Comprehensive Lake Management Plan

Moose Lake, Langlade County, Wisconsin

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Friends of Moose Lake Association

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Carlson, R.E. 1977. A trophic state index for lakes. Limnol. Oceanography 22. Pp.361-369.

Christensen, D.L., Herwig, B.J., Schindler D.E., Carpenter, S.R. 1996. Impacts of lakeshore residential development on coarse woody debris in north temperate lakes. *Ecological Applications* 6: 1143-1149.

Crow, G.E. and C. B. Hellquist. 2000. Aquatic and Wetland Plants of Northeastern North America, Vols 1&2. University of Wisconsin Press. Madison, Wisconsin.

Elias, J. and M. Meyer, *Wetlands,* Vol.23, No. 4, December 2003, pp. 800-816.

Haskell, Daniel E.; Quantifying the Ecological Benefits of Lakeshore Restoration in Northern Wisconsin. A Thesis, Chapter 2. Michigan Technological University, 2009.

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. Available from Wisconsin Department of Natural Resources, PUB-SS-1068. Pg. 46

Shaw, B., C. Mechenich, L. Klessig. 2004. Understanding Lake Data, UW Extension PUB G3582.

Lillie, R.A. and Mason, J.W., 1983, Limnological characteristics of Wisconsin lakes: Wisconsin Department of Natural Resources Tech. Bulletin No. 138, 116 p.

Lindsay, A.R., S.S. Gillum, M.W. Meyer. 2002. Influence of lakeshore development on breeding bird communities in a mixed northern forest. *Biological Conservation* 107(1): 1-11.

Horne, Alexander J. and Goldman, Charles R., 1994. *Limnology, Second Edition*, p 115.

Horne, Alexander J. and Goldman, Charles R., 1983. *Limnology*, p. 139.

Newbrey, M.G., M.A. Bozak, M.J. Jennings, and J.E. Cook. 2005. Branching complexity and morphological characteristics of coarse woody structure as lacustrine fish habitat. *Canadian Journal of Fisheries and Aquatic Sciences* 62: 2110-2123.

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.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. *Annals of the Association of American Geographers*. 77:118-125.

Omernik, J.M., C.M. Rohm, S.E. Clarke, and D. P. Larsen. 1988. Summer total phosphorus in lakes: a map of Minnesota, Wisconsin, and Michigan. *Environmental Management* 12:815-825.

Ozimek, T., E. Pieczynska, A. Hankiewwicz. 1991. Effects of filamentous algae on submerged macrophyte growth: a laboratory experiment. *Aquatic Botany* 41(4): 309-315.

Panuska, J.C., and J.C. Kreider. 2003. Wisconsin Lake Modeling Suite Program Documentation and User's Manual. WDNR Publication PUBL-WR-363-94.

Schupp, D.H. 1992. An Ecological Classification of Minnesota Lakes with Associated Fish Communities. MDNR Division of Fish and Wildlife, Section of Fisheries, Investigational Report 417, St Paul, MN.

Skawinski, P.M. 2014. Aquatic Plants of the Upper Midwest: A photographic field guide to our underwater forests. Second Edition.

United States Environmental Protection Agency. 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. Development of Shore Assessment

WisCALM Guidance Document: 2016. WDNR Bureau of Water Quality Program Guidance #3200-2015-01: "Wisconsin 2016 Consolidated Assessment and Listing Methodology (WisCALM) for CWA Section 303(d) and 305(b) Integrated Reporting

Wisconsin State Laboratory of Hygiene. 1993. Manual of Analytical Methods. Environmental Science Section, Inorganic Chemistry Unit, Wisconsin Laboratory of Hygiene, Madison, WI.

Whittier, T.R., Ringold, P.L., Herlihy, A.T. and S. M. Pierson. 2008. A calcium-based invasion risk assessment for zebra and quagga mussels (*Dreissena* spp). Frontiers in Ecology and the Environment. Vol. 6(4): 180-184.

Woodford, J.E. and M.W. Meyer. 2002. Impact of Lakeshore Development on Green Frog Abundance. *Biological Conservation* 110: pp.277-284.

SOURCES – Online

https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

http://www.friendsofmooselake.org/index.html

Purdue University Agricultural and Biological Engineering website

http://www.waterontheweb.org/index.html

http://www.vertexwaterfeatures.com/aeration/pond-or-lake-surface-area-volume-calculato

QGIS Development Team, 2015. QGIS Geographic Information System. Open Source Geospatial Foundation Project. http://qgis.osgeo.org

WDNR – http://dnr.wi.gov/topic/nhi/wlist.html

WDNR – http://www.in.gov/dnr/files/Chinese_Mystery_Snail.pdf

WDNR – http://dnr.wi.gov/topic/Fishing/Outreach/PanfishPlan.html

WDNR – http://dnr.wi.gov/lakes/lakepages

WDNR – SWIMS database

WDNR – Surface Water Data Viewer

WDNR – http://dnr.wi.gov/lakes/Model/WiLMSDocumentation.pdf Wisconsin Lake Modeling Suite Program Documentation and User's Manu, Version 3.3 for Windows Wisconsin

USGS – www.water.usgs.gov/GIS/huc.html

COMMUNICATIONS

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SUMMARY

Moose Lake is a popular fishing destination nestled within the Red River Watershed located in North Central Wisconsin, Langlade County. It is a lowland drainage lake with an area of 113 acres and a maximum depth of 20 feet. Moose Lake's drainage basin is approximately 8 square miles or 5006.3 acres in size, consisting mostly of forestland and mixed agriculture. The lake and surrounding area has a rich history that consists of early settlements, railroads, dairy operations, marl mining, and even homicide!

The Friends of Moose Lake (FOML) received a grant from the Wisconsin Department of Natural Resources (WDNR) to help fund a Comprehensive Lake Management Plan and hired Waterways, LLC in 2015 to complete it. Members of the association were concerned about the amount of plant and algae growth throughout the lake, fish kill events, declining trout population, and the accumulation of bottom sediments.

The intent of this project was to collect baseline information (Tier 1) and develop a comprehensive plan that provides management direction for the lake association so that they may begin to address the various concerns and needs of the lake community while also protecting the lake ecosystem from further degradation. To accomplish this; a social survey of lake users was conducted and investigations of the shoreline habitat, water quality, aquatic plant community, angler habits, the watershed, and soils were completed and appropriate management strategies are offered.

Moose Lake was found to be a phosphorus limited system with high levels of algae growth along the entire shoreline edge of the lake. High phosphorus levels are thought to originate from nonpoint nutrient inputs from the drainage basin, from internal loading of phosphorus, and potentially from septic systems around the lake. According to DNR fish biologists, the fishery of the lake is normal and doing fine as far as species populations and size structure. The occasional fish kills are normal and shouldn't raise too much concern.

The management recommendations result from a combination of data findings, numerous discussions with the FOML planning committee, and from discussions with other potential partners. Summarized strategies for management are:

To EDUCATE

To PROTECT

To conduct a DIAGNOSTIC STUDY

To initiate a NUTRIENT REDUCTION project

Implementation of strategies listed here will take place as time, money, partnerships, and volunteers become available for FOML.

1 – INTRODUCTION

Moose Lake is located in North Central Wisconsin in the southern portion of Langlade County (*map shown left*), nestled within the Red River Watershed. Land use within Langlade County and the Red River watershed specifically, is made up primarily of mixed agriculture and forestland, with some areas of pasture, wetland, and residential. Langlade County visitors and residents alike can enjoy approximately 900 miles of mostly Class I rivers and streams and 843 lakes (*Caring for Our Shores*).

The Red River connects to a series of five spring ponds which drain into the northwest side of Moose Lake. There is a widening of the river (known as Moose Lake) and the drainage outlet is located on the southeast side of the lake where it then narrows and continues to flow downstream into the Red River and then to the Wolf River. The lake is spring fed with evidence of deep spring holes in many areas, especially in the northwest section where pockets of plant-free, cold water are scattered amongst the dense vegetation. The far northwest complex of small spring ponds and channels is classified as a separate body of water, known as Moose Springs (3 acres, Waterbody Code 338800), and was included as part of the aquatic plant survey for this project.

Moose Lake is known to be a popular destination in the area for recreational fishing and is utilized for this purpose year around. Users of Moose Lake also enjoy recreational opportunities such as hiking, boating and/or picnics at the County Park along the shoreline. A fish population survey was completed by the Wisconsin DNR back in 2002 and 2009, however, a comprehensive study and collection of baseline water quality information about the lake and its immediate watershed have never been completed for the Moose Lake ecosystem.

For several years now, siltation at the bottom of Moose Lake has been notably increasing, especially in the western portion of the lake near the entrance to the spring ponds. The accumulations of silt and aquatic plant growth in this area has been the cause of limited accessibility for many lake users. Another problematic issue that has been noted by lake residents is a perceived decline in the fishery population over time.

1.1 The Planning Process

To begin the project, the FOML planning committee members met with the consultant to discuss their growing concerns about Moose Lake and a grant to complete a baseline assessment was submitted in December of 2014, and approved in early 2015. The planning committee met with the consultant in early spring when the project was reviewed and task assignments for the members were explained. One of the committee members took on the responsibility of compiling the history of Moose Lake and the surrounding community, another member would continue with collecting water quality data, and this process continued until all project tasks were assigned. Immediately following ice out in 2015, the consultant started water quality assessments and, using the most current state protocol, long-term water level gages were set at a volunteer's site. The consultant introduced the project to members of FOML via a Powerpoint presentation at their annual meeting. A spring fish kill was reported in 2015 and the local fish biologist confirmed that a bacteria was the primary cause. The shoreline habitat assessment, aquatic plant inventory, and monthly water quality sampling activity took place throughout the summer of 2015. During two of the sampling events (spring and summer), surface algae samples were collected and brought into the local DNR for consultation. FOML volunteer activities continued normally throughout the entire process, in addition to the few added responsibilities. Volunteers that enjoy fishing on the lake took on the duty of filling out Angler Diaries following each angler outing, water levels were noted and placed into SWIMS weekly, the Lake User Surveys were distributed to collect community feedback about the health of Moose Lake and the surrounding watershed, and generous time was placed into compiling a history of the Moose Lake community.

Over the next several months and into 2016, the consultant worked to compile the data collections, create visual displays of the data, research the natural history of the area, and begin drafting the plan document. Part of the data collection involved significant time working online and on the computer completing research of the lake and modeling of the watershed, the watershed soils, and the lake water quality. The consultant made contacts with the County Zoning and the Land & Water Conservation Departments to gather additional information about the Moose Lake shoreland and the watershed. The local DNR Fish Biologist was consulted and interviewed about the past and current status of the fishery population and management initiatives. During the winter months, the consultant and FOML planning committee met to discuss specific ideas about the lake, the community, and the history of the lake association itself. The consultant was able to share some preliminary findings about the lake and the surrounding area at the same meeting.

Once the lake data collections were compiled and analyzed, a draft of the management plan and management recommendations were created. The consultant was able to share the initial outcomes of most of the data at a third meeting with the planning committee during late summer of 2016. Following a Powerpoint presentation of findings, members of the planning committee were assigned sections of the written draft to review. Feedback and comments were taken and minor changes to the draft document were completed.

The planning committee met with the consultant one last time in the fall of 2017 to discuss final conclusions and the strategies for lake management were explained.

2 – Historical Perspectives

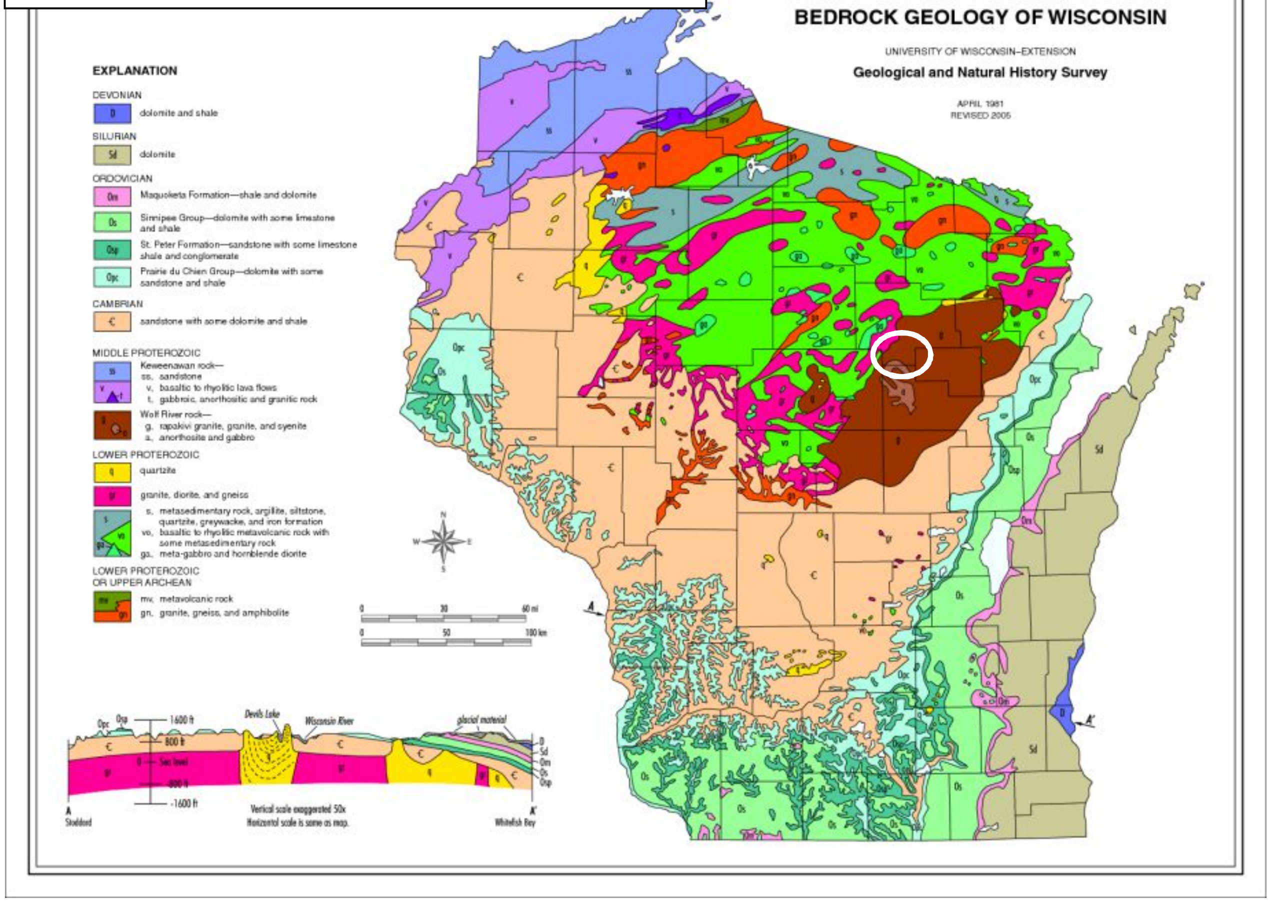
2.1 Natural History

Bedrock Geology

During the middle Proterozoic Era (about 1,500 million years ago), the extensive lower volcanic and sedimentary rock formations of the Wolf River complex were formed. These formations included granites, syenites, and anorthosites.

Map 1 shows that the bedrock layer underneath the area of Moose Lake consists exclusively of rapakivi granite, granite, and syenite. Wolf River batholith igneous rocks: granite of Ninemile Swamp area near Wausau, syenite and associated rocks near Stettin and Wausau, and other granitic and syenitic rocks.

***Map 1.** Bedrock Geology of Moose L area circled in white. WI DNR Ecologic Landscapes of Wisconsin Handbook,*



Glaciation and Moose Lake

Roughly 20,000 years ago the last of the glaciers, the Laurentian Ice Sheet, moved southward into the upper midwest from Canada. The ice sheets were as much as a mile thick, and they advanced and retreated over several thousand years. They scoured the pre-glacial landscape, and carried with them vast quantities of rock – from sand to huge boulders – that were deposited as the glacial ice finally melted.

Six lobes of the glacier pushed into Wisconsin as shown in figure 1. Much of Wisconsin's landscape is a product of this last age of glaciation. The glacial history of the Antigo area is particularly interesting. From the northeast an ice sheet now termed the Antigo Lobe met another from the east now called the Green Bay Lobe. As they retreated, each left a complex and hilly landscape behind. The "Antigo flats" in turn was just beyond the maximum extent of each lobe; the flat, loamy plain that is famous for potato farms was formed as an outwash plain. From Highway 64 east of Antigo one can easily see to the north the east-west line of higher ground that marks the beginning of the Langlade Lobe moraine.

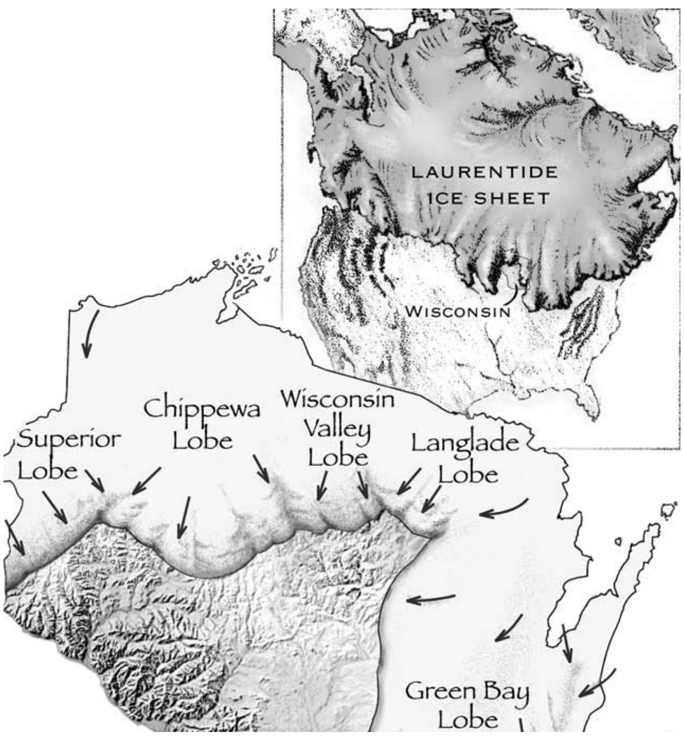


Figure 1. *The six lobes of Laurentide Ice Sheet that pushed into Wisconsin*

To the east one sees the line of high ground marking the beginning of the moraine formed by the Green Bay Lobe. The Green Bay Lobe, which fully scoured the area where Moose Lake is today, deposited tons of silt and rock, thus forming a ridge (approximately 1,500 feet above sea level), extending from central Langlade County southward all the way down to the Kettle Moraine area of Wisconsin. The prominent ridges left by both lobes are quite dramatic, and can be seen clearly on topographic maps today.

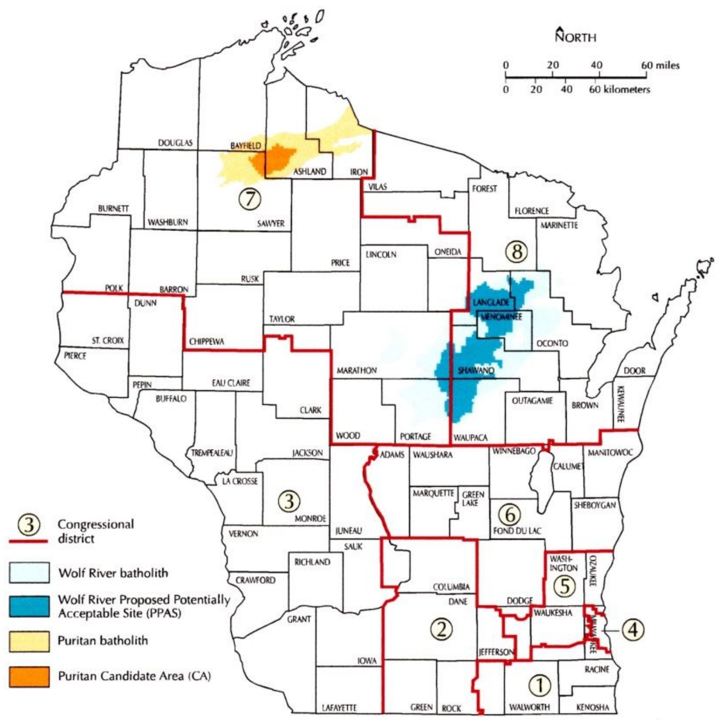
Moose Lake lies within the tumbled landscape left by the Green Bay Lobe moraine, only a few miles inside its maximal extent. Glacial till is deep. Small, steep hills, and small lakes and ponds are common; there are areas of sand and a few of peat. Moose Lake itself was scoured out by the retreating glacier. The lake and the streams in Norwood Township all drain to the southeast away from the terminal moraine which creates a divide between Great Lakes and Mississippi drainage. The northeastern edge of the Moose Lake drainage basin begins at the crest of the ridge created by the Green Bay Lobe, and sits between 1,200 – 1,400 feet above sea level (Mickelson, 1986).

The glacial events have left a lake of about 113 acres, about twice as long as it is wide, and running east-south-east (WDNR). Moose Lake is fed by many springs, but is fed on its upper end by small streams (variously named) that originate a mile or so to the north-east. Among the many springs within the lake is a powerful one at the northwest end which forms a large and, in places, deep spring pond. From these sources a faint current passes through Moose Lake all the way to its exit on the southeast side. The exit stream becomes the Red River, flowing southeast to join the Wolf River in Shawano County.

Wolf River Batholith

Beneath it all is an interesting pre-glaciation geological feature called the Wolf River Batholith (Wisconsin Geological and Natural History Survey, 2002). This is a large 1.5 billion-year-old deposit of granite that underlies parts of Langlade, Menominee, Shawano and Waupaca counties. In the 1980s this granitic batholith was among several sites around the country that were seriously considered for a national high-level radioactive waste disposal site. Most of us are very happy now that in 1987 Congress directed the Department of Energy toward Yucca Mountain, Nevada, and to cease exploration of the Wolf River batholith. Map 2, shown at right, is the Wolf River batholith.

Map 2. *Wolf River Batholith is shown in blue*

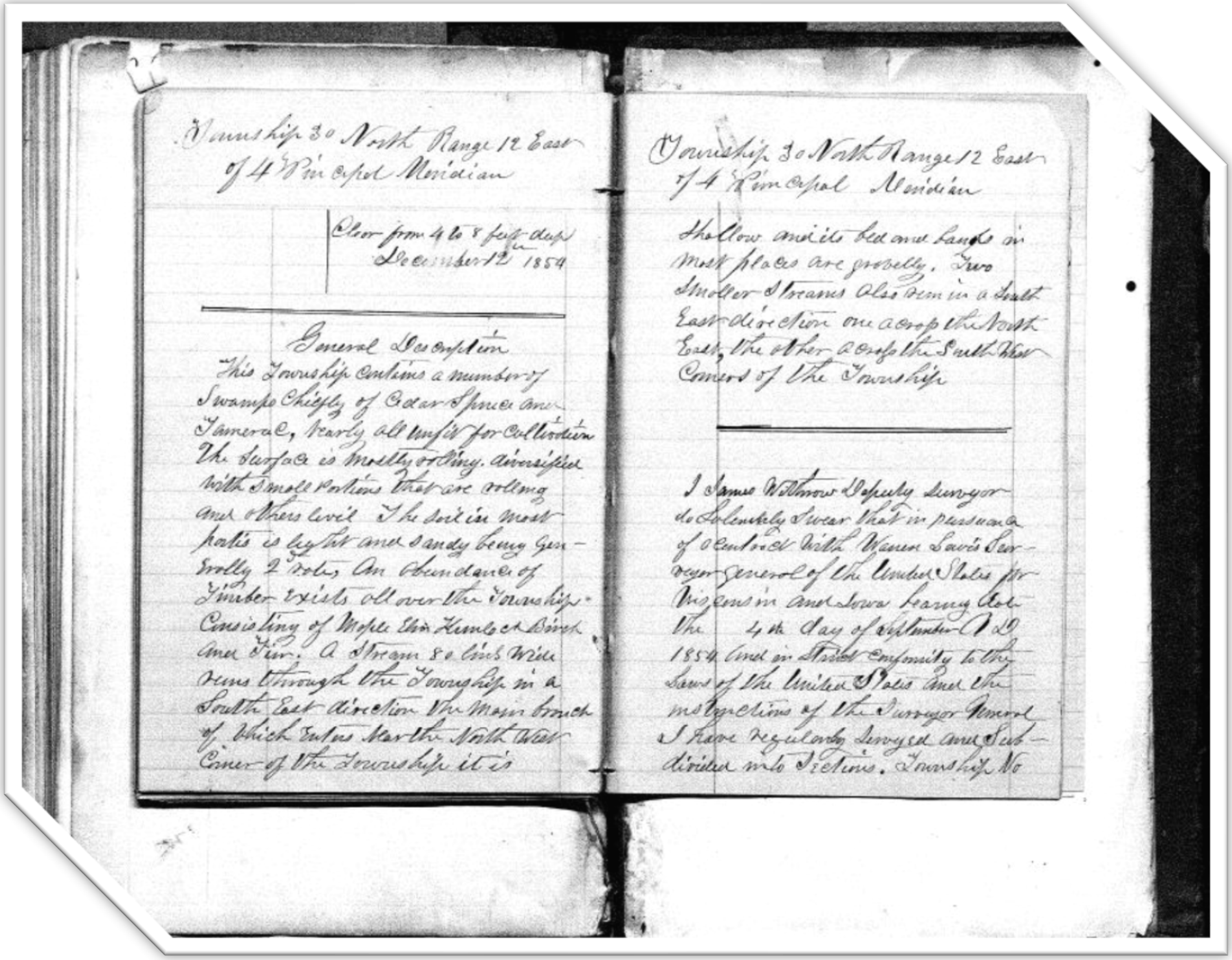


2.2 Social History

Settlement

By 1854 all of the northern half of Wisconsin had been opened for potential white settlement, as all of the Native American tribes (Menominee, Ojibwe, Potawatomi, and Ho-Chunk) had been persuaded or forced to cede the land to the U.S. Government. The tribes had been either confined to reservations or transported out of Wisconsin to the west or the north. Immediately after, the federal government commissioned surveys of the area that is now Langlade County, following the system established by the Land Ordinance of 1785 and the Northwest Ordinance of 1787.

What is now Norwood Township (Township 30N, Range 12E) was surveyed by Deputy Surveyor James Withrow in November and December 1854 and his original notes are digitally available


Township 30 North Range 12 East
of 4 Principal Meridian

Clear from 4 to 8 feet deep
December 12th 1854

General Description
This Township contains a number of
Swamps chiefly of Cedar Spruce and
Tamerack, nearly all unfit for cultivation
The surface is mostly rolling. diversified
with small portions that are rolling
and others level The soil in most
parts is light and sandy being gen-
erally 2 rate, An abundance of
Timber exists all over the Township.
Consisting of Maple Elm Hemlock Birch
and Fir. A Stream 80 links wide
runs through the Township in a
South East direction the main branch
of which enters near the North West
Corner of the Township it is

Township 30 North Range 12 East
of 4 Principal Meridian

shallow and its bed and banks in
most places are gravelly. Two
smaller streams also run in a South
East direction one across the North
East, the other across the South West
Corners of the Township

I James Withrow Deputy Surveyor
do solemnly swear that in pursuance
of a contract with Warren Lewis Sur-
veyor General of the United States for
Wisconsin and Iowa bearing date
the 4th day of September A.D.
1854 and in strict conformity to the
Laws of the United States and the
instructions of the Surveyor General
I have regularly surveyed and sub-
divided into sections. Township No

Figure 2. *James Withrow's Survey Notes, Township 30N, Range 12E (Town of Norwood), 1854.*

(Figure 2). Surveyors were enjoined to note topography, soil type and vegetation along with their records of chains (1 chain = 66 feet) and compass readings. According to Withrow's notes, Moose Lake's township was heavily wooded not with white pine but with hemlock, maple, birch, cedar, fir and elm. He rated most of the forest as "second rate timber." The topography was generally termed rolling. The township, and especially around Moose Lake and the Red River and tributary streams, was plentifully supplied with swamps forested in cedar, spruce and tamarack.

It was not until the end of the 1870s that permanent settlers began to trickle in to the area around Moose Lake. Land was available under the homestead program; according to an early account, homesteaders could gain title to a quarter section (160 acres) for about fourteen dollars (Palmer, 1921).

Many of the first arrivals moved up from Outagamie County, WI, especially from Menasha. They made their way through virgin woods, brush and soft ground with extreme difficulty. The dense forest was penetrated only by Indian trails, and the paths made by animals. Early accounts mention the way, at night, animals' eyes shown in the light of settlers' campfires and wolves' howls rose not far away. Only rough "tote" roads were developed initially, and often the travel was on foot from the closest railhead at Clintonville, some 50 miles away (Pioneer Accounts, 1920s).

After a certain amount of bouncing around Norwood township was established as part of Langlade County by act of the state legislature on February 19, 1881. Early on, the township was organized in six school districts. The two that most closely adjoined Moose Lake were the Riverside District on the east side and the Apple Grove District on the west side. A little to the south was the Phlox or Red River District. In the early days the school district names were a common and convenient way to refer to the areas they served.

Development

Railroads: The founders of Phlox had high hopes for the town. But something important was missing: a railroad connection. In Antigo, about 12 miles to the northeast, the first railroad train arrived in August, 1881 (Langladehistory.com). Even little Mattoon, four miles to the south, got a railroad connection by about 1890.

The 1913 property ownership map of the Town of Norwood shows a "proposed" Wisconsin and Northern railroad line as a dotted line running north along the eastern side of the township to connect Phlox with Antigo. But the operative word is "proposed;" the line was never built (Standard Atlas, 1913). Phlox's ultimate destiny was forever constrained by the lack of a railroad connection. Antigo, meanwhile, became a railroad center, the seat of Langlade County, and its most developed town.

Figure 3. *Photo of a logging train at Mattoon*
http://freepages.genealogy.rootsweb.ancestry.com/

Sawmills: In that first era of settlement logging and milling were the principal economic opportunities and a surprising number of sawmills were established around the township. Fires destroyed many, and other mills were simply moved elsewhere. The Phlox mill seems to have operated on a larger scale from the beginning and lasted much longer. John Kaufman owned and operated the Phlox mill for a number of years. But as was noted in the previous section, the mill's development was constrained by a lack of railroad connection. Product from the Phlox mill had to be transported (often on sledges on iced roads in the winter) to the Mattoon railhead. And after a series of fires and bankruptcy, the phlox mill closed in 1918. At the time of writing (2015) the Mattoon mill continues to operate, though rail service is a distant memory. But the Phlox mill is remembered mainly in the name of the village's tavern, "The Old Mill."

Creameries: Small creameries also abounded in the early 1900s. Poor transportation necessitated dairy processing and, especially, cheese making, close to the source dairy farms. Among the many of these was the Moose Lake Dairy Product Company. A member of FOML happened across the following exhibit in the Langlade Historical Society.

Figure 4, Left. *Moose Lake Cheese Factory.* The caption reads: *"Located on County Road S north of Valey [Valley] Road. It was started in 1917 by C.F. Brightman & Jens Larson was the cheesemaker. It ra12n into financial problems and was reorganized as a farmer's co-op. The building was moved in one piece to Bowler in the late 1930s."*

From the 1920s onward the development of automobile and truck transportation coupled with improved roads led toward consolidation in the creamery industry. Consolidation in the dairy industry was accelerated with the establishment in Antigo in the late 1920s of the Kraft Food Company factory. In more recent decades the number of active dairy farms in the area around Moose Lake has sharply diminished. The Schulz Creamery also eventually closed and the site is now used for storage by the Karl Schulz trucking company (Karl's Transport of Antigo).

Moose Lake

It is much easier to reconstruct the past as it refers to the region *around* Moose Lake than that of the lake itself. Dessureau provides the following tantalizing reference:

> *The Antigo Pioneer Club was formed by Jessie Armstrong, S. E. Leslie, D. F. Chandler, Jule Grant, H. M.Chandler, A. P. Menting, W. H. Dawley, and G. J. Schintz, November 22, 1891. The purpose of the club was to "maintain and manage fishing and sporting facilities at Moose Lake, Norwood Township.*

Clearly, however, Moose Lake's fishing resources were known from an early time, and clearly fishermen were able to access the lake, either from the north or south side. A later plat map, undated but probably from the early 1940s, sketches in undeveloped access roads both from the north and the south, leading to what are now the north and south landings.

We are fortunate to have an aerial photo of Moose Lake and the surrounding area which dates back to October 1938 (Figure 5). Note that at this time, on the north side of the lake, there was no

Figure 5. Early aerial photo of Moose Lake and surrounding area. 1938.

connection to Crestwood Road to the west. The connecting road west from the landing and park area was not created until the 1950s.

Marl Mining: Few present users and residents of Moose Lake are aware that the lake functioned as a mine for a period during the late 1930s and the early 1940s. The mineral mined was marl, a whitish deposit that underlay the lake bottom. Patches of marl – strangely white against the generally dark lake bottom – can still be seen scattered around the lake, especially where they are carried up by the numerous springs that feed the lake. Marl mining was supported by the federal government as a jobs-creation measure during the Great Depression. On Moose Lake, the marl excavator was positioned 40 or 50 feet from the southern shore, near the south landing. Great piles of marl were accumulated near the landing, and hauled away in trucks. Robert Brennecke who lived for most of his childhood in the farmhouse above what is now Lakeview Lane remembers playing in the piles of marl. Traces of the operation can still be seen in a deep hole, called by some "the crappie hole". A second dredge was located near the southeast end of the lake and the marl was taken out through a forest road toward Valley Road.

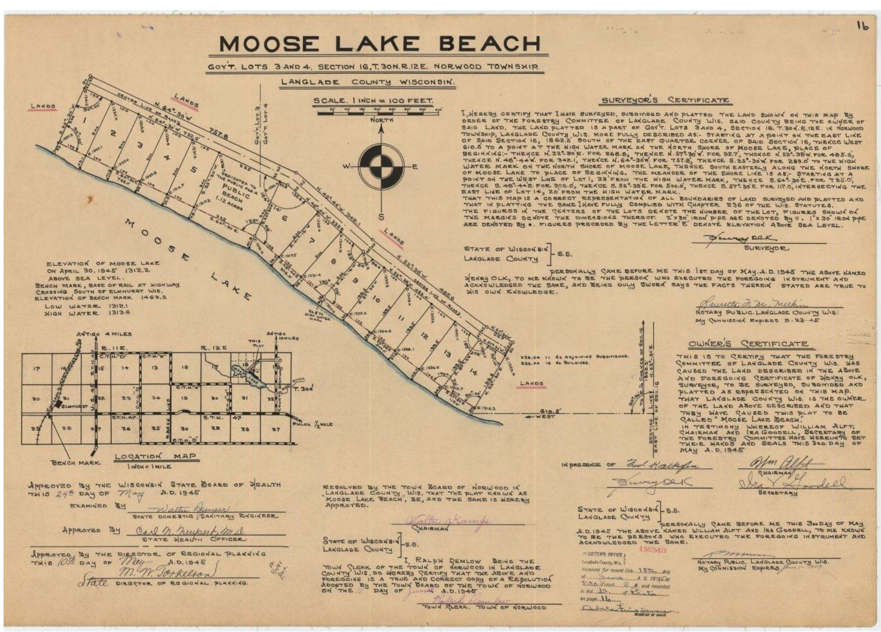


Figure 6. "Moose Lake Beach" (From Langlade County property records)

Shoreline Development: As World War II drew to a close, Langlade County seems to have decided to sell off lake-front lots from county-owned land along the northern lakeshore. A detailed survey and plan was carried out, and the plat map shown here (Figure 6) from 1945, was the result. The map lays out 14 lots to be individually owned, as well as a larger public "beach" between lots 5 and 6. The lots are mainly public “beach” (the present landing) a little more than one acre. As indicated in the figure the 1945 lots are exactly the same as the present lots (except that lot 2 was recently divided between lots 1 and 3).

Louis Klemp, whom the history committee interviewed the year before his death in 2012, was among the first to buy one of the lots and put up a structure. Klemp was born in 1924 and grew up in the stone house on Highway W, about 4 miles from Moose Lake. He said he owned the lot from 1948 to 1964. He bought a discontinued railroad station building in Phelps and, after cutting it down, had it moved to the Moose Lake property where it served as his cabin. What we believe are the remains of this structure can still be seen close to the lake shore below the house presently occupied by Kathi Fink.

Figure 7. *Remains of Louis Klemp’s lakeside cabin.* Photo by Paul Beckett

During the 1950s all the “Moose Lake Beach” lots were sold and all but two were built on. It is interesting (and a testimony to the qualities of the lake) that over half a century later several of the lots and cottages (on both the north and the south sides) remain within the families of the original purchasers (now second-generation or, in the case of the Spindler property, now third-generation).

Moose Lake Park:
Moose Lake Park (or “Wayside” as it officially named) is on the north side at the terminus of the road that snaked in west and south from what is now Highway S. When the park was created as a county park is uncertain. Possibly it began as a Depression era project, like so many other parks and wilderness trails around the country. The Antigo Daily Journal of August 17, 1934 mentions work done at Moose Lake park under the Depression era Federal Emergency Relief Act (FERA). The workers made “roads” through the park, clearings were made, and springs were “boxed” for the use of visitors. Figure 5 provides an aerial photo dating from 1938 and little can be discerned in the way of park development (at least, not by the FOML History Committee).

Homicide: A fascinating element in the “oral history” of Moose Lake is the story of the tavern which was there, in the park area, for at least a brief period in the late 1930s or very early 1940s. But one thing that is in the realm of fact is that a killing occurred there. We do not know the exact date, but we do know it was between 1939 and 1942. One man killed another, apparently in a fit of jealous rage. The case went to trial, and the presiding judge was none other than Joseph McCarthy, later Senator Joseph McCarthy. In the case of the Moose Lake killing Fred Berner, who is knowledgeable about the case, remembers McCarthy as having listening to the evidence which suggested that the person killed had had a romantic relationship with the wife of the killer. McCarthy intoned "justifiable homicide!" slammed his gavel, and the case was closed. Not long after the Moose Lake case, the U.S. joined World War II. McCarthy abandoned his judgeship and took a commission in the Marines. He became "Tail Gunner Joe" and the rest is history. Rather soon after the case (and, unfortunately, we do not have date) the tavern is said to have burnt down. It seems to have been closed then for good. At present, there seems to be no physical trace of the tavern building or its exact location.

How has Moose Lake Changed Since White Settlement Began?

A principal topic of conversation among members of the Friends of Moose Lake Association is the lake's siltation and excessive vegetation. How has it changed since 1878 when Henry Mitchell and Ross Young settled and established their saw mill at the exit? And how much has it changed in living memory?

Unfortunately, the work of the FOML History Committee can make only limited contributions on these questions. To our knowledge, there are no documentary descriptions of Moose Lake in the 19^{th} Century. We know only that the lake was valued as a fishing spot by Antigo sportsmen as early as 1891 (Dessureau, p 41). Alas, we have so far found no further information from that time.

Turning to oral accounts we can report that almost all informants whose experience (and memories) go back to the 1940s or 1950s agree that there was MUCH less silt and vegetation in most of the lake at that time. People speak of swimming off "Rocky Point" near the present Shipman/Lucas home on a rocky bottom, and at many other places in the lake on a sandy bottom. Sue Spindler Coleman remembers swimming off the base of the big hill at the County Park: something that no one would want to do now. To confuse the issue, George Spindler (Sue's father) remarked to the history committee that he did not think the differences in the lake were enormous since the late 1940s when he first got to know it.

The suggestion from our research is that overall, and certainly at the west end, the lake has deteriorated a great deal since 1938. This was the near-consensus position of informants. But the photos themselves suggest (to this author, at any rate) that the pattern of siltation at the west end was already developing in 1938. To the extent to which logging and agriculture run-off are causal, it may be that much of the damage was done in the first decades after settlement.

But there are also things to be grateful for. We are fortunate that the lake is mainly spring-fed, and the water remains relatively clear and cold, and that, so far, invasive species in the lake are limited. And while Moose Lake as a fishery is irrevocably *different* (trout have largely been displaced by bass, northern pike and pan fish), it remains a very productive one. The vegetable growth that humans may deplore probably increases the lake's richness as a fishery. Eagles, osprey, herons, cranes, loons, many species of water fowl, and a host of wild animal species still frequent the lake. On a sunny day in either summer or winter, Moose Lake is a place of great beauty.

The memories collected by the history committee will encourage us as users and owners to do what we can to slow, if not reverse, the natural eutrophication processes and to keep Moose Lake a beautiful place for future generations to enjoy.

2.3 Lake Association History & Activities

The Friends of Moose Lake (FOML), formed in the spring of 2010 as an incorporated, non profit lake association dedicated to preserving and protecting Moose Lake. One of the reasons behind the formal organization of FOML was because of the marked difficulty for lake users to access the Moose Springs area. Over the years, the decay of aquatic plants and the resulting accumulation of bottom sediment and deep muck in the shallows near the Springs area has made navigation very troublesome. In order to address this issue with proper lake management steps, organizers of the lake association took necessary action to create the association, and today FOML remains as a thriving and active organization.

The mission statement for the association is to "preserve, protect, and improve Moose Lake and its surroundings; enhance water quality and fish populations, serve as advocates with watershed organizations, state, county, and local government and the public" (FOML website).

The members of FOML have been very energetic and proactive from the very beginning of their organization in 2010. In a relatively short time period, their strong volunteer work force has engaged in a number of activities that coincide well with their overall mission. This proactive group of people is eager to learn about the lake, their surrounding community, and to learn about new ways that they can protect it. Each year the group meets for a spring meeting, a summer family potluck picnic, and a fall meeting. Activities they are currently engaged in are: newsletter outreach, maintenance of the website, an annual spring Lake Cleanup Day, citizen volunteer water quality monitoring, the *Bag It & Tag It* program, Moose Lake hiking trail and interpretive signage maintenance at the county park; Clean Boats/Clean Waters program, Zebra Mussel Watch, Purple Loosestrife project (raise and release beetles near spring brook area near fairground), WI Turtle Watch, the history committee, the Little Library, shoreline restoration near the boat landing, and Loon Watch.

3 – Watershed Features

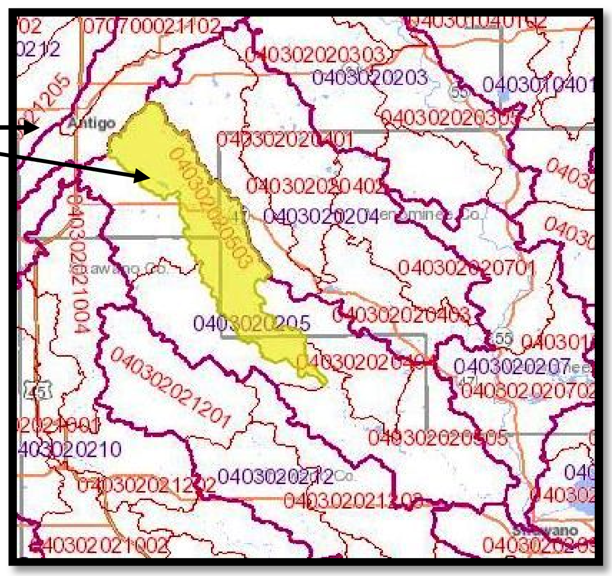
The health and quality of a waterbody is a direct reflection of the region of land which surrounds it – its' watershed. A watershed is the total area of land that drains into a lake, stream, river or wetland. As rain and snow melt flow downhill; any sediment, nutrient, or pollutant that exists on the landscape of the drainage watershed can eventually be delivered into low lying waters.

