Smoky Lake

Vilas County, WI & Iron County, MI

Comprehensive Lake Management Plan

Vision

"To preserve and enhance the ecological integrity of Smoky Lake and its surrounding habitat by promoting policies and practices that support ecosystem stability and resilience, recreational opportunities and the qualities which make Smoky Lake beautiful."

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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 Smoky Lake 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.

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 **(EPA, 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 Smoky Lake. This establishes baseline information to detect change that might identify and guide the need for future action.

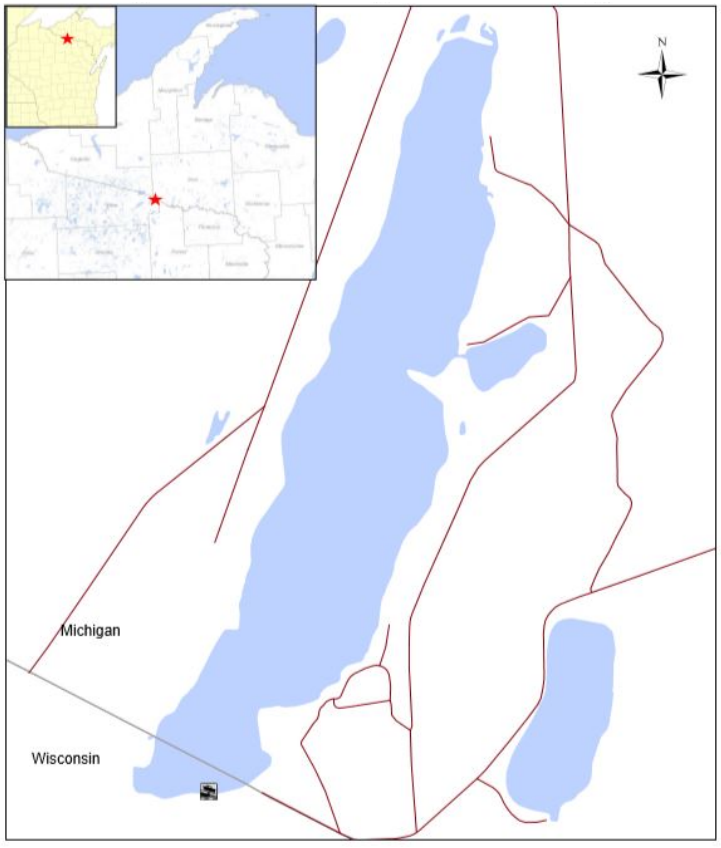
The vast majority of data collected for this project focused on in-lake and riparian habitat features. These features relate well to understanding and describing the health of a lake and its surrounding landscape. In addition to inventorying the ecological condition of Smoky Lake, a description of historical, social and governance context is included. The historical and social context chapter summarized some of Janet Adam Oatman's "Historical Sketch" revised 2006; it should be read as a compliment to her original work. Much of the social and organizational history lies in older documents including meeting minutes, letters, and other correspondence. To understand the differences in land regulation on Smoky Lake, a section comparing Vilas County, WI and Stambaugh Township, MI zoning ordinances is included. The plan has a five year scope; however, periodic review is recommended to insure content is relevant to the current situation.

All readers are invited into the lake management planning process to gain a better understanding of the scientific data, research findings, community perspectives, and organizational information presented in this report. Fully considering the detailed contents of this plan, it is possible to identify and affirm the goals, objectives, and strategic action plan recommendations offered to preserve Smoky Lake for the generations. This engagement is the essence of lake stewardship, and your participation is greatly appreciated.

1.0 INTRODUCTION

Smoky Lake, located in Vilas County, WI and Iron County, MI, is a 612-acre two-story lake with a max depth of approximately 70 feet (WDNR & MDNR). The Wisconsin Department of Natural Resources (WDNR) considers Smoky Lake's general condition excellent for recreational use, fish and aquatic life and fish consumption. The Town of Phelps, WI owns and operates a public boat launch and recreational facility at the southern end of the lake. Riparian ownership includes the Town of Phelps, State of Wisconsin, Wisconsin, and Michigan riparians.

Map 1: *Smoky Lake Location- Vilas Co., WI & Iron Co., MI*



Located in the Deerskin River watershed, land cover consists primarily of forest and wetlands with a small portion in other uses. The Deerskin watershed consists of two ecological landscapes. The North Central Forests encompass roughly two-thirds of the watershed to the north and the Northern Highlands to the south. Smoky Lake is located within the North Central Forests landscapes. Soils consist of mainly sandy loam, sand, and silt. Historical vegetation mainly consisted of hemlock-hardwood forests dominated by hemlock, sugar maple, and yellow birch with pockets of white and red pine forests. Over-harvesting of hemlock during the turn of the century and lack of natural regeneration results in hemlock being a minor component of these forests today.

2.0 HISTORICAL AND SOCIAL CONTEXT

2.1 Settlement and Development History

An interesting history of Smoky Lake was documented by Janet Adam Oatman's "Historical Sketch" revised 2006. This section is not meant to replace her work, but compliment and augment the historical outline she presents, and provide more recent lake history.

It appears that Smoky Lake's dramatic, glacially carved shoreline and clear, deep water has been admired by a succession of human inhabitants: Native Americans, explorers, lumbermen, farmers, and settlers. Some of these families are still part of the Smoky community today. When the first Anglo explorers came to the region in the mid 1800's, the area around Smoky Lake was known as KA-TA-KIT-TE-KON Country, land of the Lac View Desert, CHI-CA-GON, and Badwater Native American's. These tribes were related and spoke the Ojibwa dialect, calling Smoky Lake GI-CHI-SHE-GA-MAG: Big Swift Lake.

One of the first Anglo explorer-Native American interactions occurred when Captain Thomas Cram set out to survey the Wisconsin/Michigan border in 1841. There was resistance on the part of the Native Americans to allowing Cram the right to pass through KA-TA-KIT-TE-KON Country, but eventually Cram purchased a right-of-way and limited privileges through the Country, using the overland Native American trail, and pioneering a shortcut between the Brule River and Lac View Desert across Smoky Lake.

The area including Smoky Lake was in the middle of an early "thoroughfare" for miners and early settlers moving west. Until the Northwestern Railroad was extended between Iron River and Watersmeet, MI in 1888, the former Native American trail, later called "state line" foot was the only way for miners and settlers to travel between Iron River and the Gogebic Range. The trail, though a grueling walk, was well traveled in the mining rush around 1885. Smoky Lake proved a significant obstacle on the "state line" trail. An entrepreneurial Native American operated a ferry out of his cabin on the west side of the lake. If he was not at home, travelers had a long detour around the south end of the lake, sometimes staying overnight in his cabin.

The logging era of roughly 1890-1935 also left its mark on the lake. Pines were logged off by the first loggers to reach the area in late 1800's, as they were easy to float away. Timber demand was high in cities rapidly growing with the Industrial Revolution. Around 1900, the Hackley Phelps Bonnell Co. acquired large tracts of timber in Township #43, which still contained high quality hardwood stands. Four lumber camps (Camps 6, 7, 8 & 9), early access roads, and a railroad spur from Phelps, WI (1906-1908) facilitated the movement of logs to sawmills and factories. Logs harvested with horse drawn sleds were skidded across the lake in the winter and loaded from various landings into freight cars. Oatmen mentions an early ice break up in 1915 causing many hardwood log piles (that don't float well) to be lost in the lake before they could be skidded to Camp 8, which served largely as a railroad camp and the main point of departure from the lake. This railroad causeway was built from timber and did not contain any culverts, serving to effectively dam the drainage from the higher elevation of Smoky Lake into Sand Lake.

Some of this timber still provides fish habitat today. In the summer, a tugboat gathered logs from various landings and rafted them to Camp 8, on the southwest edge of the lake. Reportedly, it was the clouds of white smoke settling over the lake from these freight trains that led to the lake being named "Smoky Lake." The logging era contributed the name, ecological and infrastructure impacts, and movement of people. The logging industry enticed many farm settler families to the area, knowing that clearing the dense forest for their farms would produce large quantities of lumber for the sawmills. These early settlers were of Finnish descent, moving primarily from Minnesota. Ms. Oatman's "Historical Sketch" details family names, dates, and locations of early farmers purchasing property around the lake and has been updated in various editions to record subsequent purchasers over the years.

Smoky Lake and the Big Sand Lake Club also have an intertwined history. The Club, with land adjoining the south end of Smoky Lake in Wisconsin, started operation as a hunting and fishing club in 1899. Its development and utilization of Smoky Lake for its vistas and fishery, initiated a long-standing history of recreational use of Smoky Lake, attracting people of means to this area for hunting and fishing. The "Northwood's hunting camp" was attractive to wealthy entrepreneurs from Chicago in particular and formed the next generation of landholdings during the 1920-30s. As the lavish hunting camps were springing up, so did a Scandinavian settlement on the southeast end of the lake. These were smaller summer home cottages owned by Finnish descendants mostly from the Chicago area…as the area reminded them of Finland.

The next significant development at Smoky Lake was the purchase of what would become the Smoky Lakes Estates property by C.M. Christiansen Company. The land was purchased from the Von Platten-Fox Company C.M. in the 1940's. C.M. Christiansen died in 1957, with Phil and Robert Christiansen inheriting the holdings of their father. Phil Christiansen continued to manage the sawmill in Phelps, while Robert moving to Milwaukee to work in advertising. In about 1966 the Smoky Lake Reserve was created, with the land fenced using a 10 ft. chain link fence topped with barbed wire; the initial acreage being about 600 acres. Over time the acreage was increased to include approximately 5,000 acres within the fence, with additional acreage of 6,000 beyond the fence. It was initially stocked with elk from Yellowstone and Alaska, moose from Alaska, caribou and other stock traded with the Milwaukee Zoo. Two cabins were available for rental on the grounds. The Reserve was inspired by the Sylvania tract property in the Upper Peninsula, where C.M. Christiansen was a once a part owner.

At about the same time in the mid-60's, the brothers created the Smoky Lake Corporation owned largely as equal owners by the brothers, with a third party having a minor share. Dirk de Young served as the real estate developer representing the corporation as primary agent in the transactions. The first step was to develop an access road that brought electric and phone service to eventual owners. The land on the western shore north of the Wavering (now Shotwell) property was platted by the Town of Phelps in two stages up to the Murphey property at the top of the lake.

The Murphey property and some other parcels including the Corig-Hansen (formerly Cousins now Kohne) property, the Oatman, Svoboda, and Ruck properties, and the parcel that would eventually become the Smoky Lake Lodge, pre-existed the creation Smoky Lake Estates and are not numbered lots.

The proposal for a third plat on the eastern shore was not approved by Stambaugh Township but the remaining property was sold off in individual metes and bound divisions. The parcels on the east shore were ¼ mile deep, with 400 feet of frontage and only one house permitted per 250 feet of lake frontage.

As a developer, Phil was interested in modeling the Estates along the lines of a private and exclusive hunting property, with locked gates initially installed at both entrances to the Estates. During hunting season, Phil would control access by closing the east gate, where he had a private hunting ground just east of the access road. All properties in the initial two plats and the individual metes and bounds parcels were sold with covenants and restrictions drafted in 1963 intended to run with the deed **(Appendix A).**

Once the lake real estate lots were sold, the Smoky Lakes Corporation was liquidated and dissolved between 1982-90. Eric Christiansen, Robert's son, retains an interest in property on Spirit Point and a daughter of Phil, Gail Cervera, is the former owner of the Smoky Lake Lodge, (now Despot.) The access road property was sold to the Smoky Lake Access Road Corporation.

2.2 Smoky Lake Organizational Foundations and Timelines

2.2.1 Lake Association Formation

Smoky Lake is a Michigan/Wisconsin border lake with much of its property in Michigan. The border lake status brings differences in areas such as riparian rights, zoning, DNR regulatory, management and grant strategies, fire, emergency, police, and medical services. Even the matter of postal delivery is made more challenging as mail for lake owners is delivered with a Phelps Wisconsin address despite property being located over the Michigan line. Fortunately, the lake owners sought to work together to consider concerns and find solutions.

Landowner participation in the social/organizational evolution of Smoky Lake began with the formation of the Smoky Lake Property Owners Association in 1971.

The initial objectives offered at the first meeting held on July 4, 1971, helped set the tone and shape direction for the new association:

- "To furnish a means by which the point of view of property owners on Smoky Lake may be organized and expressed on any and all matters affecting their interest."
- "To develop the Smoky Lake area in a way that will maintain to the maximum extent its present appearance and character."

- "To provide a means for deciding upon and financing develop projects that require community use or agreement."
- "To embrace the point of view of property owners both on Smoky Lake Estates and on other property fronting on the lake."

The agenda topics at this meeting were also indicative of the broad range of property owner concerns that in many cases framed organizational discussions in the decades ahead:

- Power lines
- Sanitary Codes
- Building Setbacks
- Subdividing
- Boathouses
- Minimum Improvement
- Access Road
- Boat Control
- Watchman's Service
- Marker signs
- Business usage
- Property Owners Association
- Tree Screen

Additions to the agenda included:

- Preliminary study of pollution protection under current codes,
- Fish populations, and
- Porcupine Lake access

The introductory letter accompanying the meeting signed by C.W. Sorenson, Dirk de Young, Jack T. Hammond and P. B. Warner summary notes the protective attitude of the owners toward Smoky Lake and closes with a quote from Thoreau's Walden:

"A lake is the landscape's most beautiful and expressive feature. It is the earth's eye; looking into which the beholder measures the depth of his own nature".

At the second meeting held in Kenosha, Wisconsin on February 19, 1972, it was unanimously agreed, "an informed, loosely-structured property owners association be formed"[1]. The first officers were Peter Werner, Chairman, Dirk De Young, Secretary and Casey Apolinski, Treasurer.

[1] Source: Meeting summary February 19, 1972

2.2.2 Dual Corporations Serving the Lake

Smoky Lake Property Owners Association, Inc. (SLPOA) was incorporated in 1980 as a Michigan non-profit corporation. At incorporation, its stated purpose was "To promote the health, safety, and general welfare of members."

The discovery of invasive species in 2013 prompted significant activity to preserve Smoky Lake. Wisconsin Department of Natural Resources (WDNR) grant funding for Eurasian watermilfoil remediation and lake planning came to drive some organizational changes in 2015-16. The Michigan organization revised its bylaws to conform with WDNR grant standards and developed a restated purpose: "to preserve and protect Smoky Lake and its surroundings and make improvements to enhance the water quality, fishery and aesthetic values of Smoky Lake as a public recreational resource for today and future generations."

Being served by a Michigan organization, Smoky Lake's access to WDNR funding could only be obtained through a sponsorship, which was formed with the Town of Phelps, as a government entity eligible to receive WDNR grant funds. The association determined that it would be in its best interest to form a Wisconsin corporate entity to be able to access WNDR funding more directly.

Bylaws for the Wisconsin non-profit corporation, Smoky Lake Preservation Association, Inc. (SLPA) were approved on July 30, 2016 and filed on October 24, 2016. An application was made to the IRS for approval as a 501c3 organization. It was approved on January 26, 2017, retroactive to October 24, 2016, making donations tax deductible for donors. SLPA was granted WNDR status as a Qualified Lake Association on December 11, 2017 and able to apply directly for WDNR funds without the need of sponsorship.

On July 30, 2016, the members of the Smoky Lake Property Owners Association members voted to approve the dissolution of the Michigan entity. The organization would remain in existence until the conclusion of the WDNR Lake Management Plan Grant to honor the Memorandum of Understanding with the Town of Phelps and the representations made in support of the Town of Phelps Resolution filed in conjunction with the WDNR grant application for Smoky Lake. The grant was expected to wrap up December 31, 2018, but the grant period was extended to December 31st, 2019. Following the conclusion of this grant SLPOA will be dissolved, with the Smoky Lake Preservation Association continuing to serve lake interests.

The 2016 bylaws are largely identical between the groups and envision a concurrent Board of Directors and Officers elected by members at the annual meeting.

2.2.3 Association Management

The board of directors is charged with managing the business of the organization, with officers elected for the roles of president, vice-president, secretary, and treasurer. Though committees are not defined in the bylaws, several committees have been formed to address ongoing concerns over the years. In the early years of the organization areas of concern included zoning, basic service such as road access, phone service, fishing and boating courtesy rules were

handled by ad hoc committees or individuals that reported back at the annual meeting. Currently the Conservation Committee, which evolved from the Aquatic Invasive Species (AIS) Committee, is charged with environmental concerns including: lake management planning, AIS remediation and monitoring, grant management and reporting, elevation and water quality data, Clean Boats Clean Waters inspections, Town of Phelps Lake Committee representation, and wildlife reports.

2.2.4 Association Business

Zoning

Right from the outset the association sought to work with Stambaugh Township to address zoning concerns. At the second meeting, the Chairman reported that he attended Township zoning meetings to work out discrepancies in the ordinance relative to lake development needs. One of these included a limitation that did not permit year-round residence on the lake. Others related to the area for lots and minimum frontage, with these being inconsistent with existing conditions and future development needs. Other early issues related to business usage and the acreage involving Porcupine Lake.

Property setbacks for lake frontage were also a matter of concern and were inconsistent with some Michigan properties originally having no setbacks, and others controlled by the Smoky Lake Covenants. When the association first approached Stambaugh Township, it deferred decision-making until Wisconsin had considered some of the same questions. In the mid-1990's proposals were recommended by the association to create a 75' natural foliage greenbelt and to limit the creation of roads down to the lake. Initial efforts were found to be too broad and unenforceable.

In response, a good faith consensus statement was approved in 1996 by members:

"Property Owners shall maintain a greenbelt of trees and native vegetation of not less than 40 feet in depth parallel to the shoreline measured inland from the normal high water mark. Thinning for the purpose of lake view should be done in such a manner as to provide a substantial screening from the water of the dwelling, accessory buildings and parking area. The natural condition of this greenbelt shall be preserved to help control erosion and prevent effluent and nutrient flow into the lake".

In 2005 and 2006, renewed proposals were taken to the Stambaugh Township with passage of an amendment to Art. 8.5, stating as follows:

To preserve and protect natural resources, water quality, and community scenic recreational values, a greenbelt shall be established and maintained on all waterfront property. The purpose of the greenbelt is to maintain a vegetative strip, which is to stabilize banks and shorelines, prevent erosion, absorb nutrients and contaminants in water runoff from adjacent lands, structures, and impervious surfaces, and provide a scenic view from and to the body of water. The greenbelt shall include all of the land area located within seventy-five (75) feet of the ordinary high watermark of any watercourse abutting or traversing the property.

Business Use

The business use of properties was also a matter for zoning concern. In 1973, the question was raised related to farming and Smoky Lake Lodge usage. The issue continues into the 2010's with the presence of rental properties on the lake, particularly in relation to the Covenants for the properties originally a part of the Smoky Lake Estates. This issue is made more complex by the differing standards of Wisconsin and Michigan.

At several points the association considered issues related to powerboat use, waterskiing and jet skiing. Beginning in 1987, several iterations of courtesy rules were developed and promulgated to property owners to encourage members to be courteous, polite, and respectful in their watercraft and fishing practices. At the 2018 annual meeting, the suggestion was made to revisit this topic and to report in 2019.

2.2.5 Environment

Fishery

Fish population and stocking reports by the Michigan DNR (MDNR) and WDNR were a regular part of early lake reports, with appearances less frequent in recent years. Periodically fish population surveys were conducted, but funding became more limited in recent years. The Michigan DNR conducted a fish survey in 2005 and the most recent survey being conducted by the Wisconsin DNR was done in 2015.

The SLPOA Fisheries Committee was created in 1992 with objectives to maximize the unique habitat of the lake, to conduct an annual assessment of the fish population and forage, to preserve Small Mouth Bass, to report on Walleye stocking and trout stocking and to determine the advisability of Musky. In 1993, the MDNR presented to SLPOA covering topics about tagging Musky, controlling Suckers and perch, bass population and trout stocking. The committee made regular reports in the late 90s, but over time, the MDNR budgets limited the availability of state programs. The committee is now inactive. However, the association in 1989, 1991, and 2017 voted on recommendations regarding size and slot limits to encourage a strong presence of Small Mouth Bass in the lake. Smoky Lake fishing regulations are controlled by both Wisconsin and Michigan and summarized in the Boundary Lakes Rules sections of the fishing rules for both states.

Water Quality and Lake Elevation

From the inception of the organization, members were alert to water quality issues, with early members considering potential pollution arising from active farming and cow stables close to the lake.

Water quality testing, clarity measurements, and depth reports performed by a mix of volunteers and professionals make regular appearances in the minutes. In the 1990's and 2000's water quality information was frequently shared by individual members and sometimes by the MDNR, which reported Smoky as a high-quality lake. In 2001, the Water Committee presented a summary report prepared by White Water Associates. This study analyzed water for alkalinity, chloride, phosphorus, and nitrogen. In addition, it documented weed beds for

fish habitat reporting no Eurasian watermilfoil or zebra mussels and observed waterfowl. The report stressed the importance of controlling phosphates and fertilizers, performing septic system clean-outs every three years and maintaining a natural buffer to the lake to filter run-off. Members received regular reminders for several years on these recommendations.

In 2005, members authorized the purchase of testing equipment for volunteer led water quality monitoring. Volunteers, trained by the WDNR, report results to the WDNR and share findings at annually at meetings. Water level monitoring began in 2012. Volunteers work cooperatively with the North Lakeland Discovery Center on these efforts.

Smoky Lake is a seepage lake, and lake levels are cyclical. A period of high water existed in the 1970s and 1980s and resulted in the development of a culvert system helping to restore the natural drainage through the lowlands between Smoky and Big Sand Lake. This high water period was followed by a period of dramatic drop in depth in the 2010's. During this low period, members had concerns about water use for road projects and the Sand Lake Golf Course, the later practice being subsequently discontinued. Warnings were shared about low spots at the landing, and the north and south sand bars in the mid-section of the lake. In 2017, the cycle reversed itself with lake levels rising more than two feet in one year following heavy spring rains. This again brought inquiry into the culverts and drainage at the south end of the lake.

Wildlife

Wildlife reports were, and continue to be, a regular part of annual meeting discussions, with reported sightings of loons, mergansers, eagles, bears, otters, moose, foxes, and wolves. The decline in swallows and bats were also noted over the years. Speakers also presented on topics such as the wolf population, maintaining environments for loons and eagles, and Brook Trout. A loon-nesting program developed with nesting islands installed off the south and northern shores of the lake and continues to be maintained through owner sponsorship.

Invasive Species

In the early 2000's the association began to follow the development of Aquatic Invasive Species (AIS) in area lakes. At the 2000 meeting, Eurasian watermilfoil (EWM) was reported in Long Lake and members were asked to report any sightings to the Michigan or Wisconsin DNR. In 2001 a sign was added to the landing warning other boaters not to bring milfoil into the lake.

In 2010, the spread of thistle and garlic mustard was reported. Remediation and removal was discussed, but members were cautioned about spraying near the lake.

The Vilas County Land and Water Conservation Department gave a presentation on AIS species of concern including spiny water fleas, zebra mussels, rainbow smelt, rusty crayfish, curly pondweed, and EWM. The lake was encouraged to develop and participate in a program for watercraft inspections, lake monitoring and remediation methods (hand pulling and herbicides).

In August of 2007, the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), during an AIS survey of Smoky Lake, found two Eurasian watermilfoil (EWM) fragments along the southern

shore of Smoky Lake at the boat landing. One fragment was partially dried and the other had a flowering shoot. A thorough survey of the lake did not detect any rooted EWM plants. GLIFWC reported these findings to the Vilas County AIS Coordinator (GLIFWC, 2007). In September of 2011, a USFS surveyor, contracted with the USFS Ottawa National Forest, conducting an AIS survey of Smoky Lake found one stem of EWM within the southwestern bay just west of the boat launch. The plant was removed, and no other rooted plants were found during the remainder of the survey. In August 2013, a USFS surveyor also contracted with the USFS Ottawa National Forest documented EWM again within the southwestern bay of Smoky Lake. This survey did not detect EWM elsewhere in the lake. This discovery initiated efforts by the WDNR, with assistance from the Vilas County Land and Water Conservation Department, to complete an aquatic plant survey using the WDNR point intercept methodology (WDNR, 2010). Results of this survey did not detect EWM outside of the southwest bay on the lake. The WDNR met with lake owners to present more information and suggestions for initiating remediation programs. Many Waters, LLC was retained as a consultant to guide the process. The Aquatic Invasive Species Committee worked to provide information and to engage lake owners as volunteers in the process.

Clean Boats Clean Waters was introduced in 2013, which contracted with the University of Oshkosh to provide inspections and education to boaters entering and exiting the lake at the landing.

In 2014, the AIS Committee reported on volunteer training and remediation sessions for hand pulling in shallow waters in the southwest bay. The Town of Phelps filed a sponsored grant application. It was initially funded at $17,094.53, but later increased to $20,000. Herbicides were researched and a recommendation to consider their use was brought to the WDNR but not approved for use by the WDNR due to the limited density and acreage covered by the infestation. Two additional grants were awarded by the WDNR at the same $20,000 level.

From 2015-18, EWM became a growing item of discussion with reports on hand pulling remediation by volunteers and professionals, including DASH and snorkel efforts. Three WDNR Early Detection and Response grants were approved providing grant funding of $60,000. Clean Boats Clean Waters inspections at the landing continued through contracted services with the University of Wisconsin-Oshkosh, upon inspection hours increasing to 200 with the approval of a WDNR grant to the Smoky Lake Association. Town of Phelps Lakes Committee grants were sought and approved.

Funding issues led to creation of the Smoky Lake Preservation Association as a Wisconsin Corporation to facilitate direct applications without the need for Town Sponsorship. Appeals were also successfully made for donations from members and from the Town of Phelps.

2.2.6 Services

Road Access

Road access, particularly for Smoky Lake Estates properties, was a subject of concern for many years with a road committee providing regular reports. Though this road was initially developed and maintained by the developer Smoky Lake Corporation, by the mid-seventies road maintenance became a regular topic of concern.

In 1997, the SLPOA Board of Directors recommended that a new Michigan non-profit corporation be created to manage the care and maintenance of the Smoky Lake Drive access road. This led to the incorporation of the Smoky Lake Access Road Corporation, which continues to manage road repair, maintenance, and plowing for the residents of the Smoky Lake Estates using Smoky Lake Drive for access to their properties. Other road access issues for Hansen Road and Highway 16 in Michigan and Highway 17 in Wisconsin were also followed with interest.

Basic Services

Association meetings were a frequent source of information regarding basic services such as fire protection, police protection, hospital and EMT services, and basic utilities such as electricity and internet. As a border community these all brought complications. Even something as basic as postal delivery to Michigan property comes over the state line from Wisconsin. Meeting presentations helped keep members abreast of developments in reciprocal agreements between Phelps and Stambaugh Townships for key services such as fire, EMT and police coverage to help facilitate communications to the appropriate Wisconsin and Michigan authorities should such a need arise.

2.3 Land Use and Zoning Regulations for Smoky Lake

Smoky Lake being a seepage lake (not containing an inlet or a well-defined outlet whose principal source of water is precipitation or runoff supplemented by groundwater from the immediate drainage area) has its advantages and disadvantages. Without an inlet, Smoky Lake is not susceptible to pollutants entering the lake from upstream sources. However, without a well-defined outlet it lacks the ability to cleanse itself. Therefore, any pollutants entering the lake remain with the lake. Because of this fact, sound land and water stewardship principals demonstrated by public access users, Smoky Lake watershed owners and the effective administration of land use and zoning regulations become imperative to preserve its present pristine quality.

Because Smoky Lake is a boundary water lake located in the states of Michigan and Wisconsin, the administration of land use and zoning regulations lies with two governmental agencies. In Michigan Stambaugh Township, through its Zoning Board and Zoning Administrator, is responsible and in Wisconsin, the Vilas County Zoning Committee, and Zoning Administrator are responsible.

The following is a partial summary of land use and zoning regulations that apply to lands adjacent to Smoky Lake and within the Smoky Lake Management Plan Study Area (SLMPSA). The regulations discussed in the following pages are not meant to be inclusive of all ordinance provisions but only address those that may be of most interest and frequently questioned by property owners in the SLMPSA.

2.3.1 Town of Stambaugh Zoning and Land Use Regulations

The Stambaugh Township Zoning Ordinance sets forth zoning and land use regulations guiding the development within the SLMPSA. The Township also created and adopted a Wellhead Protection Zoning Ordinance. Its purpose is to preserve and maintain existing and potential groundwater supplies, wetlands, floodplains, the natural environment, aquifers, and groundwater recharge areas of the Township and to protect them from adverse land use development or land use practices.

Lands lying 300 feet inland from the ordinary high-water mark (OHWM) of Smoky Lake are designated in the L-2 (Lake Areas) zoning district. Regulations allow for the development of single-family residences on lots containing a minimum of 75,000 square feet with a minimum of 250 feet of lake frontage. Structures shall have a minimum setback from the lake (front yard) OHWM of 75 feet. No accessory buildings or structures other than a dock are permitted in the front yard setback area. All structures must be offset and setback a minimum of 50 feet from side and rear lot lines. No access roads may be constructed within 200 feet of the OHWM. However, driveways serving dwellings are permitted. In addition, lake front parcels may not have more than one dock per 125 feet of lake frontage.

The L-2 zoning district extends only 300 feet from the OHWM of Smoky Lake. Since most, if not all, of the Michigan lake lots have depths greater than 300 feet, another zoning district has been mapped for these lands. The AR district (Rural Residential, Agriculture, and Forestry District) has been utilized. This district permits agriculture, forestry, mining and rural one-family residential uses. Mining is not a permitted use and requires the granting of a special land use permit from the Stambaugh Township. Residential lots in the AR district require a minimum of 2 acres and having a minimum road frontage of 200 feet. Front and rear building setbacks require at least 50 feet and side lot offsets require no less than 40 feet.

The zoning ordinance includes provisions for a greenbelt area located 75 feet landward from the OHWM or any watercourse abutting or traversing a property. The purpose and intent of the greenbelt corridor is to preserve the natural shoreline character of the lake, filter run off, prevent erosion, absorb nutrients, and stabilize shorelines. Only the removal of dead or diseased vegetation may occur. Vision corridors are not permitted. It also precludes the storage and application of pesticides, herbicides, fertilizers, bio-solids, and any product containing phosphates or nitrates. Only trails or walkways providing access to the lake are permitted. Upon the proposed development of a property, a greenbelt plan must be submitted to the Township Zoning Administrator for review and approval.

Wetlands located in the SLMPSA have been identified and are regulated by the Michigan Department of Environmental Quality (MDEQ). Wetland regulations state that within the first 500 feet of land from the OHWM of the lake, all wetland alterations, regardless of size, require a MDEQ permit. Over 500 feet from the lake wetlands over 5 acres in area are regulated unless they are contiguous to a lake. Lake bottoms are also regulated by the MDEQ. Such things as dredging, permanent docks, fish cribs, mats used to inhibit weed growth and shoreline structures require permits. Lake chemical treatment is administered by another governmental agency. The Stambaugh Township Zoning Ordinance does not contain a wetland-zoning district therefore; wetlands are not identified on their Zoning District Map. However, the Township Zoning Ordinance and Wellhead Protection Zoning Ordinance do reference wetlands and states the intent to protect all wetlands regardless of size. Violations to the Michigan wetland regulations and lake bottom regulations are self-policed by local residents and in some cases Zoning Administrators. The MDEQ will investigate any alleged violation and prosecute if necessary.

Lake flood plains have not been mapped by FEMA and accordingly are not regulated by MDEQ. However, the town zoning ordinance states that no dwelling unit shall be constructed on lands subject to flooding. In addition, the Township Wellhead Protection Zoning Ordinance calls for the preservation of floodplains. State health codes and building codes also contain regulations requiring septic systems to be located outside the 100-year flood elevation and building codes require structures to be located a minimum of 1 foot above the 100-year flood elevation. If the 100-year flood elevation has not been established, as is the case for Smoky Lake, the MDEQ will provide this service free.

Any use of land or structure that existed prior to the enactment of the Stambaugh Township Zoning Ordinance and does not conform to its requirements may continue to exist. These structures or uses may be altered subject to provisions set forth in the ordinance.

2.3.2 Vilas County Zoning and Land Use Regulations

The Vilas County Planning and Zoning Department and Zoning Committee administer all zoning regulations lying within the SLMPSA. The Township of Phelps does not have a zoning ordinance and only administers state building codes. The Vilas County Shoreland Ordinance, having jurisdiction 1000 feet from the OHWM, and the Vilas County General Zoning Ordinance set forth land use regulations that guide development within the SLMPSA. The Vilas County Flood Plain Ordinance is not administered within the SLMPSA on lands that may be subject to flooding since lake flood plains have not been mapped.

All Vilas County lands lying in the SLMPSA are zoned in the AP (All Purpose). Additionally, some lands are within the Shoreland-Wetland Zoning District. The intent of the AP District is to provide areas for a variety of mixed uses. Some uses require the issuance of a conditional use permit (i.e. mining, junkyards, gun clubs, etc.) The intent of the regulations contained in the Wetland Zoning District is to minimize adverse impacts, prevent water pollution, and preserve shore cover and natural beauty. Ordinance locational regulations for the AP District require a

building setback for principal structures to be a minimum of 75 feet. Boathouses require a 5-foot minimum setback and must be located in a viewing corridor. Side yard and rear yard offsets and setbacks are 15 feet for principal structures and boathouses.

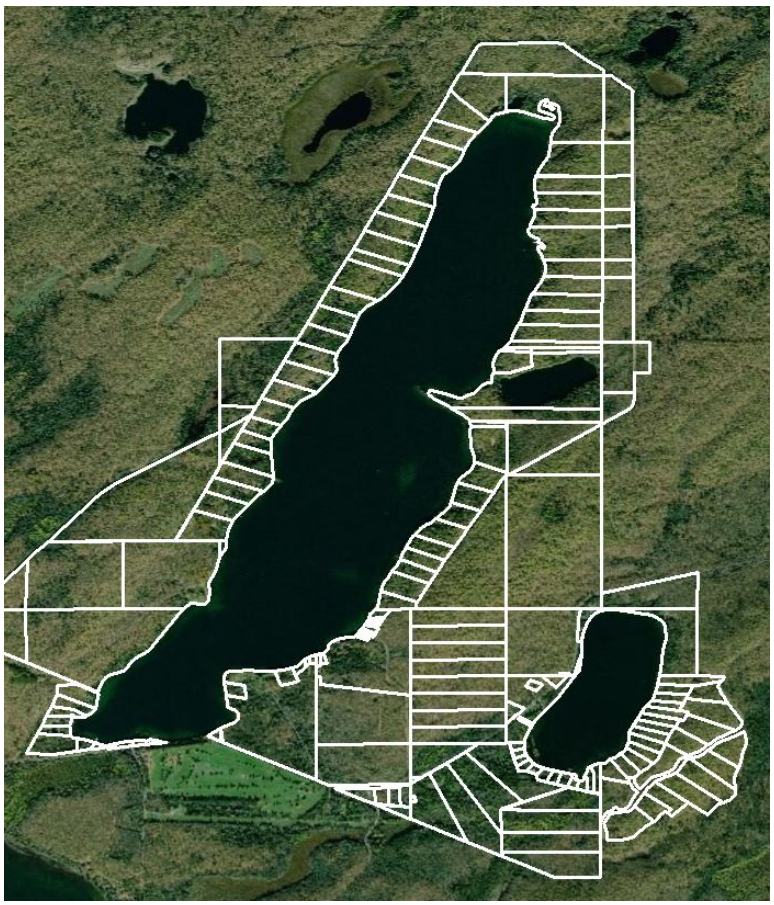
Accessory structures (200 sq ft or less) are permitted 35 feet or greater from the OHWM having a minimum offset of 5 feet. The approval of the Zoning Administrator is required.

Newly developed lake lots require a minimum of 20,000 square feet of area, a minimum of 100 feet of lake frontage~~.~~, and 16, 500 square feet of contiguous buildable area. Back lots need 65,340 sq ft of area.

A shoreland alteration permit must be approved by the Vilas County Zoning Committee for any land disturbance activity that exceeds 750 sq feet of area located 75 feet to 300 feet from the OHWM or 400 sq feet within 35 feet to 75 feet of the OHWM.

Lands extending 35 feet from the OHWM are considered to be in a vegetative buffer zone not allowing the removal of trees, shrubs or undergrowth unless dead or diseased. The Planning and Zoning Department administers a viewing corridor allowing 35% of the owner's shoreline to be selectively cleared. The clearing may occur in more than one area on the lot but the total permitted clearings may not exceed 35% of the lots lake frontage. This administrative practice is not consistent with the language contained in the Vilas County Shoreland Ordinance. However, it is consistent with the way the Wisconsin Department of Natural Resources wants it regulated.

All lots created or structures constructed prior to the adoption of the Vilas County Zoning Ordinance that are not in conformance with the current ordinance are considered to have a legal non-conforming status. These uses, structures, or lots may continue to exist subject to ordinance regulations regarding non-conforming uses and structures.



Map 2: *Smoky Lake Parcel Map*

3.0 LAKE INVENTORY RESULTS

3.1 Water Quality

3.1.1 Formation of Lakes and Water Source

Lakes in the upper Great Lakes region are glacial lakes, formed during the last glacial period about 10,000 years ago. Retreating glaciers scoured the landscape creating depressions, ridges or moraines and deposited large ice blocks. These glaciers dramatically altered the landscape creating the diverse types of waterbodies and waterway of today. Smoky Lake is one of many lakes in Northern Wisconsin and the Upper Peninsula of Michigan formed from this process. Lakes are often grouped based on the source of water to a lake. Lakes fed by precipitation and groundwater, which do not have an inlet or outlet and have occasional overflow, are seepage lakes. These lakes typically echo ground water levels and precipitation and have seasonal water level fluctuations. They are the most common type of lake in Wisconsin. Smoky Lake is a seepage lake. Lakes fed by a surface water inlet, such as a stream and have a surface water outlet are drainage lakes. Drainage lakes may be natural or manmade impoundments. Spring lakes, fed mainly by groundwater, have no inlet, but do have an outlet. Spring lakes are often headwater lakes to streams and quite common in Northern Wisconsin.

3.1.2 Lake Mixing and Stratification

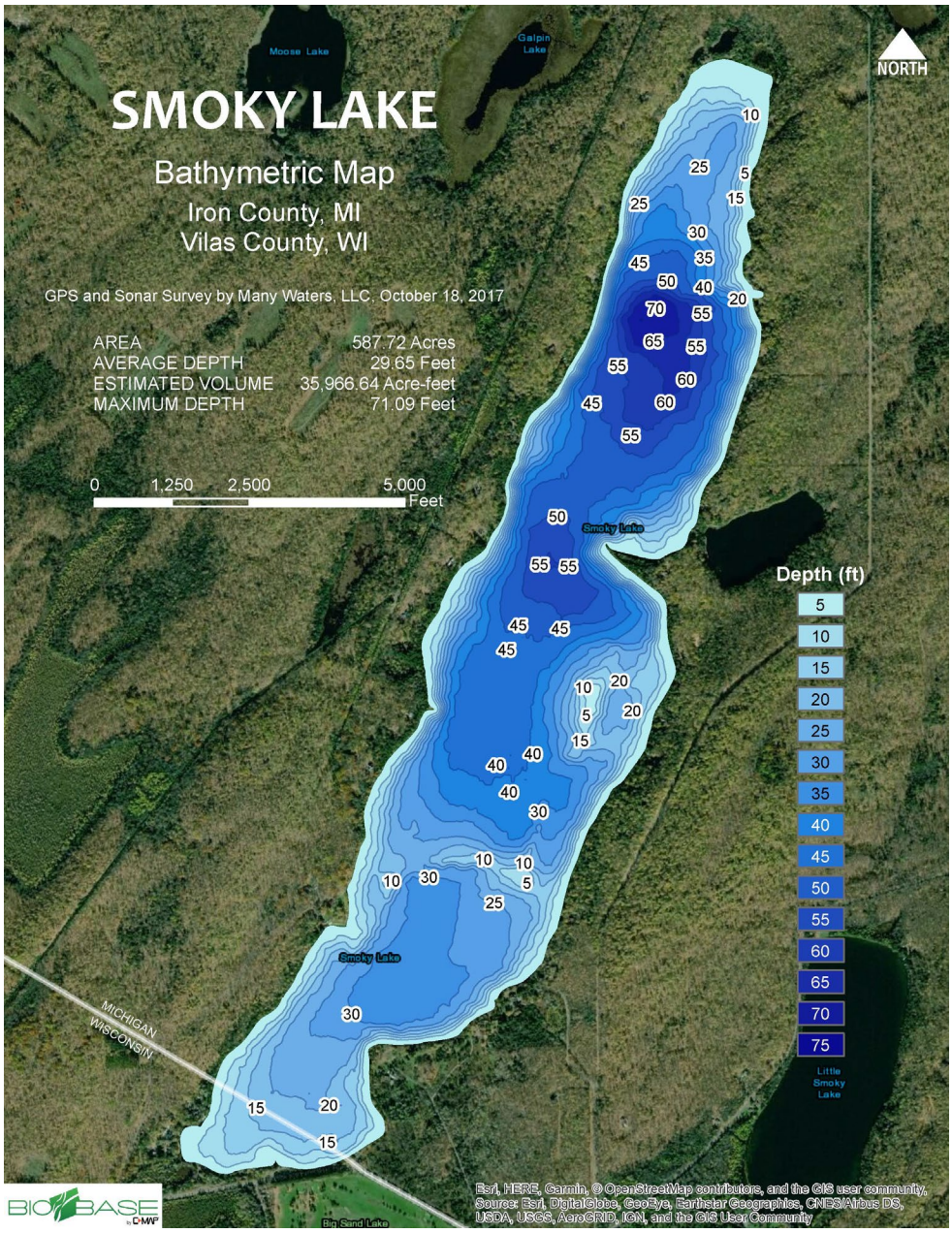
Lake depth, size, and climate affect how lake water mixes throughout the year**.** In the spring, when water temperatures reach 39˚F (when water is most dense) water temperature and density will be uniform from top to bottom, allowing water to mix throughout the water column (spring turn-over). During the summer, in shallow lakes, wind and waves may continuously mix water throughout the entire water column, whereas in deeper lakes this mixing may be limited to the upper 20-30 feet of water. In these deeper lakes, the warmer upper water will not mix with cooler deeper water due to differences in water density thus causing thermal stratification. Stratification is the separation of upper warmer water from cooler deeper water. The upper layer, called the epilimnion will remain warm, with wind action and biological activity keeping oxygen present. Whereas deeper waters, called the hypolimnion, will remain cool and over the course of the summer may become oxygen depleted. The transition zone between the epilimnion and hypolimnion is called the thermocline. A thermocline is a change in 1˚C water temperatures per one meter of depth **(Horne & Goldman, 1994).** In the fall, surface waters cool and temperatures become uniform from top to bottom. This allows mixing of the entire water column again (fall turnover). Winter ice prevents surface waters from mixing during the winter months. This creates a temperature gradient where water at the lake bottom will remain at 39˚F and surface waters below the ice will be cooler at 32˚F.

3.1.3 Smoky Lake's Physical Habitat Characteristics

Historical estimates of Smoky Lake's acreage vary. The Michigan Conservation Department survey (1938), estimates Smoky Lake to be 590 acres and the WDNR estimates Smoky Lake to be 610 acres **(WDNR, 2009).** Recent acoustic mapping (2017) suggests Smoky Lake's acreage to be roughly 587 acres. Maximum water depths for Smoky also vary. During a fish and water

survey in 1938, the MDNR noted 68 foot maximum depth, whereas the WDNR reports 39 foot maximum depth. Most recent sonar mapping detected the maximum depth on Smoky Lake to be 70 feet**.** Sonar mapping, estimates the water volume of Smoky Lake to be 17,567 acre-feet. Mean and average water depths on Smoky Lake are 29.92 and 29.47 feet respectively[2].

