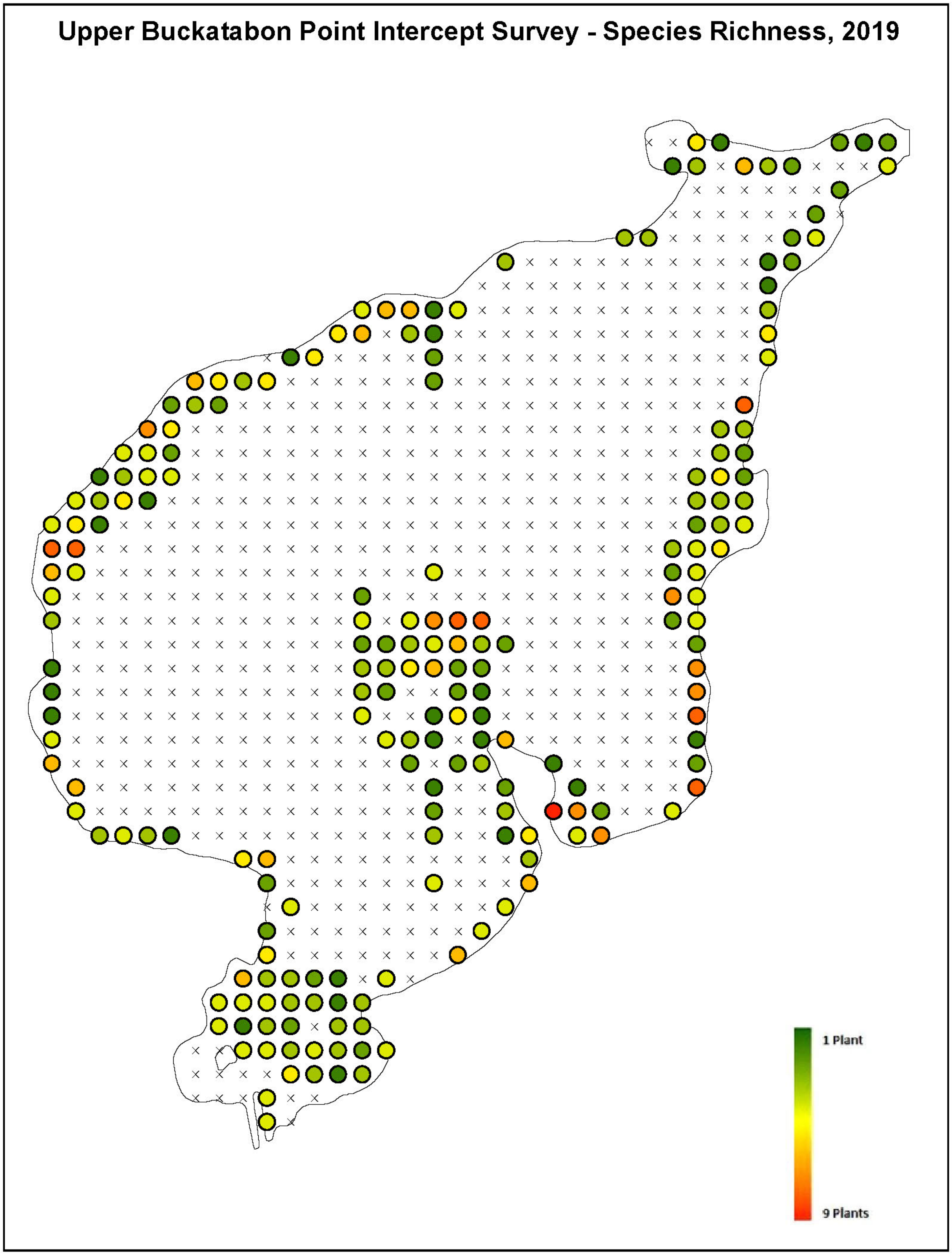
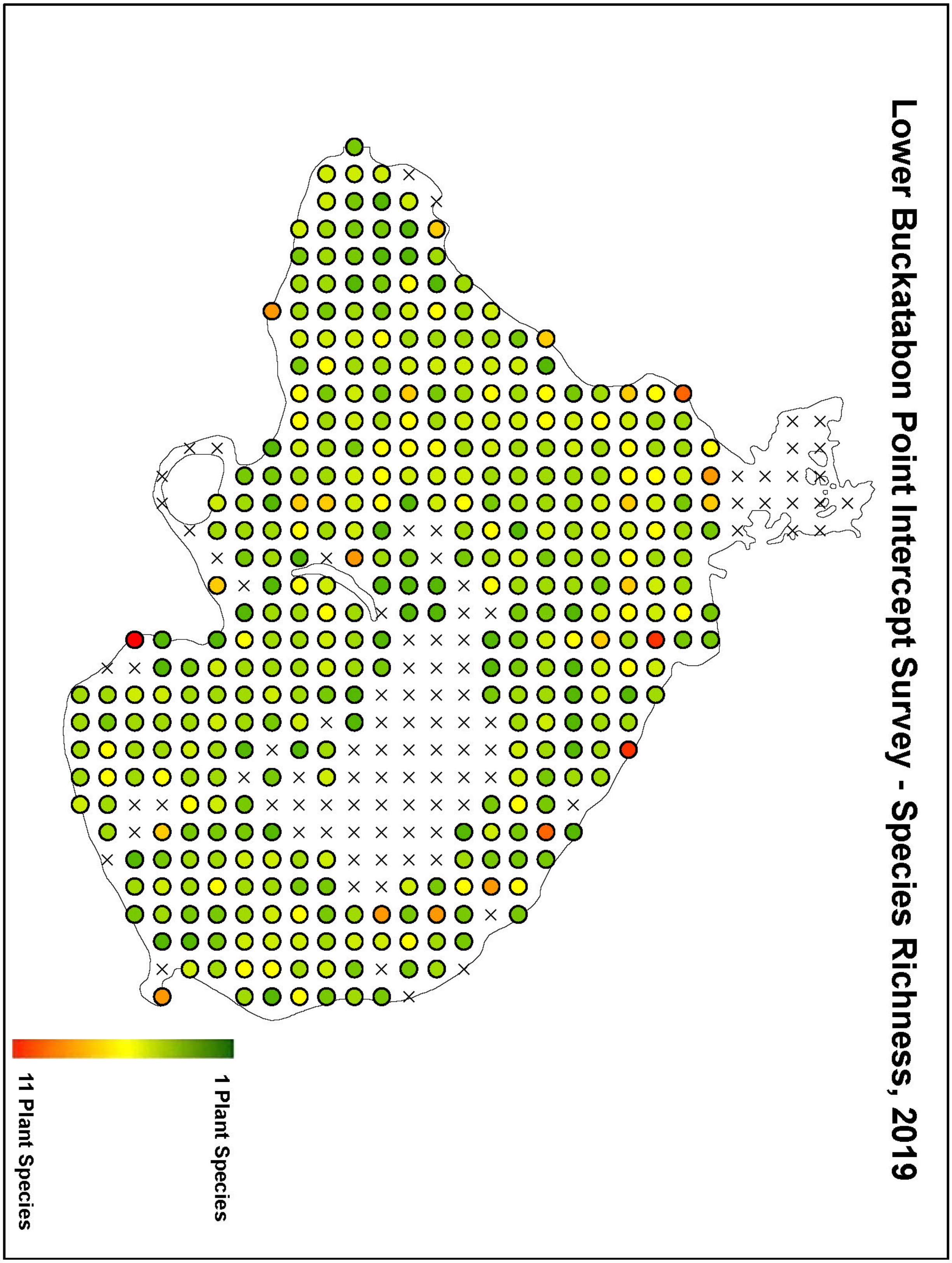


Figure 2.16: *Lower Buckatabon Species Richness Map, 2019.*



Emergent and Floating Leaf Community Mapping

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

Mapping of emergent and floating leaf plant communities on Upper Buckatabon Lake estimates 41 acres of mixed emergent and floating leaf plant beds, zero acres of emergent plant beds and 5 acres of floating leaf plant beds[9] **(Appendix C).** This represent approximately 9% of the total surface water acres. Mapping of the emergent and floating leaf plant communities on Lower Buckatabon Lake estimates 23 acres of mixed emergent and floating leaf plant beds, zero acres of emergent plant beds and 1/10 of an acre of floating leaf plant beds **(Appendix C).** This represent approximately 6% of the total surface water acres.

[9] 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.

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 Buckatabon Lakes. However, a basic understanding of their applicability is important to understand the rationale for choosing methods specific to Buckatabon Lakes.

Shoreland Protection & Restoration

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

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

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

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

Photo 7: ***Before and After:*** *Shoreline Restoration Example from the MI Natural Shoreline Partnership - Middle Lake, Oakland County, MI*

Shoreland Restoration/Protection Considerations:

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

Physical Control of Aquatic Plants

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

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.

Application Considerations for Benthic Barriers

- Best suited for small areas including regions along shorelines or creating boating lanes
- Results typically seen within a couple weeks
- Requires seasonal maintenance

- Decomposing material under the barrier may create gas bubbles that need to 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 indivdual plant free from the lake bed. However, in most cases divers will use their hands to physically remove the root of the plant from the lakebed. Suction harvesting or DASH is also a form of manual removal. Instead of a diver coming to the surface to dispose of invasive plants they hand removed, plants are hand fed into a hose and the entire plant is vacuumed from the diver's hands to the surface. Once the plants reach the surface, a series of bins or bags located on a boat collects the material. These bins/bags allow water to filter out, leaving the entire plant captured. Plants are then disposed of offsite in an upland location. This process improves efficiency allowing the diver to remain underwater for longer periods and minimizes potential for plants to fragment.

Application Considerations for Manual Removal

- Hand removal can be selective
- May minimize the need for herbicide management
- Can be effective when populations are at small scales
- There are no restrictions to water use
- Bottom substrate, under water obstacles and plant abundance affects efficiency
- Low water clarity or visibility affects efficiency
- May not be effective for lakes with very poor water clarity
- May require large economic investment
- Might not be practical for larger areas
- Labor intensive
- Volunteerism levels will vary and would mostly be appropriate for shallow waters only
- Plants can fragment when hand removed
- Check with WDNR on permit requirements

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

Application Considerations for Drawdowns

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

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

Application Considerations for Cutting and Mechanical Harvesting

- Aquatic habitats are maintained because plants are typically not harvested to the lake bottom
- There are no restrictions to water use
- Efforts are site specific, there is no risk of offsite impacts
- New technologies in harvesting are improving the ability to capture fragments
- Non-selective
- Small fish and other aquatic organisms may be accidentally harvested
- Generally an expensive approach given the size of the operation, accessibility and transport of material to disposal site
- Re-growth of harvested areas occur and may require several cuts

- Fragmentation may lead to the spread of the invasive plant when the overall footprint of the invasive plant is small
- Check with WDNR on permit requirements

Biological Control

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

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 and the Upper Peninsula of Michigan
- *Eurychiopsis* stocking costs are high because of the amount of weevils that need to be continuously stocked over several years
- *Eurychiopsis* stocking programs have been received with mixed results
- Check with WDNR on permit requirements

Chemical Control

All chemicals used to control aquatic plants in the US are approved and registered by the EPA ***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[10].

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

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

Below is a description of a few commonly used herbicides to control aquatic vegetation in Wisconsin. Further information on approved herbicides in Wisconsin can be found in the Aquatic Plant Management in Wisconsin: Strategic Analysis[11].

Diquat

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

Endothall

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

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

2, 4-D

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

Triclopyr

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

Fluridone

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

Flumioxazin

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

Imazapyr

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

Florpyrauxifen-benzyl

A relatively recent registered herbicide, florpyrauxifen-benzyl 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.

<u>General Application Considerations for Chemical Control</u>

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

Considerations for Herbicide Use

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

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

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

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

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

Management Considerations-Buckatabon Lakes

Several management techniques discussed above may be feasible on Buckatabon Lakes, however, many would not be applicable at this time including drawdowns and mechanical harvesting. Water level drawdowns would impact both lakes, even if only one lake was being targeted for management and additional water level regulations may apply with WVIC and FERC. Mechanical harvesting would be a somewhat costly operation considering the current low density. Benthic barriers would be feasible and appropriate for small-scale application. Biological control is being explored and a tentative project using weevils is scheduled to begin in 2020.

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

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

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

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

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

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

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

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

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

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

History of Eurasian Watermilfoil and Association Efforts 2015-2019

<u>2015</u>

Lake resident Dan Benson detected EWM near his property on Upper Buckatabon Lake during the summer of 2015. Upon WDNR confirmation, a point intercept survey of Upper and Lower Buckatabon Lakes occurred. This survey detected two EWM locations on Upper Buckatabon Lake and one location on Lower Buckatabon. Additional detailed EWM surveys found several small colonies of moderate density EWM on Upper Buckatabon near the initial discovery, and additional colonies along the east shore, and the southern island **(Appendix E).** These surveys detected four locations of very sparse EWM on Lower Buckatabon. Surveys mapped a total of .25 acres of EWM on Upper and Lower Buckatabon Lakes combined. The management strategy proposed for 2016 would be to dive and hand pull individual to small very sparse colonies and deploy DASH for the larger moderate density EWM colonies.

For manual removal using scuba divers, divers locate EWM plants visually from the boat and mark them with buoys before entering the water. The first diver reaches down into the substrate and slowly works the plant's roots free of the sediment. The plant is rolled up and carefully placed into an open bag held by the second diver and then closed prior to moving to the next plant. While one diver is hand pulling the second diver is watching for any fragments and collecting them in the bag. Divers inspect the general area for any remaining plants and fragments before moving to the next location.

The DASH technique typically begins with a diver locating a EWM plant from the surface. The diver then descends next to the plant while lowering the nozzle. Divers works along the bottom by using fin pivots, kneeling on the bottom or hovering above the bottom at a distance where the root mass of the plant is within reach. Divers either feed the top of the plant into the hose first and then uproot the plant or uproot the plant and feed the root wad first into the hose. Once plants reach the surface, a hose dispenses the plant material into a series of screened bins located on the deck of the boat. These bins capture plants and allow water to drain out back into the lake. Plants are placed in sealed bags or other containers for transport to the dumping site. The dumping site is pre-determined site upland, away from any water body.

The discovery of Eurasian watermilfoil in 2015, initiated efforts by lake riparians to organize and formalize a lake association. The Buckatabon Lakes Association, Inc. rapidly began to support work to minimize the ecological and recreational impacts that EWM and other aquatic invasive species may pose to Buckatabon Lakes. This organization began to apply for and receive WDNR funding to aid monitoring, management and prevention activities beginning in 2015.

2016

Eurasian watermilfoil continued to be present at the initial discovery site on Upper Buckatabon and management efforts reduced the population along the east shore and locations around the islands. No EWM was detected on Lower Buckatabon after seasonal diving efforts. Surveys mapped a total of .43 acres of EWM total on Upper and Lower Buckatabon Lakes combined. Dive efforts removed approximately 593 EWM plants from Upper and Lower Buckatabon. DASH efforts removed 521 pounds of EWM from Upper Buckatabon.

The BLA's membership continued to grow and secured membership renewals from 115 families and businesses. At the end of 2016, seven new letters updating membership on BLA activities were sent to membership. New educational signs were placed at the boat launch and special buoys that helped keep boat traffic away from the densest EWM areas on the lake were deployed. Educational efforts included training 52 adults and 45 Camp Rama campers to conduct Clean Boats Clean Waters water craft education and inspections. The BLA reported over 200 volunteer boat landing inspection hours. Nine volunteers were trained on EWM identification and snorkel pulling EWM and two additional volunteers were trained on how to collected water samples to monitor water quality.

2017

Several newly detected EWM colonies on Upper Buckatabon in 2017 include areas along the far southeast shore and north of the entrance to the springs. The majority of EWM located on Upper Buckatabon Lake remained within the region of the initial discovery in 2015. A single location at the entrance to the dam on Lower Buckatabon remained at the end of the 2017 season. Surveys mapped a total of .93 acres of EWM total on Upper and Lower Buckatabon Lakes combined. Dive efforts removed approximately 587 EWM plants from Upper and Lower Buckatabon. DASH efforts removed 403 pounds of EWM from Upper Buckatabon.

2018

A notable expansion of EWM occurred on Upper Buckatabon Lake to date and included many new regions across the lake. Most sites consisted of single plants to small very sparse to sparse clusters; however, several moderate to moderate-dense colonies were documented. The majority of expansion occurred along the eastern and southeast shore. One location of EWM found during evaluation efforts occurred on Lower Buckatabon at the end of the season. Surveys mapped a total of 3.17 acres of EWM total on Upper and Lower Buckatabon Lakes combined. Dive efforts removed 136 EWM plants on Upper and Lower Buckatabon. DASH efforts removed 788 pounds of EWM from Upper Buckatabon Lake.

2019

The largest single year increase in abundance and extent of EWM occurred on Upper and Lower Buckatabon Lakes. Roughly, half of the documented acreage on Upper Buckatabon fit the moderate to moderate-dense abundance estimates and many new small sparse clusters of plants on Lower Buckatabon were documented mainly along the western end. Given the expansion, management strategies included pulling all known locations on Lower Buckatabon, given these are fairly small and the population of EWM is relatively low. Management strategies on Upper Buckatabon focused on reducing lake-wide foot print by targeting regions of the lake that have relatively little EWM rather than spending all resources dedicated in a single site of higher density EWM. Dive efforts removed a total 267 plants from Upper and Lower Buckatabon Lakes.

Figure 3.1: *Change in EWM acreage (point based and polygon based mapping combined) categorized by estimated abundance 2015-2019 – Upper and Lower Buckatabon Lakes combined.*

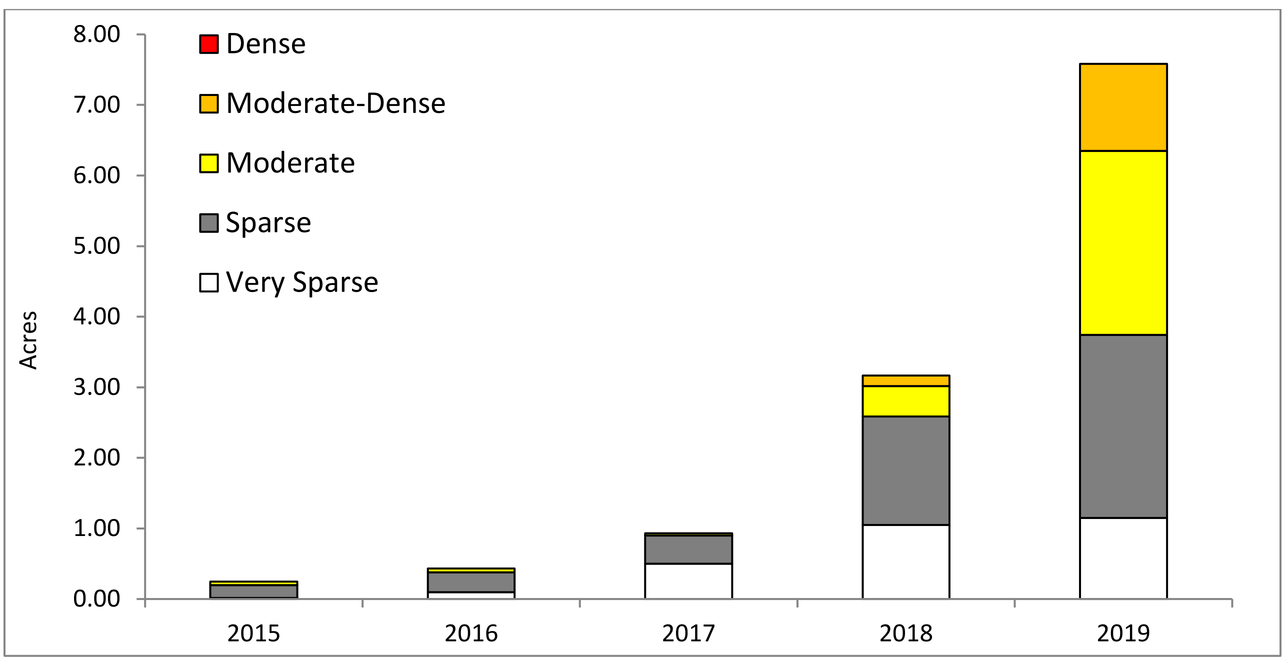


Table 3.1: *Change in EWM* *<u>acreage</u>* *(point based and polygon based mapping combined) categorized by estimated abundance 2015-2019 – Upper and Lower Buckatabon Lakes combined.*

EWM Abundance Estimate	2015	2016	2017	2018	2019
Very Sparse	0.02	0.10	0.50	1.05	1.15
Sparse	0.18	0.28	0.40	1.54	2.60
Moderate	0.05	0.05	0.03	0.43	2.61
Moderate-Dense	0.00	0.00	0.00	0.15	1.23
Dense	0.00	0.00	0.00	0.00	0.00
TOTALS (acres)	**0.25**	**0.43**	**0.93**	**3.17**	**7.58**

4- Shoreland Assessments

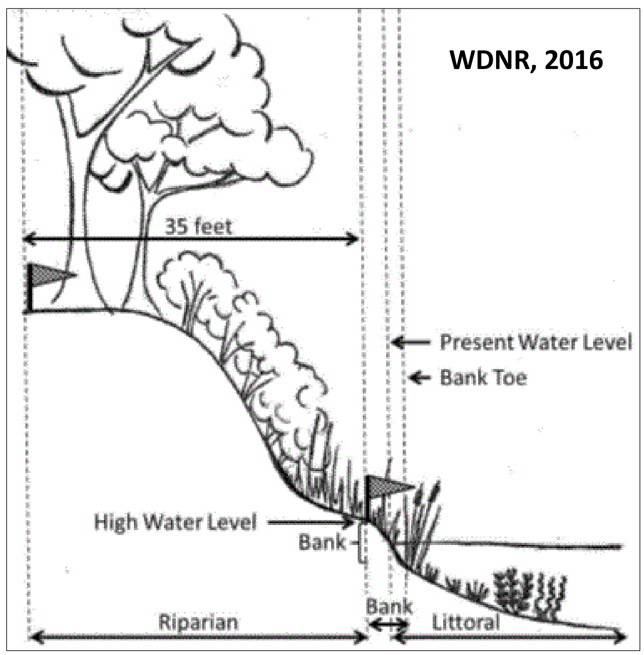
Shoreland Habitat Overview

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

Shoreland Survey Methods

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

Figure 4.1: *Lakeshore habitat area definitions.*



This protocol emphasizes habitat features key to lake health and focus on the riparian buffer, bank, and littoral zones **(Figure 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 individual parcels. In cases where multiple parcels are owned by the same entity, one assessment was conducted for each parcel separately. Parcels with condominiums were assessed as one parcel, even though there might be several owners. Spatial data for the Wisconsin parcels boundaries was obtained from the Vilas County Land Information Office.

Riparian features documented include:

- Percent vegetation coverage
- Impervious surface coverage
- Listing and description of human structures
- Run off concerns
- Evidence of point[12] 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.[13] 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 regions on Buckatabon Lakes support little to no natural vegetation, but do allow water to infiltrate.

Most assessed properties had a canopy (tree) layer, shrub, and herbaceous layer **(Figures 4.2 & 4.3).** Thirty-seven percent of assessed properties on Upper Buckatabon Lake and fifty-eight percent of assessed properties on Lower Buckatabon have some degree of manicured lawns. Sixty-six percent of assessed properties on Upper Buckatabon had impervious surfaces covering

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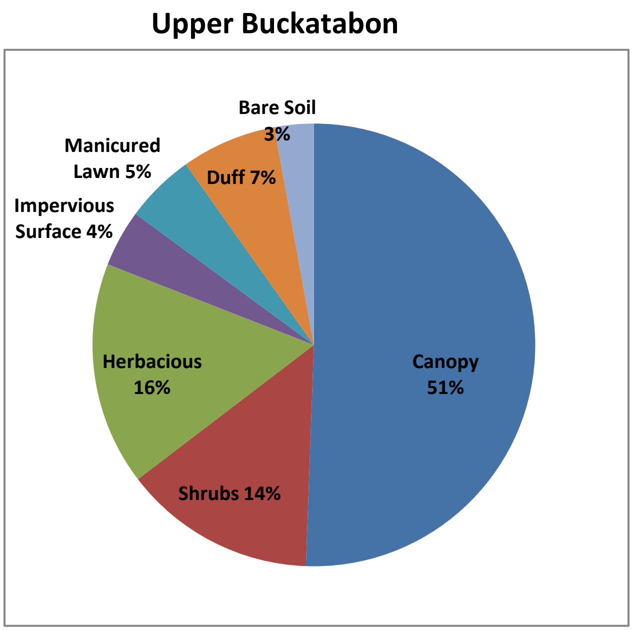
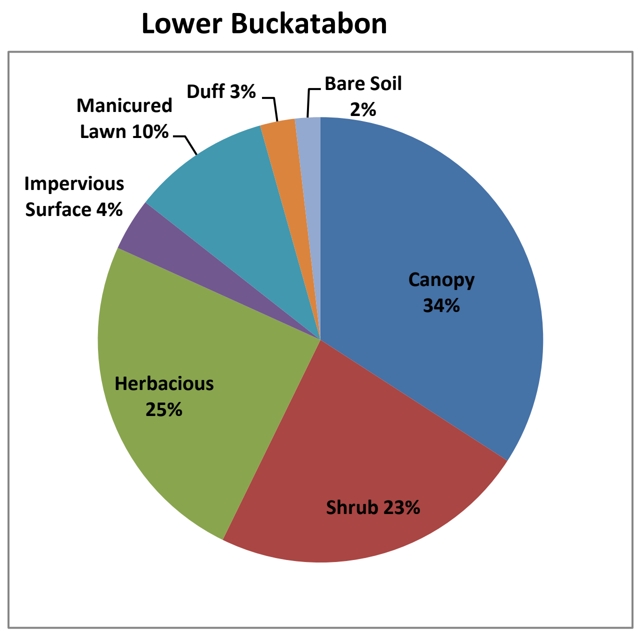
[12] Point source runoff or pollution is identified by a definable source, such as a pipe

[13] Coarse woody debris assessment took place in the middle of October 2019, once most piers had been removed from the water.