All locations on the worlds' landscape lie within a given watershed, and each area of land consists of unique physical and biological characteristics. No two watersheds are alike. The watershed size, soil types, topography, development density, land use patterns, and annual precipitation patterns are just a few components that can ultimately have an effect on the health of the receiving waters.

Scientists and lake managers recognize that the best way to protect surface and groundwater resources is to understand and manage on a watershed-scale basis, because all activity within a given watershed affects the receiving systems.

3.1 Hydrologic Units

All lakes are part of larger watershed units. A lake's drainage basin is the smallest unit of land that drains into the lake. Moose Lake, Langlade County is located in Sub-Watershed 040302020503, otherwise known as the Moose Lake-Red River system, and consists of an area that is 54 square miles as shown at right.



Map 3. *Antigo, WI and Moose Lake shown here within the context of a HUC 12 Watershed (040302020503)*
Source: www.dnr.wi.gov/water/watershedDetail

Hydrologic unit codes (HUC) are a digital dataset developed by the Natural Resources Conservation Service (NRCS) and the United States Geologic Survey (USGS). The HUC dataset is made up of nested regions, called hydrologic units, which delineate progressively into smaller watersheds – each having a unique code assigned to it. A HUC is a series of two-digit groupings of numbers that describe a hydrologic unit's scale, plus where it fits in the larger hydrologic unit framework. Numbers were assigned in an upstream to downstream fashion – starting with regions in the United States. Table 1 shows the unique number coding of the Moose Lake area as it fits into the geography of the United States.

Map 3 above also illustrates the larger Red River Watershed (outlined in dark purple) where the yellow highlighted HUC 12 sub-watershed is nested. The Red River Watershed is 208 square miles and extends southward into Shawano County and southwest to Menominee County. The upper reaches of the watershed in Langlade County, support some agriculture operations, which may contribute pollutants or sediments to stormwater runoff.

Table 1. Hydrologic Unit Code classification for Moose Lake, Langlade County

	HUC Digits	HUC Number	Unit Name	Area (sq miles)
Region	2	04	Great Lakes	178300 mi²
Sub-Region	4	0403	Northwestern Lake Michigan	18700 mi²
Basin	6	040302	Fox River	6340 mi²
Sub-Basin	8	04030202	Wolf River	3720 mi²
Watershed	10	0403020205	Red River	208 mi²
Sub-Watershed	12	040302020503	Moose Lake-Red River	54 mi²
Drainage Basin	Lake		Moose Lake	8 mi²

Source: www.water.usgs.gov/GIS/huc.html

3.2 Moose Lake Drainage Basin

The smallest area of direct drainage for Moose Lake is approximately 8 square miles or 5006.3 acres in size. The drainage outline is illustrated in Map 4, where the light green lines represent the basin outline and the blue lines indicate streams.

The relationship between drainage size and lake size is an important concept for managers to know when trying to understand how nutrient sources may affect a lake. A lake that is small in relation to the size of its direct drainage has a greater potential to be affected more readily by sediment or nutrients, whereas, the opposite is true of a large lake that lies within a small drainage basin. This size relationship is defined as a ratio of drainage basin area to lake area (DB:LA). The DB:LA for Moose Lake is 43:1 which means that for every one acre of lake size, there are 43 acres of drainage basin land that drains off to it. The Moose Lake 43:1 ratio is considered intermediate on the sensitivity scale when compared to other types of Wisconsin lakes (Understanding Lake Data).

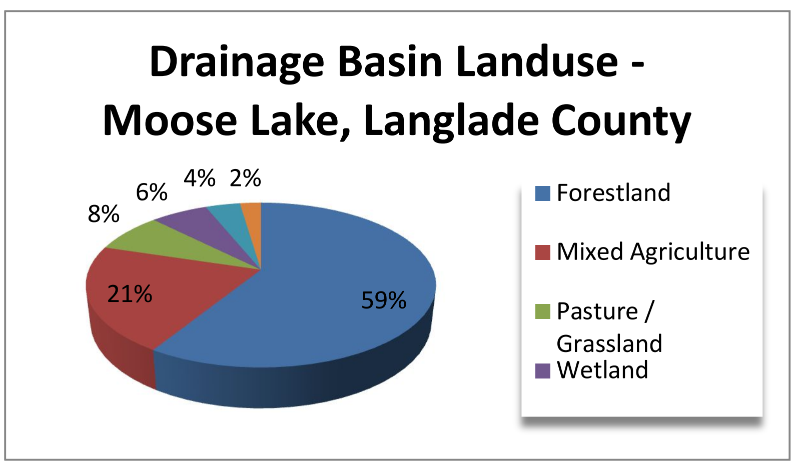
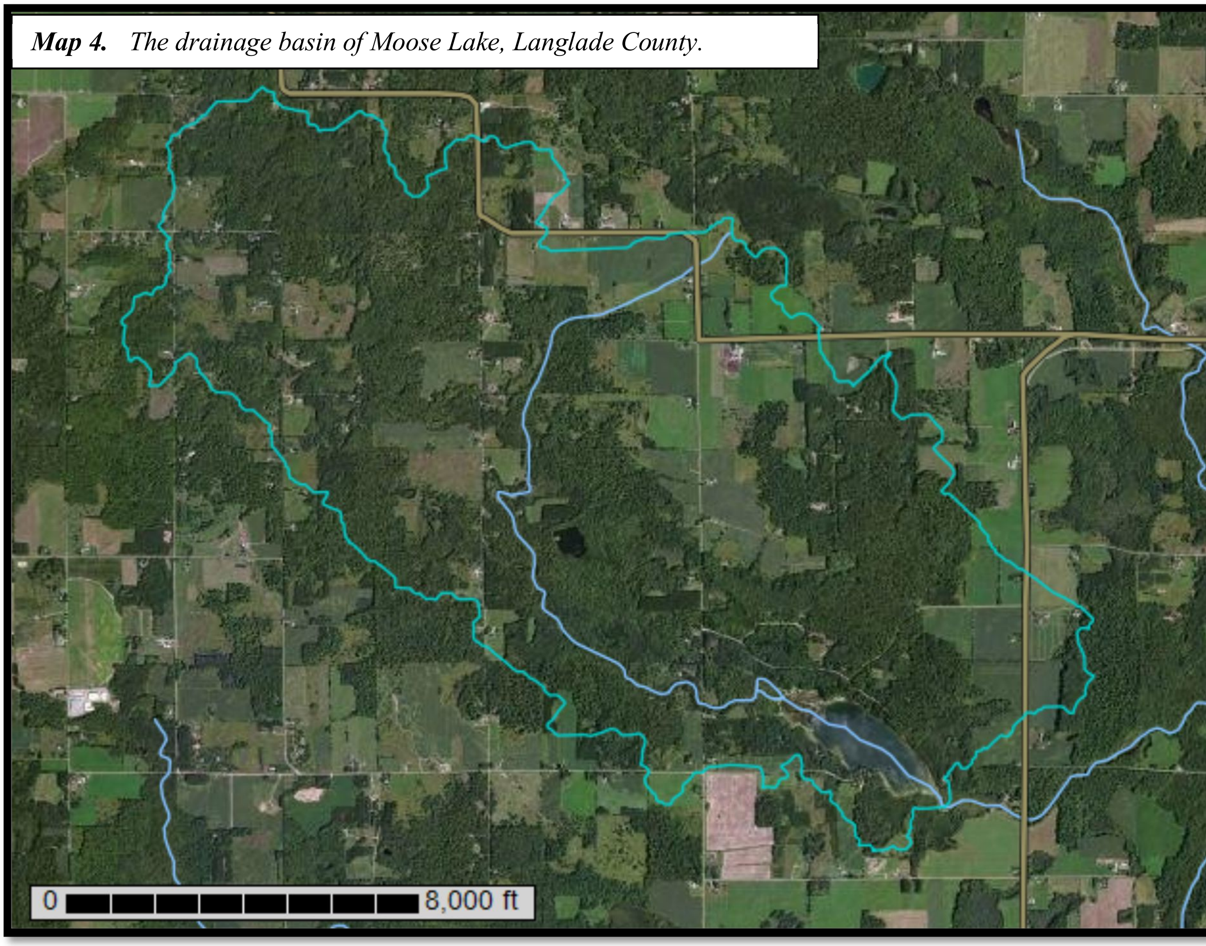


Figure 8. *Percentage breakdown of landuse in the Moose Lake drainage basin.*

The way the land is utilized, the types of soils, and the lay of the land (topography) within a lake drainage basin can all have a direct bearing on the overall health of the lake. The landuse within the Moose Lake drainage is made up of: 59% Forestland, 21% Mixed Agriculture, 8% Pasture & Grassland, 7% Wetland, and 4% Residential. As illustrated in Figure 8, the greatest use of land within the watershed consists of Forestland and Mixed Agriculture. Together they make up 80% of the total drainage area; where grasslands, wet, and residential areas round out the remaining 20%.



Map 4. *The drainage basin of Moose Lake, Langlade County.*

Precipitation

Regional precipitation patterns (frequency, intensity, or timing) have a direct influence on lake water quality. The erosive energy produced by heavy rains and fast snowmelt events work to displace soil particles and "wash" pollution off the landscape. In turn, sediments and pollutants are then easily transported to a lake either directly or indirectly via a stream. This concept is mentioned here because the landuse within the lake drainage area have a large bearing on the amount of pollution that is transported during rainfall or snowmelt events.

"Perviousness"

The landuse within a given watershed can give a good indication of what the quality of the lake may be. For example, impervious surfaces (such as black top or concrete) do not allow water to soak into the ground. Instead, large volumes of water are able to runoff quickly which can pick up and carry more pollutants and/or sediments to the receiving waters. The opposite is true for pervious surfaces which slow down the velocity of runoff flow and allow for water to infiltrate into the ground. Since the majority of the Moose Lake drainage basin is pervious and allows for water infiltration, less "contaminated" runoff water may reach the lake. However, it would depend largely on how the land is managed for stormwater runoff.

Wisconsin Lake Modeling Suite

The Wisconsin Lake Modeling Suite (WiLMS), is a water quality planning tool developed by the state and was used to analyze the Moose Lake drainage area. The WiLMS tool can predict various levels of point and non-point sources of phosphorus input from a lake and watershed, thus allowing lake managers another tool to reach reasonable conclusions in regard to potential versus actual observed phosphorus concentrations. Factual morphometric and hydrologic data about the lake and watershed landuse data are collected at the front end of the modeling program and in-turn, the model generates annual predictions of phosphorus loading and trophic response.

Calculations of the lake flushing rate and hydraulic residence time are also generated during the WiLMS modeling procedure. Both of these terms are related to how much water a lake holds (volume) over a given time period. The flushing rate is the total time it takes for the entire volume of lake water to be exchanged with new water coming in from watershed runoff, precipitation, or groundwater seeps. The model predicted that the entire volume of Moose Lake is flushed 4.73 (~5) times per year. The water residence time is the total amount of time that the lake water volume remains in the system. The Moose Lake residence time was calculated to be 0.21 years. Longer flushing rates or water residence times will result from larger lake volumes and smaller input/output volumes. So it can be said that both of these concepts directly relate to the lake hydrology scheme and its placement on the landscape (refer to Chapter 4).

Phosphorus Contribution

The WiLMS model predicted that the Moose Lake drainage basin contributes approximately 1137 pounds of nonpoint source phosphorus to the lake ecosystem each year, and the largest contributor comes from mixed agriculture followed by forestland (Figure 9). During the modeling procedure, the input data runs through several different phosphorus prediction equations. Based on the *Rechow, 1979 General* model of phosphorus prediction in WiLMS the growing season mean for Moose Lake total phosphorus concentrations should most likely be near 42µg/L. The actual observed growing season mean for total phosphorus concentration in Moose Lake during 2015 was 22.7µg/L, nearly two times less than the predicted value. A probable reason for this difference has to do with the relatively swift flushing rate of the lake, since the entire volume of water is replaced almost 5 times annually and rids the system of some phosphorus inputs rather quickly.

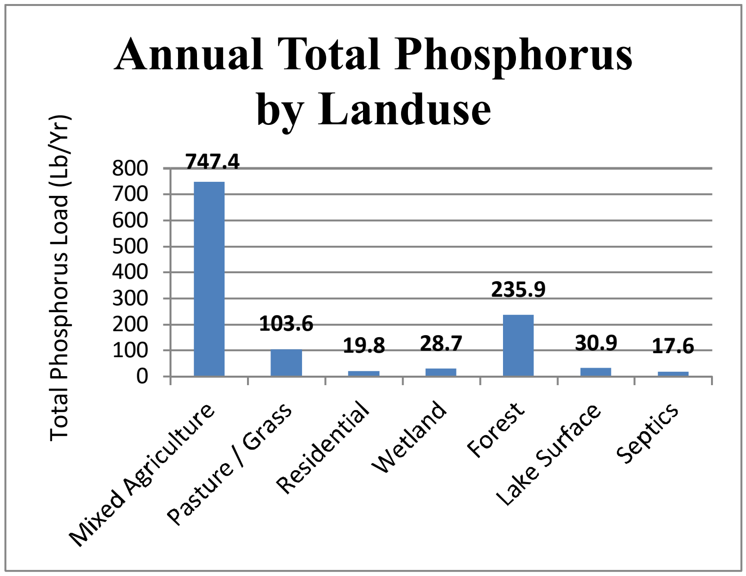


Figure 9. *Annual contributions of Phosphorus to Moose Lake as predicted by WiLMS*

3.3 Soils

Soils information can be very useful to help understand things like pollution control, identify areas of high soil erosion or even water runoff potential. This information can help identify areas most suitable for underground projects like septic tank absorption fields. An online query of the watershed soils was conducted for the Moose Lake drainage basin and the soils map that was generated is included in Appendix 1.

Table 2 lists information specific to soils contained in the Moose Lake drainage basin. *Qualifier: Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site. The following written information is quoted from the NRCS Web Soil Survey: "The rating of "Very Limited" in the last column of the table indicates the extent to which the soils are limited by all of the soil features that affect the specified use – in this case septic suitability. The ratings are based on the soil properties that affect absorption of the effluent, construction, public health and maintenance of the system. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. Some soils are underlain by loose sand and gravel or fractured bedrock at a depth of less than 4 feet below the distribution lines. In these soils the absorption field may not adequately filter the effluent, particularly when the system is new. As a result, the groundwater may become contaminated."

Table 2. *Soils information for the drainage basin of Moose Lake, Langlade County, Wisconsin.* Source: NRCS Web Soil Survey

Map Unit	Unit Name / Slope	% in Basin	K Factor	Soil Group	Septic Suitability
AoB	Antigo silt loam, 2 to 6 percent slopes	4.9	0.49	B	Very Limited
AoC	Antigo silt loam, 6 to 15 percent slope	9.2	0.49	B	Very Limited
HyB	Hatley silt loam, 2 to 6 percent slopes, stony	0.3	0.32	B/D	Very Limited
KnC	Kennan loam, 6 to 15 percent slopes, stony	32.2	0.28	B	Very Limited
KoB	Kennan silt loam, 2 to 6 percent slopes, stony	24.8	0.32	B	Very Limited
Kw D	Keweenaw sandy loam, 15 to 45, stony	12.3	0.24	B	Very Limited
Lx	Loxley peat	0.5		A/D	Very Limited
MnB	Menominee loamy sand, 0 to 6 slopes	0.1	0.1	A	Very Limited
Ms	Minocqua, Cable, and Sherry mucks	0.1		C/D	Very Limited
Os	Oesterle silt loam	2.0	0.37	B/D	Very Limited
PsB	Pence sandy loam, 0 to 6 slopes	0.5	0.2	A	Very Limited
PsC	Pence sandy loam, 6 to 15 slopes	0.6	0.2	A	Very Limited
PsD	Pence sandy loam, 15 to 45 slopes	6.4	0.2	A	Very Limited
Sy	Lupton and Cathro soils, 0 to 1 slopes	3.6		A/D	Very Limited
VsC	Vilas loamy sand, 6 to 15 percent slopes	0.2	0.24	A	Very Limited
W	Water	2.5			Not Rated

Lettered hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission, and are the predominant type in the Moose Lake drainage.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. K Factor is one of six factors used in the Universal Soil Loss Equation (USLE) and the Revised Universal Soil Loss Equation (RUSLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values of K range from 0.00 to 0.69. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by stormwater.

Soil Erosion & Water Quality

What is the relationship between soil erosion and surface water quality? There are multiple factors that all play a role in how soil could affect a waterbody. First, at the molecular level, soil particles may possess high amounts of nutrients like phosphorus or nitrogen. Depending on the geographic location where the soil lies and the type of soil, nutrient levels can vary significantly from location to location. For a given rain event (dependent on severity), soil particles can saturate and begin to get carried off with stormwater runoff. The muddy runoff water runs downhill, picks up more particles and pollutants along the way and gets delivered to the nearest outlet (a wetland, a stream, a pond, or a lake). If those soils contain high levels of nutrient, a significant load of non-point pollution enters the waterbody. Once in the waterbody, the nutrient may get flushed out over time, it may be absorbed by an actively growing aquatic plant or algae, or may settle onto the bottom of the waterbody. Second, the soil particles that are deposited at the bottom of the lake may create problems for a prime spawning area of that waterbody. For example, it may have been the only suitable habitat left in the waterbody for the naturally reproducing population of walleye that require clean rubble to spawn. If it wasn't the last spawning area, at the very least, the suitable spawning habitat available to that walleye population is reduced. Third, the nutrient rich muddy deposits may settle down into the lake sediments where the level of dissolved oxygen will determine if the nutrient is available for plant or algae growth at a later time. Phosphorus is chemically bound up when oxygen exists, but if the lake bottom becomes anoxic (as is normal in stratified lakes in the summer), the phosphorus will be available for additional plant or algae growth, otherwise referred to as internal nutrient loading or nutrient recycling.

4 – LAKE PERSPECTIVES

4.1 Lake Categories

Scientists often categorize the environment at various spatial scales to explain variability in the type, quality, or quantity of resources within an ecosystem. These differentiations allow for general comparisons and inferences to be made from one ecosystem to another as to what is average or "normal" in a given geographical area or ecological community type. Separating lakes into categories or "classes" can be a useful tool for scientists because if data collections from a lake seem way off the "normal" thresholds for a given class, biologists are alerted early on of potential water quality problems. A range of variability within a category is normal and even expected, but if data waivers too far from the norm, it would set off a red flag for further investigation.

The following sections help us to see how Moose Lake is categorized and compared to other similar types of lakes in Wisconsin.

Lake Type – *Hydrology-based Classification*

For years, Wisconsin lakes were simply separated into categories based on major water source inputs and outflows, otherwise referred to as hydrology-based classification. In the lake type classification scheme, Moose Lake is categorized simply as a *Drainage Lake*. Input water sources for Drainage Lakes come from groundwater springs, watershed runoff, inlet stream(s), and precipitation from rain or snowmelt. Water is lost from this type of system by outlet stream(s), groundwater flow, and evaporation. Drainage lakes tend to have more variable water quality and nutrient levels, depending upon the amount of land area drained by the lake's watershed. For this reason, watershed size also plays a key role in the classification of Drainage Lakes.

Wisconsin Lake Classification – *Stratification-based Classification*

To refine lake categories further, the WDNR has determined that lake size, hydrology and depth are more critical factors for initial classification of lakes. The primary influences on lakes are physical characteristics such as the size and depth of a lake, thermal stratification character, hydrology factors, and the size of the lake's direct drainage basin (2016 WisCALM document). Table 3 defines typical Wisconsin lake communities based on these physical characteristics.

Upon review of this table, Moose Lake is categorized as a *Drainage Lake*, so further refinement was necessary to place Moose Lake into a defined category. Because Moose Lake is a drainage lake, the thermal stratification character and the size of the lake's drainage basin were evaluated. Moose Lake has a maximum depth of 20 feet. The mathematical equation shown below predicts the stratification status of deeper lake systems (WisCALM Lathrop & Lillie).

$$\frac{\text{Maximum Depth (feet) X (0.3048 – 0.1)}}{\text{Log 10 (Lake Area (acres) X (0.40469)}}$$

The size and depth of Moose Lake was placed into this model and returned a value of 3.6. In the Lathrop/Lillie model, values less than 3.8 predict a mixed (or non-stratified) lake, which is defined as a *Shallow Lake*. Based on the model, Moose Lake falls into this category.

Table 3. *Lake and reservoir natural communities and defining characteristics - adapted from Wisconsin Lakes Classification (2016 WisCALM)*		
Natural Community	Stratification Status	Hydrology
Lakes/Reservoirs <10 acres - Small	Variable	Any
Lakes/Reservoirs ≥ 10 acres		
1 Shallow Seepage	Mixed	Seepage
2 Shallow Headwater	Mixed	Headwater Drainage
3 Shallow Lowland	Mixed	Lowland Drainage
4 Deep Seepage	Stratified	Seepage
5 Deep Headwater	Stratified	Headwater Drainage
6 Deep Lowland	Stratified	Lowland Drainage
Other Classification (any size)		
Spring Ponds	Variable	Spring Hydrology
Two-Story Fishery Lakes	Stratified	Any
Impounded Flowing Waters	Variable	Headwater or Lowland Drainage

As defined in 2016 the WisCALM guidance document, "mixed lakes tend to be shallow, well oxygenated, and may be impacted by sediment re-suspension. In addition, shallow lakes have the potential to support rooted aquatic plants across the entire bottom of the lake." Confirmation of these two observations for Moose Lake are supported in a review of results for both the dissolved oxygen profiles and the aquatic plant survey (Chapter 6). Dissolved oxygen profiles collected for Moose Lake during the summer of 2015 indicate that although thermal stratification was achieved during the summer, it was weak and short-lived and did not last over one month duration. Further, dissolved oxygen was always present (minimum 0.11ppb) in the lower depths of the lake. WisCALM guidance states further that "If the watershed draining to the lake is greater than or equal to 4 square miles, the lake is classified as a Lowland Drainage Lake". Considering these criterion, Moose Lake fits within the category of a Class 3 - Shallow Lowland, Mixed Drainage Lake because as shown in Table 1, the drainage basin area for the lake is 8 square miles.

Langlade County Waterway Classification – *Protection-based Classification*

In response to concerned citizens, the Langlade County Board of Supervisors adopted a countywide waterway classification system back in 1999 in an effort to protect water resources from degradation. In this system, lakes greater than 20 acres in size are classified as 2 or 3 based on the following seven criterion: Surface Area, Shoreline Development Factor, Lake Stratification, Flushing Index, State Water Designation, Hydrology, and Existing Development. Within this classification scheme, Moose Lake is a Class 3, where it experiences the greatest leniency with respect to shoreland protection ordinances, and for every 100 ft of shoreline, a 30ft wide strip of viewing corridor is allowed.

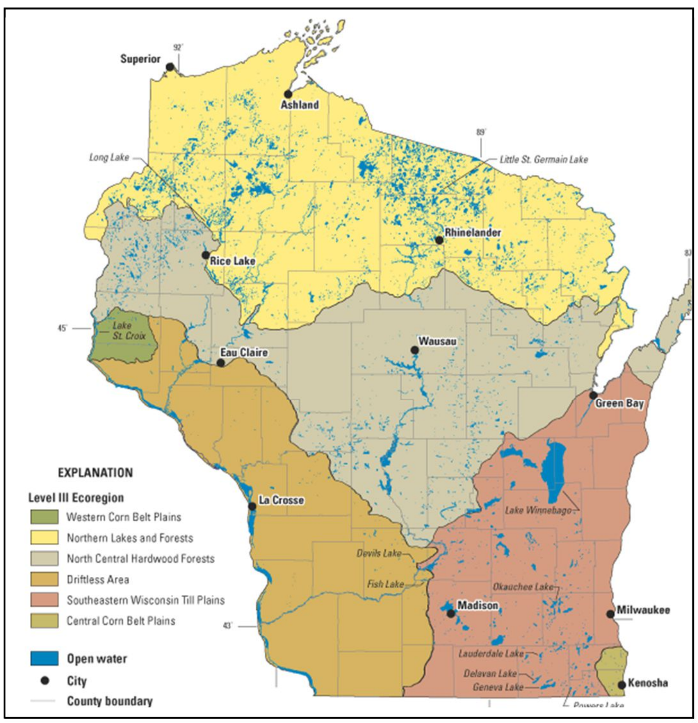
Trophic State Classification – *Age-based Classification*

As lakes "age" over time, there are age-based categories that they fall into – Oligotophic, Mesotrophic, or Eutrophic. Figure 32 in Chapter 6 depicts the natural aging process that all lakes undergo over prolonged periods of time. There is a direct correlation between the level of nutrients within a lake ecosystem and the lake's overall water quality or "age". For example, lakes with high phosphorus levels (30-50 µg/L) have the ability to sustain consistently high levels of plant productivity and are categorized as Eutrophic. The opposite is true of a lake with very low nutrient levels (3-10 µg/L), thus are categorized as Oligotrophic. Moose Lake is classified as *Mesotrophic* (middle-aged), because total phosphorus levels typically measure between 18-27 µg/L. Further detail about the trophic state of Moose Lake is described later in Chapter 6.

Ecoregion – *Geography-based Classification*

Ecoregions are mapped geographical areas within which all components of the terrestrial and aquatic ecosystem exhibit slightly different patterns or qualities in comparison to that of other areas (Omernik, 1987). At regional scales then, these defined areas can serve as the framework for ecosystem comparisons. Analysis of ecoregions allow scientists to compare and manage resources at a landscape scale and there are many applications that these defined areas can be useful. One application of ecoregion mapping that is of particular interest to lake managers is the incorporation of regional landuse and the identification of potential sources of nonpoint pollution. Map 5 shows the defined ecoregions for Wisconsin and Moose Lake is located within the North Central Hardwood Forests (NCHF). This region (shown in gray-brown on the map) is described as nearly level to rolling till plains, lacustrine basins, outwash plains, and rolling to hilly moraines. The land use and cover in this region consist of a variety of forests, wetlands and lakes, cropland agriculture, pastures and dairy operations. The growing season is typically longer and warmer than that of the Northern Lakes and Forests region to the north, and soils are more fertile, contributing to the greater land use of agriculture. The density of lakes on the landscape are lower here than to the north and lake trophic states tend to be higher, with higher percentages in the eutrophic categories. Although eutrophic lakes are more common in this ecoregion, Moose Lake remains relatively pristine in comparison to other lakes in the ecoregion because it contains less total phosphorus and is less productive than similar lakes. Stream density is highly variable, with some

Map 5. *Wisconsin Level III Ecoregions (Omernik, 1987)*



areas having virtually no streams – in wetland and kettle terrain - to others with high densities of perennial streams.

Regional differences in soils, climate and land use may explain additional variation in the indicator metrics used in lake classification, but Wisconsin lake biologists believe that these characteristics are secondary in the categorization of lakes.

Table 4. *Summary median comparisons between Moose Lake, NCHF, and WI Lake Class 3.*

	Moose Lake	Ecoregion NCHF	WI Lake Class 3
Lake Size (Acre)	113	247	511
Max Depth (Feet)	20	28	18
TP µg/L	23	52	33
Secchi (Feet)	16.6	5.2	5.6
Watershed Size (Mi^2)	7.8	7	27
Watershed Agriculture	21%	46%	12%

Outstanding & Exceptional Resource Waters

DNR definition "Waters designated as ORW or ERW are surface waters which provide outstanding recreational opportunities, support valuable fisheries and wildlife habitat, have good water quality, and are not significantly impacted by human activities. ORW and ERW status identifies waters that the State of Wisconsin has determined warrant additional protection from the effects of pollution". The Red River is classified by the Wisconsin Department of Natural Resources as exceptional resource water (ERW), but not Moose Lake itself.

Impaired Waters Listing 2016

Every two years, Section 303(d) of the Federal *Clean Water Act* requires states to publish a list of all waters that *do not meet* water quality standards. This list is known as the Impaired Waters List, and is updated to reflect waters that are newly added or removed based on new information or changes in water quality status.

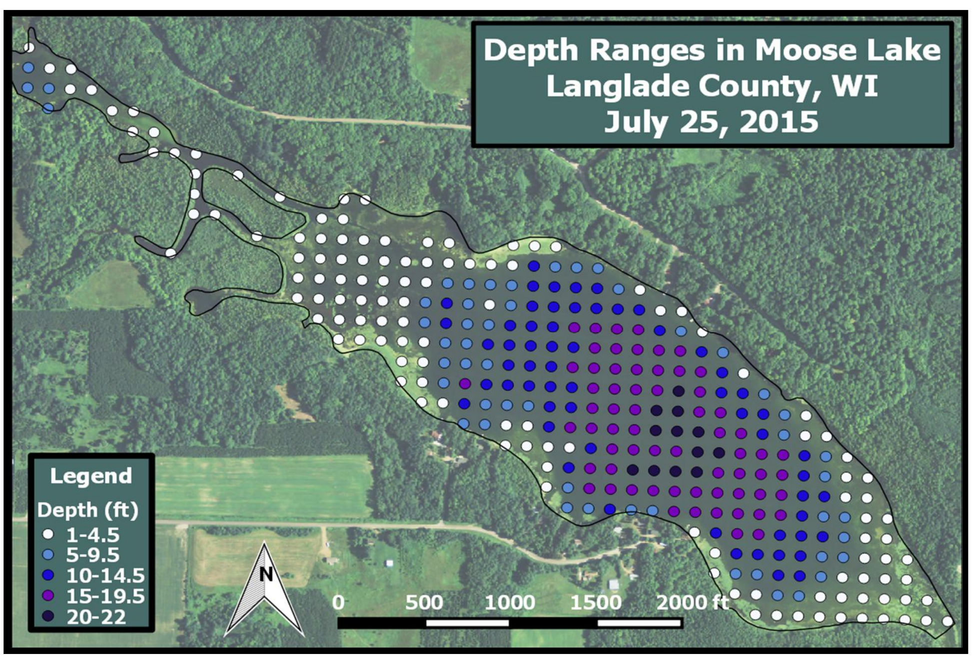
Moose Lake was assessed in 2015 by the Department of Natural Resources for the 2016 listing cycle and was placed on the proposed listing of 303(d) waters for point and non-point sources of pollution. The total phosphorus sample data exceeded the 2016 WisCALM listing thresholds for the Recreational use (REC) and Fish and Aquatic Life (FAL) use, however chlorophyll data did not exceed REC or FAL thresholds. Both uses were listed in "poor" condition.

**Important Note: We believe an error occurred in the classification process for Moose Lake. The consultant has classified Moose Lake as a lowland, shallow, drainage lake, but the DNR has it listed as a Two-Story fishery lake. If in fact Moose Lake was misclassified and is re-classified in 2018 as a lowland, shallow, drainage lake, then the 303(d) impairments do not exist in either category.

4.2 Physical Characteristics – Moose Lake, Langlade County, Wisconsin

Summary Morphology & Hydrology

Surface Area	113 acres
Maximum Depth	20 feet
Mean Depth	9 feet
Volume	949 ac feet
Shoreline Length	2.2 miles
Flushing Rate (times/year)	4.73 annual
Residence Time Low Est	64 days
Residence Time Med Est	140 days
Residence Time High Est	290 days
Hydrology Type	Drainage
Drainage Basin : Lake Area	43:1

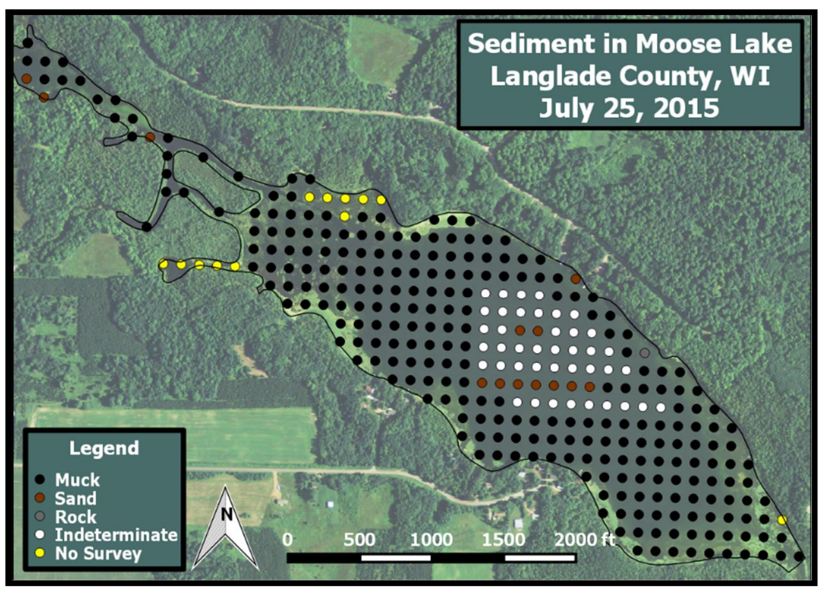


Map 6. Depth map of Moose Lake

Bottom Sediments

The Moose Springs complex has high water clarity with dark organic sediment (i.e., muck) in some areas while other areas are covered with marl, which is a mixture of clay, sand, and limestone. The marl bottom is often associated with hard water and contributes to a turquoise or bright green appearance (Figure 10). Moose Lake is similar in that the majority of the lake sediment was classified as "muck", or in other words it was either dark organic material or lighter-colored marl (clay, sand, and limestone). Although these are two very different types of sediment, they both have the same "feel" when surveying for aquatic plants since the rake head is easily pushed into the soft sediments. There were only 13 sites with sand substrate and one that was classified as rocky substrate (Map 7).

Figure 10. *Channel in the Moose Springs complex shows bright green*



Map 7. *Sediment types within Moose Lake*

Ice On / Ice Out

Over the years a citizen volunteer has recorded the observed ice on and ice out dates for Moose Lake. The graphed data is displayed in Figure 11, a and b. Fluctuations from year to year are normal and coincide with annual climate and precipitation patterns. As shown in the twelve years recorded, the earliest observation for "ice on" occurred in the 2004 calendar year, while the latest occurred more than one month later in 2009. Alternatively, the earliest observation for "ice out" on Moose Lake occurred in 2012 and the latest occurred just one year later in 2013.

Figure 11a

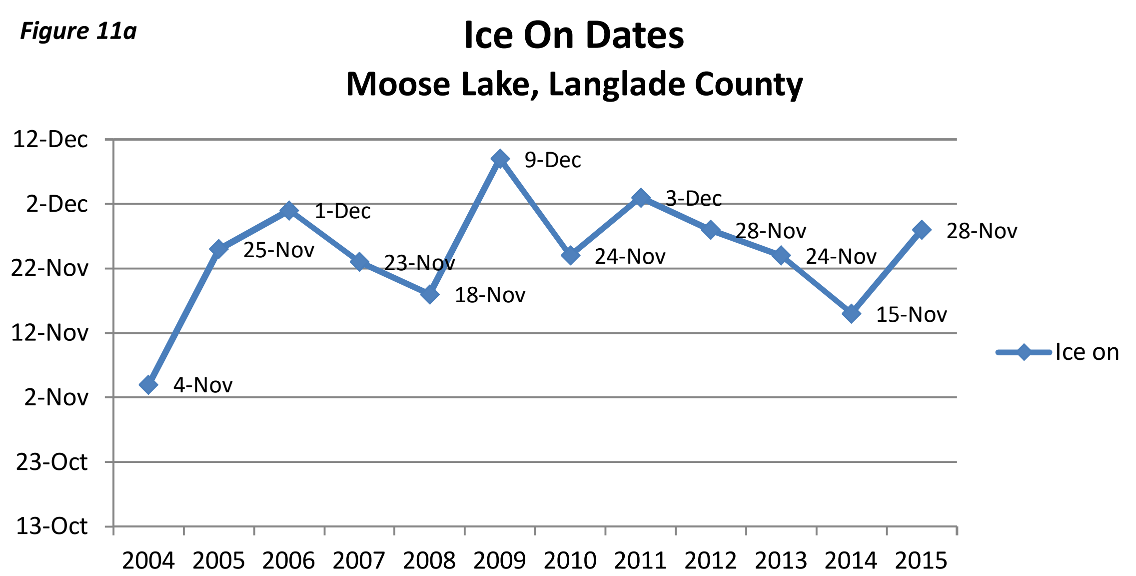
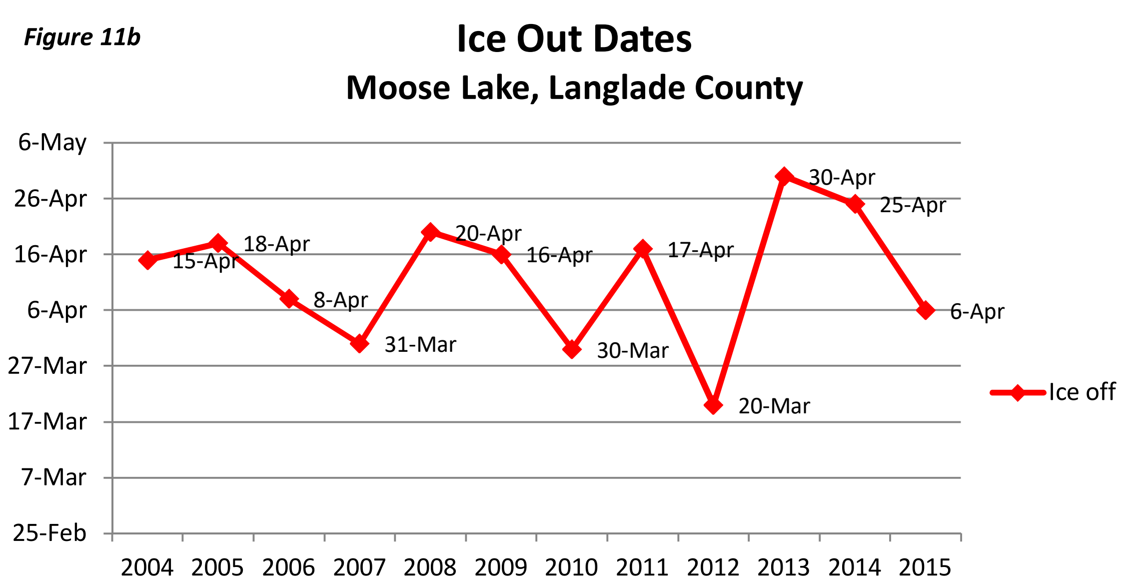


Figure 11b



Field Observations

Algae - During the 2015 field season, samples of algae were collected on two separate occasions and brought into the Rhinelander DNR office for analysis. The first sample was collected shortly following ice out on April 13, 2015 because there were unsightly mats of black/brown detritus floating on the surface of the lake (Figure 12). James Kreitlow, DNR Lakes Coordinator, analyzed the sample and found 28 algae genera, dominated by *Oscillatora* (a filamentous blue-green) and diatoms (*Cymbella, Gomphonema*) that are usually attached to plants that grow on lake bottoms. According to Kreitlow, one of two things may have happened: 1) Organic material from the lake was suspended within the water during fall turnover and frozen within the winter ice layer. Along with the water column movements of spring ice out, this material floated to the surface and the large unsightly surface mats resulted; or 2) Sheets of filamentous algae including *Oscillatora* (highly buoyant) and detritus from the lake bottom floated to the surface. However, this would typically occur around early June[1].

Figure 12. *Floating mats of algae and detritus blown into the boat landing area of Moose Lake; April 13, 2015*

Figure 13, *Left. Floating mats of algae on southern shore of Moose Lake; July 12, 2015*

The second algae sample was collected on July 12, 2015 along the southern shoreline, and again analyzed by James Kreitlow of the DNR. Kreitlow reported 30 different algae genera were present in the sample, but the majority of the sample consisted of filamentous green *Sirogonium* with some *Spirogyra* mixed in. These closely related algae typically grow in shallow areas amongst decaying vegetation. *Spirogyra* is frequently found in Wisconsin lakes, *Sirogonium* is less common. Other than for the unsightliness of the floating mats (Figure 13), there should be no health concern that these algae exist in the lake[2].

[1] *Email correspondence with James Kreitlow, Wisconsin Department of Natural Resources. April, 2015.*
[2] *Email correspondence with James Kreitlow, Wisconsin Department of Natural Resources. July, 2015.*

Aquatic Invasive Plants & Animals - There is a large population of the Chinese Mystery snail (*Cipangopaludina chinensis)* that exists in the Moose Lake ecosystem and were observed in high density as they washed up at and near the boat landing. Communications with John Pruess, Aquatic Invasive Species Coordinator for Langlade County confirmed that these observations are correct and that these species do appear to be a current problem in Moose Lake. One potential problem is that they may serve as vectors for the transmission of parasites or disease (DNR website). Once in the system, they are considered rather "benign" and there is little that can be done to rid them. The picture shown here is approximate size of the invasive snail. The snails feed non-selectively by scraping the lake bottom for bethic algae and diatoms. Other than the snails, no other invasive species were observed during the 2015 field survey.

5 – METHODS

The following section is a review of the various methods used to gather data and complete the comprehensive lake management plan assessments.

5.1 Development of Surveys

Social Survey

The consultant, in cooperation with the FOML comprehensive planning committee, drafted a social survey by using an example from a survey completed for Moose Lake at a previous time. The committee decided on what information to gather and which questions to include for the current survey. The goal was to develop a socially nonbiased and anonymous survey so that people could share open and honest communication about their Moose Lake concerns or comments. After several drafts were reviewed by a DNR Sociologist, the final approved document was completed. The survey was separated into easy to follow sections where the participant could give an opinion on each section that was pertinent to them. Appendix 2 shows the final 6 page blank document that was shared with the public.

Once the survey form was approved by a DNR sociologist, members of the FOML planning committee made copies and distributed the surveys to each residence around Moose Lake. They also made them available at the public boat landing kiosk for any lake user to take and complete at their leisure (*pictured at left*). Additionally, when FOML volunteers worked at the boat landing they encouraged lake users to fill one out and return it. A deadline date for survey returns was set for the fall of 2015.

Angler Diaries

Waterways, LLC developed a short written survey in order to collect current information about the fishery of the lake and to gain a perspective about the overall angler experience that occurs on Moose Lake (Appendix 3). The form was submitted to a DNR Fishery Biologist (D. Scholl) for comments, adjustments, and approval prior to its use. The FOML planning committee assigned volunteers (who were likely to fish the lake) that would fill out a form each time they fished on Moose Lake. Diary forms were filled out for one year starting in the spring of 2015 ongoing through the spring of 2016, so that summer and winter fishing experiences could be logged.

5.2 Lake Fishery

Fishery data used for this management plan was gathered by professional DNR fish management staff in 2002, more than ten years ago. At that time, the DNR conducted a comprehensive spring survey using fyke nets, followed by electro-shocking and mini-fyke net surveys. The DNR conducted another, less comprehensive survey of Moose Lake in 2009. It should be noted that new fishery data was not collected for this comprehensive management plan, but rather the 2002 and 2009 data, along with new information gathered from the lake user survey and from angler diaries, was assimilated into this report as reference material. At the time of this writing, WDNR fishery biologists had just conducted another complete population estimate survey on Moose Lake during April 2016, but the results were not yet available.