Map 3 : *Smoky Lake Bathymetric Map, GPS and Sonar Survey by Many Waters LLC, Oct 2017*



Shoreline complexity is a unit-less measure of lake's roundness, which takes into account the relationship between lake shoreline and lake shape. A perfectly round lake has a shoreline

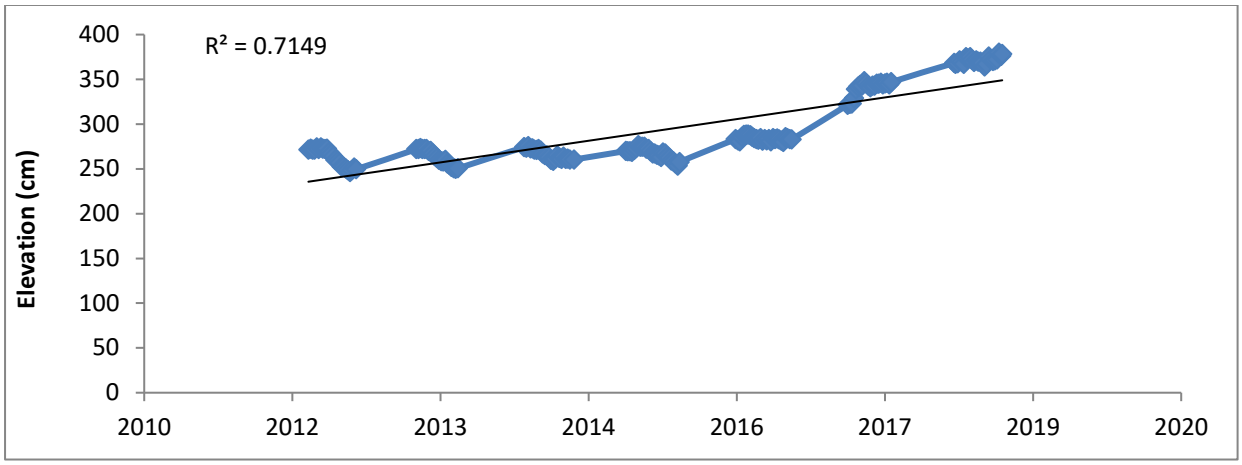
[2] Average depth calculated from point intercept depth collection during 2017 aquatic vegetation surveys.

complexity value of one; whereas lakes with irregular shorelines, bays, and coves have shoreline, complexity values greater than one. Lakes with complex shorelines generally support more species and different types of habitats. Smoky Lake has a shoreline complexity value of 1.89. For comparison, Lac Vieux Desert's shoreline complexity is 4.3 and Long Lake's shoreline complexity is 1.65 **(Onterra, 2012 & 2013).**

3.1.4 Water Levels

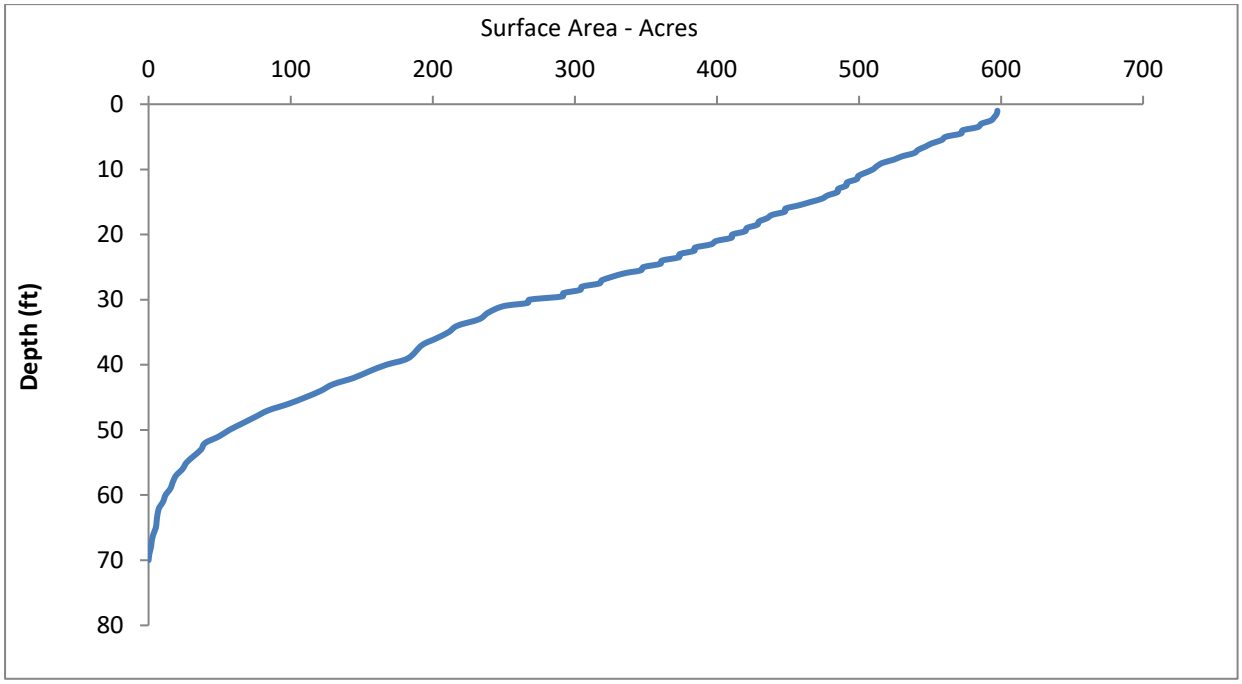
Starting in May of 2012, Smoky Lake volunteers in partnership with the North Lakeland Discovery Center, Manitowish Waters, WI, collect water level data. This data shows seasonal water level fluctuation during the open water season, not uncommon for seepage lakes such as Smoky Lake. More recent data shows seasonal water level fluctuations consistent from 2012 to 2015 **(Figure 3.1.1).** Water levels began climbing recently, with 2018 being the highest recorded water levels on Smoky since monitoring began**.** However, high water levels were reported in the 1970's and 1980's.

Figure 3.1.1: *Water level monitoring data 2012-2018 – Smoky Lake. NOTE - Elevation data is relative to Smoky Lake and not comparable to other lakes.*



Hypsographic curves show the relationship between surface area and lake volume to depth of a lake **(Figure 3.1.2).** This curve plots depth on the vertical axis and either cumulative water volume or surface area along the horizontal axis. This is a useful way to look at lake acreage or volume relationships within a specific lake basin. Reservoir managers use these curves to know what the surface area of lake would be at a certain water level drop. Up until 2016, Smoky Lake had been experiencing lower water levels, as many Northern Wisconsin and Michigan seepage lakes were experiencing. **Figure 3**.1.2 may be useful to predict the approximate change in lake acreage based on a known water level drop or decrease.

Figure 3.1.2: *2017 Hypsographic curve of depth to cumulative surface water acres – Smoky Lake[3].*



3.1.5 Water Quality Overview and Importance

When asking individuals to define water quality, the answers may vary by respondent. Arriving at a swimming beach, and finding out it is closed due to a toxic algal bloom, may bring awareness to health-related water quality issues stemming from toxic algal blooms. Poor water quality may mean changing water levels that limit boating access or poor fishing. In these examples, quality of the water reflects personal experience, framing what is important or valued to an individual. The intent of this section is to provide a description and analysis of what water quality *does* tell us about the health of Smoky Lake from an ecological framework, whereas other sections of this plan describe the social aspect of water quality.

So why is it important to collect information on water quality? **Lille and Mason (1983)** describe three general purposes: (1) to assess water quality conditions for current/immediate management purposes, (2) to document existing conditions to assess changes over time and (3) to "gain a better understanding of the factors and interrelationships which affect water quality in lakes." Immediate management or actions may occur for issues related to health and human safety, as in the example above with algal blooms. More relevant to Smoky Lake is having a long-term record of specific water quality parameters helps resource managers and lake stewards to understand water quality trends and changes that may be occurring within the lake. For instance, to detect a 15% change in average phosphorous concentrations and a 20% change in water clarity in a lake, 10 years of consecutive monitoring is required **(NPS, 2008).**

[3] Water depth readings collected from 2017 depth collection during aquatic vegetation surveys. Lake acreage taken from 2017 acoustic survey.

3.1.6 WDNR Water Quality Standards and Assessment Process

Just as *defining* water quality is complex, so is *assessing* water quality. If a lake has "excellent" or "poor" water quality, what does that mean and how is the characteristic of "excellent" or "poor" given? To understand this, local, state, and federal programs have developed criteria for water quality standards and assessing water quality.

Three general elements guide water quality standards for Wisconsin waters. They include use designations, water quality criteria, and anti-degradation provisions. Designated uses define goals for that water body including fish and aquatic life, recreational use, public health and welfare and wildlife[4]. To determine if a waterway meets designated use goals, specific water quality criteria using numerical (quantitative) values or narrative (qualitative) criteria are used. Numerical data designates acceptable values whereas the narrative criteria[5] describes unacceptable water conditions such as nuisance algal blooms, floating solids, scum or conditions that interfere with public rights, health and safety. Anti-degradation policies maintain and protect existing water quality condition, not allowing water quality degradation when reasonable control measures are available[6].

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. Water bodies identified with water quality issues may be placed on a State Impaired Waters List. The final Tier 3 monitoring includes follow up monitoring on impaired waters that are undertaking measures to abate water quality impairment to see if improvements are being made.

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 uses a continuum of water quality condition from "excellent" to "poor." Excellent means the water body fully supports designated uses, and poor means a waterbody does not meet such standards.

General condition assessments compare a lake's natural community type to tropic state index (TSI) or lake productivity. The WDNR recognizes 10 natural community types in Wisconsin Lakes. Smoky Lake's natural community type is a two-story lake. Two-story lakes are often more than 50 feet deep and stratify during the summer. These lakes may support cold-water fisheries such as Lake Trout or Cisco. Lake volunteers that participate in water quality monitoring are familiar with the specific water quality tests for TSI, including water transparency, total phosphorous and chlorophyll *a*.

[4] NR 102, Wis. Adm. Code
[5] NR 102.04(1) Wis. Adm. Code
[6] NR 102.05(1) Wis. Adm. Code

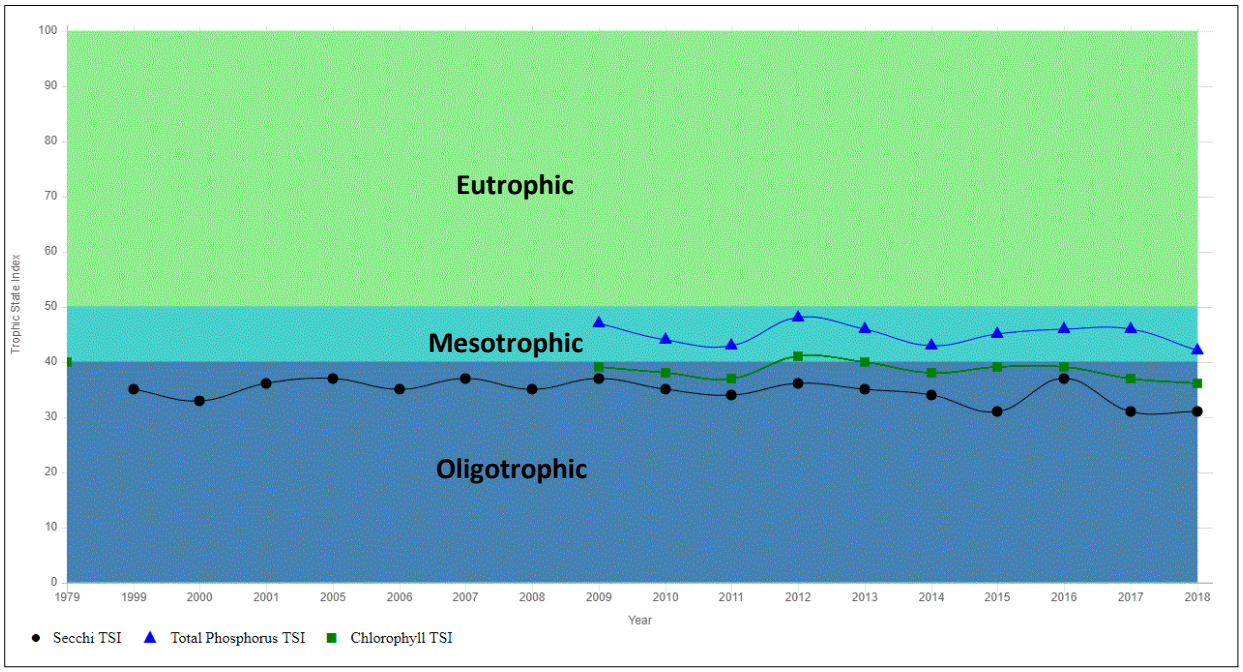
Water transparency, or clarity, is measured using a secchi disc, which is an 8-inch disk painted black and white attached to a long rope. Measurements are taken by lowering the disk into the water until it just disappears from sight and raising the disk until it is just visible. The average of the two 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) suspended materials such as silt, and other matter dissolved in the water.

Phosphorous is the nutrient most responsible for excessive aquatic plant and algae growth. There are various sources of phosphorous, some natural but many are from human activities on the lake and in the watershed. A concentration unit expresses total phosphorous values, for example milligrams/liter.

The abundance of algae is more difficult to measure directly, so it is common to measure the green pigments or the **chlorophyll *a*** in algae that are responsible for photosynthesis. Chlorophyll *a* values are represented as a concentration unit similar to phosphorous.

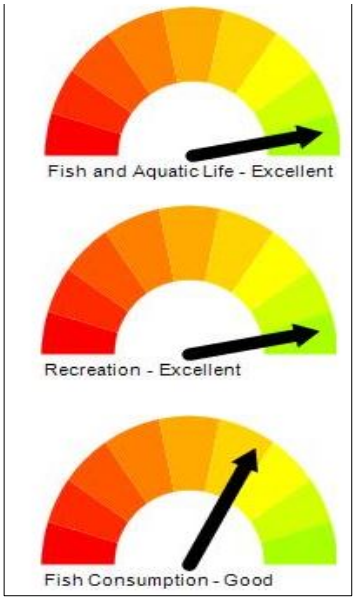
Using water transparency, total phosphorous and chlorophyll *a*, a trophic status value for each parameter can be calculated. Based on those values, lakes are divided into three general trophic state categorizes including oligotrophic, mesotrophic and eutrophic. Oligotrophic lakes are generally deep, clear lakes, low in nutrients and have relatively few aquatic plants and algae. Smoky Lake is an oligotrophic lake based on the three measured parameters, water transparency, total phosphorous, and chlorophyll *a* **(Figure 3.1.3).** 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 aquatic vegetation during certain times of the year are common. These lakes often support a large fish population. Mesotrophic lakes fall in between oligotrophic and eutrophic lakes.

Figure 3.1.3: ***Smoky Lake's trophic status based on water transparency, total phosphorous and chlorophyll a[7].***



Comparing TSI values and Smoky Lakes natural community type, Smoky Lake's general condition is considered to be "excellent[8]", meaning water quality parameters meet or are below designated thresholds for that particular lake use designation **(Figure 3.1.4).** In the last 2018 assessment, the WDNR specifically used TSI values for chlorophyll *a* to determine general condition, where excellent thresholds generally need a TSI value of 43 or less.

Figure 3.1.4: *General condition assessment for designated lake use –Smoky 2018*



3.1.7 Water Quality Trends

The earliest water quality records for Smoky Lake date back to 1938 from the Institute for Fisheries Research, a division of the Michigan Dept of Conservation, cooperating with the University of Michigan—what would later become the Michigan Department of Natural Resources, Fisheries Division. Records examined included data taken by MDNR and WDNR fisheries/resource staff over the past 80 years in the course of conducting fish surveys for management prescriptions and occasional water reports **(Appendix B).** STORET Legacy Dataset from 1979 captured the

[7] Data based on Citizen Lake Monitoring Network reporting adapted from https://dnr.wi.gov/lakes/clmn/reports/tsigraph.aspx?stationid=643104 (2.25.2019)

[8] WDNR 2018 WisCALM listing thresholds – taken from https://dnr.wi.gov/water/waterDetail.aspx?key=128614 (2.25.2019)

earliest detailed water chemistry records, originally reported by the WDNR (WDNR SWIMS, 2019). Smoky Lake was fortunate to have early adopters of the Citizen Lake Monitoring Program (WI) and volunteers have consistently collected data since 1999. Parameters collected include temperature and dissolved oxygen profiles, secchi readings (water clarity), chlorophyll *a*, total phosphorus, water levels, and ice on/off data.

As described above, Lille and Mason (1983) provide a rationale for collecting long-term water quality data. Longer-period data sets allow resource managers and lake stewards to understand water quality change and address why these changes may be occurring within a waterbody. One way to look at change graphically is to plot water transparency, total phosphorous and chlorophyll *a* over time. A best-fit line drawn determines how close the data conforms to a linear relationship between the plotted variables and has a numerical value (r^2), ranging from zero to one. A value of zero would mean there is no correlation between the data and a value of one would mean a strong correlation between the data. In addition, this analysis generates a p-value. This value ranges from zero to one and reflects the significance of the data. Large p-values (>0.05) suggest a statistically valid change has not occurred, where as small p-values (<0.05) suggest a statistically valid change has occurred.

Using the method above, in-season Smoky Lake average values for secchi, total phosphorous and chlorophyll *a* were plotted over time **(Figures: 3.1.5-3.1.7)**. The analysis for secchi data (1999 to 2018) suggest a moderate positive (r^2=0.3015) and statistically valid (p=0.012159) relationship between increasing water clarity over time. Whereas total phosphorous and chlorophyll *a*, both show weak to no relationship and are not statistically valid, suggesting time is not a predictor of change at this point for these parameters on Smoky Lake.

Figure 3.1.5: *Linear regression for average summer secchi (ft) from 1999 to 2018 – Smoky Lake.*

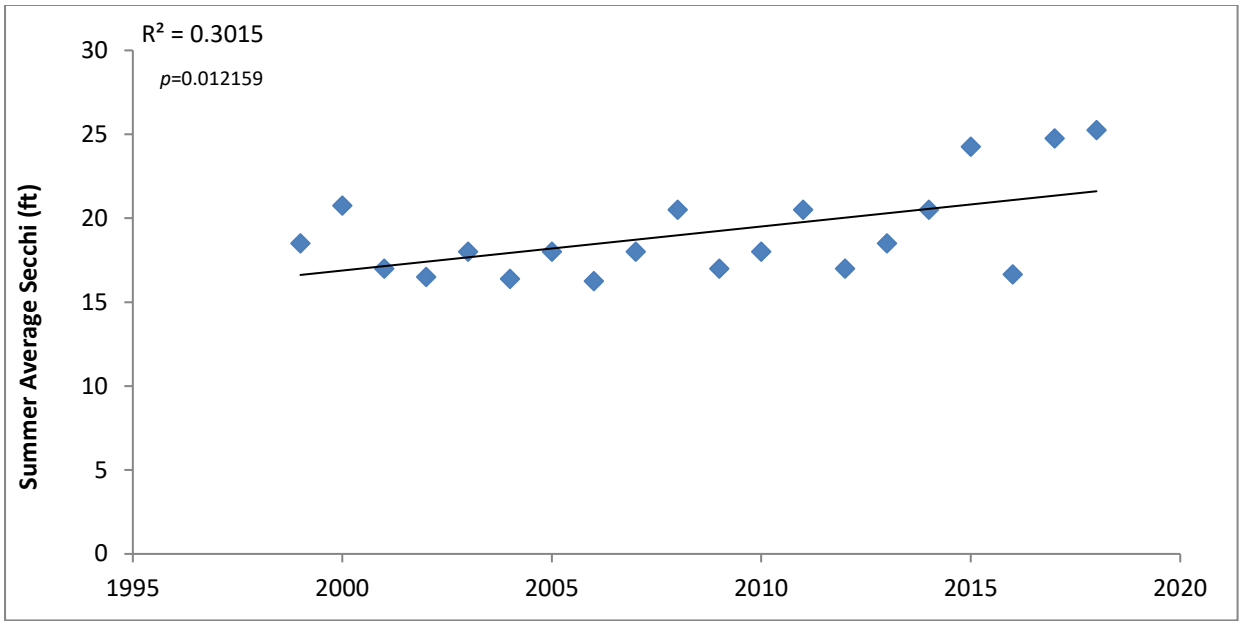


***Figure 3.1.6**: Linear regression for average summer total phosphorous (ug/l) from 2009 to 2018 – Smoky lake.*

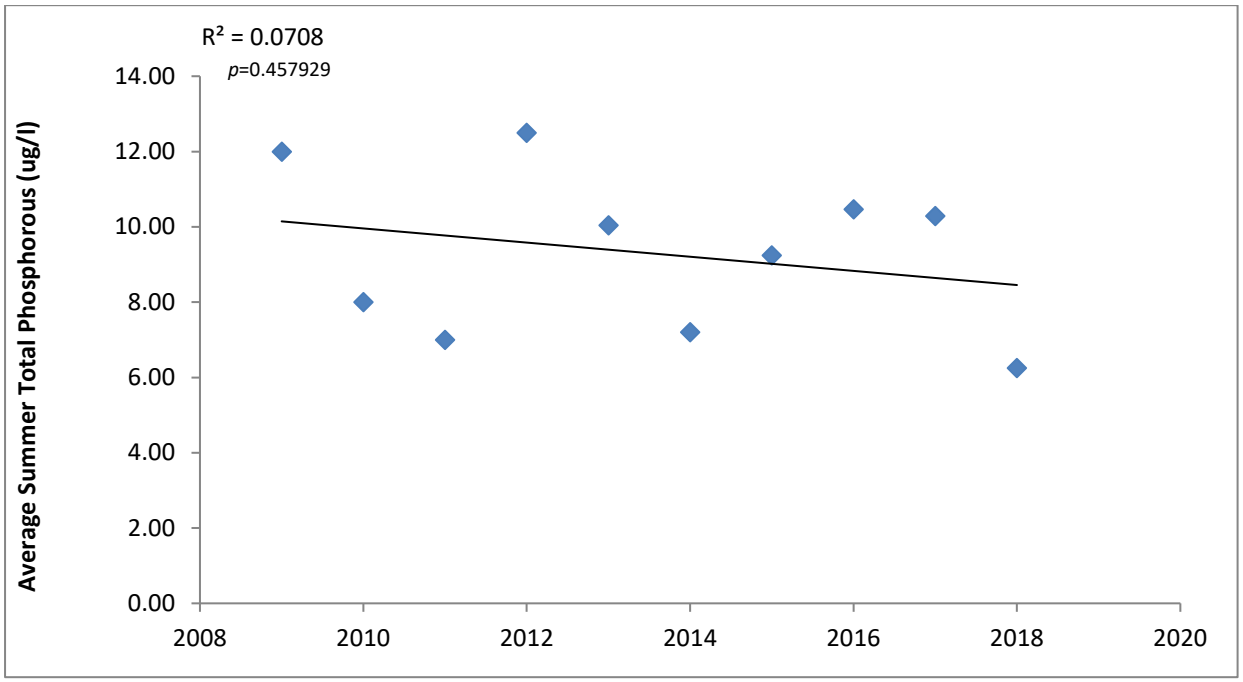
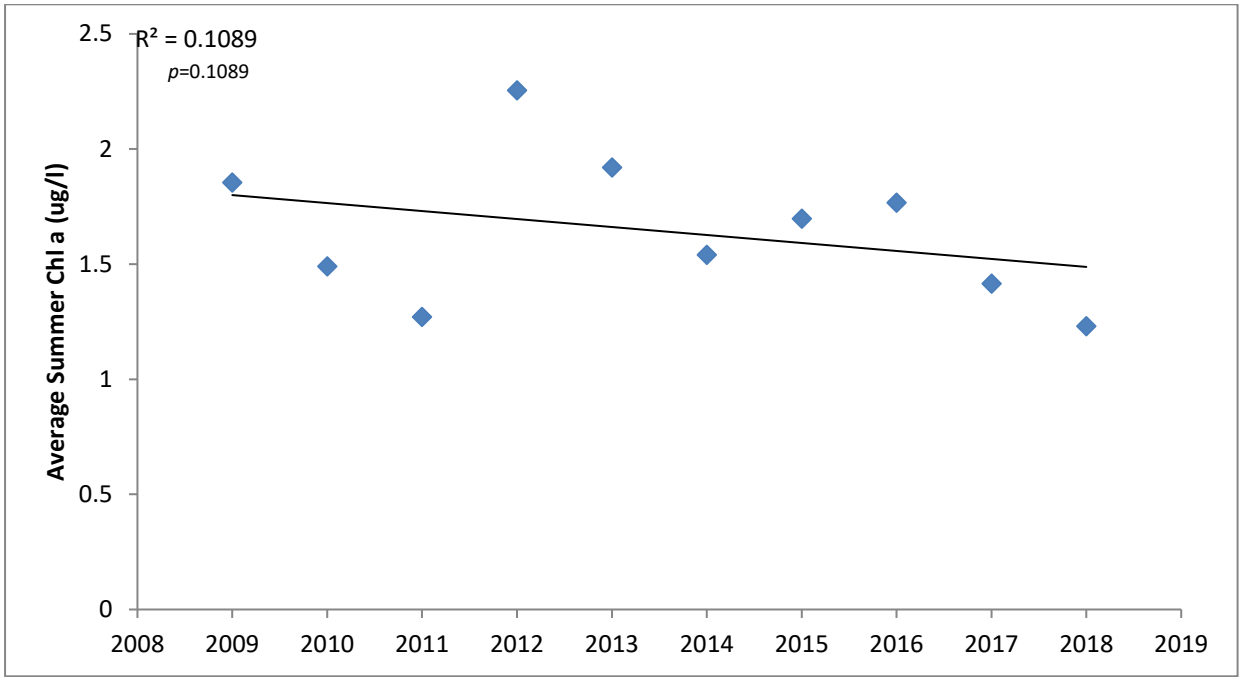


***Figure 3.1.7:** Linear regression for average summer chlorophyll a (ug/l) from 2009 to 2018 – Smoky lake.*



3.1.8 Phosphorous and Nitrogen Relationship

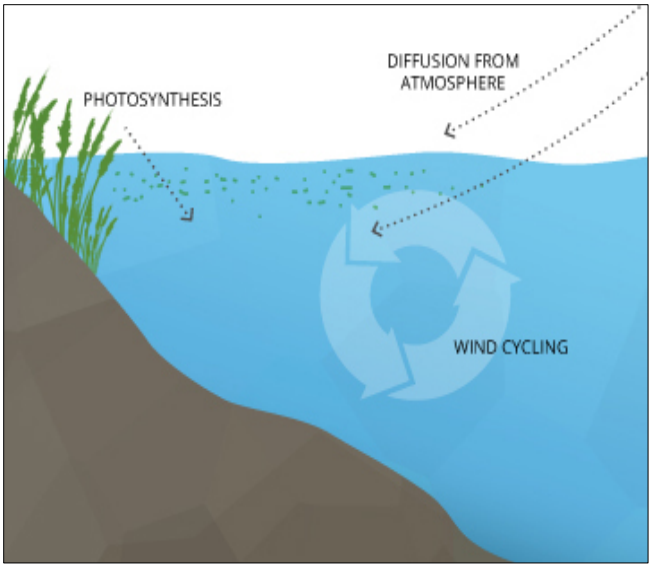
In most Wisconsin lakes phosphorous is the key nutrient for plant and algae growth. Excessive phosphorous in lakes may allow plants and algae to grow excessively. Phosphorous in lakes comes from a variety of sources, most of which are human driven including soil erosion from poor land practices, run off from the surrounding landscape, septic systems and detergents. Nitrogen, second to phosphorous, is also an important nutrient for plants and algae. Sources of nitrogen in a lake vary, including atmospheric inputs from rain and ground water and surface water runoff from the surrounding watershed. Soil minerals created by weathering 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 directly tie 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 or septic systems.

Between phosphorous and nitrogen, the nutrient in the least supply to algae in a lake is considered the limiting nutrient thus limiting potential algae growth. For most lakes in Wisconsin, phosphorous limits algal growth. To determine if a lake is nitrogen limited or phosphorous limited, the ratio of nitrogen to phosphorous is used. Nitrogen limited lakes have a ratio less than 10:1, whereas phosphorous limited lakes have ratios greater than 15:1. Transitional lakes fall in between these two ratios. Based on in-season 2017 water quality data, Smoky Lake is phosphorous limited, with nitrogen to phosphorous rations greater than 40:1. **Drowning and McCauley (1992)** looked at the nitrogen to phosphorus relationship in lakes. By plotting this ratio, they found that high ratios are more common in oligotrophic lakes compared to eutrophic lakes, suggesting that in oligotrophic lakes sources of total nitrogen and phosphorus more often derived from natural and less disturbed landscapes.

3.1.9 Dissolved Oxygen

Most aquatic life depends on oxygen, making it one of the most important dissolved gases in a lake. Wind, groundwater, surface water entering a lake, and biological activity influence the amount of dissolved oxygen in a lake **(Figure 3.1.8).** 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**.** These waters will remain warm. Below the thermocline, waters are usually cooler, and oxygen levels will decline throughout the

Figure 3.1.8: *How oxygen enters the water (Fondriest).*



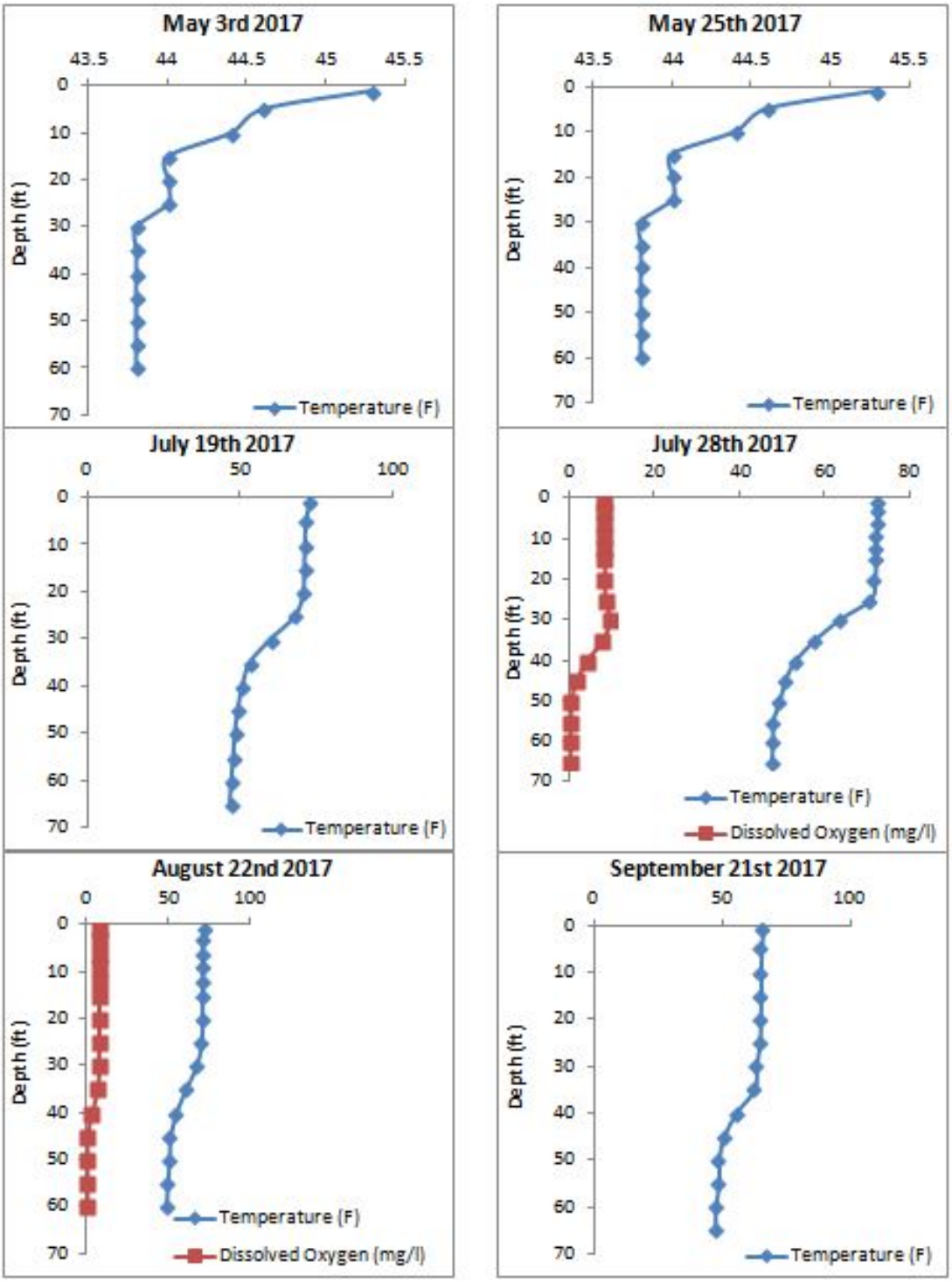
summer months due to lack of exposure to atmospheric influence and respiration from organisms that consume oxygen.

By late summer, some lakes become nearly devoid of oxygen in deep waters – which creates an intolerable situation for fish. Seasonal dissolved oxygen data for Smoky Lake is somewhat limited, but suggests that Smoky's thermocline is depleted of oxygen sometime between mid to late July. However, Smoky's deep water still provides cool water and enough oxygen to support cold water fish species.

Most fish tolerate narrow ranges of water temperature and dissolved oxygen. Therefore, moving back and forth between warm upper waters and cooler, less oxygenated, deep water is often not an option. The MDNR considers summer fish kill due to low oxygen a natural phenomenon associated with weather. Fish species most prone to summer kill are Northern Pike, Perch, Suckers, Bass, and Bluegills living in shallow, productive lakes or bays with excessive amounts of algae or rooted aquatic vegetation. Local lake management strategies may exacerbate these conditions. Chemical treatment of aquatic plants and algae results in the accumulation of dead plant material at various depths. Naturally occurring bacteria, in the process of breaking down and biodegrading dead plant material, begin to multiply and increase their oxygen demand resulting in less oxygen for fish. Lake-wide chemical treatment of aquatic plants and algae, under hot summer conditions, can create even more stress on fish populations.

Pollutants entering a lake may exacerbate oxygen demand on lakes. Examples include sewage, lakeshore erosion, lawn clippings, and other types of organic matter that increase sediment and nutrient inputs to a lake. Decomposing organic matter uses oxygen and may increase nutrient availability to algae in a lake. Algae will produce oxygen. However, if the amount of organic material entering a lake is not balanced with nutrients available for algae, oxygen production and oxygen consumption may become out of balance. Anoxia, or the lack of oxygen in the hypolimnion, may increase phosphorous release from lake sediments, creating situations where phosphorous levels in a lake may continue to rise even if all other inputs of phosphorous are removed. Chemicals such as ammonium and hydrogen sulfide may build up on the bottom affecting bottom dwelling organisms. In rare cases, sudden mixing of these substances into upper water levels may result in fish kills.

Figures 3.1.9-3.1.14: *Dissolved oxygen and temperature profiles for Smoky Lake – 2017. All data collected by lake volunteers except for September 15, 2017.*



3.1.10 Other Water Quality Parameters

Lake Acidity

pH measures lake water's acidity level. 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 et al, 2004).** Smoky Lake's pH (measured in summer of 2017) was 7.28, which is slightly above neutral and in normal range for natural lakes **(Holdren, 2001).**

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 the Western Portion of the Upper Peninsula of Michigan and Northeastern Wisconsin ranges in pH from 4.8 to 5.1[9]. Without a lake's carbonate system, buffering pH levels from water sources to a lake, many lakes would not support the diversity of aquatic life they do now. 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 not only toxic to fish, but may be harmful if consumed by humans and other animals such as loons, eagles, and ospreys. Acidic pH levels less than seven 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

Alkalinity, measured as calcium carbonate ($CaCO_3$), 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 type from the surrounding landscape, influence lake alkalinity, and hardness. Alkalinity levels (14.5 mg/l) in Smoky Lake indicate it is a soft water lake and has low sensitivity to acid rain **(Shaw et al, 2004).** Smoky Lake's water chemistry buffers fairly well against the effects of acid rain. 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.

Color

Color of water affects water transparency and the absorption and transmission of heat in a lake. Measured color values depend on the amount of dissolved material in the water, including organic or humic materials. Bog lakes or lakes with inputs from surrounding wetlands, may naturally have more organic or humic materials in the water, creating brown tinted water. Color readings for Smoky Lake were quite low with a value of 10 (SU). This value predicts what is apparent to the visual eye, that Smoky's water is mostly clear to blue in appearance.

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

Calcium and Magnesium

Regional underlying bedrock 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 exists in the Upper Peninsula of Michigan from Dickinson County to the east. Fifty five percent of Wisconsin Lakes have calcium levels of less than 10 mg/l whereas 77% of Wisconsin lakes have levels of 20 mg/l or less. Most Wisconsin Lakes (77%) have magnesium levels below 10 mg/l **(Lille & Mason, 1983).**

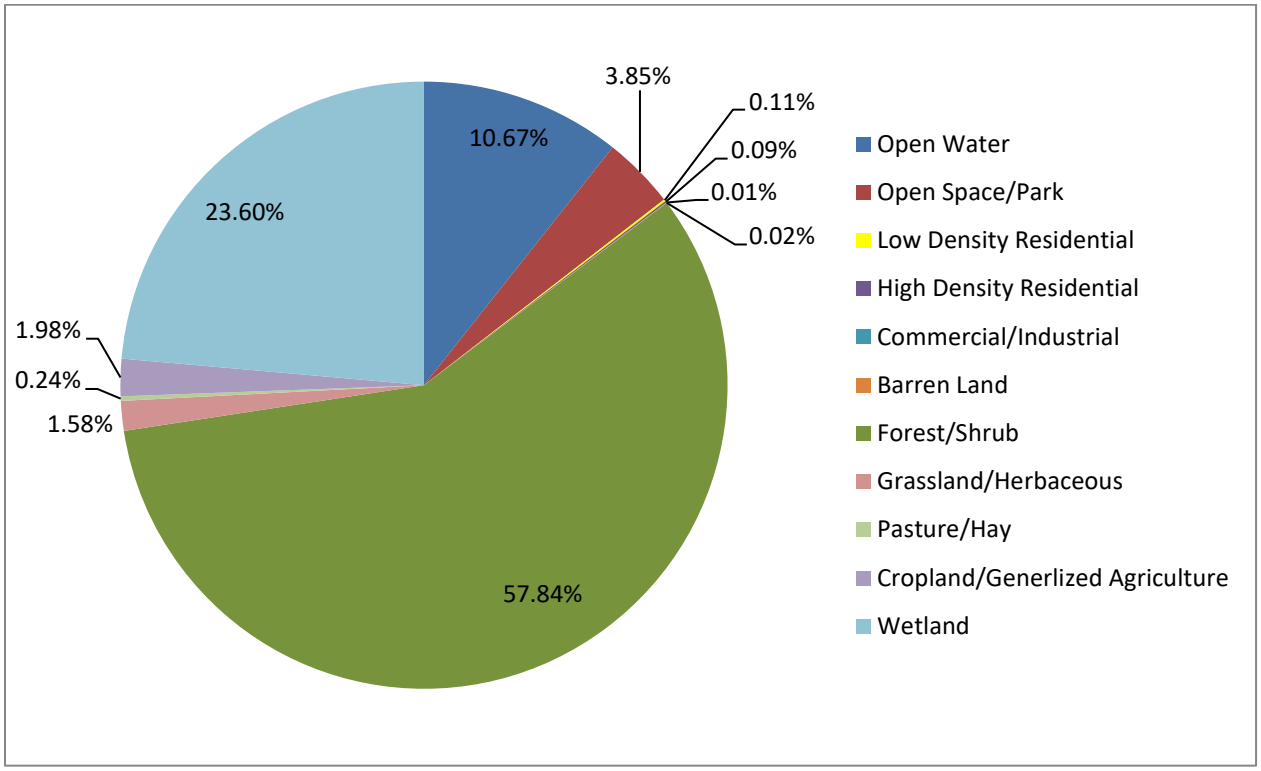
Measured calcium and magnesium levels for Smoky Lake were 3.65 mg/l and 1.53 mg/l respectfully. Calcium is important for lakes to support organisms like mussels that need calcium to build shells. Lake suitability research for zebra mussels, an aquatic invasive species, suggests that calcium may predict the ability for zebra mussels to colonize a lake. Measured calcium levels make Smoky Lake unsuitable (< 10mg/l) for zebra mussels **(Papes, M. et. al., 2011).**

3.2 Watershed

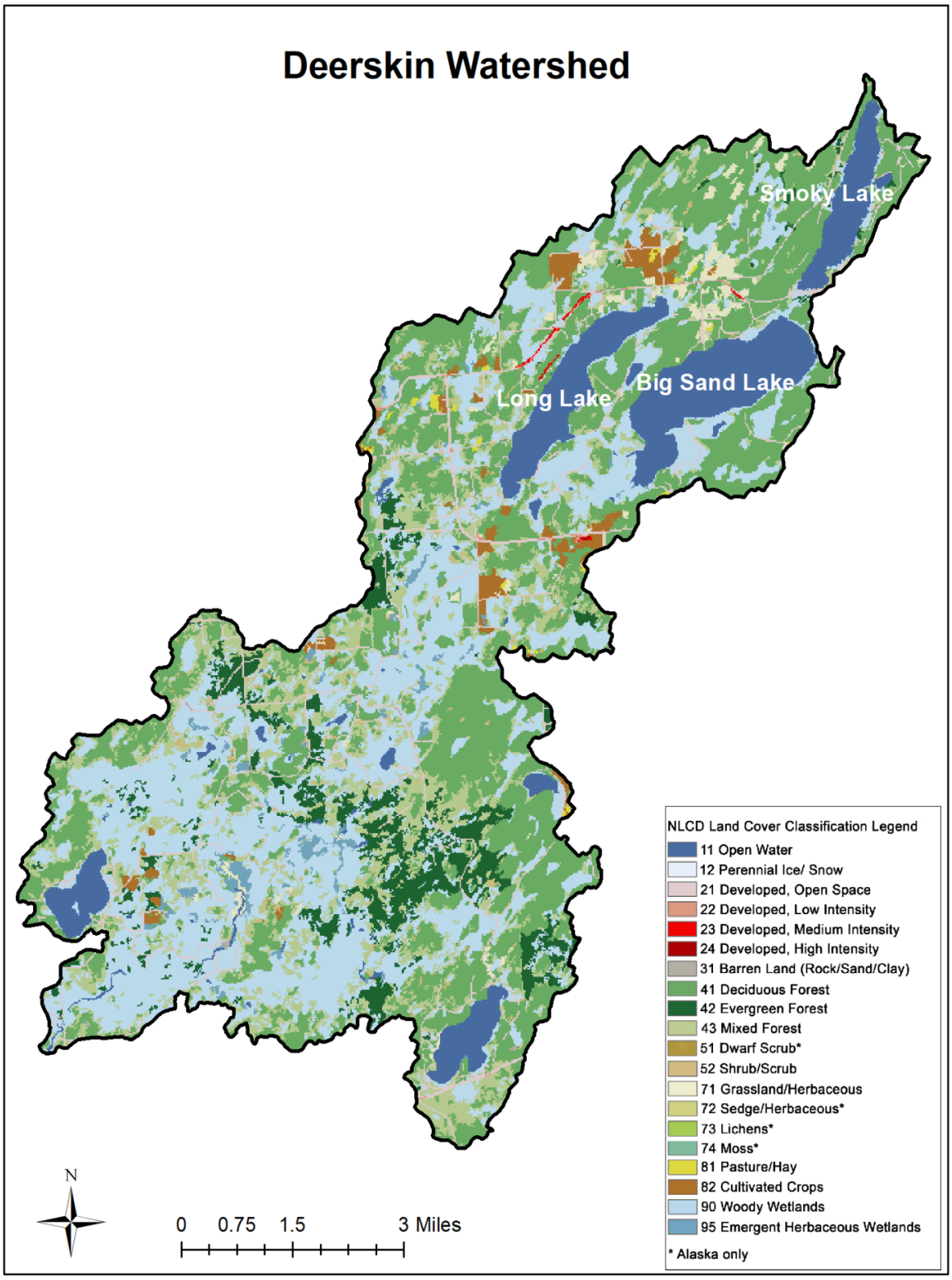
A watershed is an area of land where all water drains and collects at a central location, to a river or lake at a lower elevation. Land use in the surrounding watershed is important to lake health because water flowing across the land picks up pollutants such as nutrients and sediment that may run off 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. Smoky Lake is located at the northern tip of the Deerskin Watershed**.** The Deerskin watershed feeds into the larger Upper Wisconsin River Basin. Primary land cover in the Deerskin River watershed is forests (58%) and wetlands (24%) **(Figure 3.2.1).**

Figure 3.2.1: *Deerskin watershed land use by percent of total watershed. (LTHIA)*



Map 4: *Deerskin Watershed and its Land Uses*

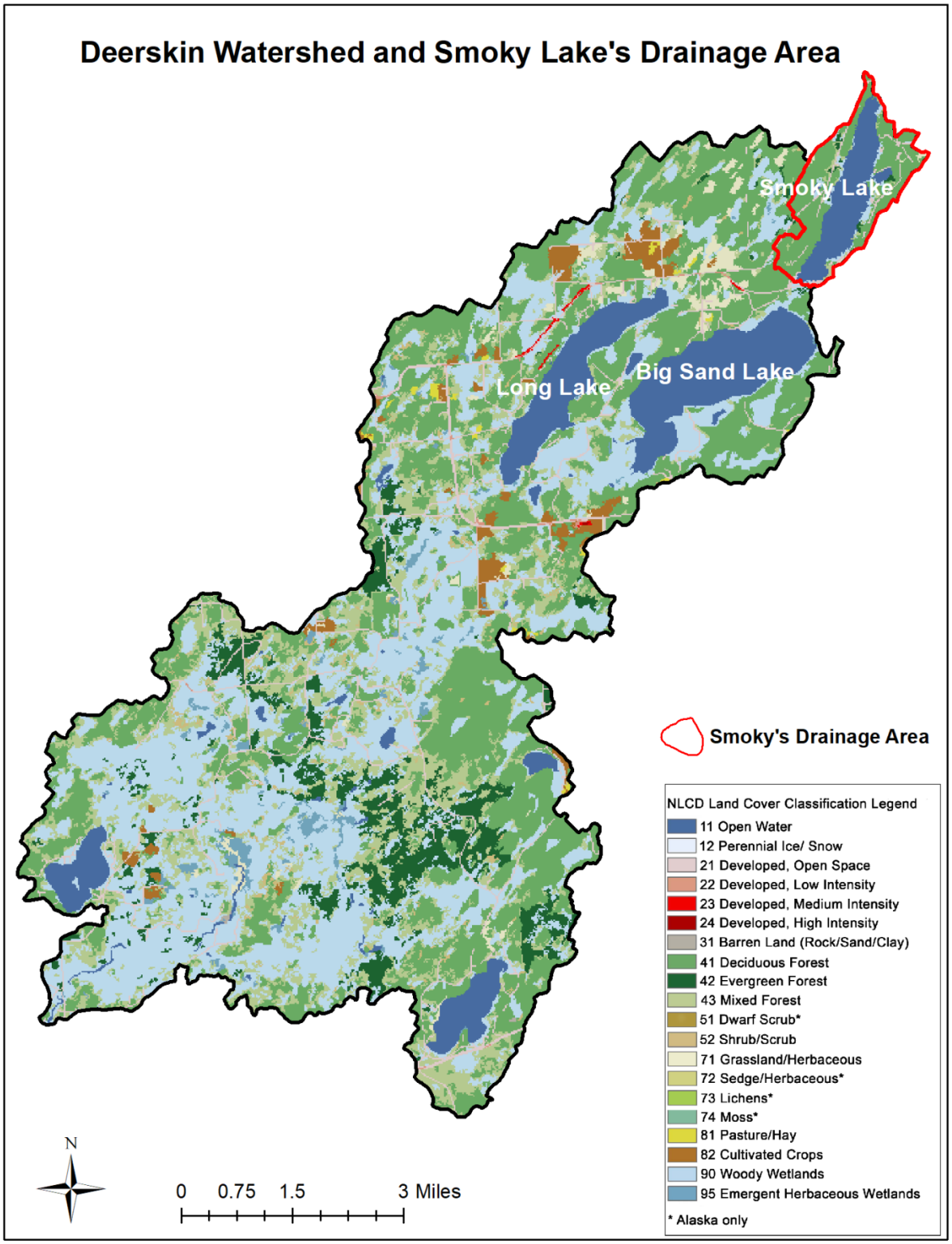


A lake's hydraulic residence time is the time required to refill a lake with its natural water inflow **(Horne & Goldman, 1994).** The size of the lake, watershed, and sources of water to a lake affect residence time. If a lake is relatively shallow, with a high inflow of water, residence time may be short. Whereas in deep lakes such as Smoky 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. A flushing rate is simply the number of times a lake flushes in one year, typically expressed to the nearest 1/10 of a year. Being a seepage lake, Smoky Lake's residence time is expected to be quite long. This is important because changes in the surrounding landscape that affect runoff and nutrients entering Smoky Lake, may impact the lake for a very long time, even after mitigation to those impacts occur. See Section 3.6 for a discussion of specific best management practices for riparian landowners.