6% of the total riparian buffer. Whereas sixty-two percent of assessed properties on Lower Buckatabon had observed impervious surfaces covering 9.25% of the total riparian buffer. Compacted soils, mainly from pathways to the lake account for the majority of the impervious surfaces observed. Other observed riparian coverage features included bare soils, landscape mulch, and beaches.

Figures 4.2 & 4.3: *Breakdown of total riparian buffer by riparian coverage type, Upper and Lower Buckatabon – 2019.*





Sloping soils followed by trails or pathways to the lake represented the highest observed potential runoff issues recorded. Bare soils account for a higher degree of potential runoff observed on Upper Buckatabon versus Lower Buckatabon. Many of the bare soils observed on Upper Buckatabon were associated with other runoff concerns including exposed tree roots and steep sandy sloping riparian zones. These steep landscape features are not as prevalent on Lower Buckatabon. Other runoff issues include high traffic areas, beaches, and lawn fertilization (**Figures 4.4 & 4.5**).

Figure 4.4: *Percent of total properties contributing runoff to the lake by runoff type, Upper Buckatabon – 2019.*

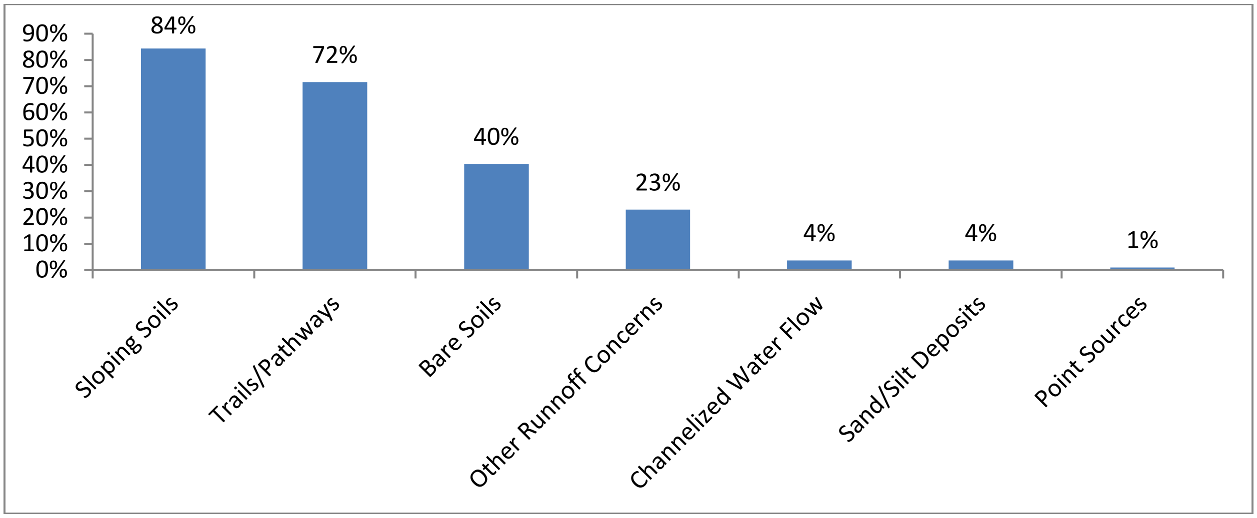
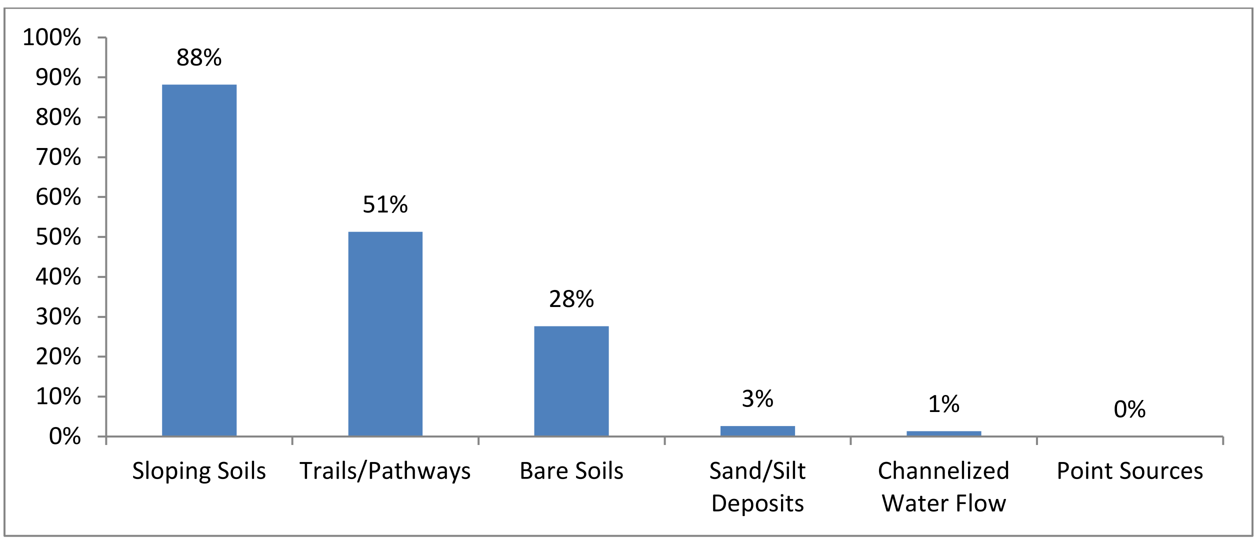


Figure 4.5: *Percent of total properties contributing runoff to the lake by runoff type, Lower Buckatabon – 2019.*



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 rip-rap, observed on 15% of the total Upper Buckatabon properties and 34% of the total Lower Buckatabon properties **(Figures 4.6 & 4.7).** Average length of rip-rap on Upper Buckatabon is 80 feet whereas average length of rip-rap on Lower Buckatabon is 74 feet. Of those properties that had rip-rap, roughly 6% had these features across the entire length of the property on Upper Buckatabon and 28% had this feature across the entire length of their property on Lower Buckatabon. Other observed bank zone modifications included the use of cement blocks, logs and randomly placed large rocks. Erosion greater than one foot in height was observed on 17% of Upper Buckatabon properties with an average length of 11 feet of shoreline. Erosion less than one foot in height was observed on 12% of Upper Buckatabon properties with an average length of 10 feet of shoreline **(Figure 4.8).** Roughly, a quarter of the observed erosion appears to be the result of ice scouring. Erosion greater than one foot in height was observed on 4% of Lower Buckatabon properties with an average length of 8 feet of shoreline. Erosion less than one foot in height was observed on 5% of Lower Buckatabon properties with an average length of 6.25 feet **(Figure 4.9).**

Figure 4.6: *Percent of properties with observed erosion and bank zone modifications by type – Upper Buckatabon, 2019.*

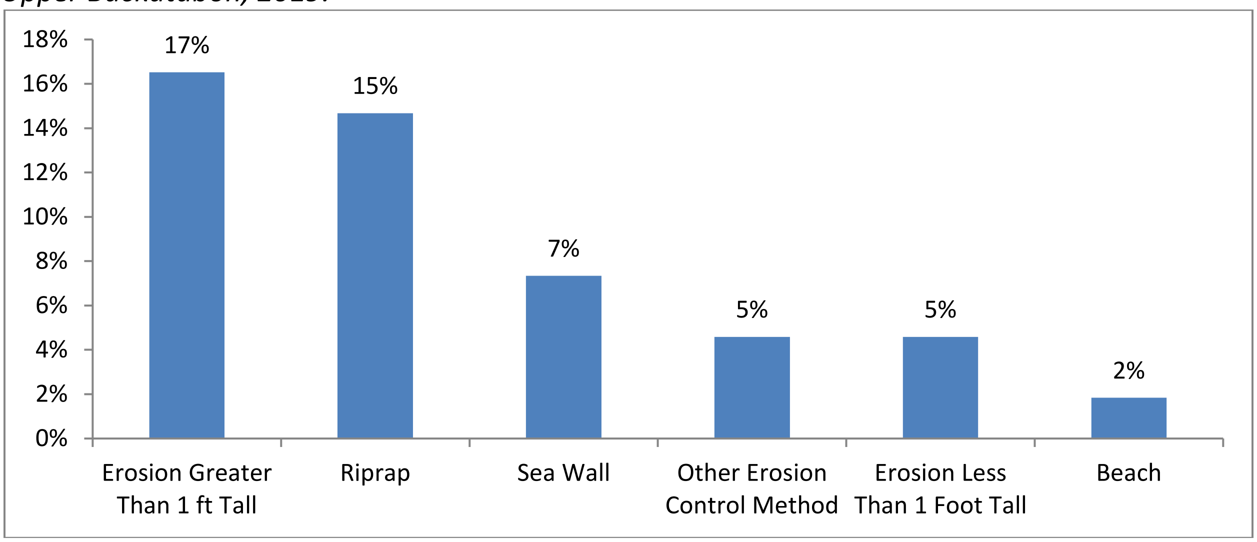


Figure 4.7: *Percent of the entire Upper Buckatabon's bank zone with observed erosion and bank zone modification by type, 2019.*

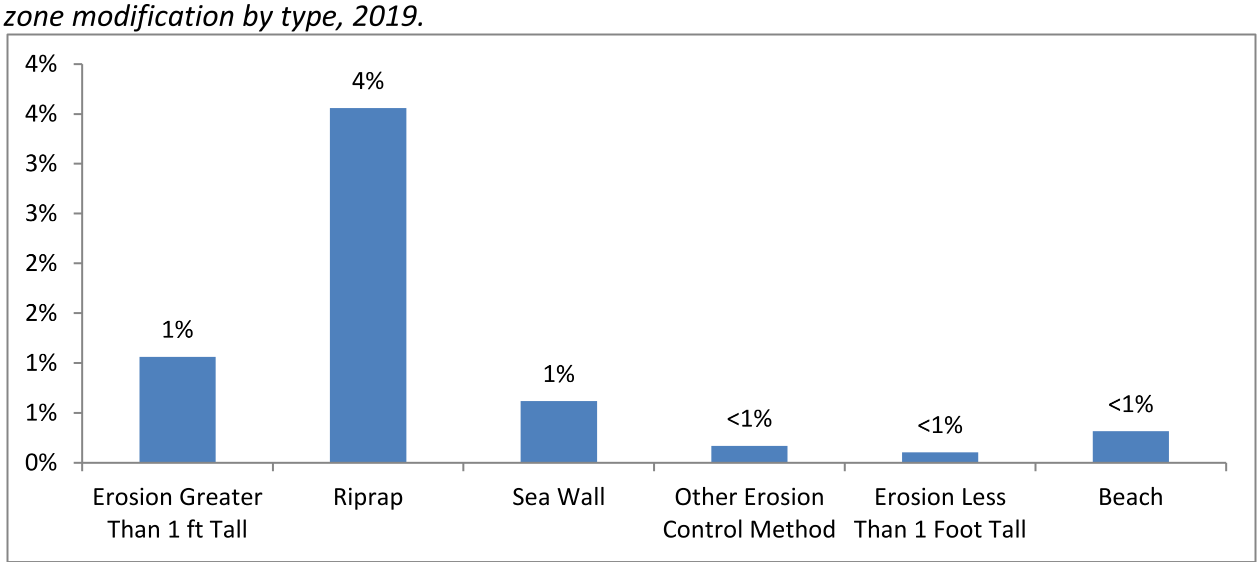


Figure 4.8: *Percent of properties with observed erosion and bank zone modifications by type – Lower Buckatabon, 2019.*

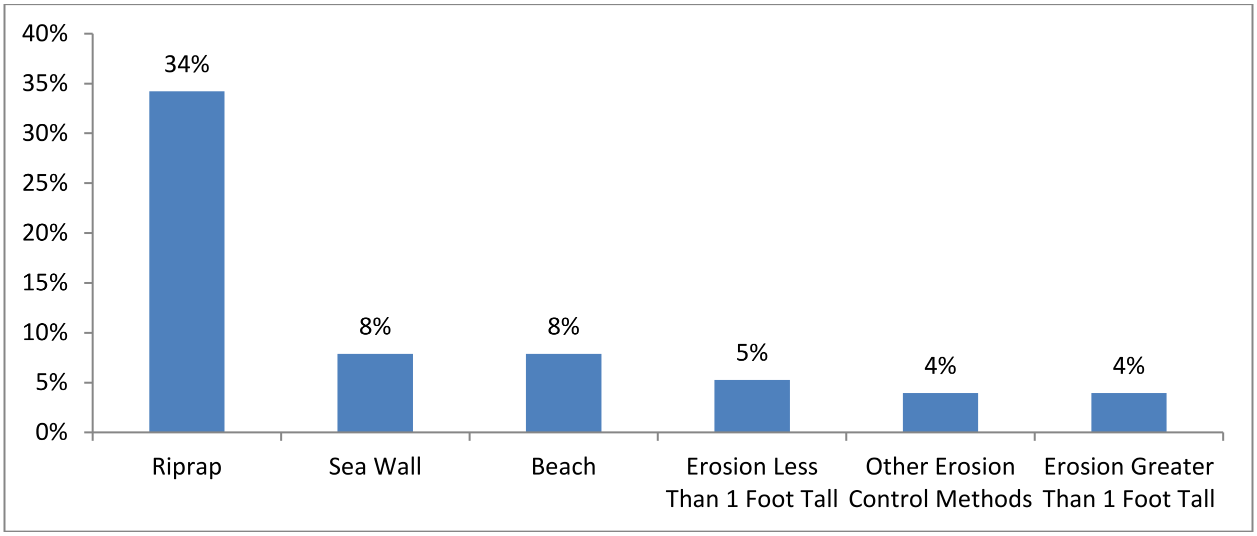
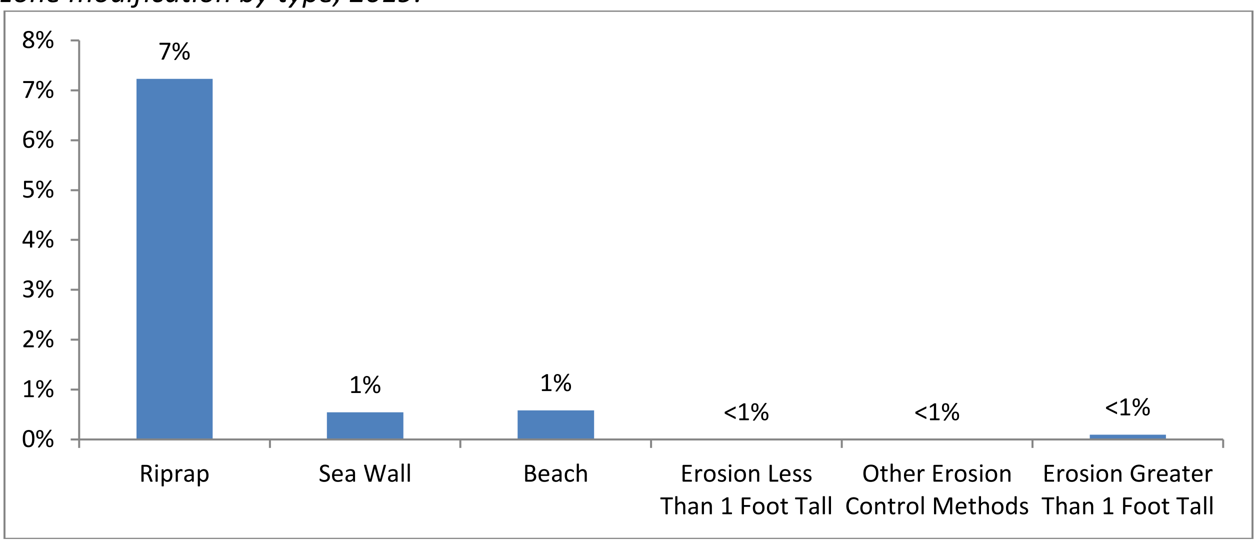


Figure 4.9: *Percent of the entire Lower Buckatabon's bank zone with observed erosion and bank zone modification by type, 2019.*



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. Seventy-eight percent of parcels on Upper Buckatabon and eighty-three percent of the parcels on Lower Buckatabon had piers **(Figures 4.10 & 4.11).** Of properties that had piers, Upper Buckatabon averaged 1.46 piers per property, whereas Lower Buckatabon averaged 1.82 piers per property. Emergent leaf and floating leaf aquatic vegetation was observed along 40% and 32% of parcels respectfully for Upper

Buckatabon. Whereas emergent and floating leaf aquatic vegetation was observed along 32% and 21% of parcels respectfully for Lower Buckatabon. Emergent and floating leaf plant removal was observed on 10% of Upper Buckatabon parcels and 14% of Lower Buckatabon parcels **(Figures 4.12 & 4.13).**

Figure 4.10*: Percent of properties with observed littoral zone features – Upper Buckatabon, 2019.*

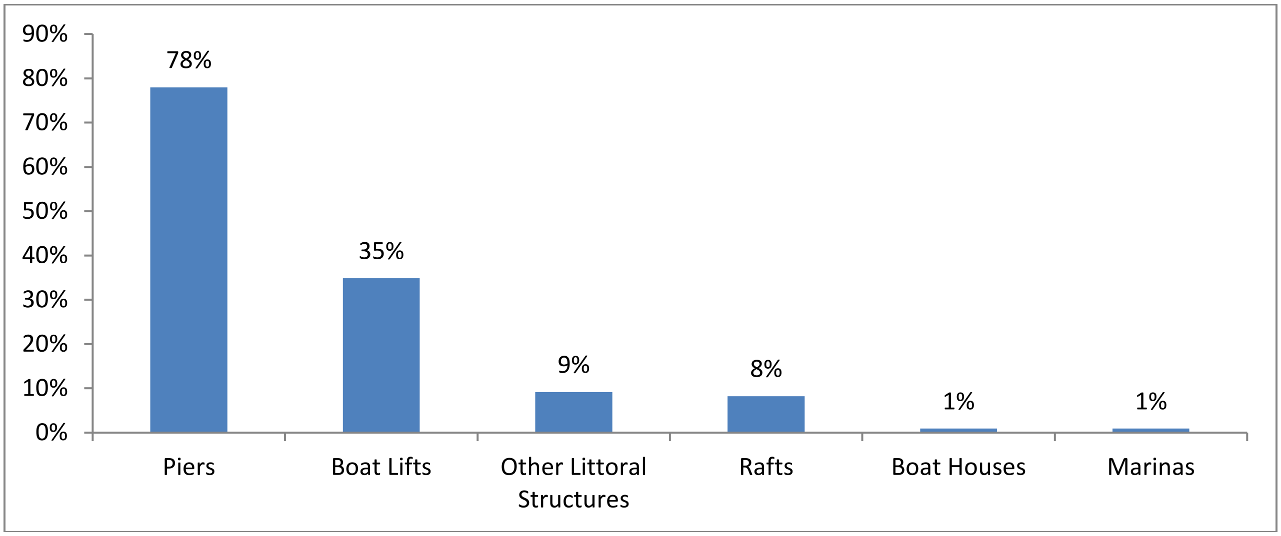


Figure 4.11: *Percent of properties with observed littoral zone features – Lower Buckatabon, 2019.*

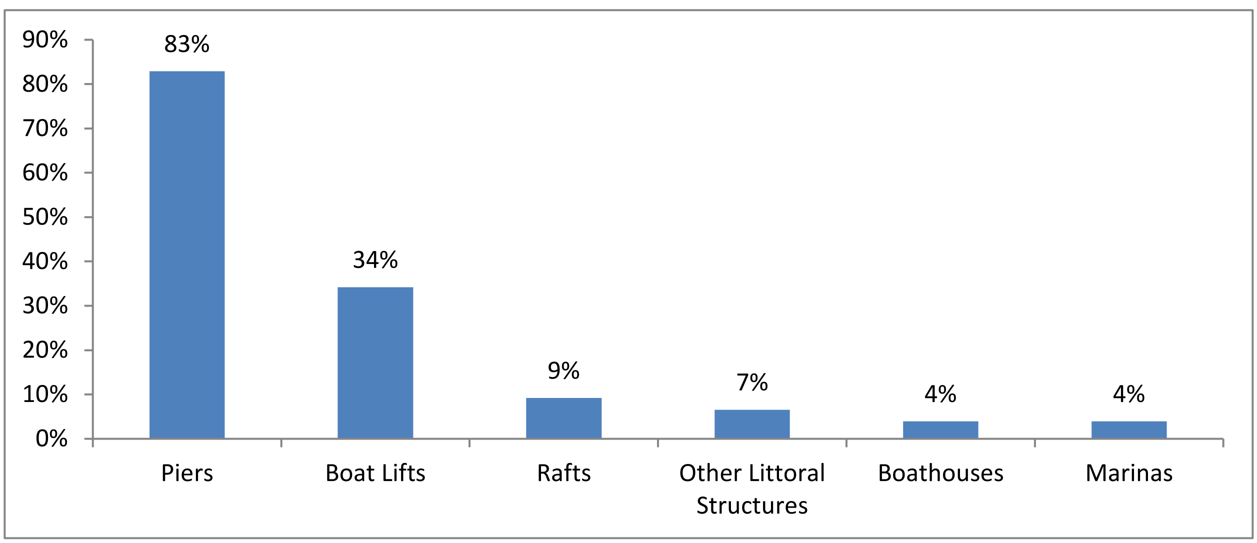


Figure 4.12: Percent of properties with emergent and floating leaf vegetation– Upper Buckatabon, 2019.

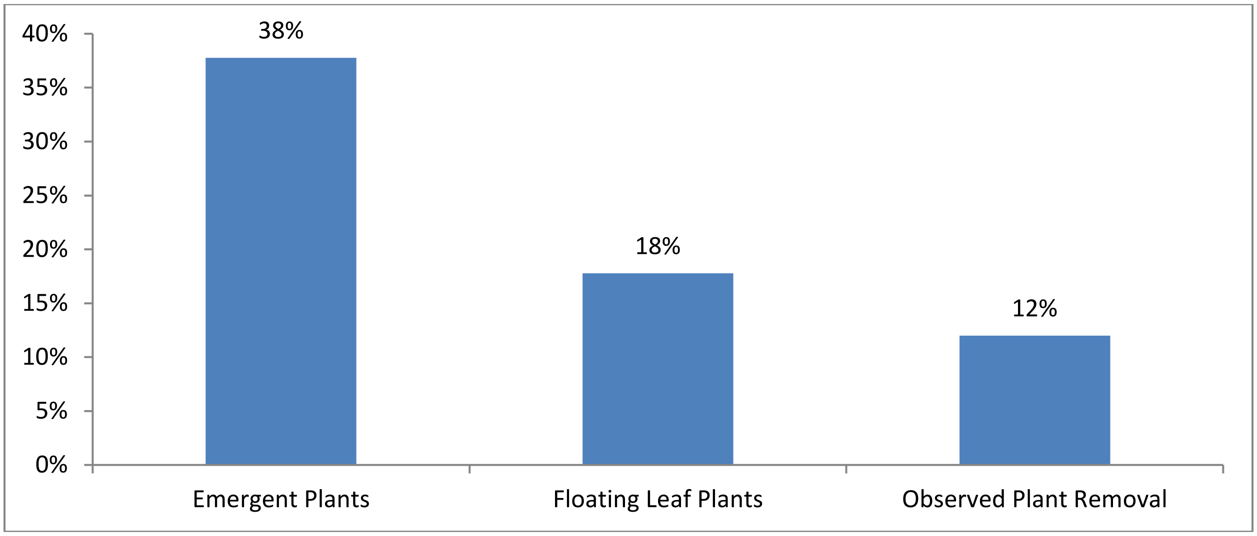
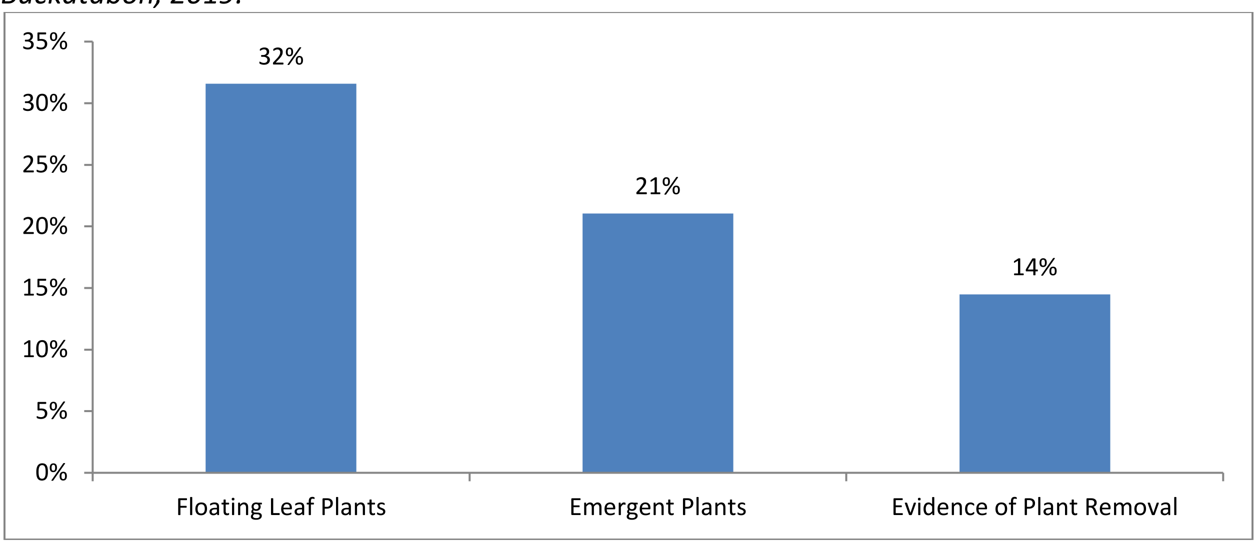


Figure 4.13: Percent of properties with emergent and floating leaf vegetation – Lower Buckatabon, 2019.