5.3 Citizen Lake Monitoring Network (CLMN) Activities

Water Level Monitoring CLMN

A brand new graduated water level gage was installed at a private property along the southwestern shoreline using the newest volunteer monitoring protocol for CLMN, Version 1, 2015. One volunteer collected water level readings as per the new protocol during open water throughout the project and data was added to the DNR SWIMS database.

Figure 14, above. Moose Lake volunteer and Waterways staff place a new water level gage into Moose Lake, Spring 2015.

Figure 15, right. Completed water level gage installation with the bubbles leveled as per the DNR protocol.

Water Quality Monitoring CLMN

Water quality data for Moose Lake has been collected by a citizen volunteer since 2010 using the protocols outlined in the Wisconsin Citizen Lake Monitoring Training Manual, Version 3. Data for all of the collection years are located in the Wisconsin DNR online SWIMS database.

5.4 Lake Water Quality

Field & Data Analysis Methods

Baseline water quality data was collected throughout the 2015 open water field season (April – October) as per the 2014 revised state protocol methods for long-term trend lakes. The following parameters were measured: Ortho Phosphate, Total Phosphorus, Total Kjeldahl N, Nitrate-Nitrite N, Ammonia NH3-N, Conductivity (Lab) UMHOS/CM @ 25C, pH (Lab), Alkalinity CaCo3, Chloride, Chlorophyll-a, Color, Total Hardness, Suspended Solids, Calcium, and Magnesium. The parameters and sampling schedule is available in Chapter 6, Table 14. Samples were taken at the deep hole location indicated for Moose Lake (20 feet) with an Integrated Sampler device from 0 to 6 feet in depth. For each of the sampling events, the boat was anchored to prevent drift. Lake transparency was recorded along with profiles of temperature and dissolved oxygen at 3 foot intervals using a Hach DO/Temperature Meter. Transparency measurements were taken with an 8 inch round black and white disk (secchi disk) that was weighted to reduce drifting within the water column.

Figure 16. *Hach dissolved oxygen and temperature meter*

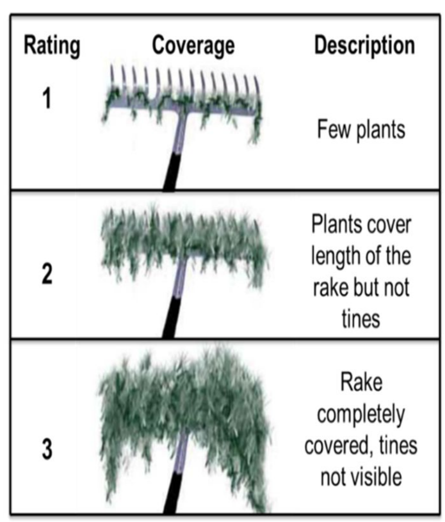
Sterile sample bottles were used for collecting the samples, acidified with nitric or sulfuric acid as appropriate for the specific laboratory analysis, kept dark and cool, and placed on ice as per shipping protocol. All sample collections were analyzed by the Wisconsin State Laboratory of Hygiene (SLOH) by standard methods outlined in *The Manual of Analytical Methods*, 1993.

5.5 Aquatic Plants

Field Methods

Field methods followed the standardized protocol developed by the Wisconsin Department of Natural Resources by Hauxwell et al. (2010), and the surveys were completed on July 24th and 25th, 2015. The WDNR generated a point-intercept map for Moose Lake resulting in 326 sample points (Appendix 4). The sample points were uploaded to a Garmin 76CSx GPS unit, which was used at 50 feet of resolution to navigate to each point. A double-sided rake head on a telescopic pole was used to sample each point <15 feet deep for aquatic plants, depth, and dominant sediment type (muck, rock, or sand). Sonar was used to gauge depth at points that were ≥15 feet deep and a weighted double-sided rake attached to a rope was used to sample aquatic plants. Sediment type was sometimes indeterminable at points where the rope-rake assembly was used. The rake

Figure 17. *Rake Fullness Rating illustration*



fullness rating for total coverage of plants on the rake and a separate rake fullness rating for each species present were recorded (Figure 17). Any survey points that were inaccessible were recorded as such and no sample was taken. Aquatic plants found within 6 feet of the sample point but not found on the rake were counted as visual observations. Occurrence of species greater than 6 feet from any survey point were recorded to note their presence as part of a boat survey, but were not counted in statistical calculations. These boat survey species were only recorded if their roots were in standing water. Plant identification was verified using Crow and Hellquist (2000) and Skawinski (2014).

Data Analysis Methods

Survey data were used to calculate statistics including Simpson Diversity Index, species richness, Nichols (1999) Floristic Quality Index, frequencies, rake fullness and number of visual sightings among other summary statistics. The "Aquatic Plant Survey Data Workbook" was downloaded from the UW-Extension Lakes webpage[1] and the spreadsheet was populated with data collected from Moose Lake. Per guidelines in Hauxwell (2010), species that were recorded as visuals (i.e., within 6 feet of a survey point but not sampled with the rake) were not included in Simpson Diversity Index and FQI calculations. Also, filamentous algae data were not used in any statistical calculations but were collected to gauge its frequency throughout the lake.

Summary Statistics

Summary statistics provide a general overview of the plant community and can be used to compare Moose Lake to other lakes in the region or state. Floristic Quality Index (FQI) is summarized in Table 5, but elaborating on this metric developed by Nichols (1999) is worthwhile. Aquatic plant species native to Wisconsin have a Coefficient of Conservatism (C) ranging from 0 to 10. The C value estimates the likelihood of that plant species occurring in an environment that is relatively unaltered from pre-settlement conditions. As human disturbance increases, species with a lower C value occur more frequently while more sensitive species with a higher C value occur less frequently. To calculate floristic quality, the mean C value of all species found in the lake is multiplied by the square root of the total number of plant species in the lake. Only plants found on the rake are included in the calculations. In other words, the FQI metric helps us understand how close the aquatic plant community is to one of undisturbed conditions. A higher FQI value assumes a healthier aquatic plant community. Floristic quality values can be compared on a statewide value, but Nichols (1999) recommends comparing values within one of the four ecoregional-lake types.

Individual Species Statistics

Individual species statistics assess the plant species composition in Moose Lake and allow for comparisons of the plant community within the lake.

Relative frequency values are particularly helpful because they consider the number of times a particular species is found divided by the total number of times vegetation occurred.

[1] http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/ecology/aquaticplants/default.aspx

Map Development – Aquatic Plants

Aquatic plant survey data were uploaded to an open source geographic information systems (GIS) program known as QGIS (QGIS, 2015). Maps were created to illustrate depth ranges, sediment type, total rake fullness for all species, and individual plant species distribution.

Table 5. Summary Statistics Explanation

	Summary Statistic	Explanation
1	Total number of sites visited	The total number of sites sampled, which is not necessarily equal to the number of survey points because some sites may not be accessible or are too deep.
2	Total number of sites with vegetation	Number of sites where at least one plant was found on the rake (does not include moss, sponges, algae, or liverworts).
3	Maximum depth of plants	Depth of deepest site where at least one plant was found on the rake (does not include moss, sponges, algae, or liverworts).
4	Total number of sites shallower than maximum depth of plants	Number of sites where depth was less than or equal to the maximum depth where at least one plant was found on the rake.
5	Frequency of occurrence at sites shallower than maximum depth of plants	Total number of sites with vegetation (2) / Total number of sites shallower than maximum depth of plants (4).
6	Average number of species per site (split into four subcategories)	a) Shallower than maximum depth – the average number of species found per site at sites less than or equal to the maximum depth where at least one plant was found on the rake (4).
		b) Vegetated sites only – the average number of species found per site at sites where at least one plant was found on the rake (2).
		c) Native species shallower than maximum depth – Same explanation as 6(a), non-native species excluded from average.
		d) Native species at vegetated sites only – Same explanation as 6(b), non-native species excluded from average.
7	Species Richness (split into two subcategories)	a) Total number of species found on the rake at all sites (does not include moss, sponges, algae, or liverworts
		b) Including visuals – Same explanation as 7(a) and including visual observations within 6 feet of the sample sight
8	Simpson Diversity Index	Estimates the heterogeneity of a community by calculating the probability that two individuals randomly selected from the data set will be different species. The index ranges from 0-1, and the closer the value is to one, the more diverse the community. Visual observations (within 6 feet of sample point) are not included in calculation of index.
9	Coefficient of Conservatism (C)	This is not a statistical calculation, but rather a value assigned to each plant species based on how sensitive that species is to disturbance. C values range from 1 to 10 with higher values assigned to species that are more sensitive to disturbance (Nichols, 1999).
10	Floristic Quality Index	How similar the aquatic plant community is to one that is undisturbed (Nichols, 1999). This index only factors species raked at survey points and does not include non-native species. The FQI is calculated using coefficient of conservatism (C) values (9).

Table 6. Individual Species Statistics Explanations

	Individual Statistic	Explanation
11	Average Rake Fullness	Mean rake fullness rating ranging from 1 to 3. See Figure 17.
12	Number of sites where a species was found	The total number of survey points where a particular species was found on the rake.
13	Number of visual sightings	The total number of times a particular species was visually observed within 6 feet of a sampling point, but not collected on the rake
14	Frequency of Occurrence (split into two subcategories	a) Among vegetated sites only – The number of sites at which a particular species is found on the rake divided by the total number of vegetated sites (Table 5, #2)
		b) Among sites shallower than the maximum depth of plants – The number of sites at which a particular species is found on the rake divided by the total number of sites less than or equal to the maximum depth of plants (Table 5, #4)
15	Relative frequency (%)	This value represents the degree to which a particular species contributes to the total of all observations. The sum of all relative frequencies is 100%.

5.6 Shoreland Assessment

Protocol Development

Protocols from both the existing National Lakes Assessment (US EPA, 2009) and the Wisconsin Sensitive Area Survey were combined to create the Shoreland Habitat Assessment information collection form for this project. It should be noted here that the newest state protocol for shoreland assessment was under construction at the beginning of this project and was not ready to be utilized at the time of the survey. Shoreland data that was gathered during this process were separated into sections as follows: Section 1) *General Information*; Section 2) *Riparian Terrestrial Zone*; Section 3) *Shoreline Transition Zone*; Section 4) *Littoral Zone*; and Section 5) *Critical Habitat Summary*. Evaluation zones were defined as follows: the *Riparian Terrestrial Zone* includes the area that starts 5 feet above the waters' edge to a visual endpoint of approximately 35 feet upland. The *Shoreline Transition Zone* includes 5 feet above the waters' edge to where water meets land. For purposes of this survey, the *Littoral Zone* was defined as where water meets land to approximately 20 feet lakeward. A blank template of the Shoreland Habitat Assessment form that was used to collect shoreland data is available in Appendix 5.

Field Assessment

An on-lake visual assessment of the shoreline was conducted by Waterways staff. Prior to the assessment, a parcel map of Moose Lake was printed off of the Langlade County Land Records and Regulations Department website[2] to give perspective as to site start and end points. After each site location start and end points were identified, each of the zone sections on the assessment form were filled out and completed. For each new site, a new data collection form was completed, and twenty-six sites around the lake and spring areas were assessed. Each site was an approximate length of 300 feet and the site start and points were noted on the county parcel map. Important: Because the habitat was so similar throughout the entire Moose Springs area, it was identified in its' entirety as one site.

Data Scoring

Assessment scores were compiled and a total score was calculated for each of the 26 sites around the lake. Separations in scores were analyzed for significant breaks or changes, and the most notable separations were as follows: 0 to 8 points; 12 to 19 points, and 27 to 31 points. The consultant selected these significant breaks (between 8 and 12, and between 19 and 27) for setting low, medium, or high disturbance areas along the shoreline of the lake. Low scores represent least disturbed areas and higher scores represent shoreland areas perceived as higher in human disturbance. Shoreland scoring was completed by one person to maintain consistency and points were allotted as shown in Table 7.

[2] http://langladecowi.wgxtreme.com/

Table 7. Score allotments for Shoreland Assessment

RIPARIAN TERRESTRIAL ZONE	0 Points	1 Point	2 Points	3 Points	4 Points
Human Influence	No	Structure	Lawn	Pavement	Crops
		Landscaping			Bare Soil
Ground Cover	75 - 100%	51 - 74%	26 - 50%	0 - 25%	
Soil Erosion	No	Low	Moderate	Severe	
Visible Pollution	No	Trash	Yard Waste	Oil Grease	
SHORELINE TRANSITION ZONE	0 Points	1 Point	2 Points	3 Points	
Human Influence	No	Pier	Boat Ramp	Seawall	
		Beach		Riprap	
		Boathouse			
Bank Erosion	No	Low	Moderate	Severe	
Bank Steepness	Flat	Gradual	Steep	Vertical	
Invasive Species	No	Each = 1pt			
LITTORAL ZONE	0 Points	1 Point	2 Points		
Human Influence	No	Pier	Boat Lift		
		Beach			
		Raft			
Bottom Substrate	Gravel	Muck			
	Rock	Sand			
Macrophytes	Yes	No			
Invasive Species	No	Each = 1pt			
Algae	No	Filamentous	Surface Scum		
		Water Column			
Fish Cover		No			
CRITICAL HABITAT SUMMARY	0 Points	1 Point	2 Points		
circle all that apply	9 - 12	5 - 8	0 - 4		

Map Development – Shoreland Assessment

The shoreland assessment map was created manually by the consultant in Microsoft Paint. An aerial photo map of Moose Lake was utilized to mark disturbance areas around the lake. Low, medium, and high areas of disturbance were color coded as green, yellow, and red respectively. The corresponding color for each site score was then drawn neatly onto the aerial map so that human disturbance levels would be easily identified for each site.

5.7 Watershed Assessment

The Moose Lake drainage area was delineated and illustrated using the Long Term Hydrologic Impact Analysis (L-THIA) Watershed Delineation model (Purdue University Agricultural and Biological Engineering), which used spatial runoff analysis to calculate the drainage area and all percentages of various landuse within the watershed. Information captured during this process was then utilized for further modeling by the Wisconsin Lake Modeling Suite (Panuska and Kreider 2003).

6 – DISCUSSION, RESULTS, & DATA ANALYSIS

6.1 Lake User Survey

A clear understanding of how the lake is used and perceived by riparian residents and visitors is essential for lake management efforts to be efficient, effective, and meaningful. For this purpose an unbiased social survey of lake-users was incorporated into this study. Seventy two surveys were distributed widely during the summer of 2015, and a total of 58 were completed and returned by October of the same year. Both public lake users and riparian property owners were given the opportunity to complete the survey. Honest opinions were encouraged by keeping the participants anonymous, and no names were identified on the returned surveys.

Participants were guided through the survey and answered questions that were relevant to their personal experience on Moose Lake. The survey contained seven distinct sections as follows: 1) How familiar the participant was with the lake; 2) How they enjoy the lake; 3) If they were familiar with the Moose Lake fishery; 4) Their perception of the lake water quality; 5) Their knowledge of aquatic invasive species; 6) What concerns they have about the lake; and 7) Their knowledge about the lake association. A summary of results to all of the questions are compiled and included in Appendix 6 while only some are discussed here.

Table 8. *Summary results from lake user survey question 1.*

Q1	Total	%
Visitor / Guest	23	40
Property Renter	2	3
Property Owner	33	57
TOTAL	58	100

Results show that survey participants represent mostly those who own property on the lake (Table 8). Most interesting is that the large majority have a lot of experience on Moose Lake and had first visited or spent time there better than 15 years ago. Of those respondents who own property around the lake, most utilize their property seasonally and 13 persons indicated that they utilize their property as a primary residence. Some of the families who own property around Moose Lake have been there for multiple generations and have passed the property onto additional family members.

Enjoyment on or around Moose Lake takes many forms - from highly energetic activities to relaxation and solitude. Participants ranked their top 3 activities, and the results are shown in Figure 18. Most people just like the relaxation and solitude aspects of living on or visiting the lake, as this was selected the number one activity and ranked as the top priority. Not surprising, the other top important activities that people enjoy on the lake are nature viewing, fishing, and boating (particularly kayaking or canoeing).

Forty-five of the respondents indicate that they have enjoyed the opportunity of fishing Moose Lake over the years, and 35 indicated that they have fished the lake relatively recently in the last five years. Bluegill, Crappie, and Largemouth Bass are the fish most often targeted by those that fish the lake, but by far, Bluegill is the species caught most frequently. Respondents indicate that the practice of catch and release is most often utilized by people that fish Moose Lake and overall, most think that the fishing quality is fair to good (Figure 19). Although as the years have passed, most indicate that the fishing has changed for the worse.

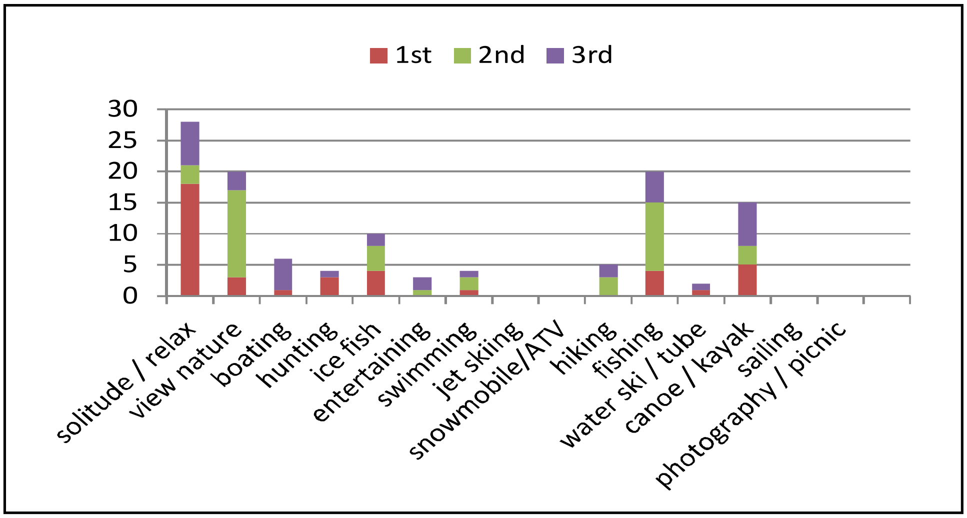


Figure 18. *Activities enjoyed on or around Moose Lake, ranked as first, second, or third priority.*

Figure 19. *Survey response to the quality of fishing on Moose Lake.*

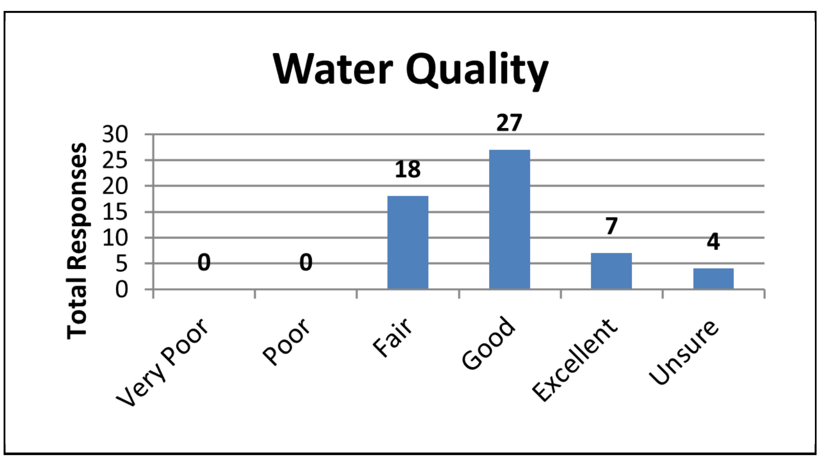


Figure 20. *Survey response to perceived water quality of Moose Lake.*

Table 9. Summarized results for Question 22 of the lake user survey.

Q22	Total
Rusty Crayfish	16
Curly-leaf pondweed	1
Purple loosestrife	5
Zebra mussel	2
Spiny waterflea	1
Eurasian water milfoil	2
Carp	2
Chinese mystery snail	8

Water quality on Moose Lake is perceived by lake users as fair to good (Figure 20). Respondents also think that since they first visited the lake, the water quality has stayed the same or has declined over time. It is important to note here that the written comments about quality indicate people associate water quality with "clarity".

Prior to the lake user survey, most respondents had already heard about the existence of aquatic invasive species. However, when asked if they were aware of any type of invasive species in or around the shoreline of the lake, the responses were split; 13 said "yes", 13 said "not sure", and 29 responded with a definite "no". Those that responded with a yes or not sure were asked to further identify what they thought was in or around Moose Lake. Table 9 shows the summarized responses for what species were thought to be present. It is uncertain if the question was interpreted correctly because 37 people responded and only 26 had indicated yes or not sure in the previous question.

A large listing of the more common lake user concerns were given (Figure 21) and the top 3 that survey participants identified most were: 1) Lake Bottom Siltation, 2) Algae Growth, and 3) Aquatic Plant Growth. Following a close fourth on the list of top concerns was Fishing Pressure. This information is useful for FOML to have because they can plan future education programs, meetings, speakers, and possible management actions to alleviate these concerns for their members

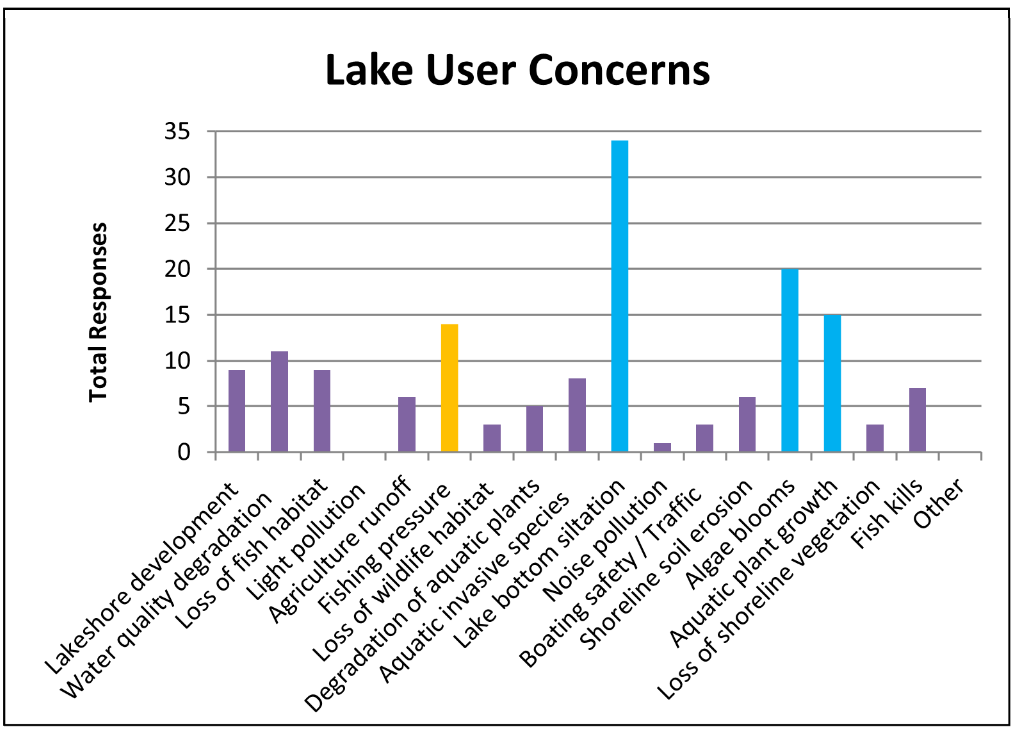


Figure 21. *Summarized results for Question 24 of the lake user*

Table 10. Summarized results for Question 27 of the lake user survey.

Q27	Support	Neutral	Oppose	Unsure
Chemical Treatment	7	5	17	12
Biological Control	24	4	6	9
Hand Pulling	28	3	0	9
Combination	34	8	0	10
Do Nothing	1	2	23	6

and the concerned public. Aquatic plants and blooms of algae were identified as being a typical nuisance to ones' enjoyment of the lake. And therefore, it was not surprising to see that most respondents were in agreement that some kind of aquatic plant management action or control may be necessary in the future. It was identified further in the survey that many were opposed to or unsure of chemical treatment of the problem (Table 10), where the opposite was true for less invasive management techniques such as biological control or hand pulling of plants. Often, management of aquatic plants and/or algae requires a combination of responsible techniques, and many of the respondents indicated that they would support this approach if necessary. It was clear that most people agreed some kind of management program does need to proceed because 23 people responded that they would oppose the "Do Nothing" option.

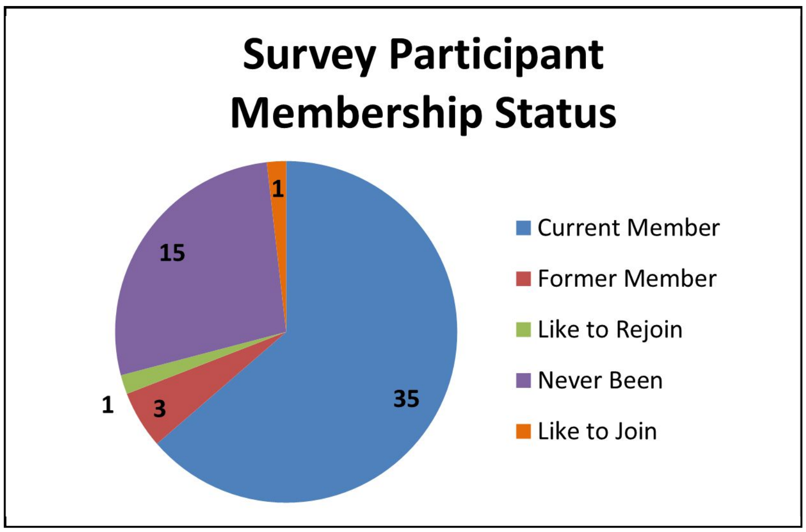


Figure 22. *FOML membership status of those who participated in the lake user survey*

Most survey participants had heard of the Friends of Moose Lake (FOML) association prior to taking the survey, as 35 of the 58 total respondents were current members at the time of the survey (Figure 22). Persons were encouraged to contact the association President if they wanted to join or rejoin the association. The majority of people indicated that the current association board of directors keeps them informed about association news, lake events, and social events and only a few did not feel this was the case. When shown a listing of lake education topics, the top 3 topics of interest that lake users want to learn more about were: 1) Shoreline Restoration; 2) Human Impacts on Lakes; and 3) Aquatic Invasive Species. Learning about water quality monitoring and how invasive species spread from lake to lake were topics of higher interest as well.

6.2 Angler Diaries

An Angler Diary was included as part of this project in order to systematically collect fishing data over all seasons of the year, and to better understand the experiences that anglers are having on Moose Lake. Participants of the lake user survey identified the quality of the fishery as "Fair –

Good" (Section 6.1 above). The focus of the Angler Diary instead was to ascertain the overall fishing experience of the angler, regardless of whether they were frequent users or infrequent guests on Moose Lake.

The Angler Diaries were distributed during the spring of 2015, and data on individual fishing events were logged for an entire year until the spring of 2016. Many were encouraged to participate in the journaling exercise following each fishing trip they experienced and a total number of 96 angler surveys were returned and evaluated. A blank collection form is available in Appendix 3 to see all questions that were asked of participants.

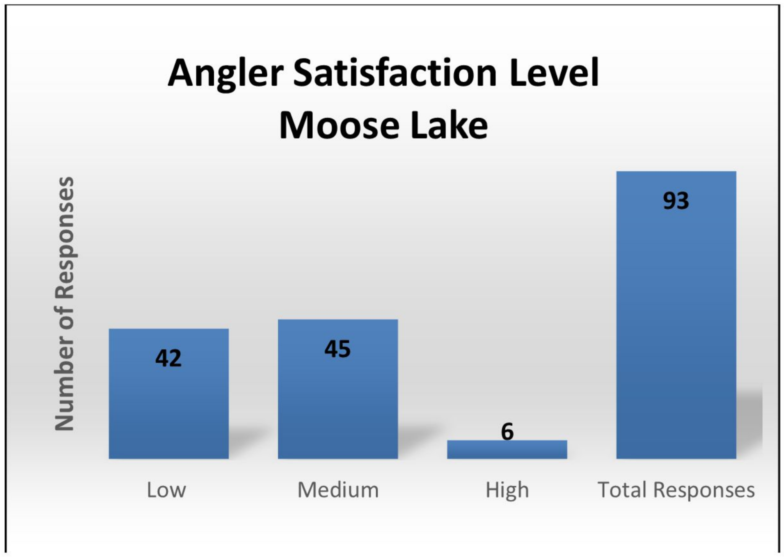


Figure 23. *Satisfaction levels that anglers experienced during individual fishing trips on Moose Lake from spring of 2015 through spring of 2016.*

Angler diary participants were asked to evaluate the satisfaction level of each fishing experience and the responses are displayed at right. Most angling experiences were perceived as medium on a 3 tier satisfaction scale, followed closely by low satisfaction levels. Only 6 of the 93 total angling experiences were ranked as highly satisfactory. In evaluation of this data, one can only speculate that an angler's personal satisfaction during a particular trip out on the lake was tied mainly to how many fish were caught, if the targeted species was captured, or if good sized fish were caught. Other factors may have influenced an individual's experience on any given trip, for example if they had good companions or if the day's weather was particularly enjoyable (or unenjoyable).

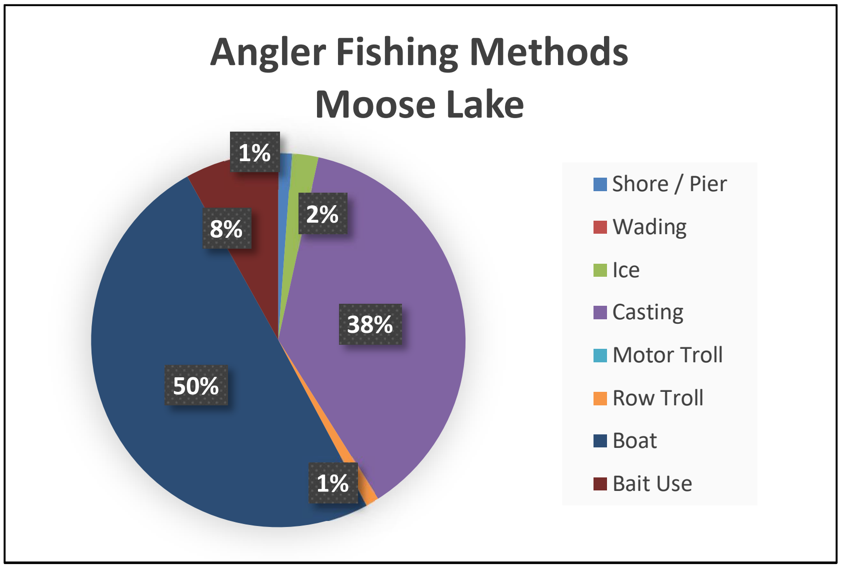


Figure 24. *Methods of fishing utilized on Moose Lake by journal keepers during 2015 – 2016.*

The collection of angler information journals was also incorporated into this project to gather additional fishery data that will augment the periodic collections from the Wisconsin Department of Natural Resources. Angler Diaries should continue long after a project like this is complete because the more data collected by different participants over time, the better the scientific value the data will have. Scientists can use this data to monitor the general size distribution of fish caught during angling, the species of fish that are typically sought by anglers, the catch per unit effort, catch and harvest rates, what style of fishing is typical for Moose Lake anglers, and if catch and release behaviors are being incorporated into the fishing experience.

The diaries indicate that casting artificial lures from a boat was the most common method used by anglers to seek their catch. There was equally small amounts of row trolling and fishing from a shoreline or pier (both 1%), and a small number of diaries were returned over winter during the

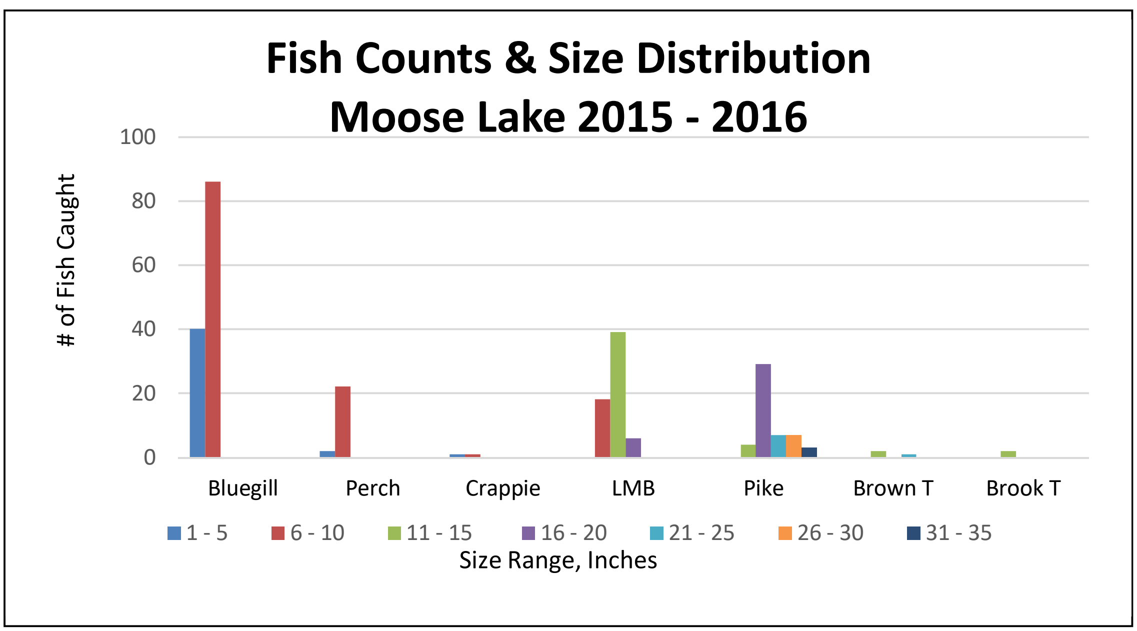


Figure 25. *Total numbers of fish captured by angler diary participants separated by size categories in Moose Lake, Langlade County.*

ice fishing season (2%). During the summer months, 8% of the participants utilized bait to catch fish, as Figure 24 illustrates.

Figure 25 shows the number of species caught by anglers and the size distribution of the catch between spring of 2015 and 2016. Out of 96 total diaries returned over the course of one year, there were only 20 instances that anglers reported “no bites”. Bluegill, Largemouth Bass (LMB), and Northern Pike are the species most frequently sought after by anglers on Moose Lake, so it stands to reason that Bluegill followed by Largemouth Bass (LMB) and Northern Pike (Pike) are most frequently captured. From the counts and size distribution of the fish caught over the year, it appears that only certain year classes of fish are thriving in Moose Lake, and some of the species do not have high numbers in the population. Bluegills fit mostly into the 6 to 10 inch size category, LMB mostly into the 11 to 15 inch size range, and Northern Pike are frequently of the 16 to 20 inch size range. However, some anglers did find some nicer sized Northern Pike in the 31 to 35 inch range, and a Brown Trout between 21 and 25 inches, but these were rare. The estimated total number of hours that diary participants spent fishing for any given species is illustrated in Figure 26. This is just an estimate because only 83 of the diaries included number of fishing hours information on the form.

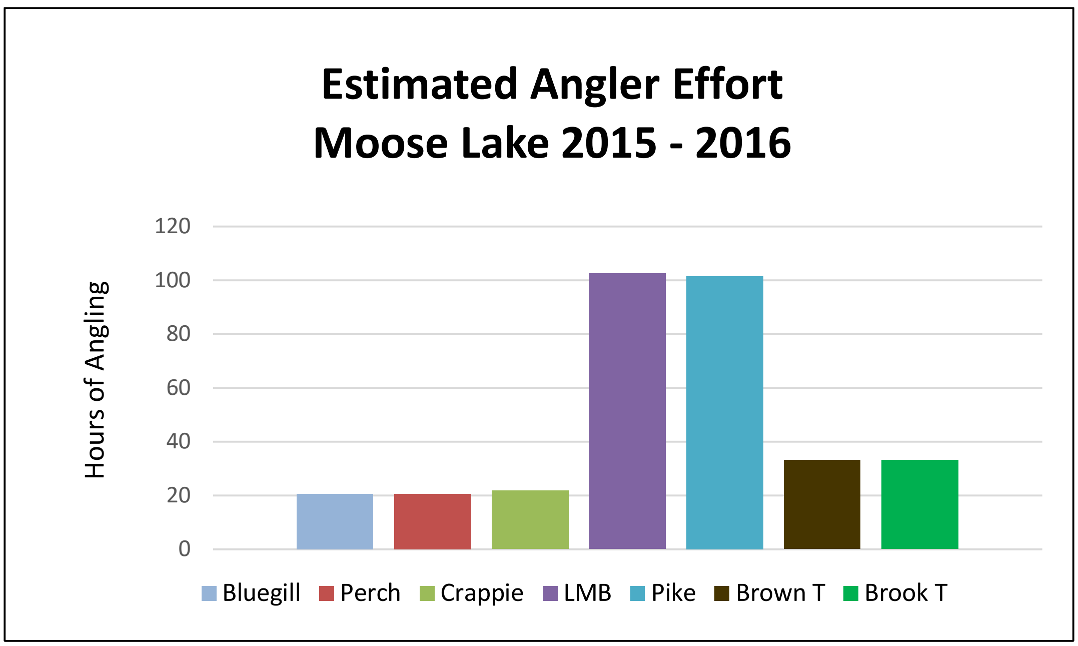


Figure 26. *Estimated amount of time that anglers took to fish for the given species.*

6.3 <u>Lake Fishery</u>

Moose Lake holds a wide variety of fish species including northern pike, perch, largemouth bass, black crappie, bluegill, pumpkinseed, black bullhead, brook and brown trout, white sucker, creek chub, golden shiner and common shiner (WDNR website). Trout are found in the deeper and colder water of the Moose Springs located at the western end of the lake. For generations, Moose

Lake has enjoyed a good fishing reputation and is known to be a very popular destination for recreational fishing all year round.

Fishery Food Chain & Energy Flow

When examining how a fish population is sustainable within a waterbody, we must understand the flow of food and energy. In a lake ecosystem, it is the large predator sport fish populations that hold the top position of the biological food chain. The population has an underlying support system that, when healthy, can support a healthy fishery. Food chains in any ecosystem are fragile biological balancing acts that ultimately drive the animal populations. The energy biomass of any individual tier of a food chain is determined by the biomass of all the other tiers. This concept is called "energy flow". When the fragile food chain of a lake ecosystem becomes disturbed or unbalanced, we can often pinpoint the underlying problem(s) within the dynamics of energy flow and the food chain.

For purposes of describing a simple lake food chain, imagine the shape of a triangle with the top tier of the food chain located at the tip of the triangle, and the bottom tier of the food chain located at the widest part of the triangle. It is difficult to describe the food chain without also discussing how energy travels through the system. As we move up toward the top of the triangle, more energy is required to sustain a given population. Figure 27 illustrates this principle. Animals located at the top of the triangle require significantly more energy than the same number of organisms at the bottom. Larger sport fish species (piscivores) such as Northern Pike, Largemouth Bass, and Trout hold the very top position of the food chain in Moose Lake and in Moose Springs. Moving down on the triangle are the smaller fishes (planktivores) such as Yellow Perch, Bluegill, and Crappie. The next two tiers down the triangle are the zooplankton (herbivores) and the phytoplankton (primary producers). Small green algae cells are the primary food producers in any lake ecosystem. Algae growth begins by the harnessing of energy from the sun along with available nutrients (Phosphorus and Nitrogen) in the water column which drive photosynthetic reactions. It makes sense then that the amount of available nutrients in the water column is the determining factor in the amount of primary

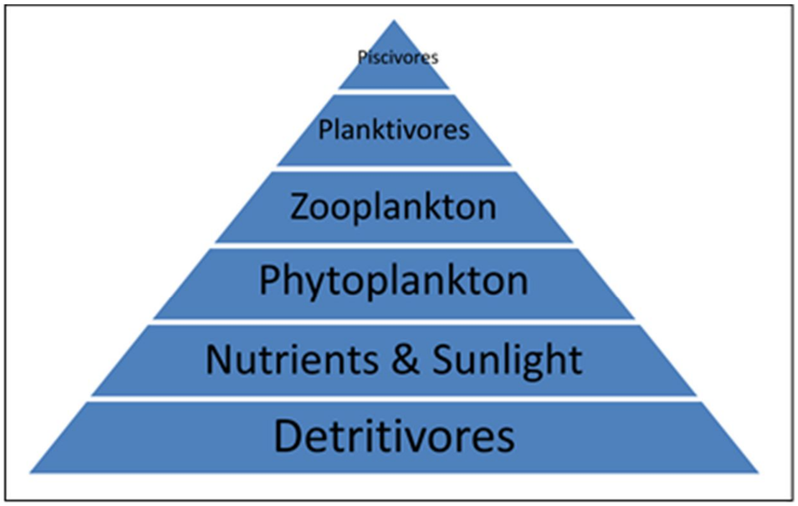
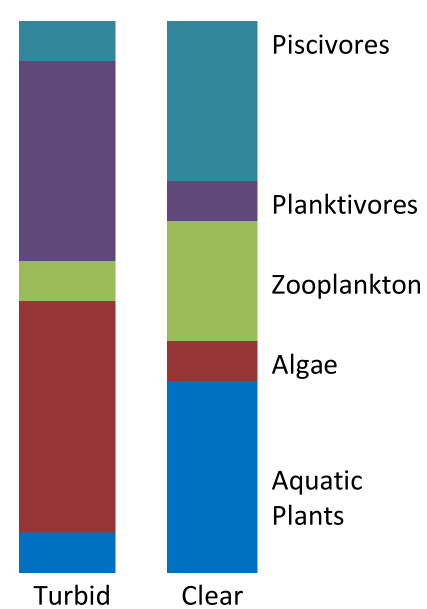


Figure 27. *The food chain and energy flow of a lake ecosystem.* Adapted from Water on the Web.

Figure 28. *The makeup of the aquatic food chain in turbid and clear lakes.* Adapted from Water on the Web



production that can occur. The primary producers provide food for herbivores and oxygen for all the animals. The bottom sediments of a lake hold the benthic organisms (Detritivores) like bacteria that eat away at dead sunken organic matter. As they live and feed, these bottom dwelling organisms use up available dissolved oxygen in the process of respiration. Figure 28 illustrates how slight changes in the makeup of an aquatic ecosystem food chain can affect how clear or turbid the water appears in that system. Moose Lake appears very clear, so it is likely that the makeup of the food chain within the system is similar to that which is shown on the right side of the figure.

Fishery Habitat

The success of a fish population depends largely on the habitat and environment that the population is exposed to the majority of the time. That is why it is so important for fish biologists to manage lakes to the highest attainable quality for all species of fish that are present in a given ecosystem. Schupp (1992), states that a lake fishery is a very reliable indication of the overall health and water quality of the system. Trout species in particular have very specific and critical needs in the lake environment in order to sustain the population. They have a need for cold (50 – 65 degrees Fahrenheit) and highly oxygenated water. Members of the sunfish family, like Bluegills, are more tolerant of a wider range of conditions, but still need clear and clean water in good condition in order to survive in large numbers. These conditions are met in some mesotrophic lakes, such as Moose Lake at most times throughout the summer.