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 et al, 2001).** In addition, lakes with large ratios will typically have shorter residence times, allowing nutrients and other pollutants to flush out. Lakes with small ratios typically have a much longer residence times, holding pollutants, and other nutrients longer. In these cases, land practice improvements to mitigate water quality issues may take many years to see any change in water quality. In very large drainage area to lake area ratios (>10:1), land cover plays a role, but the sheer amount of land contributing run-off to a lake may drive characteristics of a lake regardless of land cover. For example, lakes with largely forested watersheds may have higher nutrient levels, even though most of the watershed remains undeveloped.

Smoky Lake's drainage area to lake area ratio is 2:1**.** This means approximately two acres of land drain to each surface water acre of Smoky Lake. This is important because Smoky's residence time is quite long and land use changes to improve water quality may take a very long time to notice the effects.

Map 5. *Deerskin Watershed and Smoky Lake's Drainage Area*



Pollution load estimations for phosphorous to Smoky Lake varies by land cover type, with forests predicted to provide the largest annual load **(Table 3.2.1).** Total annual phosphorous loads based on WDNR estimation tools ranged from low estimates of 49.3 pounds/yr to high estimates of 243.1 pounds/yr (WDNR PRESTO, 2013). Approximately 50% of the direct drainage to Smoky Lake comes from adjacent waterfront property owners. These properties are currently primarily forests, however, land use development adjacent to Smoky Lake, where forests are developed into more residential type landscapes, may increase the total annual load of phosphorous to the lake. Further discussion on shoreline activities and nutrient enrichment of the lake may be found in Section 3.6.

Table 3.2.1: *Predicted phosphorous loading to Smoky Lake – low to high estimates (WDNR PRESTO, 2013)*

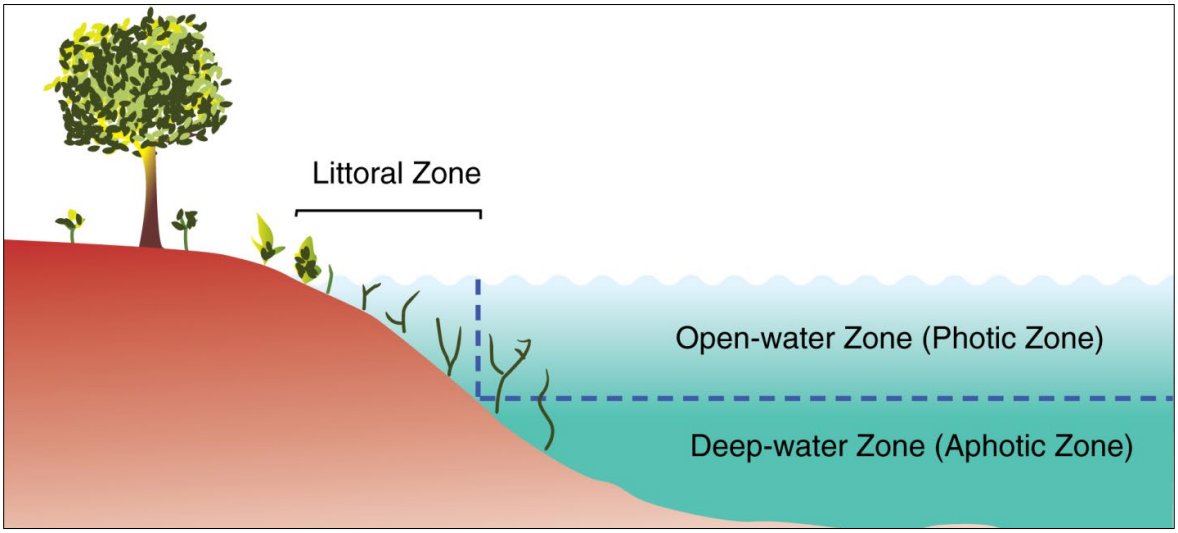
	Low Phosphorous ($lb/mi^2/yr$)	**Med Phosphorous ($lb/mi^2/yr$)**	**High Phosphorous ($lb/mi^2/yr$)**
Rural Residential	3.77	7.41	18.59
Pasture/Grassland	0.87	1.71	4.29
Forest	40.89	80.37	201.63
Wetland	3.77	7.41	18.59
TOTAL	**49.3**	**96.9**	**243.1**

3.3 Aquatic Plants

3.3.1 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 3.3.1).** 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 3.3.1: *Littoral Zone*[10]



<u>Categories of Aquatic Plants</u>

<u>Emergent Plants</u>

Emergent plants, typically associated with the shallowest portion of the littoral zone, tolerate fluctuating water levels and usually root along the edge of a lake. 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 most impacted with shoreline development. Examples of emergent plants include cattails, bulrushes, and irises.

[10] 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 as water depth increases. Floating leaf plants common to Northern Wisconsin and the Upper Peninsula of Michigan have circular shaped leaves with a leathery texture to resist tearing from waves and wind, making them ideal to dissipate wave energy reaching shore. Common floating leaf plants include white water lilies, pond lilies and the American lotus. Another category of 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*).

Submersed Plants

Very diverse groups of plants found in both shallow and deeper portions of the littoral zone are submersed aquatic plants. 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.

3.3.2 Smoky Lake's Aquatic Vegetation

Assessing a lake's aquatic plants not only provides detailed information on the types and distribution of aquatic plants in a lake, but the data is also useful for analyzing in-lake habitat structure, ecosystem stability, identifying high quality and at risk in-lake habitats. Furthermore, repeating this assessment provides comparisons of these data over time.

Aquatic plant assessments at Smoky Lake included point intercept surveys, emergent/float leaf plant community mapping and acoustic or sonar- based bottom mapping. Point intercept surveys followed the WDNR Monitoring of Aquatic Plants in Wisconsin (2010) protocol, which uses a grid of predetermined points evenly spaced across the lake. These points are up-loaded into a GPS for field navigation**.** At each site, a double-sided rake lowered over the side of the boat collects a sample of aquatic vegetation. Each species on the rake is identified and an abundance or rake-fullness for the rake and each species is estimated **(Figure 3.3.2).** Species richness ranged from zero to five species detected per rake sample with an average rake fullness of 1.06**.**

Map 6: Plant Survey Sampling Grid-Smoky Lk 2017

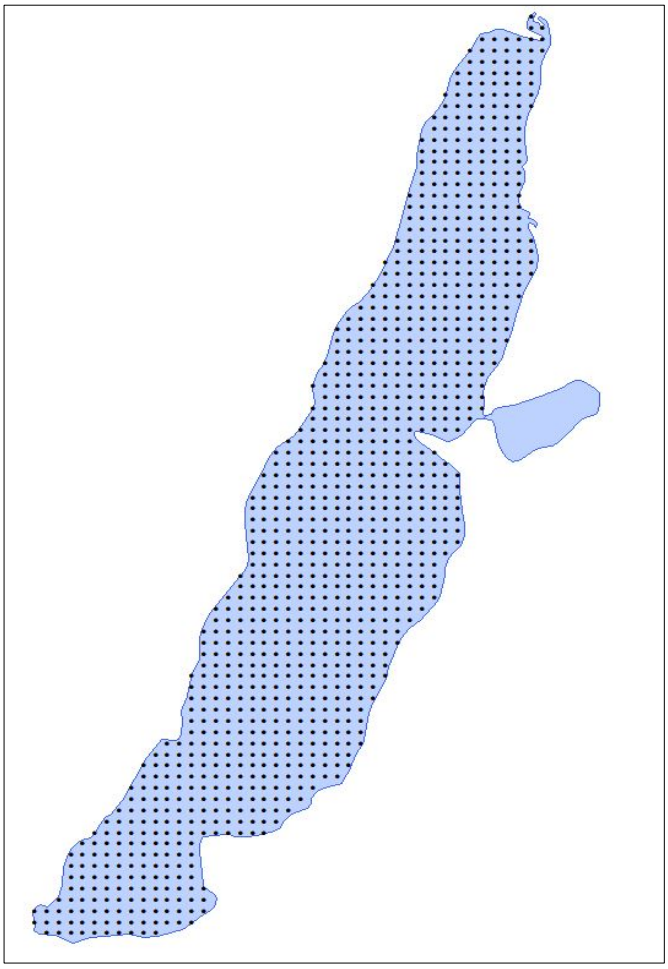
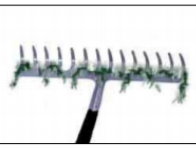
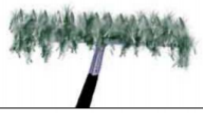
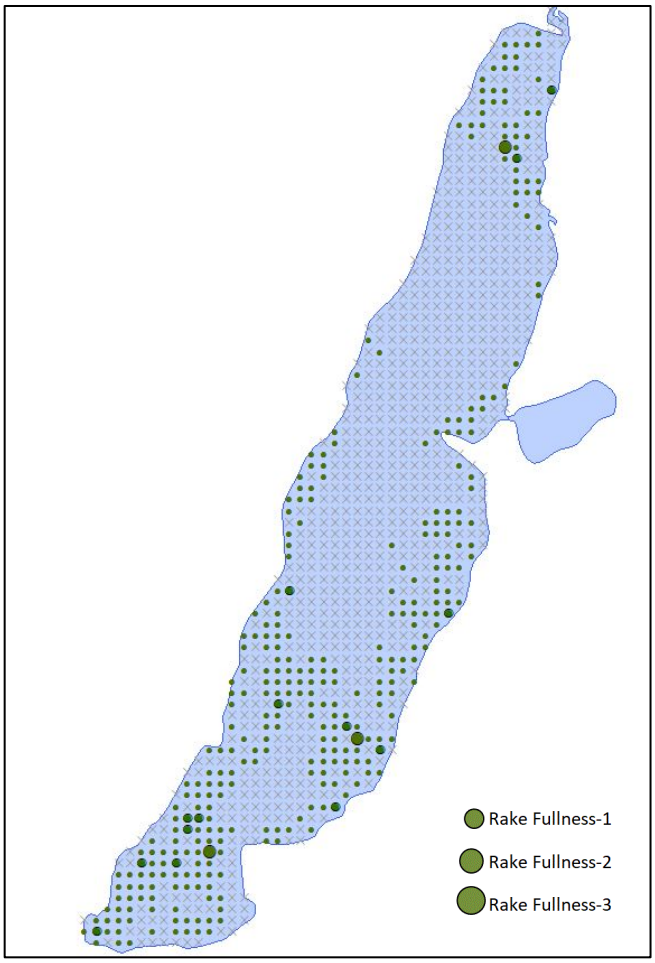


Figure 3.3.2: *Rake fullness description*[11]

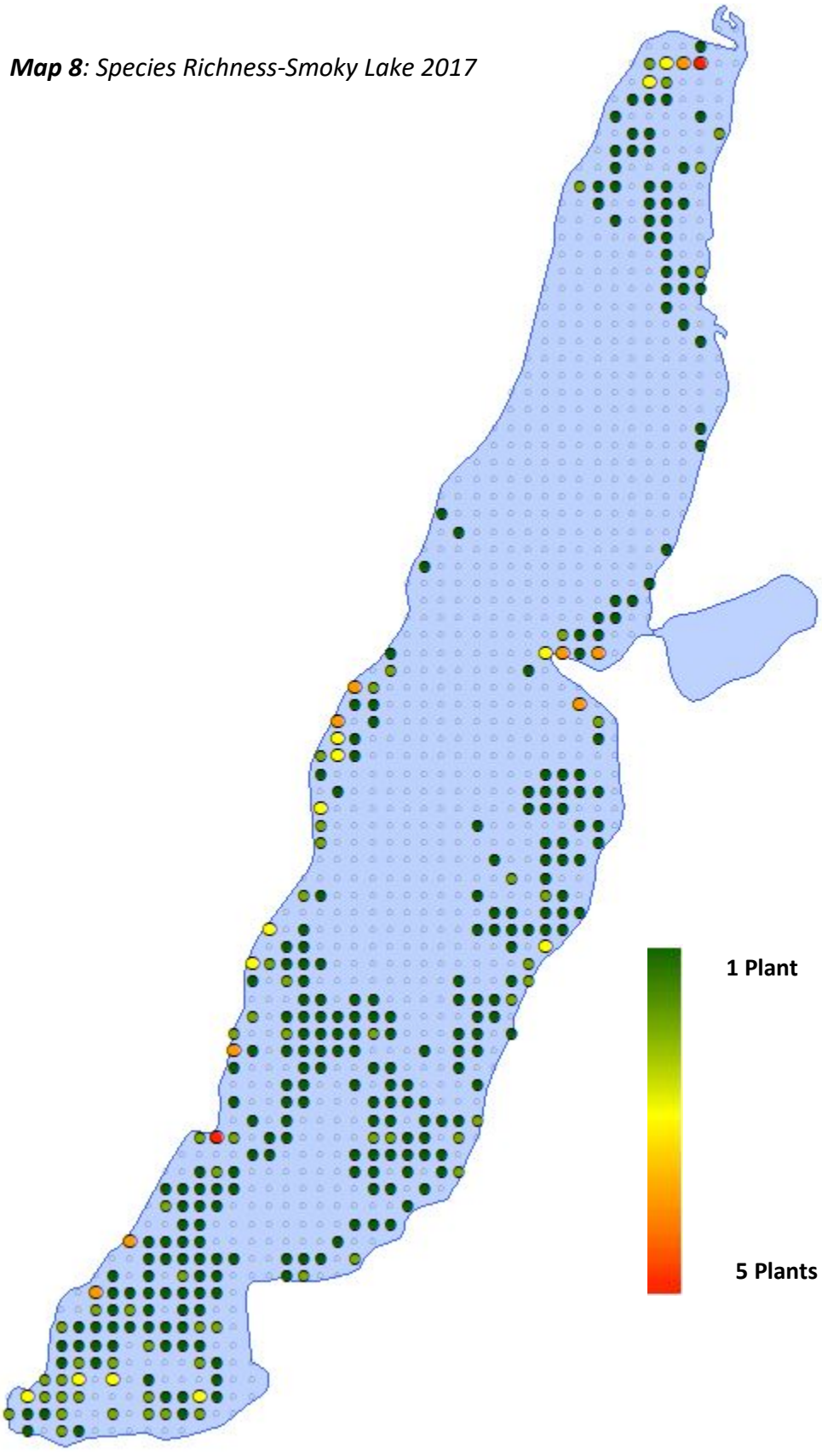
Fullness Rating	Coverage	Description
1		Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer.
2		There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines.
3		The rake is completely covered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



Map 7: *Rake Fullness – Smoky Lake 2017 (Right)*

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

***Map 8**: Species Richness-Smoky Lake 2017*



At each sampled site, water depth and sediment type is recorded. 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 F).** Using sonar, the entire lakebed was mapped and these recordings were analyzed by a third party.

Aquatic vegetation surveys took place from August 20th-23rd 2017[12]. This survey sampled 659 locations, identifying 32 native aquatic plant species and 2 invasive plant species. Rake samples detected 22 native plants species **(Table 3.3.1)** and nearshore visual observations recorded eight additional species **(Appendix E).**

Table 3.3.1: *Plant species detected on Smoky Lake and associated depths and plant type. These are species detected on rake samples only and do not include additional species visually identified.*

Plant Species	Minimum Depth Plant Found (ft)	Maximum Depth Plant Found (ft)	Plant Type
Northern manna grass	1.0	1.0	Emergent
Narrow leaved bur reed	3.0	5.5	Emergent
Bur-reed	6.0	8.5	Emergent
Crested arrowhead	5.5	5.5	Emergent
Brown-fruited rush	3.5	9.5	Emergent
Needle spikerush	1.0	11.5	Emergent
Common waterweed	13.5	13.5	Submersed
Small purple bladderwort	6.5	6.5	Submersed
Eurasian watermilfoil	3.5	16.5	Submersed
Spiral-fruited pondweed	3.0	11.5	Submersed
Creeping spearwort	1.0	7.5	Submersed
Dwarf watermilfoil	4.0	9.0	Submersed
Water lobelia	5.0	6.5	Submersed
Waterwort	4.0	9.0	Submersed
Fern pondweed	6.0	23.0	Submersed
Slender waterweed	14.0	14.0	Submersed
Clasping-leaf pondweed	4.0	21.0	Submersed
Muskgrasses	11.0	30.0	Submersed
Quillwort species	3.5	14.5	Submersed
Slender naiad	3.0	18.0	Submersed
Small pondweed*	7.0	21.5	Submersed
Nitella	3.0	33.0	Submersed

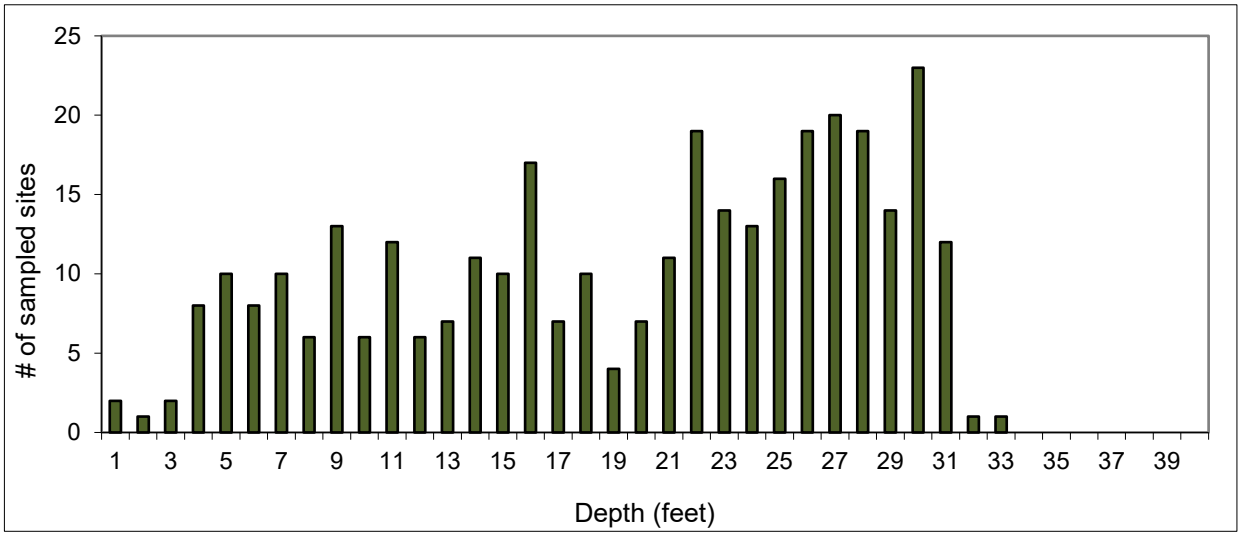
[12] The WDNR conducted a vegetation survey on Smoky Lake in 2013.

The two invasive species detected include Eurasian watermilfoil (*Myriophyllum spicatum*) (Left below) and reed canary grass (*Phalaris arundianceae*)(Right below)

Eurasian watermilfoil is known to occur in Smoky Lake. Reed canary grass is a non-native species to Wisconsin. It is common in many habitats in Wisconsin and is widespread throughout the State.

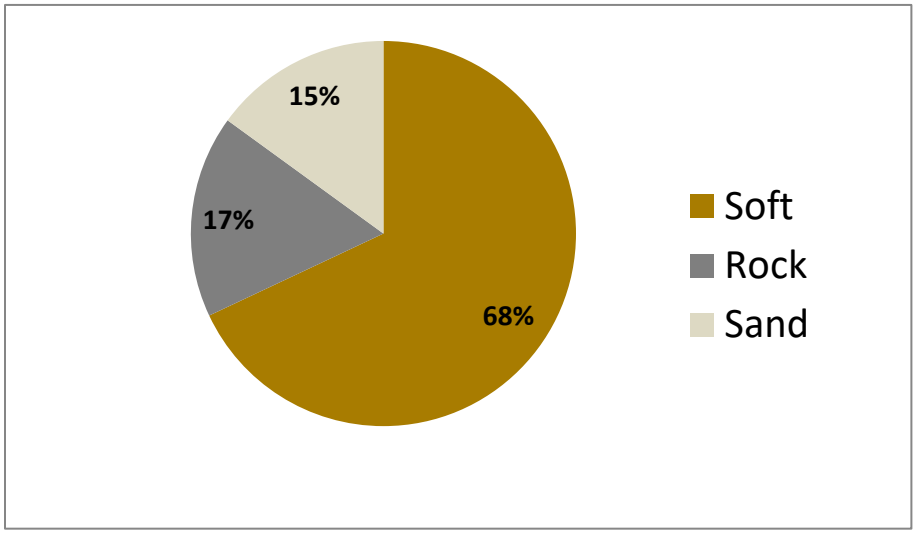
Maximum depth of plant colonization occurred at 38 feet, with the majority of vegetated sites occurring between 23 to 30 feet **(Figure 3.3.3).**

Figure 3.3.3: *Depth of aquatic plant colonization*



Most sites sampled consisted of soft or mucky sediments (68%) followed by sand (17%) and rock (15%) (**Figure 3.3.4).**

Figure 3.3.4: Lake-wide percentage of substrate consistency – Smoky Lake 2017.



In 2017, sonar mapping collected data on water depth, substrate composition, and aquatic plant bio-volumes across Smoky Lake. A third-party translated this data from in-field sonar readings to create bathymetric, substrate hardness and aquatic plant bio-volume maps. Bathymetric maps show the different underwater depths of a lake. Substrate hardness uses a sliding scale from soft to hard to characterize lake sediment composition. Aquatic plant bio-volume looks at the total percentage of the water column occupied by plants. Bio-volumes take into account all species rather than individual species and values are represented as a percentage of the total water column. For example, if the water depth is ten feet and plants detected at that location are five feet tall, the percent bio-volume would be 50%. Based on 2017 bathymetric estimates, Smoky Lake is 587 acres with an estimated water volume of 17,566.95 acre-ft. In 1938, the Michigan Institute for Fisheries Research estimated Smoky Lake to be 590 acres, whereas the WDNR estimates Smoky Lake to be 612 acres. Smoky Lake has a maximum depth of 72 feet with a mean depth of 29.5 feet. The majority of the bio-volume analysis (~80%) suggests that aquatic plants make up a very small portion of the total water column. This analysis does include depths deeper than where aquatic vegetation may grow. On average, for water depths 10 feet or less, bio-volumes tended to be around 10%**.** Overall, the majority of waters 20 feet or less consists of firm to moderately firm substrates**.**

3.3.3 Plant Analysis Primer

Floristic Quality measures the natural quality of a lake's aquatic plant community or nearness of the lake's aquatic plants to those seen in undisturbed conditions. This value specifically uses a combination of species richness and coefficients of conservatism to calculate a value used comparatively over time to monitor changes to plant communities **(Nichols, 1999).** Species richness can often be confused with species diversity. Species richness refers to the total number of different plants, 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 a value ranging from zero and ten assigned to each plant that relates the likelihood of that species being present in a pristine or undisturbed environment. For example, a plant that can tolerate disturbance may have a value of one whereas a plant that is not tolerant to disturbance might have a value of ten. Floristic quality assessments generally compare the floristic quality of lakes within a similar Ecoregion **(Figure 3.3.5).** An Ecoregion is a defined landscape that has similar characteristics including land-use, vegetation, soils, and landscape formations. Smoky Lake is located within the Northern Lakes and Forests Ecoregion, which consists of conifer and northern hardwood forests, numerous lakes, perennial streams and poor agricultural potential **(Omernik & Gallant, 1988).**

Figure 3.3.5: Wisconsin's ecoregions.

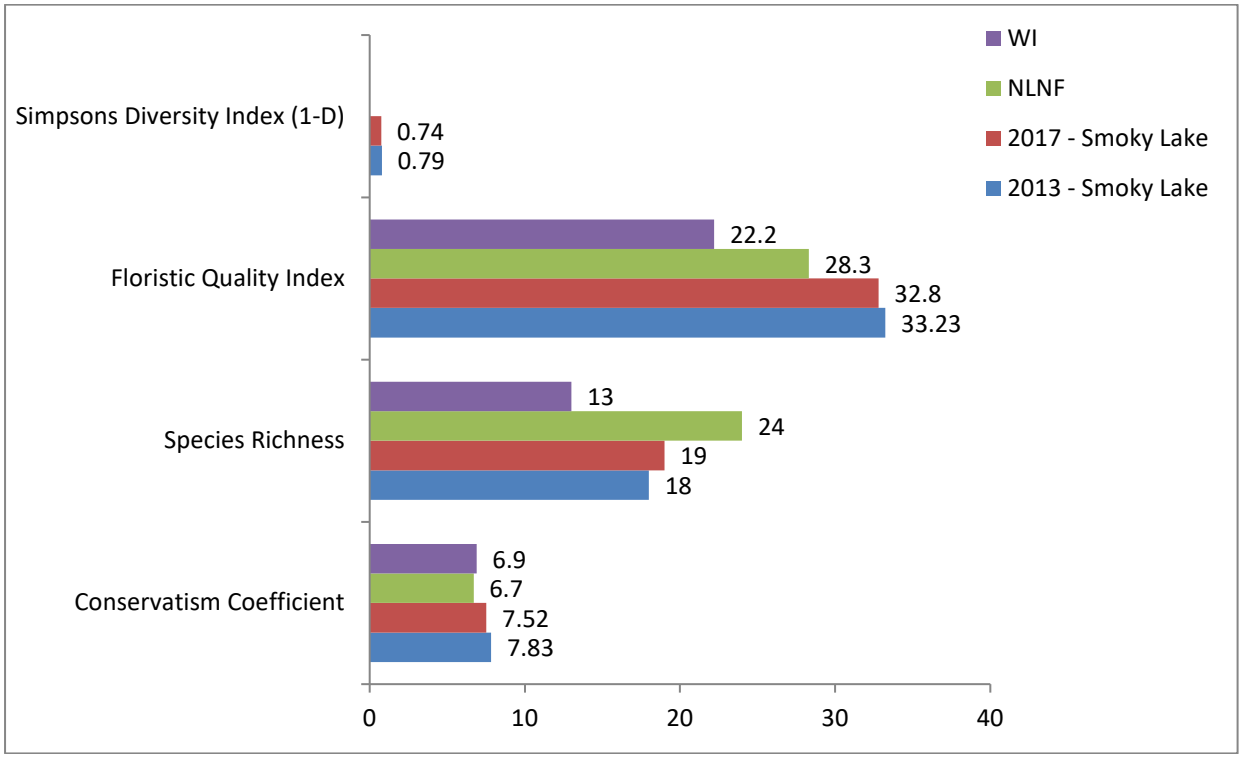
3.3.4 Aquatic Plant Analysis

Smoky Lake's floristic quality changed very little in 2017 compared to 2013 with an overall ranking above the median value for the Northern Lakes Northern Forests region and Wisconsin statewide values **(Figure 3.3.6).** Average species conservatism ranged from 7.83 in 2013 to 7.52 in 2017, again above ecoregion and Statewide median values. 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 data being analyzed. Species richness remained similar between the 2013 and 2017 surveys and trended less than the local and Statewide. It is important to note that floristic quality uses the average of the total conservative values for all plant species, meaning, some lakes may have less species overall, but the average of the conservative values may be higher than a lake with more species. The floristic quality data suggests that Smoky Lake's native plant community represents species more typically found in lakes with fewer disturbances compared to Ecoregion and Statewide values, in other words the aquatic plant community of Smoky Lake is currently healthy and of good quality.

In addition to floristic quality, a Simpson's Diversity Index, is one of many indices useful in ecology to measure 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 resilience of lakes to recover from 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.

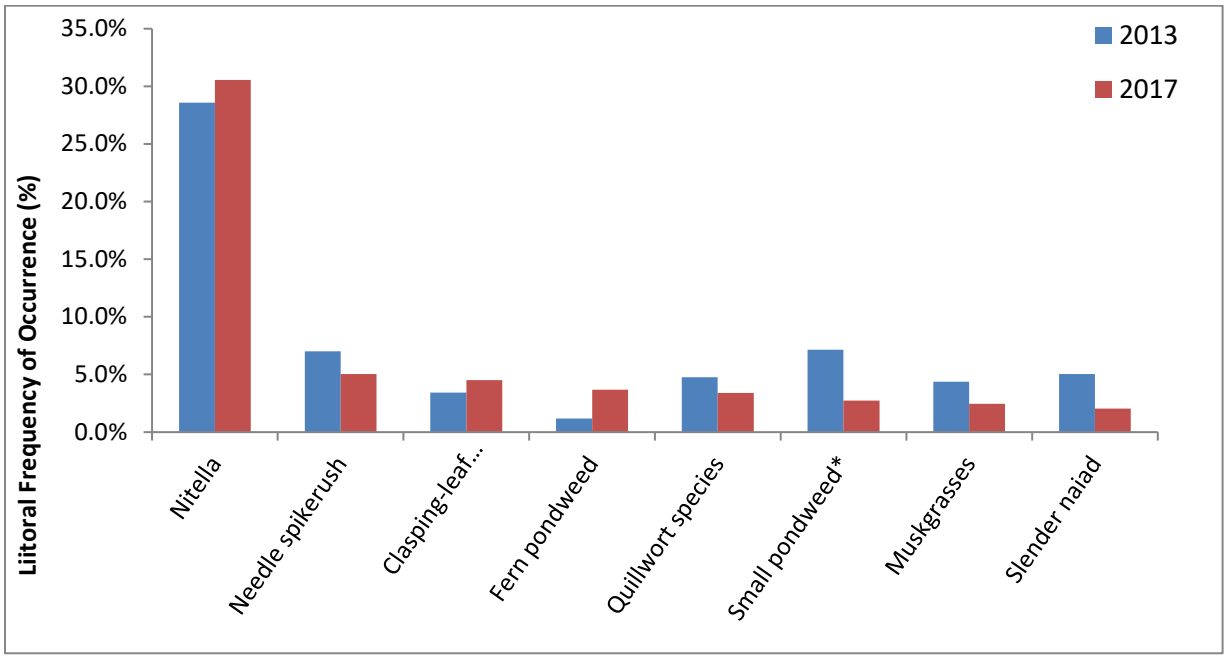
The closer the value is to one, the more diverse the measured population is. Simpson Diversity Index values for Smoky Lake fell slightly from 0.79 in 2013 to 0.74 in 2017.

Figure 3.3.6: *Summary of Smoky Lake's floristic quality and diversity analysis*



Frequency of littoral occurrence is the percentage of total surveyed points a species was detected on a rake sample divided by the total number of sites within the littoral zone **(Figure 3.3.7).** Over time, these values can provide evidence of changes to the plant community at the species level. This level of detail becomes important for several reasons. These changes may indicate disturbances happening within a lake, such as changes within the watershed, shoreland practices, water levels, or climate. Specific aquatic management techniques, such as herbicide use, may have unintended impacts to native plants. Some species showed a statistically significant increase or decrease in 2017 compared to the 2013 survey**.** Species showing a statistical valid increase include dwarf watermilfoil, nitella, fern pondweed, and creeping spearwort. Species showing a statistical valid decrease include musk grasses, slender waterweed, slender naiad, blunt-leaf pondweed, and small pondweed **(Appendix G)**. For the purpose of this analysis, small pondweed identified in 2013 and Berchtoldii pondweed identified in 2017 have been combined. Taxonomic classification for these species has recently occurred and this group of narrow leaved pondweeds shows a great deal of vegetative variability, making morphological identification challenging.

Figure 3.3.7: *Comparisons of littoral frequency of occurrence greater than 5% - Smoky Lk 2013 & 2017. Note: Only species with a 5% or greater littoral frequency of occurrence are represented.*



It is speculative to determine the exact cause of statistical change because relatively little aquatic plant and watershed manipulation has occurred during this timeframe. Native species do exhibit natural inter annual variation, meaning their populations ebb and flow from year to year. However, one plausible explanation is the increase in water levels on Smoky Lake from 2013 to 2017. Water level monitoring by Smoky Lake volunteers recorded a 2.6-foot increase in water levels from August of 2013 to August of 2017. The average depth and mean depth of plants detected rose from 17.8 feet and 18 feet in 2013 to 19.5 feet and 22 feet in 2017. A substantial portion of shallow and deep end sampling sites declined from 2013 to 2017 **(Figure 3.3.8).** Species may be adjusting to life at their new depths, causing some species to increase and others to decline. Another reason may be less sampling occurred in certain depth zones due to water levels rises from 2013 to 2017.

Frequency of littoral occurrence is the percentage of time a species is identified across the 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 a 45% frequency of littoral occurrence for a particular species means that each time you sample you have a 45% chance of sampling that species. To look at the number of times a species is likely to be sampled; relative frequency of occurrence is calculated. In other words, relative frequency of occurrence is the proportion of times that a species is sampled relative to the total population. The three most common species in 2017 based on relative frequency of occurrence are nitella, needle spikerush and clasping-leaf pondweed 49%, 8% and 7% respectfully **(Figure 3.3.9).** Again, analysis combines small pondweed identified in 2013 and Berchtoldii pondweed identified in 2017.

Figure 3.3.8: *Comparison of number of sampling sites with vegetation versus depth for 2013 and 2017 plant surveys – Smoky Lake.*

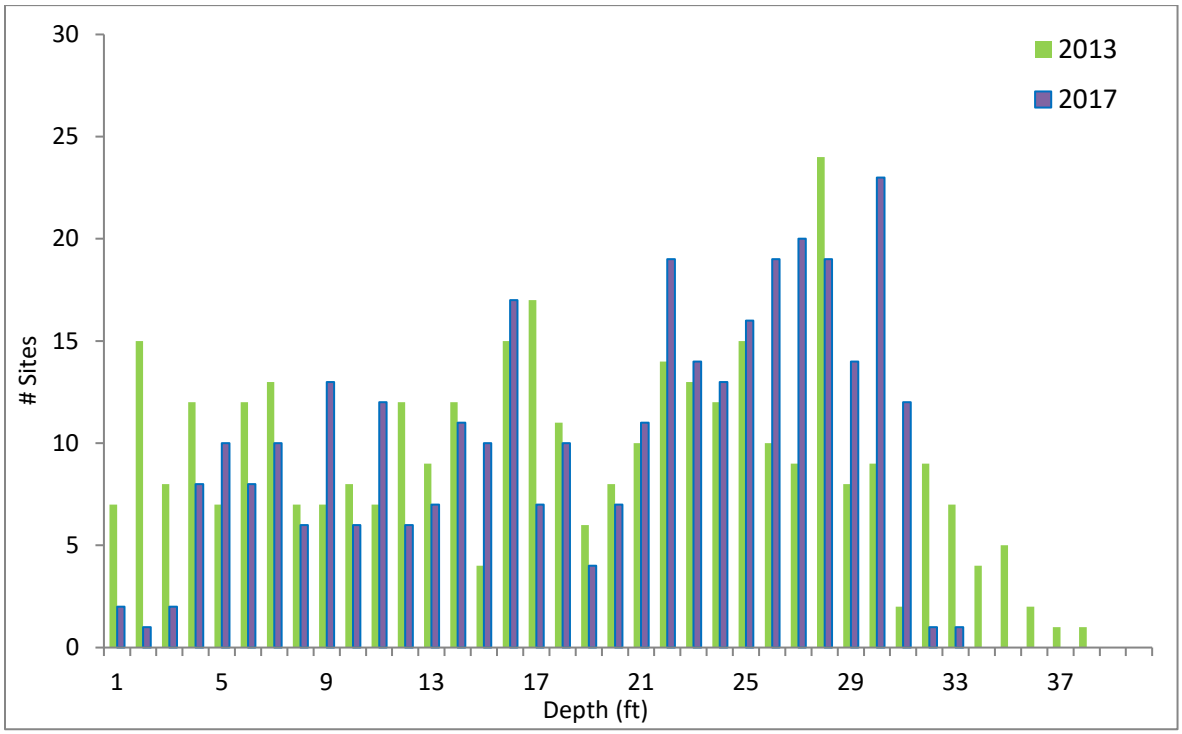


Figure 3.3.9: *Relative frequency of occurrence of aquatic plants (5% occurrence or greater) – Smoky Lake 2013 & 2017. EWM occurrence is less than 1%.*

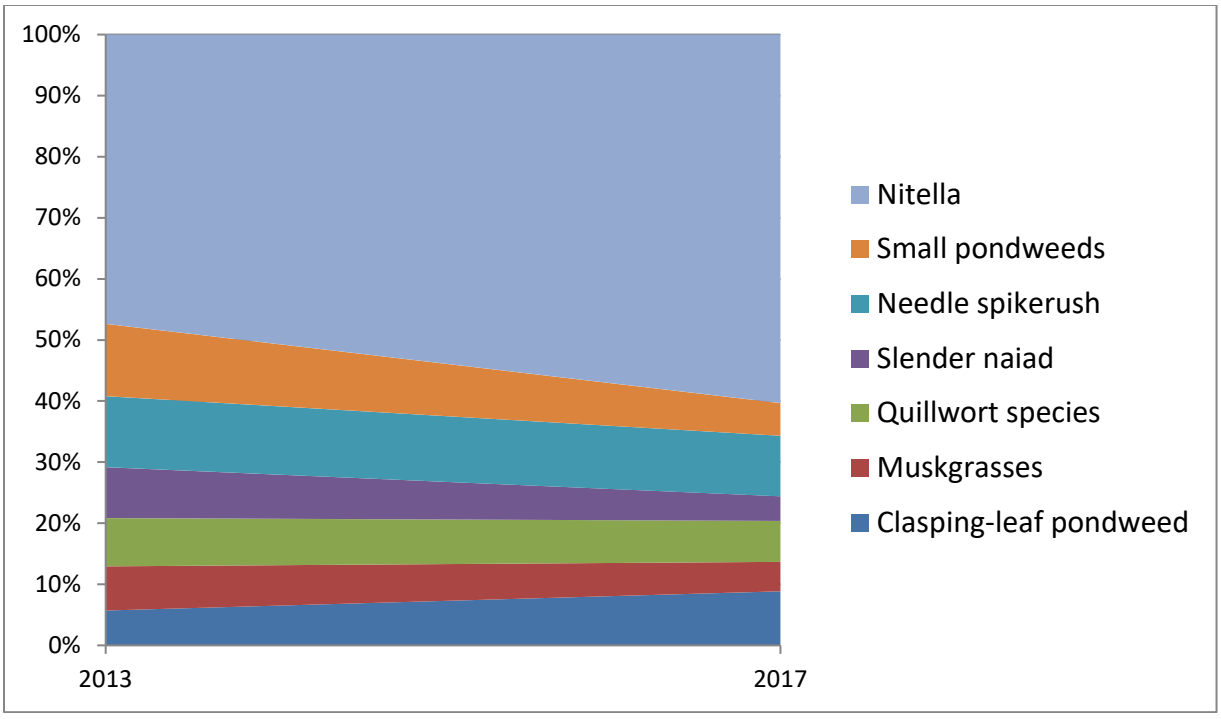


Figure 3.3.10: *Images of most common aquatic plants in Smoky Lake*

Source: https://bugwoodcloud.org/mura/mipn/assets/File/UMISC-2016/Monday/1/Skawinski_etal_Workshop_Native%26ExoticAquaticPlantID.pdf

Smoky Lake supports a diverse and healthy native aquatic plant community. Aquatic invasive species, such as Eurasian watermilfoil remain at very low densities and are not impeding the recreational use of the lake. Water levels will continue to fluctuate with high and low water periods expected. Aquatic plants generally are well adapted to take advantage of these changing conditions, especially emergent plants. During low water periods, emergent plants will use seed production as its primary reproductive strategy, whereas during high water levels these plants will spread vegetatively out by growing horizontal roots that send up new plant shoots. Emergent plants will also have differing vegetative forms depending on how deep they are growing in the water.

3.4 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 Smoky Lake. However, a basic understanding of their applicability is important to understand the rationale for choosing methods specific to Smoky Lake.

3.4.1 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 & Meyer, 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.

Examples of shoreline development that can lead to negative ecological impacts include:

- 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.

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 MDEQ and WDNR on permit requirements

3.4.2 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 **(Engel, 1983).**
- Check with MDEQ and 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 MDEQ and 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 MDEQ and WDNR on permit requirements

3.4.3 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 MDEQ and WDNR on permit requirements

3.4.4 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.

Smoky Lake is a border lake with Michigan and Wisconsin, therefore, chemical control of aquatic plants will require authorization and permitting from the State where the chemical control will occur. Michigan and Wisconsin have their own set of regulations, and a certain chemical or chemical formulation legal in one state, may not be legal in the next. For example, the State of Michigan does not allow the use of liquid 2, 4-D, but allows the use certain granular 2, 4-D products, whereas the State of Wisconsin allows certain formulations of both liquid and granular 2, 4-D.