Coarse Woody Debris – Results

Seven hundred and thirty-nine (739) pieces of wood that fit the pre-determined categories were recorded on Upper Buckatabon[14]. Eighty-one percent of wood observed did not have any branches, followed by 15% with few branches and 4% had full crowns **(Figure 4.14).** Thirty-three percent of the wood observed crossed the observed high water level whereas 67% did not. Seventy-four percent of the wood had at least five feet currently underwater, whereas the remaining 26% had less than five feet underwater.

[14] The Springs not included in the assessment.

Four hundred and thirty-seven (437) pieces of wood that fit the pre-determined categories were recorded on Lower Buckatabon. Seventy-three percent of wood observed did not have any branches, followed by 22% with few branches and 5% had full crowns **(Figure 4.15).** Thirty percent of the wood observed crossed the observed high water level whereas 70% did not. Eighty percent of the wood had at least five feet currently underwater, whereas the remaining 20% had less than five feet underwater.

Figure 4.14: *Percent of coarse wood debris by branching type – Upper Buckatabon, 2019.*

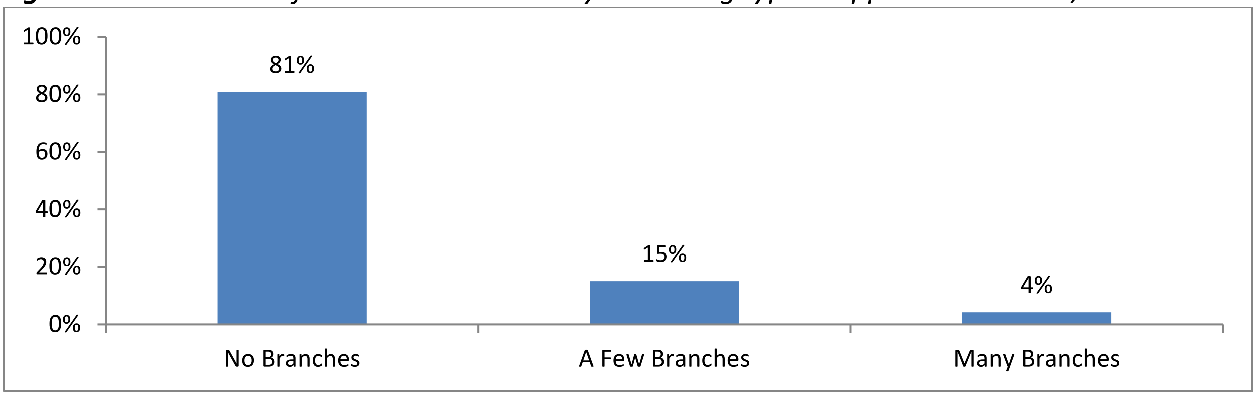
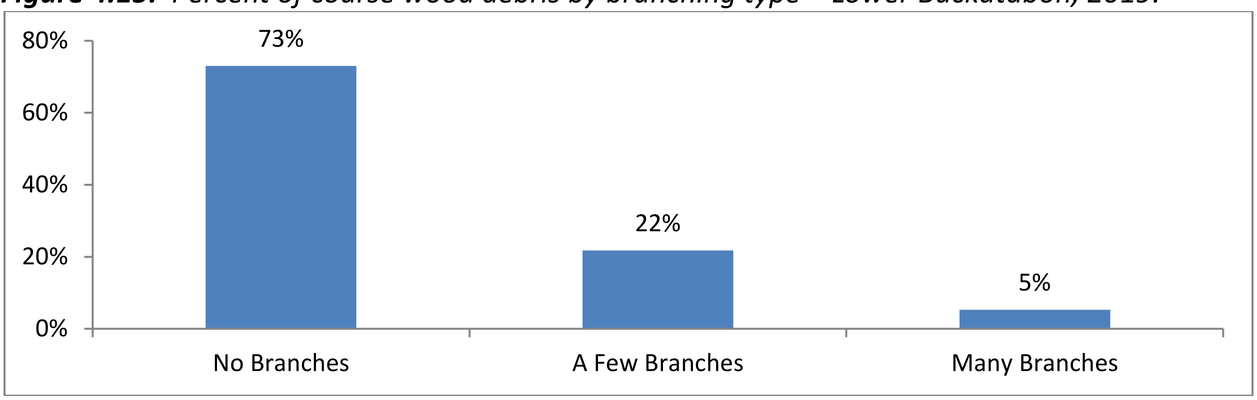


Figure 4.15: *Percent of coarse wood debris by branching type – Lower Buckatabon, 2019.*



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 continues to increase. The WDNR estimates that from 1965 to 1995 alone, Wisconsin shoreland building increased on average by 216%.[15] Like many Northern Wisconsin shoreline development continues to expand on Upper and Lower Buckatabon, following patterns of shoreline development seen across the local landscape.

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

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 five 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.[16] While this comparison is somewhat generalized, it illustrates the potential impact that lake-lot development can have on water quality.

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.[17]

These shoreland assessments provide a wealth of information useful in educating lake residents on the importance of shoreland habitat protection and improvement. In addition, some of this information can be useful when looking at the quality and function of a lake's natural habitat. For example, does pier density or the removal of coarse woody debris affect certain lake organisms? Work completed by the Minnesota DNR found 10 piers per kilometer (or 6.25 piers per mile) of shoreline resulted in substantial shoreline disturbances that negatively affected habitat function and fish communities (Jacobson, 2016). Other work suggests shoreline disturbances began to disrupt habitat function at five 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

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

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

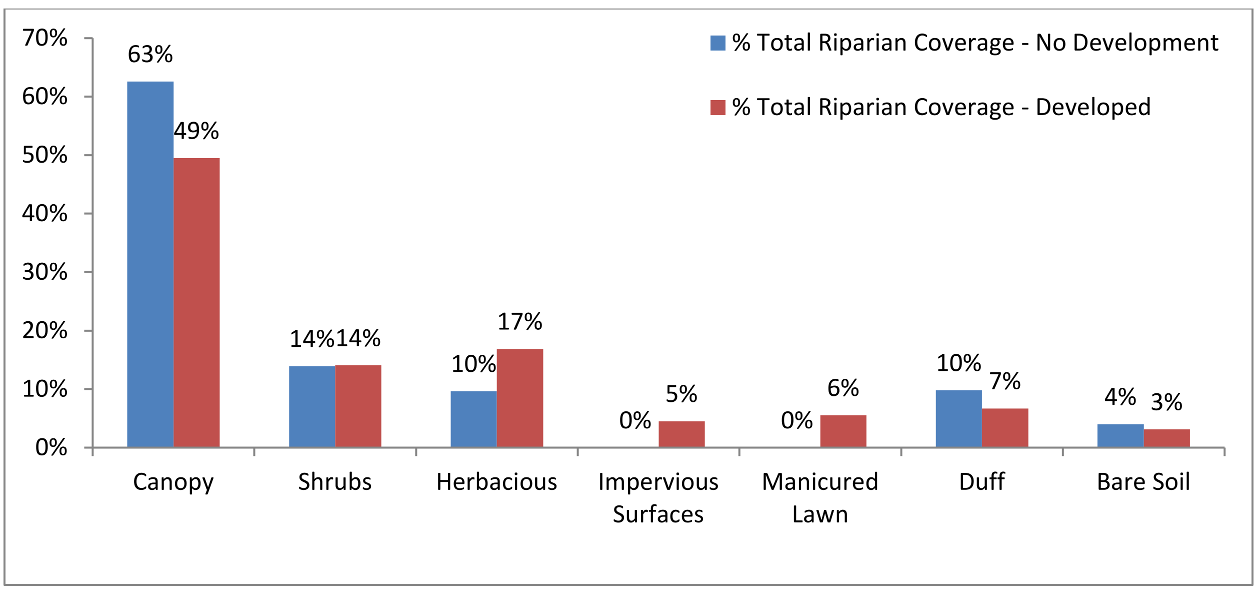
intricate relationships between fish and other aquatic organisms, and the links between lake organisms and nearshore habitat.

Shoreland Habitat Considerations for Upper and Lower Buckatabon

The adjacent riparian parcels to Upper and Lower Buckatabon Lakes encompass approximately 800 acres of land, which are mainly in private ownership. Roughly, 95% of the total parcels (public and private) on Upper Buckatabon, exhibited some degree of human influence, ranging from just a pier or small footpath to highly manipulated shoreland areas. No development was observed on the remaining 5% of parcels. Roughly 70% of the total parcels (public and private) on Lower Buckatabon exhibited some degree of human influence, where 30% were considered undeveloped. Most non-developed properties are in public ownership along the far north end of Lower Buckatabon.

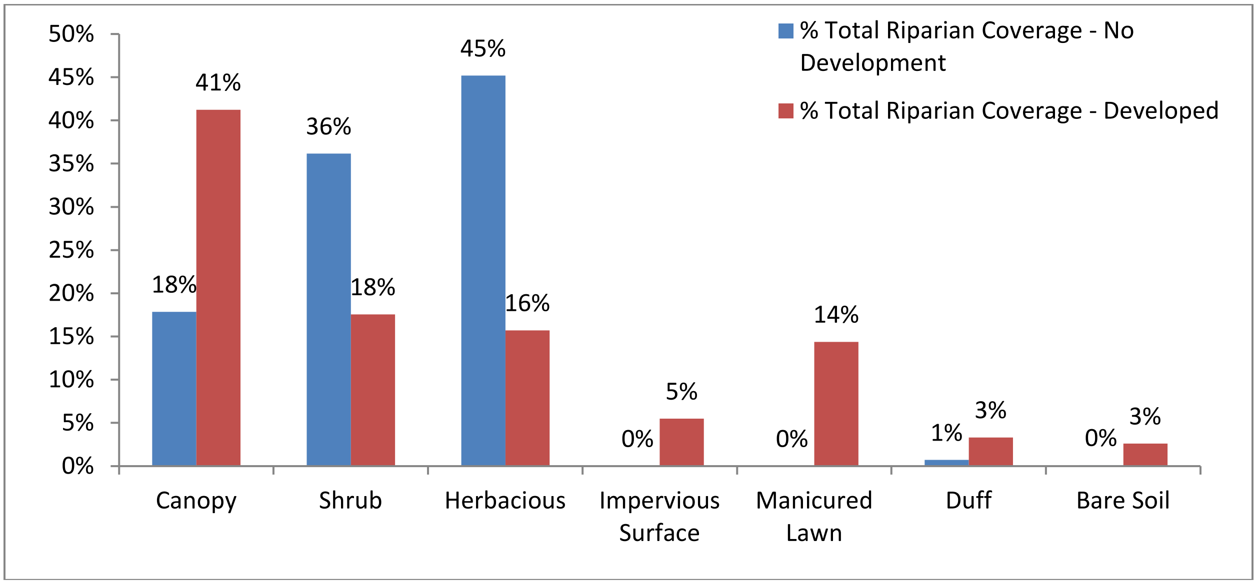
Tree canopy coverage on Upper Buckatabon averaged 49% on developed parcels versus 63% on undeveloped parcels **(Figure 4.16).** Herbaceous cover was higher on developed parcels versus undeveloped parcels, whereas no difference in shrub cover between developed and non-developed parcels was detected.

Figure 4.16: *Comparison of average riparian coverage of undeveloped and developed parcels – Upper Buckatabon, 2019.*



Tree canopy coverage on Lower Buckatabon averaged 41% on developed parcels versus 18% on undeveloped parcels **(Figure 4.17).** This is most likely due to undeveloped parcels being wetland complexes that naturally do not contain a canopy cover as defined by the survey protocol. Shrub and herbaceous cover were higher on developed parcels versus undeveloped parcels.

Figure 4.17: ***Comparison of average riparian coverage of undeveloped and developed parcels – Lower Buckatabon, 2019.***



On Upper Buckatabon, bank zone soil erosion greater than one foot tall was observed more often on undeveloped properties than on developed properties, whereas bank zone erosion less than one foot in height was observed more often on developed properties than undeveloped properties **(Figure 4.18).** On lower Buckatabon, observed erosion generally occurred more on undeveloped parcels versus developed parcels. **(Figure 4.19).** Development did not alter the presence of aquatic emergent plants and floating leaf plants on Upper Buckatabon, but all evidence of plant removal occurred on developed parcels. Developed parcels on Lower Buckatabon generally had fewer emergent and floating leaf plants compared to undeveloped parcels, and again all evidence of plant removal occurred on developed parcels.

Figure 4.18: *Comparison of bank zone features of undeveloped and developed parcels – Upper Buckatabon, 2019.*

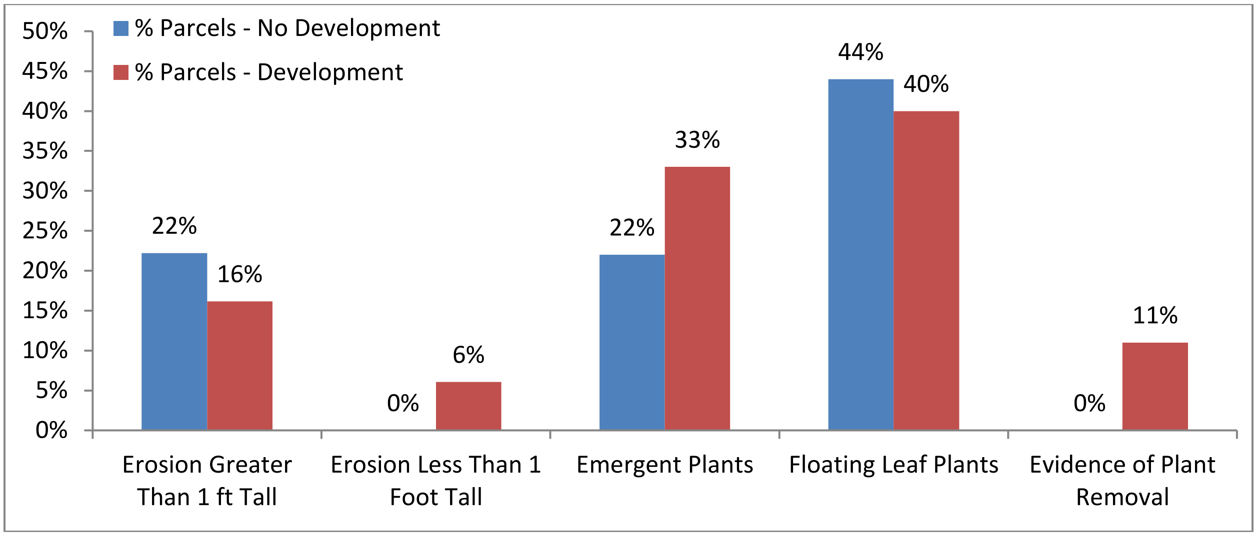
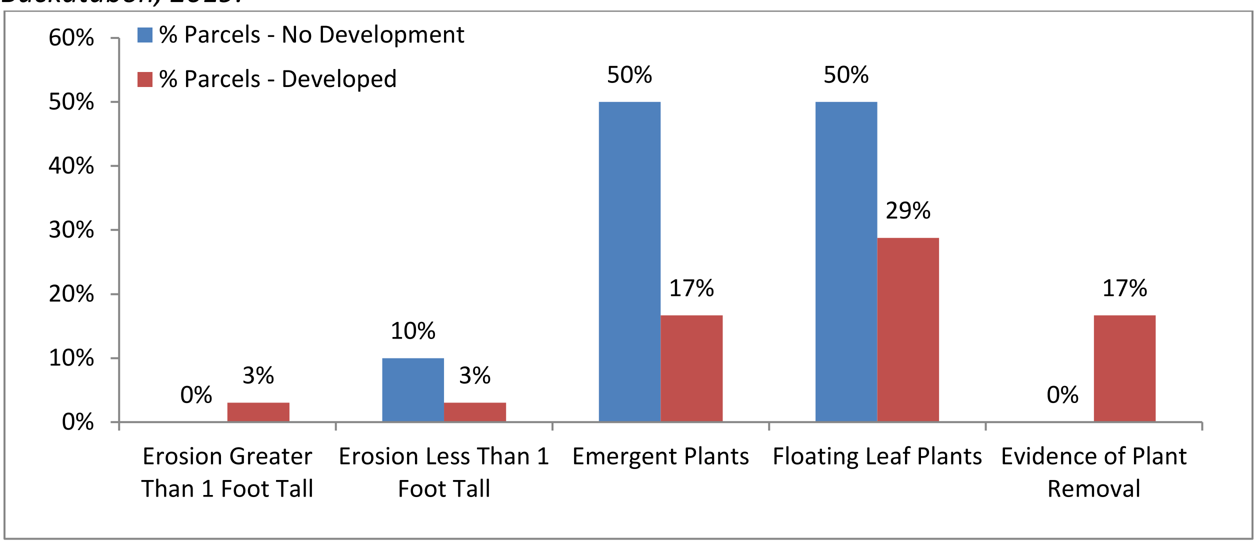


Figure 4.19: *Comparison of bank zone features of undeveloped and developed parcels – Lower Buckatabon, 2019.*



Pier density on Upper Buckatabon averaged 1.15 piers across all properties, with an average of 11 piers/km. The highest pier density observed on any individual parcel was 5 piers. Pier density on Lower Buckatabon averaged 1.51 piers across all properties, with an average of 15 piers/km. The highest pier density observed on any individual parcel was 13. Pier densities are exceeding the described "threshold" of 10 piers per kilometer on both Upper and Lower Buckatabon.

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. Upper Buckatabon's estimated density of CWD is ~165 pieces per kilometer of shoreline, whereas Lower Buckatabon's estimated density is ~55 pieces per kilometer of shoreline. It is important to note that the survey methods from the example study and the data collected on Buckatabon Lakes do vary, and should not be a direct comparison, but rather provides an illustration on the overall importance of CWD to a lake. Structure estimates within the riparian zone on Upper Buckatabon totaled 25 structures, averaging 6 structures/kilometer. Structures estimates within the riparian zone on Lower Buckatabon totaled 19 structures averaging 4 structures/kilometer.

Photo 8: *Native Riparian Wetland Complex on Upper Buckatabon*

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.[18] 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[19] 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.[20]

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.

[18] NR 102, Wis. Adm. Code

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

[20] 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. Upper and Lower Buckatabon Lakes are considered two-story lakes. The WDNR defines two-story lakes as those that "are often more than 50 feet deep and are always stratified in the summer". These lakes have the potential to support coldwater fish, such as Cisco, in cooler deeper waters of the lake. 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 Upper and Lower Buckatabon Lake to be mesotrophic lakes **(Figures 5.1 & 5.2).**

Figure 5.1: *Upper Buckatabon's trophic status based on water transparency, total phosphorous, and chlorophyll a.*[21]

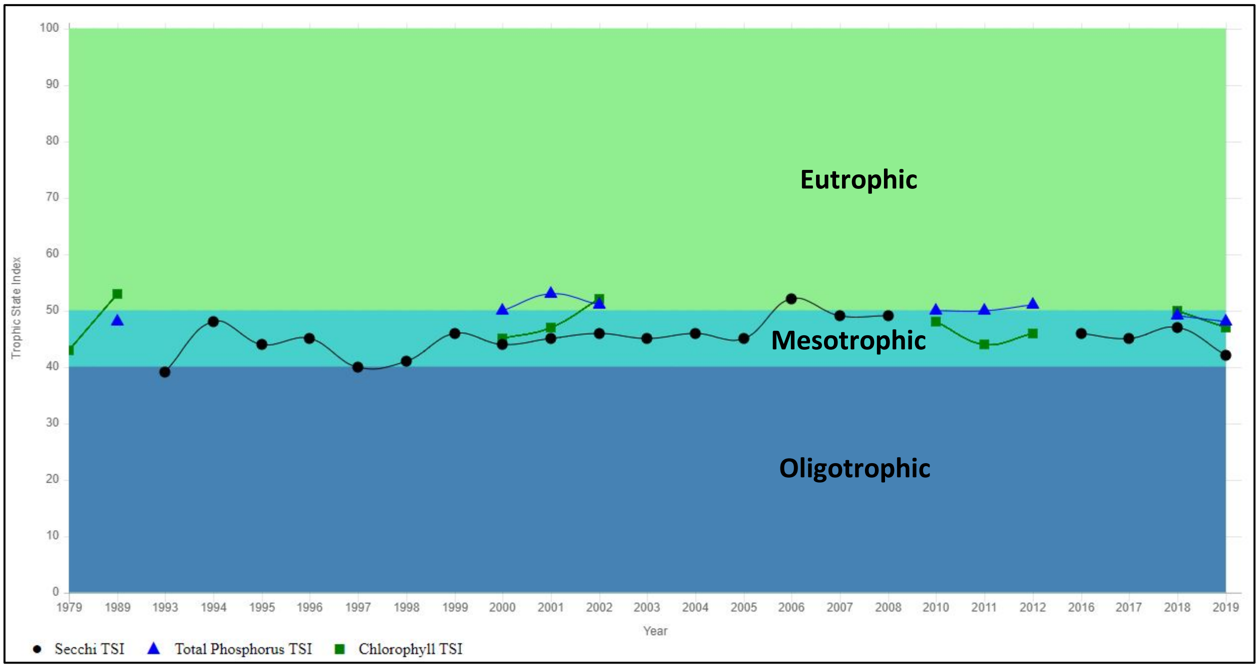
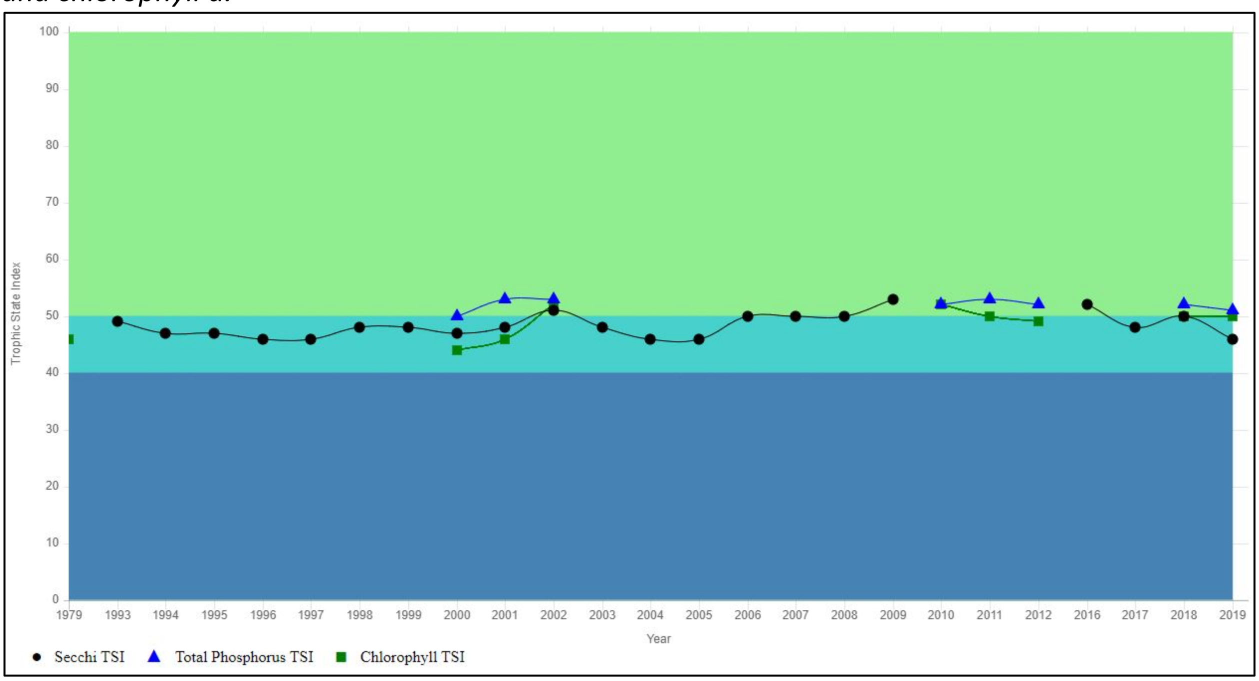


Figure 5.2: *Lower Buckatabon's trophic status based on water transparency, total phosphorous, and chlorophyll a.*[22]



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

Comparing TSI values to Upper and Lower Buckatabon's natural community type, both lakes' general condition is considered poor **(Figures 5.3 & 5.4).** A poor condition means that the water quality may not be attained based on the designated uses for a waterbody. In addition, WDNR also uses water quality monitoring data to compare how often a certain parameter, such as total phosphorous exceeds the numerical threshold values for the lake's natural community type. If these levels exceed the threshold, a lake may be placed on the State's impaired waterbody list. In the case for Upper and Lower Buckatabon Lakes, the measured value for total phosphorous exceeds the numerical criteria placed on two-story lakes. This resulted in both lakes being listed on the State's impairment list for total phosphorous. Of the general conditions assessed, both lakes are listed impaired for recreation.