Besides the physical needs for reproductive purposes, the entire lake fishery also require adequate forms of food, cover, structure, and edge habitat in order for populations to thrive. Fish tend to cluster where food resources are plentiful. For smaller fish, invertebrates will be their food target. Downed wood and other structure are a perfect area for invertebrates, and these are the areas where small fish will concentrate. Where the small fish can feed is typically where the larger fish will take advantage and hide in wait to grab a meal. Cover and structure in lakes are very important to the survival of most fish species because of the role it plays in predator / prey relationships. Some species of fish literally spend most of their lives near or under cover, and only move out to feed. Things like aquatic vegetation, downed or overhanging trees, artificial habitat, or large rocks all serve as cover for fish. These areas can also provide much needed shade protection from the hot sun during the course of the summer. Edges in lakes are also considered structure and are great habitat to find fish living out their lives. Edges are places like a depth drop off which provides some cover for larger fish, a transition zone between different types of habitat, a place of temperature or oxygen variation, or the margin of a weed bed.

Panfish Regulation Study

Fisheries Biologists from the Wisconsin DNR are trying to come up with a feasible panfish management approach to increase the size of individual fish that anglers catch throughout Wisconsin. Why are they doing this now? Because many lakes in Wisconsin are suffering from high numbers of small sized panfish. Following the 2015 spring Natural Resource hearings, the WDNR solicited public input throughout Wisconsin on a proposed panfish regulation research project, and overall the proposal received positive public feedback. Moose Lake was one of 8 lakes in Langlade County and 94 statewide that are participating in the research project to potentially improve the size of individual panfish. There were 3 scenarios of regulation proposed for the study as listed here:

Proposed Study Regulations:
25/10 *- a total of 25 panfish but no more than 10 of any one species.*
15/5 *- a total of 15 panfish but no more than 5 of any one species.*
15/5 Seasonal *- a total of 15 panfish but no more than 5 of any one species during May and June, 25 panfish in total the rest of the year.*

The 94 study lakes throughout the state were then randomly assigned a regulation from the list above, and Moose Lake was assigned to the *15/5 Seasonal* scenario. The study regulations will go into effect in 2016 on selected lakes and run through the 2021 fishing season, when fishery biologists will conduct initial evaluations of the regulations after five years. For more information about this research project, refer to the factsheet in Appendix 7.

Fish Kills

Fish kills are common and natural phenomena in Wisconsin lakes that are caused by oxygen deprivation. The underlying cause of the low oxygen level is the variable factor. One example of how oxygen levels may sink below a normal range is in shallow lakes. Shallow lakes may naturally have fluctuations of dissolved oxygen due to higher aquatic plant populations and mucky bottoms. In this type of environment, when the plants die off, biological respiration activity (oxygen consumption) is very high. The types of fish that populate systems like these can normally live within a wide range of dissolved oxygen levels and are able to live through normal fluctuations. If the springtime thaw is delayed due to prolonged winter weather, prolonged ice/snow cover may prevail and oxygen levels may plunge lower yet, beyond the range that certain species need for survival (WDNR Website). Often, the kills do not wipe out an entire species of fish and there are usually a fair number of strong survivors in the population.

Moose Lake experienced spring warm-water species fish kills in 2014 and 2015. Bullhead, bass, bluegill, and crappie populations were affected in these kills. The underlying cause of the kill was confirmed to rise from a naturally occurring bacteria called ***Columnaris*** (D. Seibel verbal communication). In the spring of the year, when water temperatures begin to rise between 60-70 degrees Fahrenheit, spawning activity begins and can take a physically demanding toll on an individual fish. High energy is expended during the act of spawning in the shallows which suppresses a fish's immune system. When this happens, the fish is ripe for contracting an infection.

Concurrently, *Columnaris* bacteria populations in the shallow waters begin to thrive at those very temperatures at a time when nutrient levels in the shallows have increased following spring thaw. If the bacteria thrive at high levels, two things are likely: 1) An infection outbreak of the lake's spawning fish population; and 2) Respiring bacteria are consuming oxygen at a greater rate. During an outbreak, the gills of the individual fish develop lesions and normal oxygen absorption is impeded, causing many of the fish to suffocate.

Figure 29. *Lesions on gills of a fish with Columnaris infection.* WDNR website

Mixed Warm-water, Cool-water, & Cold-water Fishery

Moose Lake and the Moose Springs areas are connected by a shallow channel. This is where the similarities end. There is a variation in temperature between the two waterbodies, which allow two of the top tier sport fisheries (cool-water vs cold-water species) to coexist in a somewhat harmonious fashion. There is some crossover between the populations because of the channel opening, and it is likely that small trout that make it over to the "big lake" become prey for larger cool-water fish. The Moose Springs area can be described as a cold-water fishery and Moose Lake proper is managed as a warm-water fishery system by the DNR, even though it supports cool-water species like northern pike.

Moose Lake has a maximum depth of 20 feet, but it successfully supports populations of both brown trout and brook trout. Most of the trout are found in the deep holes of Moose Springs on the west end of Moose Lake. This would be the case because the very clean and clear water welling up from the groundwater springs would be cold and would support higher levels of dissolved oxygen that trout species require. Brown Trout thrive best in water temperatures between 65-75 degrees Fahrenheit, where Brook Trout prefer temperatures between 53-57 degrees Fahrenheit. Trout populations also have a specific tolerance level for dissolved oxygen concentrations at or above 6 mg/L. If these conditions are not met, cold water species are forced to seek oxygen wherever they can find it, thus, smaller trout may be placed at peril and forced in with larger predators.

Displayed below are the dissolved oxygen readings through the 2015 field season taken at the deep hole of Moose Lake. Oxygen levels remained high throughout the water column most of the season and trout congregate to areas around the lake that meet their needs. However, the deep holes of the spring pond provide the best environment for the trout because of the constant up-welling of cold oxygenated groundwater that best serve the physiological needs of the trout population.

Table 11. *Dissolved oxygen (milligrams/Liter) readings taken during the 2015 field season in the deep hole of Moose Lake*

2015	12-Apr	14-Jun	12-Jul	16-Aug	10-Oct
Depth (Ft)	DO mg/L	DO mg/L	DO mg/L	DO mg/L	DO mg/L
0	13.59	11.26	15.18	11.83	9.81
3	13.77	11.47	14.84	11.95	9.94
6	13.72	10.51	17.79	11.67	10.16
9	13.64	10.22	16.91	13.98	10.1
12	13.58	5.29	12.44	6.81	9.67
15	13.67	2.19	13.3	5.53	11.03
18	13.31	0.79	11.75	2.4	5.57

Fish Stocking

Starting back in 1938, Moose Lake was stocked with thousands of trout almost every year until 1967 when this management activity stopped. The stocking records in Appendix 8 indicate that all size classes of rainbow, brook, or brown trout were stocked, depending on the year. There were only a few gap years where no stocking activity took place. The last of the fish that were stocked, likely survived into the mid 1970's. It is important to note that any of the brook and brown trout that remain in Moose Springs today result from natural reproduction in the system and not from stocking management efforts.

WDNR Fishery Surveys

In comprehensive lake management planning, it is important to understand a lake's fishery, as it is a large piece of a healthy lake ecosystem and in the case of Moose Lake, an integral piece of recreational enjoyment. It is important to note that no new fishery data was collected for this report, but rather existing WDNR fish survey data was compiled to provide a summary condition of the fish population. A comprehensive fish population estimation survey was completed by the Wisconsin DNR in 2002 and another took place in the spring of 2016, during the drafting of this document. In addition, a spring electroshocking survey of the population took place in 2009. State fishery surveys are conducted for a variety of reasons, for example: 1) to have a baseline of fish data to identify existing species and compare changes in their composition over time; 2) to set angler bag limits or size restrictions for cold, cool, and/or warm-water fish species; 3) to assess the panfish population for the on-going panfish regulation study; or 4) to survey for presence or absence of fish diseases or invasive species.

The summary results from the 2002 WDNR comprehensive fish population survey on Moose Lake are displayed in Table 12. The main objectives of these extensive surveys are to estimate species abundance and size structure of the populations and to screen for the presence or absence of diseases or invasive species (Written communication D. Seibel, WDNR Fisheries Biologist). The DNR captured 24 different species of fish, and all fell within expectations for population numbers and size structure. According to Seibel, all species of fish in Moose Lake proper are doing very well in both size structure and population numbers. The fish look to be thriving and healthy. Bluegill are the most abundant panfish followed by black crappie, yellow perch, yellow bullhead, and pumpkinseed. Trout that had moved over to the big lake, were also sampled in the survey and displayed a healthy size structure. Seibel indicated that the breakdown of species numbers and abundance in the 2009 WDNR survey had very little noticeable change from the 2002 survey that is summarized in the table.

Table 12. *Summarized results of the 2002 WDNR Comprehensive Fishery Survey for Moose Lake, Langlade County.* Provided by D. Seibel, WDNR

Water: Moose Lake   Gear: Fyke Nets & EF
Year: 2002   Effort: N/A

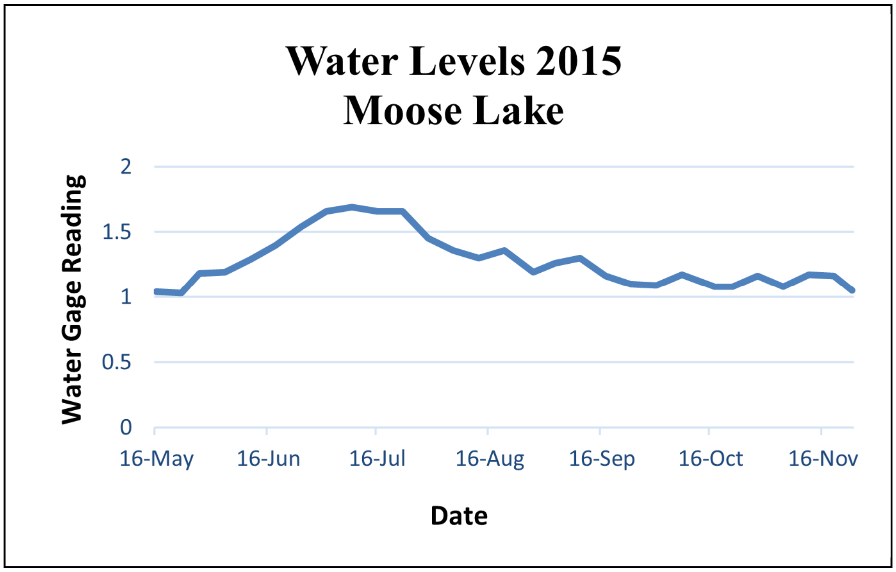
	Early Fyke		Boom EF		Panfish Fyke		Mini Fyke					
Species	Measured	Counted	Measured	Counted	Measured	Counted	Measured	Counted	Total Measured	Total Counted	Totals	%
Northern Pike	114	0	29	0	8	1	0	0	151	1	152	1.2
Grass Pickerel	0	0	1	0	0	0	1	0	2	0	2	0.0
Largemouth Bass	64	0	258	0	25	0	314	355	661	355	1016	8.0
Brook Trout	9	0	0	0	1	0	5	0	15	0	15	0.1
Brown Trout	7	0	4	0	0	0	0	0	11	0	11	0.1
Yellow Perch	311	506	120	0	20	0	173	595	624	1101	1725	13.6
Bluegill	6	1152	346	0	340	135	296	590	988	1877	2865	22.6
Black Crappie	278	1431	18	0	47	0	97	34	440	1465	1905	15.0
Pumpkinseed	0	178	43	0	210	0	101	44	354	222	576	4.5
Green Sunfish	0	8	0	0	0	0	22	0	22	8	30	0.2
Hybrid Sunfish (BGXPS)	0	6	3	0	8	1	1	0	12	7	19	0.1
Yellow Bullhead	0	945	26	0	102	0	13	0	141	945	1086	8.6
Black Bullhead	0	3	1	0	2	0	0	0	3	3	6	0.0
White Sucker	0	137	124	0	5	3	5	0	134	140	274	2.2
Golden Shiner	0	9	11	0	4	0	0	0	15	9	24	0.2
Common Shiner	0	0	46	0	0	0	2	0	48	0	48	0.4
Blackchin Shiner	0	0	0	0	0	0	1	0	1	0	1	0.0
Creek Chub	0	2	0	0	0	0	0	0	0	2	2	0.0
Bluntnose Minnow	0	0	6	0	0	0	45	0	51	0	51	0.4
Iowa Darter	0	0	12	0	0	0	44	0	56	0	56	0.4
Mottled Sculpin	0	0	0	0	0	0	1	0	1	0	1	0.0
Brook Stickleback	0	0	4	0	0	0	104	2705	108	2705	2813	22.2
Totals	789	4377	1052	0	772	140	1225	4323	3838	8840	12678	100.0

6.4 CLMN Activities

The Citizen Lake Monitoring Network (CLMN) is a very successful collaboration between thousands of citizens and the Wisconsin Lake Partnership. Over the years, citizens have collected extensive data sets for lakes. The information collected is important for many reasons, in particular, to establish a baseline of what is "normal" for a given waterbody. Volunteer data has been used in numerous reports and is frequently used by scientists and water resource planners for a variety of purposes. The Friends of Moose Lake is fortunate to have a few volunteers that have been busy collecting useful information described further in the next few sections.

Water Level Monitoring CLMN

The lake environment is subject to daily and seasonal fluctuations which can have direct or indirect effects on the system. One noticeable change of a lake over short or long periods of time is the fluctuation of water levels. Water levels in lakes fluctuate all the time, and this a normal process. There are many factors that can influence these levels such as the amount of annual precipitation, surrounding land-use, amount of stormwater runoff, climate and temperature changes in the region, beaver dam activity, and groundwater consumption rates can all play a role in fluctuations of lake water levels. Fluctuating water levels are typically not an issue to the average lake observer, however, there are times when levels can be of concern. Riparian homes on low lying shorelines can be affected by large storm events and flooding, or to the other extreme, entire lakes can shrink or dry up when groundwater pumping has exceeded the rate of groundwater recharge or when drought weather patterns are persistent.



A water level gage was installed and surveyed along the shoreline of Moose Lake in the spring of 2015 and a citizen volunteer collected weekly level readings. Shown at left are the weekly readings that the volunteer logged from May 16 through November 16, 2015. As seen by the line graph at left, lake levels fluctuated only minimally over the course of the summer.

Figure 30. *Water level measurements collected by a citizen volunteer over the summer months of 2015, Moose Lake.*

Water Quality Monitoring CLMN

With the help of citizen volunteer data collections, scientists are able to make comparisons on the same lake from year to year, and to create ecoregion averages in which to compare similar types of lakes in a given year. Since 2010, Moose Lake has been consistently monitored by a volunteer

for water clarity readings, dissolved oxygen levels, and temperature profiles; and since 2012 for the additional parameters of phosphorus and chlorophyll-a.

Figure 31 below, illustrates that the average clarity readings of Moose Lake have increased over a 6 year span. In 2002, DNR staff had an average summer clarity reading of 4.75 feet, which is a much lower reading than more recent years.

Water Quality Trophic State Index CLMN

A very reliable and valuable use of long-term volunteer water quality collections is the calculation of the lake TSI, the trophic state index. All lakes change over time, and are in a constant state of progression, sometimes referred to as lake succession, eutrophication, or the "aging" of a lake. This aging process may take thousands of years. Scientists measure the succession process of lakes by measuring the fertility status (the productivity), or trophic state of a lake. In Wisconsin, TSI scores range from 0 - 110 and lakes fall into predictable productivity patterns (with some exceptions) based on measures of secchi water clarity and the total average measured values of chlorophyll-*a* and phosphorus in the water during the summer months. Appendix 9 shows the TSI scores and descriptions.

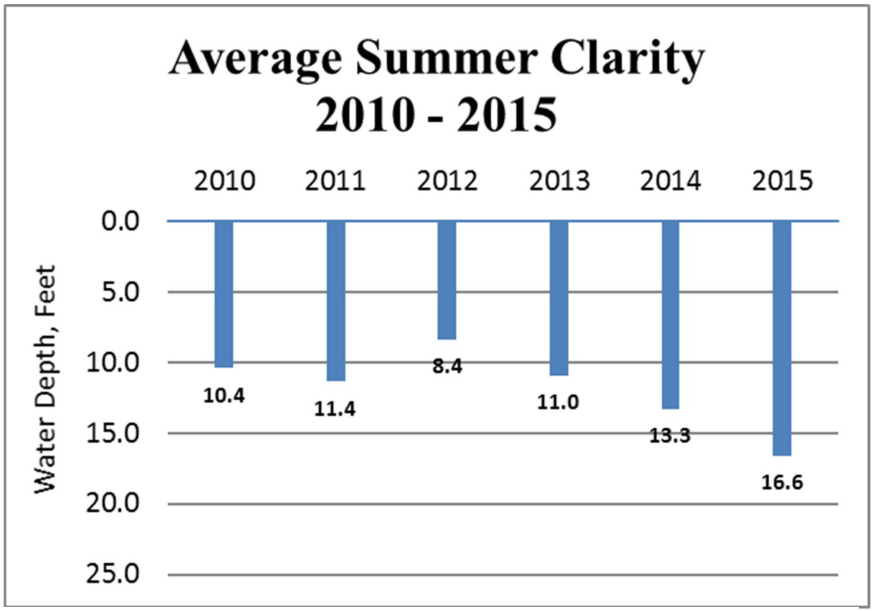


Figure 31. *Average Clarity readings collected by a citizen volunteer for Moose Lake, Langlade County.*

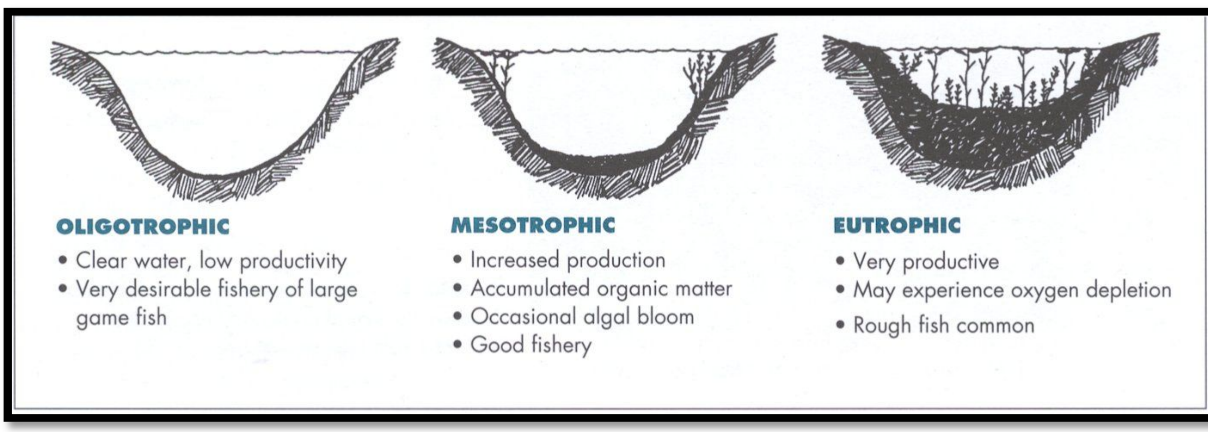


Figure 32. *The natural aging process of lakes over thousands of years.*
Source: Understanding Lake Data

The calculation of TSI gives lake managers a long range look at the quality of lake water in comparison to similar lakes, and the more data accumulated and averaged into the calculation, the more accurate is the TSI when comparing the lake to others in the same ecoregion. Figure 32 shows a diagram of lake trophic states. As pictured from left to right, as a lake "ages", they become more "productive". Increased amounts of nutrients are present in the sediments as lakes age, opening up opportunity for increased plant and algae growth and a loss of good habitat for preferred game fish.

Table 13. *Moose Lake TSI results for Secchi, Chlorophyll, and Total Phosphorus during the summer months of 2015.*

	TSI (Secchi)	TSI (Chl-a)	TSI (Phos)
6/5/2015	42		
6/12/2015	44		
6/14/2015		51	>52
6/21/2015	41		
6/23/2015	40	44	>56
6/27/2015	38		
7/8/2015	40		
7/12/2015	36	44	>53
7/15/2015	39		
7/27/2015	38	44	>50
8/8/2015	37		
8/15/2015	37		
8/16/2015		46	>52
8/26/2015	43		>54

The Moose Lake 2015 calculated summer average TSI for Chlorophyll-*a* was 45, in 2014 it was 50, and in 2013 it was 49. All of these TSI scores place Moose Lake in the mesotrophic category (Appendix 9). Mesotrophic lakes are characterized by moderately clear water, but have an increasing chance of low dissolved oxygen in deep water during the summer because of the increased amounts of decaying organic matter at the lake bottom (SWIMS database).

Trophic state parameters relate to one another in various ways. Consider Table 13 and the following two relationships described in the Citizen Lake Monitoring Network Training Manual:

Relationship 1: Chlorophyll TSI > Secchi TSI
Meaning: Large particulates, such as *Aphanizomenon* (algae) flakes, dominate in the water column.

Relationship 2: Phosphorus TSI > Chlorophyll TSI = Secchi TSI

Meanings: a) If this happens once or twice during the monitoring season, it suggests that a peak population of zooplankton may have consumed large amounts of algae, resulting in clear lake water. However, the nutrients (Phosphorus) would still exist in the water column; and b) If the total phosphorus was greater than the chlorophyll-*a* and secchi readings throughout the entire season, it suggests that total phosphorus may have been entering the lake, but additional algae growth was limited by nitrogen. This is often due to septic system influences.

In the case of Moose Lake, relationship 1 and 2b seemed most likely in 2015, but we need to delve deeper. Moose Lake had a very healthy population of rooted aquatic plants and very clear water which suggests that the TSI calculations could be a mischaracterization of the true nutrient status within the water column of the lake. The water samples only measure total phosphorus available within the water column, after aquatic plants have had the opportunity to utilize available nutrients for summer growth. It makes sense then, that lakes with high density aquatic plant growth have low readings of water column total phosphorus. It would make further sense that Moose Lake has an additional source(s) of total phosphorus as evidenced by the higher readings of the nutrient in the water column after the aquatic plants were established and by the excessive algae growth that the lake experiences. Nitrogen plays a role in plant growth also, and as discussed later in Section 6.5, it was definitely not limited.

Aquatic Invasive Species CLMN

Moose Lake is monitored annually for the presence / absence of zebra mussels by regular observation of a zebra mussel sampling device submerged underneath a citizen volunteer pier. To date, there have been no sign of zebra mussels on the device or in the lake. Scientists have studied the optimal conditions associated with zebra mussel populations. They have found that lakes measuring within a pH range of 7.0 to 9.0, and lakes having a calcium concentration greater than 12 milligrams per liter are more likely to accommodate the physical needs of zebra mussel establishment (Whittier et al, 2008). Moose Lake pH measured 8.34 – 8.69 and the calcium level was found to be 43.6 mg/L in April of 2015, so both measures provide optimal ranges for the colonization of zebra mussels.

One invasive animal that has made its home in Moose Lake is the Chinese Mystery Snail. The shell of the snail is smooth, strong, and of uniform coloring of various shades of olive green. It can growth to a couple inches in length. These snails can serve as vectors for parasites and diseases, but nothing can be done to rid the population once they have arrived.

During 2015, there were a few volunteers that participated in the *Clean Boats / Clean Waters* monitoring program at the boat landing. The schedule of the volunteer coverage at the landing varied. As boaters launch their watercraft, these volunteers educate the lake user about aquatic invasive species and ask questions about other lakes that user has recently visited. The Clean Boats program has been very successful in bringing awareness of AIS to the lake user public and providing a way for lake groups to be proactive in protecting their lake.

The *Bag It & Tag It* program, managed by a citizen volunteer on Moose Lake, encourages lake users to bag up samples of “unknown” or questionable plants or animals for identification. The volunteer will then ID the sample or take it in to be identified by a local professional.

6.5 Lake Water Quality

Table 14. *2015 Moose Lake summarized water quality data.*

Sampling Parameter	APRIL	JUNE	JULY	AUGUST	OCTOBER
NUTRIENTS					
Ortho Phosphate (*mg/L*)	ND		0.0087		
Total Phosphorus (*mg/L*)	0.0253	0.0221	0.0248	0.0211	0.0330
Total Kjeldahl N (*mg/L*)	0.466		0.556		
Nitrate-Nitrite N (*mg/L*)	1.39		0.824		
Ammonia NH3-N (*mg/L*)	ND		0.027		
WET CHEMISTRY					
Conductivity (Lab) UMHOS/CM @ 25C	381		341		
pH (Lab)	8.34		8.69		
Alkalinity CaCo3 (*mg/L*)	180		162		
Chloride (*mg/L*)	8.4				9.7
Chlorophyll-*a,* Fluorescence *(µg/L)*	5.85	9.08	3.19	4.41	14.1
Color	10		5.0		
Total Hardness (*mg/L*)	209		197		
Suspended Solids (*mg/L*)	2.2		2.0		ND
METALS					
Calcium (*mg/L*)	43.6		35.4		
Magnesium (*mg/L*)	24.2		26.3		

There are many physical, biological and chemical factors that influence the unique character of all lakes. Lakes are a complex of external and internal influences and are ever changing ecosystems based on the inter-connectedness of all the factors. Fortunately, scientists have studied lakes for decades and have been able to understand how lake water quality is directly related to these factors. Shown in Table 14, is a summary of Moose Lake data results and brief explanations of the data follow.

Water Clarity

Water clarity is a measurement of two components of a lake system: 1) the color, which is determined by the amount of dissolved substances in the water column; and 2) the turbidity, the amount of suspended material within the water column. Individual readings of water clarity for a lake fluctuate over a field season, so it is the average clarity that is calculated to determine a lake's overall clarity status for a given year. The clarity, or transparency, of lake water is measured by a simple black and white disk called a secchi disk that is lowered vertically down into the water column until it disappears from sight. The vertical measurement is taken and recorded as the water clarity. Over the course of time, averages of clarity readings are graphed and trends of a given waterbody can be observed.

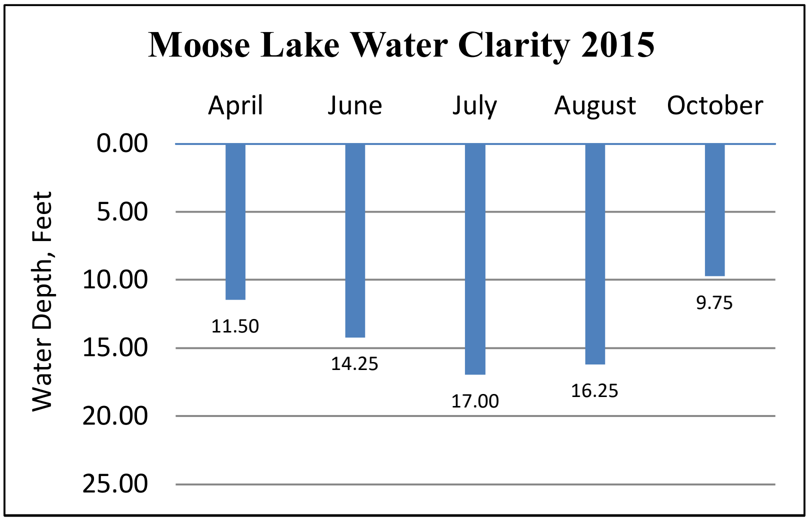


Figure 33. *Secchi disk clarity measurements for Moose Lake during the summer months of 2015.*

There is an inverse relationship between the secchi disk reading and chlorophyll-*a* values. For example, as more algae growth occurs in the water column, it follows that the secchi transparency reading would decrease. As the transparency reading increases, both the phosphorus and chlorophyll-*a* values understandably decrease (unless there are additional source(s) of nutrient running into the lake as explained in the previous section).

Moose Lake is clearer than other lakes in the same ecoregion on average, and the 2015 measures are shown above. In 2015, Moose Lake had an average reading of over 14 feet, whereas, similar lake types in the Northeast region only had an average of 10 feet. In 2014, regional lakes averaged 10.3 feet and Moose Lake averaged over 13.3 feet of clarity.

Chlorophyll-*a*

Chlorophyll-*a* is a green pigment located inside plant cells that is used during the process of photosynthesis. The concentration of chloropyhll-*a* in lake water samples is directly related to the amount of suspended phytoplankton (algae) in the lake's water column on any given day. Thus, if the water column has a high abundance of algae, the value of the chlorophyll reading will be a direct reflection of that abundance and result in an increased pigment value. Over the course of the open water season, the amount of algae will fluctuate as shown in the 2015 Moose Lake values (Figure 34). For this reason, scientists use the average of 3 summer months to indicate the normal reading of a lake for a given field season.

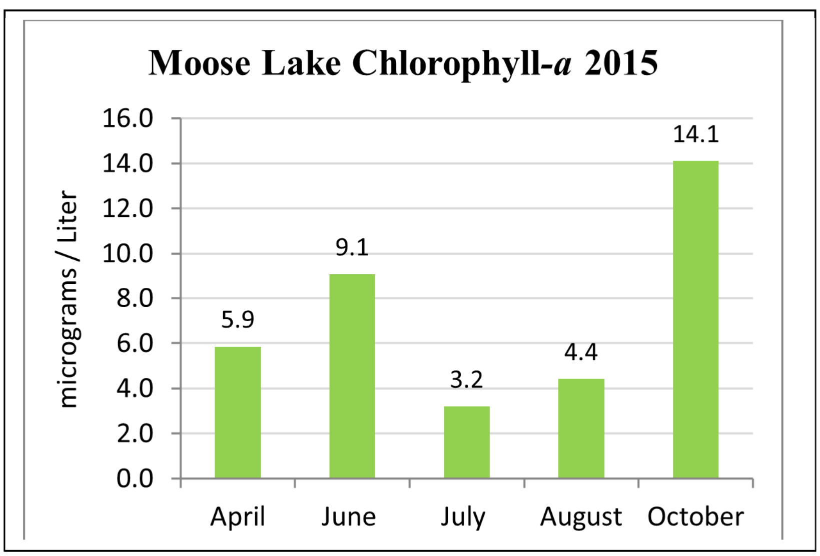


Figure 34. *2015 values of Chlorophyll-a from April through October in Moose Lake, Langlade County.*

The 2015 average summer chlorophyll-*a* level for Moose Lake was found to be 3.7 µg/L, a much lower concentration when compared to the Northeast region summer average of 8.8 µg/L (SWIMS database). A suspended algae bloom is considered nuisance level when the pigment readings reach >20 µg/L when the water sample is very green, like "pea soup". Moose Lake did not reach that level of bloom in 2015 and remained fairly clear over the entire open water season. Chlorophyll-*a* records for Moose Lake in the previous 2 years show that in the summers of 2013 and 2014, chlorophyll measures were 6.8 µg/L and 7.2 µg/l respectively, and for both of those years, the measures for Moose Lake were below the Northeast ecoregion summer averages.

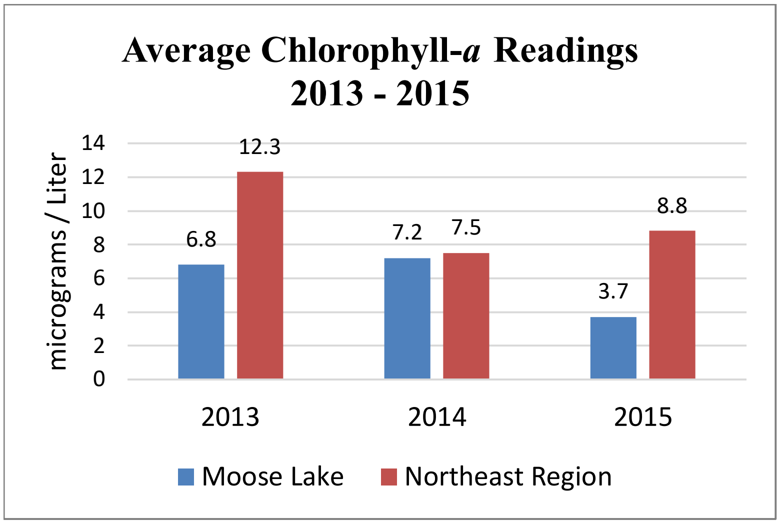


Figure 35. *Average Chlorophyll a readings 2013 through 2015 for Moose Lake and Northeast Regional Lakes.*

Phosphorus

Phosphorous is a nutrient found naturally in our environment and more often than not, the amount of available phosphorus controls the limit of aquatic plant and algae growth in most Wisconsin lakes (Lillie and Mason, 1983). There are many sources of phosphorus and these include soil and rocks, runoff from wastewater treatment plants, runoff from fertilized lawns and croplands, failing septic systems, runoff from barnyard manure, disturbed land areas, drained wetlands, and from cleaning agents. Phosphorus is typically the nutrient in shortest supply in surface waters, and because of this it is known as the "limiting" nutrient. It is a good thing that it is limiting because even a small increase in the amount of phosphorus is able to set off a number of undesirable events that modify the quality of our lakes and streams. Accelerated plant and algae growth, lowered oxygen levels, and fish kills are just a few of the undesirable effects. Phosphorus can have such powerful affects to a lake or river system, that a Fertilizer Law (WI Stat. 94.643) has been placed in Wisconsin which restricts the use, sale, and display of lawn and turf fertilizers which contain phosphorus. The goal of this action is to reduce the impact of cultural eutrophication from human development actions, especially near waterbodies.

The natural aging process of a lake takes place very slow over thousands of years. As discussed in Chapter 3, many human activities that take place daily and annually on the landscape can enhance and accelerate the eutrophication process of lakes. That is why it is so vital that watersheds are managed to efficiently to slow down water flow and to hold soil and nutrients on the land. During the WiLMS modeling procedure, it was found that Moose Lake receives approximately 1173 pounds of phosphorus annually from its direct drainage area. Of that total amount, the model predicted that 5.5 pounds of that may originate from septic systems that surround the lake.

Figure 36 shows the 2015 summer total phosphorus (TP) readings for Moose Lake. The average level of TP for Moose Lake was 22.7µg/L. Lakes that have total phosphorus readings greater than 20 µg/L may experience noticeable algae blooms, as was the case for Moose Lake (Lillie and

Mason, 1983). Looking back to TP data results for Moose Lake from 2014, the summer average reading was 24.6 µg/L. Data taken by DNR staff back in 2002 had a TP summer average of 46 µg/L, which was double that of the 2015 average (SWIMS database).

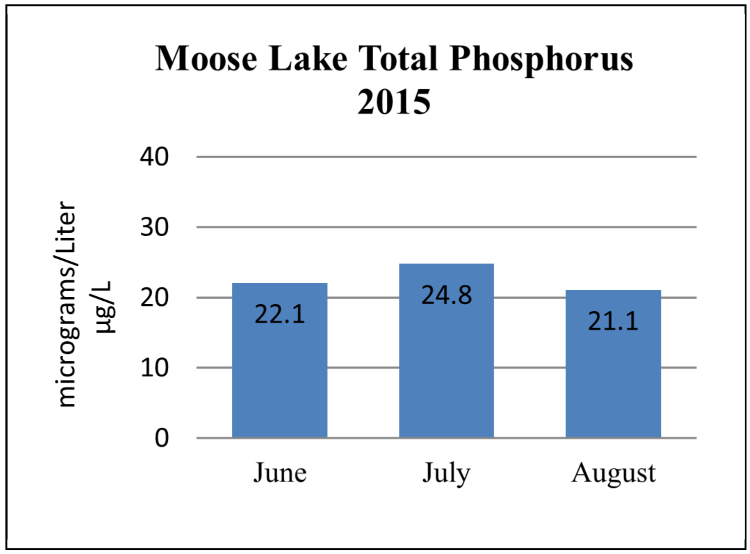


Figure 36. *Total Phosphorus readings for Moose Lake during the summer months of 2015.*

Phosphorus Recycling

Lakes that experience strong summer stratification may also experience an annual "recycling" of phosphorus, otherwise known as internal phosphorus loading. This would be a normal occurrence in lakes that reach and hold zero oxygen readings in the hypolimnion (lower depths). When the bottom waters go anoxic (zero oxygen), phosphorus gets chemically released from the sediments to the water column. Phosphates, the soluble form of phosphorus, are then available for cellular uptake for growth of plants or algae. This chemical cycling of phosphorus from its insoluble to soluble forms has the potential to feed plant and algae growth to high nuisance levels year after year. This concept will be discussed further in the dissolved oxygen and temperature profiles section.

Nitrogen

Nitrogen levels for Moose Lake were fairly high as shown in Table 14, especially the inorganic sources, Nitrate + Nitrite and ammonia. Presence of nitrogen with in the lake ecosystem is completely normal and comes from sources such as plant decay (from respiration processes), or from the atmosphere. Activities occurring within the lake drainage basin may also be source(s) of nitrogen input and include point or non-point sources such as sewage effluent, agriculture wastes, or crop fertilizers. Unnaturally elevated readings of nitrogen may indicate the presence of any or all of these activities in a lake watershed.

Nitrogen is also measured to derive an important ratio for lake biologists. The ratio of total nitrogen to total phosphorus (N:P) is indicative of whether plant growth in a lake is limited by phosphorus or nitrogen (Shaw et al. 2002). If the ratio of N:P is less than 10:1 then a lake is nitrogen-limited, but if the ratio is greater than 15:1 algal growth is controlled by phosphorus and therefore, the system is phosphorus-limited. The N:P calculation is average (Kjeldahl + inorganic N) divided by average Total Phosphorus. The calculated N:P ratio for Moose Lake is 32:1, thus giving a clear indication that it is a phosphorus-limited system and plant growth is controlled by the amount of phosphorus nutrient available.

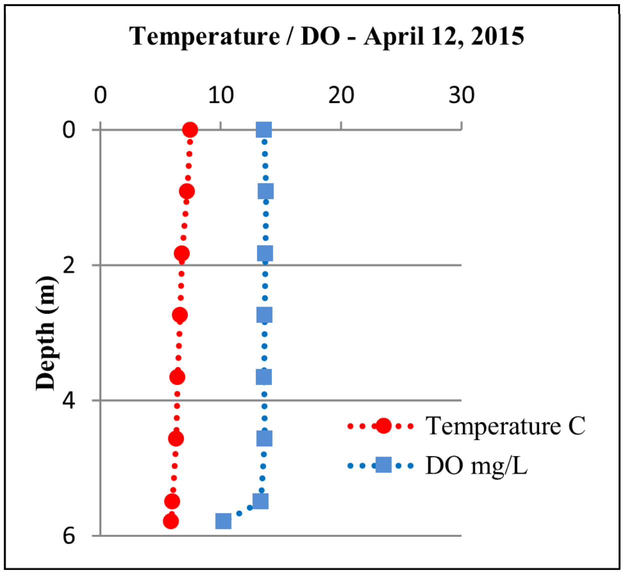
Dissolved Oxygen / Temperature Profiles

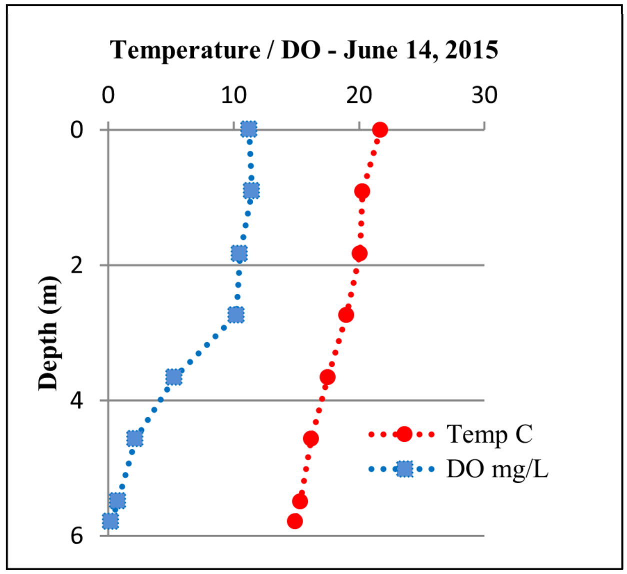
Dissolved gases such as nitrogen, carbon dioxide and oxygen, are very important chemical components that are present in all lake ecosystems. Oxygen is a critical component in lakes, not only for the survival of aquatic organisms, but for many ongoing molecular level biological and chemical reactions (Horne and Goldman, 1994). The amount and depth placement of dissolved oxygen in a lake are critical to understanding the biological patterns within the system. Oxygen is continually consumed in animal respiration and decomposition processes and produced by plant photosynthesis in the lake's epilimnion (upper depths). The solubility of oxygen within lakes is dependent on the water temperature, and for this reason, these two data parameters are collected and analyzed together.

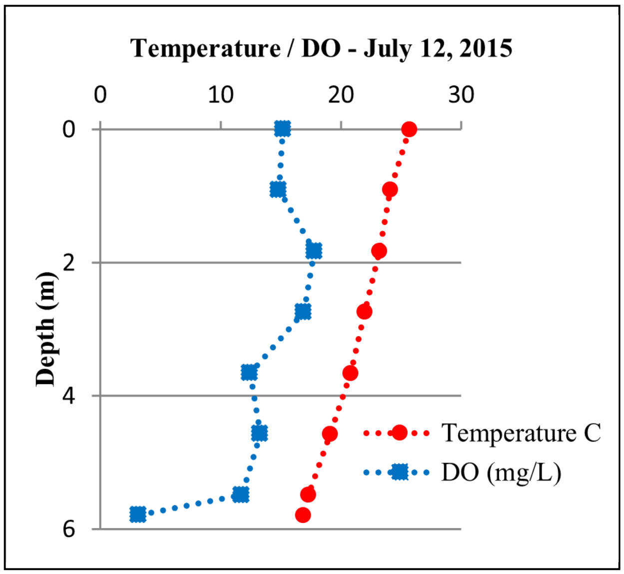
Typical of most mesotrophic lakes, the levels of summer dissolved oxygen in Moose Lake were low in the deeper water. Dissolved oxygen and temperature profiles that were collected by the consultant for Moose Lake from April through October 2015 are displayed in Figures 36 a - e. Samples were taken at the deep hole. The vertically graphed profiles give a visual depiction of the numerical data that was collected and tell a story about the lake's thermal stratification pattern.