The Northern Region WDNR Aquatic Plant Management Strategy includes best management practices that limit chemical treatments to spring applicatins to protect native plant species **(APM Strategy Northern Region-WDNR – 2007).** This strategy seeks to minimize impacts to native plants during chemical treatments, by treating when it is presumed that many of the native species are still dormant. The use of herbicides can potentially be hazardous and only trained licensed professional applicators should apply aquatic herbicides. Further information regarding aquatic plant control in Michigan can be found on the Michigan Department of Environmental Quality (MDEQ[13]) Aquatic Nuisance Control website[14]. For information about aquatic plant control in Wisconsin, please contact the regional aquatic plant management coordinator[15].

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 Michigan and Wisconsin. Further information on approved herbicides in Wisconsin can be found in the Aquatic Plant Management in Wisconsin: Strategic Analysis[16].

<u>Diquat</u>

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

[13] This program is now called the MEGLE – Michigan Department of Environment, Great Lakes, and Energy
[14] www.mi.gov/anc
[15] https://dnr.wi.gov/lakes/contacts/Contacts.aspx?role=AP_MNGT
[16] https://dnr.wi.gov/topic/eia/apmsa.html

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.

2, 4-D

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

General Application Considerations for Chemical Control

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

3.4.5 Management Considerations-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 & Westerdahl, 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 et al., 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 by 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 et al, 2012, Parks et al, 2016**). Furthermore, not all hybrids may respond equally, meaning certain hybrid clones may have various responses to treatment **(LaRue et al, 2012).** Rotating the mode of action of the herbicide may reduce the potential of resistance issues. Laboratory analysis of milfoil samples from Smoky Lake, confirmed pure strain Eurasian watermilfoil, and no hybrids **(GVSU, 2014).** This does not mean hybrids do not exist on Smoky Lake; 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. **(EPA-DRAFT, 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.

3.4.6 Management Considerations-Smoky Lake

Several management techniques discussed above may be feasible on Smoky Lake, however, many would not be applicable at this time including biological control and mechanical harvesting. Biological control would entail a local entity or volunteer raising and releasing milfoil weevils since no commercially raised weevils are currently available for purchase. Mechanical harvesting would be a somewhat costly operation considering the current low density. Based on meetings with the WDNR in 2016, the WDNR would not permit the use of herbicides to treat EWM on Smoky Lake. Benthic barriers would be feasible and appropriate for small-scale application, whereas water level drawdowns would not be operationally or fiscally feasible because Smoky Lake does not have a water level control structure. Water would have to be mechanically pumped out of Smoky Lake to a designated location. Hand removal continues to be the sole management technique available at this time given the scale of the population.

3.4.7 Permitting

Michigan

The State of Michigan requires permits for the chemical treatment of aquatic plants. Permits are submitted and issued through the Michigan Department of Environmental Quality, Water Resource Division – Aquatic Nuisance Control Program. For more information on permit requirements, please contact the MDEQ – Water Resources Division – Aquatic Nuisance Control.

Hand removal with the use of auxiliary power, such as diver assisted suction harvesting, does require a joint MDEQ/USACE permit from the State of Michigan. Waters under USACE jurisdiction may have additional permitting requirements. Depending on the waterbody, diver assisted suction harvesting may have seasonal restrictions. Please contact the local MDEQ permitting agent for details on permit requirements.

When treating with herbicides or hand removal using auxiliary power (i.e. Diver Assisted Suction Harvesting-DASH) in Michigan, the presence of State listed threatened and endangered species, such as loons, may require additional permitting from the MDNR Wildlife Division. Please contact the MDNR Wildlife Division for information on permitting.

Wisconsin

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.

3.4.8 Aquatic Plant Management Guiding Principles & Framework

Eurasian watermilfoil can potentially alter native 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, 2016).** Recent WDNR research suggests that across the State of Wisconsin, many lakes do not reach lake-wide high densities, as previously once thought. Nonetheless, it is important to recognize that aquatic ecosystems are dynamic. Annual variation does occur, and further research is needed to understand how lake ecology and climate may play a role in EWM population variability.

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

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

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

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

Regardless of the options adopted, management will follow well-accepted best management practices including monitoring and an evaluation component. Quantitative metrics are favored, however there are challenges posed with small-scale management, including sampling size

(replicates), controls (which are used to verify effects), non-uniform treatments (varying treatment and monitoring dates) and pseudo-replication (sample units not being independent but rather subsamples of the same unit). The degree of statistically verified information regarding management will vary however, it is important to mention these limitations and thus reliance many times on more qualitative monitoring methods.

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

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

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

3.4.9 History of Eurasian Watermilfoil and Association Efforts 2013-2018

In 2007, the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) found two EWM fragments at the boat launch, one partially dried and one a fresh shoot with flowers. During survey efforts, GLIFWC did not detected any root plants on Smoky Lake. In 2011, a USFS Ottaw National Forest contracted surveyor reported one stem of EWM in a protected area near the boat launch. No other rooted plants were detected. On August 15th 2013, a USFS Ottawa National Forest contracted surveyor documented EWM within the southwest bay, west of the boat launch. This survey did not detect EWM elsewhere on the lake. This 2013 discovery, confirmed by the Wisconsin Department of Natural Resources (WDNR), initiated efforts by the WDNR with assistance from the Vilas County Land and Water Conservation Department to complete an aquatic plant survey using the WDNR point intercept methodology. Results of this survey, detect EWM only within the southwest most bay of Smoky Lake.

The Association retained Many Waters, LLC to provide professional consulting services to guide management in assessing options for remediation. In 2014, the Town of Phelps, sponsoring the Smoky Lake Property Owners Association (SLPOA), applied for and successfully received a WDNR Aquatic Invasive Species Early Detection and Response Grant (Rapid Response Grant) to manage for EWM on Smoky Lake. At that time, being a Michigan organization, SLPOA was not eligible to receive WDNR funding and worked with the town to secure sponsorship. These

funds assisted in management efforts from 2014 to 2015. Additional funding was raised by SLPOA in 2015 to continue management efforts (hand removal) beyond the original budgeted scope of the grant.

The proposed management program for Smoky in 2014 and 2015 was to hand remove (without DASH) individual to small clusters of plants and use DASH for larger more dense and contiguous areas. This work was primarily done by trained volunteers under the supervision of Many Waters LLC. As the summer of 2014 progressed, the level of need within the southwestern bay exceeded the efficiency of hand removal alone. Because the overall work area permitted for DASH in Wisconsin was relatively small, moving the DASH equipment from location to location did not require substantive amount of set up and break down time. Pumps and hoses could be towed with the diver remaining in the water from location to location. Therefore, with the exception of the hand removal days by volunteers and training days with Many Waters, all hand removal efforts consisted of the use of DASH. A total of 851 pounds of wet weight EWM were removed in 2014. A similar DASH program took place in 2015, focusing mainly within the southwestern bay. A total of 865 pounds of wet weight EWM were removed.

A member of the lake association and Many Waters met with Kevin Gauthier from the WDNR in early November 2015 to discuss directions for the AIS remediation program. The use of herbicides for 2016 was discussed at this meeting but a decision was not reached. This final decision would entail a broader team review by the WDNR. Kevin stressed the need to be reasonable in expectations, and that remediation rather than eradication is a more realistic goal. He expressed caution and a change in WDNR policies regarding the repeated use of herbicides in small-scale applications. In early 2016, after considerable study and research with other regional lakes, SLPOA met with Kevin Gauthier of the WDNR to discuss the possible use of herbicides. The WDNR determined that the extent and density of EWM did not justify the issuance of a permit and so management consisted of hand-pulling during the summer of 2016 and 2017.

The Smoky Lake Property Owners Association, working with the Town of Phelps as sponsor, pursued a second Rapid Response Grant in the winter of 2016. Kevin Gauthier (WDNR) specifically requested that resolutions from the Association and the Town to be tendered to him by February 2016 to indicate commitment to the long-term lake planning. In 2016, the Town of Phelps, as sponsor for Smoky Lake, applied for and successfully received a second WDNR Aquatic Invasive Species Early Detection and Response Grant to manage for EWM on Smoky Lake. These funds assisted in management efforts for the proposed project period of 2016 and 2017. Additional funding was raised by SLPOA to further management efforts in addition to the WDNR grant funds. These funds were specifically used to continue management efforts (hand removal) beyond the original budgeted scope of the grant.

In 2016, early season survey efforts detected 1.63 acres of polygon- based mapping beds of EWM at sparse to very sparse levels all within the far southwest bay of the lake. Several small pockets of moderate density EWM existed within these mapped beds. A three-pronged management approach in 2016 included the use of divers alone, DASH and snorkel pullers. The western shore locations were done with the use of scuba gear, due to the fact these sites were

relatively deep. Small pockets of moderate density and deeper water colonies in the southwest bay were managed with the use of DASH. The remaining sites located within the far southwestern bay were dove with the use of snorkel gear by contracted professionally and with the use of volunteers. DASH efforts removed 497 pounds of wet weight EWM; diving efforts removed 35 pounds of wet weight EWM, whereas snorkel pulling removed 135 cubic feet of EWM. By the end of the 2016 season, all detected EWM consisted of isolated sparse to very sparse locations.

In the spring of 2017, a substantial amount of rain and runoff elevated Smoky Lake's water levels to over 30 inches from the previous year. Due to the unusual delay in EWM growth in 2017, dive efforts mainly took place during the second half of the growing season. With very little shallow growth, it was determined that organization of volunteer efforts may not be the most beneficial use of volunteer time. Rather, volunteers periodically checked on the far southwest bay for growth and reported any findings to adjust survey timing and hand removal efforts. Due to sporadic EWM growth, management emphasized professionally led snorkel pulling, while continuing some DASH and deeper water diving. DASH removed 44 pounds of wet weight EWM; diving efforts removed 50 pounds of wet weight EWM and professional snorkel-pulling removed 61.5 cubic feet of EWM.

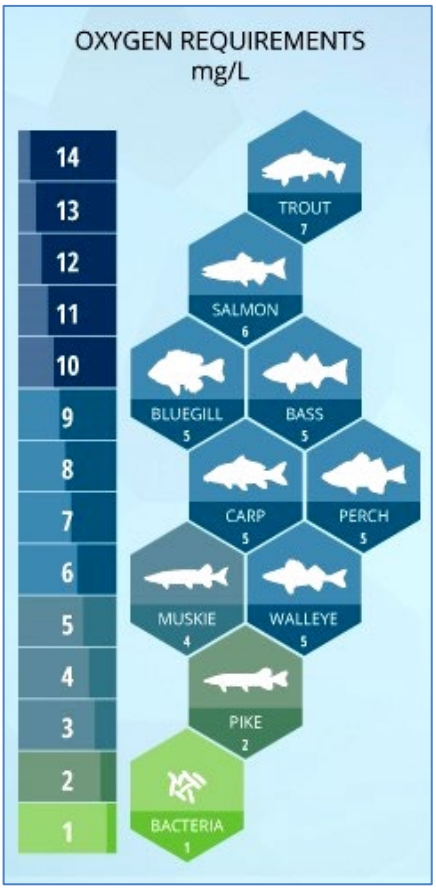
A third WDNR rapid response grant was awarded to the Smoky Lake Preservation Association, new Wisconsin Corporation, to continue EWM management of Smoky Lake for 2018 and 2019. Program details were like the two previous WDNR grants, with seasonal monitoring and EWM management using hand removal. DASH efforts were limited due to non-repairable issues to the DASH boat pump; however, snorkel-pulling efforts removed 64 cubic feet of EWM.

At this time, EWM makes up a very small portion of the aquatic plant community on Smoky Lake. Acreage of EWM from 2013 to 2018 has ranged from .24 acres in 2016 to 1.09 acres in 2015, with an average of .66 acres since monitoring began in 2013. Based on the 2017 lake-wide vegetation assessment, EWM occurrence represents 0.1% frequency of occurrence of the Smoky Lake's littoral area. Comparing this to the 2013 (the year EWM was initially discovered) value of 0.1%, there has been no percentage change of EWM from 2013 to 2017. **(Appendix H)** The WDNR suggests that recreational nuisance and possible lake impairments occur when populations reach 35% **(Wagner et al, 2006).**

3.5 Fisheries

Smoky Lake has several interesting attributes that impact the fishery and its management: cold, clear relatively infertile water; its "two-story" temperature classification; the presence of Cisco (formerly called Lake Herring); and abundant submerged log substrate (Bass habitat), which was dropped while logs were being floated across the lake to be picked up and hauled by train to a sawmill in the early 1900s.

Figure 3.5.1: *Minimum dissolved oxygen requirements for freshwater fish (Fondriest).*



Both the WI and MI Departments of Natural Resources identify Smoky Lake as a two-story lake, meaning it has a "top-story" (epilimnion layer) that supports warm and cool water fish (e.g. Bass, Bluegill, Musky, Walleye) and a "bottom-story" (in the thermocline Layer) supporting cold water fish (e.g. Cisco; Lake Trout; Lake Whitefish; Brook, Brown, Rainbow Trout.) Two-story lakes are somewhat rare. Only about 1.3% of WI lakes are two-story fisheries[17]**.** For a two-story habitat, the oxythermal (oxygen-temperature relationship) lake condition necessary to support the "bottom-story" cold water species needs cold enough temperatures and adequate dissolved oxygen (DO) in an adequate depth in the water column. Recent research on the WI definition of a two-story habitat by Lyons et al., identified general cool-cold water species oxythermal habitat needs as a water column section greater than one meter, with a temperature less than 73^{o}F and greater than 6mg/l of dissolved oxygen. Different species may require more specific oxythermal habitat windows, such as lake trout, which require water temperatures between 46-59˚ F and dissolved oxygen above 6 mg/l[18] and Cisco, which prefer waters cooler than 60˚ F and oxygen above 3.0 mg/l **(Latta, 1995).**

In examining historic water quality records from Smoky Lake, it appears this thermocline (bottom story) layer begins around 30-40 ft depth, and may only have viable dissolved oxygen levels for another five to ten feet before dropping quickly to near zero. This special habitat may be quite narrow in some years, depending on the weather and degree of stratification or temperature layer in the water. A shallow lake does not have the opportunity to form this colder bottom layer, as the influence of air temperature, sunlight, and wind influence a greater percentage of the lake's water column. The profile of the lake's water column might be compared to a layer cake, with specific fish species inhabiting distinct layers in the column, based on temperature and available dissolved oxygen.

[17] Minahan, Kristi. 2017. WI Lake Convention. Presentation-Water Quality Standards. What's coming up for our lakes?
[18] https://www.njfishandwildlife.com/pdf/fishfact/trout_lake.pdf

Smoky Lake, a boundary water lake, has been "managed" since the 1930s, with concurrence and coordination between WI and MI DNR. With the larger share of the lake in MI, MDNR conducted most of the management work, which consisted of surveying the fish populations, taking early water quality measurements, and prescribing the stocking or removal of fish species. A spreadsheet that includes the history of fish stocking, fish surveys, and management prescriptions between 1934 and 2019 is included as **Appendix I.** This history shows a progression of priorities and theories aimed at balancing habitat specific predator-prey interactions and public demand for sport fishing.

Fish stocking as a management tool, first recorded in 1934, peaked from 1936-1940. Over 1,300,000 total Walleye were planted in the 1930s, but they were not found in subsequent surveys and were not planted after 1939. The salmonid species (Lake Trout, Brook Trout and their hybrid-Splake) were the most consistently stocked over the years, being valued as a game fish, and slotted to be successful in the deep, cool water of the lake. As predators, they intended to keep the native Cisco fish in check. Surveys described Cisco in 1938, 1953, 1968, 1989, and 1990 and described as historically abundant.

Today, Cisco (*Coregonus artedi*) is a species of local special interest, according to MDNR Fisheries. 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 mid-water (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 spawn in the middle depths of Smoky Lake in the late fall, about the time surface ice forms. Eggs fall to the bottom and develop over winter to hatch in the spring. Maintaining a viable Cisco presence in Smoky Lake has been the shared management emphasis for both Michigan and Wisconsin DNR for about the last decade. Stocking of piscivorous fish (Brown Trout, Walleye, Musky, Lake Trout) is therefore not indicated, but maintaining Smoky Lake's assemblage of Smallmouth Bass, Cisco, Perch, Suckers, and Muskellunge was the shared strategy in a communication dated 2009. No fish stocking has occurred since 2005 due to lack of budget and a disease outbreak restricting rearing operations.

Lake residents have worked with the MDNR consistently since the late 1980s to foster Smallmouth Bass as a game fish in Smoky Lake. Numerous DNR fish surveys took place over the past 30 years to assess their population. When the 1989 survey found the Smallmouth Bass population size structure in decline, (fair population but small growth rate,) a special regulation in 1990, created a 16" minimum size limit. The relative infertility of the lake, habitat loss, over

predation of Smallmouth Bass fry by White Suckers and Yellow Perch, and possible overfishing have been indicated as possible challenges to the Smallmouth Bass population. Unfortunately, similar unfavorable population trends have continued through today, as demonstrated in the most recent comprehensive survey (2015). Public concern over the Smallmouth Bass fishery, combined with DNR survey conclusions, resulted in a new special regulation for Smallmouth Bass on on Smoky Lake that will take effect in 2020. The new special regulation, endorsed by the association, for Smallmouth Bass on Wisconsin waters **ONLY** would set no minimum size limit, not allow for harvest of bass between 14"-18", and set a five fish daily limit where only one bass 18" or larger may be kept. Michigan sought to pass the same regulation, unfortunately, this regulation will not be in place for Michigan waters in 2020.

Other fish management highlights include an unauthorized introduction of Muskellunge in the mid- 1970s. This species survived and sizeable Musky were noted in 1980, 1983, and 1989. In 1990, ninety-five Musky were caught in a fyke net survey, but their growth index was -2.5 (smaller than state average). Management strategies from 1993-2005 included stocking a total 5,571 Musky fingerlings. By 2005, MDNR noted that musky reproduction had dropped, and the population was not sustaining. At that time, there was interest in continuing fingerling stocking to rebuild the population, maintain this popular fishery, and to act as a predator for Common White Suckers, but it appears that interest faded in more recent deference to preserving the Cisco population. Yellow Perch were only stocked once, in 1935.

Bluegills were stocked between 1934 and 1941. Yellow Perch and Bluegill are still common panfish, but Perch outnumbers Bluegill and are decently sized. Both Yellow Perch and Common White Suckers have been managed by removal. A manual removal project was permitted and led by lake resident Bill Koski from 1977-1991, with some 7,000 suckers and 397 pounds of Yellow Perch taken out of the lake. As bottom feeders, Suckers dine exclusively on aquatic plants, algae and small invertebrate animals-especially worms, insect larvae and crustaceans. White Suckers have been accused of consuming large quantities of eggs from more desirable fish species, but there is no conclusive evidence to support this contention. Salmonids Rainbow Trout, Brook Trout, Brown Trout, and splake were also stocked over the years. A total of 18,744 Rainbow Trout were planted between the years 1943, 1944, 1945 1967, and 2004. Brook Trout and Brown Trout were only planted once each in years 1979 (qty 15,000) and 1989 (qty 7,500) respectively. The hybrid Splake fish (Brook Trout x Lake Trout) were stocked almost annually from 1981-1988, totaling over 88,300 over those years (average about 12,000 per year), but have not been planted since.

Invasive organisms (including diseases, crustaceans, mollusks, and vertebrates), can threaten the fishery when introduced into a lake. Their high reproduction rates, lack of natural predators, adaptability to a wide range of conditions equates to them consuming resources such as zooplankton, plants, or small fish, which are needed by members of the lake's natural fish community. Rusty Crayfish, a crustacean and Rainbow Smelt, a fish, are two invasive species identified in Smoky Lake (in addition to the plant, Eurasian Watermilfoil.) Rusty Crayfish were noted as present in Smoky Lake during a 1989 fish survey and were verified as present in 2006 according to the SWIMS (WI) data base. Sixty-nine Rainbow Smelt were captured during a 2008 fish survey and entered as verified in the SWIMS data base on that date. Invasive species

often have significant impact on the “bottom of the food chain”: the smaller organisms eaten by the fry of desired game fish or the natural “food” in a lake.

Focus on the game fish in the lake is well documented during fish surveys and is of most concern to the public, but every natural lake community also has a food chain grounded in the smaller creatures often referred to a “natural food.” Natural food in Smoky Lake would include a suite of phytoplankton (microorganisms that photosynthesize) and zooplankton (tiny free floating or weakly swimming animals), aquatic macroinvertebrates (e.g. midges, dragonfly and mayfly nymphs, aquatic worms) and small fish, such as minnows (common name for a number of small freshwater fish, usually belonging to several genera of the *Cyprinidae* family) and Sculpin. Bluntnose Minnow and Mottled Sculpin were specifically mentioned in a 2008 WDNR survey. Like the plant community in a lake, the animal community is a complex set of inter-relationships, often manipulated or changed according the desires and actions of the humans using the watershed and climatic factors.

3.6 Shoreland Assessments

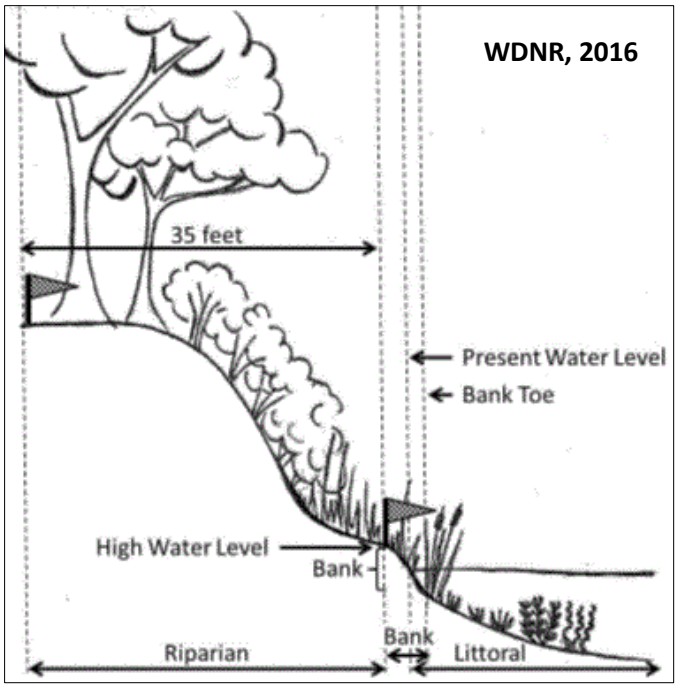
3.6.1 Shoreland Habitat Overview

As lakes become developed, piece-by-piece manipulations of natural landscapes result in fragmentation and loss of critical habitat that many species rely on. These manipulations may seem subtle. However, over time, an accumulation of slight habitat changes that go undetected may result in irreversible ecosystem degradation and species loss. Based on the U.S. EPA National Lakes Assessment, lakeshore disturbance is increasing **(U.S. EPA 2009).** Subsequently lakes with poor lakeshore habitats are three times more likely to have impaired biological conditions **(U.S. EPA, 2009).** These disturbances potentially affect water quality, in-lake habitat and increase the likelihood of spreading aquatic invasive species (AIS). A substantial portion aquatic life will depend on shoreland areas to provide shelter, spawning and nursery grounds and food sources. Understanding the role that shoreland habitats have to 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.

3.6.2 Shoreland Survey Methods

Shoreland assessments conducted by Many Waters, LLC took place in early September of 2017 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 lakeshore 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 understand long-term trends in shoreland habitat and lake ecology.

Figure 3.6.1: *Lakeshore habitat area definitions*



This protocol emphasizes habitat features key to the ecological health of a lake and focuses on the riparian buffer, bank, and littoral zones **(Figure 3.6.1).** 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 the case where an individual or family owned several lake parcels, each parcel was surveyed separately. Eighty-four of the total eighty-seven identified individual parcels on Smoky Lake were assessed. Two properties were un-intentionally missed and one property's boundaries could not be defined in the field. Even though water levels rose dramatically over the past few years, current water levels are still well below the estimated high water level. Because of this, Smoky Lake's bank zone features, which would be the transition between the riparian buffer zone and the littoral zone, at times blended with the riparian buffer zone. Tag alders and some pine trees began to dominate the exposed lakebed, with trees reaching 10-15 feet in height. In some instances, vegetation growth was so dense riparian and bank zone assessments were challenging.

Riparian features documented include:

- Percent vegetation coverage
- Impervious surface coverage
- Listing and description of human structures
- Run off concerns
- Evidence of point and non-point run-off concerns.
- Run off concerns present beyond the riparian area

Bank zone characteristics mainly focused on erosion and hard-scape (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. Because of the low water levels, additional information on the exposed lakebed collected included canopy cover, such as tag elders and lakebed soil disturbance, such as raking the lake sediments and removing vegetation or woody debris.

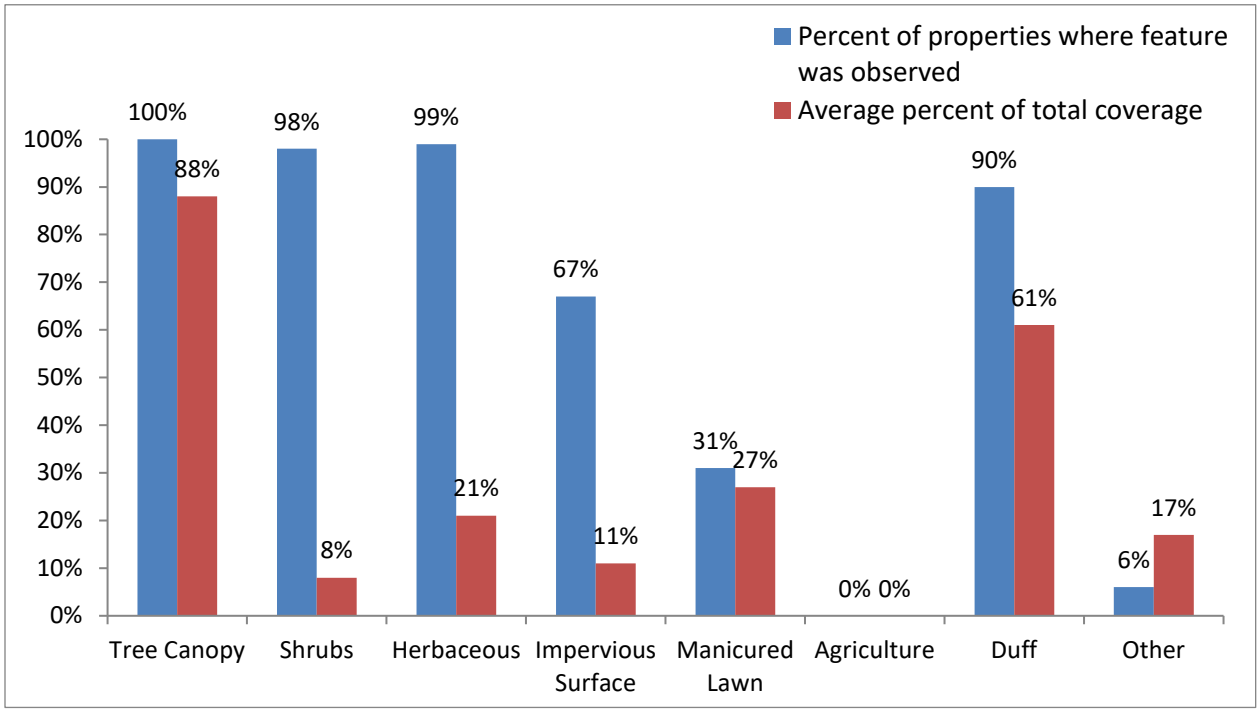
The final loop included a coarse woody debris assessment. This assessment documented all woody habitat located in two of feet of water or less, at least 5 feet in length and 4 inches in diameter. A geo-referenced location was collected for each piece of wood that fit the criteria and a description of the wood was noted. This description includes "branchiness" (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.

3.6.3 Riparian Buffer Zone - Results

Percent cover for each individual parcel assessed included trees, shrubs, herbaceous vegetation, impervious surfaces, manicured lawns, agriculture, and duff. Herbaceous vegetation is not part of the original WDNR protocol but was added and includes forbs and natural grasses, not lawns. Impervious surfaces include anything that would 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 Smoky Lake support little to no natural vegetation.

All assessed properties contained a canopy (tree) layer, and most had a shrub, herbaceous and duff layer **(Figure 3.6.2).** Thirty-one percent of the total properties had manicured lawns. Of the 31% that had manicured lawns, total riparian coverage estimates ranged from 5% to 95%, with an average of 27%. When looking at all properties as a whole, most properties on Smoky Lake do not have lawns. Sixty-seven percent of the total properties had some degree of impervious surface. Of the 67% that had impervious surfaces total riparian coverage ranged from 5% to 50% with an average of 11%. Again, when looking at all properties as a whole, most (mode) properties on Smoky Lake had about 5% impervious surface observed. Compacted soils, mainly from pathways to the lake, account for the majority of the impervious surfaces observed. Most properties contained a shrub and herbaceous layer, on average this made up a small percentage of the overall riparian cover. The second highest total riparian coverage, behind trees, observed within the riparian layer was duff. Ninety percent of the total properties on Smoky had a duff layer, with an average covered of 61%. Other observed riparian coverage included bare soils, landscape mulch, and beaches.

Figure 3.6.2: *Percent of total properties with riparian feature & coverage estimates, Smoky Lake, 2017*



Point source run-off within the riparian zone was limited to mainly culverts observed at the southern end of the lake within the WDOT right of way and a limited number of drain tiles on private properties. Sources of the drain tiles are not known; however, presumably capturing water from somewhere on the property and diverting it towards the lake. Additional run-off observations included channelized water flow directly to the lake, bare soils, and sand/silt deposits. On six percent of the total properties, channelized flow was observed. Sand/silt deposits were observed on 7% of the total properties. Bare soils were observed on 39% of the properties. Most bare-soil observations occurred in the steeper transition zone between the riparian and bank zone areas.

Common bare-soil observation on Smoky Lake

3.6.4 Bank Zone – Results

Hard-scape armoring of bank zones many times includes 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. Smoky Lake's water levels are rising however, the water mark during the survey remained below the observed high water level. Many observed sea walls and rip-rap installations were perched above the current water line, sometimes blending into the lake side of the riparian zone. Most common bank zone modifications observed include rip-rap and sea-walls **(Figure 3.6.3).** Thirty-two percent of the total parcels observed had rip-rap with an average length of 109 feet. Fourteen percent of the total parcels observed had a sea wall, with an average length of 21 feet **(Figures 3.6.4).** Rip-rap averages include the WDOT right of way along the southern end of the lake. Not accounting for this, the average length of rip-rap along properties where this feature was present is 97 feet. A few properties maintain artificial beaches (7%) with an average length of 41 feet. Other observed bank zone modifications include public and private boat landings. Erosion greater than one foot in height was observed on 7% of the properties with an average length of 13 feet. Erosion less than one foot in height was observed on 5% of the properties with an average length of 8 feet **(Figure 3.6.5).**

Figure 3.6.3: *Percent of properties with bank zone modifications and type – Smoky Lake, 2017*

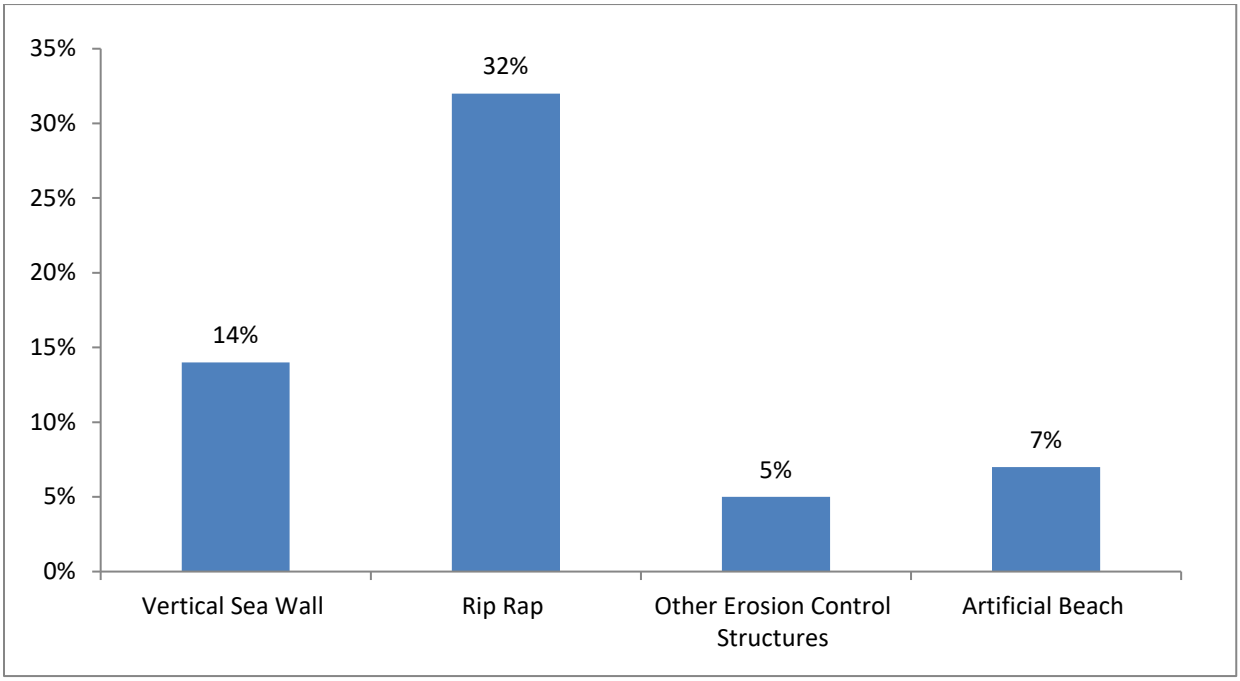


Figure 3.6.4: *Average length of bank zone modification for properties where feature was observed – Smoky Lake, 2017*

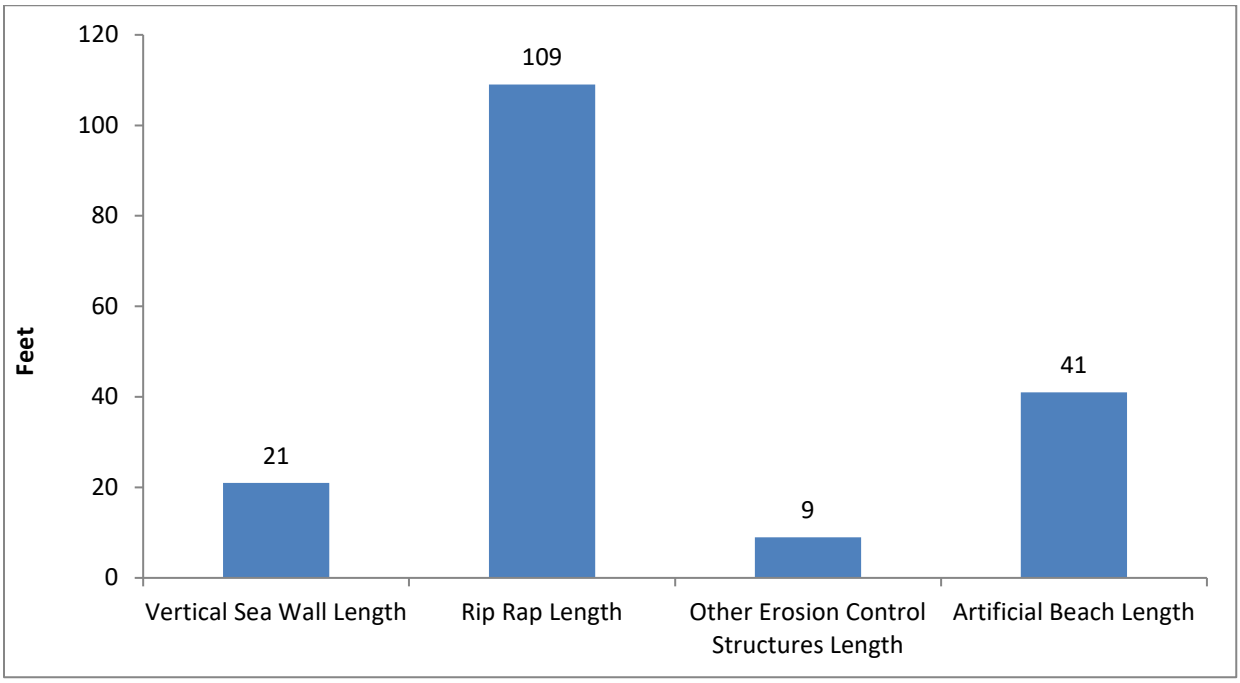
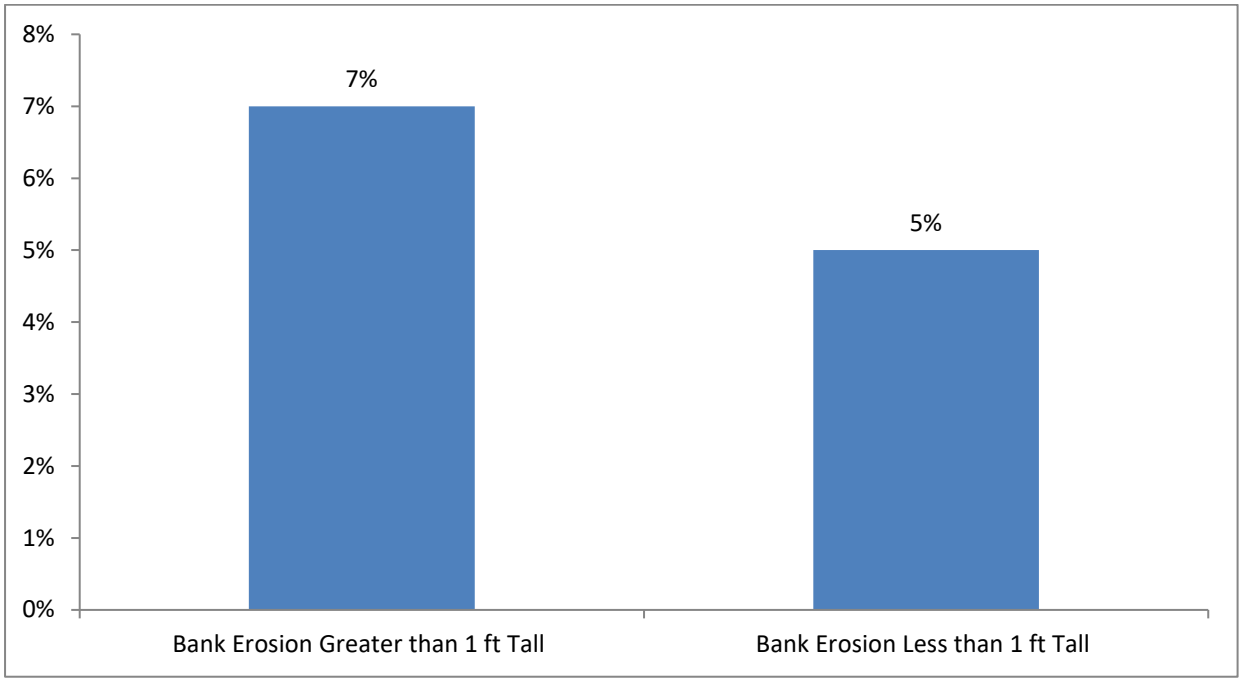


Figure 3.6.5: *Percent of properties with bank zone erosion and estimated height– Smoky Lake, 2017*



3.6.5 Littoral Zone – Results

Littoral zone observations included noting the number of piers, boat lifts, swim rafts, and other near shore features. A pier is defined as a "structure leading out from shore into the waterbody." One pier is counted for each access to shore. Sixty-two percent of properties have piers and just under half (44%) of properties have boat lifts **(Figure 3.6.6).** Eighteen percent of properties observed had additional structures including swim rafts and water trampolines. Low water levels exposed the lakebed, allowing terrestrial and wetland vegetation to establish. Many properties have trees, shrubs, and other forbs present along the exposed lakebeds. Thirty-seven percent of properties had a tree canopy component, mainly red and white pines, some trees estimated up to 6-8" in diameter **(Figure 3.6.7)**.


High water levels inundate and stress shoreline trees that proliferated during a previous low water period.

Increases in water levels inundated existing tree and tree stress (browning needles) was observed. Alders dominated the shrub layer with 89% of properties observed having shrubs in the exposed lakebed. Ninety-three percent of properties had an herbaceous (including grass) layer along the exposed lakebed. Emergent leaf and floating leaf aquatic vegetation was observed along 85% and 35% of the properties respectfully.

Figure 3.6.6: *Percent of properties with observed littoral zone features – Smoky Lake, 2017*

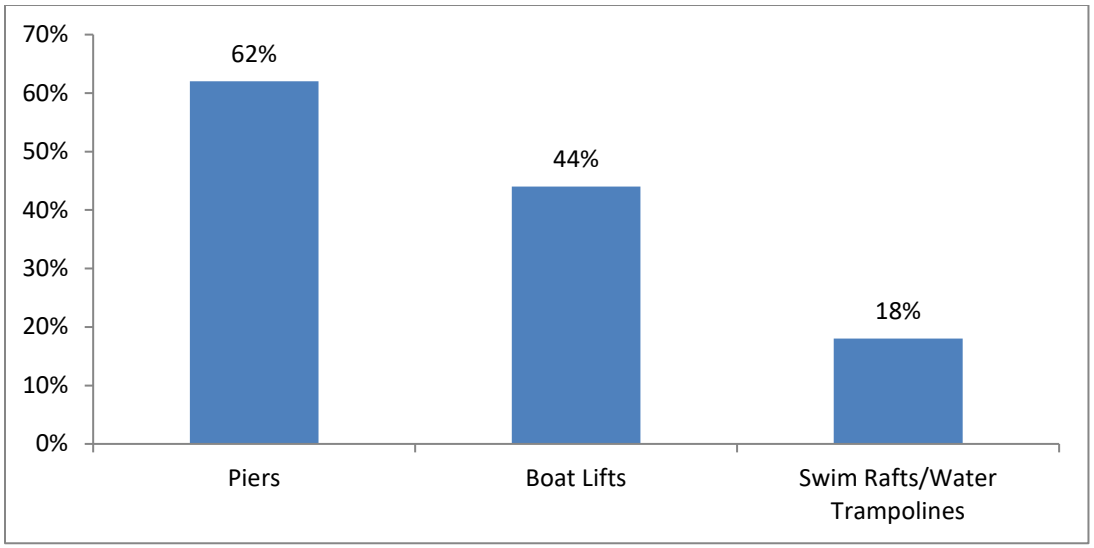
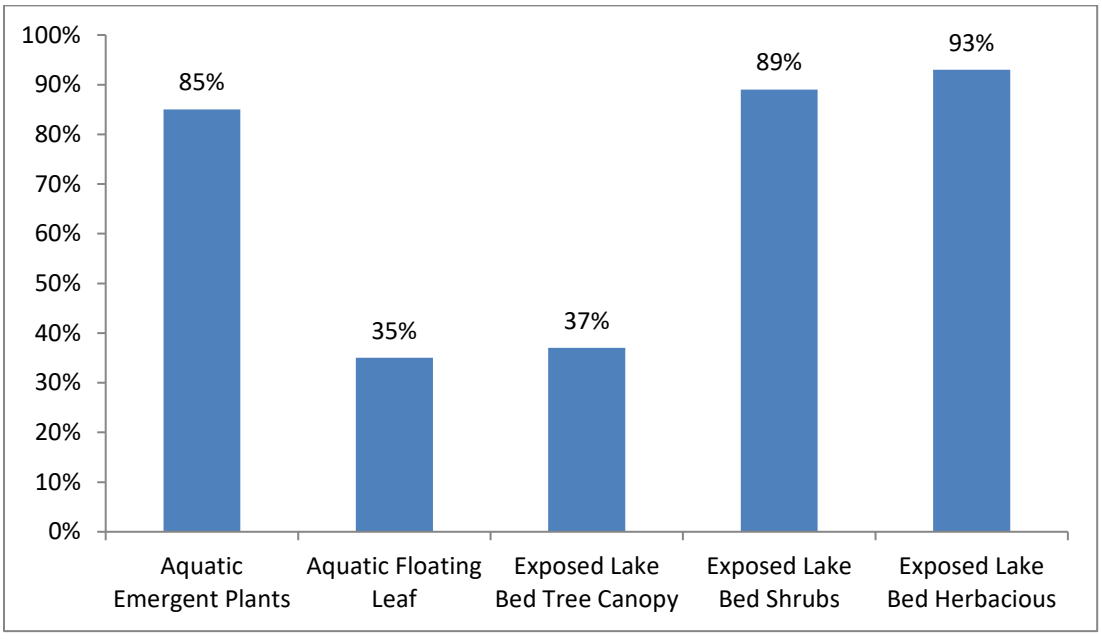


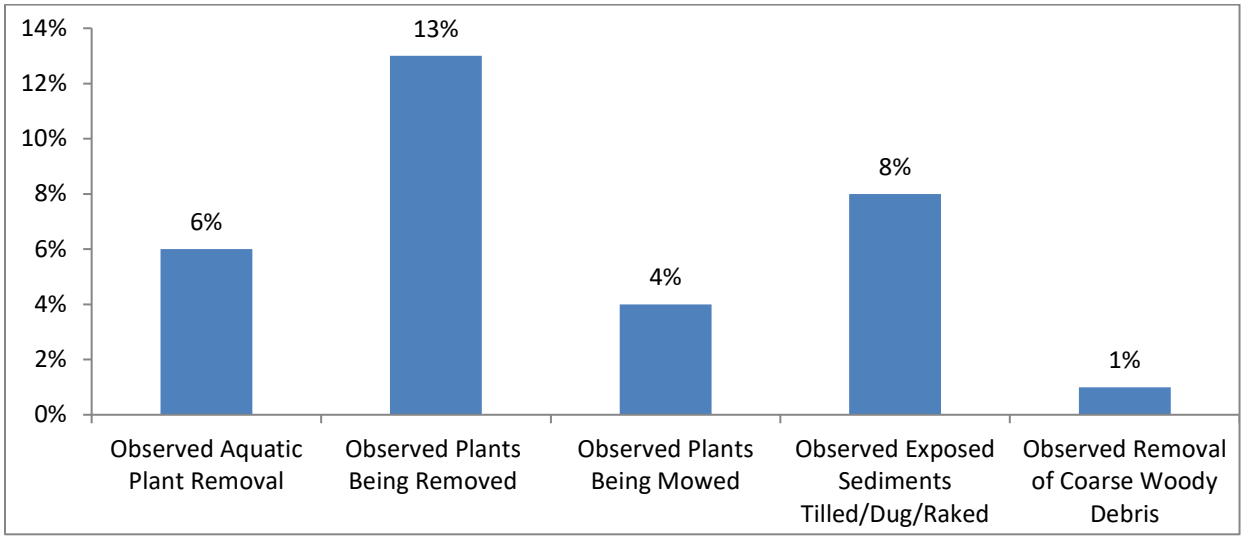
Figure 3.6.7: *Percent of properties with littoral zone feature– Smoky Lake, 2017*



Observations of manipulated exposed lakebed sediments included plant removal (mainly terrestrial/wetland), plants being mowed, digging, or raking of exposed lake sediment and

removal of coarse wood debris **(Figure 3.6.8**). The most common activities observed included plants being removed (13%) and lake sediments being dug or raked (8%).