Figure 5.3: *General condition assessment for designated lake use – Upper Buckatabon, 2019.*

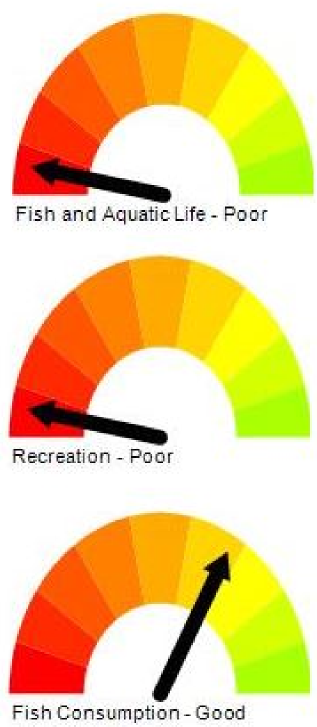
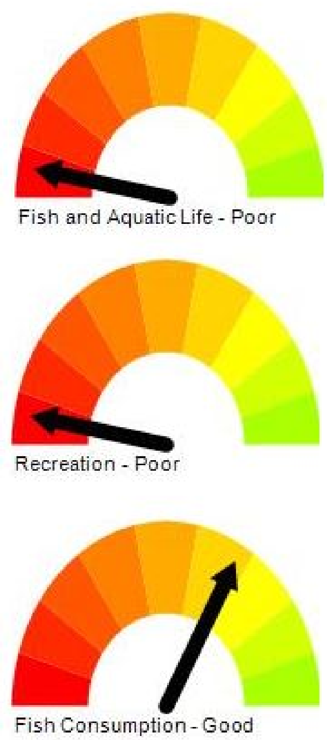


Figure 5.4: *General condition assessment for designated lake use – Lower Buckatabon,* 2019.



Water Quality Trends

Historical water quality data varies for both Upper and Lower Buckatabon lakes, limiting the ability to discern historical trends or changes to water over time. Records for TSI parameters date back to 1989. Lake volunteers began collecting data in 2016.

Figure 5.5: *July 15th- September 15th average secchi (ft) from 1993 to 2019 – Upper Buckatabon.*

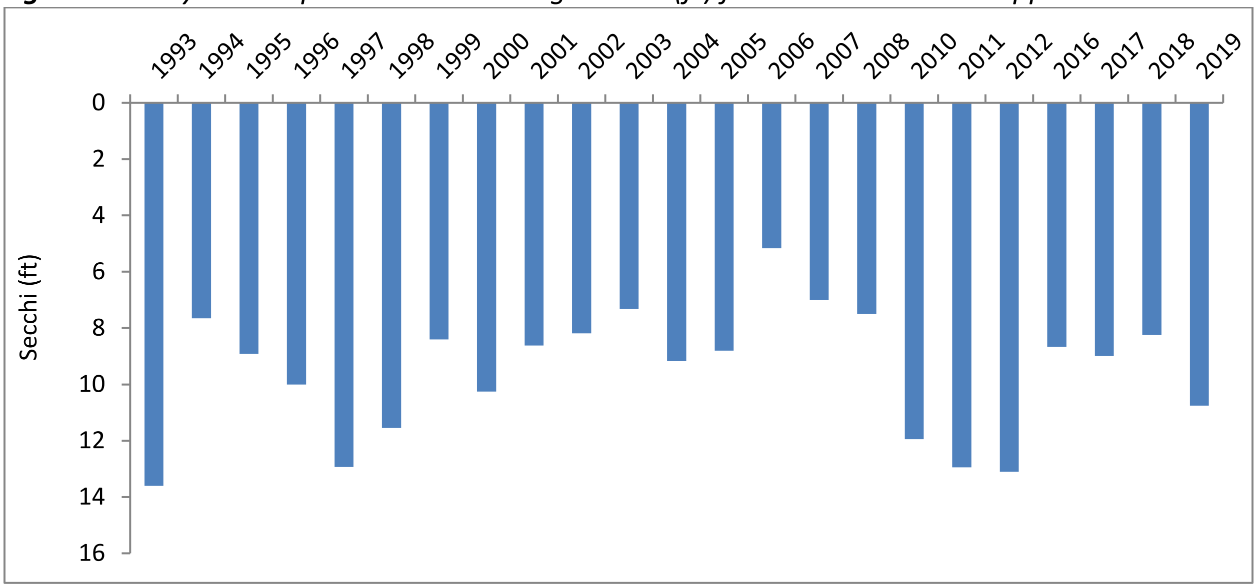


Figure 5.6: *July 15th- September 15th average secchi (ft) from 1993 to 2019 – Lower Buckatabon.*

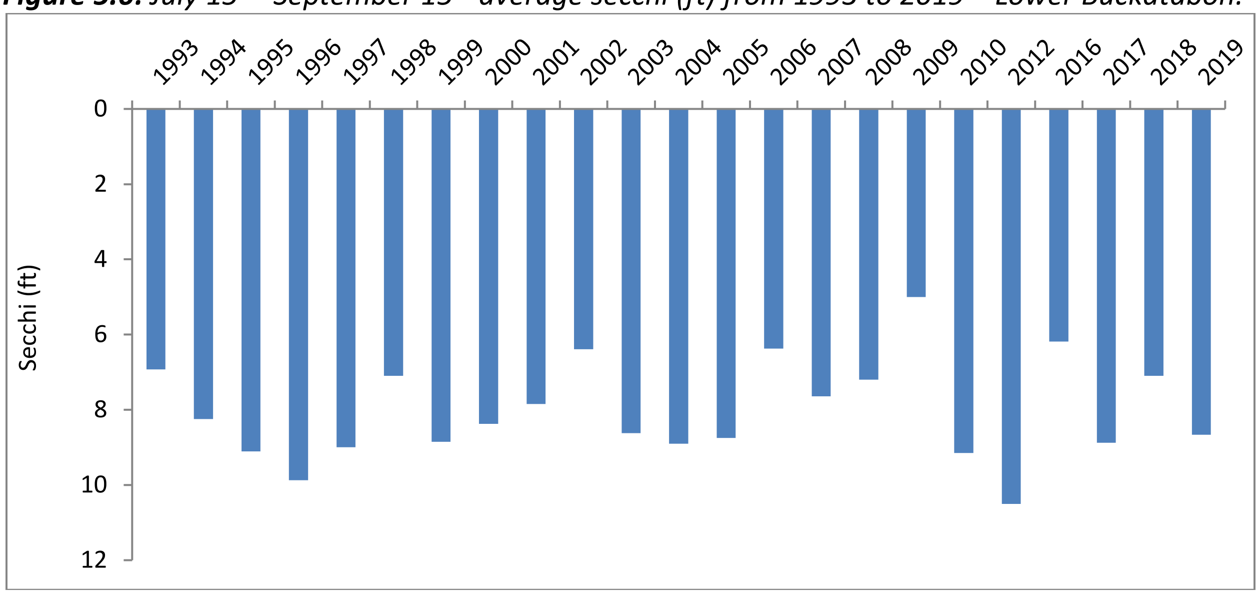


Figure 5.7: *June 1st - September 15th average total phosphorus concentrations (ug/l) from 1989 to 2019 – Upper Buckatabon.*

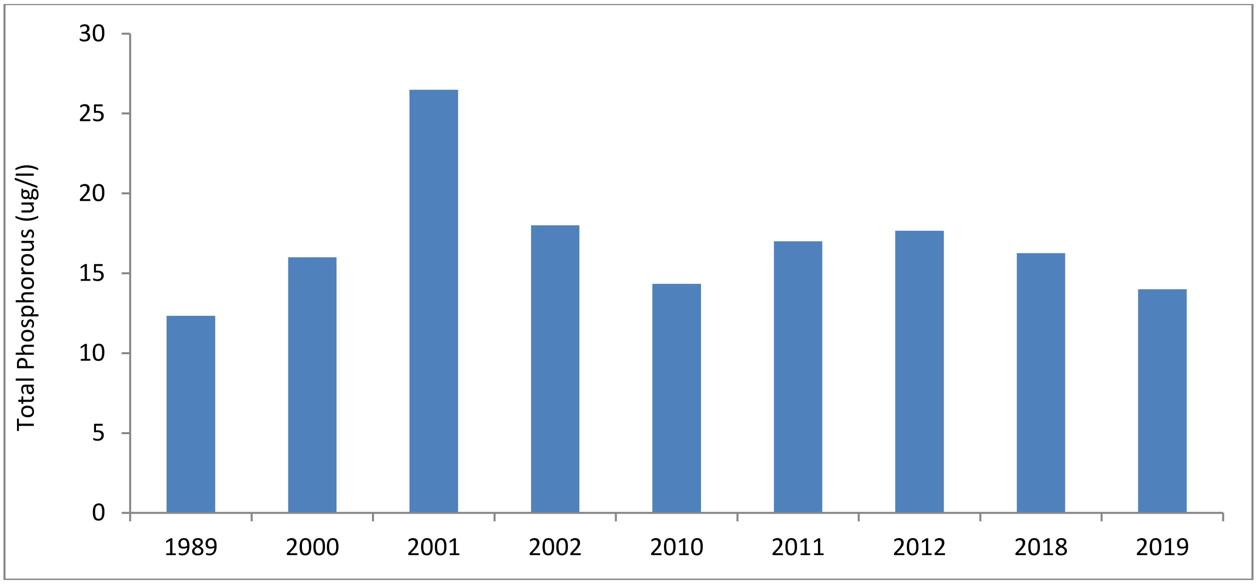


Figure 5.8: *June 1st - September 15th average total phosphorus concentrations (ug/l) from 1989 to 2019 – Lower Buckatabon.*

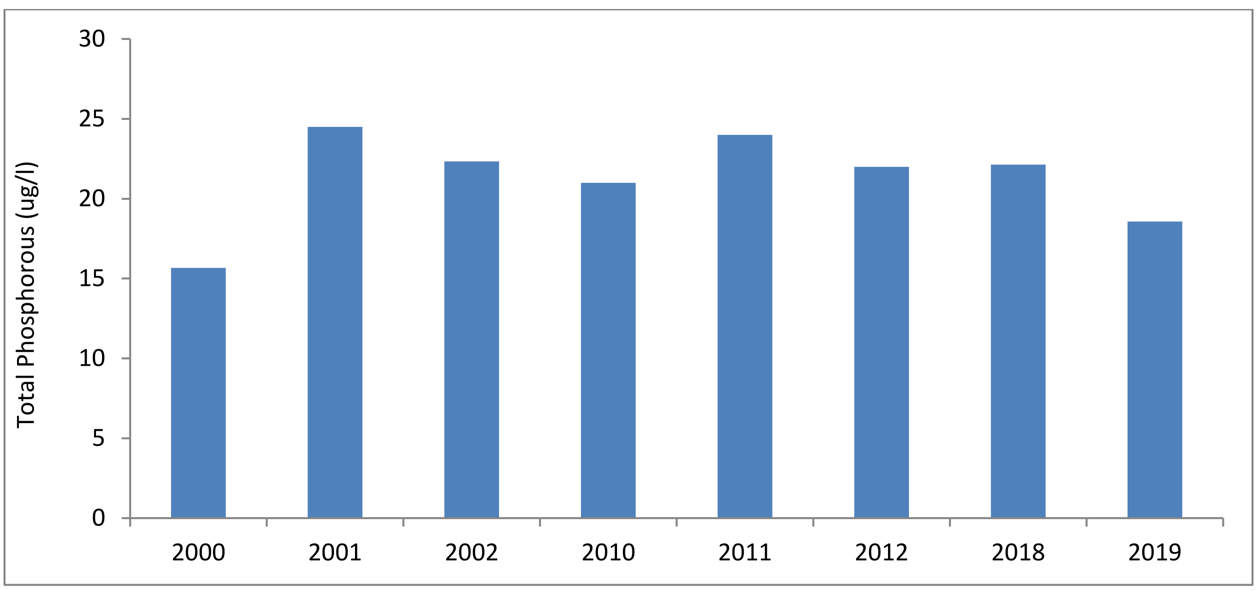


Figure 5.9: *July 15th -September 15th average chlorophyll a concentrations (ug/l) from 1989 to 2019 – Upper Buckatabon.*

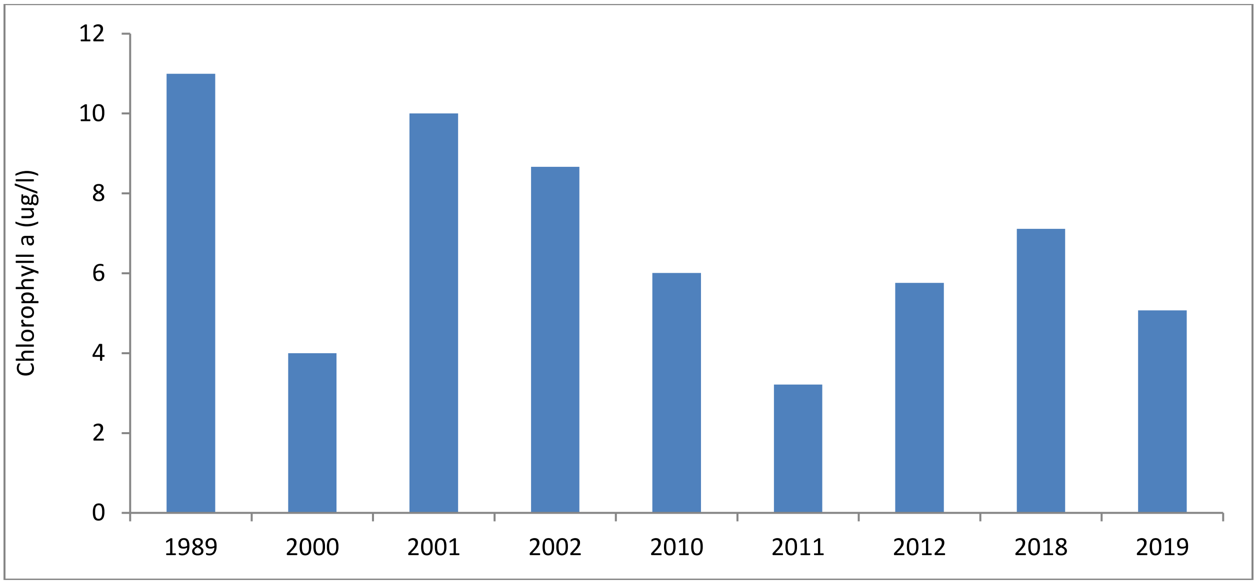
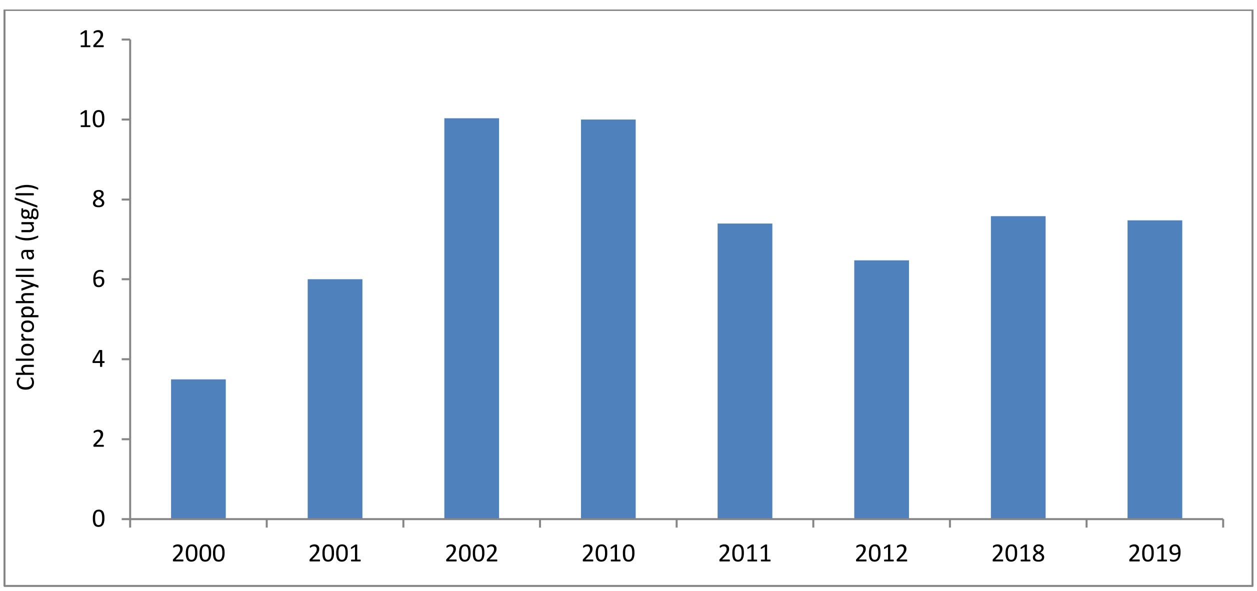


Figure 5.10: *July 15th -September 15th average chlorophyll a concentrations (ug/l) from 1989 to 2019 – Lower Buckatabon.*



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.

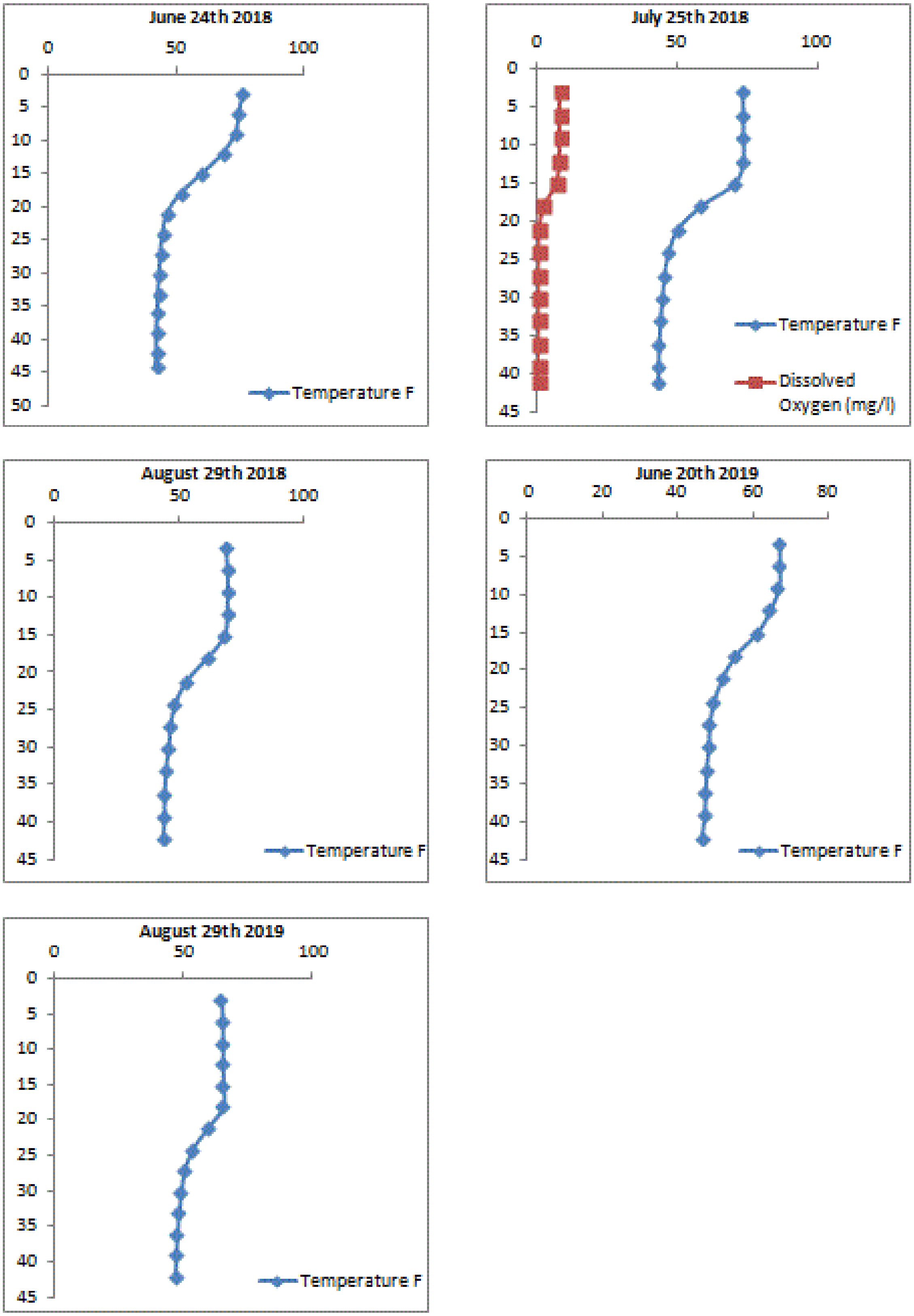
After phosphorous, nitrogen is the second most important nutrient for plants and algae. Sources of nitrogen in a lake vary and include atmospheric inputs from rain and ground water and surface water runoff from the surrounding watershed. Mineral soils, created by weathered rocks, do not naturally contain 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, Upper and Lower Buckatabon Lakes are both phosphorous limited with a ratio of 22:1 and 21:1 respectfully.

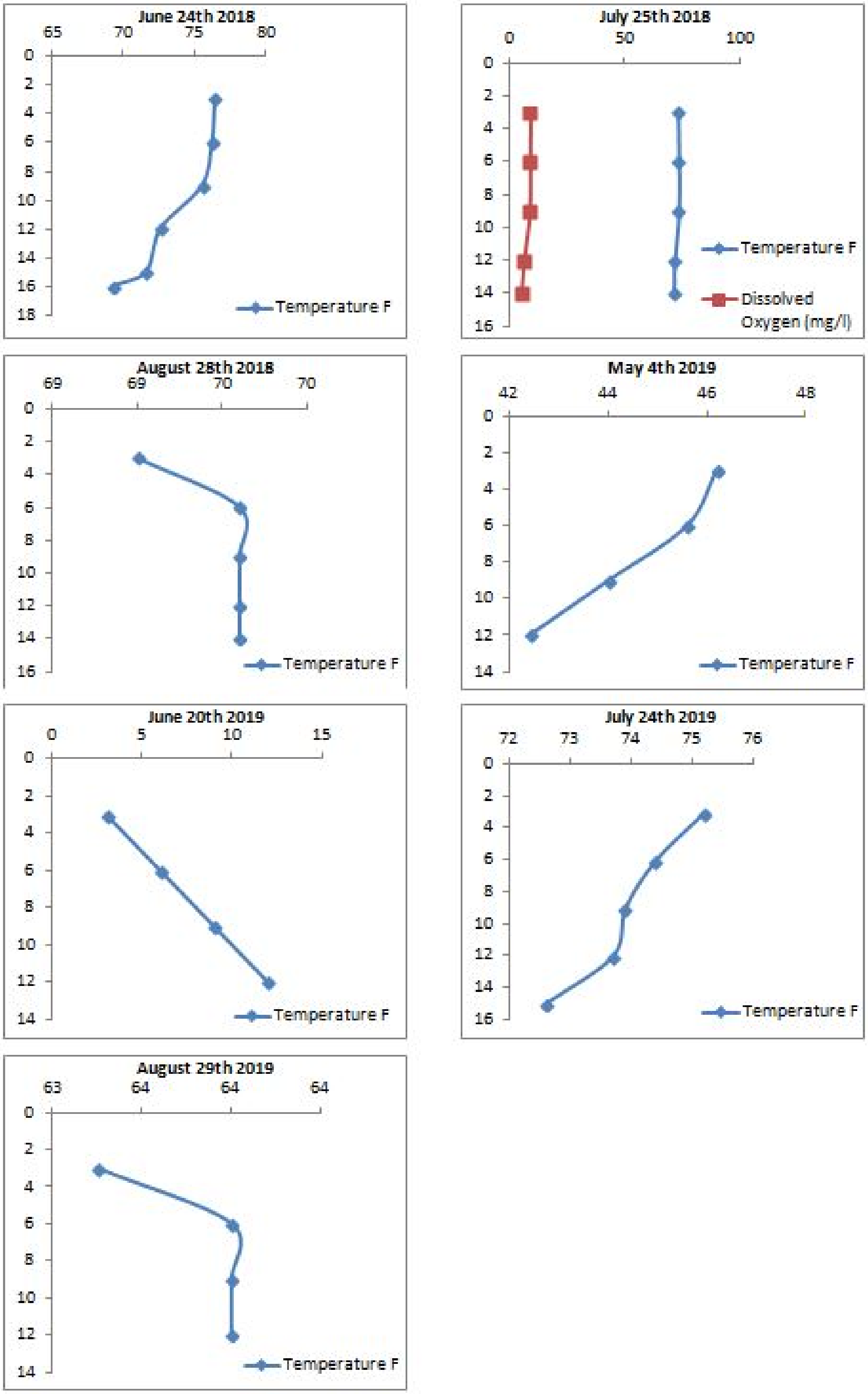
Dissolved Oxygen

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 Upper Buckatabon Lake stratifies whereas Lower Buckatabon lake does not stratify but remains mixed with oxygen from top to bottom throughout the growing season.