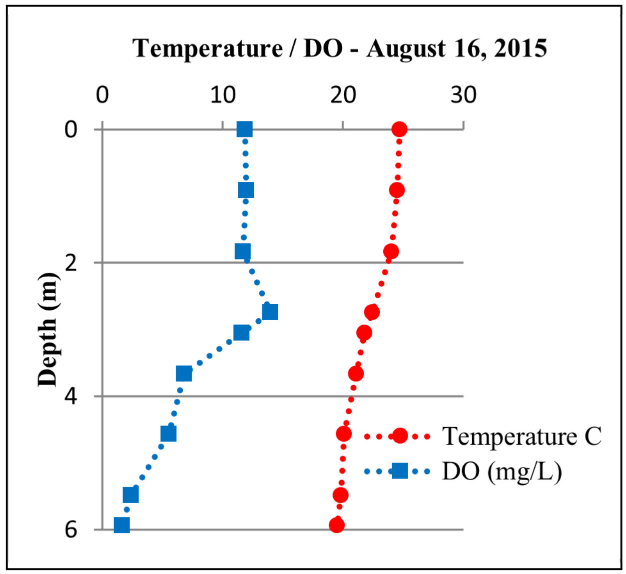
Shortly following ice out (April Figure 37a), the lake water was vertically mixed from top to bottom with the event of spring turnover. Cold lake temperatures and high dissolved oxygen levels were predictably uniform throughout the depths of the lake at that time. As surface water temperatures rose in June, oxygen levels remained higher at the surface because of increasing plant photosynthesis but dropped to near zero at and below the metalimnion (mid depths). This is normal near the bottom sediments where respiration activity is at its highest point in the lake. As summer continued (July Figure 37c - August Figure 37d), lake temperatures rose in the epilimnion with increased energy from the sun but a distinct thermocline was not achieved in the metalimnion layer as it does in some Wisconsin lakes. Instead, a steady decline of temperature occurred, and the lowest temperatures were reached as expected in the hypolimnion (lower depths). Dissolved oxygen patterns waivered during this time, but never reached true anoxia (minimum 0.11 ppb). If a true thermal stratification pattern was achieved, it may have occurred in late July or August, but was short-lived. As fall arrived (October Figure 37e), temperatures and dissolved oxygen levels began to level out again from top to bottom.

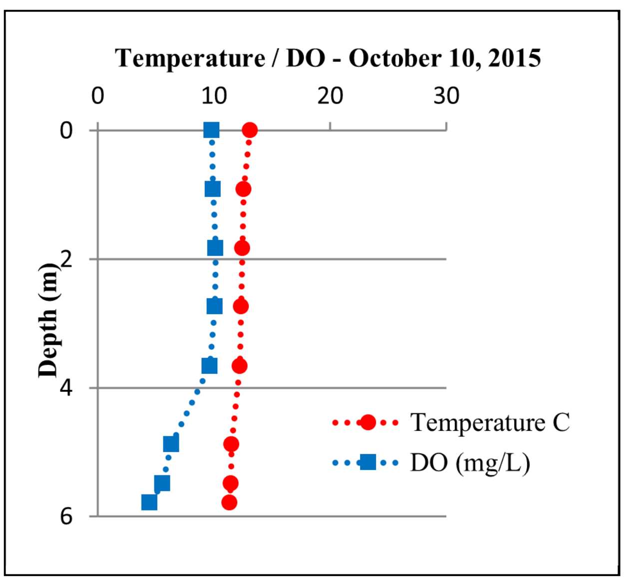
The graphed profiles show that a clear and defined summer thermal stratification did not occur for Moose Lake. Moose lake is on the "deeper end" of how shallow Wisconsin lakes are classified (Section 4.1). Shallow lakes typically do not experience defined thermal stratification in the summer months and remain somewhat mixed, whereas, deeper lakes show a clear curved stratification pattern with a defined thermocline. Because of this, shallow lakes are typically managed differently than deeper lakes in Wisconsin.











Figures 37 a-e. *Moose Lake dissolved oxygen (DO) and temperature profiles collected April through October 2015.*

Chloride

Naturally occurring chloride concentrations in lakes vary throughout Wisconsin, but are generally lower in northern counties, including Langlade (Lillie and Mason, 1983). Based on a random data set, 3 mg/L or less is typical of lakes located in the Northeast region of Wisconsin. The springtime measurement of chloride in Moose Lake was found to be 8.4 mg/L, a much higher starting level than the average northern lake. The increased amount of chloride measured is not in and of itself a significant threat to Moose Lake. What is more significant, is that chloride is easily measured and increased levels can indicate increases in other, more harmful contaminants which are less easily measured and traced. Increases of chloride concentrations in lakes, either throughout a summer season or over longer time periods can indicate possible pollution from sources such as agriculture or lawn fertilizers, animal waste, road salt from watershed runoff, or from riparian septic systems.

Measurements of chloride were collected in the spring and in the fall for Moose Lake. From April to October (the duration of one summer field season), a 1.3 mg/L increase of chloride level was observed. Since an increase of chloride was observed over the course of one summer, septic system leakage and/or use of lawn fertilizers may be having an effect along the shoreline of Moose Lake. The excess nutrient runoff into the lake may be the cause of high density algae growth, particularly along immediate shoreline areas. Over time accumulations of gas formed by the algae cells begin to rise to the lake surface and result in unsightly mats. Additional studies of chloride levels and perhaps the septic fields located near the lake would be necessary to confirm where the chlorides are originating.

The Carbonate System

The carbonate system in lakes is a complex inter-mixing of natural molecules and ions (Ca, Mg, C, H, and O) that are in a constant state of flux based on changes in temperature, sunlight, or biological occurrences within the ecosystem. This system provides acid rain buffering capacity for the lake, which is very important because natural rainfall is slightly acidic with a 5.6 pH average (Understanding Lake Data). Numerical results for carbonate system parameters are displayed in Table 14, under the Wet Chemistry and Metals sections.

The measurement of a lake's level of acidity (or the amount of H+ ions in water) is known as the pH, where 7 is neutral on a scale of 0 to 14. Lakes with low pH readings have more hydrogen ions and lakes with higher pH have less hydrogen ion concentrations. An average pH of 8.5 was measured for Moose Lake, which is located on the absolute high end of the normal range for lakes in Wisconsin. Moose Lake has very high alkalinity and hardness levels, which makes it an excellent buffer against the effects of acid rain. On the sensitivity to acid rain scale, Moose Lake is virtually non-sensitive, with an alkalinity reading average of 171 mg/L. Moose Lake is considered very hard, and the average reading for hardness over the 2015 season was 203 mg/L. Lakes with hard or very hard characteristics tend to have higher fish and aquatic plant populations, typical of Moose Lake. Hard water lakes are likely to be located within regions that have high fertility soils (such as in agricultural watersheds), which is characteristic of Moose Lake.

6.6 Aquatic Plants

Whole-Lake Survey Results

Table 15. *Aquatic Plant Survey, Whole-Lake Results*

Summary Statistic			Result
1	Total # of sites visited		314
2	Total # of sites with vegetation		281
3	Max. depth of plants (feet)		22
4	Total # of sites shallower than max. depth of plants		314
5	Frequency of occurrence at sites shallower than max. depth of plants		89.49
6	Average # of species per site	a) Shallower than max. depth	1.88
		b) Vegetated sites only	2.10
		c) Native shallower than max. depth	1.88
		d) Native species at vegetated sites only	2.10
7	Species Richness	a) Total # species on rake at all sites	22
		b) Including visuals	26
8	Simpson's Diversity Index		0.79
9	Mean Coefficient of Conservatism		5.95
10	Floristic Quality Index		27.3

A total of 326 predetermined survey points were attempted in Moose Lake (Appendix 4), 12 of which were not accessible due to dense submersed vegetation, meaning a total of 314 points were actually surveyed. The maximum rooting depth was 22 feet, which was the maximum depth recorded in the lake. Of the 314 points surveyed, 281 actually had vegetation present (Table 15). The average number of species found at vegetated sites was 2.10 per site and the average rake fullness was 2.06. A total of 26 species of aquatic plants were found, four of which were "visual only" (i.e., within 6 feet of the survey point but not found on the rake) and two of which were documented as part of the boat survey (> 6 feet from any survey point). Filamentous algae is not counted as one of the 26 species. The Simpson Diversity Index was calculated to be 0.79 on a scale from 0 to 1 (See Methods for explanation).

Table 16. *Floristic Quality Results*

Common Name	Scientific Name			C value
Coontail	*Ceratophyllum demersum*			3
Muskgrasses	*Chara*			7
Common waterweed	*Elodea canadensis*			3
Water star-grass	*Heteranthera dubia*			6
Small duckweed	*Lemna minor*			4
Forked duckweed	*Lemna trisulca*			6
Northern water-milfoil	*Myriophyllum sibiricum*			6
Slender naiad	*Najas flexilis*			6
Nitella	*Nitella*			7
Spatterdock	*Nuphar variegata*			6
White water lily	*Nymphaea odorata*			6
Leafy pondweed	*Potamogeton foliosus*			6
Fries' pondweed	*Potamogeton friesii*			8
White-stem pondweed	*Potamogeton praelongus*			8
Small pondweed	*Potamogeton pusillus*			7
Clasping-leaf pondweed	*Potamogeton richardsonii*			5
White water crowfoot	*Ranunculus aquatilis*			8
Large duckweed	*Spirodela polyrhiza*			5
Fine-leaved pondweed	*Stuckenia filiformis*			8
Sago pondweed	*Stuckenia pectinata*			3
Horned pondweed	*Zannichellia palustris*			7
N	*Statewide 13*	*Region 14*	Moose	21
Mean C	*Statewide 6.0*	*Region 5.6*	Moose	5.95
FQI	*Statewide 22.2*	*Region 20.9*	Moose	27.3

This table includes only those species that were found on the rake at survey points and those that are listed in Nichols (1999). Mean values are listed for statewide and eco-region comparisons to Moose Lake.

Floristic Quality

The Floristic Quality Index (FQI) only factors species raked at survey points. Sedge (*Carex sp.*) was not included in the calculation because it could not be identified to species due to lack of flowering parts. Therefore, 21 species were included in the calculation, which is higher than the average number of species found in lakes in the North Central Hardwoods eco-region (14) and higher than the statewide average (13) (Table 16). The overall floristic quality of Moose Lake was 27.3 compared to the eco-region average (20.9) and the state average (22.2). The average C value for species included in the FQI calculation was 5.95, just higher than the eco-region average (5.6) and slightly lower than the statewide average of 6.0 (Nichols, 1999).

Plant Distribution, Depth, & Sediment

Moose Springs in the far northwest section of the survey area is connected to the main basin of Moose Lake by channels with varying characteristics. The area around points 284, 268, 296, 297, and 305 had small patches of aquatic vegetation but were otherwise lacking in plants (Map 7). This area tended to be clear water less than 5 feet deep with dark organic sediment (muck) that became easily suspended with disturbance. Survey point 309 was a very thick bed of white water crowfoot (*Ranunculus aquatilis)* in bloom (Figure 37). Starting at point 313 and heading further northwest, the water clarity remained very high with patchy aquatic vegetation, but the sediment was light colored marl instead of dark organic material. Water depths were generally less than 5 feet except for some deeper spots in the spring pond. Point 315 was especially vibrant due to the color of the marl sediment, which contributed to a turquoise-green appearance in the water that is also reflected in (Map 7). Overall, this area of the lake was diverse in its general characteristics and quite unique.

Map 8. *Moose Springs Total Rake Fullness Map*

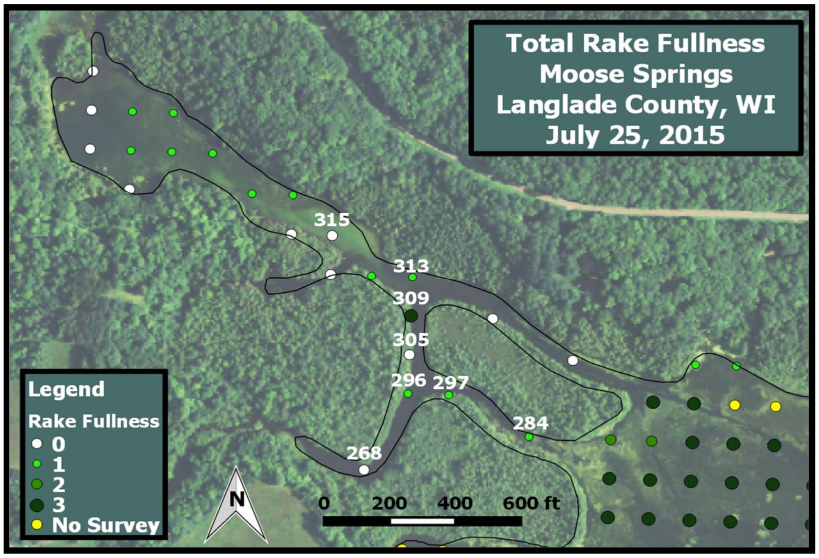
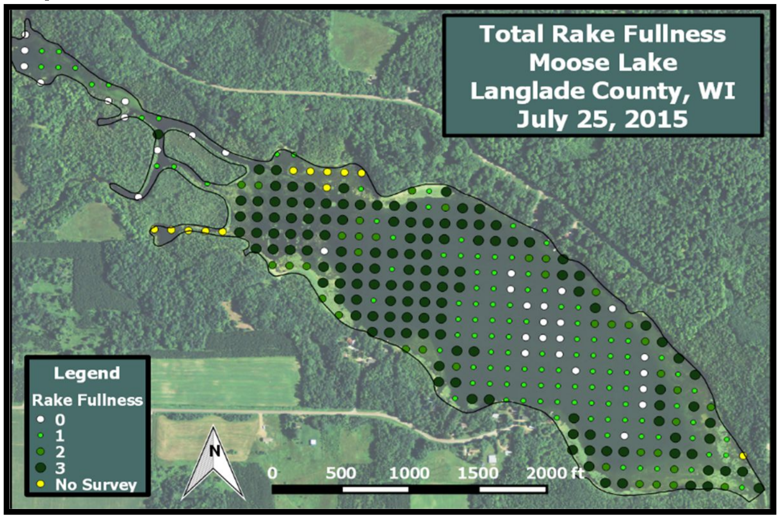


Figure 38. *White Water Crowfoot in Bloom, Survey Point 309*

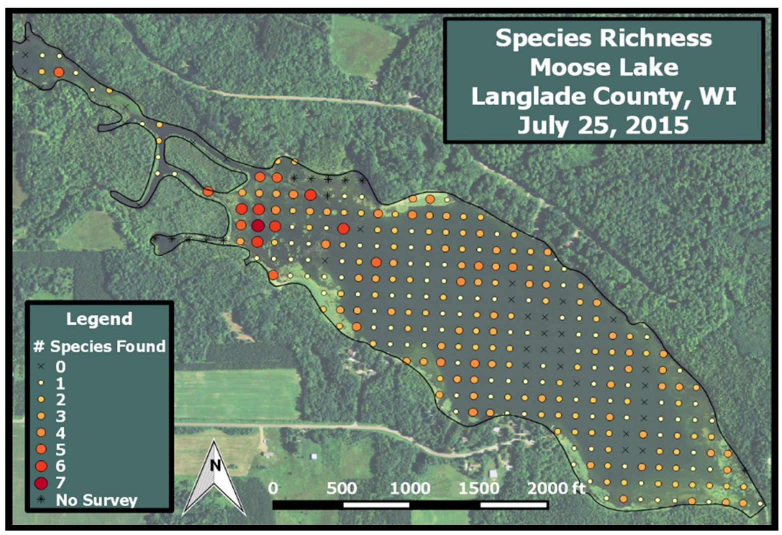
The region of Moose Lake just southeast of the springs was difficult to navigate due to very dense beds of submersed vegetation (Map 9). In fact, 11 of the 12 survey points that were not accessible for survey were in this region of the lake because the plants were too thick and/or depths were too shallow. Springs were evident at pockets of plant-free, cold water scattered amongst the otherwise dense vegetation. This area was shallow (<5 feet) with muck sediment (Map 7, Chapter 4). This area also had more species diversity per survey point than other areas (Map 10).

In the rest of the lake basin, the majority of vegetation was present in areas 9.5 feet deep or shallower. Although aquatic vegetation was present at greater depths, the rake fullness and occurrence decreased. The far southeast area where the lake drains to the Red River also had patches of dense vegetation, but to a lesser degree than the northwest section.

Map 9. Moose Lake Total Rake Fullness



Map 10. Moose Lake Species Richness



Individual Plant Species Results - Native Species

There were 26 aquatic plant species documented in Moose Lake. Muskgrasses (*Chara sp.)* were the most commonly found "plant" in the lake with occurrence at 233 sites and relative frequency of nearly 40% (Table 17). Muskgrass is more accurately described as a macro algae that looks like a vascular aquatic plant and provides structural habitat much like aquatic plants. There are many species of muskgrasses, but they are often identified simply to genus, as was done in this survey. The next most common plant species was coontail (*Ceratophyllum demersum)* at 103 sites and a relative frequency of 17.5%. The third most common species was northern watermilfoil (*Myriophyllum spicatum)* at 76 sites and a relative frequency of 12.9%. The remaining aquatic plants in Moose Lake were at much fewer sites and therefore much lower relative frequencies than the aforementioned most common species. The total relative frequency of these three plants combined is 70%, which suggests a heterogeneous plant community despite the high number of species documented. This heterogeneity contributes to a moderate Simpson Diversity Index of 0.79 despite high species richness and FQI values. There were no non-native invasive species found during the plant survey.

Table 17. *Aquatic Plant Survey, Individual Species Results*

Common Name	Scientific Name	Rel. Freq.	# Sites	# Visual	Freq. Occur. Veg. Sites	Freq. Occur ≤max depth	Avg. Rake Full.
Muskgrasses	*Chara sp.*	39.56	233	0	82.92	74.20	2.00
Coontail	*Ceratophyllum demersum*	17.49	103	0	36.65	32.80	1.22
Northern water-milfoil	*Myriophyllum sibiricum*	12.90	76	3	27.05	24.20	1.12
Small duckweed	*Lemna minor*	3.74	22	2	7.83	7.01	1.00
Clasping-leaf pondweed	*Potamogeton richardsonii*	3.40	20	11	7.12	6.37	1.00
Common waterweed	*Elodea canadensis*	3.23	19	1	6.76	6.05	1.05
Slender naiad	*Najas flexilis*	2.55	15	2	5.34	4.78	1.07
Fries' pondweed	*Potamogeton friesii*	2.55	15	0	5.34	4.78	1.13
Leafy pondweed	*Potamogeton foliosus*	2.38	14	1	4.98	4.46	2.86
Water star-grass	*Heteranthera dubia*	2.21	13	5	4.63	4.14	1.00
White water crowfoot	*Ranunculus aquatilis*	2.04	12	2	4.27	3.82	1.17
Nitella	*Nitella sp.*	1.87	11	0	3.91	3.50	1.00
Sago pondweed	*Stuckenia pectinata*	1.87	11	12	3.91	3.50	1.00
White water lily	*Nymphaea odorata*	1.70	10	12	3.56	3.18	1.10
Fine-leaved pondweed	*Stuckenia filiformis*	0.85	5	0	1.78	1.59	1.00
Large duckweed	*Spirodela polyrhiza*	0.51	3	3	1.07	0.96	1.00
Small pondweed	*Potamogeton pusillus*	0.34	2	0	0.71	0.64	1.00
Forked duckweed	*Lemna trisulca*	0.17	1	1	0.36	0.32	1.00
Spatterdock	*Nuphar variegata*	0.17	1	2	0.36	0.32	1.00
White-stem pondweed	*Potamogeton praelongus*	0.17	1	0	0.36	0.32	1.00
Horned pondweed	*Zannichellia palustris*	0.17	1	0	0.36	0.32	1.00
Sedge	*Carex sp.*	0.17	1	0	0.36	0.32	1.00
Filamentous algae		-	41	3	14.59	13.06	1.12
Wild calla	*Calla palustris*	*	*	1	*	*	*
Marsh Marigold	*Caltha palustris*	*	*	1	*	*	*
Arrowhead	*Sagittaria sp.*	*	*	1	*	*	*
Spotted Water Hemlock	*Cicuta maculata*	*	*	1	*	*	*
Broad-leaved cattail	*Typha latifolia*	**	**	**	**	**	**
Softstem bulrush	*Schoenoplectus tabernaemontani*	**	**	**	**	**	**

** Visual Observations Only (not at survey points but within 6 feet of at least one survey point)*
*** Boat Survey Only (not at survey points and greater than 6 feet from any survey point)*

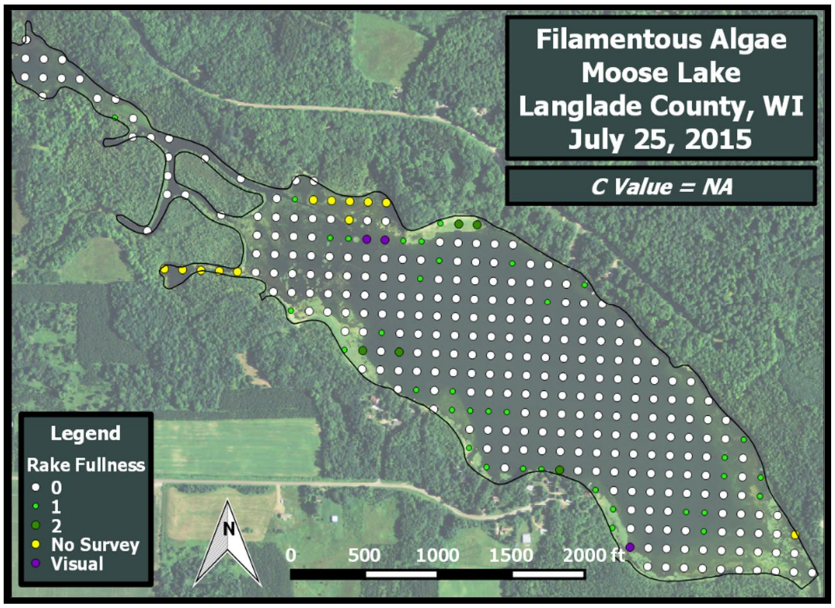
High Value, Sensitive, & Low Frequency Species

Clasping-leaf pondweed (*Potamogeton richardsonii)*, white-stem pondweed (*P. praelongus*), sago pondweed (*Stuckenia pectinata*) and horned pondweed (*Zannichellia palustris*) are species identified in Wisconsin Administrative Code NR 109 as "high value species…known to offer important values in specific aquatic ecosystems." Clasping-leaf pondweed was the most common (20 sites + 11 visual) sago pondweed was the next most common (11 sites + 12 visual) while the other two species occurred at only one site each (Table 17). None of the species found in Moose Lake are currently listed on the WDNR Natural Heritage Inventory list (NHI, 2015).

There were no species with a conservatism (C) value of 9 or 10 found at any of the survey points. However, wild calla (*Calla palustris*), with a C value of 9, was found near survey point 297. The C value estimates the likelihood of that plant species occurring in an environment that is relatively unaltered from pre-settlement conditions. As human disturbance occurs, species with a low C value are more likely to dominate a lake. There were twelve species that occurred with especially low frequency (fewer than 10 occurrences, visual observations included). The locations of these species are in Appendix 10.

Filamentous Algae

Map 11. Moose Lake Filamentous Algae



Filamentous algae are single algal cells that are microscopic as individuals but they form long filaments of cells that become visible to the naked eye. The filaments entwine to form a mat that resembles wet wool or cotton and remain submerged until enough air is trapped among the filaments to cause a floating mat. Filamentous algae are found in backwaters and near shore areas where nutrients (especially phosphorus) are readily available. At non-nuisance levels, the algae can provide cover for small aquatic organisms that serve as food for fish. However, floating mats of algae are not aesthetically pleasing and they interfere with recreation such as swimming and fishing.

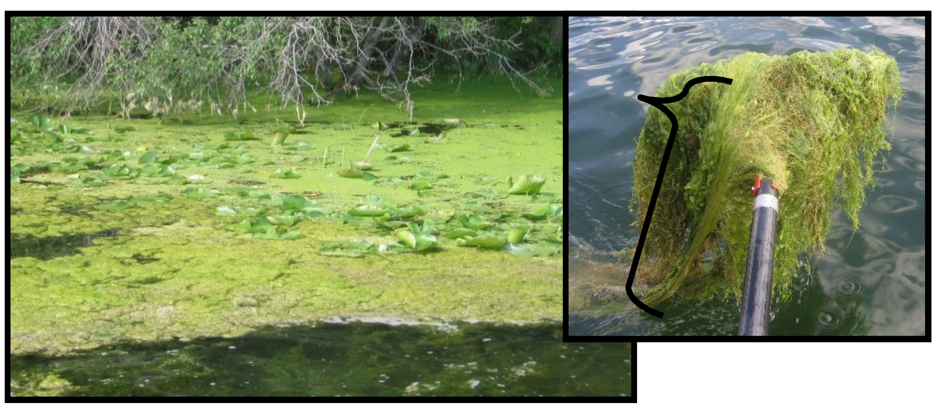


Figure 39. *Filamentous Algae Photos, Moose Lake*

Filamentous algae were documented at 41 survey points and visual observations at another 3 sites (Map 10). Although floating mats were observed at some locations, the majority of sites had submerged filamentous algae that became entwined with aquatic plants when rake samples were taken. Figure 39 illustrates a site in Moose Lake with a floating mat of algae and a rake sample with submerged algae entwined with vegetation.

6.7 Shoreland Assessment

Shoreland Areas

Scientists have learned that one of the most important areas to sustain a healthy lake ecosystem is the shoreline. What they have found is that the water quality of a lake or stream and localized wildlife populations will degrade when the shorelands have been developed and manipulated. If shoreline areas are kept as intact and natural as possible they are abundant and diverse in vegetation, contain downed trees for wildlife and fishery habitat, and have unexposed soil that is much less susceptible to erosion during rainfall events.

Shoreline vegetation provides important living space for many of the wildlife species that use the waters' edge for either all or part of their lifecycle. When the three layers of shoreline vegetation are present on shorelands (grasses, shrubs, and canopy), the needs of terrestrial and aquatic wildlife species that utilize the shoreline to live comfortably are present. Many species use the shoreline to forage for good food sources, to regulate temperature, as nursery area for their young to grow, and to hide from danger. Vegetation along the shoreline is called a "buffer" because it protects wildlife while simultaneously protecting lake water quality from potential sediment and pollution inputs. Scientific research supports this concept. It has been found that as development has increased along shore areas, the frequency of preferred songbird species (Warblers, Thrushes, Vireos, Oven birds) decreased, and less preferred species increased (Grackle, Catbird, Bluejay)(Lindsay, 2002). In a study conducted by Woodford and Meyer 2002, green frog population density decreased with the increase of human development in Wisconsin Lakes. Areas along the manipulated shorelines had degraded habitat and significantly fewer frog populations. Haskell 2009, concluded that highly developed lakes in northern Wisconsin are having a negative effect on the diversity of the mammal community in nearshore areas.

Downed trees that occur in the littoral zone of lakes (otherwise known as coarse woody habitat), consists of branches, tree trunks and root balls, provides very good living habitat for many species fish and wildlife. Newbrey et al. 2005 observed 16 different species that occupied course woody habitat areas on one Wisconsin study. Coarse woody areas provide bountiful food sources and protection that supports both fish and wildlife. Unfortunately, it has been well documented that as lakeshore areas become increasingly developed, the amount of coarse wood found along the shoreline sharply decreases (Christensen et al. 1996), as the human need for "tidy" views or lake access would provoke the removal of the downed wood along the shore.

The human practices of shoreline development also bring with it a full or partial denuding of the vegetative cover which helps to increase the potential of stormwater runoff making its way directly to the lake. During normal rainfall events, runoff water will pick up pollutants along its path and carry them directly to a lake. By altering the pathways and potentially increasing the amount and velocity of overland stormwater runoff, the likelihood of terrestrial sources of soil erosion and phosphorus traveling to the lake is greatly increased. In a study comparing undeveloped versus developed shorelands in northern Wisconsin, Elias and Meyer 2003 found that undeveloped shorelands provide significantly higher species diversity and complexity than developed sites. The developed sites were shown to have significantly lower amounts of shrub and grass cover (understory) layers. Vegetation that once existed at those developed shorelines provided deep and tangled root systems from native trees, shrubs, flowers, ferns, and grasses that all contributed to important cover habitat, provided a sink for nutrients like phosphorus and nitrogen, and stabilization of the soil. Soil erosion which occurs at the shoreline areas of a waterbody is quite destructive to lake health for two primary reasons: contributions of nutrients and sediment. Some soils are naturally very high in dissolved phosphorus, a form of phosphorus that when delivered to surface water can contribute to algae growth and severe algae blooms.

Shoreland Assessment Results

Twenty six sites were evaluated around the shoreline of Moose Lake and Moose Springs. At each of the 26 sites, data was collected in 3 zones, tallied and then summarized for a composite score. Figure 39 at right illustrates the 3 zones that were evaluated at each site around Moose Lake. The first area that was evaluated was the *Riparian Terrestrial Zone* which includes the area that starts 5 feet above the waters' edge to an endpoint of approximately 35 feet upland. Next, was the *Shoreline Transition Zone* that includes 5 feet above the waters' edge to where water meets land. Evaluated third at each site was the *Littoral Zone*, where water meets land to approximately 20 feet lake-ward. The shorelands that scored the lowest are considered least disturbed by humans and the sites with the highest scores were those with the most human disturbance. The shoreland site conditions around Moose Lake are in mostly excellent or fair condition, with only 3 of the 26 sites scoring high enough to be considered in poor condition. Total site scores ranged from 4 to 31 points, with a median score of 8 and a mean score of 9.5. Scores for each individual site are given in Appendix 11.

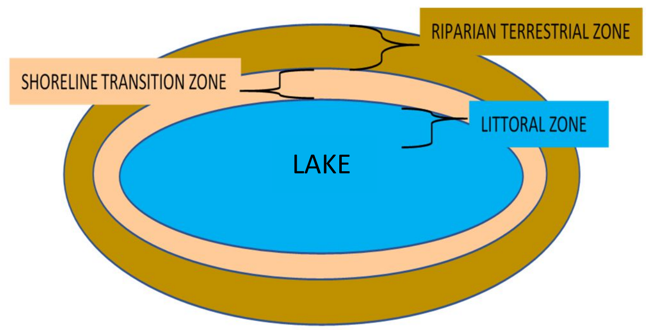


Figure 40. *Location of the Shoreland Evaluation Zones*

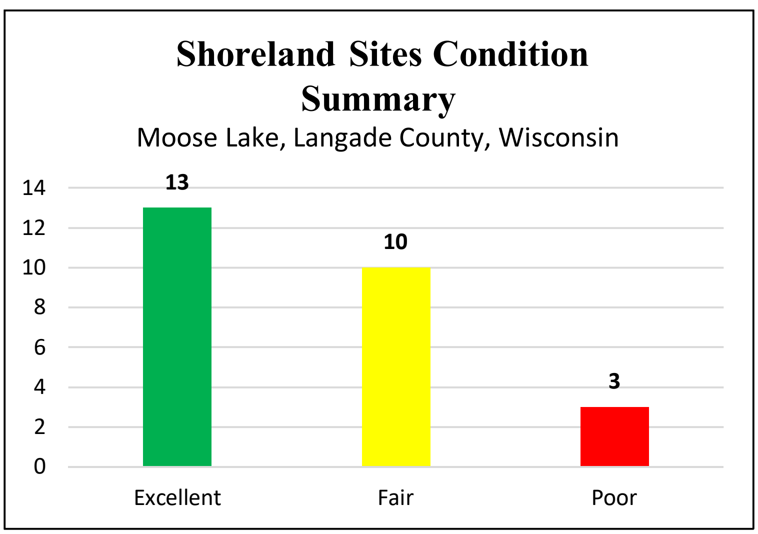
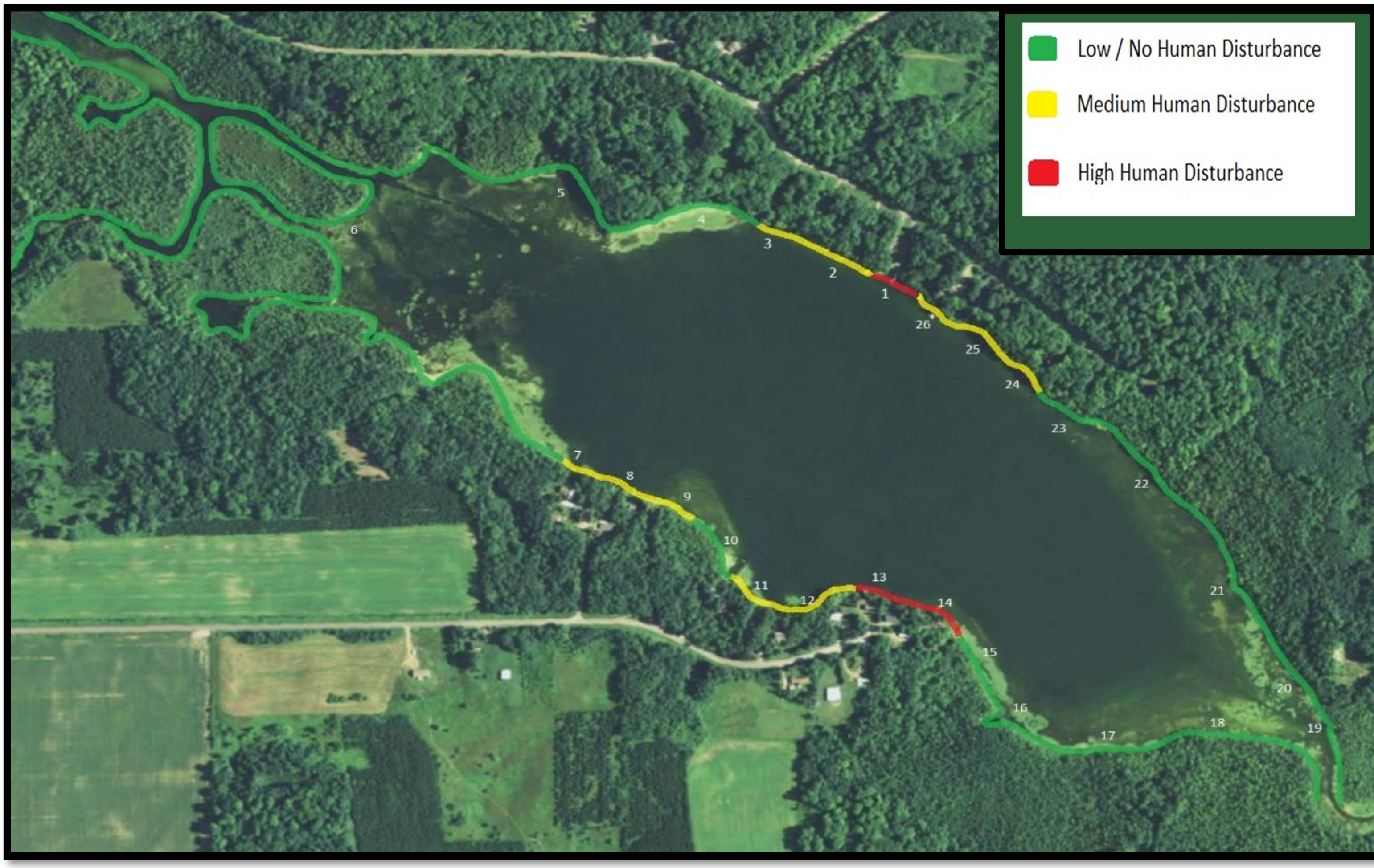


Figure 41. *Total shoreland sites in excellent, fair, or poor condition around Moose Lake in 2015.*

The summarized results of the Moose Lake shoreland assessment are shown in Map 12 below. Areas highlighted in green are considered in mostly excellent condition, whereas, those shown in red are in poor condition. Those highlighted in yellow or red are sites where some change(s) could be made to the shoreline or the nearshore area of the lake to improve the condition in some way. A detailed write up of each individual site assessment including recommendations for improvement is included in Appendix 11.



Map 12. *2015 Moose Lake Shoreland Assessment Results*

7 – CONCLUSIONS & MANAGEMENT RECOMMENDATIONS

An important outcome of a lake management comprehensive plan is the resulting management recommendations. Working consistently with these suggested goals and actions, FOML will be on the way toward improving the condition of the watershed and Moose Lake itself.

The management of lakes involves the combining of ecological principles with applied action(s) to establish and maintain a desirable goal or condition. Whatever management actions are decided on for a lake ecosystem, utmost care and observation must be taken to evaluate possible impacts of the timing and magnitude of those actions. What may seem to be a simple management action(s), may have overwhelming impact to the health or balance of the lake ecosystem. Actions may have positive effects as intended, or for some underlying reasons unknown to us, may not work well for the system.

A very important concept to keep in mind as management options are considered and implemented is that the health status of a lake ecosystem is a direct function of the lake's food chain. Maintaining the delicate balance of the food chain is very challenging to managers. For this reason, management plans are meant to be "living" documents that should adapt to changing conditions and be revised periodically as needed.

To determine the context of how Moose Lake and the surrounding watershed fit into local existing plans, reviews were conducted of Langlade County shoreland zoning ordinance and the Land & Water Resource Management Plan. These reviews were not completed for the purpose of document critique. Instead, when considering management action, we must consider how the goals of lake management plans may fit precisely into the goals of existing management activities. If goals or activities are similar in the management plans, actions may be taken together to meet the needs of each party. It is in this way that the partnering of people, technical expertise, and financial resources can benefit all.

One overlying recommendation for the leaders of FOML is to work very closely with both the Langlade County Land & Water Conservation Department and the Zoning Department. Each for different reasons, but both Departments could be working in unison to relieve Moose Lake of external nutrient inputs.

The following sections have been separated into Lake Concerns, Watershed Concerns, and Association Concerns. It is important to understand that all pieces work together to form the whole and because of that, the reader will notice overlap of suggested management actions.

7.1 Lake Concerns / Threats

Fish Kills

Moose Lake experienced springtime fish kills in 2014 and 2015, however, no kill was observed in the spring season of 2016. Affected species in these kills were bullhead, bass, bluegill, and crappie populations. Samples of the dead fish were bagged up and taken into the area DNR fish management office for examination. The underlying cause of the kill was confirmed by the DNR Fishery Biologist to arise from a naturally occurring bacteria called *Columnaris*. Bacterial outbreaks of *Columnaris* are a naturally occurring phenomenon and unfortunately, there is nothing that can be done to curtail them.

Continue to report fish kills to the DNR so that accurate records of them can be kept in the lake history files.

Trout Fishery

The membership of FOML indicate that the reduction of trout populations in Moose Lake / Moose Springs in recent years is concerning. Investigation of the Moose Lake stocking records revealed that since the mid to late 1960's, trout fish stocking management activity ceased and any of the existing trout population within the system today result from naturally occurring reproductive activity. It is a positive testament that the Moose Lake ecosystem is currently in a healthy enough state to have a sustainable population of trout in existence today. That said, it may never reach the population levels of yesteryear, when stocking management was an annual practice. It is normal that biological fluctuations in these populations will naturally occur over time and shouldn't be cause for concern.

The best management practice to sustain natural trout populations over time is to protect the watershed and keep nutrient inputs at or below their current level. FOML should focus on trying to reduce nutrient inputs from riparian areas as well as the overall drainage area. This can be accomplished through community education and partnerships. A nine key element planning process can accomplish this goal (see page 90). Protecting the watershed and the in-lake habitat not only protects the water quality and health of the lake ecosystem, but will ultimately protect the fishery.

Trout populations depend on high oxygen levels and cold-water habitats to thrive, and these environments are extremely fragile and imperiled when there is increased activity within the surrounding watershed. It is because of this sensitivity to their living environment that cold water species like trout are a very good measure of overall lake health. Cold water fisheries are extremely sensitive to increased inputs from pollutants like seepage from septic systems, soil erosion, nutrients like phosphorus, and from the resulting increases in algae and aquatic plant production.

In mid to late summer as aquatic plants die back and sink to the bottom of the lake, the decay and respiration processes use up already low concentrations of oxygen in the lower reaches of the water column. The amount of decay and the rate of oxygen depletion depend upon how fertile the lake is, and for this reason the cold water fishery of Moose Lake indicates that it is at a fragile tipping point.

For naturally reproducing trout populations to thrive well into the future, external phosphorus loading from non-point sources must be addressed.
External nutrient inputs from the watershed, from shoreland soil erosion, and from septics must be reduced to protect the fragile state of the cold water trout fishery. In addition, the occurrence of internal nutrient cycling should be further studied to find out if this compounding the aquatic plant and algae growth.

General Fishery Population

Moose Lake is a popular destination for area anglers and guests. As such, the fishery of Moose Lake is continuously harvested. Over time, heavy harvest will strain any fishery population. The area fishery manager acknowledges that Moose Lake is significantly harvested, but he also believes that Moose Lake continues to sustain good numbers and sizes of naturally reproducing populations.

Fishery biologists in Wisconsin gather fishery data by various types of survey methods. One type is the Creel Survey. Creel surveys provide information specifically about angler activities that occur on a given lake over a specific time period. The types of fishing, the catch per unit effort for a given species, the estimated number of fish, size distributions, and the rate of harvest can be calculated rather accurately from this type of survey. Creel surveys can be conducted at any time, but they typically follow a comprehensive DNR fishery population study.

From the Angler Diary information that we collected over the 2015 – 2016 year, numbers and size distribution of the fish caught appeared to have holes in certain year classes of fish and some of the species populations do not exist high in numbers. This finding is inconclusive however, and would need additional data collections to confirm.

Continue to collect and monitor fishing experiences through the angler diary program. In addition, encourage the local fish biologist to conduct a thorough creel survey on Moose Lake. The more precise the data collections are, the more useful (and accurate) the data will be for fishery biologists to monitor various populations. Participants must follow data collection instructions and fill out the forms completely, even if the fishing experience was not successful. For example, a report of "no fish" is significant data and should be submitted as such because it would be included in a catch per unit (CPU) effort calculation. The start and end times of the fishing excursion is also useful for CPU calculations. The scientific conclusions will only reflect the completeness and accuracy of the diary or creel collections.

The practice of catch and release is also important for the protection of fish populations. Encourage this practice. Not only will it increase the potential for an angler to catch something, but will allow fish size distribution to improve over time.

Partner with the local fish manager to protect the fish population and the fishery habitat of Moose Lake. It is important to maintain regular communication with these professionals. When it is completed, obtain a copy of the last population survey report for Moose Lake (2016 Survey). This report will have updated information about all species in the lake and any recommendations for future management direction will be shared within the document.

The specific habitats and timing of spawning for each species of fish in the lake should be considered an important part of lake health protection. Consider having a public speaker to talk to people about the needs of each species. Bluegills and Pumpkinseeds spawn from May to early August and they need shallow warmer water with sand or gravelly bottom. Yellow Perch spawn in April through early May and need sheltered areas where emergent and submergent vegetation is located. Largemouth Bass spawns late April to early July and needs shallow quiet sandy bays with emergent vegetation. They create nesting pockets that are visible to anglers. Northern Pike need shallow, flooded marshes with emergent, fine-leaved vegetation and they spawn from late March through early April. And, Trout spawn October to December and need streams or spring fed tributaries with harder gravel bottom.

Aquatic Invasive Species

Invertebrates: There is a large population of the Chinese Mystery Snail (*Cipangopaludina chinensis)* that exists within the Moose Lake ecosystem. They are considered rather "benign" and there is little that can be done to rid them. In July of 2015 invasive faucet snails were discovered in Elton Creek in Langlade County. Faucet Snails and Chinese Mystery Snails can become hosts to a parasite which is known to kill waterfowl that eat the infected snails.

There are volunteers on Moose Lake that monitor for presence / absence of zebra mussels. To date, they have not been discovered in the lake. Since the measure of Moose Lake pH and calcium lie within the optimal range for the establishment of zebra mussels, it is highly recommended that the zebra mussel monitoring program continue and that the data collections be captured in the SWIMS database.

Plants: No aquatic invasive plants were found during the 2015 plant survey. Protecting the native aquatic plant community from the introduction of any invasive plants, especially Eurasian watermilfoil (*Myriophyllum spicatum*), is necessary for keeping Moose Lake healthy.