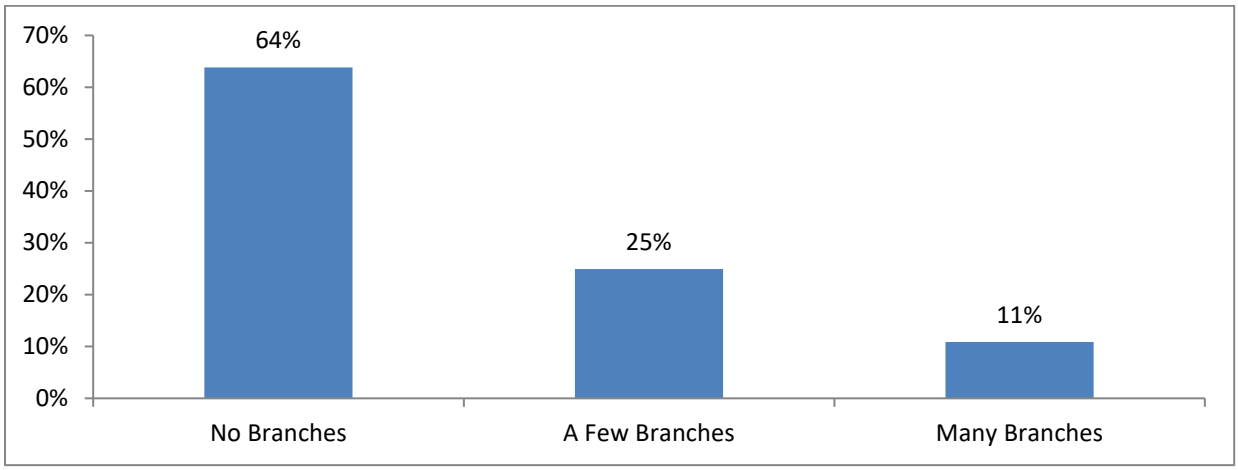
***Figure 3.6.8**: Percent of properties and associated activities along exposed lakebeds– Smoky Lake, 2017*



3.6.6 Coarse Woody Debris – Results

Six hundred and twenty five pieces of wood that fit the pre-determined categories were recorded. Sixty-four percent of wood observed did not have any branches followed by 25% with a few branches and 11% with full crowns **(Figure 3.6.9).** Fifty percent of the wood observed crossed the observed high water level; whereas 50% did not. Seventy-five percent of the wood had at least five feet currently underwater, whereas the remaining 25% had less than five feet of its total length observed underwater.

***Figure 3.6.9:** Percent of coarse wood debris by branching type – Smoky Lake, 2017*



3.6.7 Shoreland Habitat Importance

As stated above, shoreland disturbances as a whole 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 and the Upper Peninsula of Michigan has risen. The WDNR estimates that from 1965 to 1995 alone, Wisconsin shoreland building increased on average by 216%[19]. Smoky Lake, like many Northern Wisconsin and U.P. lakes followed patterns of increased development seen across the local landscape. Early in the Michigan Fisheries records, notes taken during a 1938 survey included accounts of the number of dwellings around the lake. At that time, 13 private cottages, one resort, and one boat livery were noted. Today, aerial imagery estimated 68 dwelling currently exist along lakeshore properties.

Shoreland development results in increased runoff, resulting in more phosphorous and sediment to a lake. For comparisons, 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[20]. While this comparison is somewhat generalized it illustrates the potential contribution that lake-lot development has on water quality. Maintaining good water quality is important for overall lake health but also protects economic investments 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 average lake property[21].

Shoreland assessments provide information on overall habitat quality and identify specific habitat and human features useful in measuring habitat function. 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 of shoreline equated to substantial shoreline disturbances affecting habitat function and negatively affecting fish communities **(Jacobson et al., 2016).** Other work suggests shoreline disturbances begin to disrupt habitat function at five piers per kilometer **(Beck et al., 2013**). Removal of coarse woody debris and alterations to riparian and littoral habitat affect green frogs. Green frog populations are lower on lakes with shoreland development versus non-developed lakes (**Woodford & Meyer, 2003).**

The impacts of coarse woody debris on fish are commonly studied. 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 affected compared to reference lakes **(Sass et al., 2006).** This study showed that in the absence of wood, bass initially

[19] http://clean-water.uwex.edu/pubs/pdf/margin/sld013.htm
[20] http://clean-water.uwex.edu/pubs/pdf/margin/sld038.htm
[21] Wisconsin Lakes Convention, 2019. Presentation - Economic Data on Oneida and Vilas County Waters. Thomas Kemp, Department Chair, and Professor of Economics, UW-Eau Claire.

consumed perch at high rates, possibly 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 bass growing slower in the study lake (coarse woody debris removed) versus bass from the reference lake. Perch populations, from the lake where the coarse woody debris had been removed, declined, and showed very little recruitment. (Recruitment is a popular measurement in fisheries studies and management that looks at the number of fish surviving to enter the fishery in future years.) Declines in perch occurred with the initial elevated consumption of perch by bass and the possible reduction of food source to perch caused by the removal of woody habitat. This study is one of many examples that show the intricate relationships between fish and other aquatic organisms and the links between lake organisms and nearshore habitat.

3.6.8 Shoreland Habitat Considerations for Smoky Lake

Seventy-five percent of the total properties, accounting for approximately 375 acres of riparian parcels, observed some degree of human influence, from just a pier or small footpath to highly manipulated shoreland areas. Whereas, the remaining 25%, encompassing approximately 200 acres of adjoining land, observed little to no human influence. Currently all ownership on Smoky Lake is private except for the public boat launch and the WDOT right-of-way located at the southern end of the lake. All the undeveloped land is in private ownership and accounts for about 35% of the total adjoining land to the lake.

Tree canopy coverage averaged 84% on developed parcels versus 97% on undeveloped parcels **(Table 3.6.1).** Shrubs and herbaceous cover show similar trends. The most notable difference seen in cover types between developed and undeveloped parcels is duff. Again, duff is a layer of leaves, pine needles, twigs, and other organic materials found above the true first layer of forest soil. Duff is important to forest health, moderating soil moisture and temperature, infiltrating water and providing beneficial micro-environments for many organisms. This layer is also home to many beneficial forest organisms that assist in breaking down duff to produce forest soils. Some aquatic insects will use duff along shorelines as their winter home. For example, adult native milfoil weevils *(Euhrychiopsis lecontei)* will migrate to shore to overwinter in nearshore leaf litter. Fallen leaves and pine needles are commonly raked and removed by residence during the fall season. Leaving duff in place secures over winter habitat for these and other organisms.

Table 3.6.1: *Comparison of average canopy coverage of undeveloped and developed parcels – Smoky Lake, 2017*

	Canopy	Shrubs	Herbaceous	Impervious Surface	Manicured Lawn	Duff	Other
Undeveloped Parcels	97%	7%	20%	0%	0%	74%	0%
Developed Parcels	84%	7%	22%	10%	11%	49%	1%

Observations of soil erosion in large measure occur on developed properties compared to undeveloped properties. Ten percent of all developed parcels had soil erosion greater than one foot in height compared to 0% of undeveloped parcels. Seventeen percent of developed parcels had soil erosion incidences less than one foot in height compared to undeveloped parcels. The presence of soil erosion on developed parcels versus little evidence of soil erosion present on undeveloped parcels suggests that this feature on Smoky Lake may be human use related.

The presence of aquatic emergent plants and floating leaf plants is slightly higher along undeveloped parcels compared to developed parcels **(Table 3.6.2).** Emergent plants were present on 95% of the total undeveloped parcels compared to 81% of the developed parcels and floating leaf plants were present on 43% of the undeveloped parcels compared to 32% of developed parcels.

Table 3.6.2: *Comparison of littoral zone aquatic plant presence and vegetation observed along exposed lakebed across developed* ***and*** *undeveloped parcels – Smoky Lake, 2017*

	Littoral Zone Aquatic Plants Emergent Plants	Littoral Zone Aquatic Plants Floating Leaf	Exposed Lakebed Canopy Presence	Exposed Lakebed Shrub Presence	Exposed Lakebed Herbaceous/Grass Presence
Undeveloped	95%	43%	29%	95%	100%
Developed	81%	32%	38%	86%	89%

Pier density on Smoky Lake averaged 1.16 piers across all properties, with an average of 6.82 piers/km. The highest pier density observed per property was four piers. It did not exceed the described "threshold" of 10 piers per kilometer. However, pier densities did exceed five piers/km, which some estimates indicate negative impacts to shoreland habitat. Water levels rose dramatically the year the shoreland survey took place. Many new piers were observed and many properties were in the process of disposing of old pier systems. In some cases, the older pier systems were re-configured along their shoreline, adding to the total numbers of piers present on an individual property.

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 for replacement of woody debris to 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 et al, 1996).** Studies done on lakes within Northern Wisconsin and the Upper Peninsula comparing coarse woody debris around undeveloped and developed lakes show as dwelling presence increases 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. Smoky Lake's estimated density of CWD per kilometer of shoreline is 58 pieces per kilometer.

When determining the need for hard armoring a shoreline, erosive wave energy can be calculated using a maximum fetch and water depth formula.[22] Many properties along Smoky Lake fit into low or moderate wave energy calculations, meaning rip-rap may be an "over-build" and not necessary to provide adequate shoreland protection.

[22] https://dnr.wi.gov/topic/waterways/shoreline/erosioncalculator.html

4.0 STAKEHOLDER PARTICIPATORY PROCESS

Stakeholder engagement is central to the planning process. Engagement allows the sharing of information and ideas and gives a platform for those invested in the lake to be heard. Several activities led by the steering committee gathered responses from the larger lake community including a lake owner survey, questions and answer periods at annual meetings, joint planning review with the Smoky Lake Board, and posting of the plan draft and comment period on the Town of Phelps website and a plan review session held at the Wilderness in Phelps, WI.

4.1 Planning Committee Activities

Activities completed by the steering committee include data collection, meeting time, and developing and executing a lake owner survey. Summary of meeting minutes can be found in **Appendix J**.

Lake Owner Survey

A large undertaking by the committee was to construct a lake user survey and distribute it to lake residents. This survey was accompanied by a cover letter, written by Leo Norden. This survey took place in February of 2018 and had a 70% return rate **(Appendix K).** Lew Raker compiled all the returned survey responses. In May of 2018, the committee met to review a summary of the results.

Social and Historical Information Review

Steering committee members met in August 2018 to review drafts of the social and historical information prepared by Lydia Cooley. This piece brought a lot of good discussion including zoning, covenants, and other historical information to the table. The committee felt that the differences in zoning between Vilas County and Stambaugh Township and the covenants would be important pieces of information for lake residents. However, given the length of the plan, it was recommended that these be presented in appendices. Walt Tarmann offered to write a summary of the zoning differences.

Lake Inventory Results Sharing & Plan Distribution Outline

Steering committee members met in March 2019 to review results and highlights of the lake inventories that Many Waters completed. Many Waters gave a presentation summarizing lake inventory findings on aquatic plants, water quality, shoreland habitat and watershed. Committee members were given an opportunity to ask questions. The remainder of the meeting was dedicated to developing a format for committee members to review plan drafts and develop a structure to provide edits and feedback. Additional topics included how to move the initial draft into the review phase, identify the constituent groups who would be reviewing the plan and how to process feedback. An additional sub-steering committee was held in April 2019 to continue work on the review strategy.

Action Plan Review

Drafts of the action plan were reviewed by the steering committee in May and June of 2019. The action plan draft included an outline of the planning goals, objectives, and alternative strategies. The purpose of this meeting was to discuss each alternative strategy proposed and develop a working list of strategies to be discussed with the Smoky Lake Board during a joint meeting with the Steering Committee held on July 13, 2019.

Action Plan Review

Drafts of the action plan were reviewed by the steering committee in May and June of 2019. The action plan draft included an outline of the planning goals, objectives, and alternative strategies. The steering committee met several times to discuss each alternative strategy proposed and develop a working list of strategies for further discussion with the Smoky Lake Board during a joint meeting with the Steering Committee scheduled for July 13, 2019.

Joint Steering Committee and Board Meeting

On July 13, 2019, the SLPOA/SLPA Board and the Steering Committee met jointly to discuss the overcall content of the lake management plan with emphasis on approving the current draft for release and consider association membership consent and future board action necessary for plan approval. Discussions also included detailed dialog about the Action Plan and the Board's role in specific goal, objectives and tasks. Each goal of the Action Plan was reviewed with consideration of board, membership and volunteer roles. Topics for the remainder of the meeting touched on plan distribution, how to receive comments and feedback, and the up-coming plan review meeting to be held in August at the Wilderness Lodge, Phelps, WI.

4.2 Planning Review and Adoption Process

Plan Review

The steering committee put detailed thought and held several meetings to discuss the distribution, and review drafts of the lake management plan. Starting with the steering committee review, and continuing through to the larger lake community review, the committee identified roles, responsibilities, and possible challenges throughout the process. Two challenges addressed were: providing distribution options for the large plan document to accommodate the lake community and how to make people aware of the draft being available for review and feedback.

Committee members made initial comments on chapter drafts. A second draft of the entire plan circulated to the both the steering committee and Smoky Lake Board for their review. A joint review session took place on July 13, 2019.

An update on the Plan status was shared in the annual Association newsletter. The August 17, 2019 plan presentation and review session to be held at the Wilderness Lodge was also

included. A postcard mailing followed providing additional information about how to access the document for review.

Plan Review Session - Wilderness Lodge

On August 17, 2019, a lake management plan review session was held at the Wilderness Lodge in Phelps, WI. Three weeks prior to this meeting, a postcard was sent notifying all Smoky Lake property owners and other stakeholders of this meeting, along with details on how to access the draft lake management plan. The intent of this session was to gather feedback from the lake community at large on questions, concerns, and missing content of the plan that should be addressed. Attendees were prompted with a series of questions to consider throughout the session and oral and written feedback was taken. Additional feedback would be welcome after the session, and attendees were given one week to return any additional feedback.

The meeting included two presentations. Barb Gajewski, from Many Waters LLC covered highlights and information from the lake management plan and Lydia Cooley covered an overview of the Action Plan and touched on some of the new areas of organization that the Association would be developing, including the creation of Education and Fisheries committees.

The second half of the session was dedicated to receiving input from attendees, including feedback from the list of questions distributed in advance of the meeting. A detailed list of comments and feedback can be found in **Appendix I**. Many of the comments received hit on the various topics to be included in the Action Plan, particularly within the newly formed Education Committee. These discussions solidified that the Action Plan was on track to addressing the needs of the lake and the larger lake community.

Plan Adoption

During the annual Association meeting held on July 27, 2019, the association approved a resolution authorizing the board to act on behalf of the Association to accept and approve the current Lake Management Plan draft which may include additional modifications and changes as the board considers appropriate.

Final comments and feedback received from the time of the post card mailing to one week after the Wilderness session were incorporated in the final working draft and submitted to the board for review and approval on August 29, 2019. The board met over the Labor Day weekend (2019) and approved the final draft of the lake management plan. The next step will be to submit the document draft to the WDNR for their formal review and comment. The final plan approval date will be stamped based on the approval date from the WDNR.

4.3 Lake Owner 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 Smoky Lake.

When deciding which stakeholder groups would be most beneficial to learn from, the Planning Steering Committee considered both demographic and geographical scopes including daily lake users, off-shore property owners with specific interest or connection to Smoky Lake and all property owners within a certain radius of the lake. Smoky Lake sits at the top of the Deerskin watershed. A good portion of the direct drainage area to Smoky Lake is from riparian ownership. The majority of remaining lands within the drainage area are a mix of public forests, private lands (many of which are under the same ownership as several riparian owners) and a private wildlife hunting "preserve." The Committee concluded to educate and develop action strategies specific to maintaining and preserving lake health, the stakeholder group for this survey most beneficial to learn would be immediate lake property owners. Land use changes and development occurring across the landscape and watershed are important to the regional health of local waters and do on certain levels impact Smoky Lake, for instance, the spread of aquatic invasive species. 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. Steering committee members reviewed each question, keeping those most relevant to Smoky Lake and added questions to address possible issues specific to Smoky Lake. With specific guidance from the WDNR, a series of mailings to each property owner on Smoky Lake occurred in February 2018. The initial mailing included a cover letter, a copy of the survey and specific instructions. Seventy-seven surveys were mailed, of which only one returned not deliverable. 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 76 surveys delivered, 55 were returned with a return rate of 72%.

Surveys returned varied in the detail of responses, from very comprehensive comments and all questions answered to several sections with no response and limited comments. Some surveys circled multiple responses, making final tallies difficult. In some cases, specific section tallies had to be omitted and categorized as no data available. Below is a summation of results, highlighting concerning issues and explanatory narrative.

4.3.1 Property

Most property owners (40%) utilize their property seasonally, mainly during the summer months **(Figure 4.3.1).** Some responses did not fit into the categories provided including extended stays beyond just the weekend and seasonal use beyond just summer. The average length of time for property ownership ranged from one year to 100 years with a 28-year average **(Figure 4.3.2).** The first visit to Smoky Lake ranged from two to 93 years ago, with an average first visit of 34 years ago. Days spent at each property ranged from zero to 365 days, with an average occupancy of 106 days/year**.** Over half of the respondents indicated they had a conventional septic system (~57%) and most, regardless of septic system type, reported pumping their septic every two to four years (~67%) (**Figures 4.3.3 & 4.3.4).** Eighty-seven percent of respondents indicated they are current Lake Association members and 52% attend annual Lake Association meetings **(Figures 4.3.5 & 4.3.6).**

Figure 4.3.1: *How is your property used?*

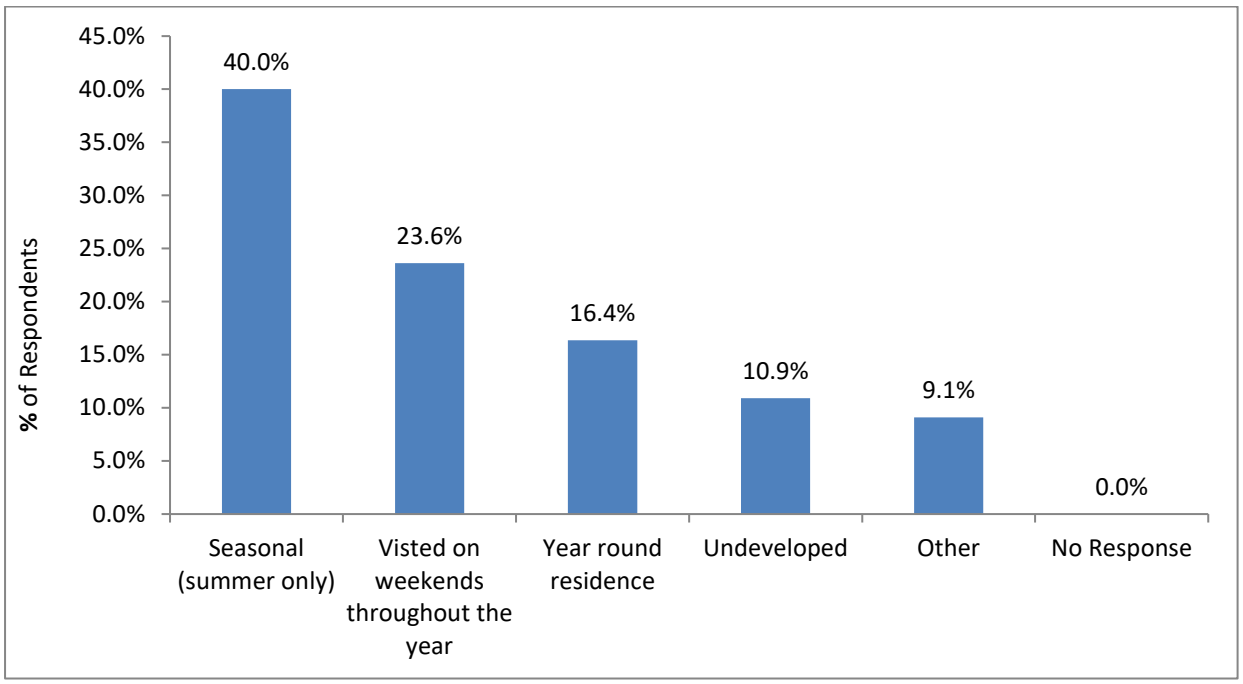


Figure 4.3.2: *How long have you owned property on Smoky Lake?*

Figure 4.3.3: *What type of septic system does your property use?*

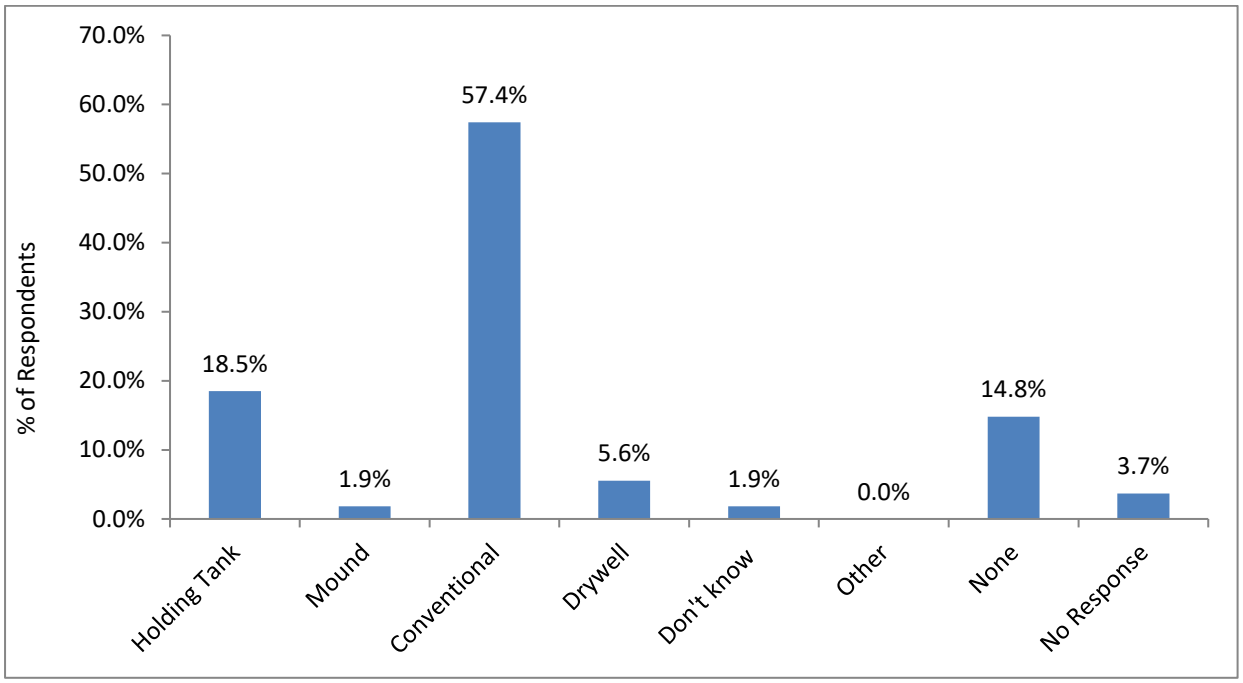


Figure 4.3.4: *How often is your septic system pumped?*

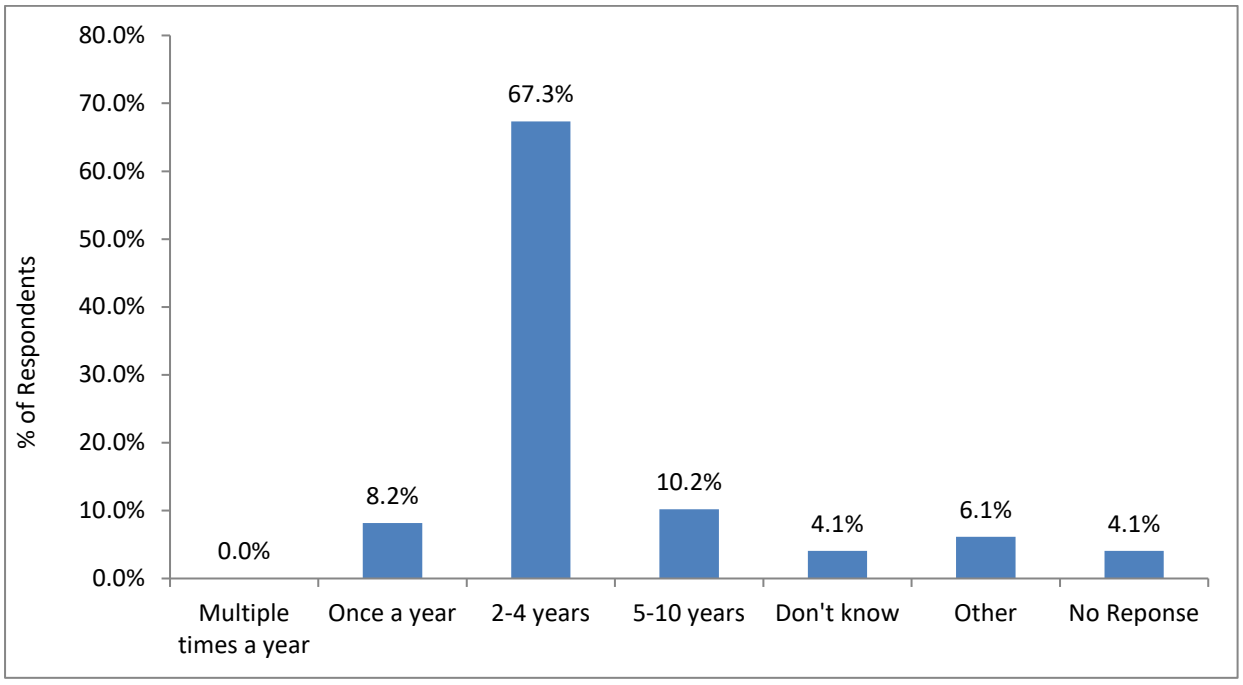


Figure 4.3.5: *Are you a member of the Lake Association?*

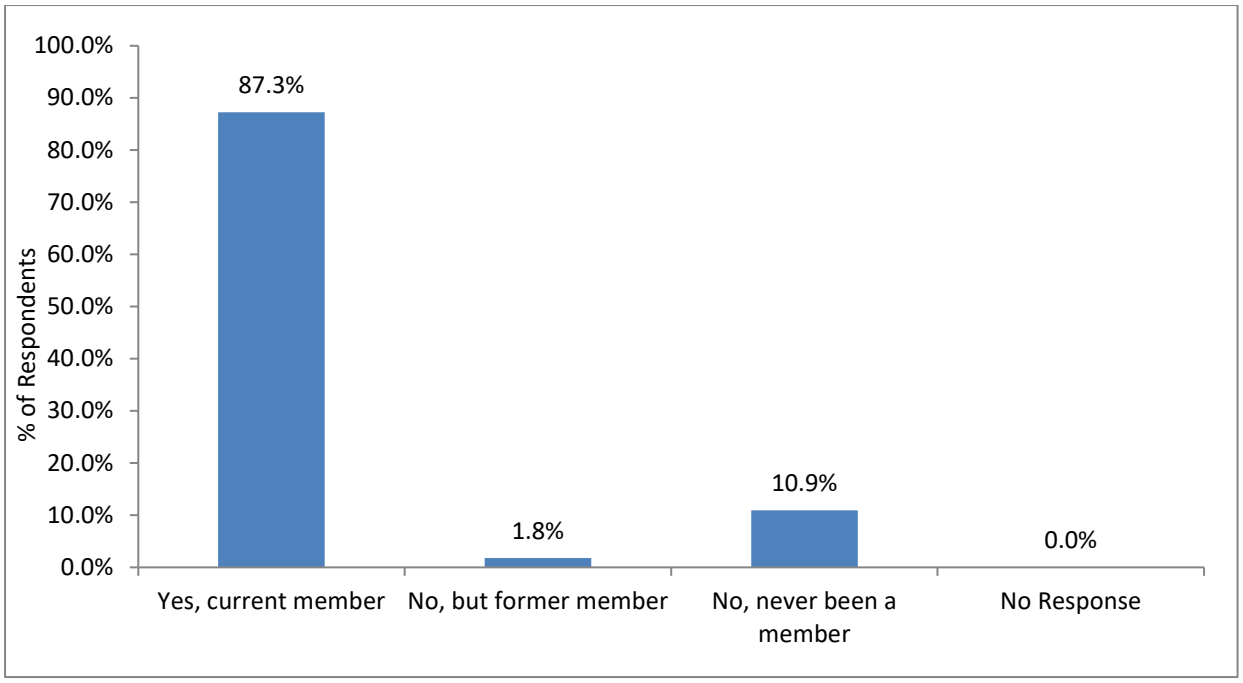
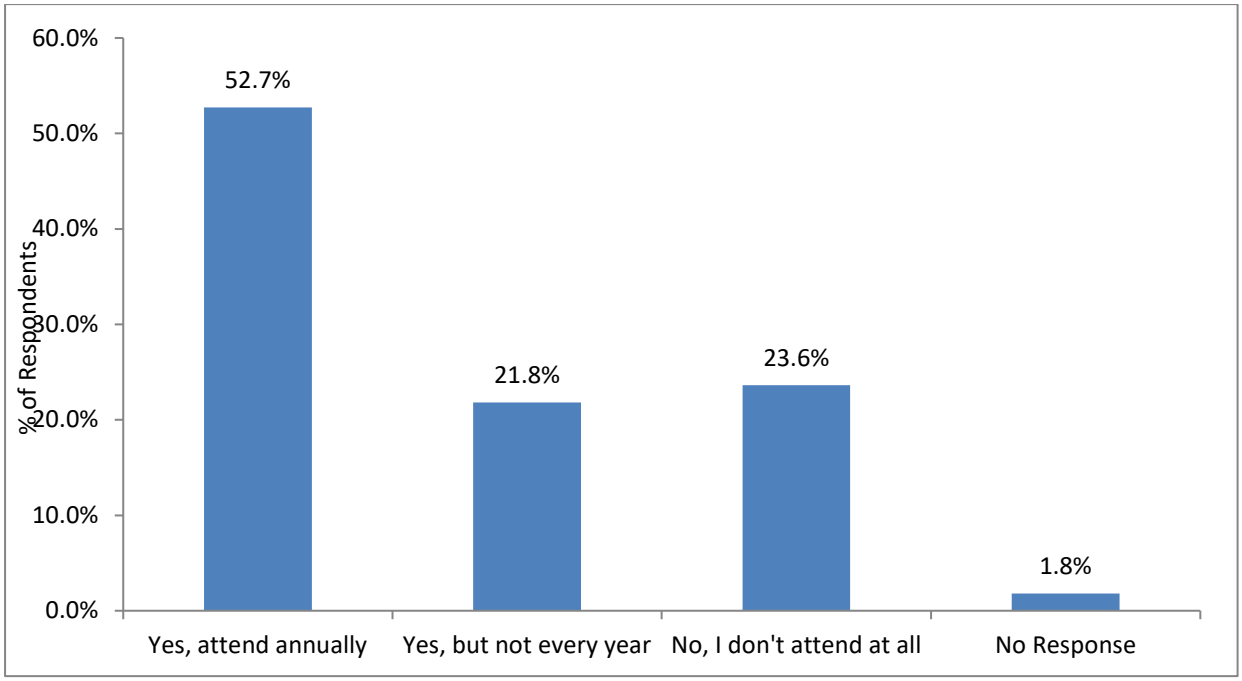


Figure 4.3.6: *Do you attend Lake Association meetings/events?*



4.3.2 Fishing

Approximately 60% of respondents reported fishing Smoky Lake and have been fishing Smoky Lake on average for 16 years. Most fishing occurs during the open water season **(Figures 4.3.7 & 4.3.8).** The top three species caught include Smallmouth Bass (57%), Bluegills/Sunfish (37%), and Yellow Perch (28%). Other fish species reported caught include Musky and Rock Bass **(Figure 4.3.9).** Generally, respondents answered that the current quality of fishing as fair to good and most agree that the quality of fishing on Smoky Lake has remained the same or has gotten somewhat worse over time **(Figures 4.3.10 & 4.3.11).**

Figure 4.3.7: *In a typical year, how often do you fish Smoky Lake during the open water season?*

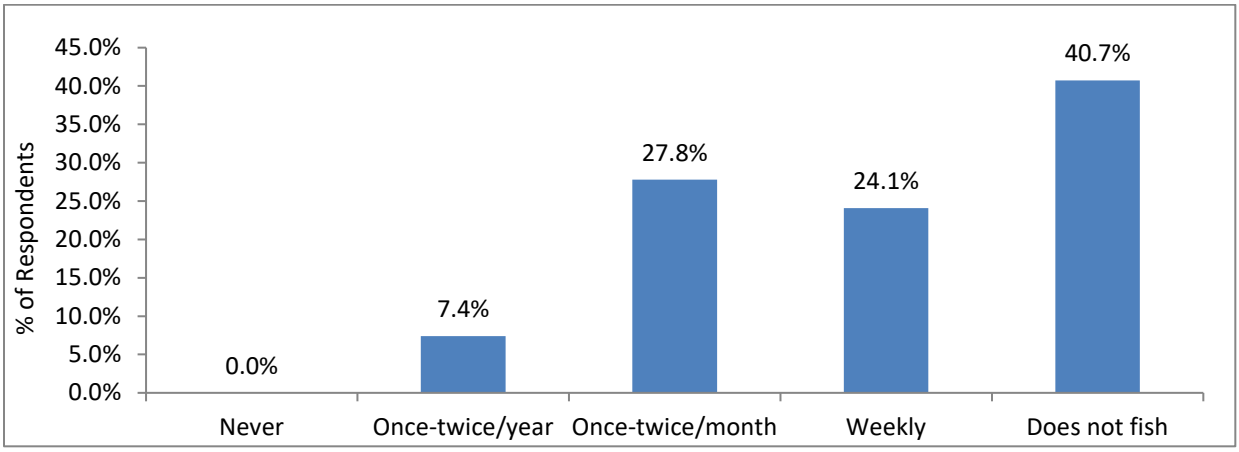


Figure 4.3.8: *In a typical year, how often do you fish Smoky Lake during the ice-fishing season?*

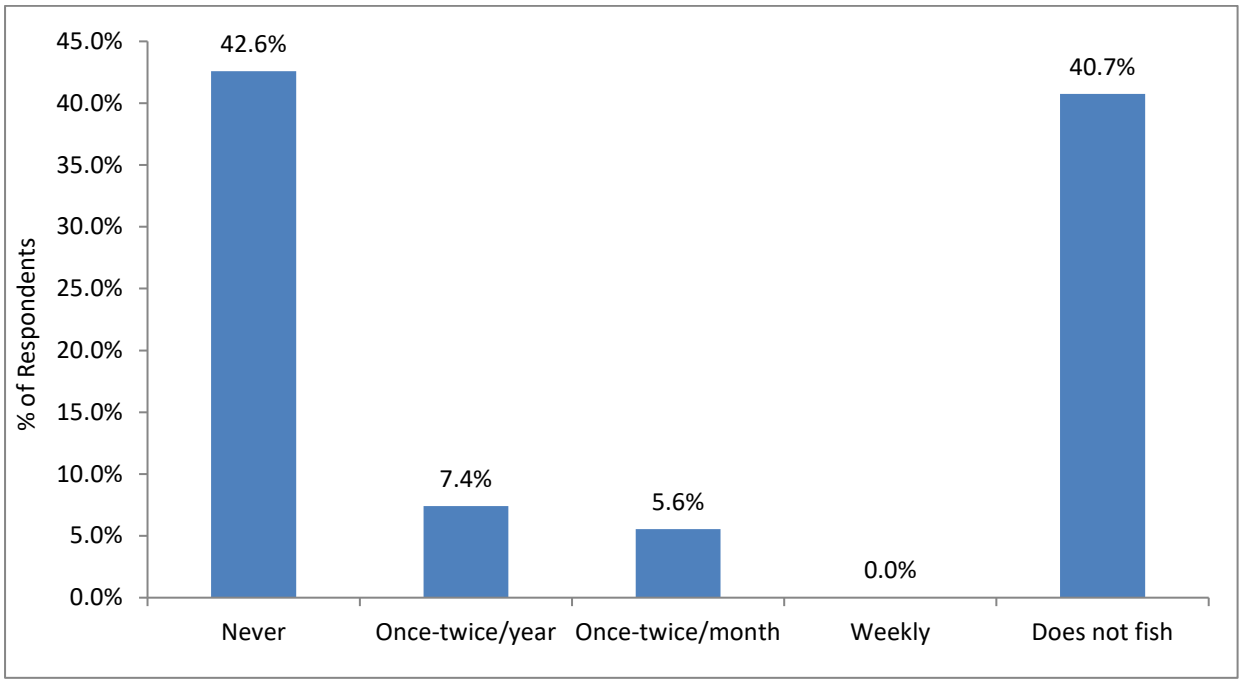


Figure 4.3.9: *What fish species do you catch when fishing Smoky Lake?*

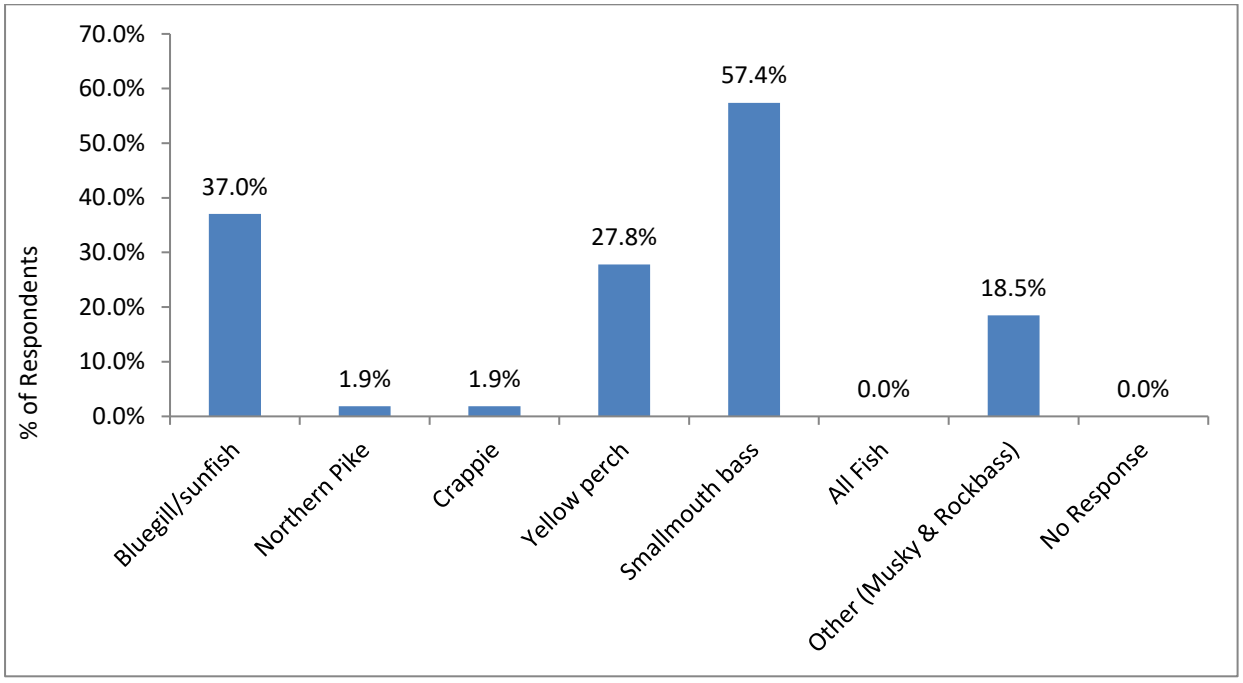


Figure 4.3.10: How would you describe the current quality of fishing on Smoky Lake?