Figures 5.11-5.15: *Dissolved oxygen and temperature profiles 2018-2019 - Upper Buckatabon.*



Figures 5.16-5.22: *Dissolved oxygen and temperature profiles 2018-2019 - Lower Buckatabon.*



pH – Lake Acidity

pH measures the acidity of water. Values range from 0 -14, where "0" would indicate high acidity, "14" would indicate high alkalinity and "7" would be considered neutral. Natural lakes in Wisconsin range in pH from 4.5 in acidic boggy lakes to above 8.4 in hard water/marl lakes (Shaw B. M., 2004). pH on Upper and Lower Buckatabon (2019) measured 8.04 and 8.08 respectfully. 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.[23] Without a lake's carbonate system, helping raise pH levels from (buffering) water sources to a lake, biological processes in a lake would be affected. Lower pH levels in water allow metals such as aluminum, mercury, and zinc if present in the lake sediment or watershed soils to become soluble. High levels of mercury and aluminum are toxic to fish and may be harmful if consumed by humans and other animals such as loons, eagles, and ospreys. Acidic pH levels (<7) may inhibit fish spawning in some species, including walleye and lake trout and at very low pH levels many fish species just cannot survive.

Lake Alkalinity – Hardness

Alkalinity measured as $CaCO_3$, measures water's ability to resist changes in pH and predicts a lake's overall sensitivity to acid rain. Like pH, it is an important component of a lake's carbonate system. Hardness is simply the amount of dissolved calcium and magnesium in the water. Minerals in the soil and bedrock influence lake alkalinity, and hardness. Soft water lakes, which are lakes with hardness values of less than 60 mg/l of $CaCO_3$, are common in Northern Wisconsin, due to types of glacial deposits and minerals present. Upper and Lower Buckatabon (2019) alkalinity levels measured 34.2 and 32.9 respectfully indicate soft water lakes with low sensitivity to acid rain (Shaw B. M., 2004)**.**

Other water quality parameters

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

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

Calcium and magnesium levels for Upper Buckatabon (2019) measured 9.28 mg/l and 3.09 mg/l respectfully. Calcium and magnesium levels for Lower Buckatabon (2019) measured 8.59 mg/l and 2.90 mg/k respectfully. Calcium is important to organisms like mussels that need calcium to build shells. 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, both Upper and Lower Buckatabon Lakes are considered unsuitable 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. These sources 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. Heavily forested watersheds infiltrate precipitation better than urbanized or agricultural watersheds due to impervious surfaces and compacted soils, which create more run-off.

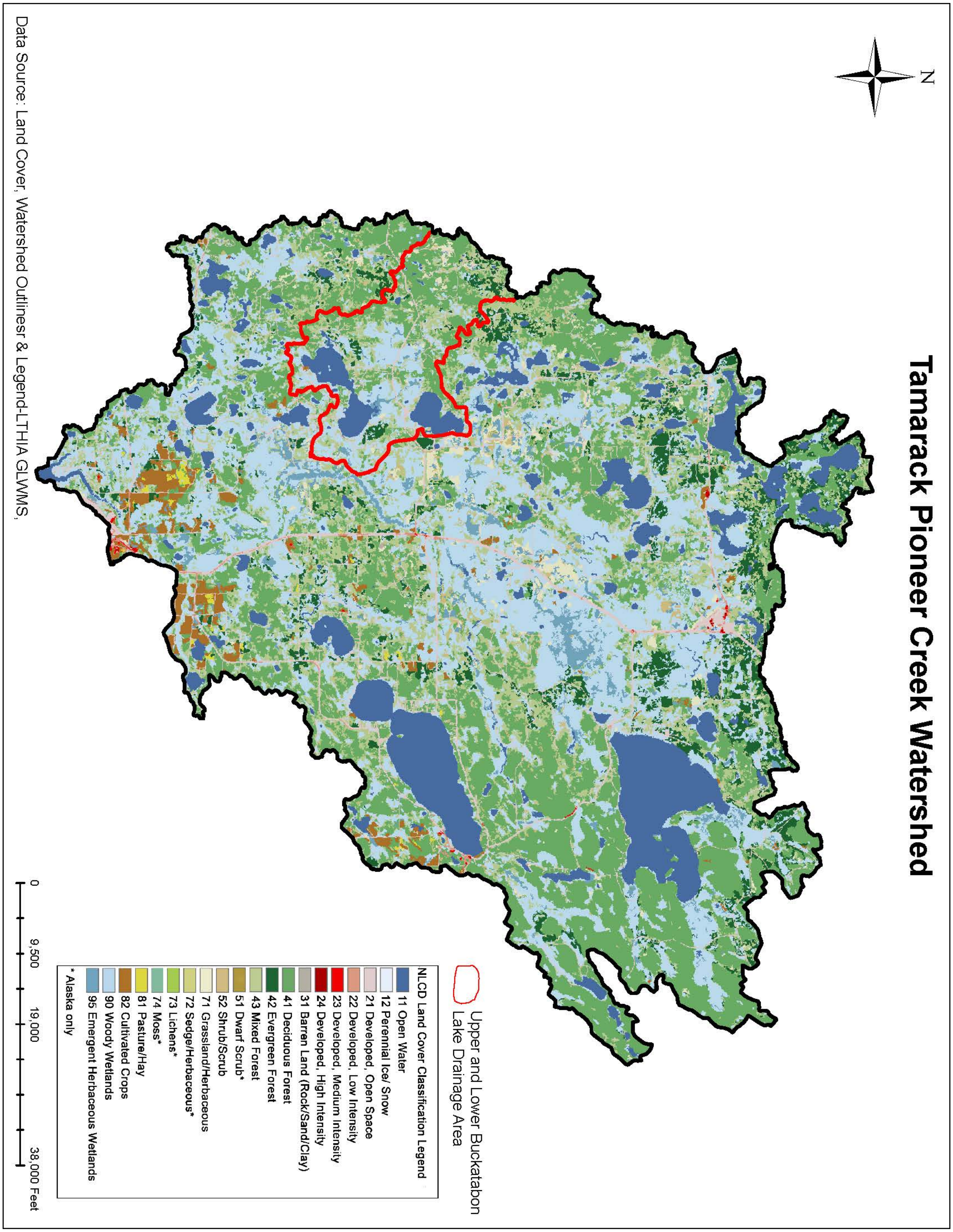
Upper and Lower Buckatabon Lakes are located in the south-western portion of the Tamarack Pioneer River Watershed. This watershed contains 183 miles of rivers and streams, 14,007 acres of lakes, and 23,826 acres of wetlands. Land cover in the Tamarack Pioneer River watershed is dominated by forests (63%), wetlands (18%), and open water (10%). It is ranked medium for non-point source issues affecting lakes (WDNR). The Tamarack Pioneer River watershed feeds into the larger Upper Wisconsin River Basin. As a result of the dam at the outlet of Lower Buckatabon, the lakes serve as one of the 21 reservoirs owned and managed by the Wisconsin Valley Improvement Company to regulate the flow into the Upper Wisconsin River.

A lake's hydraulic residence time is the time required to refill a lake with its natural water inflow. The size of the lake, watershed, and sources of water to a lake affect residence time. If a lake is relatively shallow, with a high inflow of water, residence time may be short. Whereas in deep lakes with low to minimal water inflow, residence time may be very long. Longer residence times allow nutrients from runoff and other pollutants to accumulate in a lake, versus short residence times, which flushes lakes of nutrients and pollutants. Upper Buckatabon's residence time will range between 380 to 1,600 days, whereas Lower Buckatabon's residence time will range between 69 to 330 days[24].

Factors that contribute to the amount of nutrients and other pollutants that enter a lake include the size of the watershed and land cover/land use within the watershed. The drainage area to lake area ratio (DA/LA) looks at the how many acres of land drains to each surface water acre of a lake. Lakes with large ratios (7-10 acres of land drainage per acres of water) typically have more inflow of nutrients and pollutants than lakes with relatively small ratios (Holdren, 2001). In addition, lakes with large ratios will typically have shorter residence times, allowing nutrients and other pollutants to flush out. Lakes with small ratios typically have a much longer residence times, holding pollutants, and other nutrients longer. In these cases, land practice improvements to mitigate water quality issues may take many years to see any change in water quality.

[24] WILakeData03292016 excel workbook

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. Upper Buckatabon's drainage area to lake area ratio is 15/1**.** This means approximately 15 acres of land drain to each surface water acre of Upper Buckatabon Lake. Lower Buckatabon's drainage area to lake area ration is 27/1 with 27 acres of land rain to each surface water acre of Lower Buckatabon. Total annual phosphorous loads based on WDNR estimation tools ranged from low estimates of 324 to 1,238 pounds/yr on Upper Buckatabon and 399 to 1,529 pound/yr on Lower Buckatabon **(Appendix F)** (WDNR PRESTO, 2013).



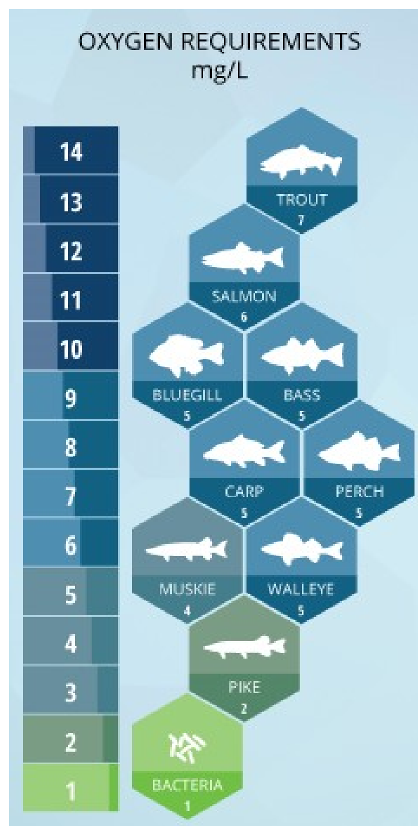
Map 2: The Buckatabon Lakes within Tamarack Pioneer River Watershed

7- FISHERIES

The fisheries of Upper and Lower Buckatabon Lakes are often described alike by the WDNR due to their inherent connection and combined roles as a natural reservoir for the Wisconsin River system. An important feature is their shared water source. They are considered drainage lakes. Drainage lakes have both an inlet and outlet where the main water source is stream drainage, in this case the Main and East branches of Buckatabon Creek entering Upper and Lower Buckatabon Lakes, respectively, and exiting the southeast end of Lower Buckatabon 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. Higher nutrient levels are evident in Buckatabon Lake's "moderately clear" water, mesotrophic trophic state, and the phosphorus level impairment.

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, both Upper and Lower Buckatabon are classified as "complex" "two-story" lakes. "Complex" refers to a lake that has four or more game species, and both lakes are home to musky, largemouth bass, northern pike, walleye, and to a lesser extent, smallmouth bass. "Two-story" refers to a lake having a top story (epilimnion layer) that supports warm and cool water fish (e.g. bass, musky, walleye, panfish) and a bottom story (in the thermocline or hypolimnion layer in summer) that supports native coldwater pelagic species (cisco, lake or brook trout, and lake whitefish), even if only a transient visitor from connected waters. A few other scenarios for the presence of coldwater fish may also apply, including lakes with naturalized, self-sustaining non-native coldwater pelagic fish, or lakes where these species have had successfully stocked populations since 2008.

Figure 7.1: Minimum dissolved oxygen requirements for freshwater fish (Fondriest)



One of the defining parameters that influences the presence of various fish species is dissolved oxygen. **Figure 7.1** portrays the minimum dissolved oxygen requirements for freshwater fish. Recent WDNR criterion (2020) for two-story lakes also include a requirement that they have a water column section greater than 1 meter, that has a temperature cold enough to support the coldwater species present and dissolved oxygen of greater than 6 mg/l.[25] Cisco is the coldwater species found in Buckatabon Lakes and it is considered permanent and sustaining in deeper (47 ft max), colder Upper Buckatabon and transient (not present in summer) in shallower (16 ft), warmer Lower Buckatabon. Two-story fishery lakes are somewhat rare, with only about 1.3% of Wisconsin lakes in that classification (Lyons, 2015). Those that know the lakes understand that the 493 acre, 47 ft deep Upper, and the 378 acre, 16 ft deep and Lower Buckatabon are quite different in character, especially in temperature and stratification. Shallow lakes, such as Lower Buckatabon experience very little turnover, while large deep lakes like Upper Buckatabon have defined temperature layers and experience major changes as waters of different temperatures mix seasonally. Their physical connection and the potential for fish to move between lakes when conditions are suitable, has placed them in the same fisheries classification.

Habitat

Another important fish consideration is habitat. Bottom habitat such as cobble, gravel, or large woody debris have a direct affect 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. The lake bottom for Upper and Lower Buckatabon is primarily sand and muck, with the proportion of muck being greater in Lower Buckatabon. 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.

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. 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. Increasing shoreline development, sea-wall construction, and in-lake modifications, such as benthic barriers and the removal of aquatic vegetation, greatly change or destroy the near-shore areas of our lakes and streams. These shallow areas, known as littoral zones, 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. While the addition of one cottage or development on a lake may seem inconsequential, the cumulative total of lost habitat areas can have a substantial effect on many waters. 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. 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).

[25] Ch NR 102, Wis. Admin. Code

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.

The most recent fish surveys found on Upper Buckatabon occurred in 2010 and 2011 **(Appendix G).** Beside determining the health of its fishery, estimating walleye abundance was the primary objective. In the 2010 WDNR survey, the lake was inhabited by 230 adult walleye (.5/acre), 97% of which were 15 inches or longer. Information about incidental catch of smallmouth and largemouth bass, northern pike, musky, and other species were also included in this report. Additional species found during WDNR fish survey include creek chub, golden shiner, grass pickerel, and white sucker. A creel survey was conducted on Upper Buckatabon in 2010-2011. The survey reported that anglers spent 21,897 hours fishing Upper Buckatabon during the 2010-2011 fishing season. This averaged 44.3 hours per acre fishing, which is higher than the Vilas County average of 34.5 hours per acre. Of the total catch reported, the top three species caught include, black crappie, musky and large mouth bass.

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. 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 [26]**.** According to this Plan, Wisconsin's fisheries management has a long history of WDNR propagating and stocking walleye. Started in the 1870s, fish stocking expanded to the northern lakes by 1900. By 1910, 77,904,996 walleye had been stocked in Wisconsin lakes. It is unclear if Buckatabon Lakes were stocked 100 years ago, but it fits the profile of a lake that might have had a healthy natural walleye population—large drainage lakes associated with major river systems. 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. 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

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

compounded by the fact that walleye are 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 walleye reach maturity in four to five years when they are about 15 to 17 inches long. Another tool in fisheries management are fishing regulations, another inexact science often impacted by public opinion and harvest pressure. For a complete list of annual regulations, visit the WDNR website or regulations received while purchasing a license.

Stocking records for Upper Buckatabon Lake were available for the years 1973 – 2019 **(Figure 7.2-7.5).** A general trend of alternate stocking of walleye and muskellunge (musky) was seen over the past 46 years, heavier on walleye stocking in the first several years of this range and exclusively musky in the last four years. Walleye fingerlings (small ~3”) were added at an average rate of close to 20,000 per stocking event (21 events.) Musky fingerling (large~10”) numbers were always much lower, at an average of about 600 per stocking event (18 events.) The number has been closer to 200 large fingerling musky in the past few years of stocking.

Figure 7.2: Walleye Stocking Data, Upper Buckatabon 1973-2010.

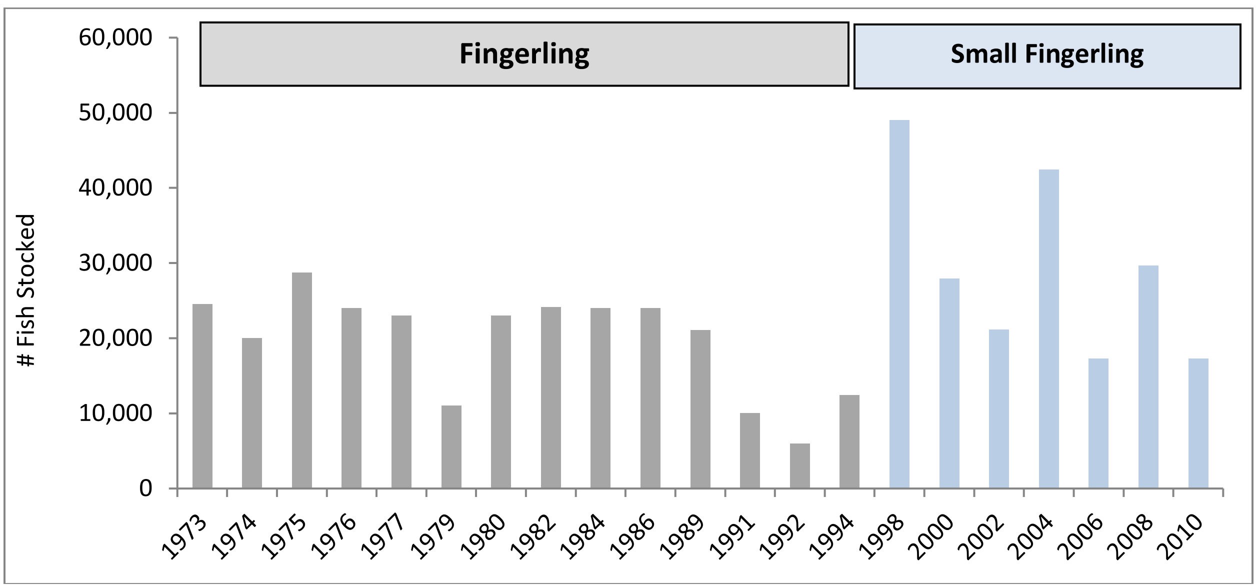
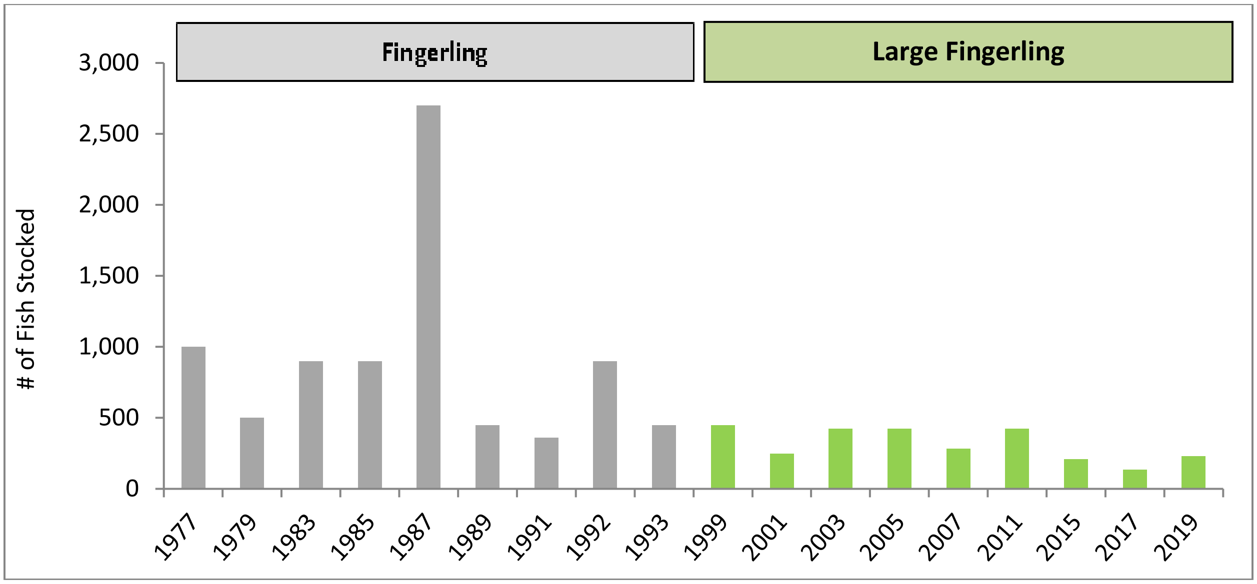


Figure 7.3: Muskellunge Stocking Data, Upper Buckatabon 1977-2010.



The WDNR Lower Buckatabon Fish Stocking Record was available for the 1974-2013 period. Musky was stocked nineteen times over the 39 year period, with an average number of 457 large (~ 11") fingerlings per event. Walleye was stocked only seven times in the date range, with an average of 11,517 (~2.5") small fingerlings. Stocking did not occur every year in Lower Buckatabon.

Figure 7.4: Walleye Stocking Data, Lower Buckatabon 1991-2012.

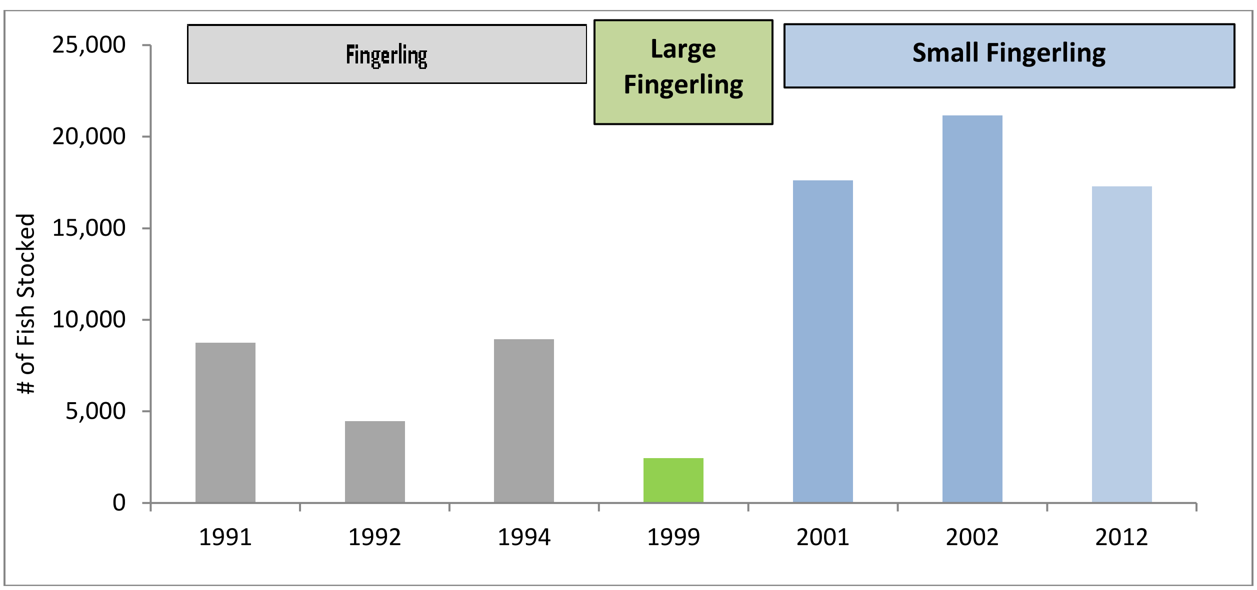
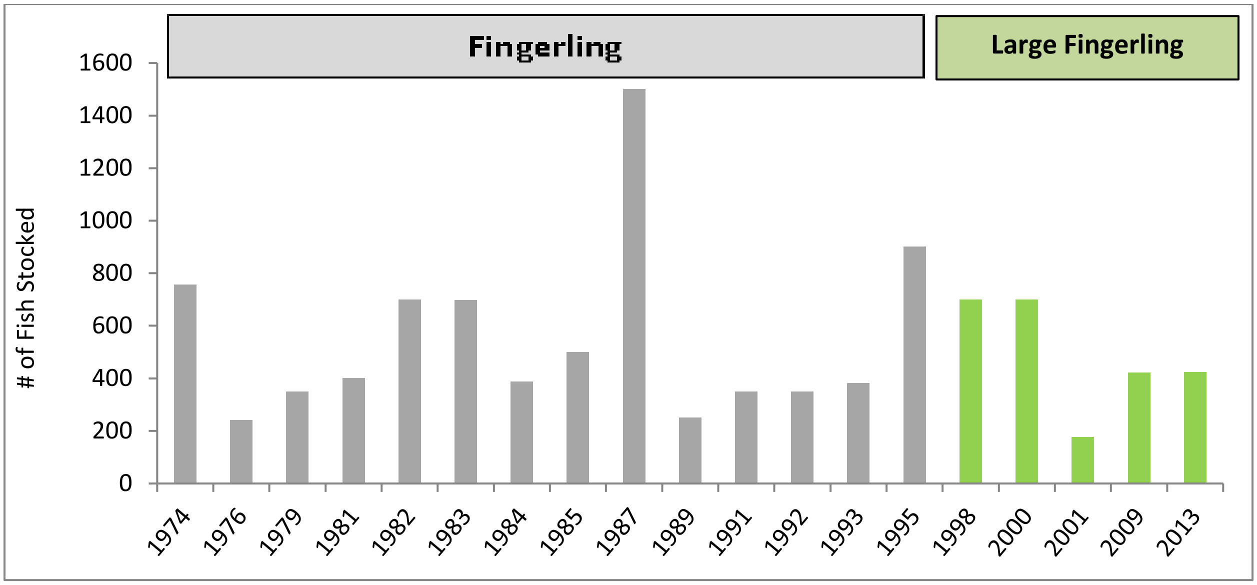
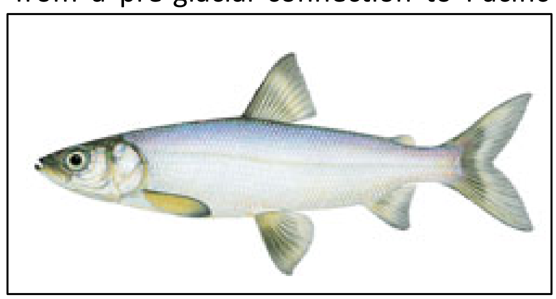


Figure 7.5: Muskellunge Stocking Data, Lower Buckatabon 1974-2013.