The *Clean Boats / Clean Waters* monitoring program is an excellent way to monitor boats that are entering the lake. Lake organizations that apply for grant dollars in this program are guaranteed to receive the money. These are non-competitive grants that organizations use to hire and pay an individual(s) to be present at the landing at specified times and/or they can purchase the materials necessary to run a successful program with volunteers. To protect Moose Lake from invasive species infestations, increase the level CB/CW program monitoring at the boat landing. Some lake organizations around the state have instituted a "Dollars OR Hours" program. Riparian landowners along the shoreline have either donated money toward the CB/CW monitoring project, or their time has been donated in volunteer hours. The DNR offers a very simple CB/CW grant program. Each year, a minimum of 200 hours of boat landing time can be covered by the grant. Many organizations have sought volunteers for this activity, but sometimes hiring a college student or retired person for this purpose has proved beneficial. The grant will cover costs for the association.

Oneida County recently conducted the "Frozen Down Under" program that promoted AIS education during the cold winter months (personal communication with M. Sadauskas). They surveyed anglers and compiled the results to find that unhurried ice anglers were much more willing to talk, listen, and learn about aquatic invasive species prevention than their open water angler counterparts. Since Moose Lake is a popular ice fishing destination, FOML could easily follow this program and get the word out about invasive species. Think of this as CB/CW on Ice. Talk with ice anglers about how these species can ruin the health of lakes and how they can take steps in AIS prevention. Take CB/CW to the ice - engage in friendly conversations about AIS, ask ice anglers to check their equipment for plants and animals, and educate them about prevention steps.

**Continue the Bag It & Tag It program. Encourage people to be vigilant about what they see in the lake and to alert a contact person if they see an unusual plant or animal.

Aquatic Plants

Aquatic plants serve many important functions in lake ecosystems. So important are aquatic plants to these systems that a lake cannot be productive and healthy without them. They provide structural habitat for small invertebrates that are the primary food source for juvenile game fish and adult panfish. Plants provide structural habitat for small fish to hide from predators and vice versa as larger predators lurk amongst plants "in wait" of forage. They offer foraging and/or hiding structure for reptiles, amphibians, and waterfowl. The banks of lakes are significantly protected from wave action when aquatic plants absorb some of the incoming wave energy. Aquatic plants are important consumers of nutrients and provide an important function in a lake's food chain. Plants "consume" available nutrients that would otherwise fuel additional algal growth, and the root systems stabilize bottom sediment, which further prevent nutrient re-suspension and turbidity. Nutrient re-suspension is suspected in Moose Lake, thus attributing to summer algae blooms.

The amount of aquatic plant growth is a direct reflection of how much nutrient is available in the sediments and water column at a time when they are growing (Spring/Summer). Once nutrient has been introduced into the lake ecosystem, it will become available for plant or algae growth in the anoxic lake bottom sediments. By eradicating some of the aquatic plant growth, the door would be opened instead to a much worse algae bloom. For all of the important reasons given, the native aquatic plants should be protected in Moose Lake and a healthy aquatic plant community should be promoted, instead of eliminated.

The aquatic plant community in Moose Lake is diverse with higher floristic quality and average conservatism value when compared to the means for other lakes in the same ecoregion. However, three species account for 70% of the relative frequency, suggesting the lake is homogeneous and dominated by only three species while the remaining native plant species are sparse (Table 17). Protecting biotic diversity is important for the lake and is achievable by carefully managing the areas where high species richness occurs (Map 10) and where the more uncommon species were found. Another reason that navigation buoys should be placed in the area near the Moose Springs channel – to protect the existing plant diversity in that area.

The plant survey provides a baseline for comparison to future surveys to note changes and trends in the aquatic plant community and frequency of filamentous algae. Aquatic plant management plans in Wisconsin generally span five to seven years, so an updated aquatic plant survey would be recommended at that time. The DNR offers lake planning grants for this purpose, and the FOML would be eligible to apply for them.

Individual riparian landowners may manage aquatic plants at their immediate shoreline by manually removing plants that inhibit in-lake boat storage or navigation. Manual removal could be in the forms of hand-pulling (including the root systems), raking, or hand-cutting and should not exceed a width of 30 feet along the shore. Special care should be taken to minimize the area of disturbance, to dispose of the plants away from the waterbody, and to make sure that fish spawning areas are not disturbed. It is a Wisconsin law to remove ALL plant fragments when utilizing this (and other) plant management strategies. This management activity should only occur after June 15th, when spring fish spawning activity is completed.

Filamentous Algae

It is difficult to pinpoint the exact cause of the filamentous algae bloom in 2015. Filamentous algae was growing at nuisance levels in various locations and at depths ranging from 1 to 19 feet, with the majority at depths of 3 feet or less. One resident reported the condition was the worst they had seen in 40 years on Moose Lake. At the time of this survey, much of the filamentous algae was submerged and visible from the surface, but there were also a number of areas with floating mats. The prevalence of algae is a hindrance to recreation (swimming, boating, angling), a potential cause for concern for water quality, and could negatively impact the aquatic plant community.

Research suggests filamentous algae can reduce aquatic plant biomass, decrease growth of new shoots, and accelerate decay of old shoots (Ozimek et al, 1991). Whether the plants in Moose Lake were impacted by filamentous algae is not known but the algae was found growing tangled amongst submerged aquatic plants (Figure 39).

Phosphorus is typically the limiting nutrient for plant and algae growth so an increase in phosphorus is often the cause for algae blooms. As discussed in Chapter 6, we know that this is the case for Moose Lake because the nitrogen phosphorus ratio was calculated to be 32:1, indicating that phosphorus determines the amount of plant and algae growth in the lake. It is entirely possible that the recent floating algae blooms in Moose Lake indicate some type of ongoing internal or external nutrient loading. Possible external phosphorus sources include fertilizers from lakeshore properties, deficient septic systems, or increased nutrient inputs related to land use in the watershed. Possible internal phosphorus sources may occur if the lake becomes anoxic ("no oxygen") at the sediment-water interface. Anoxic conditions allow phosphorus (phosphate) to be released from the sediments and become readily available in the lower water column. Phosphates can be released at rates as much as 1000 times faster in anoxic sediments than oxygenated sediments (Goldman and Horn, 1983). The lowest oxygen level found at the time of this survey was 0.83mg/L on June 23rd, 2015 at a depth of 18 feet.

Further assessment of the water quality conditions is necessary to identify the sources of phosphorus, whether they be internal, external, or some combination of both. At this point, we can only speculate the source(s).

Internal Loading: Monthly water quality monitoring of the lake by volunteers has occurred since 2010 which provides valuable information for lake management. These volunteer efforts should continue uninterrupted. Monitoring of dissolved oxygen should happen every one-two weeks over the summer months to determine whether anoxic conditions occur at any time that could cause bound up phosphorus to be released. Based on the monthly readings from this study, the oxygen readings never reached complete zero and stratification did not appear to be holding strong likely due to the flow of the system, wind and wave energy, and the relative shallowness of the lake. In addition to increasing the frequency of dissolved oxygen measures, it may be helpful to monitor the iron within the water to determine if recycling of internal Phosphorus is occurring over the summer months.

External Loading: Based on a recent office review of septic systems by the county Zoning Department, the overview of soils within the Moose Lake watershed (Chapter 3), failing septic systems and leachate from riparian soils is suspected to be a significant contributor of external nutrient loads. The on-going loads which result may be what is feeding the unsightly floating algae blooms that occur along the entire shoreline. Since deficient septic systems are one potential source of phosphorus, an inspection program for lakeshore properties along Moose Lake is most highly recommended. The county Zoning Department must encourage timely maintenance and pumping requirements and encourage the updating of older systems as they begin to fail. Work with the Zoning Department to implement an inspection program.

Lake Bottom Siltation

The channel between Moose Lake and Moose Springs is considerably filled in by detritus and silt. This has made boating navigation and travel through the two waterbodies more difficult for lake users in recent years. The cause of the accumulated siltation is a combination of occurrences: 1) the relative shallow depths in this area (1 – 4.5 feet); and 2) an increase in aquatic plant and algae growth and the resulting accumulation of decayed organic matter.

Dredging is most often used to increase depths for navigation in shallow waters, especially for channels, rivers, and harbors. However, the major downside to dredging a lake ecosystem is the considerable disruption of the entire aquatic environment. The nutrient-rich sediment is re-suspended for a time, thus providing an opportunity for phosphorus recycling to begin in the system. As a result, even more plant and algae growth would occur, thus increasing the level of sedimentation when they die off. For that reason, this management technique is not recommended for Moose Lake.

Instead, strategically place buoys in the area where the channel opening is located to encourage only one navigation pathway to and from Moose Springs. This would keep sediment re-suspension and the potential for nutrient recycling to a minimum. The physical action of the boat movements going into and out of one marked channel would help open up and maintain a navigable pathway between the two waterbodies. Lake groups need to seek a permit for this activity and it is easily done by filling out a Waterway Marker Application and Permit form (#8700-058) from the Wisconsin DNR. Placement and removal of the channel marker buoys into Moose Lake would need to become an annual volunteer activity.

Keep navigation to Moose Springs easier by placing channel marker buoys to guide boat travel.

Water Quality

The Chlorophyll-a TSI for Moose Lake in the last 3 years has been between 45 and 50. TSI scores between 40-50 indicate a mesotrophic system which is described as moderately clear, but having an increased chance of low dissolved oxygen in deep water during the summer. This is an accurate description of Moose Lake because it is very clear and the lower depth dissolved oxygen levels dipped over the summer months. The true TSI readings for phosphorus are a bit trickier to decipher, because it depends on where in the lake the phosphorus nutrient is located. Lakes dominated by aquatic plants, like Moose Lake, tend to have high amounts of phosphorus held in the bottom sediments and relatively low measurements of phosphorus in the water column. So if most of the nutrients are held in the sediments or in existing living aquatic plants, the true total phosphorus status would not be accurately reflected from a water column sample.

For this reason, a more thorough analysis of the TSI's, especially for phosphorus, is recommended. Compute water volume and nutrient budgets for the Moose Lake system to gain a truer understanding of the phosphorus loading occurrences that are happening in the system. Accurate water and nutrient budgets account for all components of nutrient sources or causes of water-quality problems in lakes. Budgets are necessary for modeling potential response(s) in lake water quality to potential changes in nutrient loading from management actions. It is in this way that remediation efforts can be focused on the input source(s) where reductions would be most beneficial.

Shorelands

Significant improvements of shoreland areas have occurred on Moose Lake through both education and implementation of the shoreland restoration project at the boat landing. Kudos to the lake association volunteers for conducting this public display of shoreland stewardship. Keep up the good work with this effort and with the annual shoreline clean up event.

Encourage private landowners to be shoreland stewards on their own properties and to reduce soil erosion and high volume stormwater runoff to the lake. Every small effort to discourage soil erosion or polluted stormwater from reaching the lake can help to keep the lake healthy. There are many opportunities and best management practices for landowners to take part in active lake stewardship.

The DNR offers a *Healthy Lakes* grant program specifically for this purpose. The *Healthy Lakes* program offers simple and fairly inexpensive best management practices to combat common riparian property problems. Private landowners can: 1) strategically place downed trees along their shoreline to protect a specific area from bank toe erosion and/or increase habitat for fish and other aquatic animals; 2) increase native plantings along their shorelines to slow down runoff water, reduce soil erosion potential and create a vegetation buffer to uptake any phosphorus; 3) re-route the direction or reduce the volume of stormwater runoff by strategically placing water diversions and/or infiltration rain gardens; or 4) place rock infiltration areas where upland or overland rill erosion may be occurring. The FOML association is eligible to apply for and sponsor the grant that only few (or several) private landowners get involved in.

Lake residents decrease nutrients entering the lake by ending or adjusting fertilizer practices, installing vegetation buffers along the shoreline, letting natural vegetation grow as a buffer between lawns and the lake, and install Healthy Lake practices on (or near) their properties.

7.2 Watershed Concerns / Threats

"The lake-watershed "system" is a functioning unit with interacting biological, physical, chemical and human components. If a lake suffers from problems such as extensive weed growth, algal scum, fish kills or filling in with sediments, often the cause of the problem can be linked to a source or sources within the watershed"... Reflecting on Lakes

Non-point Pollution Sources

Nonpoint source pollution refers to widespread, seemingly insignificant amounts of contaminants that when accumulated over time, may damage water quality. Examples of watershed sources of pollution are: septic systems, road drainage, agricultural runoff, and lawn or garden fertilizers. Most are not required to have a permit. Individually, each may not be a serious threat, but together they may become a significant threat.

Soils: Investigation into the makeup of soils within the direct drainage basin of Moose Lake revealed that the septic system absorption fields may be highly prone to leaching. Soils obtained a "very limited" suitability rating for septic system use (NRCS Web Soil Survey). Poor performance and high maintenance of systems installed in these types of soils were predicted and effluent travelling through the soil may not be adequately filtered and may contaminate groundwater.

Algae: Floating algal scums were observed around the entire shoreline of the lake during the 2015 field season, and verbal reports indicate that this is a recurring problem around the Moose Lake shoreline from year to year. The presence of shoreline algae may indicate nutrient inputs from the shoreline area(s).

Chloride: Water samples were tested for chloride levels in April and October. The level of chloride increased slightly over the summer open water season from 8.4 mg/L to 9.7 mg/L, but the increase was of minimal significance. An increase of chloride over the open water season may indicate septic leachate or water runoff containing animal manure.

Given the types of soils present, the continued observations of algae scums, and the increase of summer season chloride levels, private septic systems along the Moose Lake shoreline are suspected as a source of phosphorus input. Since deficient septic systems are one direct source of nutrient input to lakes and rivers, periodic pumping and maintenance of them is required by Langlade County Zoning ordinance. Riparian landowners have a responsibility to adequately maintain their systems, not only for the continued health of Moose Lake but to decrease the likelihood of groundwater contamination.

<u>It is for these reasons that a Tier 2 diagnostic study is highly recommended for Moose Lake to begin confirmation of suspected internal and/or external phosphorus sources.</u> Once the sources are confirmed, a targeted strategy to begin phosphorus reductions could be formulated, and algae biomass could be reduced over time. The diagnostic study would include the following: 1) more extensive water chemistry monitoring (particularly Total Phosphorus and Chloride); 2) increased frequency of dissolved oxygen monitoring to pinpoint phosphorus release events from the sediments to identify when recycling is occurring within the system; 3) evaluate all Moose Lake riparian septic systems as potential sources; 4) conduct a soil boring study to confirm the

information gathered from the web soil survey; 5) install piezometers to map the groundwater flow, and measure phosphorus levels; and 6) generate a water volume and nutrient budget for Moose Lake.

Watershed Soils

The NRCS Web Soil Survey indicated that septic suitability in the entire drainage basin of Moose Lake is "very limited". What that means is the soil types that exist within the drainage basin have properties and limitations that affect the capability to absorb effluent, affect septic construction, affect public health and septic system maintenance. Typically, septic construction in these types of soils would require special design or expensive installation procedures to overcome the limits. If special procedures were not taken when the septic systems were installed, "poor performance and high maintenance can be expected."

Soil erodibility potential (K Factor) was also queried as part of the soils review. Calculated K Factors range from 0 to .69. On this scale, just over 14% of land within the Moose Lake drainage basin met the .49 level and approximately 27% fell into the greater than or equal to .32 level. Although there is nothing that can be done about the soils in the drainage, a lot can be done to reduce the potential of soil loss into nearby surface waters during stormwater runoff events.

For these reasons, encourage and/or partner with the Langlade County Land and Water Conservation Department to reduce soil erosion from the Moose Lake drainage basin. Conservation Departments have funding and technical expertise available to help farmers or other private landowners place soil saving practices on the landscape. Appendix 12 shows a list of cost-sharable best management practices that Langlade County Conservation Department offers to landowners. In addition, the Langlade County Land and Water Resource Management plan places these projects as a priority goal activity. County personnel are trained to work with landowners and partner with professional engineers to design the best practices to place for many different situations. Landowners must be willing to work with the county to place these practices on their land, but with a little education about decreasing runoff and the ability to share the cost with the county, many landowners are encouraged to do the right thing for water quality.

Agricultural Practices

The watershed analysis revealed that the direct drainage of Moose Lake is 29% mixed agriculture and pasture/grass land uses, and the Wilms model predicted that approximately 851 pounds of phosphorus per year may come from these two land uses alone. In addition, the majority of the Moose Lake drainage contains soil in hydrologic Group B, where the water transmission rate is at a moderate level. As part of Wisconsin NR 151 implementation (Appendix 13), county Conservation Departments work with farmers to reduce phosphorus loads to surface waters, and annually administer cost-share dollars to implement best management practices for water quality onto local landscapes. There are a host of practices that can be implemented to achieve nutrient runoff reduction goals on an individual's property. A few examples of cost-shared practices that may reduce nutrient runoff are manure management pads, soil erosion reductions, or crop management practices. Once installed, county monitoring is essential to tracking progress of nutrient reductions or reductions in runoff volume or velocity.

The current status of water quality best management practices / improvements within the Moose Lake drainage basin was investigated in this study. Although specific parcels must remain anonymous, the Langlade County Conservationist confirmed that there are 5 known parcels within the surrounding watershed with approved nutrient management plans and whom consistently and annually participate in the Farmland Preservation Program. As recent as 2011, there has also been one landowner that has improved animal trails and walkways (Pasture Lanes) according to approved NRCS standards to protect the quality of runoff water from the site (M. Graupner personal communication).

Moose Lake is located in the Upper Fox-Wolf Basin where the development of a high priority TMDL is currently underway. A watershed plan using phosphorus-reduction models such as STEPL, PRESTO or SNAP Plus, would tie directly into the existing Langlade County Resource Management Plan. The plan would utilize a 9-key element plan process (pg 90) to achieve phosphorus runoff reductions within the entire drainage basin of Moose Lake, and could conceivably begin shortly following the Tier 2 diagnostic study (see non-point pollution sources). The implementation of a watershed management plan may serve to reduce soil erosion, reduce tremendous loads of phosphorus input annually from the watershed, and lessen the excess algae growth that occurs in Moose Lake over a period of time.

Shoreland Buffers

The overall condition of the shoreland areas around Moose Lake is excellent as found in the results of the shoreland assessment. Appendix 12 lists the scores of each site that was assessed alone the shoreline. For those sites that may benefit from additional shoreline restoration, unique management options are listed there.

All riparian landowners should minimize the level of nutrients entering the lake from their properties. Avoid fertilizing the lawn to prevent runoff of fertilizer into the lake. If fertilizing is necessary, have a soil test done to reveal the amount of fertilizer actually needed and adhere closely to those guidelines. Landowners can purchase fertilizers with 0 phosphorus (the middle number listed on the bag). Install vegetative buffer strips along the shoreline to minimize surface water runoff into the lake. This can be done by simply allowing vegetation along the shore to grow on its own, or embellish the area with native plants. Native vegetation also provides habitat for wildlife that depend on the shoreline to live and the deep-set root systems help hold soil particles to reduce potential erosion problems.

7.3 Lake User / Association Concerns

Lake Survey Concerns

As found from the results of the Lake Survey, the top 3 concerns identified by Moose Lake users were lake bottom siltation, algae blooms, and aquatic plant growth. It was also clear that users were not in favor of the "do nothing" option to control aquatic plants.

There would be two ways to approach the aquatic plant issue. First, control the nutrients that are entering the lake. This recommended approach is very important because by limiting the source(s) of nutrients to the lake, it would naturally follow that the level of aquatic plant growth would be restricted as well. The second approach would be to manage or treat the aquatic plants in some fashion, and is not recommended as an action to take at this time. Refer to Aquatic Plants in Section 7.1 above.

Participants of the lake survey identified the following three topics of interest to learn more about: 1) Shoreline Restoration; 2) Human Impacts on Lakes; and 3) Aquatic Invasive Species. Closely following topics were learning about water quality monitoring, and how invasive species spread from lake to lake. Educating association members and the wider public about lakes is an important step in the lake management process. There are many people and experts in the area that can help educate about these and other topics. FOML should continue to host guest speakers at their annual meetings to address the educational interests of their membership. Be sure to ask speakers to address topics of interest that survey participants wanted to learn more about. Follow up speaker topics with a newsletter article to reach people that could not attend the meetings.

Lake organizations may also take additional education approaches to specifically target farmers and other private landowners located within the drainage basin of the lake. Newspaper notices about land and lake stewardship is a subtle approach to community education, while directed mail campaigns would target particular types of landowners (i.e., farmers) and illustrate grant programs or options available to them to improve crops, manage manure or stormwater runoff from fields, or even reduce soil erosion from fields. Small-scale lake planning grants from the DNR would be available to the lake association for this purpose. Note: This approach could be accomplished in cooperation with the county conservation department.

AIS Monitoring for Early Detection

The Clean Boats / Clean Waters monitoring program is an excellent way to monitor boats that are entering the lake. Lake organizations that apply for grant dollars in this program are guaranteed to receive the money. These are non-competitive grants that organizations use to either hire and pay an individual(s) to be present at the landing at specified busy times and/or they can purchase the materials necessary to run a successful program with volunteers.

To protect Moose Lake from incoming invasive species, increase the level CB/CW program monitoring at the boat landing, and continue both the Bag It & Tag It and the Zebra Mussel monitoring programs.

Some lake organizations around the state have instituted a "Dollars OR Hours" program. Riparian landowners along the shoreline have either donated money toward the CB/CW monitoring project, or their time has been donated in volunteer hours.

Aquatic Invasive Species continue to be a threat to all surface waters of Wisconsin (and beyond). It will be important for lake users and lake organization leaders to keep monitoring programs alive and active to find invasive species populations early. Annually coordinating or hosting a community-wide AIS monitor training is an important step. Volunteers need annual refresher courses to feel informed and confident in their ability to identify the "bad" species, and to know what to do in case they find one. Volunteers also deserve "kudos" and a public display of appreciation for doing the work and providing a meaningful community service. Lake organization leaders can provide this positive feedback to any and all volunteers in a number of different ways.

AIS Contingency Plan

In the event of the discovery of invasive plants or animals in Moose Lake, it is important to be prepared in advance. In addition to taking protective actions to minimize the chances of invasive introductions to the lake system, a group must have a well thought out written action plan in place so that responses can take place quickly to remove the unwanted invader and curtail further spread throughout the lake or further downstream. Plans can be created simply or more detailed, depending on the comfort level of the lake group.

Best Management Practices Handbook

Many people who own lakefront property do not realize that they have additional responsibilities to protect the lake and the shoreline. Create a handbook to use as an educational tool and hand it out to anyone who has property on the lake. A guidebook such as this would provide information, tips, and advice for lake property owners about the best ways to protect the quality of Moose Lake (and their own property values). *Best Management Practices* are those ways of using and modifying the natural environment that preserves or enhances it, while in turn protecting or improving lake water quality. Voluntarily following the list of practices in the book would give landowners a sense of lake stewardship and a sense of accomplishment in protecting the lake.

CLMN Activities

The Citizen Lake Monitoring Network is the best way to collect useful, inexpensive, and very meaningful long term data about lakes that can be used for many purposes. The data collected through these programs is housed in the SWIMS database on the DNR website. Continue with all volunteer activities in the citizen lake monitoring program. If a volunteer is no longer willing or able to continue collecting, be sure to hand over the duties to the next willing volunteer so that the collections can continue on schedule. Sometimes having younger people participate in the volunteer activity can foster an interest in continuing.

7.4 Management Strategies & Timeline

Lake Management Plan Implementation

Now that the comprehensive lake plan is complete do not let it sit on a shelf! The Association has taken a great step forward in the collection of this baseline data. But, the work moving forward is just beginning. The recommendations listed here are to be used and acted upon to improve and protect the lake and its' watershed. It is a "living" management tool that can be revised and changed as time marches on and as conditions on and around the lake change. Be sure to ask questions and seek help from professionals if needed to begin more complicated management actions.

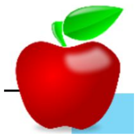
By completing this comprehensive lake management plan, FOML, county land managers, and water resource professionals will have a much better understanding of Moose Lake and the surrounding watershed. Information that was collected and summarized here can be referenced and utilized for many purposes. Well planned management actions and steps can now move forward that will enhance the lake and the watershed so that Moose Lake is protected and enjoyed by future generations. Overall, Moose Lake is in good condition, except for the algae growth that seems to be out of control. The lake may experience improvements from direct actions that reduce nutrient inputs, reduce potential soil erosion, and reduce the likelihood of establishing invasive species populations. Utmost care and observation must be a priority when any management implementation action occurs.

Summary of Management Strategies

The FOML planning committee met to discuss the study results and management options that were available. The following lake management strategies are recommended for Moose Lake, Langlade County, and the planning committee will decide what best suits their needs to initiate further lake improvement. Refer to the chart of strategies and further explanation below. Management suggestions listed here range from fairly simple tasks (blue and yellow) to much greater lake management projects (green and red) that would be set in motion, as time, volunteer assistance, partnerships, and grant funding would allow.

A suggested timeline for management actions is included in Table 18.

Suggested Management Strategies



EDUCATE

- Avoid Sediment Re-Suspension
- Catch & Release
- Panfish Regulations
- Collect Angler Information
- Promote Shoreline BMP's
- Promote Agriculture BMP's
- Educate at FOML Meetings
- Post Courtesy Code @ Landings
- Continue AIS Monitoring
- Respond Early

PROTECT

- Update AP Survey
- Protect Aquatic Plants
- Bolster CB/CW Monitoring; Take it to the Ice
- Communicate w/ DNR Fisheries
- Sponsor Healthy Lakes Projects
- Write a BMPs Handbook & AIS Contingency
- Maintain Septics

DIAGNOSTIC STUDY

- Quantify Flow
- Nutrient Budget
- Soil Study
- Groundwater Testing
- Evaluate Septic Systems
- Water Quality Collections
- Review Water Operations

NUTRIENT REDUCTION

- 9 Key Element Process
- P Reduction Modeling
- Landowner Contacts
- Site Evaluations & Planning
- Implement BMPs on the Landscape
- Post Monitor / Evaluate Success

Management Strategy – Educate

Education of the FOML members and the surrounding community is a very important component of any lake management plan. In fact, the top three topics of interest "to learn more about" that were identified in the Social Survey were: Shoreline Restoration, Human Impacts on Lakes, and Aquatic Invasive Species. FOML should concentrate on these topics first for their membership. Raising public the extended public about lake stewardship and best management practices is encouraged for FOML to lessen the effects that watershed runoff may be having on the lake.

Lake groups can coordinate educational programs by themselves because they are fairly easy to implement, they can consult with an expert on any topic, or they can find more information online for additional help. The decision to go beyond the simple suggestions in this plan are at the discretion of the association board. As time marches on and changes occur, it is likely that the need for information about the latest "hot" topic will rise up and can be addressed as needed.

Primary Management Goal: To raise awareness about lake stewardship activities for members of FOML, the lake user public, and private landowners within the direct drainage basin of Moose Lake.

How: Listed here are the recommended ideas for FOML.

1) Invite guest speakers to FOML meetings – Continue to have guest speakers at the meetings. It is important for people to hear directly from experts about topics of interest. That way questions and concerns can be addressed in person. For those people that cannot make the meetings, consider writing articles for the newsletter or placing the powerpoint presentation (or a YouTube video) on the FOML website.
2) Conduct Lake Monitoring – There are different ways to monitor a lake and FOML is already involved in many of them. Specifically, monitor the lake for aquatic invasive species. Experts can come to speak to groups about monitoring opportunities and train volunteers how to do it. Keep up the Clean Boats Clean Waters program each year. Take this concept to the ice! Consider conducting "CB/CW" during the winter months. Respond early to real or threatened sightings of invasive species. If something is suspicious, bring a sample into the local County or DNR office for identification.
3) Promote best management practices on shorelands and for agricultural producers – BMPs are fairly easy things that can be done to promote healthy surface and groundwater. Consider an education program that focuses on BMP's. The program can focus on riparian landowners or extend beyond into the watershed community (farmers and other private landowners). The more people who know about and implement just 1 or 2 practices, the healthier the lake will be. The Land & Water Conservation staff are a great resource to talk about watershed-wide BMP's and opportunities available for financial aid.
4) Post a "Courtesy Code" at the boat landing kiosk. Lake associations cannot create laws, but they can inform the public about certain courtesies that lake users should keep in mind. This can be updated annually to keep up with the times and replace faded or old signs.
5) Consider collecting more information about anglers and their catch. Adapt the Angler Data Collection form to collect the information that interests your group. The important thing about this type of information is that it is collected consistently and shared with the area fish biologist. It is in this way that fish biologists can collect additional year around information that may be useful to them for various reasons.

6) Never Stop Learning – Learn all you can about how to protect the lake. There are many resources out there to help, like attending the annual Wisconsin Lakes Convention held each year in the spring. UW Lakes website is also a wonderful source of the latest information. Know who your legislative contacts are and write to these people often about bills that effect lakes and other surface waters!

Who: The FOML board of directors and volunteers, invited guest speakers

When: If you have a larger project in mind, or have several educational ideas that might be placed into the same grant application, small scale grant applications are due December 10. A small scale grant would cover things like creating/printing of educational brochures, creating boat landing signage, creating a folder of materials for landowners, rental of a large facility for a special educational speaker and refreshments for that event, or payment for a special speaker. Consult the WDNR website for more information about what types of projects can be covered by grants.

Bottom Line: If you can think it up as an educational tool, the WDNR will likely have a grant available to help accomplish your plan. Try to extend lake education presentations to the watershed community, not just riparian landowners. They too have a role in keeping Moose Lake healthy.

Management Strategy – Protect

There is a fine line between education and protection strategies. Indeed, part of the protection strategy includes educational components, but it also extends beyond that realm into more complicated concepts. Many of the protection strategies are easy and inexpensive, but may include action on the part of FOML and / or the gathering of grant funds on a larger scale.

Lake groups can coordinate these types of protection steps by themselves because they are fairly easy to implement, they can consult with an expert, or they can find more information online for additional help. The decisions to go beyond the simple suggestions are at the discretion of the association board.

Primary Management Goal: To protect Moose Lake from unpleasant or unplanned consequences. To prepare the association in case more management action is necessary in the future.

How: Listed here are the recommended ideas for FOML.

1) Healthy Lakes Projects – This program is highly recommended as a great action to get people involved in lake stewardship. The Healthy Lakes program is designed especially for lake associations to get riparian landowners to “do the right thing” to improve their shorelines, increase habitat, and reduce soil erosion. Each property is different and this program provides 5 specific BMP practices that people can do and get them grant funded! These practices include Fish Sticks, Native Plantings, Runoff Diversion, Rock Infiltration

6) Areas, or Rain Gardens. County Conservation Departments are familiar with this program and be a wonderful technical resource for help in planning projects. Note: The only way to complete Healthy Lakes projects are through a grant that FOML would initiate. More information about Healthy Lakes can be found on their website <www.healthylakeswi.com>.
7) Conduct an Aquatic Plant Survey – As a part of this comprehensive lake planning process, an aquatic plant survey was completed. This component of the comprehensive plan should be updated every 5 to 7 years. Changes in the aquatic plant population can take place quickly, and by updating this survey these changes can be noted. In addition, an expert can be checking for aquatic invasive species during this time, which would allow FOML to respond quickly if necessary. Why? Because aquatic plant surveys MUST be recent enough for the DNR to approve certain AIS management permits. If completed alone, these surveys can be completed at relatively low cost to the association.
8) Promote Communication with Fishery Staff – It is important to communicate to area Fishery Biologist on a regular basis. This means once per year, or as the need should arise in the case of suspect conditions such as winter kills or severe decline in a known population. Another good reason to remain in contact is to gather information about the DNR's Panfish Regulation Research Study or to ask the biologist how FOML can help in gathering additional information for the DNR.
9) Bolster the CB/CW Monitoring Program – Protecting Moose Lake from unwanted species is a great step in keeping it healthy. Keep up the Clean Boats Clean Waters Program each year. You may wish to extend this AIS education program by taking it to the ice. Take the opportunity to teach ice anglers about the importance of keeping AIS out of ANY lake. Make them aware that they can take steps to check their ice fishing equipment during their time on the lake. Encourage anglers to keep aquatic plants on the ice and make the rounds to check the plants. Volunteers can have some fun and educate at the same time!
10) Create a BMP Handbook for Moose Lake – Some riparian landowners may not be comfortable attending meetings or participating in the Healthy Lakes program. However, they might be perfectly comfortable reading something on their own about how they can help improve the quality of the lake. Creating a guidebook about BMP's can be a great resource to handout to the "Watershed public" or to riparian landowners that may not be association members. These books can be a great recource for anyone, and could include things like: Steps to maintaining a septic system, How to control stormwater runoff, or Creating shoreland buffers for multiple purposes. There are great ideas online about Best Management Practices, and FOML could be as detailed (or as brief) as you wish.
11) Create an AIS Contingency Plan – What would FOML do if Eurasian Water Milfoil was found in Moose Lake? What about if Curly Leaved Pondweed was verified? Contingency plans can be a great proactive step that ALL lake groups can take to be ready in certain "emergency" cases. When the planning process is being conducted, responses from sections 5 and 6 of the Lake Survey should be considered. AIS Contingency Plans are somewhat technical, so you may wish to hire an expert to complete it or consider it a challenge and complete it on your own.

Who: The FOML board of directors and volunteers, riparian landowners, County Conservation Department staff, Aquatic Plant Survey Consultant, Wisconsin Department of Natural Resources

When: Tip 1: Always think in advance for grant funding that may be needed the following summer because most DNR grant applications are only accepted once per calendar year. Tip 2: Always consult with a DNR Lake Coordinator about a grant project you are considering, they may provide good information that you may not have considered prior to the meeting. This consultation is required and will be noted on your grant application. Grant applications for Aquatic Plant Surveys fall into the category of Large Scale Planning Grant, due on or before December 10. Small scale planning grants for a BMP guidebook or an AIS Contingency Plan are due on or before December 10. Grant applications for Healthy Lakes Projects are due on or before February 1.

Bottom Line: The protection management ideas given here are for FOML to consider. All are highly recommended, but can be implemented as time and funding allows. Refer to Table 18, for the management actions timetable.

Management Strategy – Diagnostic Study

This management strategy involves the collection of further data in an attempt to hone in on potential causes of water quality pollution from the watershed, septic systems, soils, groundwater, and additional water quality collections. It is known as a Tier II level study, which is a more comprehensive evaluation of a single waterbody. Because Moose Lake has been listed on the 303d Impaired Waters List, a diagnostic approach may be favorable to the WDNR before additional strategies are implemented. *Note: This option only valid if FOML would decide 1) against the nutrient reduction strategy altogether; or 2) waiting to move ahead with the nutrient management strategy until further investigations were completed.

It would be necessary for FOML to seek a consultant and additional lake grant dollars for this type of management action. The advantage to this management action is that potential source(s) of pollution can be found directly, and therefore the remediation of the problem can be directly targeted. In the long run, this may save money and time for FOML to address the phosphorus loading of Moose Lake.

Primary Management Goal: To gather additional data to learn more about where potential pollutant source(s) are located. To prepare the association for targeted remediation efforts in the future.

How: Listed here are the recommended ideas for a Tier II diagnostic study.

1) Calculate Nutrient Budget – A nutrient budget is a quantitative means to account for all sources of water (& pollution) entering and leaving the lake system. A simple example is how much Total Phosphorus goes in versus how much Total Phosphorus goes out. Lake managers like nutrient budgets because they are very useful for quantifying nutrient loading while simultaneously revealing problem locations <u>and</u> timing of excessive nutrient deliveries. All sources of water going into the system are monitored (stream inflow & outflow velocity, stormwater runoff, groundwater flows, precipitation, and evaporation).

1) Evaluate Septic Systems & Soils – There was a slight increase of chloride over the summer months in Moose Lake, which can indicate septic issues….somewhere in the lake ecosystem. In cooperation with the county Zoning Department an evaluation and inspection program for Moose Lake riparian landowner septic systems would be encouraged in an effort to find problematic sources of nutrient influx. Simultaneously, riparian soils would be further investigated for septic system leachate.
2) Water Chemistry Monitoring – Additional samples of total phosphorous and chloride would be taken to determine if internal loading may be playing a role in overgrowth of algae in Moose Lake. Dissolved oxygen and temperature profiles would be taken weekly throughout various locations as part of the internal load monitoring program.

Who: The FOML board of directors and volunteers, riparian landowners, County Zoning Department staff, consultant, Wisconsin Department of Natural Resources

When: When recommended as a management strategy in an approved lake management plan (Tier I). Grant applications for Diagnostic Studies fall into the category of Large Scale Planning Grant, due on or before December 10.

Bottom Line: The diagnostic study management approach outlined here are for the FOML to consider if it is decided that they do not want to initiate the nutrient management strategy. This project would be a good way to learn more about Moose Lake and the potential pollutant locations before remediation action(s) take place. Thus, management actions can be selected as appropriate in the future.

Management Strategy – Nutrient Reduction

The nutrient reduction strategy is not new to most county conservation departments in Wisconsin. In fact, this "watershed" strategy has been used for many years to reduce phosphorus loads to agricultural streams in the state. As a management recommendation for a lake management plan however, watershed-wide management strategies are unusual. Why? This type of strategy involves technical expertise and planning and monitoring components, so lake groups do not have the capacity to implement them on their own. Instead, by the nature of the strategy, lake groups could only initiate and encourage this type of management technique.

The consultant would like to propose a different way to involve lake groups in the watershed-wide nutrient reduction management process, only if FOML is interested in the concept and being one of the first lake groups in the state to embark on a much larger lake management project.

Primary Management Goal: Reduce phosphorus and sediment loading to streams that ultimately reach Moose Lake (within the lake's drainage basin).

How: 9 Key Element Plan – a collaborative strategic process taken in 9 steps to assess contributing sources of point and non-point pollution, plan and prioritize best management practices to reduce pollutant inputs.

What are the Steps?

1) Identify the causes and sources of pollution within a given watershed – this includes Private landowner site evaluations and quantifying the current background levels of phosphorus from significant sources.
2) Estimate the pollutant load reductions that will meet a given lowered goal.
3) Select and describe the management practices that will need to be achieved for the targeted pollution reduction goal.
4) Estimate the financial and technical assistance needs for the life of the project.
5) Develop an information and education strategy to gain trust in the project and to encourage community involvement (especially important for the "watershed" community).
6) Develop a schedule for each piece of project implementation. This would include annual project plans (3), budget/grant plans (4), technical assistance (4), information and education (5), milestones (7), achievements and monitoring (8-9).
7) Identify measureable project milestones to ensure project is being implemented as planned.
8) Identify criteria to determine if plan goals (nutrient reduction) are being achieved. Prepare a contingency plan to adapt best management practices as needed if reduction goals are not being met.
9) Develop monitoring program to evaluate project effectiveness over time (use 6, 7, 8).

Who: Partners in the process would include FOML, Langlade County Land & Water Conservation, private landowners within the Moose Lake drainage basin, the Wisconsin Department of Natural Resources, the Wisconsin Department of Agriculture, Trade, and Consumer Protection, and a hired consultant (if desired).

Each of the partners would have specified roles during the life of the project.

When: Process could begin now by seeking a WDNR large scale planning grant (December 10 deadline) to begin the Information and Education process. Important Note: Must have buy in of Langlade County Land & Water Conservation from the very beginning. Purpose of I&E program would be to begin the long process of educating private landowners about the current condition of Moose Lake, the challenges of keeping a lake healthy, and introducing the landowners to the watershed-wide nutrient reduction strategy that is being planned. A WDNR Lake protection grant could be submitted for the February1, 2019 cycle to begin the 9 key element plan document.

Bottom Line: Once the 9 Key Element Plan document is complete for the Moose Lake drainage basin, private landowners can contract with Langlade County to implement best management practices.

Table 18. *MANAGEMENT ACTIONS TIMETABLE*	YEAR 1				YEAR 2				YEAR 3				YEAR 4			
EDUCATE	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC
Collect more Angler Information																
Discuss questions w/ DNR																
Design Diary to address questions																
Distribute Diaries																
Complete Diaries / Deliver to DNR																
Submit data results to DNR																
Promote Shoreline / Agriculture BMP's																
Speaker presents information at FOML																
Initiate educ workshop with ag producers																
Post Courtesy Codes																
Design / Update Courtesy Code for FOML																
Post at Boat Landing																

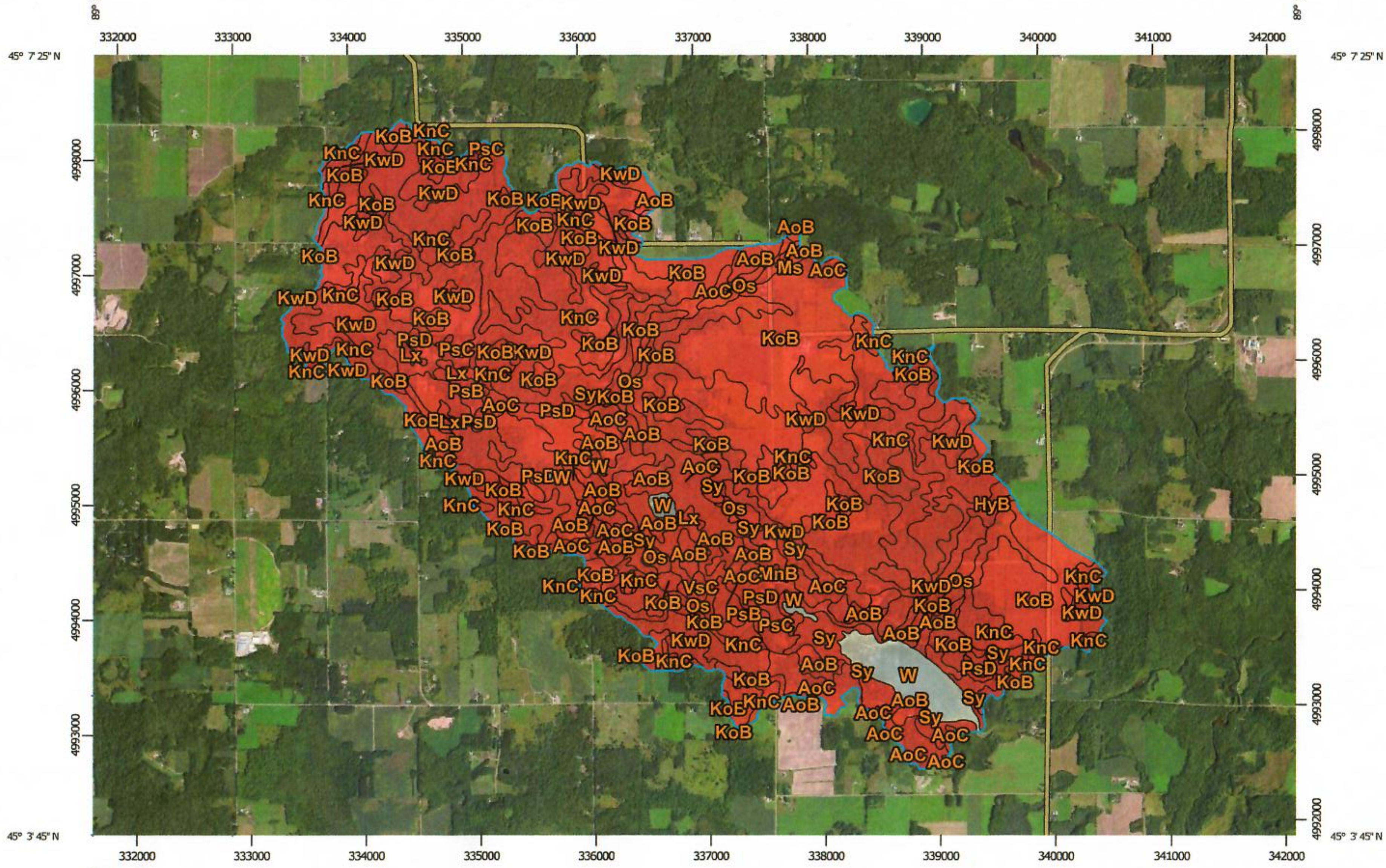
Table 18. *Actions Timetable (cont)*	YEAR 1				YEAR 2				YEAR 3				YEAR 4			
PROTECT	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC
Protect Aquatic Plants in Bay																
Contact DNR for Buoy Marker Permit																
Purchase Buoys																
Place Navigation Buoys																
Remove Navigation Buoys																
Bolster CB/CW Program																
Submit Annual CB/CW Grant																
Hire 2 persons to work landing																
Complete CB/CW inspections																
Close Annual Grant																
Take CB/CW to the Ice																
Talk to Ice Anglers about AIS																
Sponsor Healthy Lakes Program																
Riparian Landowners learn about program																
Landowner Site Visits / Sign Ups																
FOML submits Healthy Lakes Grant																
Projects implemented																
Close Grant																
Best Management Prac Handbook																
Prepare Grant Proposal																
Submit Small Scale Planning Grant																
Write BMP Handbook																
Close Grant																
AIS Contingency Plan																
FOML writes Contingency Plan																
Update Aquatic Plant Survey																
FOML seek consultant / grant for project																

Table 18. *Actions Timetable (cont)*	YEAR 1				YEAR 2				YEAR 3				YEAR 4			
DIAGNOSTIC STUDY	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC
Tier 2 Study																
FOML seeks consultant for project																
Project Planning / Grant Proposal written																
Phase 1 Large Scale Grant submitted																
Phase 1 Project implemented																
Phase 1 Large Scale Grant Closed																
Phase 2 Grant submitted																
Phase 2 Project Implemented																
Phase 2 Grant Closed																
NUTRIENT REDUCTION	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC	JAN - MAR	APR - JUN	JUL - SEP	OCT - DEC
9 Key Element Plan																
FOML seeks consultant to write plan																
Partners meet to discuss planning																
Lake Protection Grant Proposal written																
Lake Protection Grant submitted																
9 Key Element Plan written																
Close Grant																
Partners Begin Plan Implementation																
Langlade Co seeks TRM Grant																
County works w/ Landowners to plan BMP's																
FOML & Co promotes Ag BMP's																

Appendix 1

Moose Lake Drainage Basin Soils Map

Map—Septic Tank Absorption Fields



N

Map Scale: 1:47,800 if printed on A landscape (11" x 8.5") sheet.