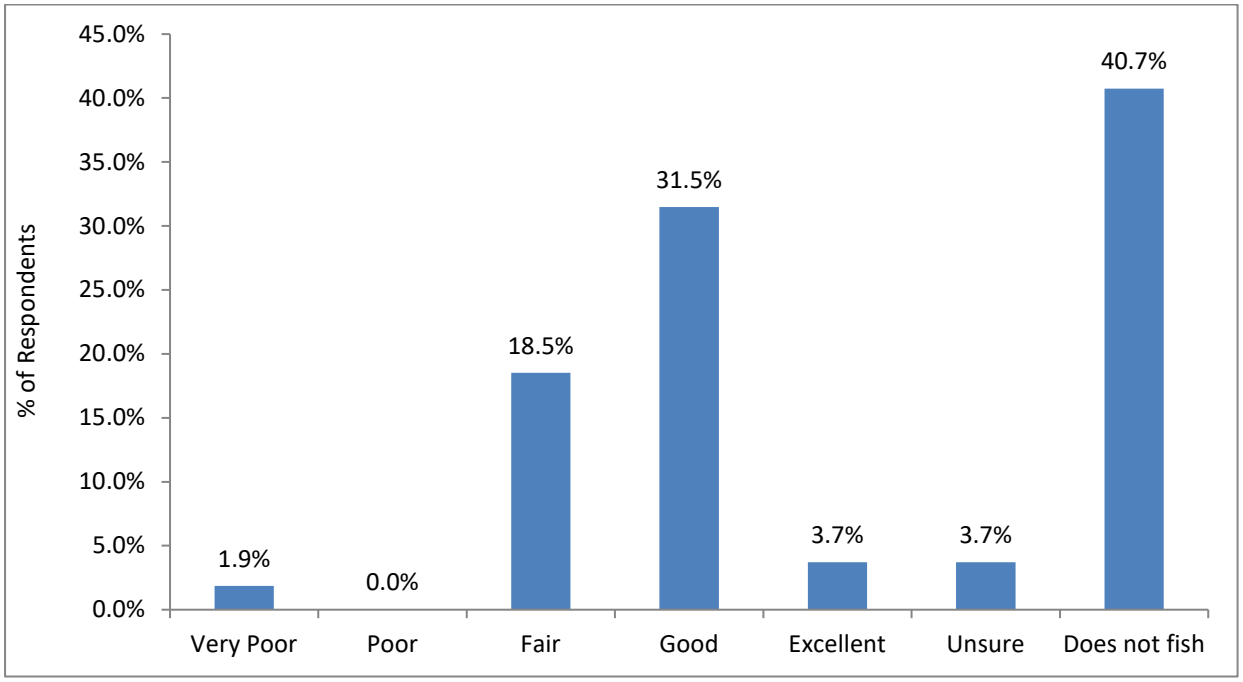
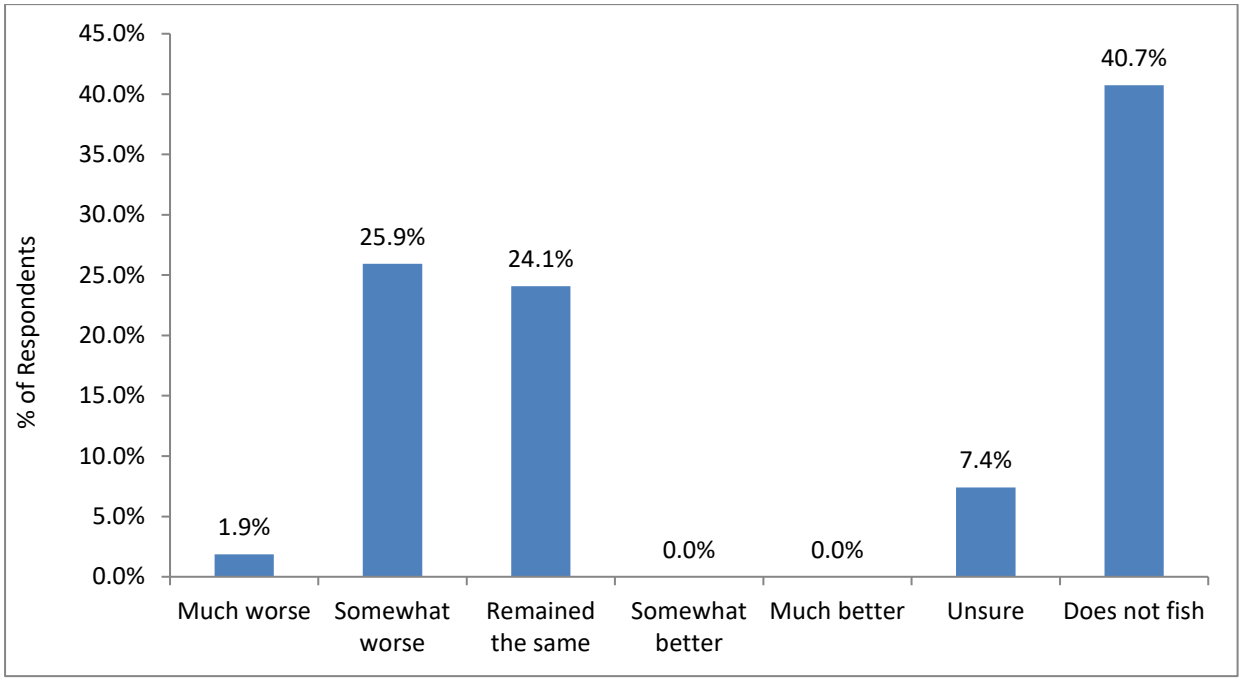


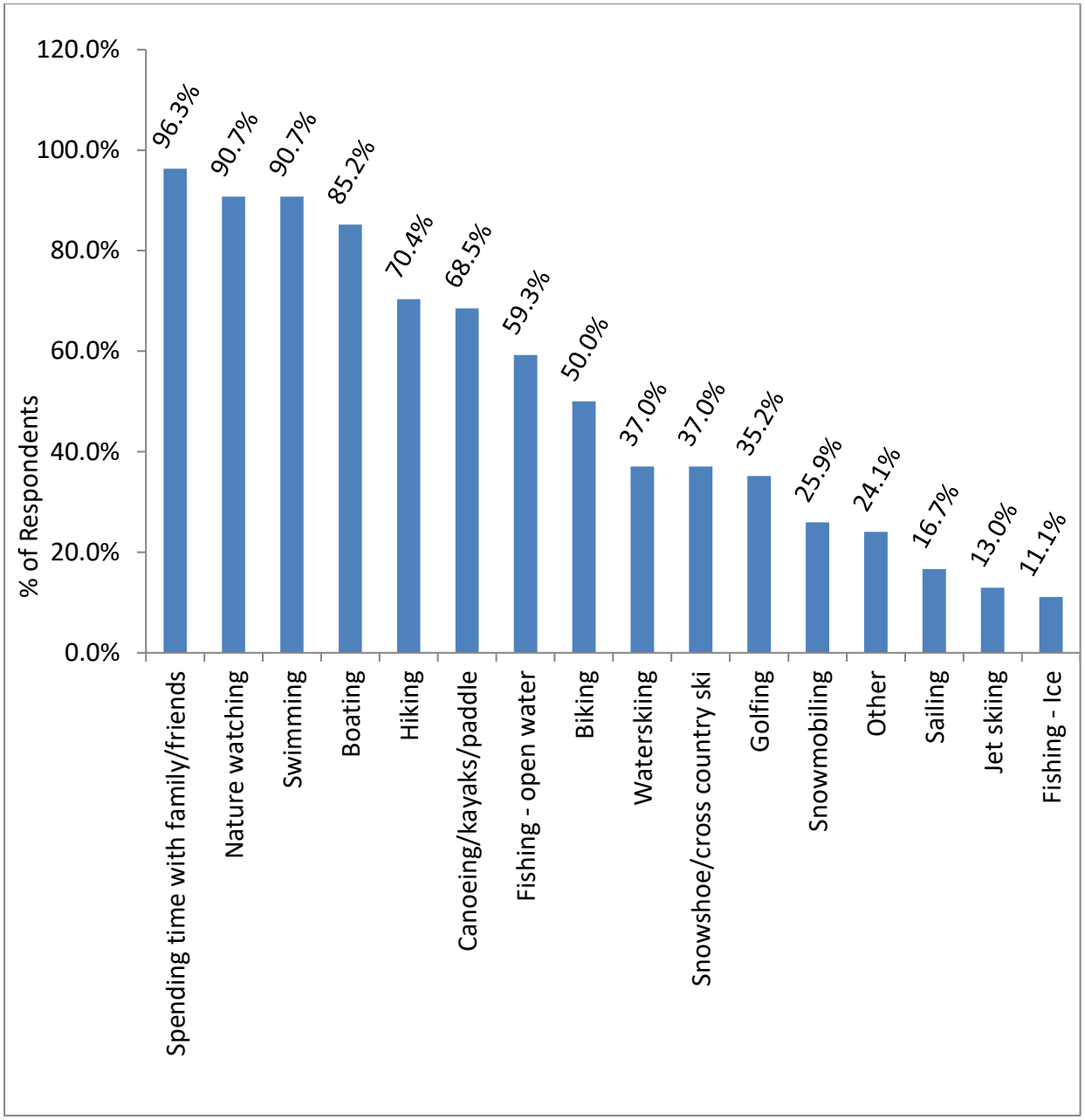
Figure 4.3.11: How has the quality of fishing changed since you first started fishing Smoky Lake?



4.3.3 Lake Use - General

When asked which activities do you enjoy on and adjacent to Smoky Lake, the top responses included spending time with family and friends (~96%), swimming, and nature watching (both ~91%) and boating (~85%) **(Figure 4.3.12).**

Figure 4.3.12: *What activities do you enjoy on or adjacent to Smoky Lake?*



4.3.4 Watercraft Use

Most respondents own a watercraft with ownership ranging from one to seven watercrafts. Respondents averaged two watercraft per property reported**.** Most popular types of watercraft used on Smoky Lake include kayaks (~54%), canoes (~52%), and larger horsepower boats (~41%) (**Figure 4.3.13).** Residents primarily keep their watercraft on Smoky Lake (~67%) and do not transport their watercraft to other water bodies **(Figure 4.3.14).** Those that do use their watercraft on other water bodies generally do some routine cleaning before putting their watercraft back onto Smoky Lake **(Figure 4.3.15).** One-hundred percent of respondents reported removing visual material from the boat and trailer, ~65% drain the bilge and ~53% rinse their watercraft. One respondent reported doing seven of the eight items listed after visiting another lake. However, on average respondents do three of the eight items listed.

Figure 4.3.13: *What types of watercraft do you use on Smoky Lake?*

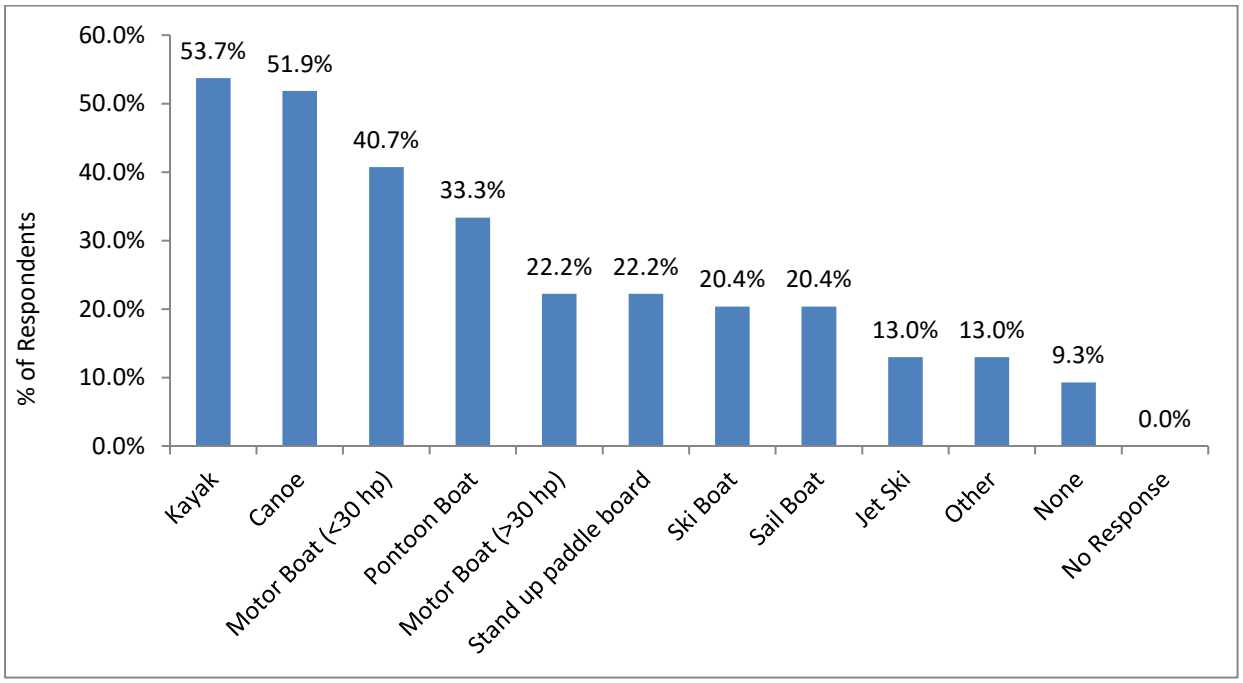


Figure 4.3.14: *Do you use your watercraft on other waters?*

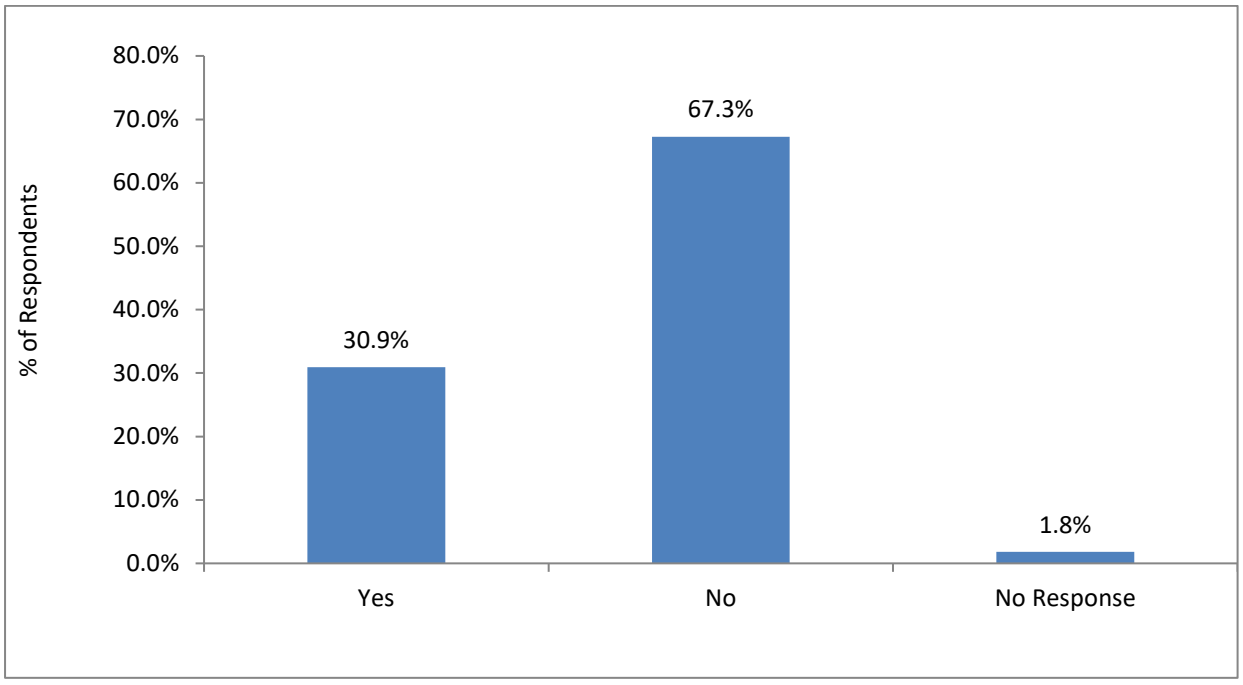
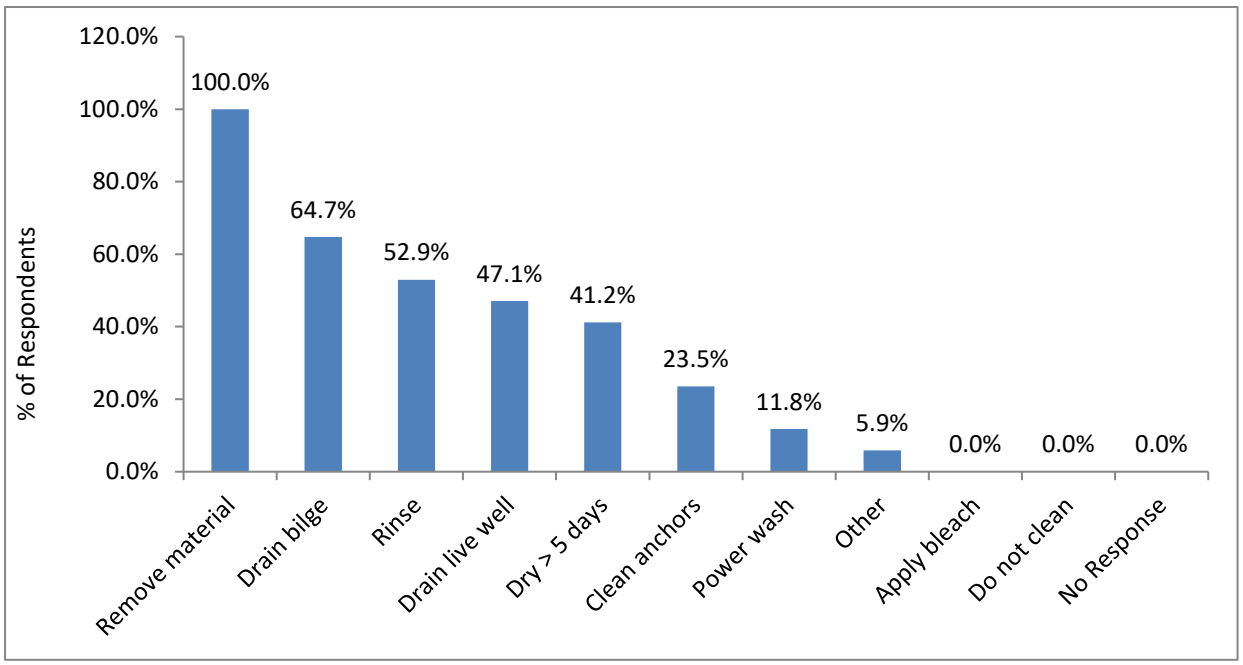


Figure 4.3.15: *If you use your watercraft on other waters, what is your typical cleaning routine after you visit another lake?*



4.3.5 Lake Health

A series of questions sought to gauge lake owners' perspectives on the current and past condition of Smoky Lake and find out what they believe may be affecting lake health. Overall, 63% described Smoky Lake's current water quality as excellent and ~61% felt the water quality has remained the same **(Figures 4.3.16 & 4.3.17).** Twenty-two percent of respondents felt the water quality has gone down since they first started visiting the lake.

Figure 4.3.16: *How would you describe the current water quality of Smoky Lake?*

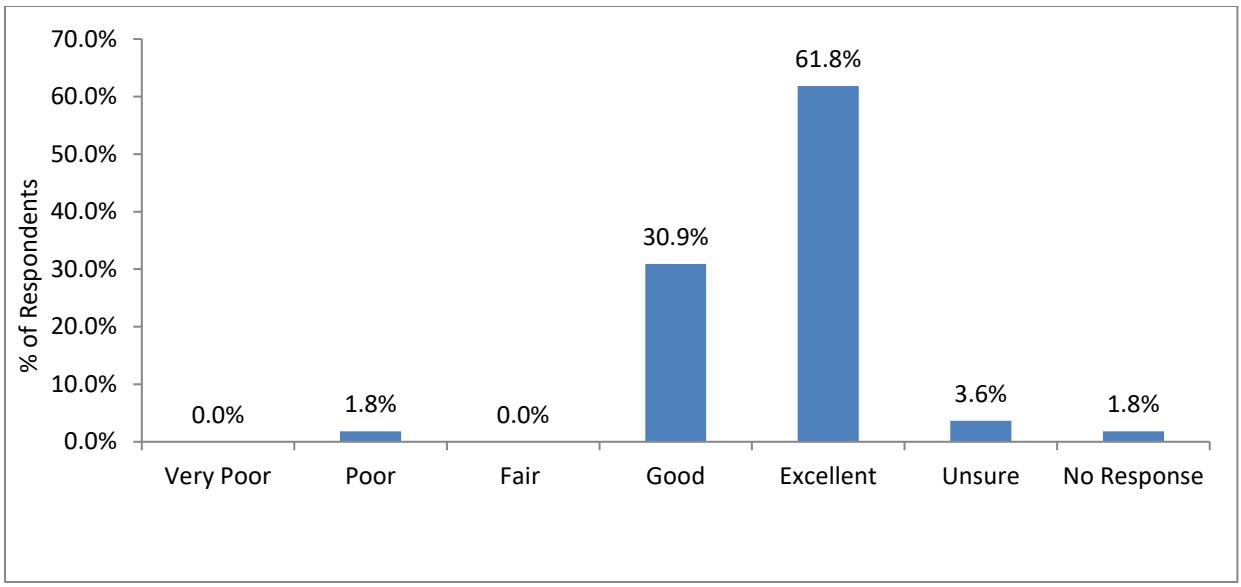
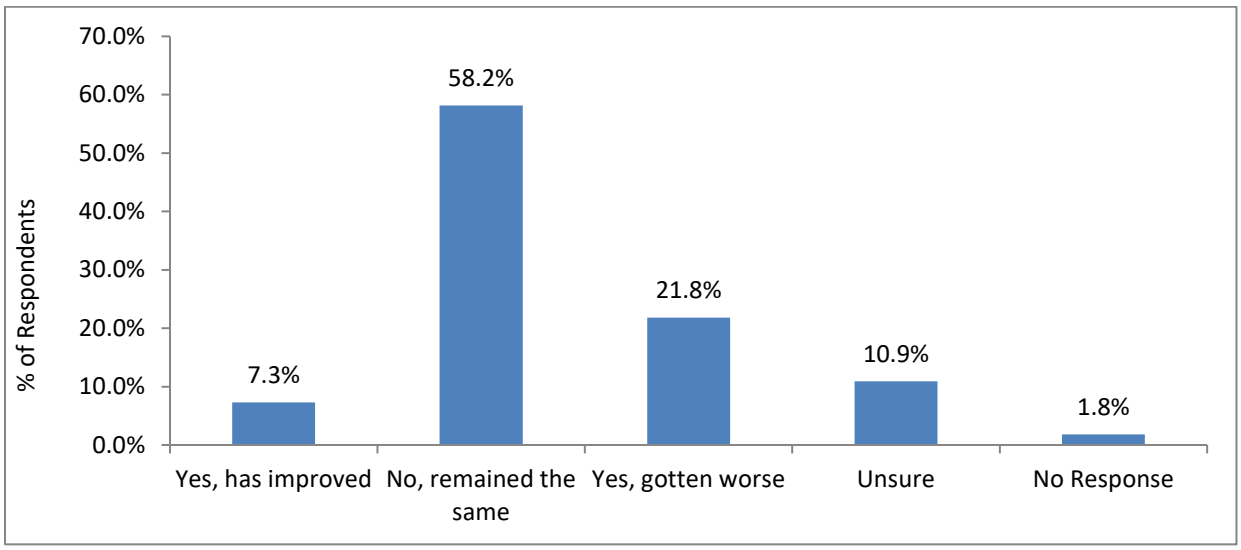


Figure 4.3.17: *Do you feel the water quality of Smoky Lake has changed since you first started to visit Smoky Lake?*



Overwhelmingly, respondents (98%) had some knowledge of aquatic invasive species and most believed they are present (91%). The three top species believed to be present in Smoky Lake include Eurasian watermilfoil (87%), Rusty crayfish (~28%), and Rainbow Smelt (~26%) (**Figure 4.3.18).** Sixteen percent of respondents that had knowledge indicated they were unsure if aquatic invasive species were present in Smoky Lake. Plants and algae do not/or rarely have a negative impact on enjoyment of Smoky Lake **(Figures 4.3.19 & 4.3.20).** About half of the respondents (51%) agree that aquatic control of *native* plants should not occur on Smoky Lake, whereas 17% believe native plant control on Smoky Lake is needed, 31% are unsure. Seventy-six percent agree that control of aquatic *invasive* plants is needed while 22% are unsure.

Figure 4.3.18: *Which aquatic invasive species do you believe are present in and adjacent to Smoky Lake?*

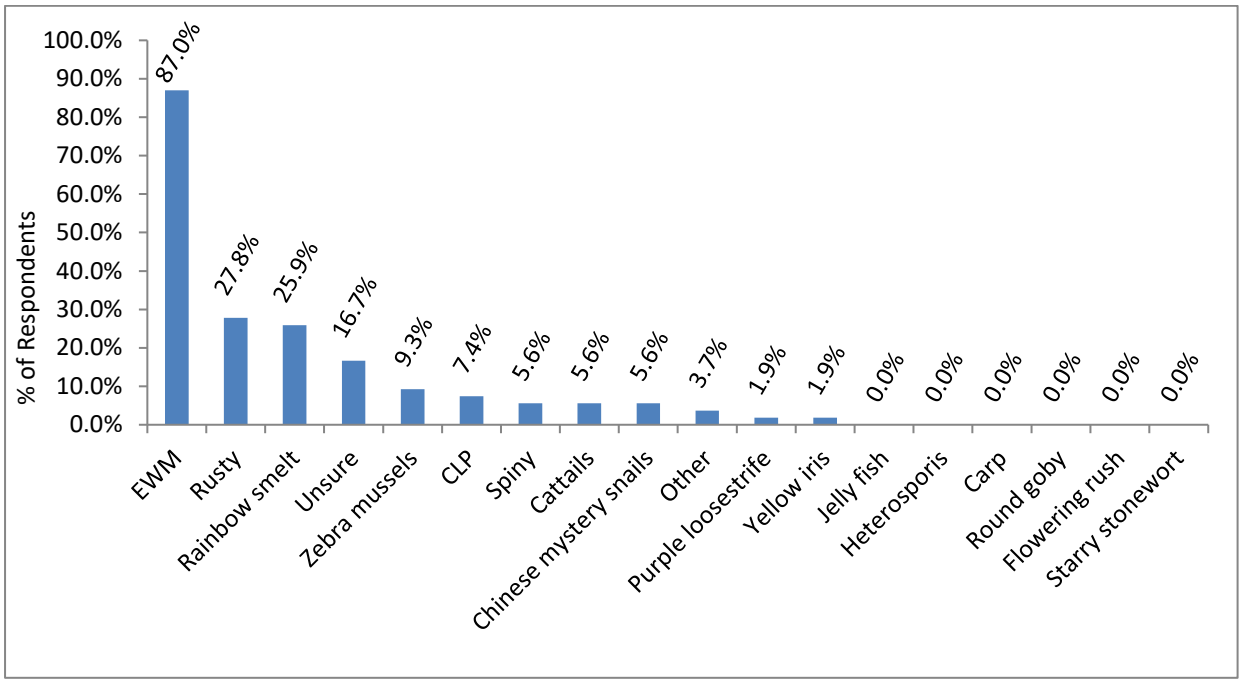


Figure 4.3.19: *During the open water season how often does aquatic plant growth (excluding algae) negatively impact your enjoyment of Smoky Lake?*

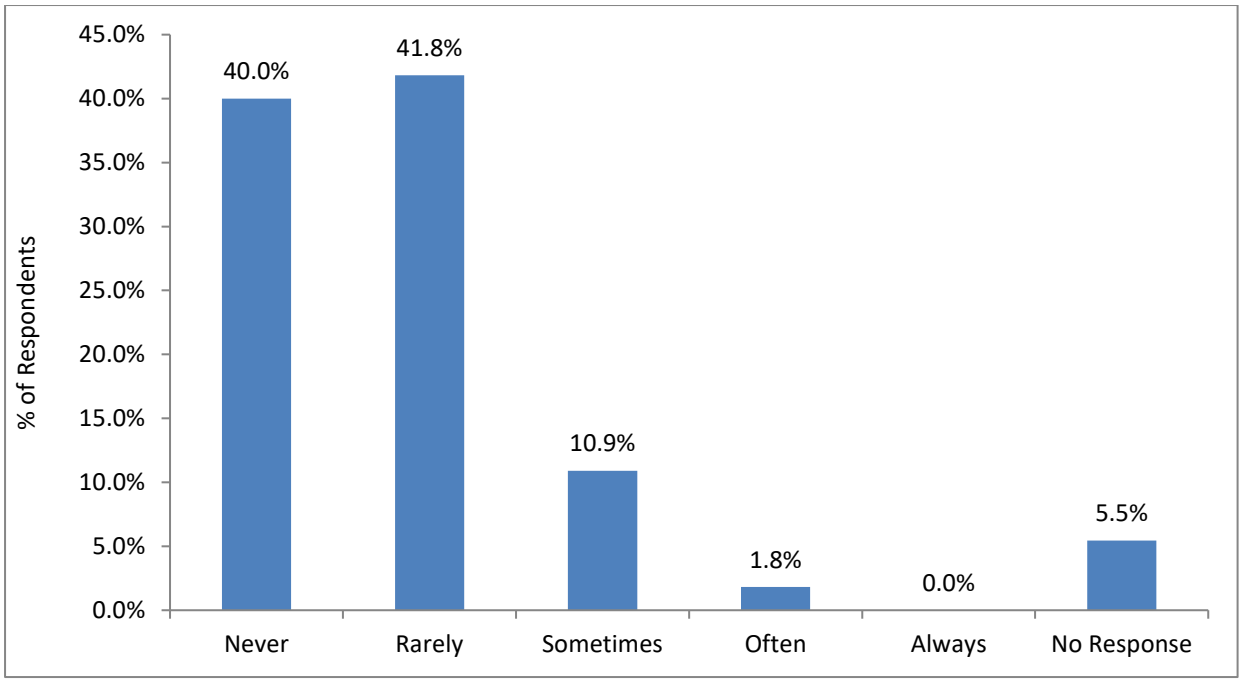
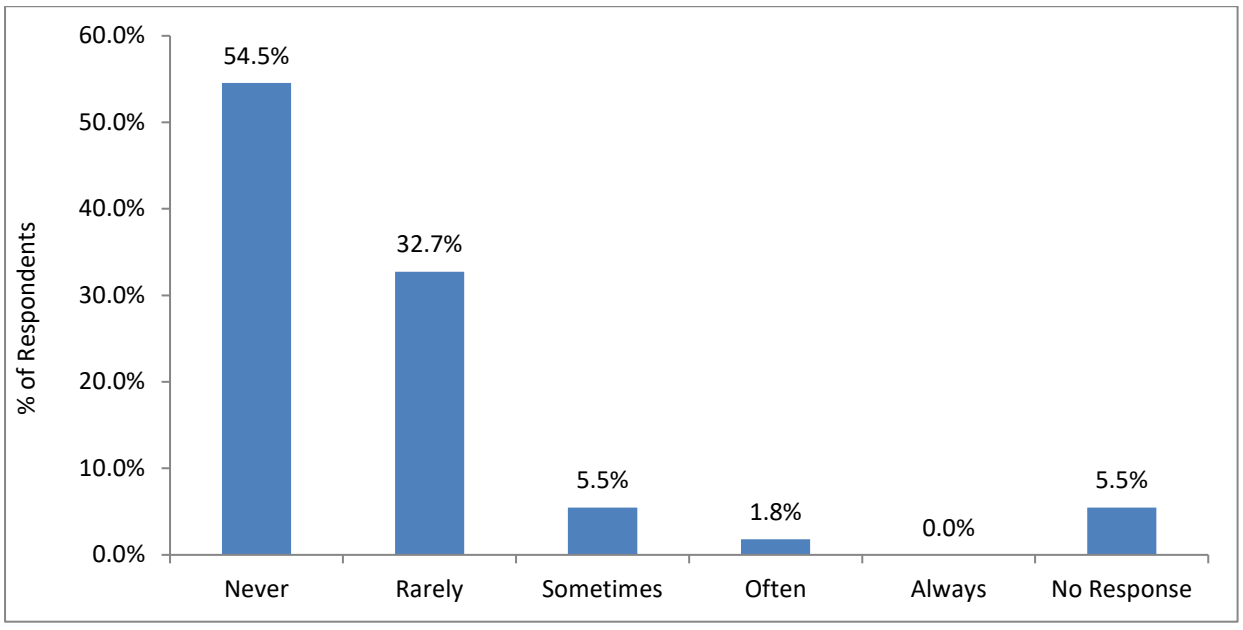
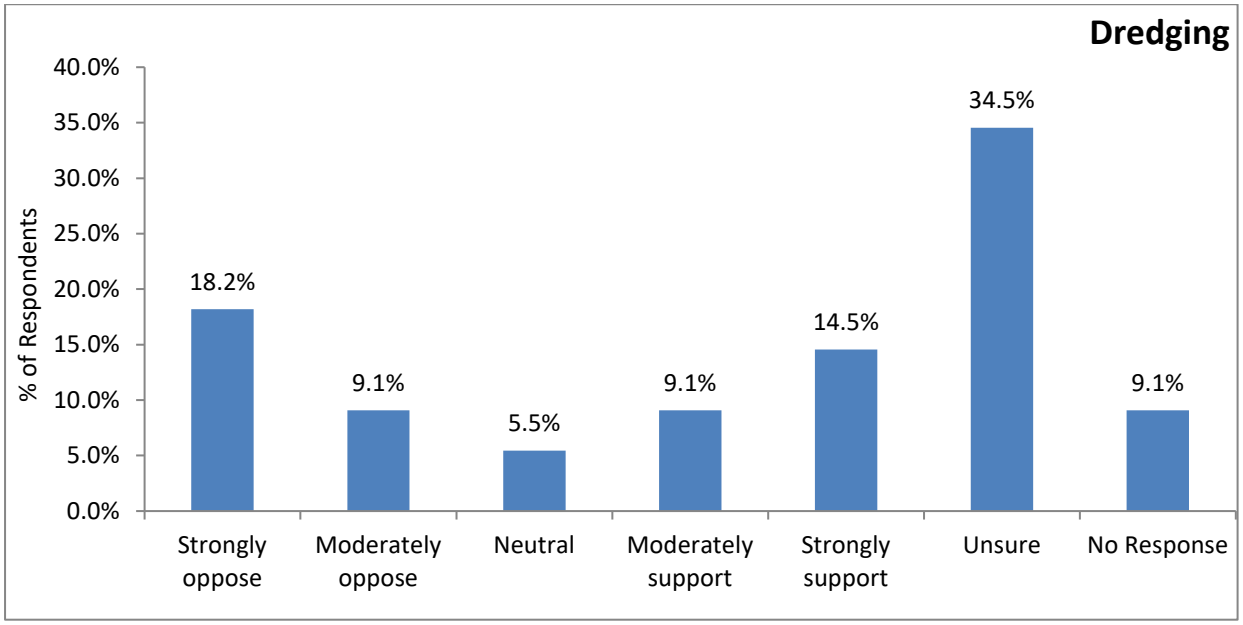


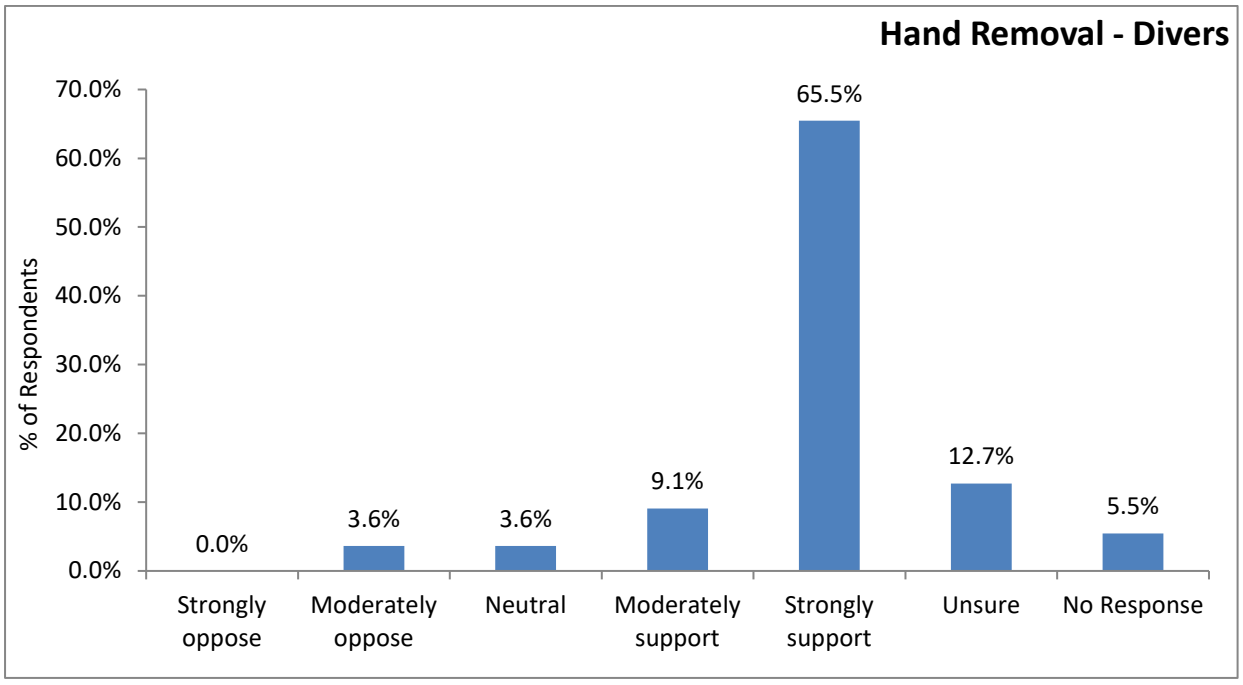
Figure 4.3.20: *During the open water season how often does aquatic algae negatively impact your enjoyment of Smoky Lake?*

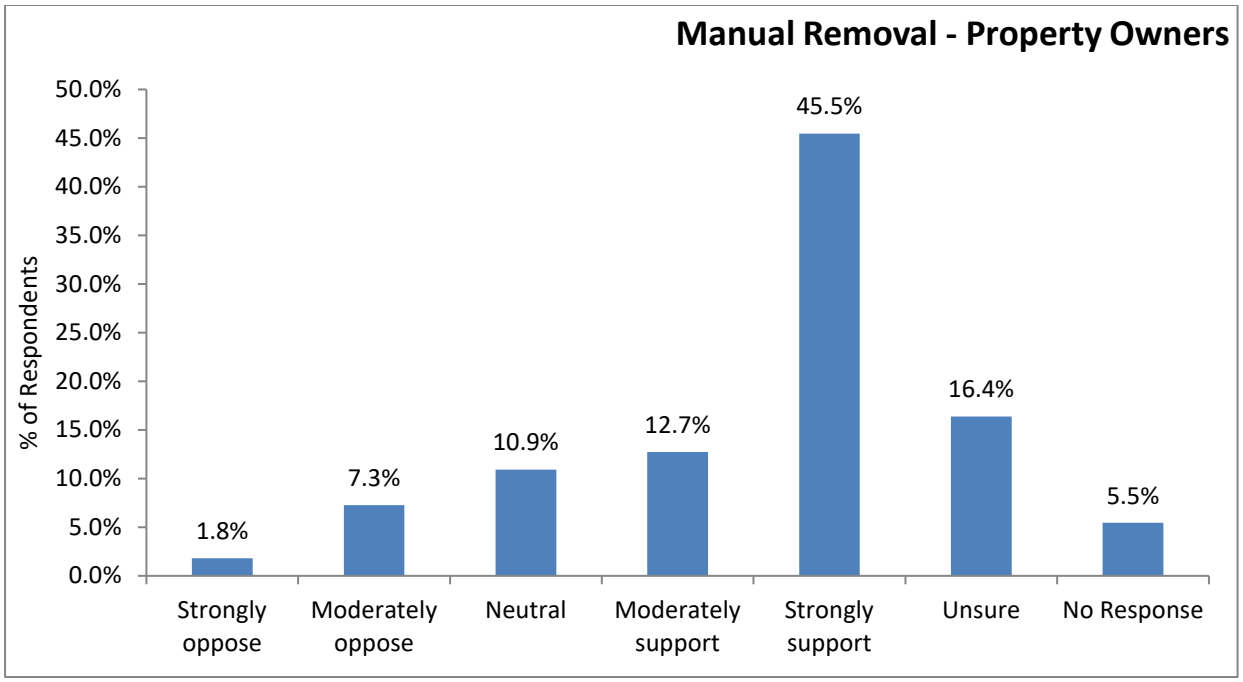


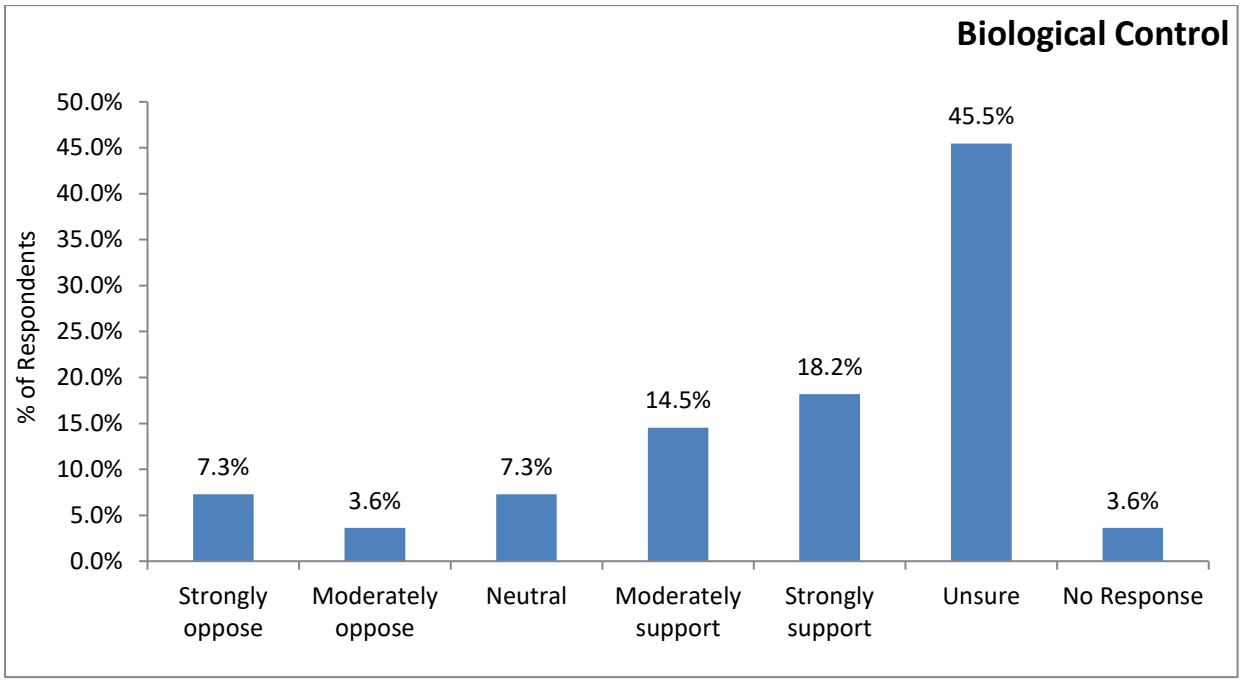
Respondents were asked to rank opposition or support for several aquatic plant management techniques **(Figures 4.3.21–4.3.27).** Over half of respondents (~57%) strongly oppose "doing nothing" as a management strategy for aquatic plants. Strongest support is for hand removal with divers (~66%) and hand removal with divers by property owners (~46%) and strongest opposition is for dredging (~18%) and herbicides (~16%). There is more uncertainty about biological control (~46%). Uncertainty across all categories ranged from ~13% to ~46%.