Also of note in the suite of fish found in Buckatabon Lakes is the **cisco**. As mentioned before, cisco are considered permanent residents of Upper Buckatabon but will move in and out of Lower Buckatabon when temperatures are cold enough and dissolved oxygen high enough. These members of the trout and salmon family are considered refugium species. Refugium species are living in a location that supports an isolated or relic population of a once more widespread species. It is believed cisco may have arrived here from a pre-glacial connection to Pacific Northwest waters and are now living in the midwater (pelagic) regions of the Great Lakes and high- quality inland lakes. During the 19th and 20th centuries, cisco made up a significant part of the Great Lakes commercial fishery, but their numbers have dropped drastically, at least partly due to the introduction of invasive alewives and rainbow smelt, which deplete the zooplankton upon which cisco feeds. Biologists are also concerned about climate change, as cold water is a key component of its life cycle, like many of the salmonids. Cisco require deep, clear lakes providing optimal oxythermal habitat, including high oxygen concentration and cool water. Cisco spawn in the middle depths of Upper Buckatabon Lake (more so than Lower Buckatabon) in the late fall, about the time surface ice forms. Eggs fall to the bottom and develop over winter to hatch in the spring. The cisco season is open all year, with no length limit, and a bag limit of ten fish in both Upper and Lower Buckatabon Lakes. Climate and land use changes will contribute to the decline in suitable habitat for cisco in the future. Future predictions for Wisconsin estimate that by 2050 an average increase in temperature of 3-9˚F, increased number of 90˚F plus days and warming winters will



occur.[27] Higher precipitation predicted during the winter and spring months will result in higher ground water levels. Increasing temperatures will affect the duration that lakes remain stratified. Lakes will remain stratified longer and oxygen concentrations will have more time to decline during this period. This will reduce optimal oxythermal habitat for cisco and other cold-water native fish such as whitefish and lake trout. High intensity rain events will lead to increases in run-off and nutrients entering a lake, reducing water quality. 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 and thereby help preserve cisco and other fish species habitats.

[27] Wisconsin Initiative on Climate Change Impacts (wicci.wisc.edu Accessed 5/2020)

8- LAKE USER SURVEY

A lake-user survey gains a better understanding of stakeholder demographics, knowledge, and interest on a variety of lake topics and issues. Specific information includes property ownership and use, recreational use of the lake, and knowledge and values regarding lake health topics including water quality, fisheries, habitat, and invasive species. Data collected shapes aspects of lake management plan, reflecting what is important to the lake group including environmental and social concerns and assist in defining plan goals and objectives. Furthermore, these results assist in creating a well-rounded action plan catered to the needs and issues of Buckatabon Lakes.

When deciding which stakeholder groups would be most beneficial to learn from, the BLA Board considered both demographic and geographical scopes including daily lake users, non-riparian owners with specific interest or connection to Buckatabon Lakes and all property owners within a certain radius of the lake. The Board concluded to educate and develop strategies specific to maintaining and preserving lake health, the stakeholder group for this survey most beneficial to learn would be immediate lake property owners. Additional surveys to reach out to a larger lake community may be considered in the future. Learning from these and other stakeholders may be priorities for plan updates, especially for proposed changes to resource management and land use. In addition, conclusions from this planning project may identify other stakeholder groups, not initially identified, to learn from to meet project goals and objectives.

Survey development started with a draft of broad questions covering a number of lake topics. The BLA Board reviewed each question, keeping those most relevant to Buckatabon Lakes and added questions to address possible issues specific to Buckatabon Lakes. With specific guidance from the WDNR, a series of mailings to each property owner on Upper and Lower Buckatabon Lakes occurred in February 2019. The initial mailing included a cover letter, a copy of the survey and specific instructions. One hundred and eighty eight surveys were mailed. One week after the initial mailing a follow-up postcard reminder to all recipients was sent. At the two-week mark after the initial mailing, a final mailing to those whose surveys had not been returned was sent with an additional copy of the survey. Of the 188 surveys delivered, 139 were returned with a return rate of 74%. Below is a summation of results, highlighting concerning issues and explanatory narrative.

Property

Fifty percent of the responses came from property owners on Upper Buckatabon and 42% came from Lower Buckatabon, 8% did not indicate either Upper or Lower Buckatabon Lake. Most property owners (47%) utilize their property seasonally, mainly during the summer months, whereas 22% indicated either year round residence or visited on weekend throughout the year **(Figure 8.1).** Most responses indicate ownership greater than 40 years and 45% indicating 25 years or more **(Figure 8.2).** Days spent at each property ranged from 1 to 365 days, with most respondents indicating 31-90 days their property is in use per year **(Figure 8.3).** Seventy three percent of respondents indicated they are current Lake Association members whereas 50% indicate they do not attend Association meetings or gatherings **(Figures 8.4 & 8.5).**

Figure 8.1: How is your property used?

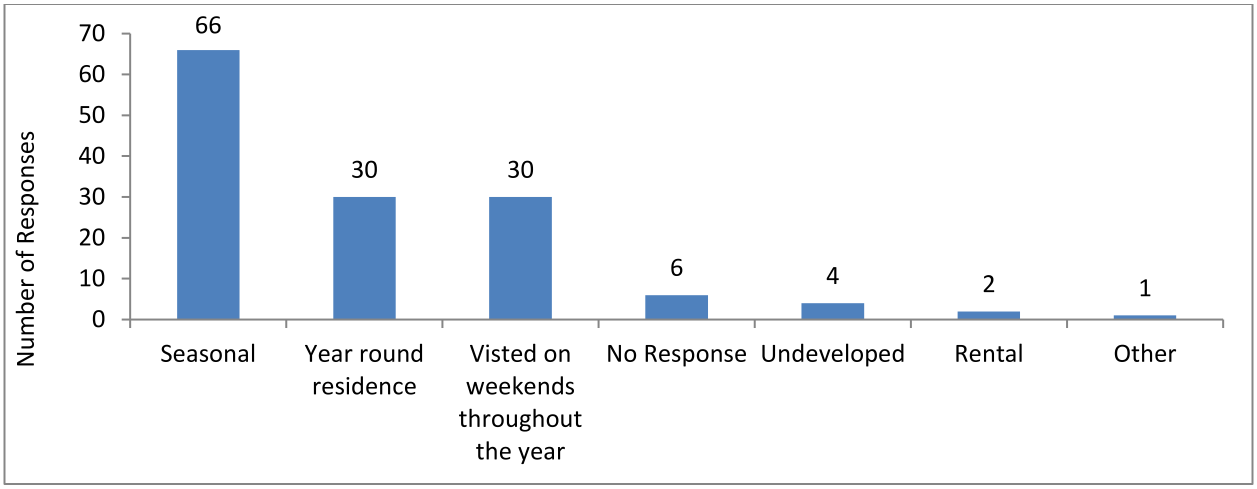


Figure 8.2: *How long have you owned property on Buckatabon Lakes?*

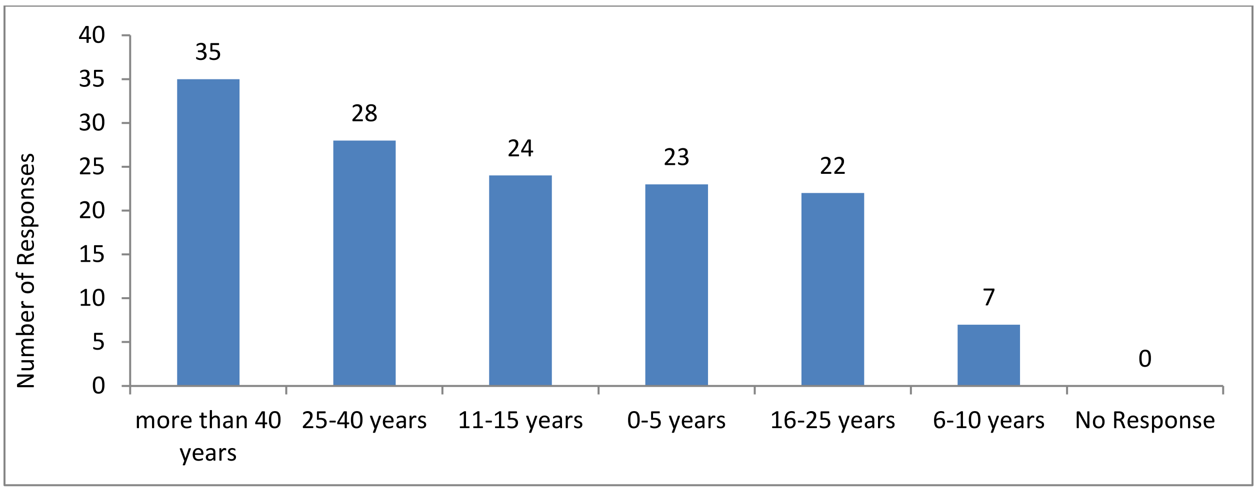


Figure 8.3: *How many days a year is your property used?*

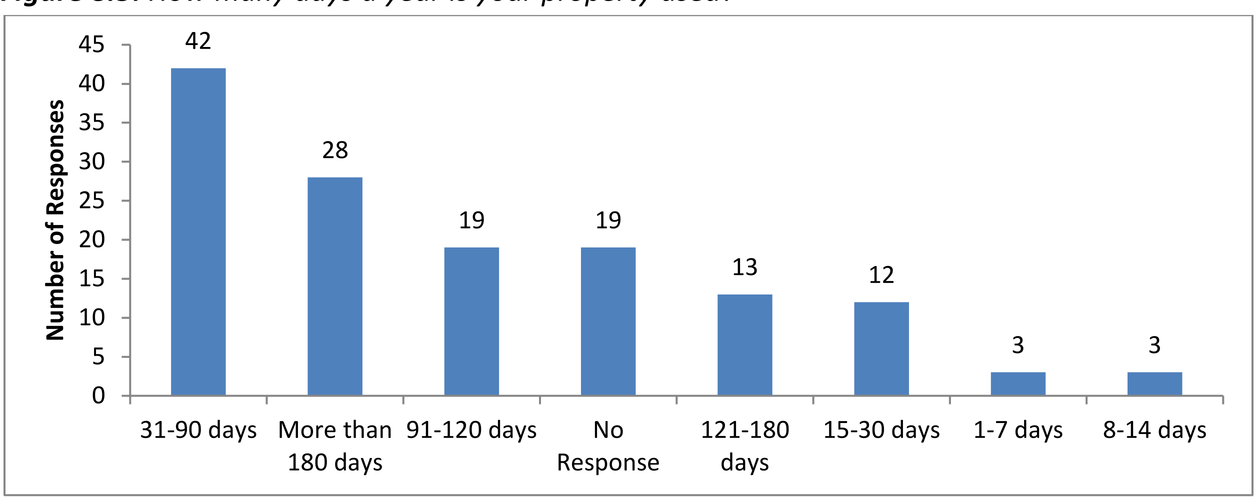


Figure 8.4: *Are you a member of the Lake Association?*

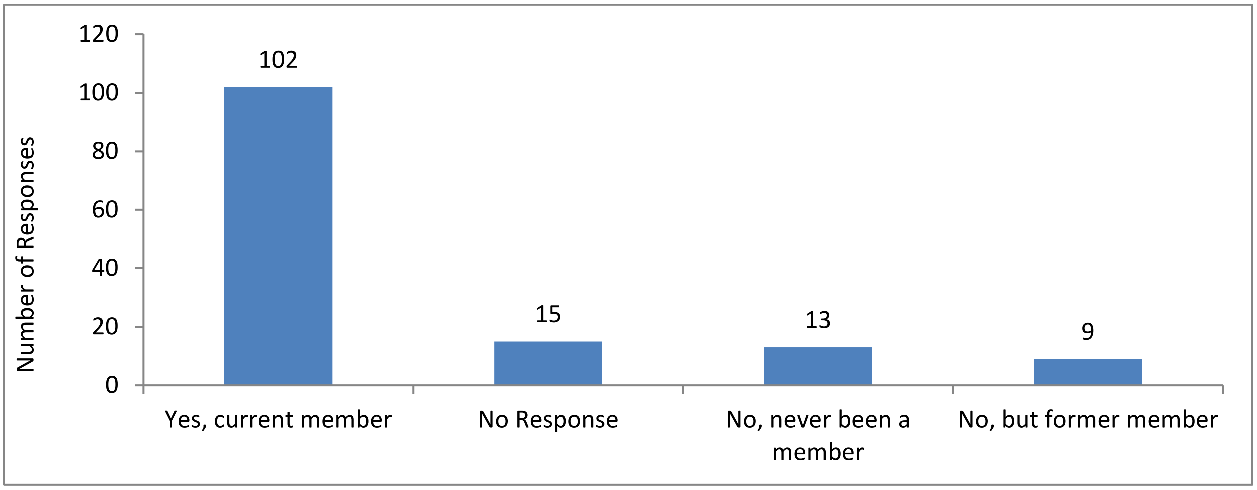
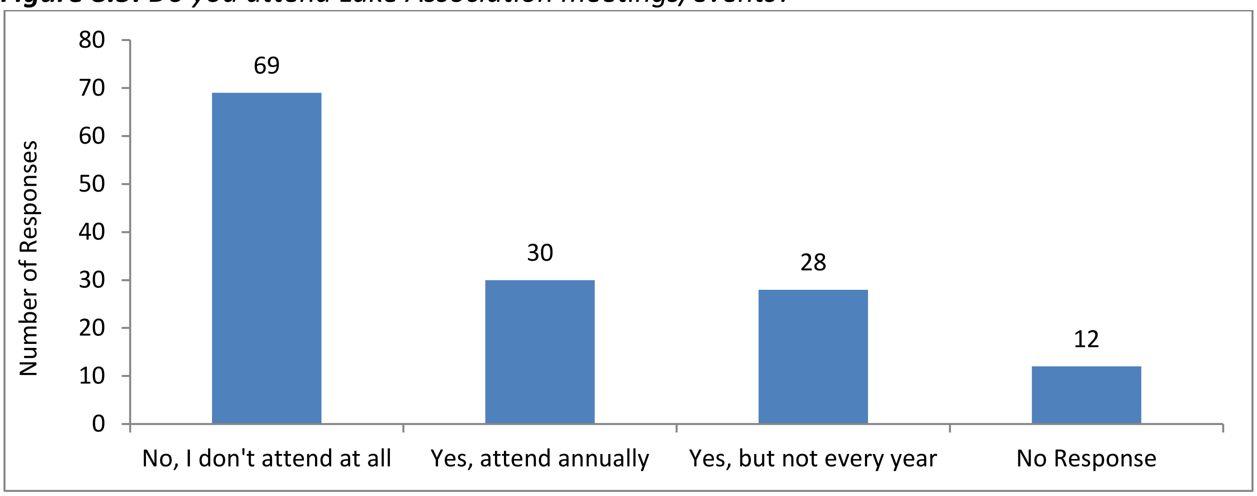


Figure 8.5: *Do you attend Lake Association meetings/events?*



Fishing

Approximately 76% of respondents reported fishing Buckatabon Lakes and have been fishing these lakes for 25-50 years. Most fishing occurs during the open water season **(Figures 8.6 & 8.7).** The top three species caught include bluegill/sunfish, northern pike, and crappie. The species reported caught the least is walleye and largemouth bass **(Figure 8.8).** Generally, respondents answered that the current quality of fishing as fair to good and most agree that the quality of fishing on Buckatabon Lakes has remained the same or has gotten somewhat worse over time **(Figures 8.9 & 8.10).** A question was asked about willingness to support walleye stocking efforts on Buckatabon Lakes. Thirty-six respondents indicated they are not willing to support efforts with neither money or time, with most monetary support coming from donations ranging from $21-$50 **(Figure 8.11).**

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

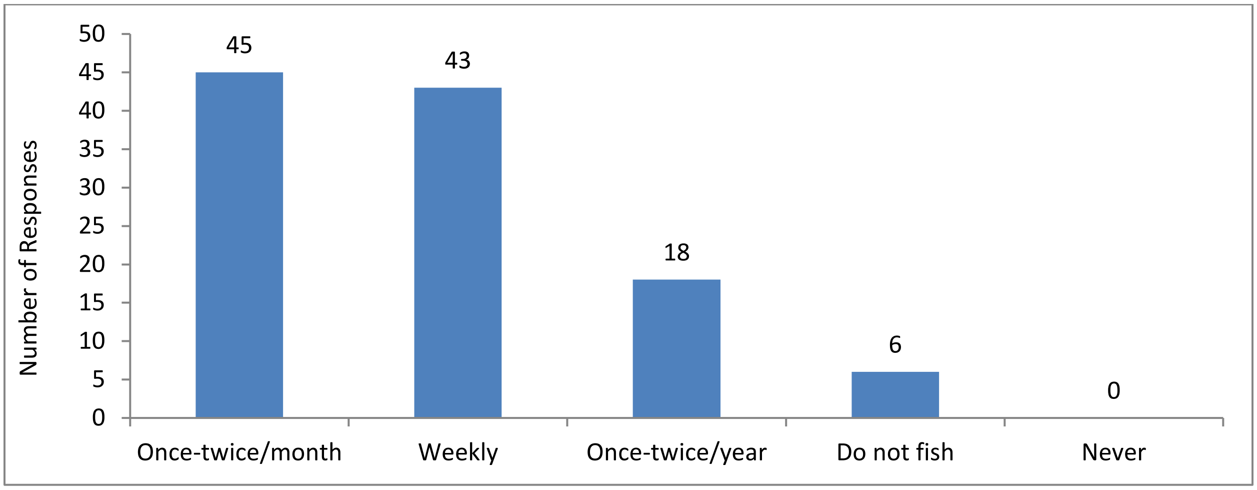


Figure 8.7: *In a typical year, how often do you fish Buckatabon Lakes during the ice-fishing season?*

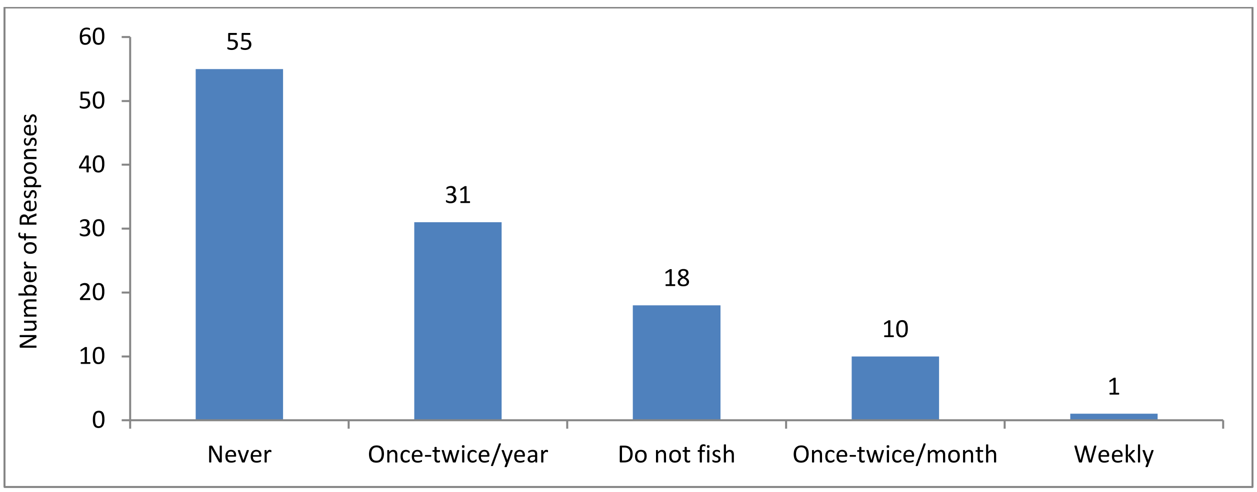


Figure 8.8: *What fish species do you catch when fishing Buckatabon Lakes?*

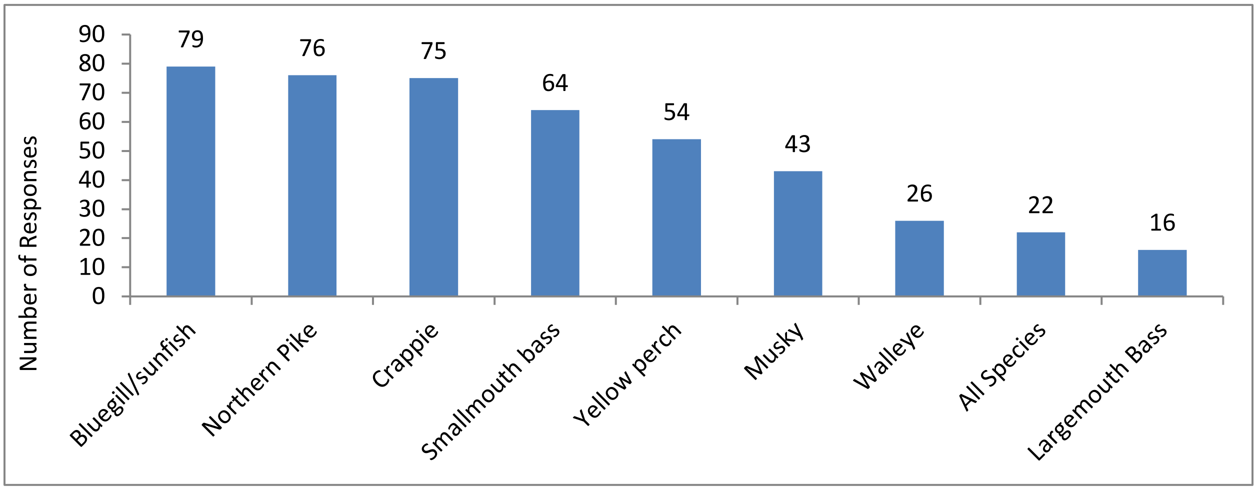


Figure 8.9: *How would you describe the current quality of fishing on Buckatabon Lakes?*

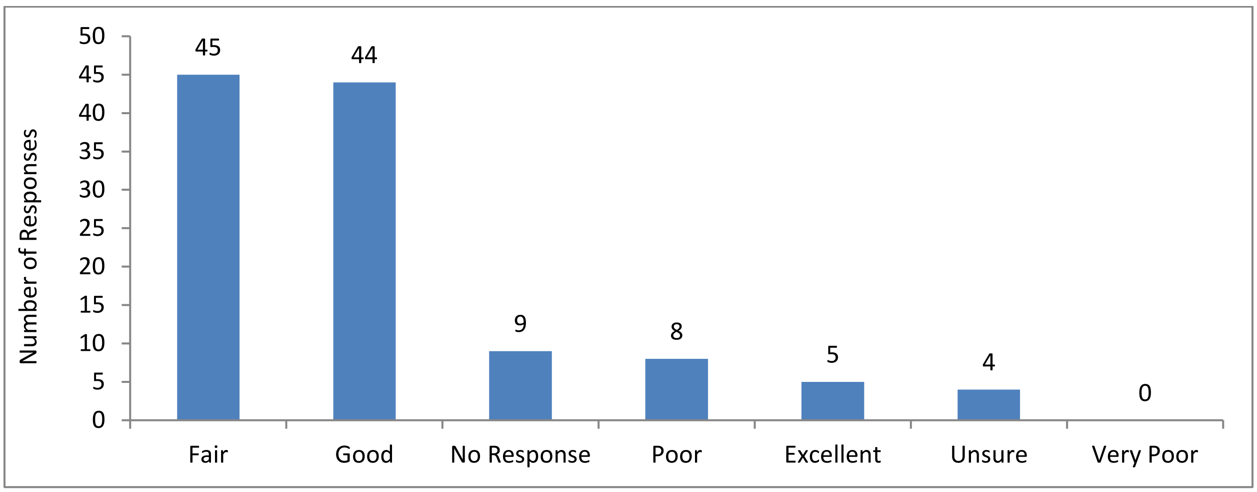


Figure 8.10: *How has the quality of fishing changed since you first started fishing Buckatabon Lakes?*