0 500 1000 2000 3000 Meters

0 2000 4000 8000 12000 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 16N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Langlade County, Wisconsin
Survey Area Data: Version 10, Sep 16, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 25, 2011—Aug 28, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Appendix 2

Lake User Survey Form - Blank

Moose Lake Survey: We need your input about Moose Lake. Your honest opinion is important to us. Please take a few minutes to fill out this survey and send it back. We want to keep this confidential, so please do not identify yourself. Thank you!

SECTION 1: FAMILIARITY with MOOSE LAKE

1) Are you a visitor, renter, or owner of property on Moose Lake? Check ONE statement which best describes your situation

____ Visitor / Guest
____ Property Renter
____ Property Owner*

**For purposes of this survey, if you own more than one Moose Lake parcel, think of the one that you frequent the most*

2) How many years ago did you first visit Moose Lake? ______ year(s)

If less than one year, enter 1
If you are a visitor/guest please answer this question, then advance to Section 2

3) How long have you owned or rented your property on Moose Lake? ______ year(s)

If less than one year, enter 1

4) Is your Moose Lake property used as a primary or seasonal residence? Circle One

Primary Seasonal*

**If seasonal, approximately how many days each year is your lake property used by you or others?*______ day(s)

5) Has your Moose Lake property been owned by a previous family member? Circle One

No Yes*

**If yes, approximately how long has the property been in your family?* ____year(s)

SECTION 2: RECREATION

6) How many days each year do you recreate on or around Moose Lake? ______day(s)

Provide you're best estimate by entering one number and not a range of days

7) Circle all activities that are important to you on or around Moose Lake.

a. Solitude / Relaxation
b. View nature/wildlife
c. Boating / Pontoon
d. Hunting
e. Ice fishing
f. Entertaining
g. Swimming
h. Jet skiing
i. Snowmobiling/ATV
j. Hiking
k. Fishing
l. Water skiing/tubing
m. Canoeing/kayaking
n. Sailing
o. Other________________
p. None of these activities are important to me (*advance to Section 3*)

8) **From the list in question 7, rank <u>your top three</u> important activities on or around Moose Lake.** *Place a letter in each rank category with 1st being your most important*

1st______ 2nd______ 3rd______

9) **What type(s) of watercraft do you use on Moose Lake?** Check all that apply

____Motor boat with > 25 hp motor
____Motor boat with ≤ 25 hp motor
____Sailboat
____Pontoon boat
____I do not use watercraft
____Rowboat
____Canoe / Kayak
____Paddleboat
____Jet ski (personal watercraft)

SECTION 3: FISHERY

10) **Have you ever fished Moose Lake?** Circle One
Yes No (*If no, advance to Section 4*)

11) **How many years have you fished on Moose Lake?** ______ year(s)
If this is your first year, enter 1

12) **Have you fished on Moose Lake in the past 5 years?**
Yes No (*If no, advance to Section 4*)

13) **What species do you target (try to catch) on Moose Lake?** Check ALL that apply

____Trout
____Northern Pike
____Largemouth Bass
____Yellow Perch
____Bluegill
____Crappie
____Other Specify______________________________________

14) **From the fish listed in 13, the target species you catch most frequently is:** List one

____

15) **Thinking of the fish you listed in 14, how frequently do you practice catch and release?**
Circle One
1 – Never 2 – Rarely 3 – Sometimes 4 – Often 5 – Always

16) **In your opinion, would you say the <u>current quality of fishing</u> on Moose Lake is:** Circle One
1 – Very Poor 2 – Poor 3 – Fair 4 – Good 5 – Excellent 6 – Unsure

Please help us understand your opinion of the fishing quality by providing a <u>brief</u> explanation:

17) **Has the quality of fishing <u>changed</u> during the years you have fished Moose Lake?** Circle One

1 – Yes, for the better
2 – Yes, for the worse
3 – No, it has remained the same
4 – Unsure

SECTION 4: WATER QUALITY

18) **In your opinion, would you say the <u>current water quality</u> of Moose Lake is:** Circle One

1 – Very Poor 2 – Poor 3 – Fair 4 – Good 5 – Excellent 6 – Unsure

Please help us understand your opinion of the water quality by providing a <u>brief</u> explanation:

19) **In the year(s) since you first visited Moose Lake, the water quality has:** Circle One

1 – Severely declined
2 – Somewhat declined
3 – Remained the same
4 – Somewhat improved
5 – Greatly improved
6 – Unsure

SECTION 5: AQUATIC INVASIVE SPECIES

Aquatic invasive species are non-native species, that when introduced to a new environment, may cause harmful disruptions within the new lake ecosystem and make recreation difficult. Examples of some invasive species that exist in Wisconsin are: Eurasian water milfoil, purple loosestrife, curly leaf pondweed, zebra mussel, spiny waterflea, or rusty crayfish.

20) **Prior to this survey, had you ever heard about AIS before?** Circle One

Yes No (*If no, advance to Section 6*)

21) **Are you aware of any invasive species in or around the shoreline of Moose Lake?** Circle One

1 – Yes
2 – I think so, but not positive
3 – No (*If no, advance to Section 6*)

22) If you answered yes or unsure in 21, which AIS are you aware of in or around Moose Lake? Check ALL that apply

____Rusty crayfish ____Purple loosestrife ____Eurasian water milfoil
____Curly-leaf pondweed ____Zebra mussel ____Carp
____Pale yellow iris ____Flowering rush ____Chinese mystery snail
____Freshwater jellyfish ____Spiny waterflea ____Heterosporosis (perch parasite)
____Alewife ____Round goby ____Rainbow smelt
____Other____________________

SECTION 6: GENERAL

23) Refer to the list of common lake pressures below. To what level do you believe the following are having a *negative* effect on Moose Lake? Place a 1, 2, 3 or 4 in front of each item below

1 – Does not exist 2 – Exists, but no effect 3 – Moderate Effect 4 – Large Effect

___Loss of fish habitat ___Lakeshore development ___Noise pollution
___Septic systems, faulty ___Watershed development ___Boat traffic
___Agriculture runoff ___Water pollution ___Boating safety
___Invasive species ___Light pollution ___Aquatic plants
___Loss of wildlife habitat ___Shoreline soil erosion ___Algae blooms
___Loss of shore vegetation ___Fishing pressure

24) From the listing below, rank your top three concerns regarding Moose Lake.
Place a letter into each rank with 1st being your highest concern

1st______ 2nd______ 3rd______

a. Lakeshore development
b. Water quality degradation
c. Loss of fish habitat
d. Light pollution
e. Agriculture runoff
f. Fishing pressure
g. Loss of wildlife habitat
h. Degradation of aquatic plants
i. Aquatic invasive species
j. Lake bottom siltation
k. Noise pollution
l. Boating safety / Traffic
m. Shoreline soil erosion
n. Algae blooms
o. Aquatic plant growth
p. Loss of shoreline vegetation
q. Fish kills
r. Other ____________________________

25) During open water how often do aquatic plants and/or algae effect your enjoyment of Moose Lake? Place a number in front of both items below

1 – Never 2 – Rarely 3 – Sometimes 4 – Often 5 – Always

___Aquatic plants
___Algae blooms

26) Do you believe aquatic plant control / management is needed in Moose Lake? Circle One

1 – Definitely Yes 2 – Probably Yes 3 – Unsure 4 – Probably No 5 – Definitely No

27) If aquatic plant management was proposed for Moose Lake, what would be your level of support for *responsible* use of the following management techniques?
Place a number in front of each item below

1 – Support 2 – Neutral 3 – Oppose 4 – Unsure, need more information

___Chemical treatment (use of herbicides)
___Biological control (use of weevils or beetles)
___Hand-pulling (by divers or volunteers)
___Combination of techniques
___Do nothing

SECTION 7: FRIENDS OF MOOSE LAKE ASSOCIATION (FOML)

28) Before completing this survey, had you ever heard of the *Friends of Moose Lake* Association? Circle One Yes No *(If no, go to Question 31)*

29) What is your membership status with the *Friends of Moose Lake* Association? Circle One
1 – Current member
2 – Former member
3 – Former member, but would like to re-join*
4 – Never been a member *(go to question 31)*
5 – Never been a member, but would like to join* *(go to question 31)*

**Please contact Larry Schaumberg for membership information at: 920-960-3087*

30) As a current or former member of the FOML, how well informed have (or had) they kept you regarding Moose Lake issues? Circle One
1 – Not at all informed
2 – Not well informed
3 – Unsure
4 – Fairly well informed
5 – Highly informed

31) From the list below, which topics would you like to learn more about? **Check ALL that apply**

___Aquatic invasive species
___Water quality monitoring
___Citizen volunteer monitoring
___Human impacts on lakes
___Wisconsin shoreland zoning and development laws (NR 115)
___Methods to restore and/or maintain natural shorelines
___Methods to minimize stormwater runoff
___How aquatic invasive species are spread between lakes
___Not interested in learning about any of these subjects
___Other____

If you have an idea(s) for future speakers or educational topics at the FOML annual meeting, please elaborate here:

32) FOML Association could serve their membership (or Moose Lake) by: Please elaborate

---

Thank you for participating in this survey. If you have additional concerns, ideas, or comments we want to hear from you. Please use the back of this page for your narrative.

Appendix 3

Angler Diary Form – Blank

VOLUNTEER ANGLER DIARY
FIELD DATA COLLECTION FORM

Important Instructions

Fill out one sheet for EACH fishing trip. Fill out form for one person only. Measure and record all gamefish caught and indicate if kept or released. For panfish, measure the length of the first ten of each species and indicate if kept or released. For additional panfish, record the number caught and if kept or released. Complete a data collection form every time you fish. Record unsuccessful trips also.

General Information

Lake Name: Moose L, Langlade Co | **Angler Name**: | **Date**:

Fishing start time: AM/PM | **Fishing end time**: AM/PM | **Total fishing time (**excluding lunch break, etc.):

List fish species sought and % of time spent fishing for each. If seeking all species listed during your outling, list 100% by each species.

Type of fishing activity (circle all that apply):
boat fishing shore/pier fishing wading ice fishing casting motor trolling row trolling bait fishing
other________________________

Weather Conditions: ***Circle one*** : sunny partly cloudy cloudy overcast ***Circle one*** : rain snow n/a
Winds : calm moderate strong gusty no wind wind direction________ ***Temperature (°F)*** : Air_______ Water_______
Notes :

Satisfaction Level (circle one): Low Medium High Explain:

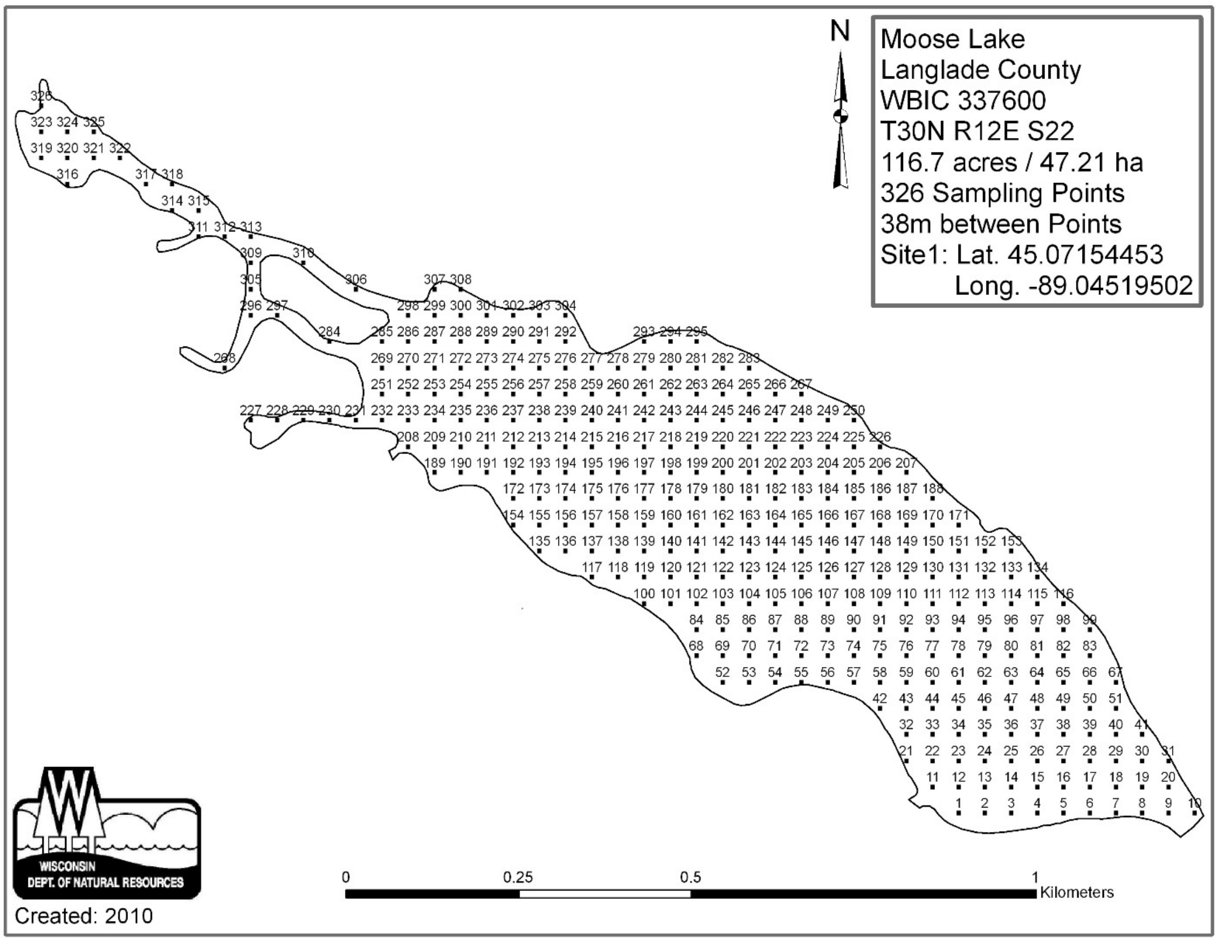
Fish Information

Catch #	Fish Species Common Name	Length (inches)	Check one: Kept	Check one: Released	Catch #	Fish Species Common Name	Length (inches)	Check one: Kept	Check one: Released
1					10				
2					11				
3					12				
4					13				
5					14				
6					15				
7					16				
8					17				
9					18				

Note: If more space is needed to record fish catch, use the backside of this sheet

Appendix 4

Sample Points for Point Intercept Survey



Appendix 5

Shoreline Assessment Form – Blank

SHORELAND HABITAT ASSESSMENT DATA COLLECTION FORM

Lake Name:

General Information	Date:	Field Evaluator(s):		
Site ID #: MLL-	GPS Start:		GPS End:	
Site Location Description:				
Riparian Terrestrial Zone	Human Influence: Absent Present	Buildings Pavement Lawn Crop Landscaping Bare Soil		
% Ground Cover:	% Understory:	% Canopy:	% Wetland:	% Other:
Soil Erosion: Absent Present/ Low Moderate Severe		Pollution: Absent Present________________________________		

Management Recommendations: Circle all that apply

Erosion Control
Protect Perch Trees
Buffer Restoration
Control Stormwater
Clean Up
Improve Wildlife Habitat
Other

Littoral Zone	Human Influence: Absent Present
Beach Pier(s) Boat Lift Raft Other	
Bottom Substrate: Muck Sand Gravel Rock Bedrock	
Macrophytes: Absent Present/ Submergent Emergent Floating	
Invasive Species: Absent Present / EWM CLP ZM Other	
Algae: Filamentous Surface Scum Water Column	
Fish Cover: Macrophytes Wood (<10 or >10) Artificial	

Management Recommendations: Circle all that apply

Add Fish Cover
Protect Spawning Site
Protect Native Macrophytes
Address Invasive Species
Protect Loon Habitat

Shoreline Transition Zone	Human Influence: Absent Present
Rip rap Sea wall Beach Boathouse Pier Ramp Other	
Bank Erosion: Absent Present/ Low Moderate Severe	
Invasive Species: Absent Present________________________________	

Management Recommendations: Circle all that apply

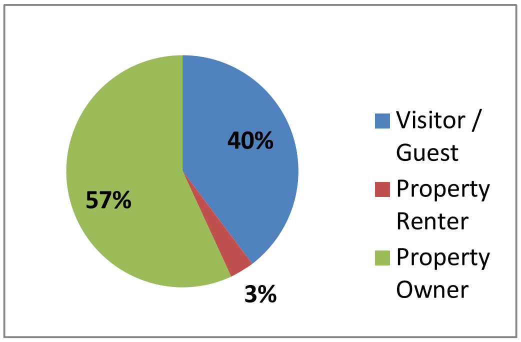
Bank Protection
Add Silt Fence
Add
Minimize the
View Corridor

Critical Habitat Summary	Circle all that apply
Macrophyte Community: Wild Rice Bulrush Rich Native Community	
Fishery Community: Spawning Area Wood Habitat Shade Canopy	
Water Quality: Natural Springs Cold Water Inlet	
Natural Scenic Beauty: Human Influence Absent	
Wetland Community: Diverse Wildlife &/or Plants	
Other: Endangered Species Historical Significance	

Appendix 6

Lake User Survey Results

1) Are you a visitor, renter, or owner of property on Moose Lake?

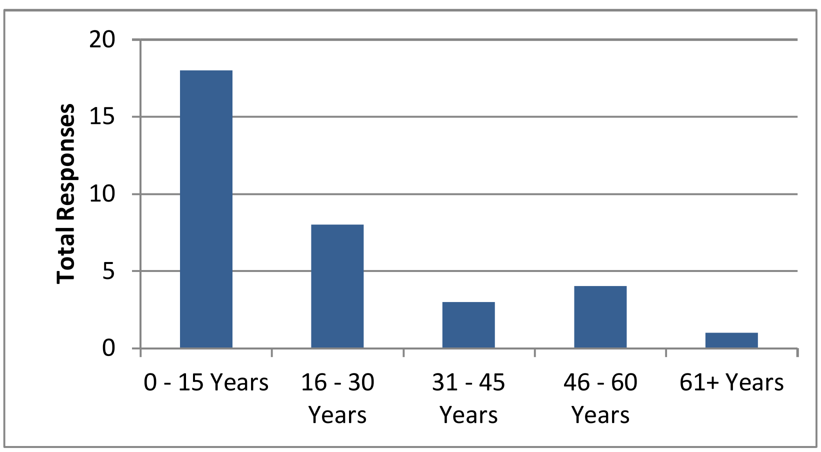


Q1	Total	%
Visitor / Guest	23	40
Property Renter	2	3
Property Owner	33	57
TOTAL	58	100

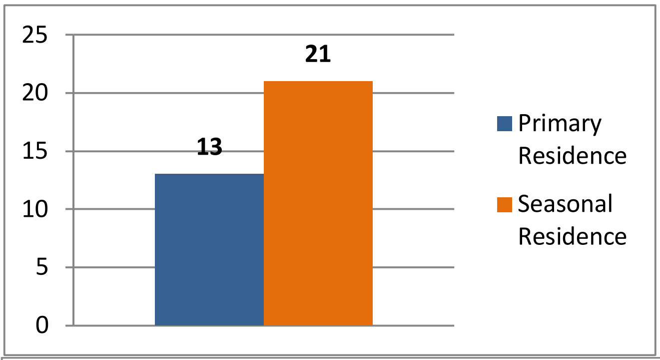
2) How many years ago did you first visit Moose Lake?

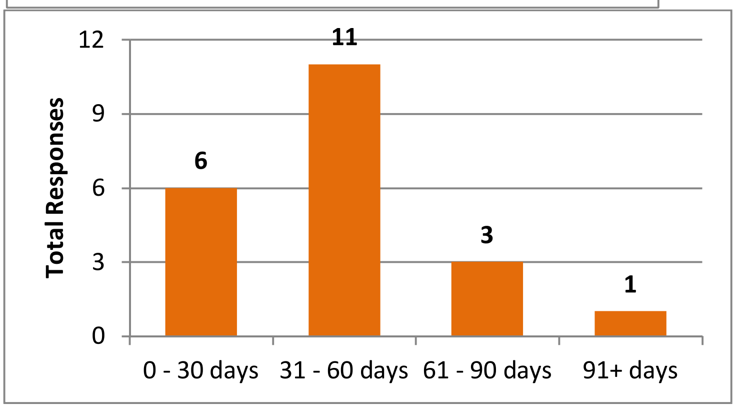
Q2	Total
0 - 15 Years	11
16 - 30 Years	8
31 - 45 Years	16
46 - 60 Years	17
61+ Years	5

3) How long have you owned or rented your property on Moose Lake?

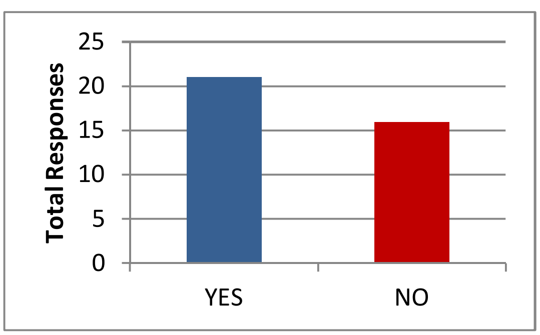


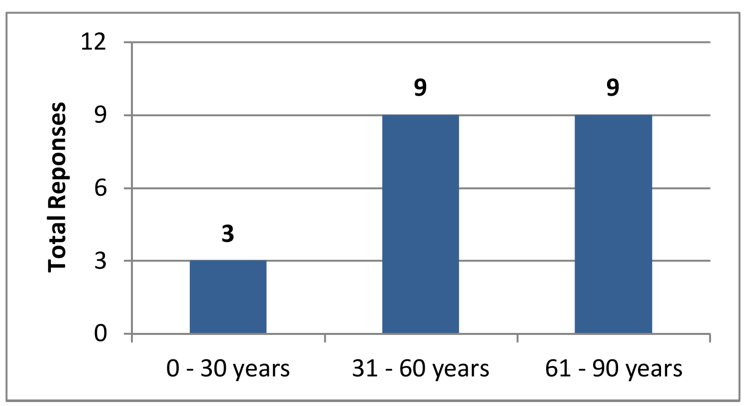
4) Is your Moose Lake property used as a primary or seasonal residence? If seasonal how many days?





5) Has your Moose Lake property been owned by a previous family member? Approximately how long has the property been in your family?

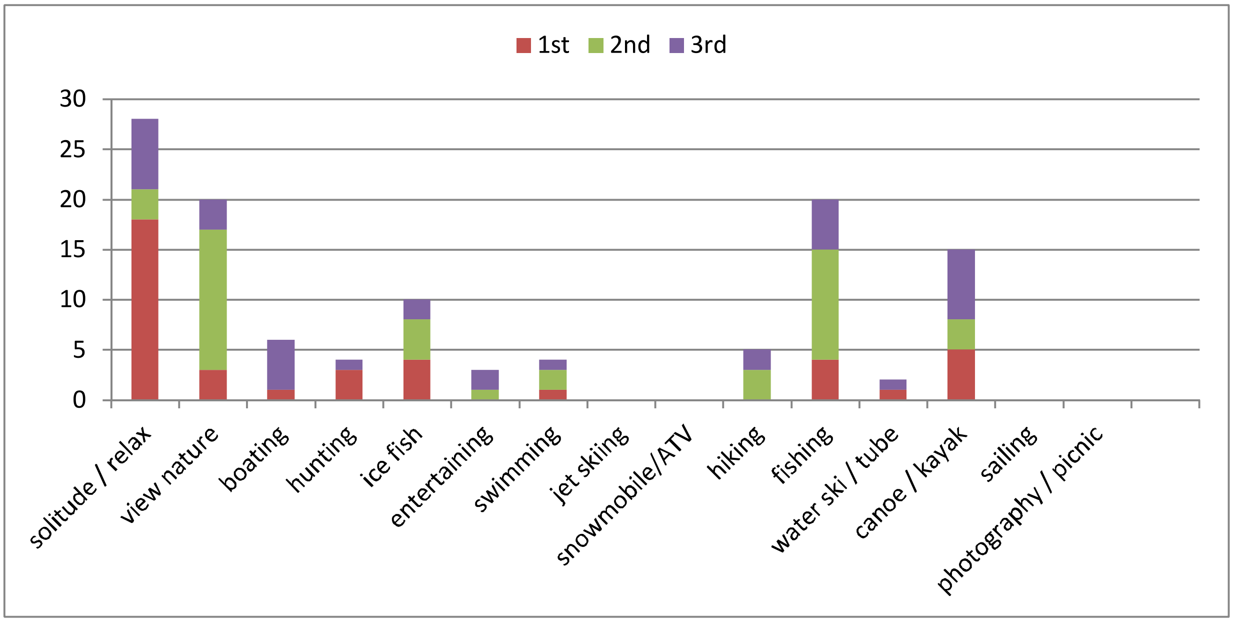




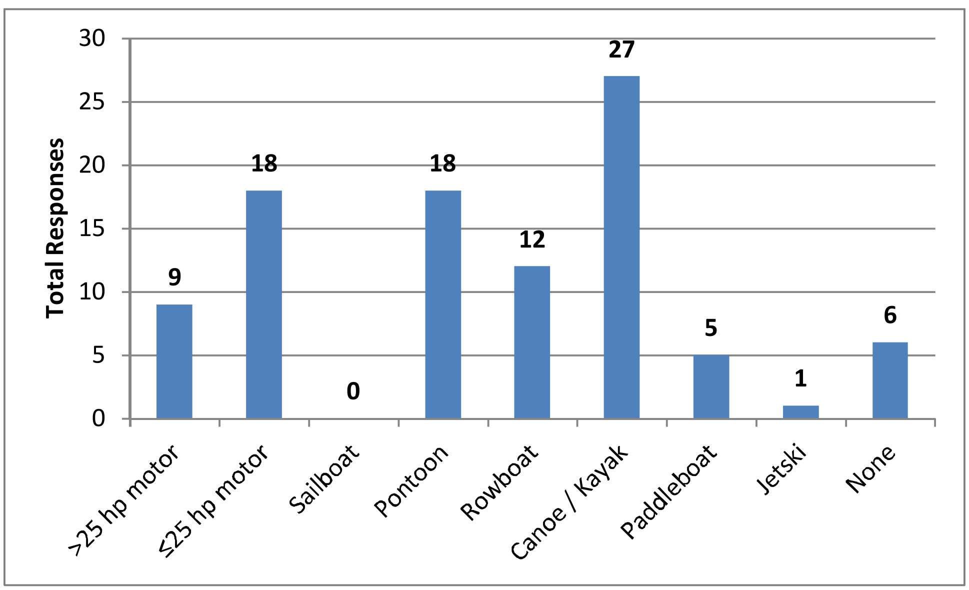
6) How many days each year do you recreate on or around Moose Lake?

Q6	Total
0 - 15 days	20
16 - 30 days	13
31 - 60 days	10
61 - 90 days	2
91+ days	7

7 & 8) Circle all activities that are important to you on or around Moose Lake. From the list in question 7, rank your top three important activities on or around Moose Lake.



9) What type(s) of watercraft do you use on Moose Lake?



10) Have you ever fished Moose Lake?

Q10	Total
YES	45
NO	12
Total	57/58

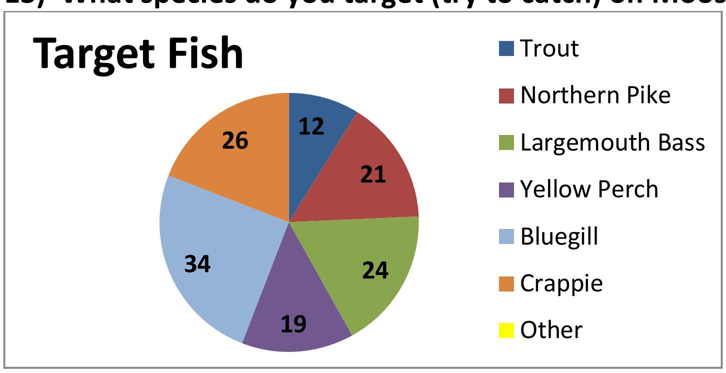
11) How many years have you fished on Moose Lake?

Q11	Total
1 - 15 Years	15
16 - 30 Years	8
31 - 45 Years	8
46 - 60 Years	8
61+ Years	2
Response Total	41

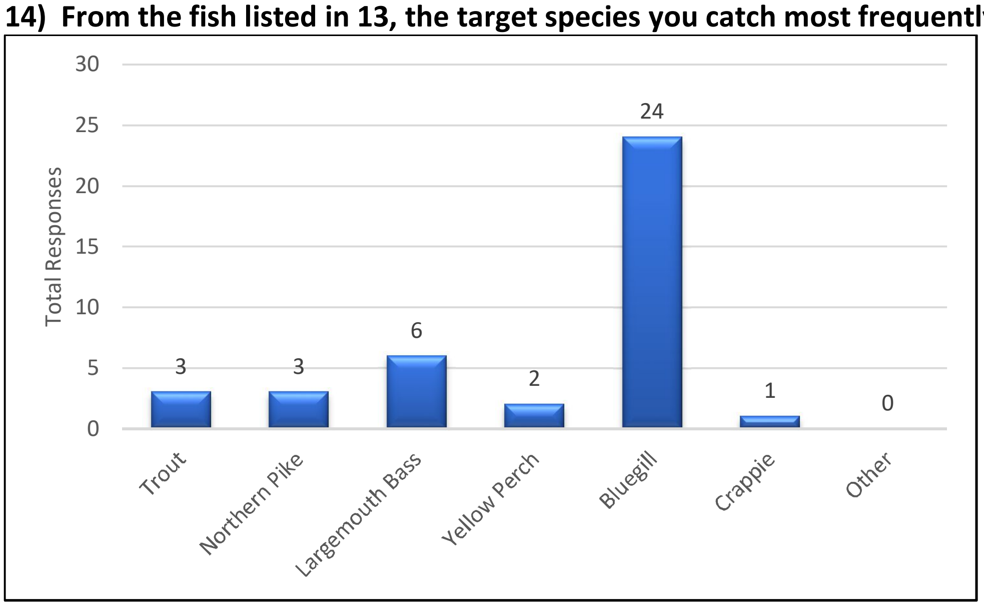
12) Have you fished on Moose Lake in the past 5 years?

Q12	Total
YES	35
NO	13
Total	48/58

13) What species do you target (try to catch) on Moose Lake?



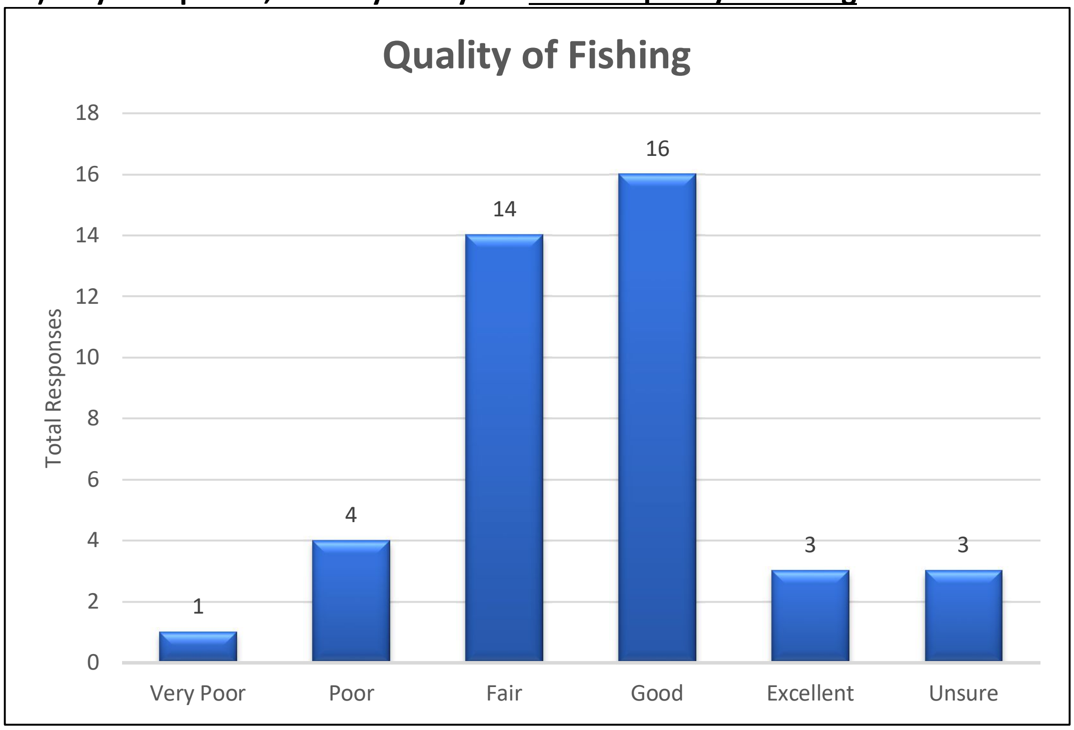
14) From the fish listed in 13, the target species you catch most frequently is:



15) Thinking of the fish you listed in 14, how frequently do you practice catch and release?

Q15	Total
1 - Never	0
2 - Rarely	3
3 - Sometimes	11
4 - Often	16
5 - Always	9

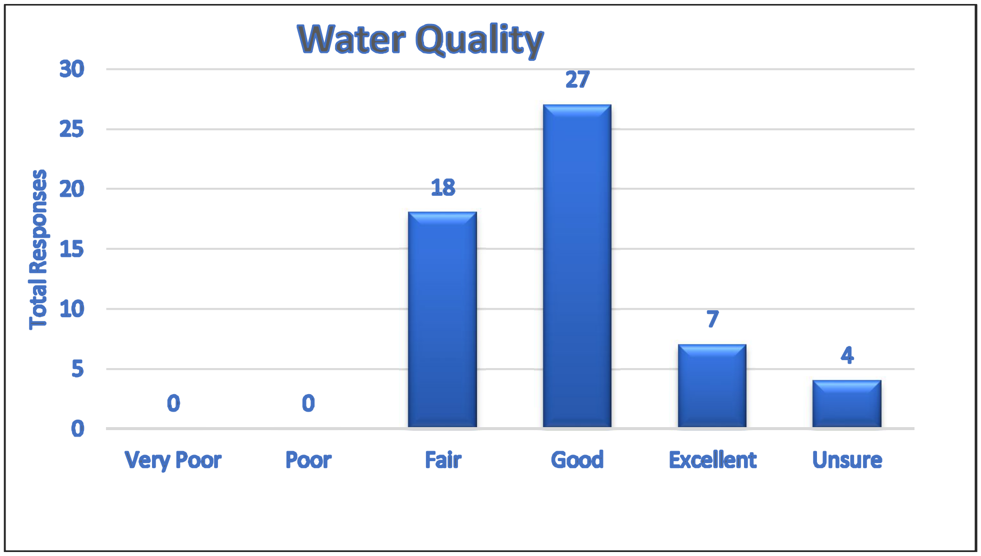
16) In your opinion, would you say the <u>current quality of fishing</u> on Moose Lake is:



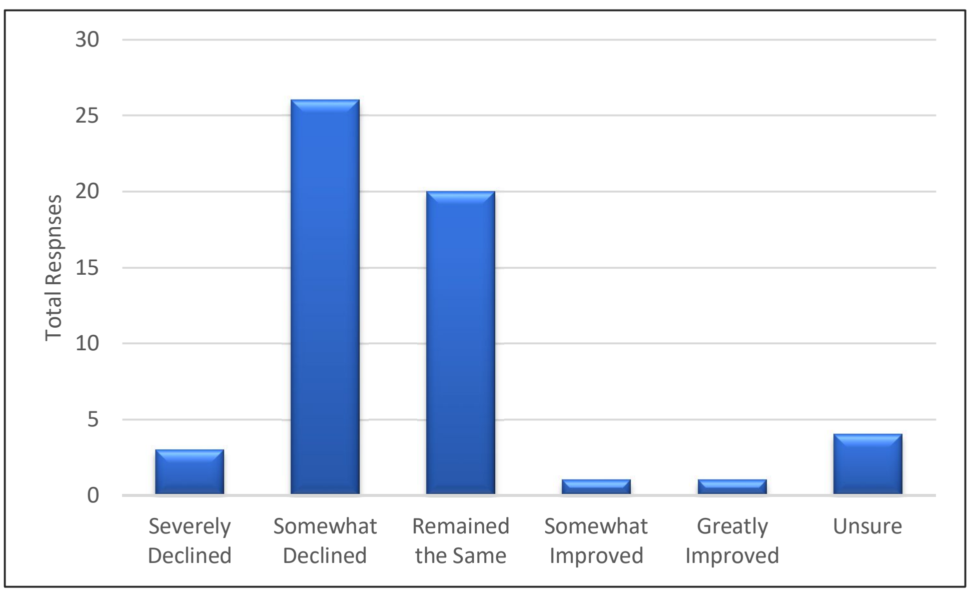
17) Has the quality of fishing <u>changed</u> during the years you have fished Moose Lake?

Q17	Total
1 – Yes, for the better	1
2 – Yes, for the worse	23
3 – No, it has remained the same	10
4 – Unsure	6

18) In your opinion, would you say the current water quality of Moose Lake is:



19) In the year(s) since you first visited Moose Lake, the water quality has:



20) Prior to this survey, had you ever heard about AIS before?

Q20	Total
YES	48
NO	9
Total	57

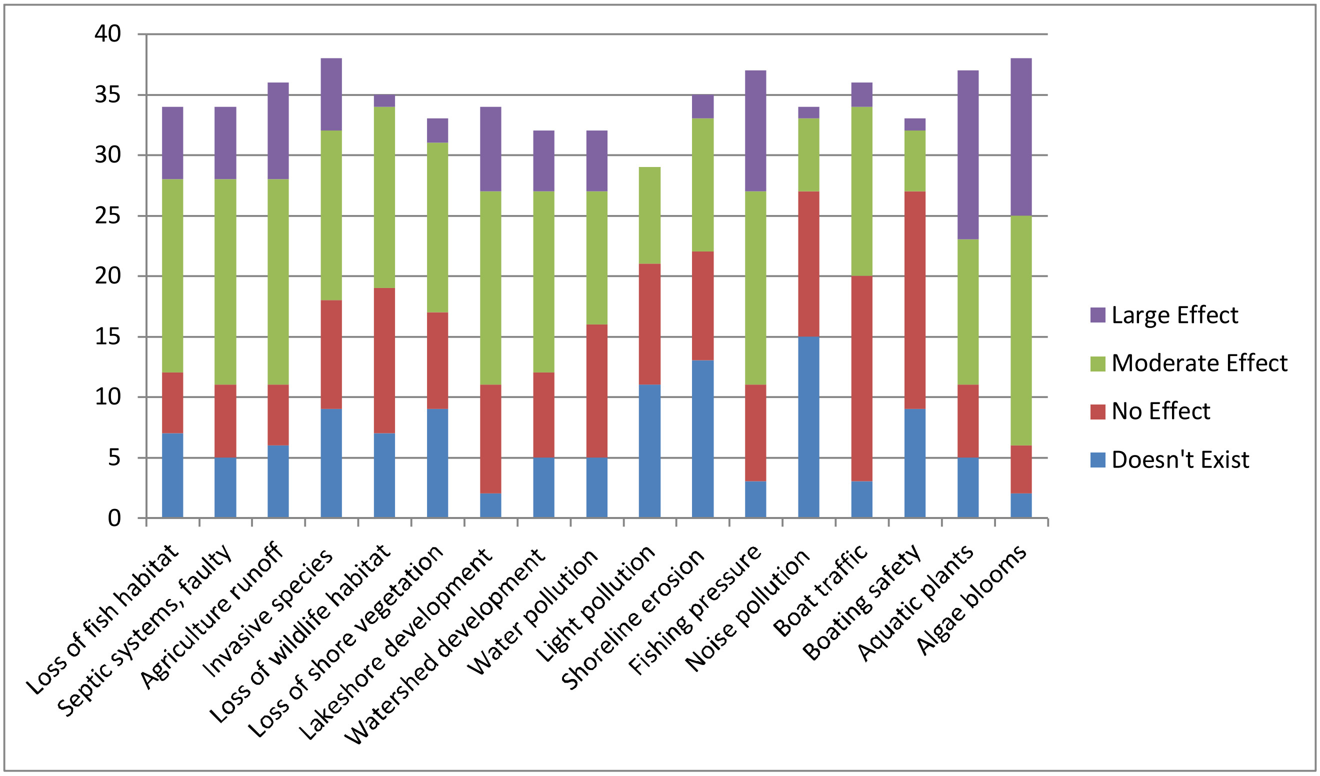
21) Are you aware of any invasive species in or around the shoreline of Moose Lake?