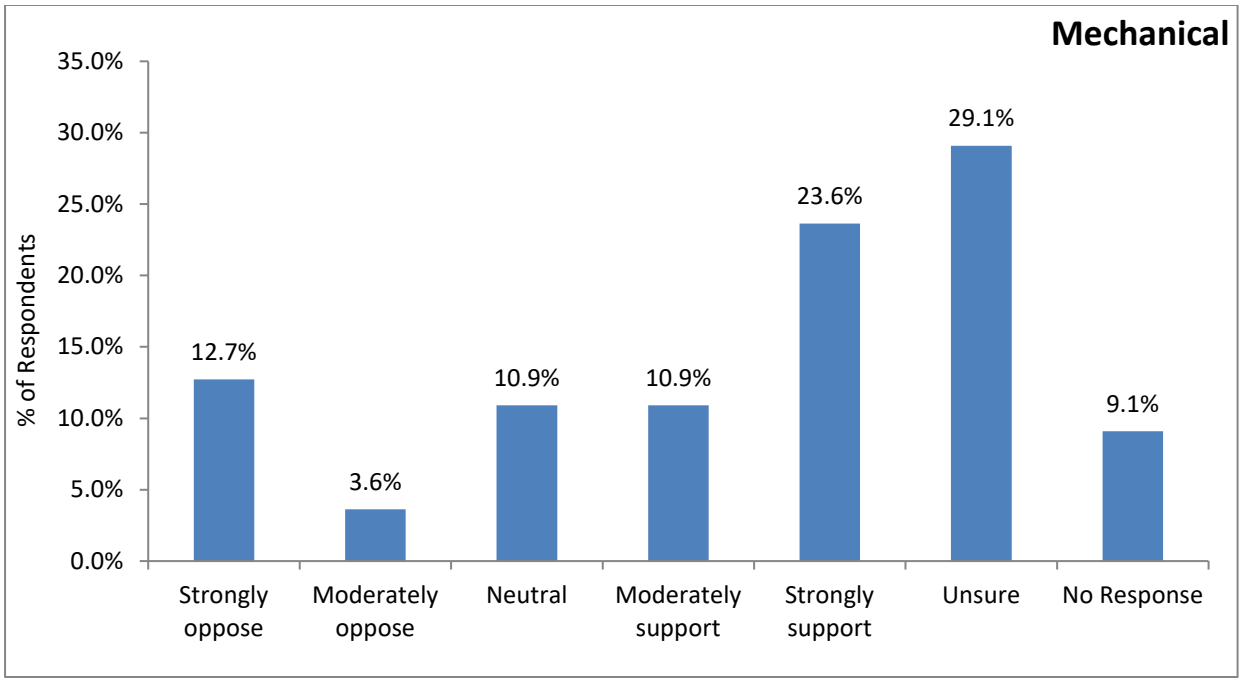
Figures 4.3.21-27: *Aquatic plants can be managed using many techniques. Please tell us if you oppose or support the responsible use of the following on Smoky Lake.*

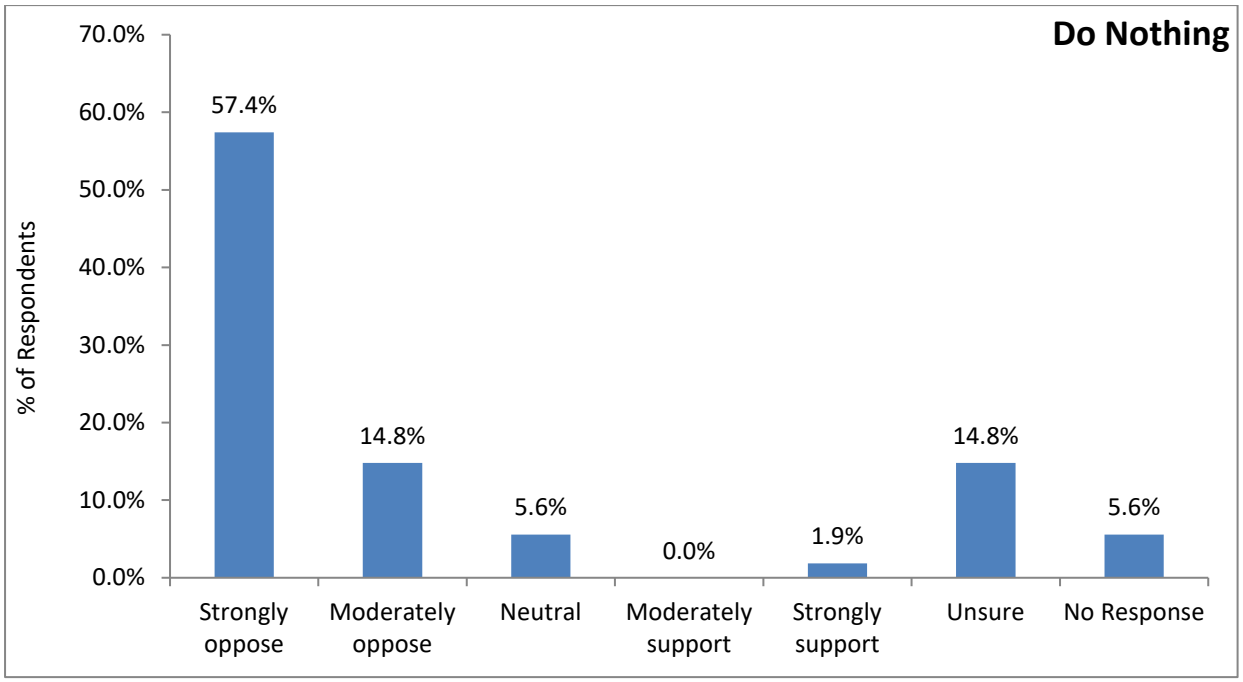


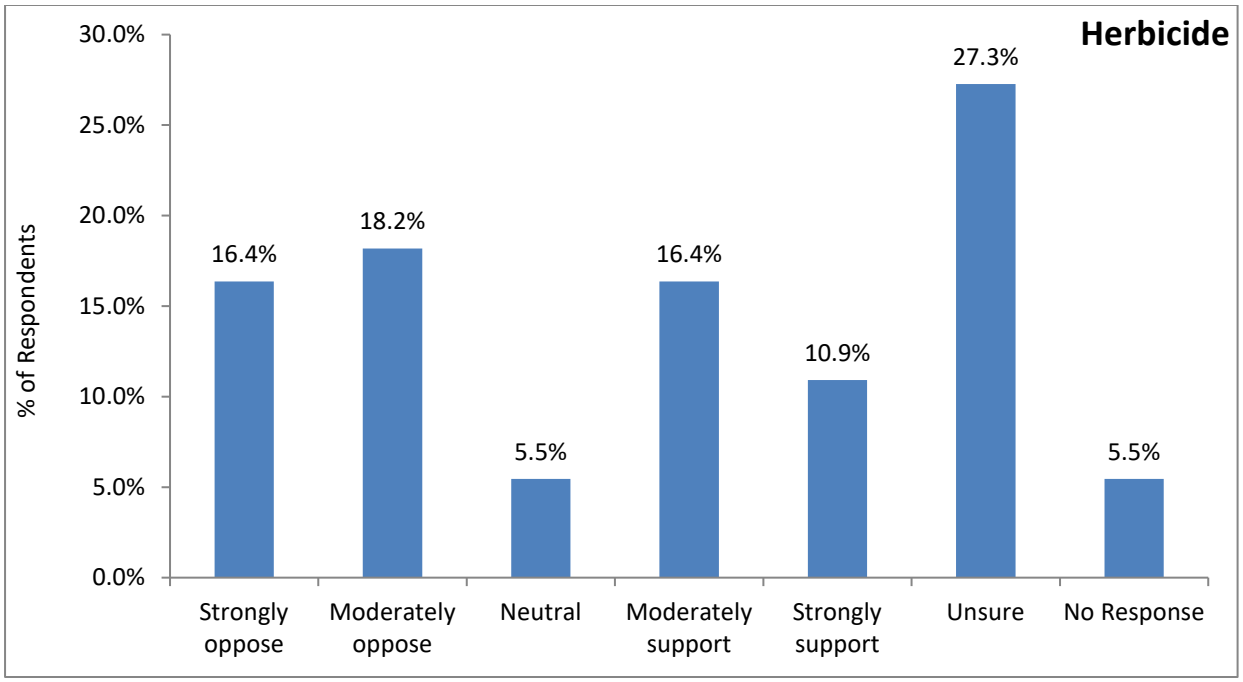



Manual Removal - Property Owners
% of Respondents
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
1.8%
7.3%
10.9%
12.7%
45.5%
16.4%
5.5%
Strongly oppose
Moderately oppose
Neutral
Moderately support
Strongly support
Unsure
No Response


Biological Control
% of Respondents
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
7.3%
3.6%
7.3%
14.5%
18.2%
45.5%
3.6%
Strongly oppose
Moderately oppose
Neutral
Moderately support
Strongly support
Unsure
No Response


Mechanical
% of Respondents
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
12.7%
3.6%
10.9%
10.9%
23.6%
29.1%
9.1%
Strongly oppose
Moderately oppose
Neutral
Moderately support
Strongly support
Unsure
No Response

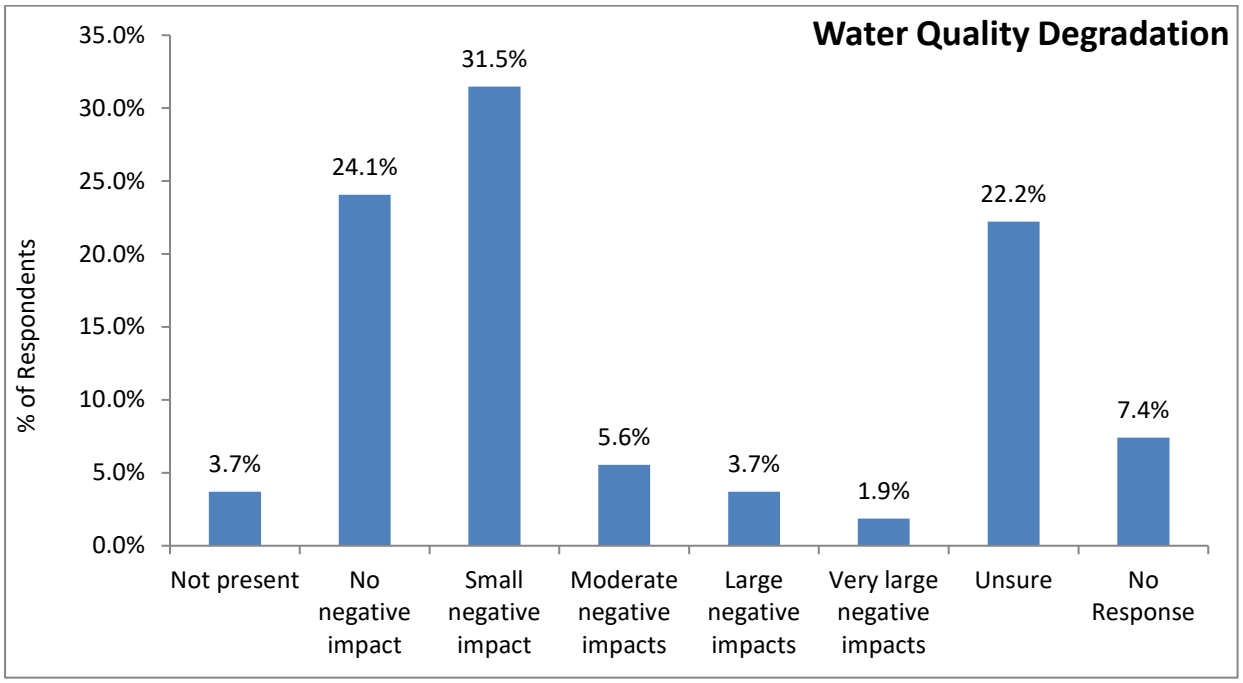

Do Nothing
% of Respondents
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
57.4%
14.8%
5.6%
0.0%
1.9%
14.8%
5.6%
Strongly oppose
Moderately oppose
Neutral
Moderately support
Strongly support
Unsure
No Response

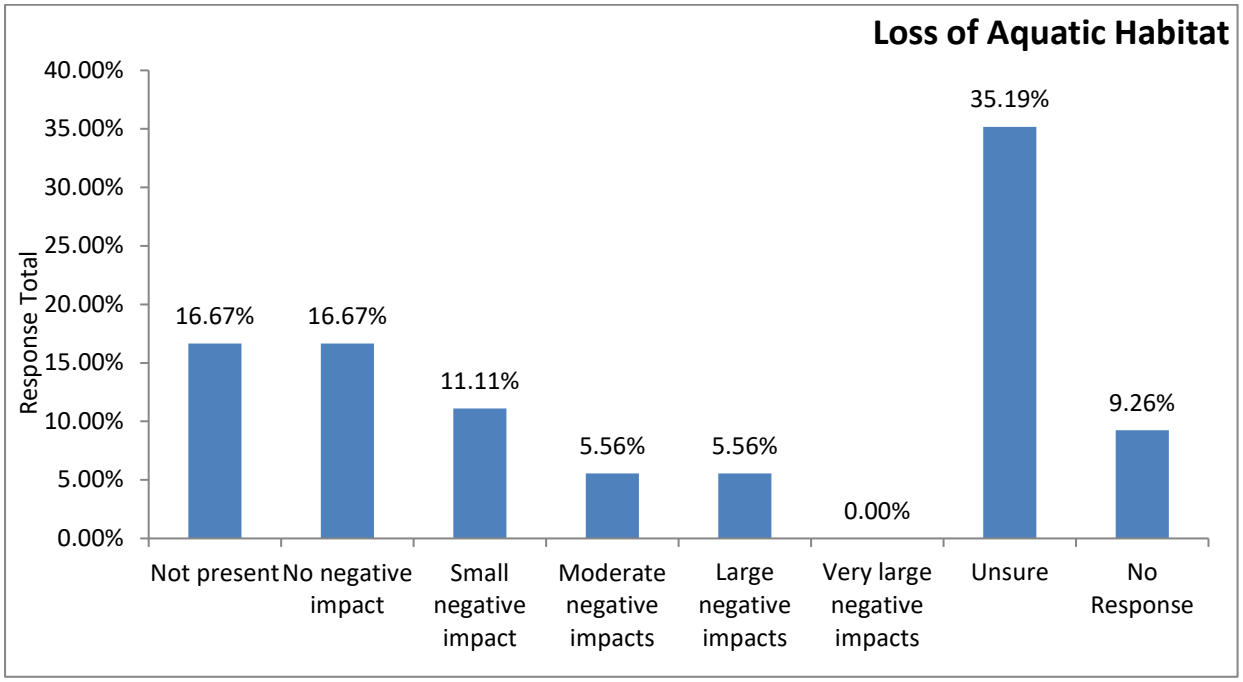


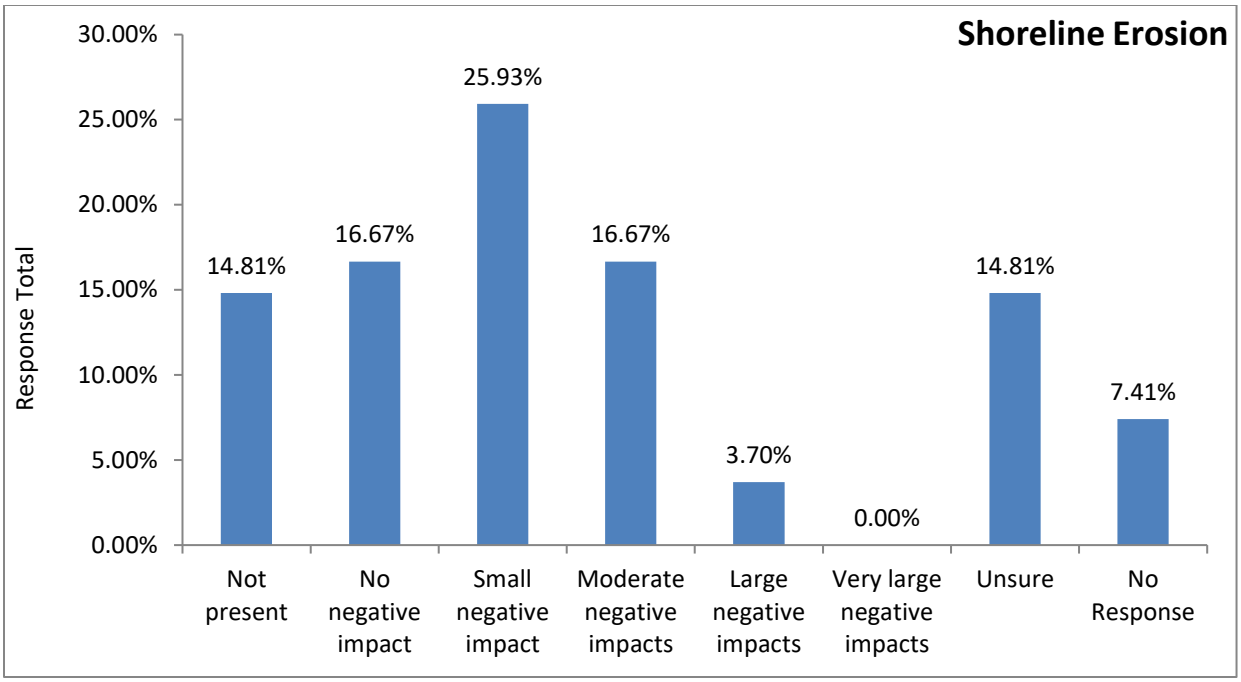
The next series of questions provide a list of possible impacts to Wisconsin lakes **(Figures 4.3.28-4.3.39).** Respondents were asked, "To what level do you believe each of the following factors may currently be negatively impacting Smoky Lake?" Circling *not present* means the respondent perceives the issue as not existing on Smoky Lake, whereas circling *no negative impact* means the issue may exist on Smoky Lake but is not perceived to be negatively impacting the lake. Sixty-seven percent of respondents agree that water quality degradation issues exists on Smoky Lake, where as ~4% believe water quality issues on Smoky Lake do not exist. Of the 67% that agree that water quality degradation exists, ~43% believe water quality issues are currently negatively impacting the lake, whereas ~24% believe water quality issues are present on Smoky Lake, but are not currently impacting water quality. Twenty-two percent were *unsure* about water quality impact issues. The issues receiving the largest response of *unsure* were septic discharge (~46%), followed by, loss of aquatic habitat (~35%).

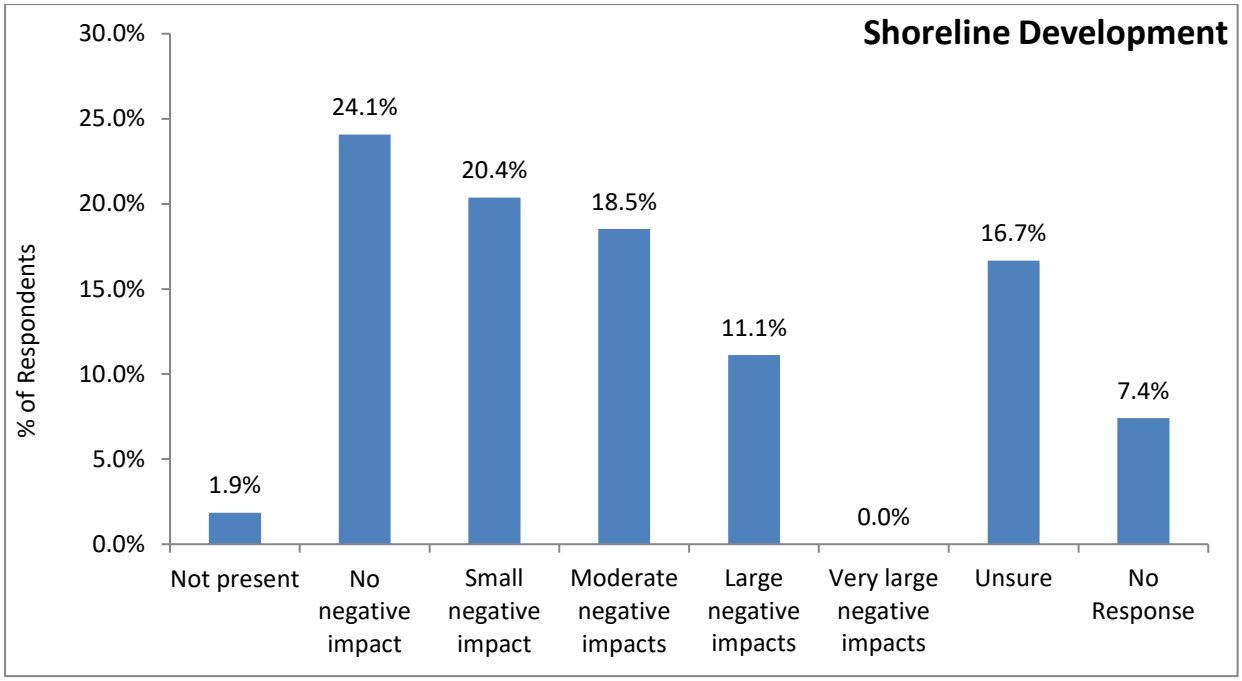
The two categories that received the largest percentage of responses for "very large impacts" to Smoky Lake include aquatic invasive species introductions (13%), followed by unsafe watercraft practices (11%). Other impacts written in included barking dogs, radios, musky guides, and jet skis.

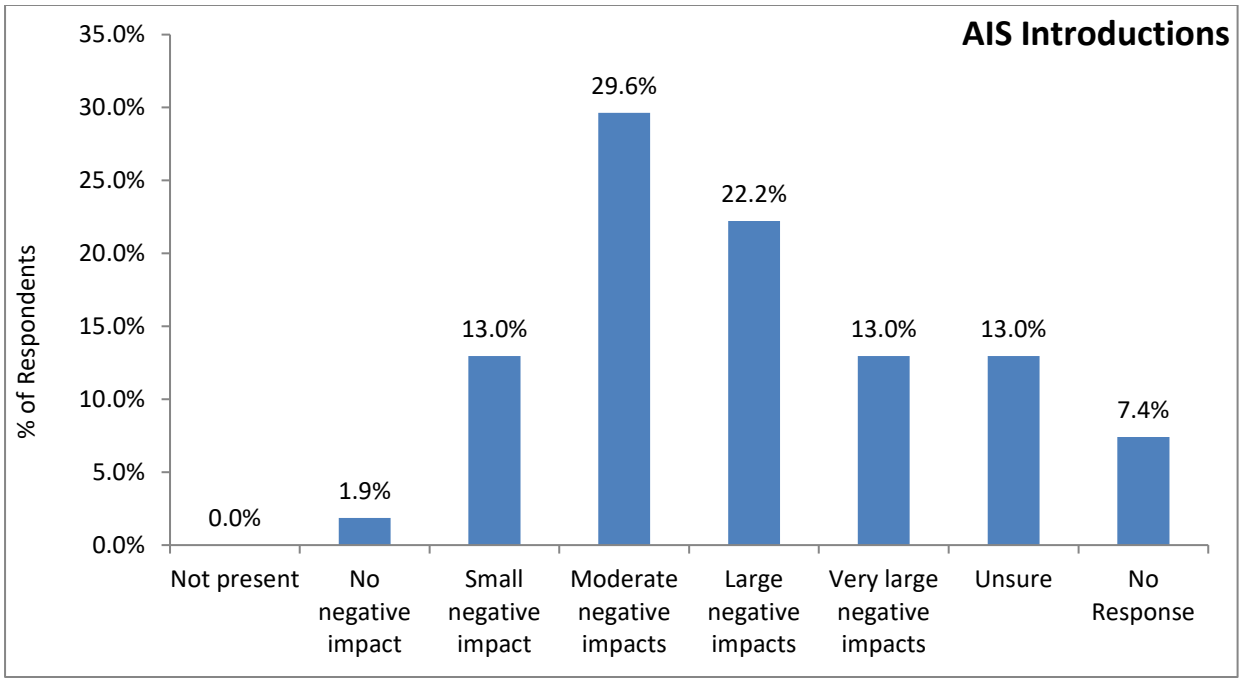
Figures 4.3.28 – 4.3.39: Below is a list of possible impacts to Wisconsin lakes. To what level do you believe each of the following factors may currently be negatively impacting Smoky Lake? *Not present* means that you believe the issue does not exist on Smoky Lake. *No negative impact* means that the issue may exist on Smoky Lake but is not negatively impacting the lake.

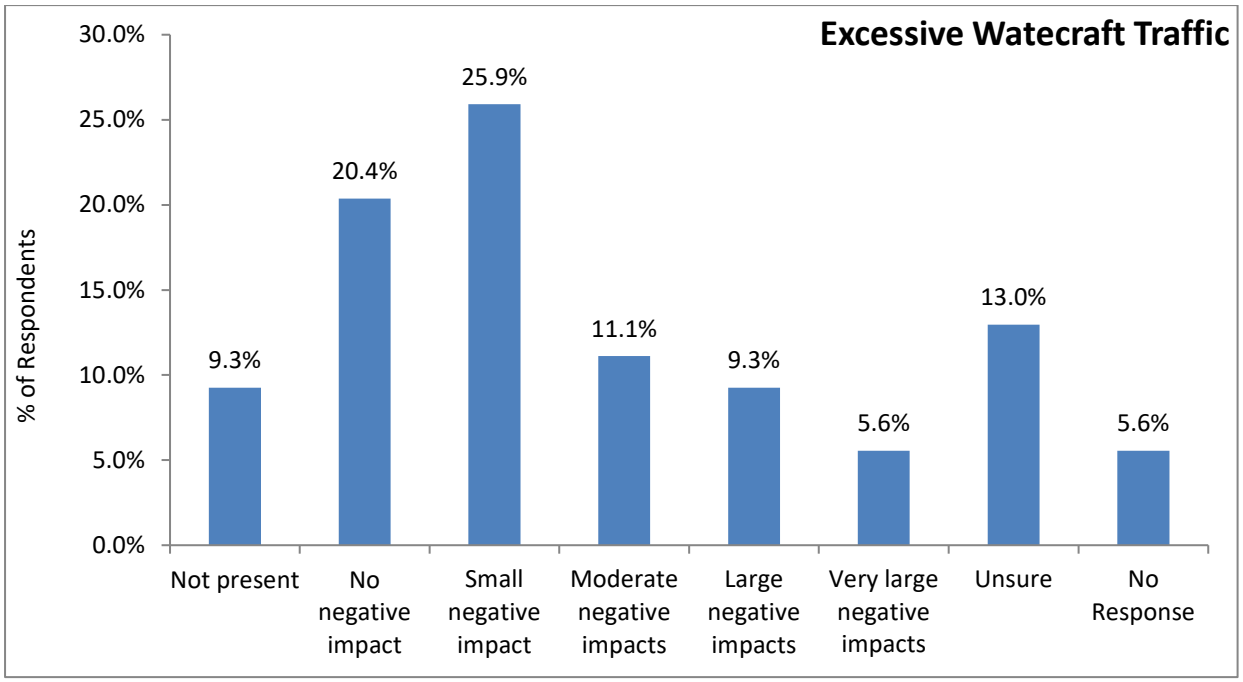


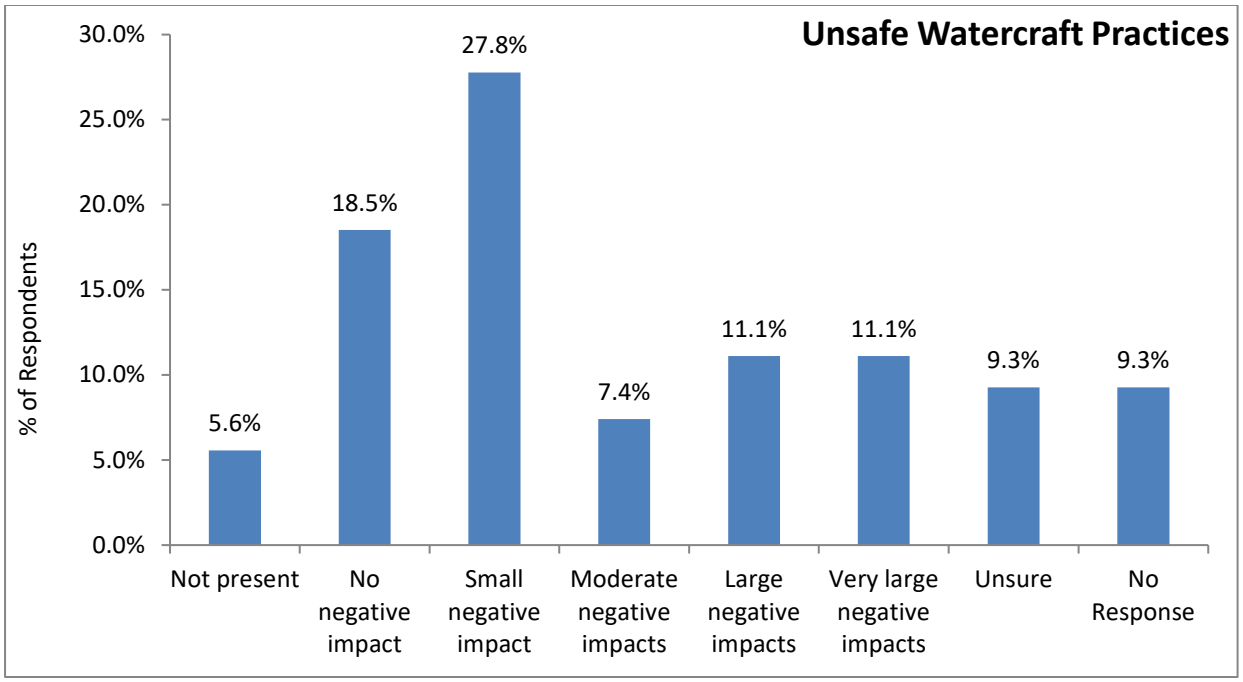


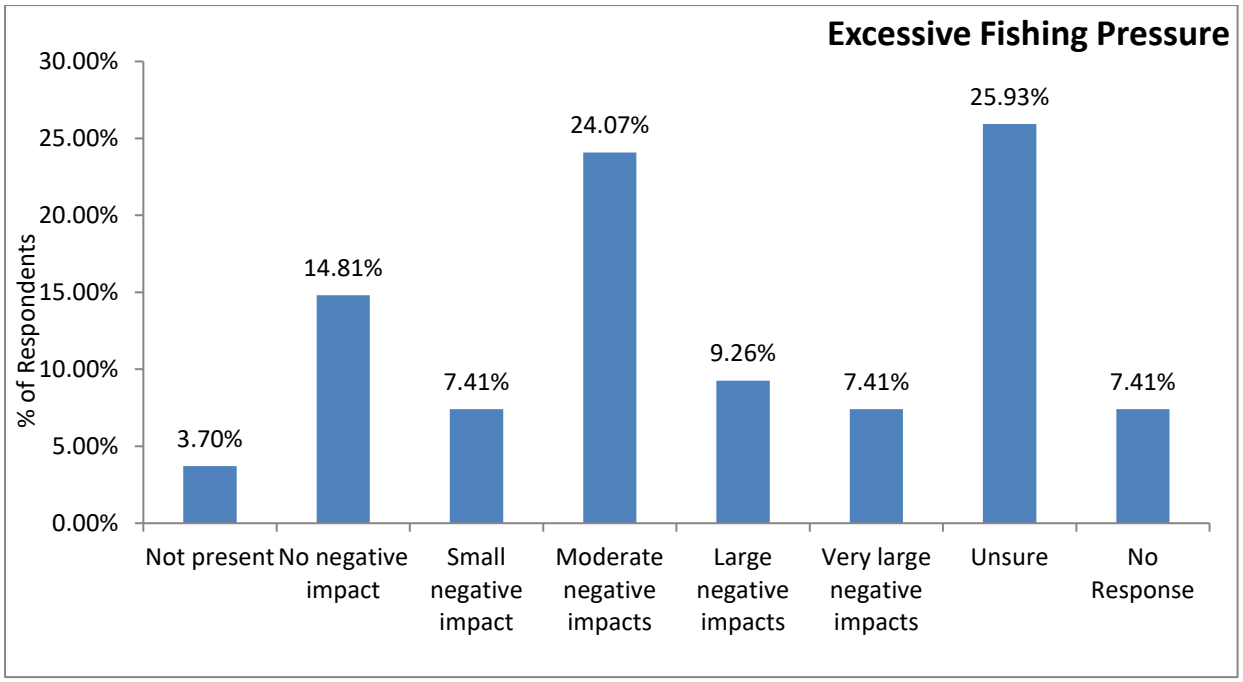

Shoreline Erosion
Response Total
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
14.81%
16.67%
25.93%
16.67%
3.70%
0.00%
14.81%
7.41%
Not present
No negative impact
Small negative impact
Moderate negative impacts
Large negative impacts
Very large negative impacts
Unsure
No Response

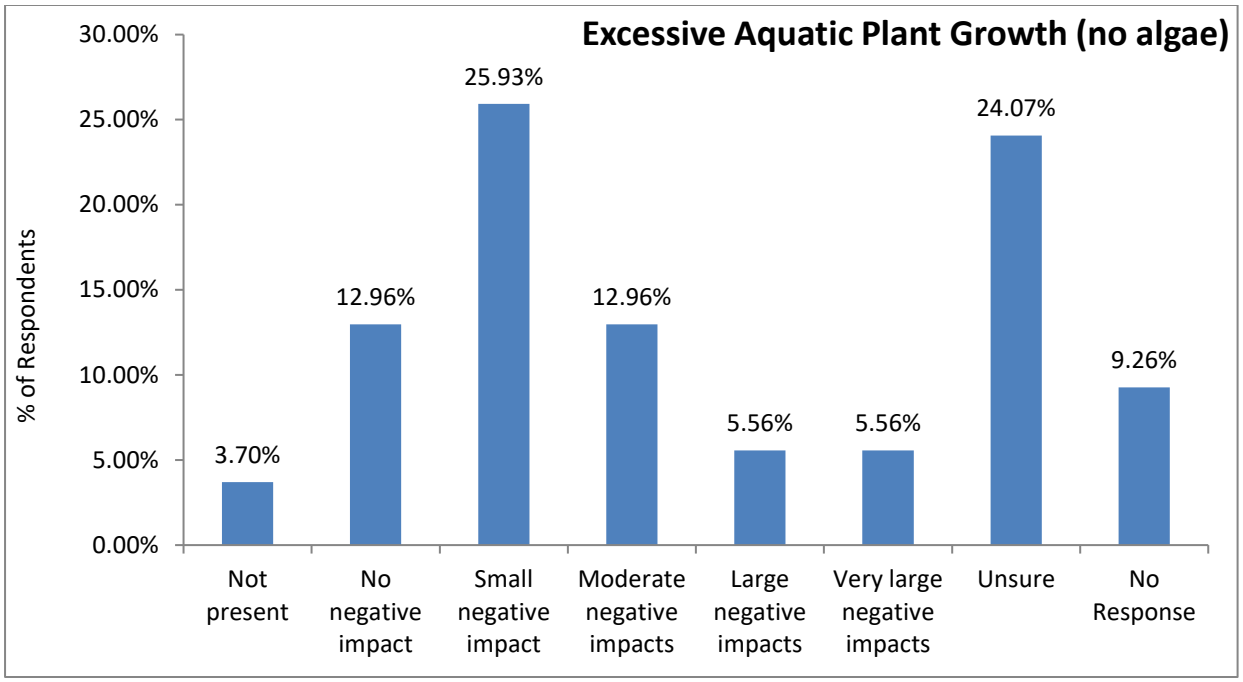

Shoreline Development
% of Respondents
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
1.9%
24.1%
20.4%
18.5%
11.1%
0.0%
16.7%
7.4%
Not present
No negative impact
Small negative impact
Moderate negative impacts
Large negative impacts
Very large negative impacts
Unsure
No Response

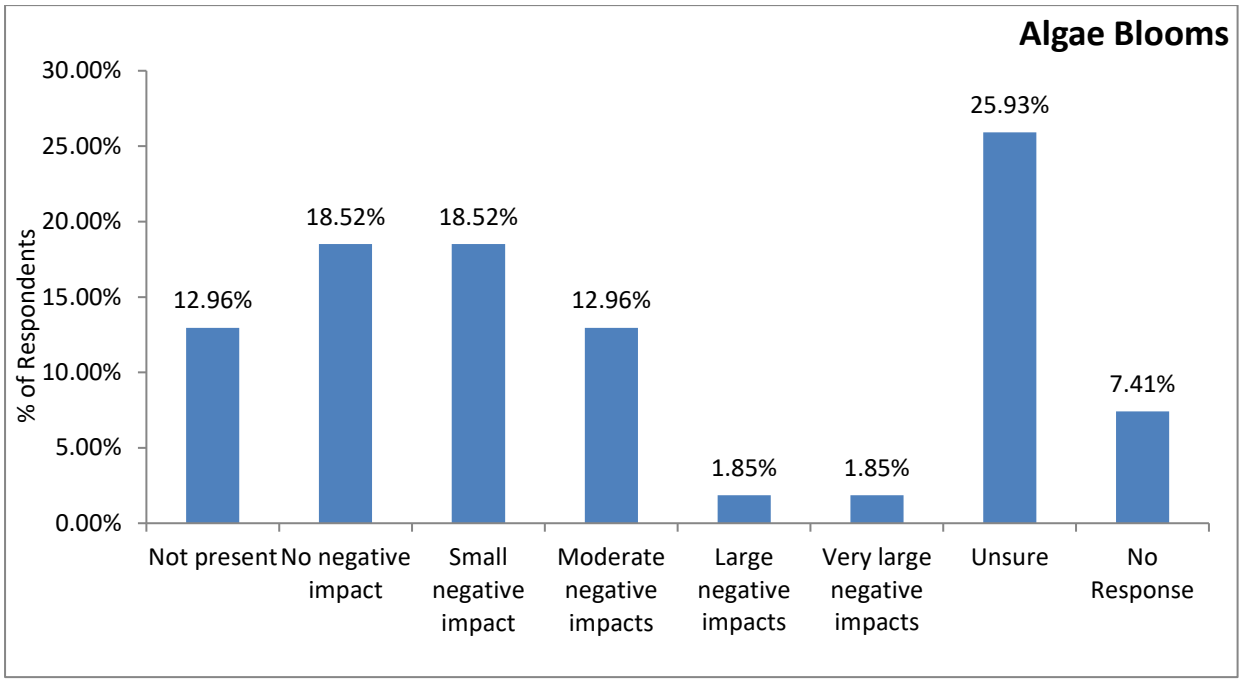

AIS Introductions
% of Respondents
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
0.0%
1.9%
13.0%
29.6%
22.2%
13.0%
13.0%
7.4%
Not present
No negative impact
Small negative impact
Moderate negative impacts
Large negative impacts
Very large negative impacts
Unsure
No Response

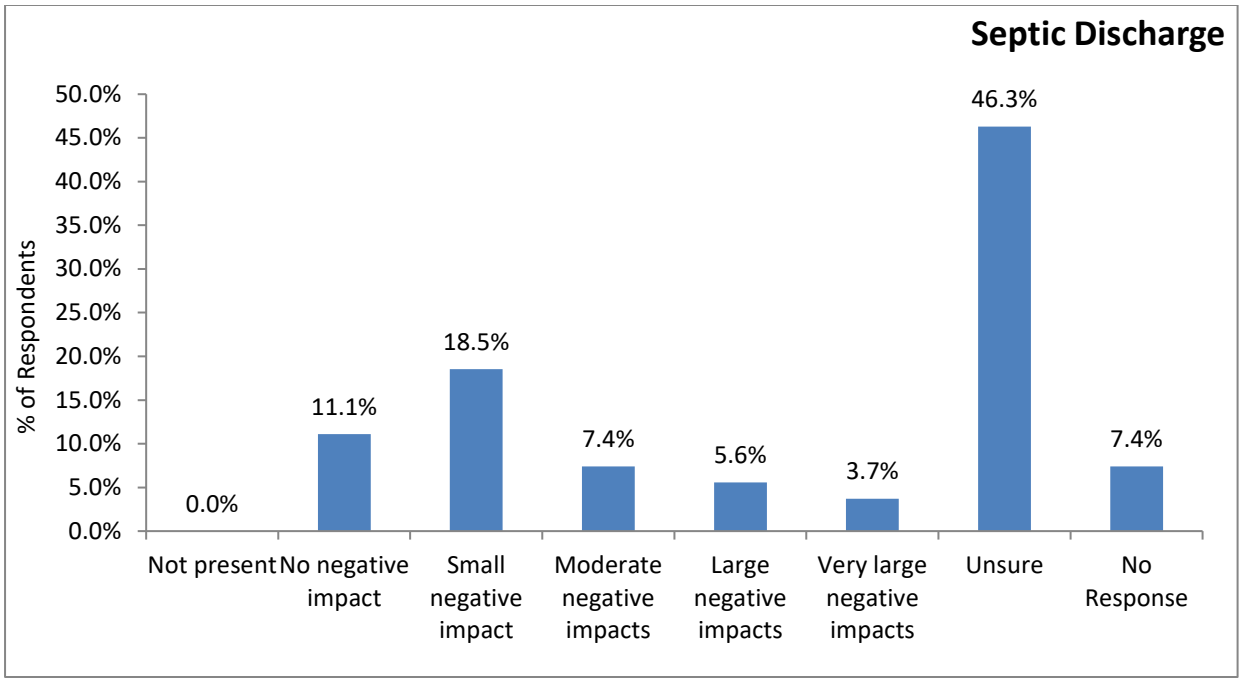

Excessive Watecraft Traffic
% of Respondents
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
9.3%
20.4%
25.9%
11.1%
9.3%
5.6%
13.0%
5.6%
Not present
No negative impact
Small negative impact
Moderate negative impacts
Large negative impacts
Very large negative impacts
Unsure
No Response

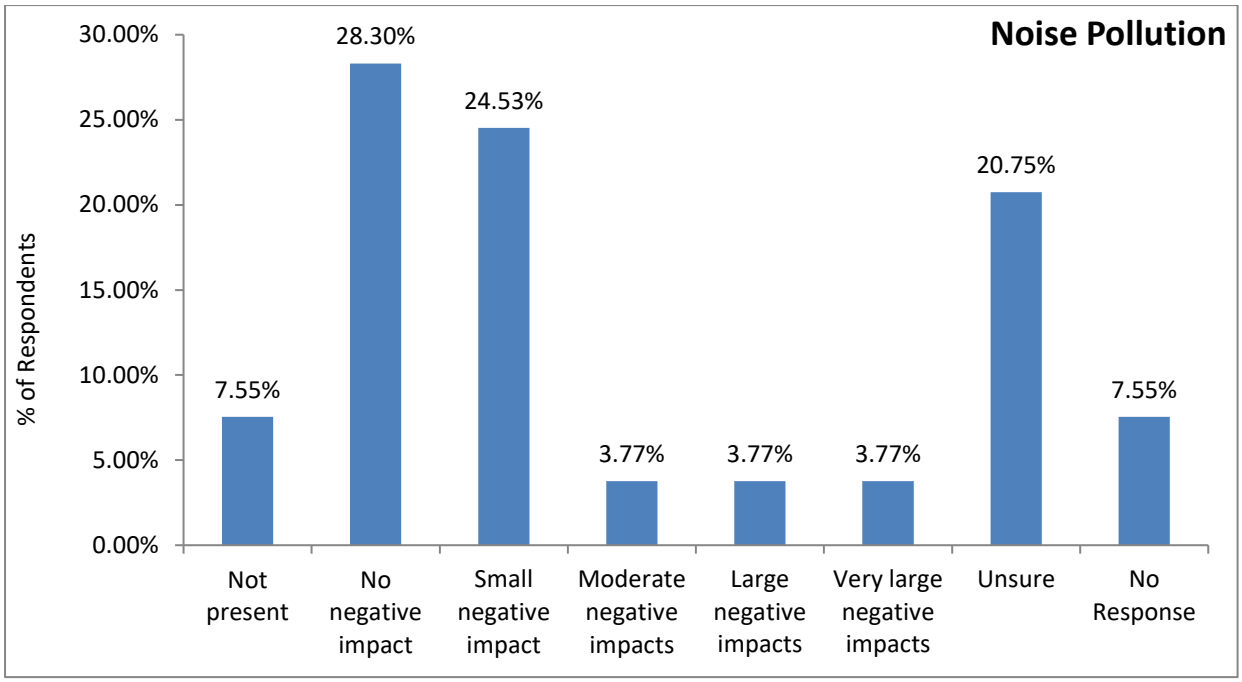

Unsafe Watercraft Practices
% of Respondents
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
5.6%
18.5%
27.8%
7.4%
11.1%
11.1%
9.3%
9.3%
Not present
No negative impact
Small negative impact
Moderate negative impacts
Large negative impacts
Very large negative impacts
Unsure
No Response


Excessive Fishing Pressure
% of Respondents
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
3.70%
14.81%
7.41%
24.07%
9.26%
7.41%
25.93%
7.41%
Not present
No negative impact
Small negative impact
Moderate negative impacts
Large negative impacts
Very large negative impacts
Unsure
No Response


Excessive Aquatic Plant Growth (no algae)
% of Respondents
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
3.70%
12.96%
25.93%
12.96%
5.56%
5.56%
24.07%
9.26%
Not present
No negative impact
Small negative impact
Moderate negative impacts
Large negative impacts
Very large negative impacts
Unsure
No Response

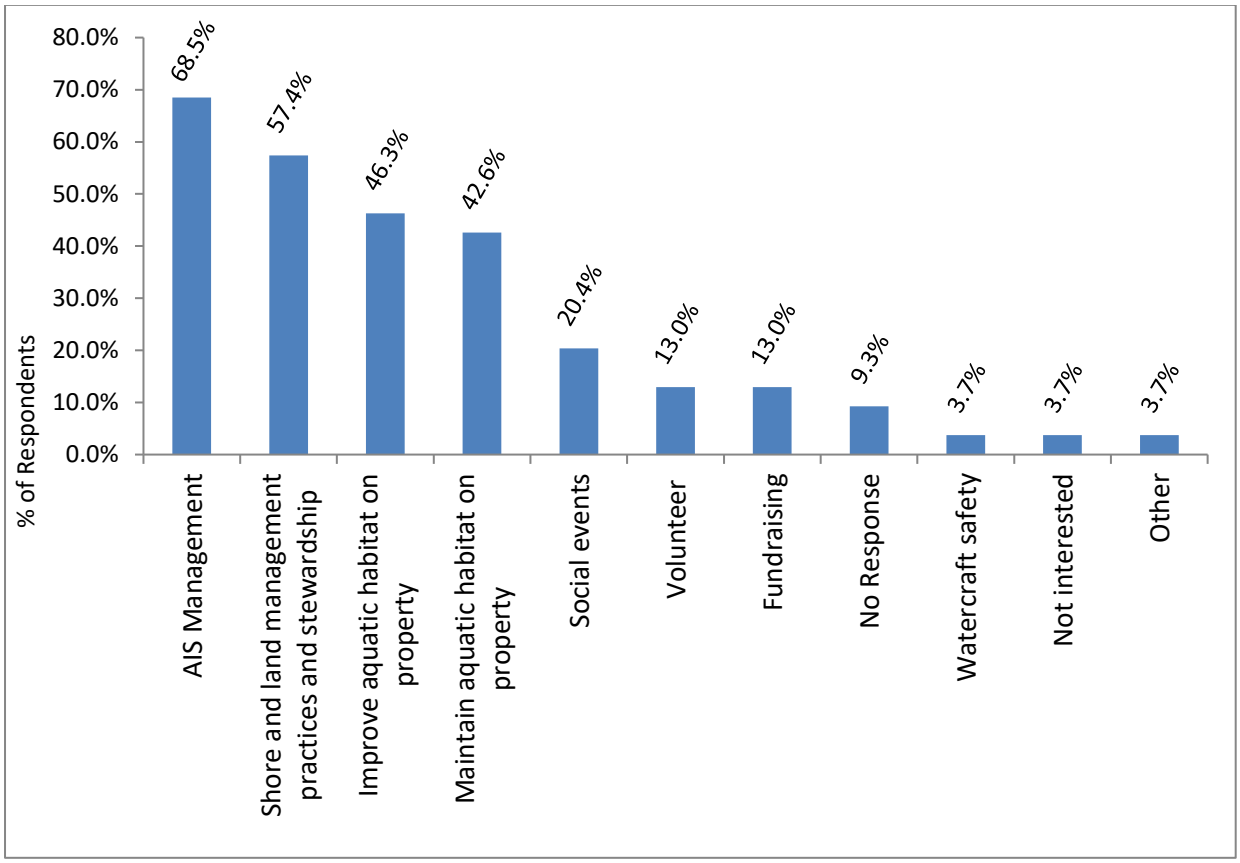

Algae Blooms
% of Respondents
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
12.96%
18.52%
18.52%
12.96%
1.85%
1.85%
25.93%
7.41%
Not present
No negative impact
Small negative impact
Moderate negative impacts
Large negative impacts
Very large negative impacts
Unsure
No Response


Septic Discharge
% of Respondents
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
0.0%
11.1%
18.5%
7.4%
5.6%
3.7%
46.3%
7.4%
Not present
No negative impact
Small negative impact
Moderate negative impacts
Large negative impacts
Very large negative impacts
Unsure
No Response


Noise Pollution
% of Respondents
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
7.55%
28.30%
24.53%
3.77%
3.77%
3.77%
20.75%
7.55%
Not present
No negative impact
Small negative impact
Moderate negative impacts
Large negative impacts
Very large negative impacts
Unsure
No Response

The final question addresses education and what topics lake residents are interested in learning about **(Figure 4.3.40).** The top three responses include AIS management (~69%), shore and land management practices and stewardship (~57%), and maintaining aquatic habitat on property (~43%). Four-percent are not interested in any more educational information and 9% did not respond. Other comments stated that they have already attended all training sessions (4%).