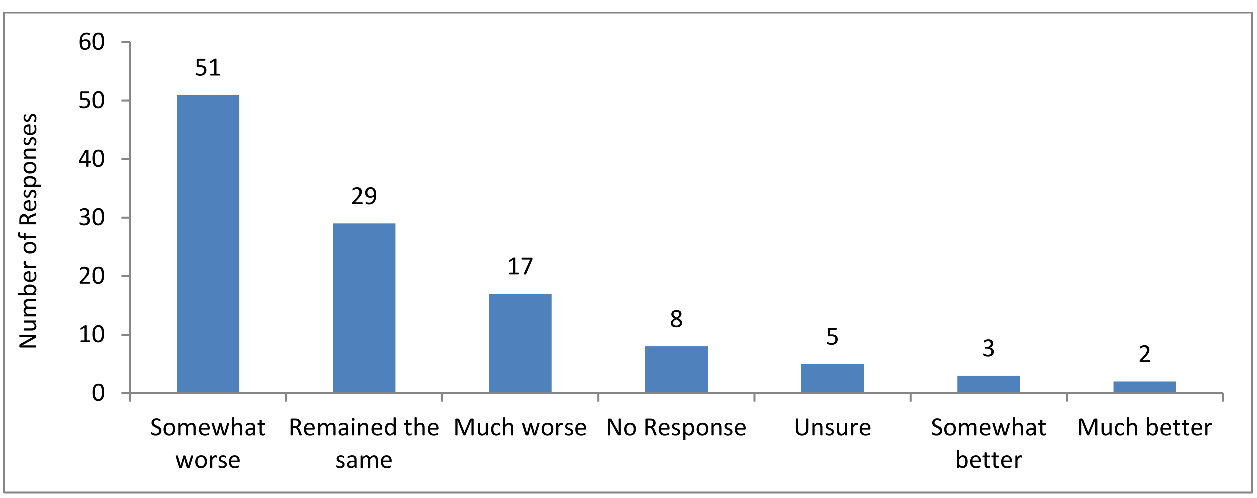
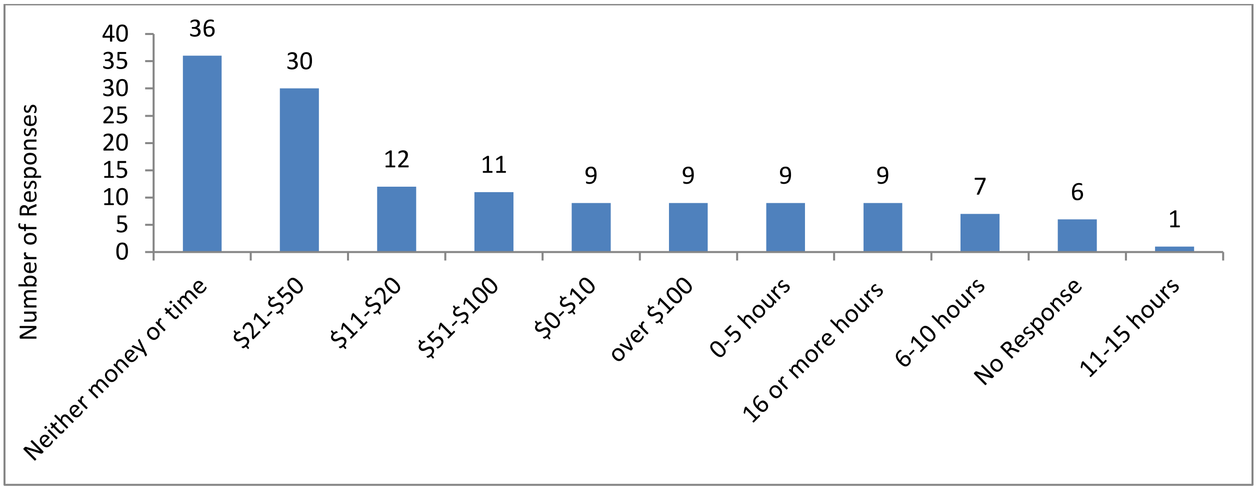


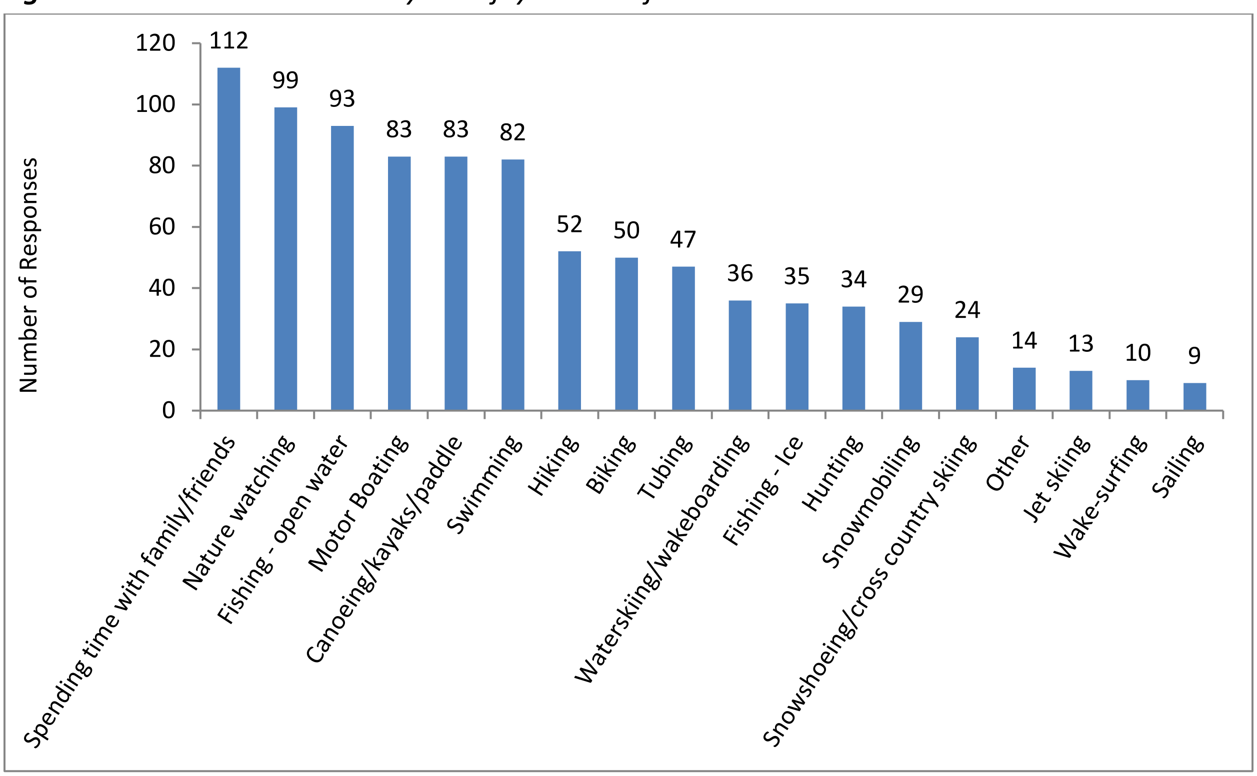
Figure 8.11: *Willingness to continue support for a walleye stocking program on Buckatabon Lakes.*



Lake Use - General

When asked which activities you enjoy on and adjacent to Buckatabon Lakes, the top responses included spending time with family and friends, nature watching, and open water fishing **(Figure 8.12).**

Figure 8.12: *What activities do you enjoy on or adjacent to Buckatabon Lakes?*



Watercraft Use

Most respondents own a watercraft, with pontoon boats, kayaks, and canoes being most popular (**Figure 8.13**). Residents primarily keep their watercraft on Buckatabon Lakes (~60%) and 40% did indicate they do use their watercraft on other waters **(Figure 8.14).** Those that do use their watercraft on other water bodies generally do some routine cleaning before putting their watercraft back onto Buckatabon Lakes **(Figure 8.15).** Eighty percent of respondents reported removing visual material from the boat and trailer, 61% drain the bilge and 57% drain the live well. On average respondents do three of the eight items listed.

Figure 8.13: *What types of watercraft do you use on Buckatabon Lakes?*

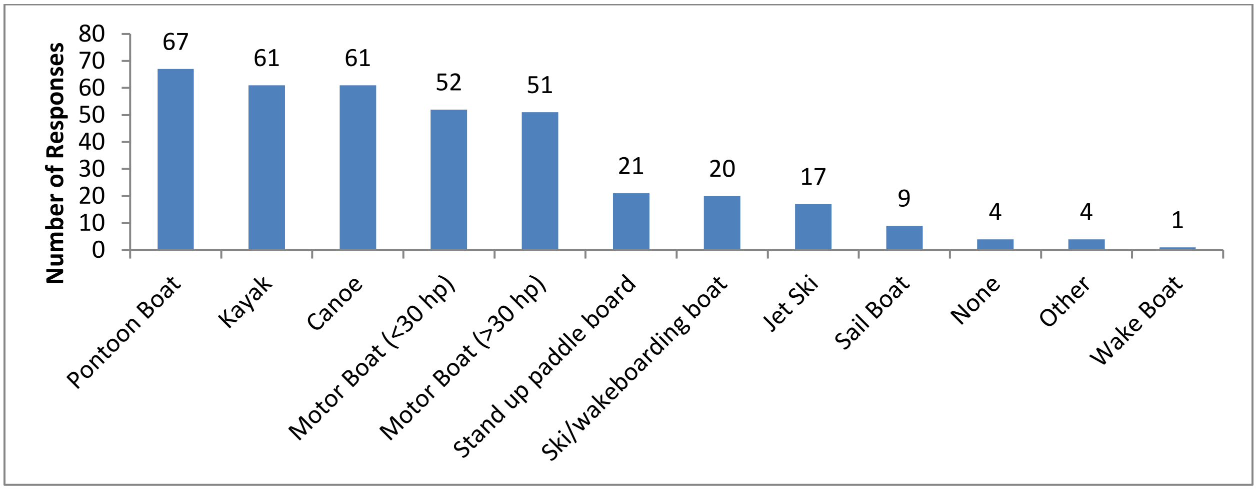


Figure 8.14: *Do you use your watercraft on other waters?*

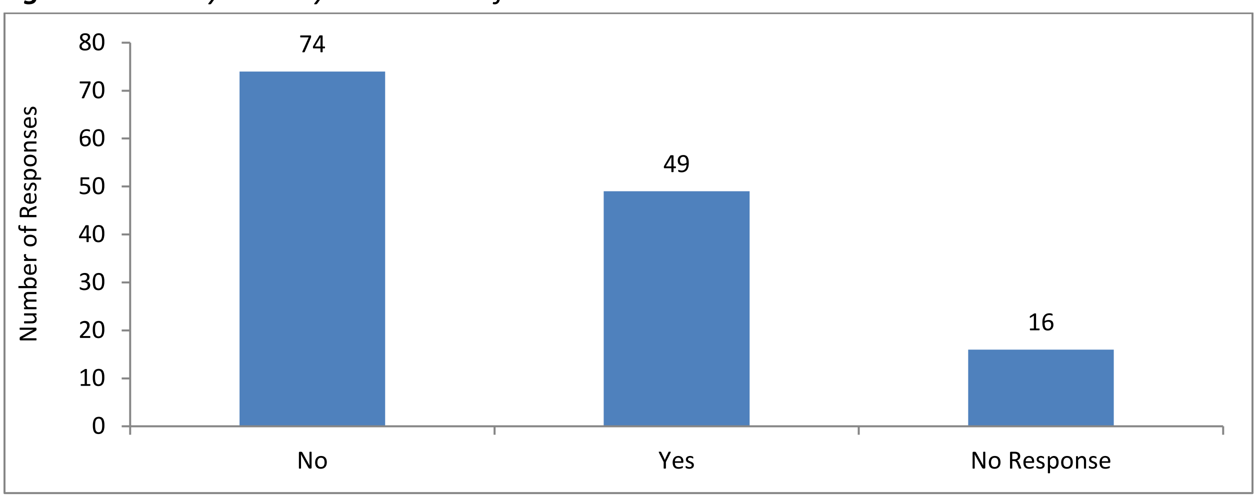
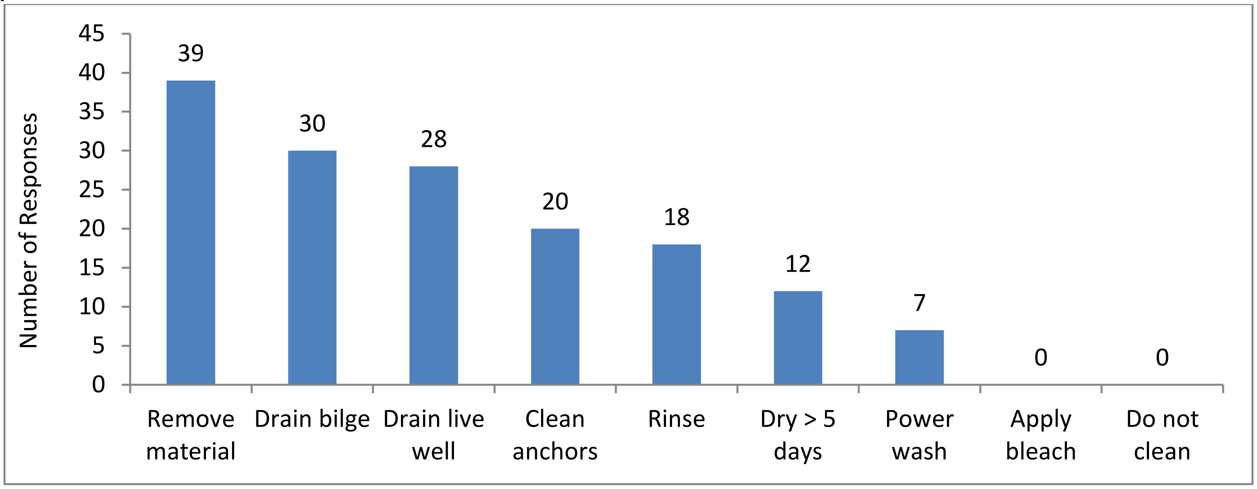


Figure 8.15: *If you use your watercraft on other waters, what is your typical cleaning routine after you visit another lake?*



Lake Health

A series of questions sought to gauge lake owners' perspectives on the current and past condition of Buckatabon Lakes and find out what they believe may be affecting lake health. Overall, 63% described Buckatabon's current water quality as good and ~42% felt the water quality has gotten worse **(Figures 8.16 & 8.17).** When asked what do you think when asked to describe water quality most respondents indicated water clarity and aquatic plant growth **(Figure 8.18).**

Figure 8.16: *How would you describe the current water quality of Buckatabon Lakes?*

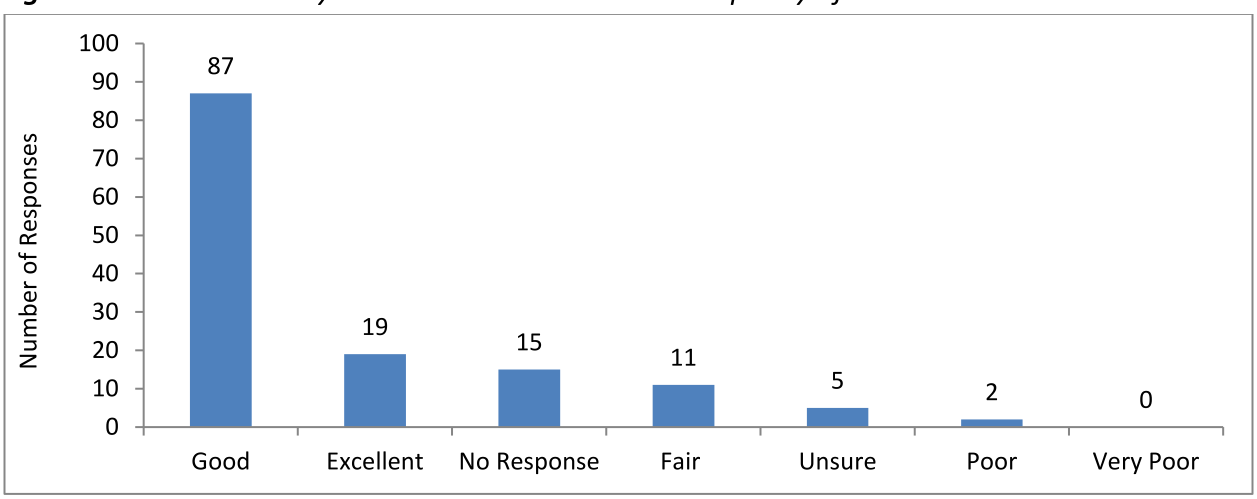


Figure 8.17: *Do you feel the water quality of Buckatabon Lakes has changed since you first started to visit Buckatabon Lakes?*

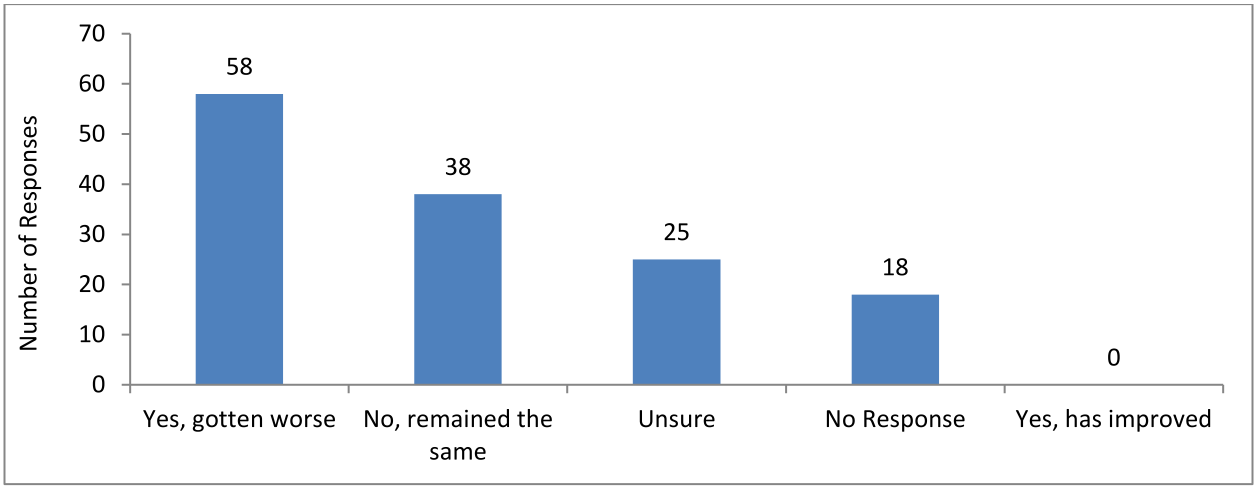
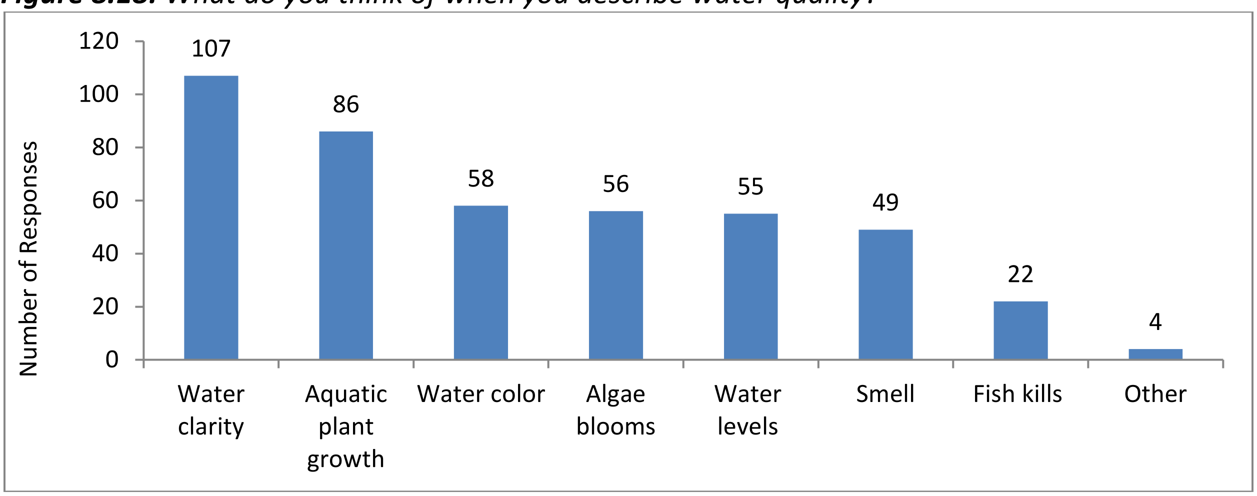


Figure 8.18: *What do you think of when you describe water quality?*



Most respondents (89%) had some knowledge of aquatic invasive species. Most believed aquatic invasive species are present in Buckatabon Lakes (71%) whereas 14% believe so, but are not certain. The three top invasive species believed to be present in Buckatabon Lakes include Eurasian watermilfoil, rusty crayfish, and purple loosestrife (**Figure 8.19).** Interestingly most respondents did not response to the question regarding if aquatic plants negatively impact enjoyment on Buckatabon Lakes but did indicate that algae rarely negatively impacts enjoyment on Buckatabon Lakes **(Figures 8.20 & 8.21).** Thirty six percent of respondents agree that aquatic control of *native* plants is needed on Buckatabon Lakes, 33% are unsure and 22% believe native plant control is not needed. Sixty eight percent agree that control of aquatic *invasive* plants is needed while 17% are unsure.

Figure 8.19: *Which aquatic invasive species do you believe are present in and adjacent to Buckatabon Lakes?*

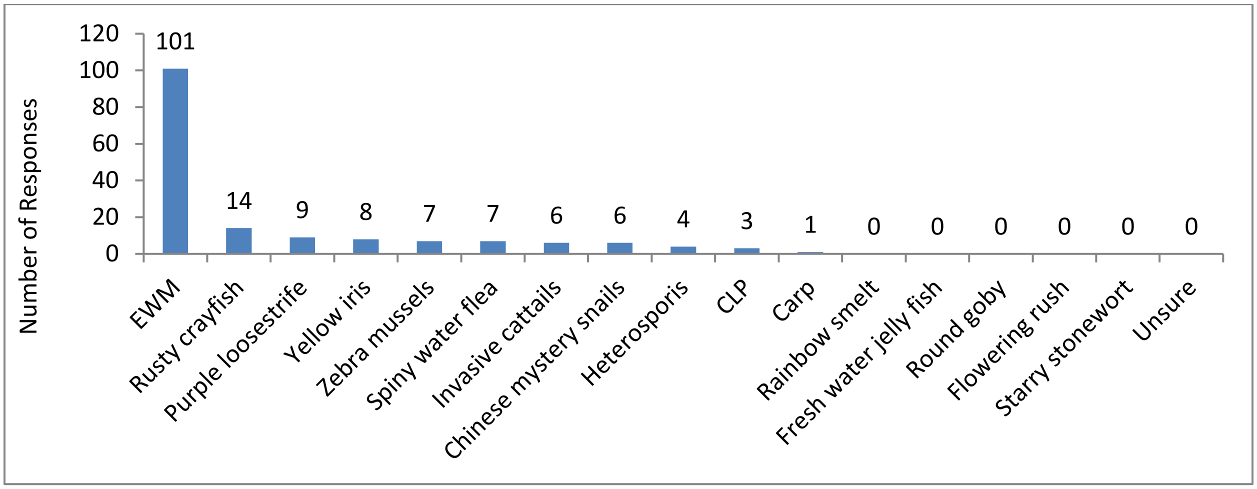


Figure 8.20: *During the open water season how often does aquatic plant growth (excluding algae) negatively impact your enjoyment of Buckatabon Lakes?*

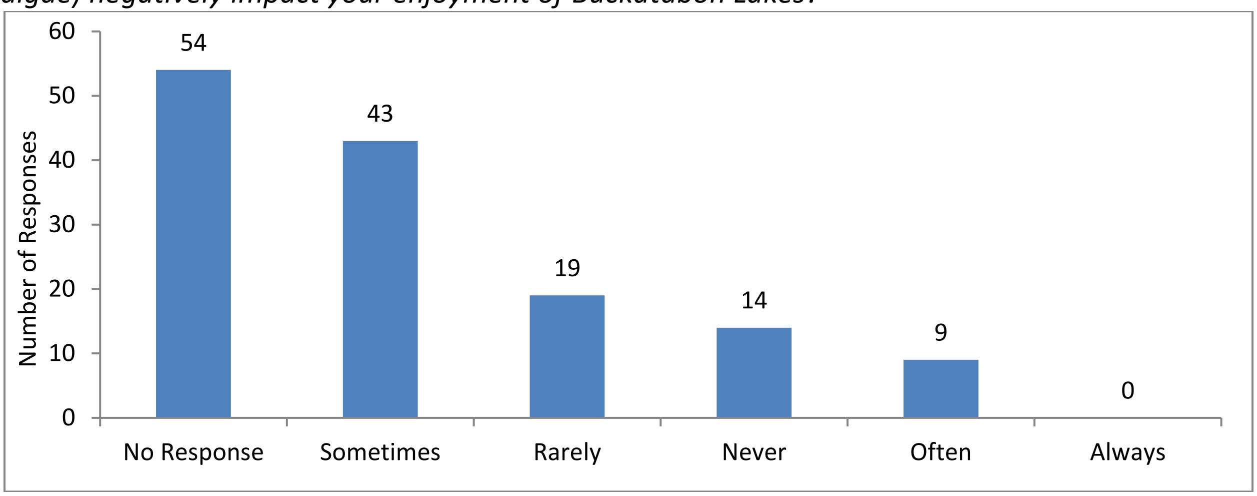
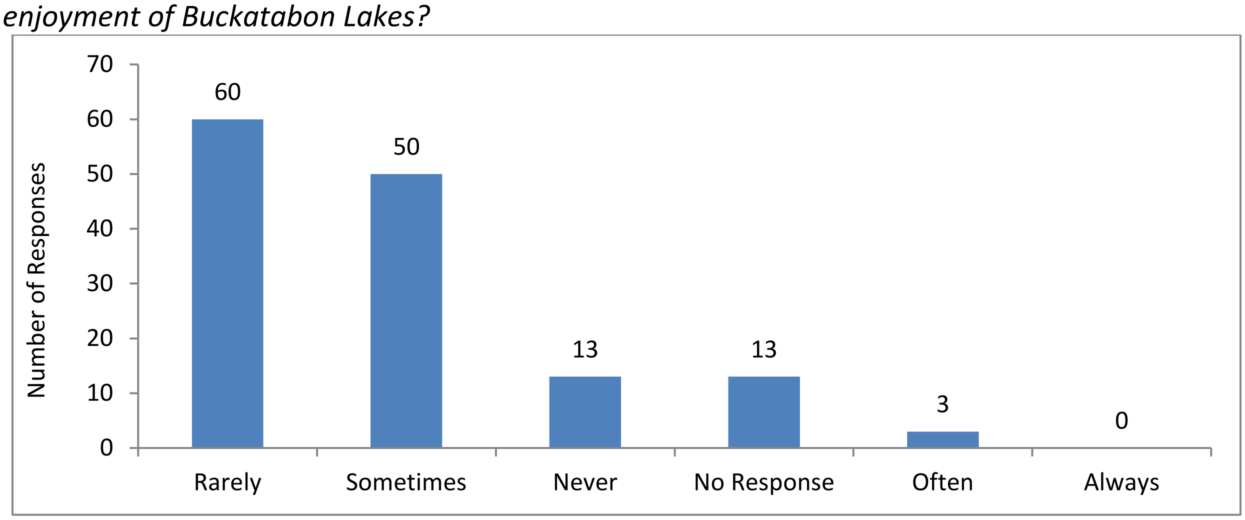
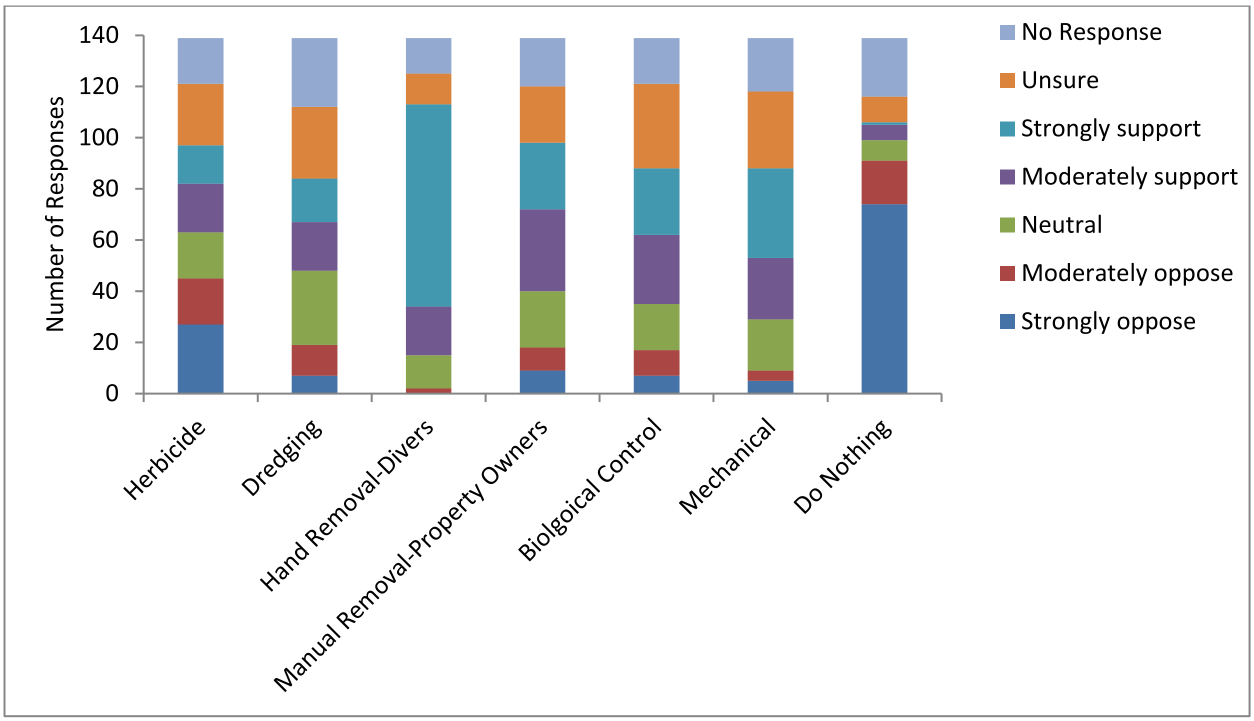


Figure 8.21: *During the open water season how often does aquatic algae negatively impact your enjoyment of Buckatabon Lakes?*



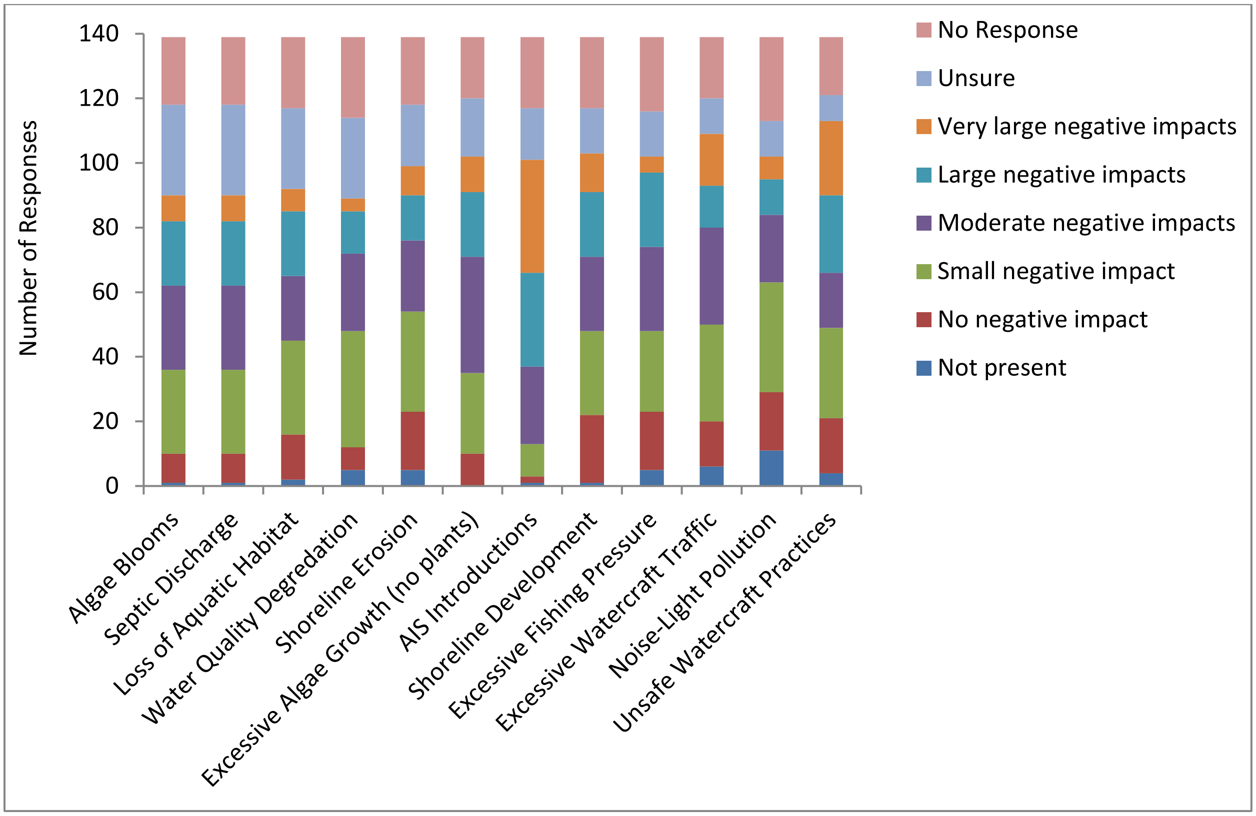
Respondents were asked to rank opposition or support for several aquatic plant management techniques **(Figure 8.22).** Fifty-three percent of respondents strongly oppose "doing nothing" as a management strategy for aquatic plants. Strongest support is for hand removal with divers (57%) and mechanical harvesting (25%). Strongest opposition is for herbicides (25%) and hand removal by property owners (6%). There is uncertainty about mechanical (21%) and dredging (20%) management options.

Figure 8.22: *Aquatic plants can be managed using many techniques. Please tell us if you oppose or support the responsible use of the following on Buckatabon Lakes.*



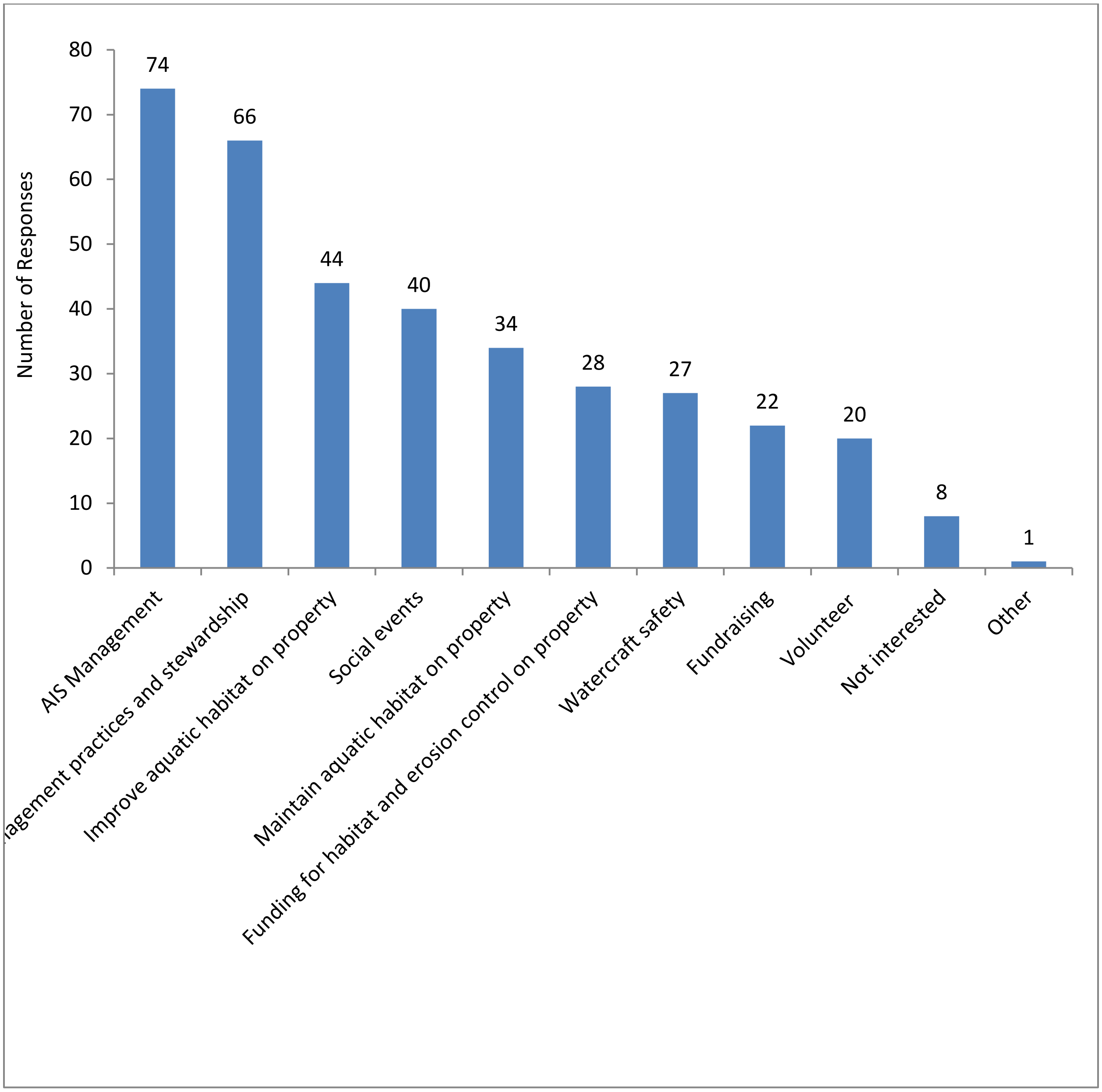
The next series of questions provide a list of possible impacts to Wisconsin lakes **(Figure 8.23).** Respondents were asked, "To what level do you believe each of the following factors may currently be negatively impacting Buckatabon Lakes?" Circling *not present* means the respondent perceives the issue as not existing on Buckatabon Lakes, whereas circling *no negative impact* means the issue may exist on Buckatabon Lakes but is not perceived to be negatively impacting the lake. Respondents indicated that aquatic invasive species introductions and unsafe watercraft practices are two very large negative impacts to Buckatabon Lakes. Issues that many respondents were unsure about include algae blooms, septic discharge, loss of aquatic habitat and shoreline erosion. Forty percent of respondents indicated that they feel they could control erosion and protect water quality on their property by engaging in tree management (40%), installing buffer strips (31%) and provide habitat for fish (28%). Forty-five percent indicated that they would be interested in learning more about funding for habitat improvement and erosion control on their properties.

Figure 8.23: *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 Buckatabon Lakes? 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 8.24).** The top three responses include AIS management, shore and land management practices, and improve aquatic habitat on property. Eight respondents indicated that they are not interested.

Figure 8.24: *What educational topics would you like to learn more about?*



Lake User Survey Summary

Though responses from Upper and Lower Buckatabon Lakes are summed in the analysis above, the data is not skewed disproportionally towards respondents on Upper Buckatabon nor Lower Buckatabon. Most properties are used seasonally, with 3-5 persons on average present when in use. Overwhelming respondents are Association members; however, only 22% of the total respondents indicated that they regularly attend Association meetings and events. It may be of interest to follow up on the lack of attendance and learn how to build participation capacity.

Seventy six percent of the respondents indicate that they fish, with preference to open water fishing versus ice fishing. The majority (62%) indicate they fish either once or twice a month or weekly. Most indicate catching panfish, northern pike, and crappie. General written comments point out the lack of walleye and too many large mouth bass. However, large mouth bass are indicated as the least caught species when asked which species do you catch while fishing. Several comments regarding fishing indicate support of a walleye stocking program, however, there appears to be less support to these efforts either in time or financial contributions indicated in the survey. Of those that responded to the question, 27% indicated they are not willing to contribute time or money to further stocking efforts.

Of those that use their watercraft on other waters, 20% indicate that removing material from their watercraft was <u>not</u> part of the cleaning routine. Forty percent do not drain their bilge and forty-three percent do not drain their live wells. However, respondents indicated that their routine includes three of the eight cleaning measures listed. Most respondents indicate some knowledge of aquatic invasive species and 71% are confident that aquatic invasive species exist in Buckatabon Lakes. Respondents generally agree that aquatic invasive species introductions negatively impact the lake (63%), 12% are unsure, 16% did not response, and less than one percent indicated that AIS introductions are not present on Buckatabon Lakes. Most strongly oppose a “do nothing” approach to AIS management, followed by the use of herbicides. Whereas hand removal with divers and mechanical harvesting received the strongest support.

Respondents most commonly described water quality in term of water clarity. Water clarity can change throughout the season and be impacted by natural and manmade factors such as natural tannins in the water, giving the water a stained appearance to excessive phosphorous from the landscape that fuels algae blooms. Aquatic plant growth, second to water clarity respondents indicated as a measure of water quality. More respondents (35%) indicated the need to control of native plants on Buckatabon Lakes whereas 22% indicated control is not needed. Interestingly, when asked if aquatic plants are negatively affecting enjoyment on the lake, 39% of respondents did not answer that question. Whereas 31% indicated that aquatic plants sometimes negatively impact enjoyment on the lake.

9- PLANNING REVIEW

5/25/2018 Lake management grant organization meeting. This meeting reviewed the lake planning grant scope of work and timelines and organized task responsibilities including local share, board involvement, grant paperwork and identifying a working group to be responsible for facilitating the lake user survey.

10/11/2018 & 12/17/2018 Lake user survey development. The board reviewed a draft of a riparian survey scope and discussed additional lake user groups to be included in the survey. Additional groups identified included residents within a certain distance from the lake, those that recreate on the lake that access from the boat launch, resort guests, and Buckatabon Lodge residents. To address the different lake users, surveys specific to those lake users would need to be developed. This would ultimately require the development of many different surveys. Privacy concerns and the additional work that may have been required by resort and Buckatabon Lodge owners were two additional issues that arose. After a lengthy discussion it was decided that for this project, the riparian owners would be the primary focus of this survey. Down the road, in plan updates, additional lake user groups may be included.

Updates to the planning process and data collected were provided during regular board meetings. Originally this planning process included a hands on planning activity ("charrett") detailed in the grant proposal. This did not occur, due to the current Covid situation. A plan review was conducted online with board and committee members.

8/14/2020 & 10/14/2020 Lake management plan review. These two meeting reviewed the current draft of the plan and action plan. Round table comments were received, outlying questions were answered, and a discussion on the next step of the review process was detailed. This process included how to solicit input and comments from the general lake community on the plan. The BLA will use its newsletter and an electronic link to the planning document to solicit feedback from membership. Identified board members would receive comments and address questions.

The intent will have the plan approved and ratified by the BLA membership in 2021 during their annual meeting; however, given the current status 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 understand the current ecological condition of the Buckatabon Lakes and develop actions that support its aesthetic qualities and ecosystem health over time. Additional goals include identifying ecological threats and formulating responses to them; maintaining high quality aesthetic and recreational opportunities; engaging and educating the lake community; and developing actions that conserve native species and their habitats. The vast majority of data collected for this project focused on in-lake and riparian habitat features commonly measured to monitor health of a waterbody. Specific monitoring standards collected a wealth of ecological data on Buckatabon Lakes 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.

During an annual association meeting in 2018, lake residents were asked to write down their perspective to the following question: "What makes Buckatabon Lakes special to me?" Attendants that participated in the exercise described a lake rich in history and a lake community with "caring neighbors." Many described times with family, friends, and spending quiet time with nature.

Written highlights include:

- *Buckatabon Lakes have a good sense of wilderness feel but still provide a community of good caring neighbors*
- *Family time on the water!*
- *Beautiful, peaceful, fishing, recreation*
- *I have so many wonderful memories here and hope to someday bring our grandkids here as well*
- *Best place in the world to get great sleep*
- *Pride to be part of such a special and beautiful place*

As discussed in the fisheries section, Upper and Lower Buckatabon Lakes are considered complex two-story fisheries. These lakes support cold-water fish such as cisco and four or more game species such as northern pike, musky, walleye, and bass. Lakes in the Upper Midwest are warming, resulting in habitat and fish community changes.[28] Future predictions for Wisconsin estimate by 2050 an average increase in temperature by 3-9˚F, increased number of 90˚F plus days and warmer winters (WICCI, 2019). Lakes will remain stratified longer and oxygen concentrations will have more time to decline during this period. High intensity rain events will lead to increase run-off and nutrients entering a lake, reducing water quality and impairing aquatic habitat. As waters warm, many lakes that that once supported cold-water fish and natural walleye reproduction are unlikely to continue to do so into the future. Building climate resilience in lakes through conservation practices such as protecting habitat and minimizing run-

[28] https://labs.waterdata.usgs.gov/visualizations/climate-change-walleye-bass/index.html

off, improves the capacity that lakes will have to buffer against future stressors and thereby help preserve cold-water and other important game fish habitats.

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 minimize runoff to the lake. At the watershed level, land cover consists mainly of forests and wetlands, which allow water to infiltrate rather than run over the landscape picking up pollutants that may enter the lake. The Vilas County Land and Water Conservation Department is planning to conduct detailed watershed assessments beginning in 2021, contingent on their (Vilas County) funding sources. These assessments will provide further information and analysis of the current condition of the Tamarack Pioneer Creek watershed, where Upper and Lower Buckatabon Lakes are located.

Shoreland development continues to increase on lakes within the Upper Midwest Region, which trends towards poorer water quality and overall nearshore habitat degradation. Watershed land use and cover may drive the "big picture" of Upper and Lower Buckatabon Lakes 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.

Upper and Lower Buckatabon Lakes supports a robust and diverse aquatic plant community. The aquatic plant data suggests that the aquatic plant communities in both lakes is above average compared to lakes in the State (WI) and within the Northern Lake and Forest Region. A small change occurred in the lake-wide littoral presence of EWM in Upper Buckatabon Lake between 2015 (0%) to 2019 (1.80%) and no littoral presence of EWM was detected on Lower Buckatabon. Though these values appear low, monitoring suggests that EWM has increased annually from 2015 to 2019, with large increases seen between 2017 and 2019. The future approach for EWM management may vary from year to year depending on resources and annual conditions observed. Education and prevention should be key elements to any management program in the future.

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[29], and expected outcomes. This document is intended to be adaptive, requiring periodic review to be responsive to new information, priorities, and needs. According to the WDNR, a formal plan update is required every five years to maintain grant eligibility for AIS control projects. This update would include updating lake studies, goals, objectives, re-prioritizing needs and review of accomplishments.

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

A take away message from this plan is to highlight the many aspects of Buckatabon Lakes that are special from its natural habitats to its rich local history.

- Buckatabon Lake's floristic quality is above average for Wisconsin lakes and specifically above average for neighboring lakes in Northern Wisconsin. Meaning, Buckatabon Lakes has a diverse and healthy aquatic plant community.
- Overall, there are relatively few invasive species, most of which have management options. Some lakes have invasive species, such as zebra mussels or spiny water fleas, which there relatively few solutions for. These species cause dramatic shifts and irreversible changes to ecosystem food webs including loss of microscopic organisms to top predator fish.
- Lake residents began to detail the historical accounts and land ownership exchanges of Upper and Lower Buckatabon Lakes. This project will be on going, but a good portion of Upper Buckatabon historical land records have been compiled.

Besides invasive species, other challenges for Buckatabon Lakes include:

- Cisco and other important game species habitat may be threatened due to warming waters and other impacts of climate change.
- The WDNR considers both Upper and Lower Buckatabon Lake's water quality impaired due to phosphorus levels exceeding what they should be for a two-story lake.
- Seventeen percent of properties on Upper Buckatabon have some degree of erosion greater than one foot in height compared to 1% of Lower Buckatabon.
- Thirty-four percent of properties on Lower Buckatabon have some degree of rip-rap (coble stone rock) along the water's edge, compared to 4% of Upper Buckatabon.

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

- 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, Buckatabon Lakes could benefit from:

- Educational and hands on learning opportunities
- Protection of existing natural shoreland habitats
- Improvement of marginal shoreland habitats for aquatic life and protecting water quality

The overarching aquatic plant management goal for Buckatabon Lakes is to balance the diversity of lake uses with sound management practices that address both short and long-term lake health. Objectives will use the guiding AIS management principles detailed earlier in this plan (*pg 31*). Additional goals that support the short and long-term management of aquatic plants include:

- Build lake community capacity to support project goals and objectives
- Continue monitoring water quality and ecosystem health
- Promote conservation of native species, their habitats, and water quality protection

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

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

Action (1) Create an 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 and septic system maintenance.
- Update membership on fish stocking efforts.
- 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 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) Continue monitoring water quality and ecosystem health.

Objective (1) Monitor water quality

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

Timeframe: Ongoing

Role/Responsibility: Volunteer

Expected output/outcome: Volunteers are responsible for collection and submission of water quality samples to the State of Wisconsin and sharing information with association committees and membership. Report findings to SWIMS. Participation in this program will continue to build long-term water quality data for Buckatabon Lakes.

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

Objective (2) Manage invasive species

Action (1) Continue management of EWM.

Timeframe: Ongoing

Role/Responsibility: Board/Volunteers/Other resource professionals

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

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

- Use integrated pest management. Integrated pest management is a framework that relies on a combination of management practices instead of a single approach. *(pg 32).*
- *Develop annual monitoring and evaluation strategies based on the annual strategies deployed. These will vary depending on scale. (pg 32).*
- Continue to track volunteer and paid management efforts.

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

Timeframe: Ongoing

Role/Responsibility: Volunteers/Resource professionals

Expected output/outcome: Continue to monitor EWM management including the effectiveness of the control techniques used with consideration to scale and impacts to non-target species.

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

Timeframe: Ongoing

Role/Responsibility: Board

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

Objective (3) Prevent the spread of aquatic invasive species to and from Buckatabon Lakes.

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 Buckatabon Lakes. 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.

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