Figure 4.3.40: *What educational topics would you like to learn more about?*



4.3.6 Summary

One limitation of the survey is understanding the respondent's characterization of what they think about when asked about water quality. It would benefit future surveys to include a few questions defining specific aspects of water when defining water quality. For example, one respondent answered that water quality on Smoky Lake has gotten worse, but later clarified that only at the south end of the lake, not the whole lake. There is some evidence suggesting a trend from the year first visiting Smoky Lake to perceived change in water quality. As the average length of time increases from the first visit to Smoky Lake, the general perception is that water quality has gotten worse **(Figure 4.3.41).** In addition, as length of time since first

visiting Smoky Lake increases, the perception of water quality has similarly decreased **(Figure 4.3.42).**

Figure 4.3.41: *Perceived change in water quality based on average length of time respondent first visited Smoky Lake*

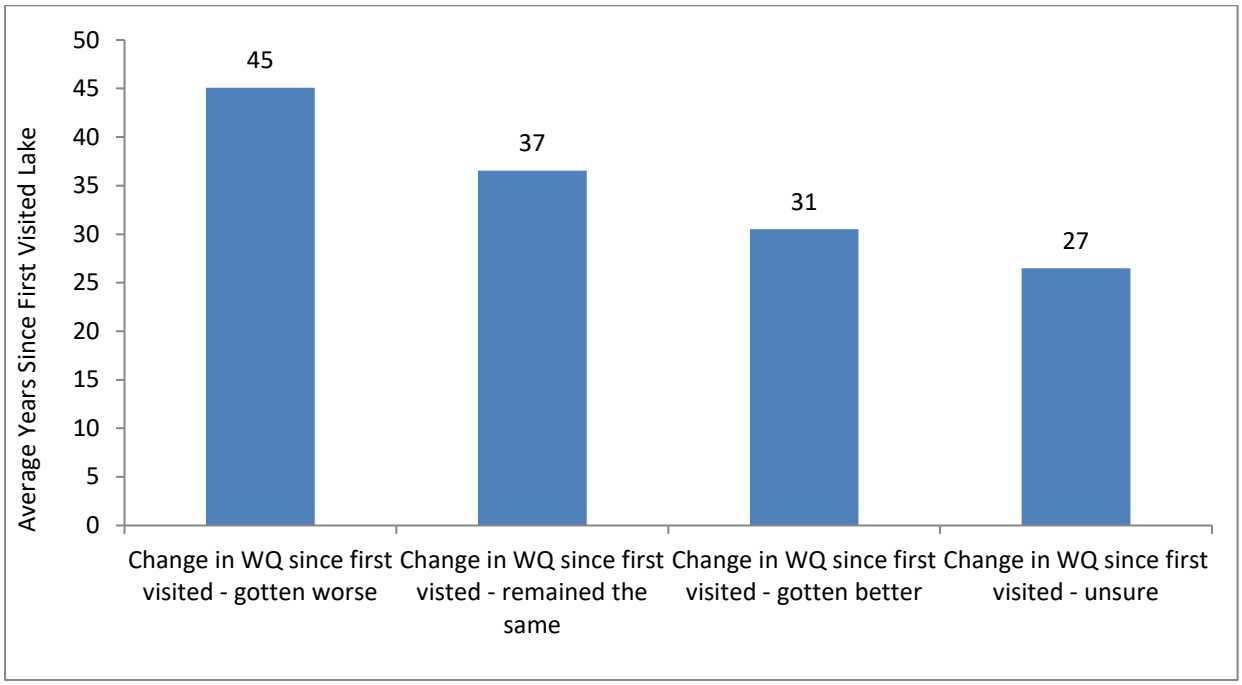
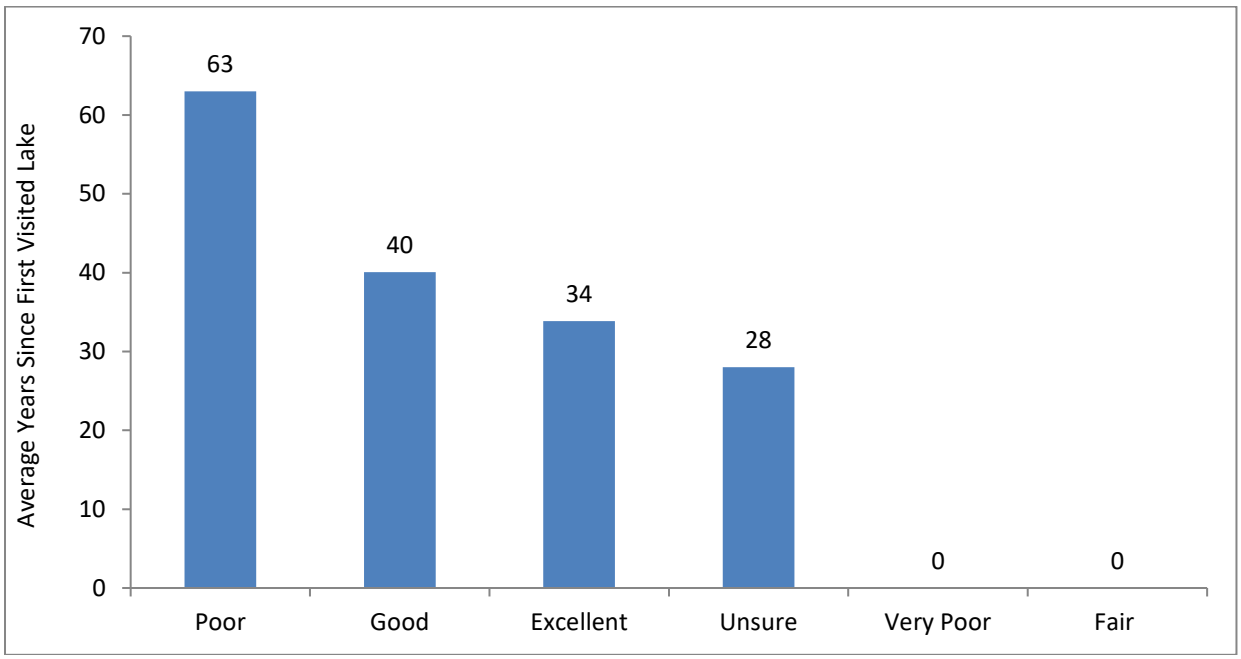
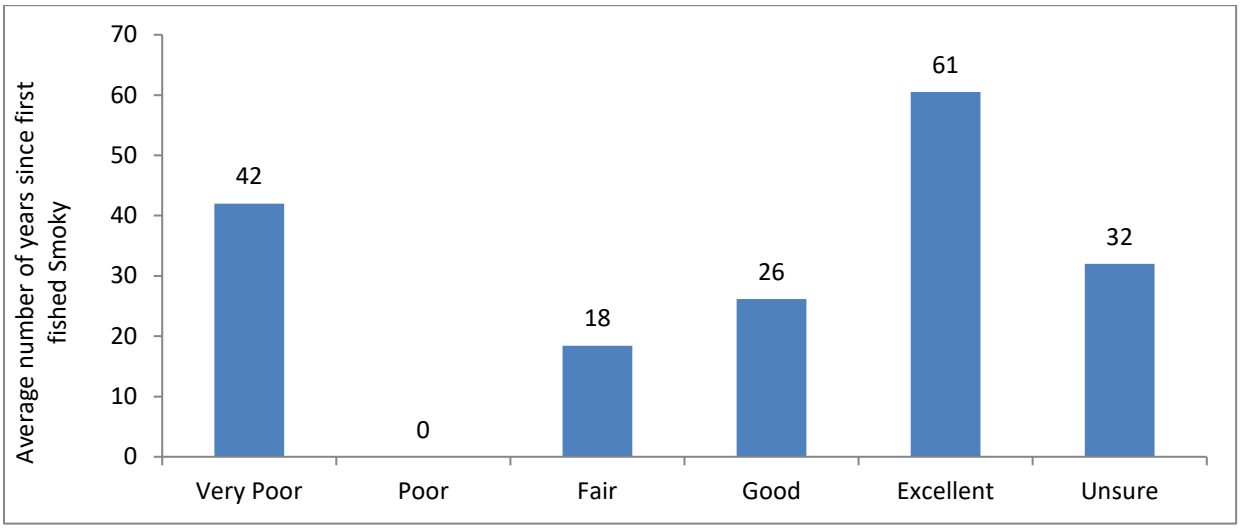


Figure 4.3.42: *Perceived current water quality condition based on average length of time respondent first visited Smoky Lake*



There does not appear to be a trend relating perceived quality of fishing based on average number of years since first started fishing Smoky. Respondents that fished Smoky Lake the longest either perceive current fishing quality as excellent or very poor **(Figure 4.3.43).**

Figure 4.3.43: *Perceived current fishing quality based on avg number of years first fished Smoky*



Respondents generally agree that aquatic invasive species introductions negatively impact the lake (78%) and no respondents indicated that this issue is not present on the lake **(Figure 4.3.44).** There is general agreement to control aquatic invasive plants (65%), while 22% are unsure. Interestingly, fifty-percent of respondents indicate that excessive plant growth is a lake issue negatively impacting Smoky Lake. However, many respondents report that aquatic plants never (41%) or rarely (42%) impact enjoyment on Smoky Lake (83% total combined).

The second and third highest ranked issues respondents identified are unsafe watercraft practices (57%) and excessive watercraft traffic (52%). Many respondents are unsure if septic systems are an issue (46%) and no respondents indicated that this issue is not present on the lake. Many respondents were unsure about loss of aquatic habitat (35%), while only 22% indicated that this issue is impacting the lake. Seventy-four percent of respondents believe that shoreline development issues exist, with 50% believing this issue is negatively impacting the lake and 24% believing the issue exists but is not currently impacting the lake.
Many additional comments addressed the use of salts and pesticides along the roadways and properties. Many also commented on chemical weed control, road-related impervious surfaces, and pollutants washing into the lake from private properties.

Types of motorized watercraft usage based on property use varies **(Figure 4.3.45).** Respondents that use their property throughout the summer rank highest on average in usage of various types of motorized watercraft. Jet ski use is most popular with summer and year-round residents and not indicated as a watercraft used by weekend visitors. However, weekend visitors are second behind summer residents to water ski on the lake. "Others" in these categories mainly include those that use their properties more regularly, but do not consider themselves year-round residents.

Figure 4.3.44: *Surveyed lake issues and responses*

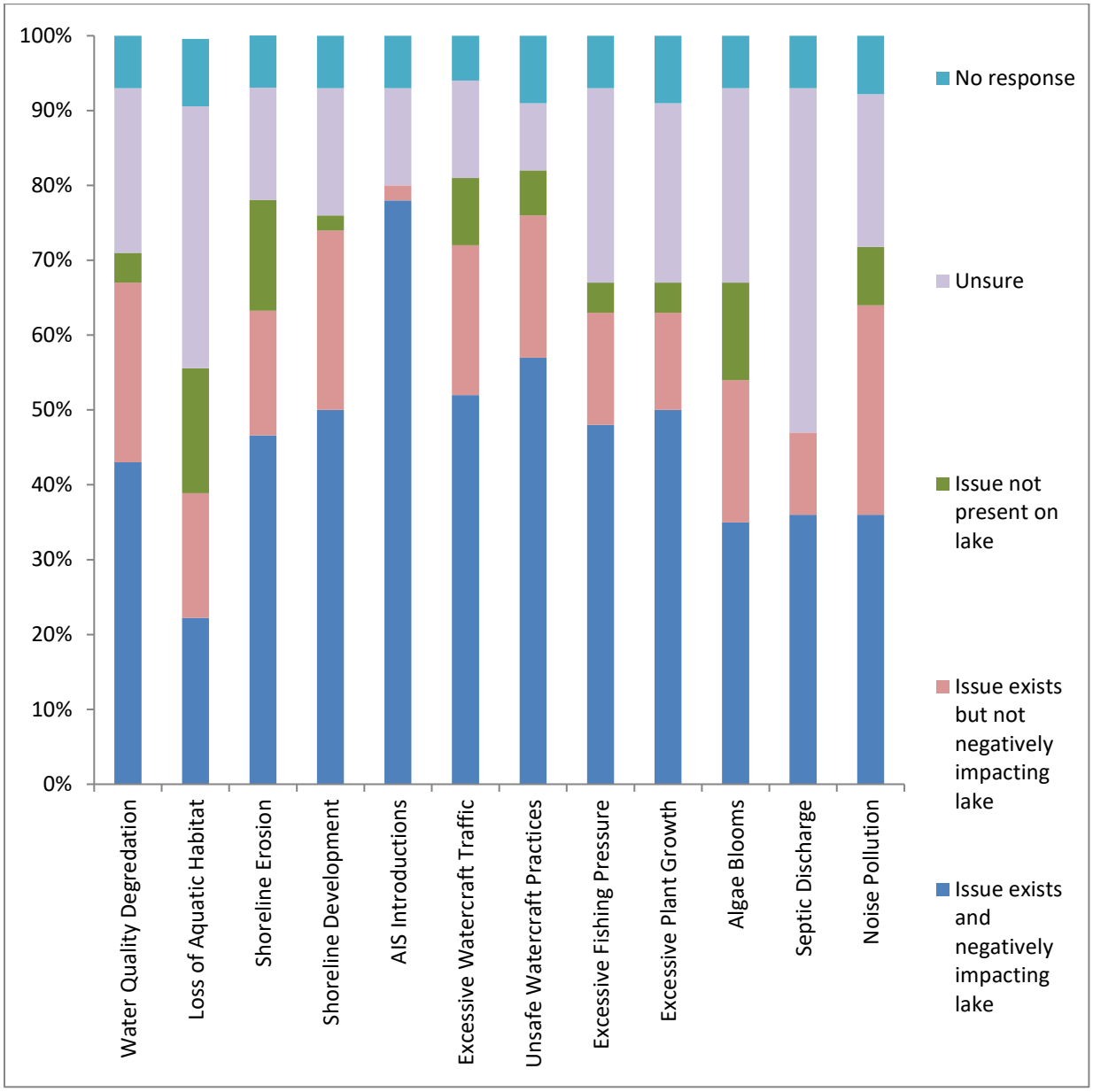
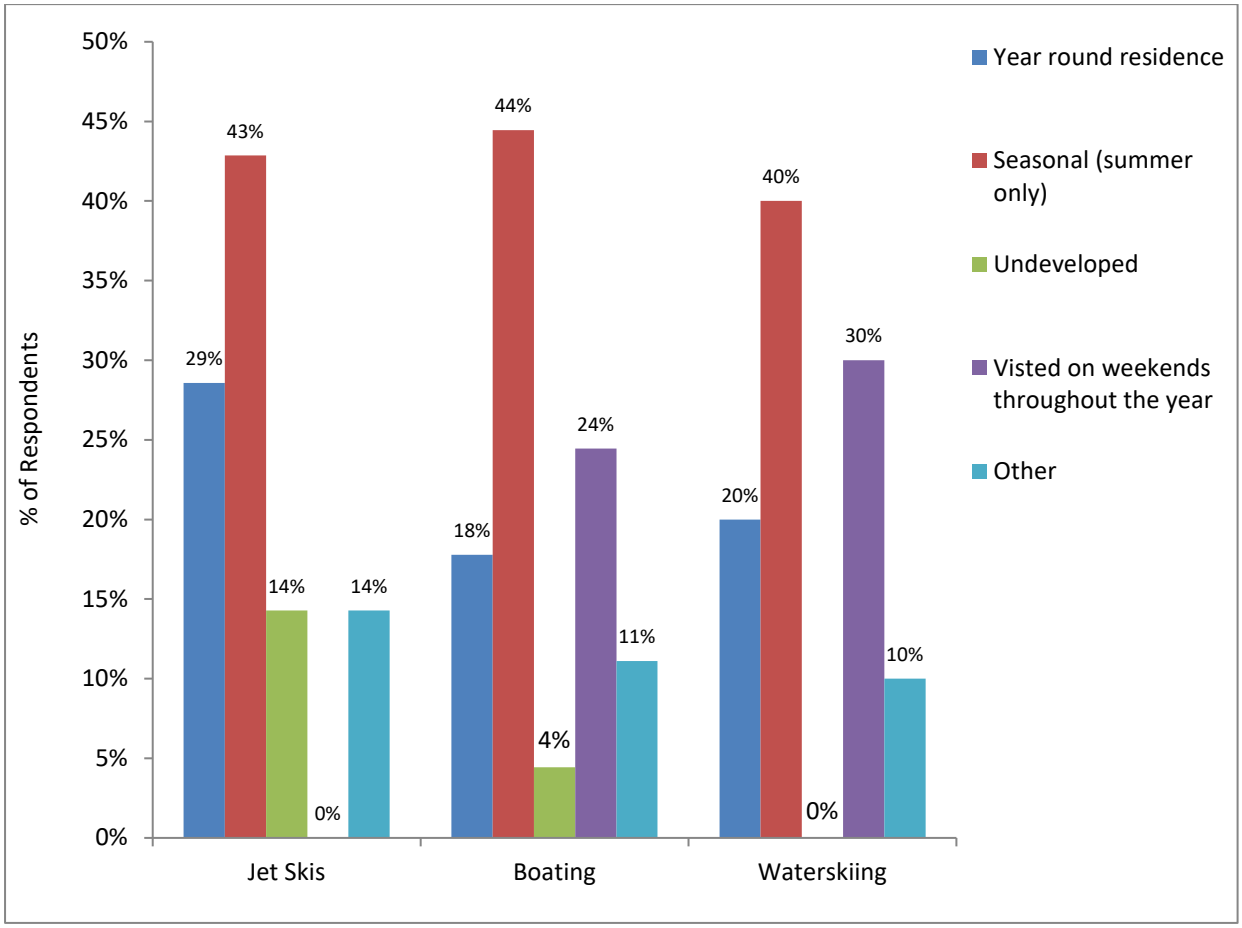


Figure 4.3.45: *Comparison of property usage to propulsion watercraft usage on Smoky Lake*



5.0 SUMMARY AND CONCLUSIONS

The ultimate goal for this project is to understand the current ecological condition of Smoky Lake 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 and possible impairments to a waterbody. Specific monitoring standards collected a wealth of ecological data on Smoky Lake including water quality, aquatic plants, and shoreline habitat. These features relate well to understanding and describing the health of a lake and its surrounding landscape.

The social and cultural history of Smoky Lake captured an understanding and the context of early Association members regarding many issues that lake residents and the Smoky Lake Preservation Association care about today. Early on, residents recognized the special natural beauty of Smoky Lake and in the early 1970s organized an Association in part to protect the quality of water and the surrounding landscape. The Association recognized water quality related issues such as preserving shoreland regions, controlling erosion and the importance of minimizing nutrients entering the lake. In the 1990's the Association went as far as asking for a "good faith" consensus to abide by a set of principles, such as greenbelts to control erosion and reduce polluted run-off from entering the lake.

During an annual association meeting in 2017, lake residents were asked to write down their perspective to the following question: "What makes Smoky Lake special to me?" Overwhelmingly, meeting attendants described the clear, clean water of Smoky Lake, the pristine quietness of the lake and the presence of caring informed landowners. Riparian survey results sought to learn more from lake owners about their perspectives and concerns about a variety of lake topics. Most agree that current water quality of Smoky is excellent, which aligns with the above statements and the WDNR general water quality assessment. Although the lake-community agrees that the water quality on Smoky is excellent, many may be unsure why this is. Water quality is linked to many natural and human related factors, several respondents marked as "unsure about" regarding their possible impacts to lakes.

The social dimension of defining water quality is often complex but defining what impacts water quality is well known. Watersheds and surrounding land use play an important role in the amount of sediment and nutrients entering a lake. Roughly 50% of the water draining directly into Smoky Lake comes from adjacent riparian owners. This means that, riparian owners can potentially control 50% of the pollutants entering Smoky Lake through wise conservation and land development. Riparian landowners can ensure that clean, pollutant free water enters Smoky Lake by reducing nutrient sources and run-off on their properties. Natural vegetation and duff will absorb rain and run-off coming from the surrounding landscape better than shallow rooted lawns. Diverting run-off from impervious surfaces such as rooftops and

driveways to areas where water can infiltrate into the soil will minimize run-off water to the lake.

Lake survey results indicate that most are unsure about that the effects of septic discharge and loss of aquatic habitat have on the quality of Smoky Lake. Aquatic habitat, as described in the shoreland assessment section, is complex, with multiple ecological connections to riparian habitat and the upland areas beyond. Property owners can provide and improve aquatic habitat along their shorelines by assessing the need for complex/multiple piers and choose not to replace existing natural vegetation with hard-scapes or lawn. When erosion control along the shoreline is necessary, considerations should be given to investigate the feasibility of using biologically engineered erosion control methods rather than rip-rap or other hard armoring materials.

As discussed in the fisheries section, the MDNR considers Smoky Lake a Cisco refugium. Ciscos require deep, clear lakes providing optimal oxythermal habitat, including high oxygen concentration and cool water. 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 (WICCI, 2019). 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 habitat.

Fluctuating water levels are not uncommon in Smoky's history. Drought, spring run-off, and high precipitation spring rain events will contribute to continued cyclic water levels. These cycles may become more pronounced as precipitation and frequency of intensive weather increases. Similar conservation practices that protect habitat for desirable fish, such as the Cisco, will help protect water quality. Building capacity on riparian properties to manage increased storm run-off and adaptive water front usage should be considered. Adaptive use means planning for low water cycles by keeping lakebed sediments intact and wisely considering designated areas of use and impact. Once water levels rise, these high and dry habitats will again become critical habitat for fish and other beneficial organisms. High water cycles may mean addressing current erosion areas and bare soils that may become inundated when water levels rise. Bare soils will increase total sedimentation to a lake, affecting water clarity. Inundation of near shore lawns, especially if fertilized, will increase direct inputs of nutrients to the lake, causing possible issues with algal blooms and excessive weed growth.

Being a seepage lake, there is no outlet or natural mechanism for water to flow out of Smoky Lake. WDNR recently investigated elevation profiles between Smoky and Big Sand Lakes, including initial investigation of drainage profiles from the two known WDOT culverts under Hwy 17. It is important to note that these findings are preliminary. For example, culvert invert elevations are not known, and the drainage effects to Smoky and wetlands adjacent to Big Sand Lake remain unclear. Further investigations, beyond the scope of this project, would be needed to clearly understand culvert and drainage relationships. This may be an additional topic the Steering Committee, with input from the Board and Association, may want to address in future planning projects.

Overall, Smoky Lake's watershed remains primarily forested, with a small portion considered developed. Water quality monitoring suggests no adverse trends or impacts to water quality from current watershed land uses. On a smaller scale, shoreland assessments suggest most property owners maintain very little manicured riparian landscape, leaving good portions of their properties natural and enhancing water quality. Approximately 25% of the parcels on Smoky Lake remain undeveloped, providing exceptional habitat and refuge. Hopefully, future development decisions will consider these benefits.

Smoky Lake supports a diverse and healthy native aquatic plant community. Aquatic invasive species, such as Eurasian watermilfoil remain at very low densities and are not affecting the recreational use of the lake. Diversity of vertebrates and invertebrates in the lake is also to be valued. The status of other invasive organisms that impact biodiversity, such as Rainbow Smelt and Rusty Crayfish, reported sporadically in the past, has not been recently quantified. Continued monitoring for these and any new invasive species that might impact biodiversity in the lake is essential.

As stated above, early lake owners valued the quality of the water and recognized the importance of good conservation to protect good water quality. Those early meetings laid the foundation for current owners acting as lake stewards- being mindful of conservation and bearing direct responsibility to protect Smoky Lake. Quoted early in Association records is a quote from Thoreau's Walden:

"A lake is a landscape's most beautiful and expressive feature. It is Earth's eye; looking into which the beholder measures the depth of his own nature."

— Henry David Thoreau, Walden

6.0 ACTION PLAN

This Action Plan blends current lake data with steering committee's discussions, identifying areas to strengthen conservation knowledge and practice. It provides a working framework that outlines the goals, actions, assigned responsibilities, timeframes, and criteria to measure progress. 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.

The steering committee began the process of defining this Action Plan from a longer list of proposed alternative strategic actions. From this list, the committee debated each alternative and developed a prioritization of need based on the information presented to and feedback from the lake community. Additional longer-term projects and emerging concerns were discussed but were determined to be more suitable for future updates.

Analysis of lake inventory data indicate that Smoky Lake's ecology ranks as high-quality, with a good portion of the shorelines in a natural state and plant species indicative of pristine environments. However, with approximately 50% of the direct drainage area to Smoky Lake lying within riparian ownership, riparian owner activity and conservation practices play key roles in Smoky Lake's preservation.

The strength in this lake community is the current level of conservation awareness to keep Smoky Lake healthy. Therefore, many actionable items are educational in focus to support existing knowledge and provide new information. Emphasis is placed on how lake residents and other lake users can take active measures to protect lake health. Survey comments about interest in educational opportunities include those that extend beyond the lakeshore edge. Conservation of up-land habitats and sound land practices relates to the overall water quality of Smoky Lake and are included as topics in this Action Plan.

Though the Smoky Lake community has a strong concern for conservation and the Smoky Lake ecosystem, the challenge will be to assure lake association capacity for the organizational structure, roles, and responsibilities necessary to undertake the projects articulated in this Action Plan. This framework is adapted from Eric Olson's (University of Wisconsin-Extension) work on community capacity to "help lake organizations be effective forces of change in protecting lake health." Some action items include existing programs such as water quality, elevation, and AIS management. However, other assigned responsibilities recommend organization changes and refinements to add assignments to cover lake management, zoning, membership, education, and fisheries.

Continued support of proposed actions will rely on volunteerism and commitment by the lake community to step into roles to support conservation and ultimately the quality of Smoky Lake.

Vision

"Preserve and enhance the ecological integrity of Smoky Lake and its surrounding habitat by promoting policies and practices that support ecosystem stability and resilience, recreational opportunities and the qualities which make Smoky Lake beautiful."

Smoky Lake Goals

(1) Build lake community capacity to support project goals, and objectives
(2) Continue monitoring of water quality and ecosystem health
(3) Promote conservation of native species and their habitats
(4) Protect existing water quality
(5) Maintain aesthetic and safe recreational opportunities

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

Objective (1) Articulate internal organizational structure and functioning roles

Action (1) Create a working document that outlines the Association's organizational framework including roles, responsibilities, succession planning, and relationships for Association committees, volunteers and the Board.

Timeframe: 3 years from plan adoption
Role/Responsibility: Board
Expected output/outcome: Improve understanding of internal organizational structure, roles, and communication plans. Document would undergo periodic review to ensure content is still relevant to current issues and structure.

Objective (2) Promote programmatic and communication capacity to achieve Action Plan objectives

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

Timeframe: 3 years from plan adoption
Role/Responsibility: Board**/** Education/Conservation
Expected output/outcome: The education committee, with input from the Conservation Committee, will propose priorities, strategies, and oversight to inform lake community and in order to meet Action Plan objectives. Priority topics identified and ordered through the planning process for the committee's consideration include:

- Provide education on water quality impacts including the use of fertilizers, impervious surfaces, run-off abatement and septic system maintenance
- Review of best management practices and policy of the use of pesticides in lakeshore environments

- Providing resources and education on site design and near shore habitat improvements
- Citizen science for land-ward activities such as native plantings, pollinator habitat improvement and terrestrial invasive species

Action (2) Identify financial needs and roles of grant administrators for proposed projects.

Timeframe: 3 years from plan adoption
Role/Responsibility: Conservation/Treasurer/Board
Expected output/outcome: Maintain updated lists of grant opportunities with attention to budgets and funding requirements, such as local share responsibilities. Define roles and administration responsibilities for those involved in grant paperwork.

Objective (3) Raise awareness with the lake community about the Lake Management Plan and current lake issues

Action (1) Identify avenues and conduct outreach on current lake issues and lake management planning activities

Timeframe: Ongoing
Role/Responsibility: Membership/Board/Conservation
Expected output/outcome: Outreach will raise awareness about lake condition, lake management planning activities, and outline opportunities for participation and engagement

Action (2) Inform and engage new property owners

Timeframe: 3 years from plan adoption
Role/Responsibility: Membership/Board/Conservation
Expected output/outcome: Create a "Welcome to the Lake" information packet to be distributed to new property owners. The intent of this packet will be to welcome new property owners and bring them up to date on Association business, lake health, volunteer opportunities, and current lake concerns.

Action (3) Educate lake users about MI and WI aquatic invasive species transport laws, policies, and regulation pertaining to management.

Timeframe: 3 years from plan adoption
Role/Responsibility: Membership/Board
Expected output/outcome: Better understanding and compliance by lake users of WI and MI AIS laws, policy, and regulation. Maintain an updated inventory of MI consent forms for EWM management.

Objective (4) Promote networking and collaboration with other organizations

Action (1) Identify and expand relationships with local/State/Federal management agencies and like-minded environmental organizations (MI & WI), such as the Town of Phelps Lakes Committee

Timeframe: Ongoing

Role/Responsibility: Lake Management/Board/Conservation

Expected output/outcome: Develop a working list of organizations and contacts with periodic review for inclusiveness and usefulness. This list will serve as a directory to identify resources and contacts for more information. Continue working with the Town of Phelps Lakes Committee.

Action (2) Engage with local governmental agencies and programs to identify policy to support planning goals and improve local knowledge of current zoning regulations.

Timeframe: Ongoing

Role/Responsibility: Conservation

Expected output/outcome: Work with the Town of Stambaugh to develop and recommend updates to L2 zoning beyond 300 foot from Smoky Lake's shoreline up to Smoky Lake Drive, clarify vision corridor regulatory inconsistencies, and generate a wetlands delineation zoning map for Wisconsin and Michigan lands approximate to Smoky Lake.

Goal (2) Continue monitoring of 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 phosphorous, chlorophyll *a,* dissolved oxygen, and temperature

Timeframe: Ongoing

Role/Responsibility: Water Quality & Elevation/Conservation

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 Smoky Lake.

Action (2) Monitor sodium chloride (road salt) levels in lake water

Timeframe: One-year post plan adoption. If testing levels return above normal ranges for natural lakes, revaluate testing frequency.

Role/Responsibility: Water Quality/Conservation/Resource Professional

Expected output/outcome: Comparison of Smoky Lake's current sodium chloride levels to historical levels (if data is available) and normal levels for natural lakes

Objective (2) Improve understanding of lake level fluctuation and Smoky Lake's drainage patterns to develop a long-term record.

Action (1) Use North Lakeland Discovery Center or an equivalent organization to assist volunteer water level monitors

Timeframe: Ongoing

Role/Responsibility: Water Quality & Elevation/Conservation

Expected output/outcome: Volunteers will document seasonal water levels and report annual findings to the Association and its membership. This information will add to the long-term record and understanding of water level fluctuations on Smoky Lake.

Objective (3) Monitor for existing and new aquatic invasive species

Action (1) Conduct annual monitoring for aquatic invasive species

Timeframe: Ongoing

Role/Responsibility: Lake Monitors/AIS/Conservation/Resource Professional

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

Action (2) Develop quantitative long-term trends data for EWM populations on Smoky Lake using standard (PI) methodologies

Timeframe: Every one to two years

Role/Responsibility: AIS/Conservation/Resource Professional

Expected output/outcome: Data quantitatively tracks EWM populations over time and may be useful to determine success of management activities.

Goal (3) Promote conservation of native species and their habitats

Objective (1) Manage for Eurasian watermilfoil

Action (1) Continue control and management of EWM

Timeframe: Ongoing

Role/Responsibility: AIS/Conservation/Resource Professional

Expected output/outcome: Propose and submit grant applications to assist in funding AIS control efforts. Use pre and post management surveys (qualitative and/or quantitative) to determine effectiveness of management.

Action (2) Continue exploring other applicable EWM management techniques

Timeframe: Ongoing

Role/Responsibility: AIS/Conservation/Resource Professional

Expected output/outcome: Stay up to date on current management techniques and applicability and keep informed of new techniques as they become available

Objective (2) Prevent the spread of aquatic invasive species to and from Smoky Lake

Action (1) Train volunteers on AIS identification and early detection monitoring

Timeframe: Every two years

Role/Responsibility: Lake Monitor/AIS/Conservation/Resource Professional

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

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

Timeframe: Ongoing

Role/Responsibility: AIS/Clean Boats Clean Waters/Conservation

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

Objective (3) 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: Education/Conservation

Expected output/outcome: The Education Committee 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.

Objective (4) Reinstate a fisheries committee

Action (1) Use the fisheries committee to stay informed on current and changes Michigan and Wisconsin fishing regulations, stocking options and keeping the lake community educated on fishing issues.

Timeframe: 2 years from plan adoption

Role/Responsibility: Fisheries/Conservation

Expected output/outcome: Report updates on fisheries to the board, Conservation Committee, and general lake community. Remain up to date with current fisheries issues through periodic contact with local, State and Federal authorities responsible for fisheries management.

Objective (5) Encourage citizen-based science on Smoky Lake

Action (1) Continue placement of loon nesting platforms

Timeframe: Ongoing

Role/Responsibility: Wildlife/Conservation

Expected output/outcome: Maintain good condition of loon nesting platforms and have them place appropriately and timely on the lake to encourage nesting loons

Action (2) Continue making and reporting wildlife observations and educating the lake community on additional citizen science opportunities.

Timeframe: Ongoing

Role/Responsibility: Wildlife/Education/Conservation

Expected output/outcome: Inform the lake community on citizen science opportunities. Update membership by reporting on activities at annual Association meetings and/or events.

Goal (4) Encourage habitat improvements to protect existing water quality

Objective (1) Promote measures to protect water quality

Action (1) Use education committee to educate on measures to protect water quality such as reducing run-off, use of fertilizers, impervious surfaces, and good septic system maintenance

Timeframe: Ongoing

Role/Responsibility: Education/Conservation

Expected output/outcome: The Education Committee will propose priorities, strategies, and oversight to meet objective. Use baseline water quality data as metric for evaluation.

Goal (5) Maintain aesthetic, safe, and courteous recreational opportunities.

Objective (1) Promote safe boating and etiquette

Action (1) Develop boater safety and etiquette brochure for riparian owners and their guests

Timeframe: 1 year from plan adoption

Role/Responsibility: Membership/Board

Expected output/outcome: Distribute a boater etiquette brochure to all riparian owners to improve safety and boating etiquette by riparian owners and their guests

Action (2) Provide new signage at boat landing on boater safety and etiquette

Timeframe: 2 year from plan adoption

Role/Responsibility: Board

Expected output/outcome: Improve boater safety and etiquette by public access users

Future Action Items

The Steering Committee additionally considered the items listed below but determined that they be considered for future Lake Management Plan updates.

Goal (2) Continue monitoring of ecosystem health.

Objective (3) Monitor aquatic plant communities and shoreland habitats

Action (1) Use standard protocols to conduct assessments of aquatic plant communities and shoreland habitat

Timeframe: Include in work plan for future plan updates
Role/Responsibility: Conservation/Resource Professional
Expected output/outcome: Comparison and analysis of current data to historical data. Floristic quality should remain above the lower quartile for the Northern Lakes and Forests Eco Region.

Objective (1) Monitor water quality

Action (3) Re-test certain water quality measurements tested for in the current lake management plan. These are in addition to volunteer lead efforts. Tests follow recommended sampling type and method defined in Lake Sampling Procedures - LLT Water Quality Monitoring Protocol (Hein, 2014) including conductivity, pH, nitrogen, calcium, and magnesium.

Timeframe: Include in work plan for future plan updates
Role/Responsibility: Water Quality & Elevation/Conservation/Resource Professional
Expected output/outcome: Comparison of updated water quality results to the historical data set

Goal (4) Protect existing water quality

Objective (2) Reduce run-off to lake

Action (2) Make recommendation to the Town of Phelps on addressing erosion concerns at the boat launch

Timeframe: 3 years from plan adoption
Role/Responsibility: Board/Town of Phelps/Conservation
Expected output/outcome: Identify sources of erosion, methods to address issues and develop an outline of key roles and partnerships to the Town of Phelps.

7.0 REFERENCES

Beck, M. W., B. Vondracek, and L. K. Hatch. 2013. Between and within lake responses of macrophyte richness metrics to shore-line development. Lake and Reservoir Management, 29:179–193.

Christensen, D.L., Herwig, B.R., Schindler, D.E. and Carpenter, S.R. 1996. Impacts of Lakeshore Residential Development on Coarse Woody Debris in Northern Temperate Lakes. Ecological Applications, 6(4): 1143-1149.

Downing, J.A., and McCauley, E. 1992. The nitrogen : phosphorous relationship in lakes. Limnol. Oceanogr., 37(5): 936-935.

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

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

Environmental Protection Agency (USEPA). 2016. Draft Herbicide Resistance PRN 2016-XX for Public Comment – May 2016.U.S.

Falck, M., Olson, D., and Garske, S. 2007. Invasive Species Program 2007. Great Lakes Indian Fish and Wildlife Commission Biological Services Division Administrative Report 08-06, January 2009.

Green, W.R. and Westerdahl, H.E. 1990. Response of Eurasian watermilfoil to 2,4-D Concentrations and Exposure Times. Journal of Aquatic Plant Management, 28: 27-32.

Hauxwell, J., S. Knight, K. Wagner, A. Mikulyuk, M. Nault, M. Porzky, and S. Chase. 2010. Recommended baseline monitoring of aquatic plants in Wisconsin: sampling design, field and laboratory procedures, data entry and analysis, and applications. Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010. Madison, Wisconsin, USA.

Holdren, C., W. Jones, and Taggart. 2001. Managing Lakes and Reservoirs. North American Lake Management Society and Terrene Inst., in coop. with Off. Water Assess. Watershed Prot. Div. U.S. Environ. Prot. Agency, Madison, WI.

Horne, A.J., and C.R. Goldman. 1994. Limnology. 2nd edition. McGraw-Hill Co., New York, New York, USA.

LaRue E.A., Zuellig, M.P., Netherland, M.D., Heilman, M.A., & Thum, R.A. 2012. Hybrid watermilfoil lineages are more invasive and less sensitive to a commonly used herbicide than their exotic parent (Eurasian watermilfoil). Evolutionary Applications, 6:462-471.

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

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

Nault, M., Knight, S., Van Egeren, S. Heath, E. Skogerboe, J., Barton, M. and Provost, S. 2015. Control of Invasive Aquatic Plants on a Small Scale. Lakeline, pgs 35-39. North American Lake Management Society.

Nault, M. 2016. The science behind the so-called "super weed." Natural Resources Magazine. Wisconsin Department of Natural Resources, Madison, WI.

Nault, M., Barton, M., Hauxwell, J. Heath, E. Hoyman, T. Mikulyuk, A., Provost, S., Skogerboe, J. and Van Egeren, S. 2018. Evaluation of large-scale low concentration 2,4-D treatments for Eurasian and hybrid watermilfoil control across multiple Wisconsin Lakes. Lake and Reservoir Management, 34 (2): 115-129.

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

Omernic, J.M. and Gallant, A.L. 1998. Ecoregions of the Upper Midwest States. U.S. Environmental Protection Agency Region 5, Library (PL-12J).

Onterra. 2012. Lac Vieux Desert, Vilas County, WI & Gogebic County, MI -Comprehensive Management Plan.

Onterra. 2013. Long Lake, Vilas County, WI - Comprehensive Management Plan Update.

Oatman, J. 1994. Smoky Lake Historical Sketch. Revised 2001, Updated 2006.

Papes, M., Sallstrom, M. Asplund, T. and Vander Zanden, M.J. 2011. Invasive Species Research to Meet the Needs of Resource Management and Planning. Conservation Biology, 25 (5): 867-872.

Parks, S.R., McNair, J.N., Hausler, P., Tyning P. and Thum, R.A. 2016. Divergent responses of cryptic invasive watermilfoil to treatment with axing herbicides in a large Michigan lake, Lake and Reservoir Management, 32:4, 366372, DOI: 10.1080/10402381.2016.1212955.

Shaw, B., Mechenich, C. and Klessig L. 2004. Understanding Lake Data. University of Wisconsin Extension Publication G3582 RP-03/2004.

Latta, W.C. 1995. Distribution and abundance of lake herring (*Coregonus artedi*) in Michigan. Michigan Department of Natural Resources. Fisheries Research Report No. 2014, 1995.

Peter C. Jacobson, Timothy K. Cross, Donna L. Dustin, and Michael Duval. 2016. A Fish Habitat Conservation Framework for Minnesota Lakes, Fisheries, 41:6, 302-317, DOI: 10.1080/03632415.2016.1172482

Sass, G.G., Kitcher, J.F., Carpenter, S.R., Hrabik, T.R., Marburg and Turner, M.G. 2006. Fisheries, 31(7): 321-330.

Wagner, K.I., Hauxwell, J., Rasmussen, P.W., Koshere, F., Toshner, P., Aron, K., Helsel, D.R., Toshner, S., Provost, S., Gansberg, M., Masterson, J., and Warwich. S. 2007. Whole-lake herbicide treatments for Eurasian watermilfoil in four Wisconsin Lakes: Effects on vegetation and water clarity. Lake and Reservoir Management, 23: 83-94.

Wisconsin Department of Natural Resources. 2012. 2, 4-D Chemical Fact Sheet.

Wisconsin Department of Natural Resources. 2012. Flumioxazin Chemical Fact Sheet.

Wisconsin Department of Natural Resources. 2012. Imazapyr Chemical Fact Sheet.

Wisconsin Department of Natural Resources. 2009. Wisconsin Lakes. PUB-FH-800 2009.

Wisconsin Department of Natural Resources. Aquatic Plant Management Strategy. Northern Region WDNR. Summer 2007.

Woodford, J.E. & Meyer, M.W. 2003. Impact of lakeshore development on green frog abundance. Biological Conservation, 110 (2003) 277-284.