Q21	Total
YES	13
NOT SURE	13
NO	29
Total	55

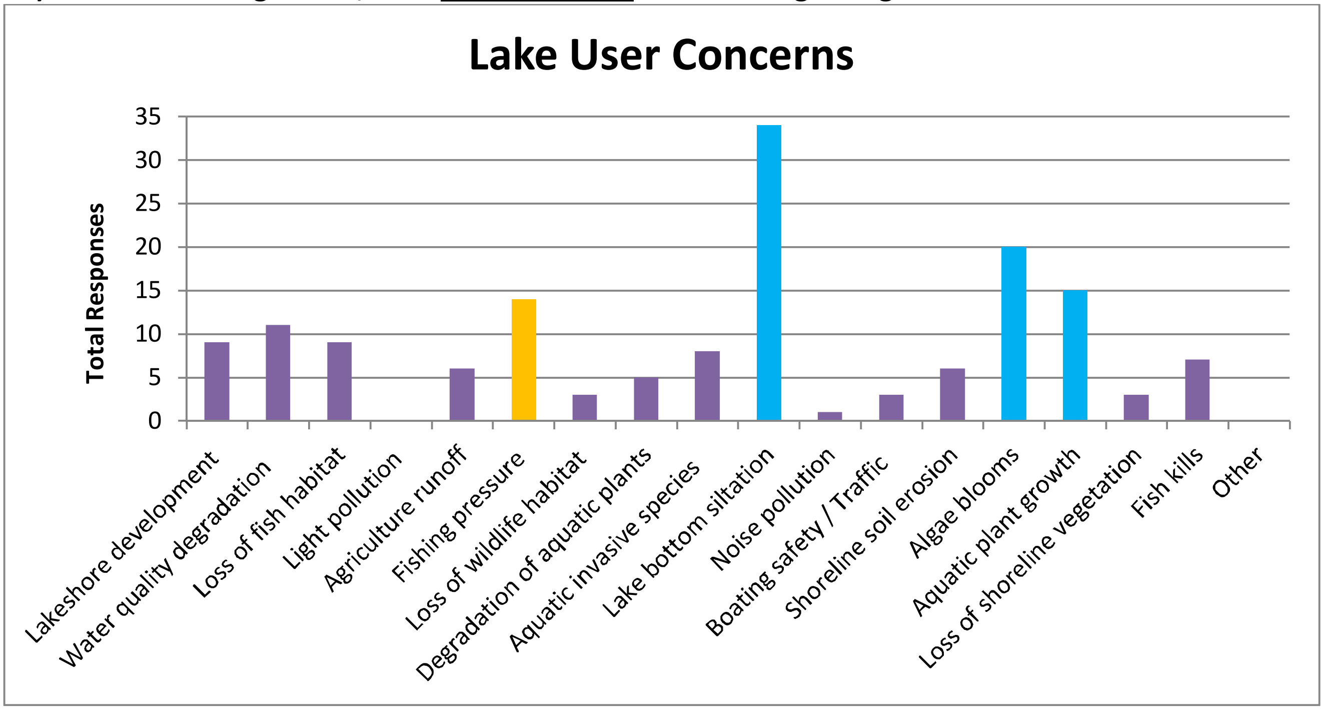
22) If you answered yes or unsure in 21, which AIS are you aware of in or around Moose Lake?

Q22	Total
Rusty Crayfish	16
Curly-leaf pondweed	1
Purple loosestrife	5
Zebra mussel	2
Spiny waterflea	1
Eurasian water milfoil	2
Carp	2
Chinese mystery snail	8

23) Refer to the list of common lake pressures below. To what level do you believe the following are having a negative effect on Moose Lake?



24) From the listing below, rank <u>your top three</u> concerns regarding Moose Lake.



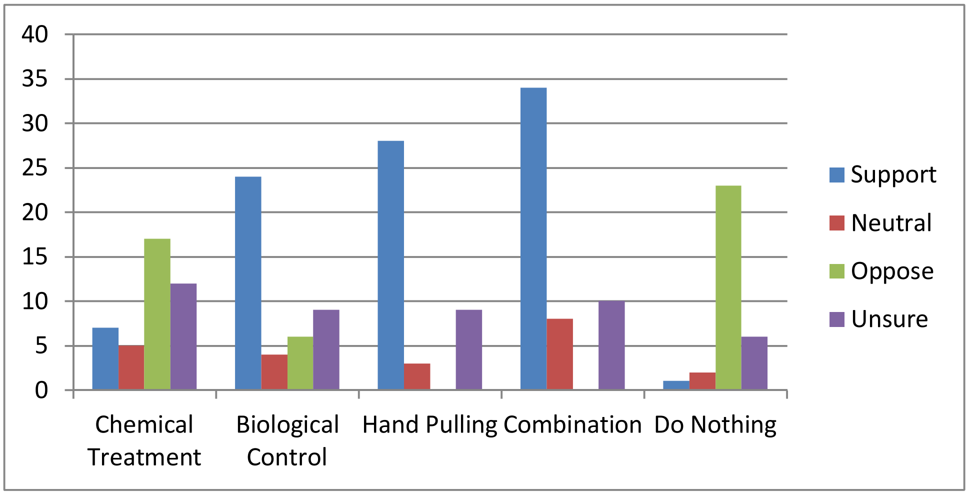
25) During open water how often do aquatic plants and/or algae effect your enjoyment of Moose Lake?

Q25	Plants	Algae
Never	5	3
Rarely	12	12
Sometimes	19	22
Often	11	10
Always	4	3
Total	51	50

26) Do you believe aquatic plant control / management is needed in Moose Lake?

Q26	Total
YES	14
Probably	23
Unsure	11
Probably not	8
NO	0

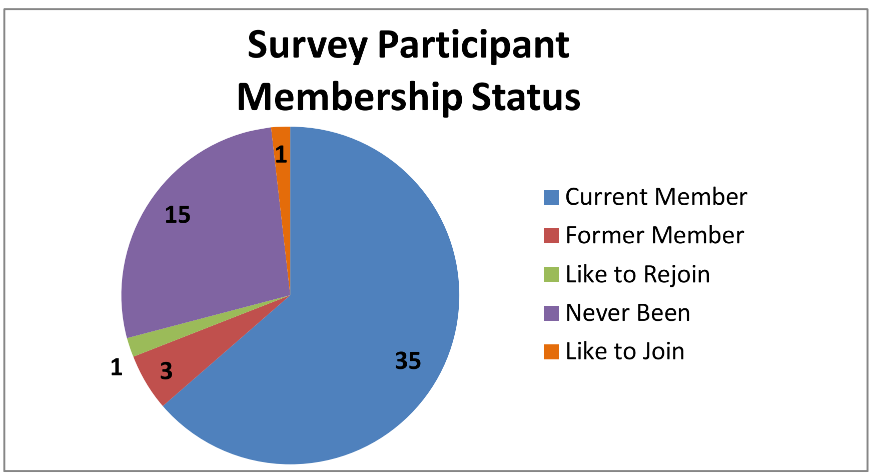
27) If aquatic plant management was proposed for Moose Lake, what would be your level of support for responsible use of the following management techniques?



28) Before completing this survey, had you ever heard of the Friends of Moose Lake Association?

Q28	Total
YES	52
NO	4

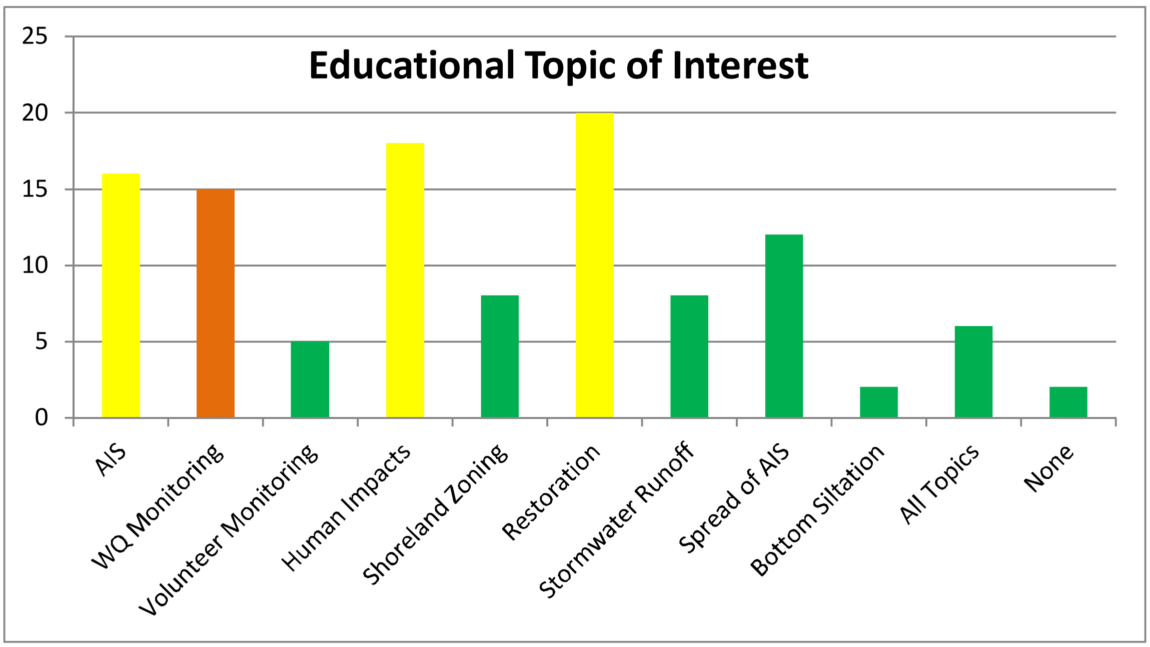
29) What is your membership status with the Friends of Moose Lake Association?



30) As a current or former member of the FOML, how well informed have (or had) they kept you regarding Moose Lake issues?

Q30	Total
Not at All Informed	0
Not Well Informed	1
Unsure	1
Fairly Well Informed	13
Highly Informed	27

31) From the list below, which topics would you like to learn more about?



32) FOML Association could serve their membership (or Moose Lake) by:

Plant hybrid perch in the lake; Expand efforts to reach more people either living around (but not on) the lake and those that use the lake on a more frequent basis

Appendix 7

Panfish Regulation Research Factsheet

In search of larger panfish
Bringing better panfishing to Wisconsin anglers.

Between 2011 and 2014, fisheries biologists with the Department of Natural Resources solicited public input on all aspects of panfish management. They found that although anglers are not interested in sweeping changes to statewide panfish regulations, they are interested in addressing specific lakes with overharvest issues. With this in mind, the Department developed a regulation package to increase panfish size on 94 selected lakes where harvest appears to be a problem. The regulation package was supported at the 2015 spring hearings and will go into effect in 2016. A thorough evaluation will be conducted in 2021 and the findings shared with the public to decide what to do next.

What we know

1) The size of panfish has decreased over time, particularly on certain lakes (see Figure 1).
2) Many lakes in WI have great panfishing, yet many are full of small fish.
3) Studies in MN and WI show that reduced bag limits can increase the average size of bluegills, particularly in lakes with fast growth.

What we propose

A total of 94 lakes across the state were identified by biologists and anglers as underperforming - that is the mean length of bluegill and crappie is less than desirable but growth potential is good (See Figure 3 and Table 1 on back for complete list).

The goal is to determine the best regulation that will increase the average size of bluegill and crappie on the selected lakes. Ultimately, a single regulation will be chosen and used to address similar lakes not meeting panfish management goals.

Proposed regulations

An effective regulation has to be restrictive enough to affect harvest but still be socially acceptable. Finding a regulation that strikes the balance between effectiveness and angler acceptance can be very challenging.

The following three options explore that tradeoff and will be applied to 94 lakes (see back for details):

1. A total of 25 panfish but no more than 10 of any one species (25/10).
2. A total of 15 panfish but no more than 5 of any one species during May and June (15/5 seasonal) - 25 panfish in total the rest of the year.
3. A total of 15 panfish but no more than 5 of any one species (15/5).

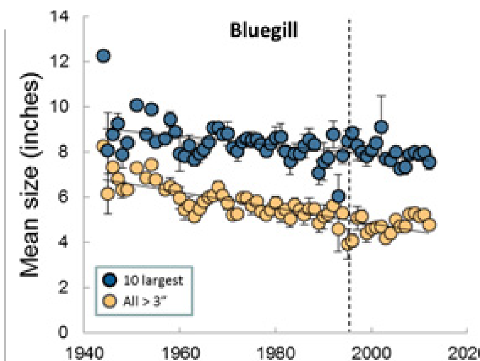


Figure 1. Decline in mean size of bluegill over time. Dashed vertical line indicates 1998 panfish bag limit change from 50 to 25.

NEXT STEPS and EVALUATION

Summer 2015 – Up to date baseline data collection where needed; electrofishing and angler surveys

April 1, 2016 – Regulations go into effect (pending NRB and governor approval)

2019 – 2021 – Regulation evaluation sampling; electrofishing and angler surveys

Fall/Winter 2021 – Initial evaluation complete, results distributed, public meetings held

CONSIDER THIS

Why are all the panfish so small?
There are two primary reasons why a panfish population is dominated by small fish:

1. **Stunting** = limited resources diagnosed by slow growth rates.

2. **Overharvest** = all the large individuals kept by anglers diagnosed by decent growth rates.

Even though anglers would take home fewer fish from some lakes, the expected increase in average size should result in the same amount of, or more, meat for the frying pan.

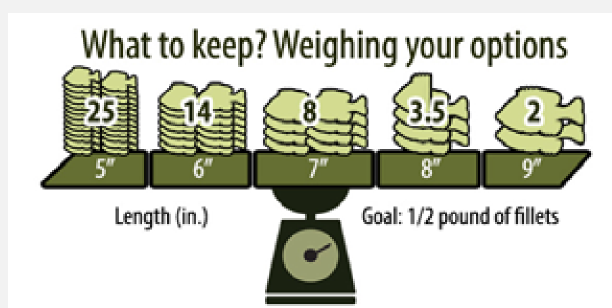


Figure 2. The number of bluegill by length that you would have to keep to equal 1/2 pound of fillets.

PANFISH STUDY LAKES

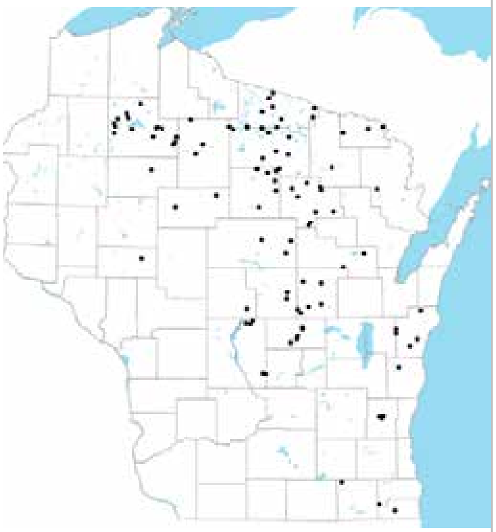


Figure 3. *Distribution of 94 study lakes identified through fisheries biologists and angler surveys with populations of panfish that exhibited poor size and decent growth.*

Table 1. Panfish study lakes and the designated regulation option randomly assigned to each.

County	Lake/Chain Name	Regulation[1]
Adams	Crooked	15/5 Seasonal
Adams	Parker	15/5
Adams	Arrowhead	25/10
Adams	Camelot	25/10
Adams	Sherwood	25/10
Eau Claire	Eau Claire	25/10
Florence	Halsey	25/10
Florence	Sea Lion	15/5
Florence	Spread Eagle Chain of Lakes	15/5 Seasonal
Forest	Wabikon & Riley (Wabikon)	25/10
Kenosha	Paddock	15/5 Seasonal
Langlade	Big Twin	25/10
Langlade	Long (T33N R10E S35)	25/10
Langlade	Moose	15/5 Seasonal
Langlade	White	15/5 Seasonal
Langlade	Crystal	15/5 Seasonal
Langlade	Dynamite	25/10
Langlade	Meyer	15/5
Langlade	Mueller	25/10
Lincoln	Crystal (Lincoln)	15/5
Lincoln	Hilderbrand	15/5 Seasonal
Lincoln	Echo	15/5
Lincoln	Rice Reservoir Chain	25/10
Lincoln	Hilts	25/10
Lincoln	Pesabic	15/5 Seasonal
Manitowoc	Bullhead	15/5 Seasonal
Manitowoc	English	15/5
Manitowoc	Long	15/5
Manitowoc	Harpt	25/10
Manitowoc	Pigeon	25/10
Marathon	Pike	15/5 Seasonal
Marathon	Lake Wausau	25/10
Marathon	Mud	15/5
Oconto	Caldron Falls	25/10
Oneida	Boom-Rhinelander Chain	15/5 Seasonal
Oneida	Gilmore	25/10
Oneida	Oneida	15/5
Oneida	Squaw	15/5
Oneida	Moen Chain	25/10
Oneida	Carrol	25/10
Oneida	Madeline	25/10
Oneida	Indian	15/5
Portage	Emily	25/10
Portage	Lime	25/10
Price	Pike Chain	25/10
Price	Solberg	25/10
Price	Butternut	25/10
Price	Phillips Chain	25/10
Racine	Bohners	15/5
Rusk	Lower Flambeau River Flowages	15/5
Sawyer	Black Dan	15/5
Sawyer	Blueberry	15/5 Seasonal
Sawyer	Evergreen	15/5 Seasonal
Sawyer	Loretta	15/5 Seasonal
Sawyer	Mason	15/5 Seasonal
Sawyer	Osprey	15/5 Seasonal
Sawyer	Windigo	15/5
Sawyer	Connors	25/10
Sawyer	Lake of the Pines	25/10
Sawyer	Lost Land & Teal	25/10
Sawyer	Round & Little Round	25/10
Sawyer	Spring	25/10
Sawyer	Winter	25/10
Sawyer	Durphee	15/5
Sawyer	Lower Holly	15/5
Sawyer	Island	15/5 Seasonal
Shawano	White Clay	25/10
Sheboygan	Crystal	15/5 Seasonal
Taylor	Rib	25/10
Taylor	Chequamegon Waters	15/5 Seasonal
Vilas	Kentuck	25/10
Vilas	Little Saint Germain	25/10
Vilas	Palmer	25/10
Vilas	Pickerel	25/10
Vilas	High, Fishtrap & Rush	15/5
Vilas	Partridge	15/5 Seasonal
Walworth	Tripp	25/10
Washington	Big Cedar	25/10
Washington	Little Cedar	25/10
Washington	Silver	15/5
Waupaca	Graham	15/5
Waupaca	Hartman	15/5
Waupaca	School Section	25/10
Waupaca	Stratton	25/10
Waupaca	White	25/10
Waupaca	Shadow	15/5 Seasonal
Waushara	Witters	15/5
Waushara	Big Hills	25/10
Waushara	Irogami	15/5 Seasonal
Waushara	Kusel Lake	15/5 Seasonal
Waushara	Porters	15/5
Wood	Nepco	15/5 Seasonal

[1] *Regulation:*

25/10 *- a total of 25 panfish but no more than 10 of any one species.*

15/5 *- a total of 15 panfish but no more than 5 of any one species.*

15/5 Seasonal*- A total of 15 panfish but no more than 5 of any one species during May and June, 25 panfish in total the rest of the year.*

For more detailed information and to keep up-to-date on panfish management in Wisconsin visit ***dnr.wi.gov*** and search "panfish plan."

Appendix 8

Annual Fish Stocking Records

RH
3-4-03

Stocking Record

Fi-238 Sept. 2000

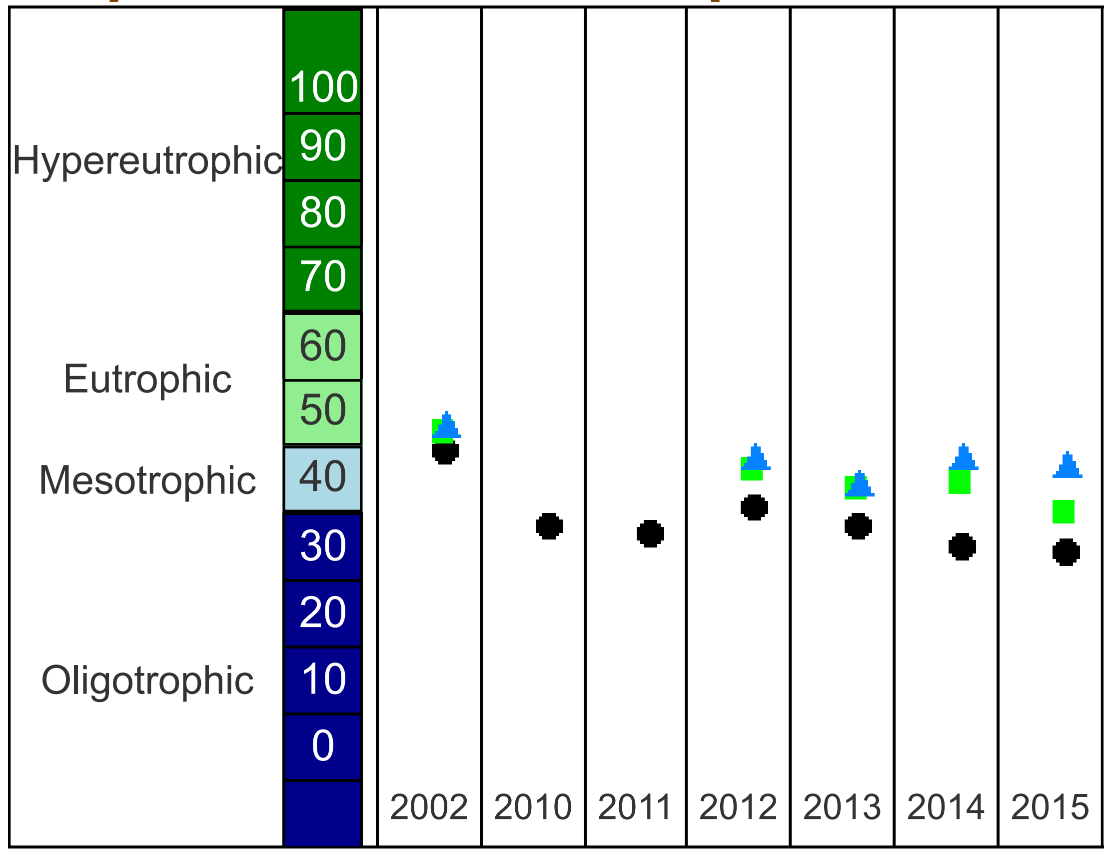
Lake/Stream: Moose Lake

Date	Species	Number Stocked	Size	Remarks
1938	Brook Trout	4,000	Fingerling	
1939	Brook Trout	23,672	Yearling	
1940	Brook Trout	20,000	Fingerling	
1941	Brook Trout	10,000	Fingerling	
1942	Brook Trout	15,000	Fingerling	
1943	Brook Trout	300	Yearling	
1945	Rainbow Trout	500	Fingerling	
1945	Rainbow Trout	5,800	Yearling	
1946	Brook Trout	1,650	Legal	
1946	Brook Trout	1,350	Yearling	
1946	Rainbow Trout	200	Adult	
1946	Rainbow Trout	750	Legal	
1946	Rainbow Trout	2,250	Yearling	
1947	Brook Trout	250	Fingerling	
1947	Brook Trout	3,000	Yearling	
1947	Rainbow Trout	450	Fingerling	
1948	Rainbow Trout	1,200	Legal	
1948	Rainbow Trout	1,200	Yearling	
1949	Brown Trout	6,000	Fingerling	
1949	Rainbow Trout	3,100	Legal	
1950	Brown Trout	8,100	Fingerling	
1950	Rainbow Trout	16,800	Fingerling	
1951	Brown Trout	23,600	Fingerling	
1951	Rainbow Trout	20,100	Fingerling	
1952	Brown Trout	6,700	Fingerling	
1952	Rainbow Trout	6,700	Fingerling	
1961	Brown Trout	12	Adult	
1961	Rainbow Trout	33	Adult	
1961	Brook Trout	366	Adult	
1961	Brook Trout	8,000	Fingerling	
1963	Rainbow Trout	2,000	Legal	
1964	Rainbow Trout	4,900	Legal	Early Spring Ice Plant
1965	Rainbow Trout	3,000	Legal	Early Spring Ice Plant
1966	Rainbow Trout	3,000	Legal	Early Spring Ice Plant
4/6/67	Rainbow Trout	3,000	Legal	

Appendix 9

Trophic State Index Categories & Descriptions

Trophic State Index Graph



Monitoring Station: Moose Lake - Deep Hole, Langlade County
Past Summer (July-August) Trophic State Index (TSI) averages.

● = Secchi ■ = Chlorophyll ▲ = Total Phosphorus

TSI(Chl) = TSI(TP) = TSI(Sec)	It is likely that algae dominate light attenuation.
TSI(Chl) > TSI(Sec)	Large particulates, such as Aphanizomenon flakes dominate
TSI(TP) = TSI(Sec) > TSI(Chl)	Non-algal particulate or color dominate light attenuation
TSI(Sec) = TSI(Chl) >= TSI(TP)	The algae biomass in your lake is limited by phosphorus
TSI(TP) > TSI(Chl) = TSI(Sec)	Zooplankton grazing, nitrogen, or some factor other than phosphorus is limiting algae biomass

TSI	TSI Description
TSI < 30	Classical oligotrophy: clear water, many algal species, oxygen throughout the year in bottom water, cold water, oxygen-sensitive fish species in deep lakes. Excellent water quality.
TSI 30-40	Deeper lakes still oligotrophic, but bottom water of some shallower lakes will become oxygen-depleted during the summer.
TSI 40-50	Water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer.
TSI 50-60	Lakes becoming eutrophic: decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident, warm-water fisheries (pike, perch, bass, etc.) only.
TSI 60-70	Blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible.
TSI 70-80	Becoming very eutrophic. Heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight).
TSI > 80	Algal scums, summer fishkills, few plants, rough fish dominant. Very poor water quality.

Trophic state index (TSI) is determined using a mathematical formula (Wisconsin has its own version). The TSI is a score from 0 to 110, with lakes that are less fertile having a low TSI. We base the overall TSI on the Chlorophyll TSI when we have Chlorophyll data. If we don't have chemistry data, we use TSI Secchi. We do this rather than averaging, because the TSI is used to predict biomass. This makes chlorophyll the best indicator. Visit Bob Carlson's website, dipin.kent.edu/tsi.htm, for more info.

Appendix 10

Aquatic Plant Survey Data

(on CD)

Appendix 11

Shoreland Assessment Scores & Site Recommendations

Appendix 11 - Shoreland Assessment Data and Management Recommendations

2015 Shoreland Assessment site scores for Moose Lake, Langlade County, Wisconsin					
Site	Terrestrial Zone	Shoreline Transition Zone	Littoral Zone	Community Summary	Total Score
1	19	3	7	2	31
2	4	7	7	2	20
3	5	3	6	2	16
4	0	2	5	1	8
5	0	2	5	1	8
Springs	0	3	4	0	7
7	5	2	5	2	14
8	2	2	6	2	12
9	6	3	6	2	17
10	0	0	4	1	5
11	1	4	6	3	14
12	6	4	6	2	18
13	8	8	7	2	25
14	7	5	6	2	20
15	0	1	3	1	5
16	0	1	2	1	4
17	0	1	4	1	6
18	0	1	3	1	5
19	2	1	4	1	8
20	0	2	4	1	7
21	0	2	4	1	7
22	0	2	4	1	7
23	0	2	5	1	8
24	1	4	4	2	11
25	1	4	4	2	11
26	9	3	3	2	17

Management Recommendations

For the riparian sites around the shoreland assessment map that have been highlighted in yellow or red, management recommendations have been included here. These sites received medium or high scores. If the sites are highlighted in green on the map, they are in excellent condition and received very low scores. Keep up the good work and protect these areas!

SITE 1 (Score 31)
Riparian Terrestrial Zone – Protect perch trees near the boat landing for wildlife habitat. Control stormwater (& oil / sand erosion) running off the paved site. Suggestion: Contact Langlade County Conservation Department to assist in the design of a runoff diversion or other best management practices that reduces velocity of runoff water; a *Healthy Lakes* project could help lower the cost.

Shoreline Transition Zone – Keep landing clean and free of pollutants like motor oil. Be aware of new introductions of aquatic or terrestrial invasive species that may appear near the boat landing. Educate users of the boat landing about the issues of AIS.

Littoral Zone – Protect native aquatic vegetation, especially near the boat landing. The vegetation is helping to protect the bottom substrate from resuspension when boat motors are near the lake bottom.

Critical Habitat – Protect all. Site has a rich native macrophyte community, woody structure for fish cover and shade, and large shade trees for birds and wildlife cover.

SITE 2 (Score 20)
Riparian Terrestrial Zone – No soil erosion or pollution was noted. Restore some vegetation at the lakeshore. Although the ground was fully covered, try plantings of additional shrub layers. This would provide habitat for wildlife as well as re-establishing that 3rd level of vegetation that's so important for biodiversity. A *Healthy Lakes* project would be beneficial here.

Shoreline Transition Zone – No bank erosion was noted. There was presence of rock riprap at the shoreline and mild ice push of the bank. Although some people perceive ice push banks as unsightly, they are actually nature's way of stabilizing a lakeshore bank. Try to keep the ice push bank there for future bank protection and reduce the potential for soil erosion. Reed Canary grass, an invasive species, was noted on the bank. An additional suggestion for this site would be to minimize the width of the viewing corridor. A *Healthy Lakes* project would be beneficial here.

Littoral Zone – There were many bluegill spawning beds noted. Protect this spawning habitat. The existing vegetation is helping to protect the bottom substrate from becoming re-suspended, especially in areas like this where boats may congregate for the fishing.

Critical Habitat – Protect all. Site has a rich native macrophyte community, woody structure for fish cover and shade, spawning habitat, and large shade trees for fish and birds.

SITE 3 (Score 16)
Riparian Terrestrial Zone – No soil erosion or pollution was noted. Suggestion: Restore some vegetation at the lakeshore. Although the ground was fully covered and the tree canopy was abundant, try plantings of additional shrub layers. This would provide habitat for wildlife as well as re-establishing that 3rd level of vegetation that's so important for biodiversity. A *Healthy Lakes* project would be beneficial here.

Shoreline Transition Zone – No bank erosion was noted. Reed Canary grass, an invasive species, was noted on the bank. No management recommendations.

Littoral Zone – There were spawning beds noted. Protect this spawning habitat. Surface scum algae noted on shoreline. The existing vegetation is helping to protect the bottom substrate from becoming re-suspended, especially in areas like this where boats may congregate for the fishing. A Blue Heron was observed here during the survey, near the large downed tree. Protect the habitat, including the downed tree. Downed trees provide cover, shade, habitat for invertebrates that small fish eat, and in some cases spawning areas.

Critical Habitat – Protect all. Site has a rich native macrophyte community, woody structure for fish cover and shade, spawning habitat, and large shade trees for fish and birds.

SITE 7 (Score 14)
Riparian Terrestrial Zone – No soil erosion or pollution was noted, however some exposed sandy soil was present and could travel. Watch that stormwater runoff does not make sand travel toward the lake. The *Healthy Lakes* program offers stormwater runoff solutions and protection. The shoreline buffer has been restored in this area. Protect that effort!

Shoreline Transition Zone – No bank erosion was noted. No management recommendations.

Littoral Zone – Abundant small nursery fish fry noted here. Protect this habitat as the fry are eating well and thriving. The existing vegetation is abundant and diverse offering important habitat and food sources for small fish. Filamentous and surface scum algae noted.

Critical Habitat – Protect all. Site is an important nursery area for small fish, has a rich native macrophyte community, and large shade trees for fish and birds.

SITE 8 (Score 12)
Riparian Terrestrial Zone – No soil erosion or pollution was noted. No management recommendations.

Shoreline Transition Zone – No bank erosion was noted. For aesthetic purposes and to provide additional wildlife habitat, try to minimize the viewing corridor with additional vegetation. A *Healthy Lakes* project would be beneficial here.

Littoral Zone – Filamentous and surface scum algae noted along shoreline. Protect the floating leaved native vegetation and the small downed logs here as a source of food for fish and for protective cover.

Critical Habitat – Protect all. Site has a rich native macrophyte community, woody structure for fish cover and shade, and large shade trees for birds.

SITE 9 (Score 17)
Riparian Terrestrial Zone – Restore some vegetation at this site. Although the ground was fully covered, try plantings of additional shrub and tree canopy layers. This would provide habitat for wildlife as well as re-establishing the 2nd and 3rd levels of vegetation that are so important for biodiversity. A *Healthy Lakes* project would be very beneficial here. Old wooden pier sections were also noted here. If they are not being utilized, remove from view.

Shoreline Transition Zone – No bank erosion was noted. For aesthetic purposes and to provide additional wildlife habitat, try to minimize the viewing corridor with additional vegetation. A *Healthy Lakes* project would be beneficial here.

Littoral Zone – Filamentous and surface scum algae noted along shoreline. Protect the floating leaved and submergent native vegetation for protective cover.

Critical Habitat – Protect all. Site has a few large shade trees for birds and a rich aquatic macrophyte population here.

SITE 11 (Score 14)
Riparian Terrestrial Zone – No soil erosion or pollution was noted. All 3 levels of native vegetation well intact. No management recommendations.

Shoreline Transition Zone – No bank erosion was noted. No management recommendations.

Littoral Zone – Filamentous and surface scum algae noted along shoreline. Protect the floating leaved and submergent native vegetation for protective cover.

Critical Habitat – Protect all. Eagle, cardinals, and frogs observed in this area. Site has several large shade trees for birds and a rich aquatic macrophyte population.

SITE 12 (Score 18)
Riparian Terrestrial Zone – Restore some vegetation at this site. Although the area has some ground and tree canopy cover, try plantings of additional vegetation for both layers. The understory (shrub) layer was sparse. Plantings of shrubs here would definitely be beneficial to add biodiversity and for additional habitat. A *Healthy Lakes* project would be very beneficial here.

Shoreline Transition Zone – No bank erosion was noted. No management recommendations.

Littoral Zone – Filamentous and surface scum algae noted along shoreline. Protect the native aquatic macrophytes for protective cover and to decrease potential for sediment re-suspension.

Critical Habitat – Protect all. Site has a rich native macrophyte community and a few large shade trees.

SITE 13 (Score 25)
Riparian Terrestrial Zone – No soil erosion noted. Removal of the yard trash would help aesthetic of the shoreline. The flower garden is beautiful, but consider plantings of some native vegetation to fill in the missing shrub and tree canopy layers. A *Healthy Lakes* Project is recommended here.

Shoreline Transition Zone – A low amount of bank erosion noted here. Rock riprap present. Riprap is helpful to reduce soil erosion but breaks up the wildlife corridor along the shoreline. Address the soil erosion on the bank to reduce sediment getting into the lake.

Littoral Zone – Fishery spawning area noted here. Large fish noted here (Bass?). Protect native aquatic vegetation because it is helping to protect the bottom substrate from becoming re-suspended from boat motors. High density filamentous and surface scum algae noted along shoreline at this site.

Critical Habitat – Protect all. Site is a fishery spawning area. Protect the rich native macrophyte community.

SITE 14 (Score 20)
Riparian Terrestrial Zone – Bare soil was noted here on the upland area along with low level erosion. Watch that stormwater runoff does not make way toward the lake. The *Healthy Lakes* program offers stormwater runoff solutions and protection and could be beneficial for the landowner AND the health of Moose Lake. Plantings of shrub and canopy layers would help to reduce soil erosion and sediment travel. *Healthy Lakes* program recommended.

Shoreline Transition Zone – Low level bank toe erosion noted here in areas close to mowed grass. Minimize the viewing corridor and add vegetation to create more buffer between mowed grass and the lake. *Healthy Lakes* program recommended.

Littoral Zone – Filamentous and surface scum algae noted along shoreline. Protect the native aquatic macrophytes for protective cover and to decrease potential for sediment re-suspension.

Critical Habitat – Protect all. Protect the rich native macrophyte community.

SITE 24 (Score 11)
Riparian Terrestrial Zone – Slight ground cover opening, but no soil erosion or pollution noted. Add a little ground cover vegetation or establish grass seed in the open area to minimize potential of future soil erosion.

Shoreline Transition Zone – Low level soil erosion noted on the toe of the bank. Since this is a steep bank area, consider tucking some rock under the eroding toe to minimize potential for bank slump.

Littoral Zone – Surface scum algae noted along shoreline. Protect the native aquatic macrophytes to decrease potential for sediment re-suspension during wave actions or with motor boat disturbance.

Critical Habitat – Deeper water here and steepness to the bank is greater than other parts of the lake. Protect the existing shade trees and the native aquatic vegetation. Mallard ducks observed here during survey.

SITE 25 (Score 11)
Riparian Terrestrial Zone – Excellent coverage of all 3 layers of upland vegetation noted. Keep up the good work.

Shoreline Transition Zone – Steep bank area noted and no bank toe erosion. The pier is nice, unobtrusive.

Littoral Zone – Surface scum algae noted along shoreline. Protect the native aquatic macrophytes to decrease potential for sediment re-suspension during wave actions or with motor boat disturbance. Small logs present for fish cover and invertebrate concentrations. Do not remove logs.

Critical Habitat – Deeper water here and steepness to the bank is greater than other parts of the lake. Protect the existing shade trees and the native aquatic vegetation. Natural scenic beauty is great here.

SITE 26 (Score 17)
Riparian Terrestrial Zone – No erosion or pollution noted. Although the ground cover is completely intact, this site would benefit by placing additional shrub and tree canopy layers. This would be especially helpful to a site such as this where the bank is steep, so that stormwater runoff can be slowed down at is moves to the lake. A *Healthy Lakes* project would be beneficial here.

Shoreline Transition Zone – Steep bank area noted and no bank toe erosion. No pier in water, the only evidence of people are the canoes at the shore.

Littoral Zone – Surface scum algae noted along shoreline. Protect the native aquatic macrophytes to decrease potential for sediment re-suspension during wave actions or with motor boat disturbance.

Critical Habitat – Protect rich native macrophyte community. Natural scenic beauty is great here.

Appendix 12

Cost Sharable Practices Langlade County

Cost Sharing is available for the following practices:

Manure storage systems – manure storage impoundment made by fabricating a structure
Manure storage closure – permanently disabling a manure storage system
Barnyard runoff control system – a system of practices used to contain, divert, retard, treat or control the discharge of runoff from outdoor areas of concentrated livestock activities
Access road & cattle crossings - provide a fixed route for livestock or vehicular travel for resource activities
Animal trails & walkways - established lanes or travel ways that facilitate animal movement.
Critical area stabilization - revegetates bare soils and stabilizes eroding sites.
Diversions - structure that directs runoff water from a specific area without causing excessive soil erosion
Field windbreaks - rows of trees and shrubs that protect areas from wind velocities at the land surface
Filter strips- vegetation the separates environmentally sensitive area from cropland, grazing or disturbed land
Grade stabilizations- structure which stabilizes the grade in a channel to protect the channel from erosion or to prevent gullies from forming or advancing
Heavy use protection – surface material to control runoff and érosion in areas subject to concentrated or frequent livestock activities (*not a standalone practice*)
Livestock fencing- excludes livestock to protect an erodible area or restrict human access to manure storage facility
Livestock watering facilities-trough, tank, pipe to deliver drinking water to livestock
Milking center waste control system – redirect waste water from the milking parlor or milkhouse
Prescribed grazing - Permanent fencing- system which divides pasture into multiple cells to graze intensively for a short period
Prescribed grazing - Permanent pasture (seeding) - cost to establish good seeding stand for pasture
Relocating or abandoning animal feeding operations- discontinue an animal feeding operation to prevent surface water or groundwater pollution or discontinue operation and commence that operation at a suitable site
Riparian buffers – installation – area in which vegetation is enhanced or established to reduce or eliminate movement of sediment, nutrient and other nonpoint source pollutants
Roofs- weather proof covering that shields an animal lot or manure storage structure from precipitation
Roof runoff systems – collecting, controlling, diverting and disposing of precipitation from roofs
Sediment basins – permanent basins that reduce the transport of waterborne pollutants
Sinkhole treatment – modifying a sinkhole or the area around a sinkhole to reduce erosion expansion of the hole and reduce pollution of water resources
Stream bank & shoreline protection – vegetation or structures to stabilize and protect the banks of streams, lakes, estuaries or excavated channels against scour and erosion.
Subsurface drains - conduit installed below the surface of the ground to collect drainage water and convey it to a suitable outlet
Terrace system- ridges and channels installed on the contour with non-erosive grades and suitable spacing
Underground outlet-conduit installed below the surface of the ground to collect surface water and convey it to a suitable outlet
Waste transfer system – components and other structures installed to convey manure and milking center wastes from buildings and animal feeding operations to a storage structure, loading zone or treatment area
Wastewater treatment strips – area of vegetation used as part of an agricultural waste management system to remove pollutions
Water & sediment control basins – earthen embankment or a ridge and channel combination installed across a slope or minor watercourse to trap or detain runoff and sediment
Waterway system – natural or constructed waterway or outlet that is shaped, graded and covered with vegetation or suitable material to prevent erosion by runoff waters
Well commissioning- permanently disabling and sealing a well to prevent contaminants from reaching groundwater
Wetland restoration – construction of berms, or the destruction of tile lines or drainage ditch functions to create or restore conditions for wetland vegetations

Nutrient Management - There is also a limited amount of **SEG** funds for nutrient management plans.

The normal cost share rate is 70% with additional provisions for hardship cases. All practices are designed and constructed to NRCS standards. With the proposed revisions to ATCP 50, cost share rate will be reduced to 50% for access roads, roof-runoff systems, streambank or shoreline protection, stream crossing, and wetland development or restoration or practices installed on local governmental units. If you are interested in doing one of these projects, please contact our office.

Appendix 13

NR 151 Information Overview

Wisconsin's Runoff Rules

what farmers need to know

January 2013 DNR Pub. No. WT 756 REV 1/13




Farms, like all major industries, must follow environmental requirements to control runoff from fields, pastures and livestock facilities. Otherwise this pollution can harm our lakes, streams, wetlands and groundwater.

Wisconsin adopted administrative rules in 2002 (NR 151), with revisions effective in 2011 that set statewide performance standards and prohibitions for all Wisconsin farms. All farmers must comply with these standards and prohibitions. Cost-share funding may be available to assist with compliance. Some state and local programs may require compliance whether or not cost-share funds are available.

This fact sheet explains the basic information that farmers need to know about these rules and how to comply with them. It is recommended that farmers contact their county land conservation staff for further details on these rules and their impact on farm operations.

► Agricultural Standards and Prohibitions:

ALL FARMERS MUST:

- *Meet tolerable soil loss ("T") on cropped fields and pastures.*
- *Annually develop and follow a Nutrient Management Plan (NMP) designed to keep nutrients and sediment from entering lakes, streams, wetlands and groundwater. Farmers may hire a certified crop advisor or prepare their own NMP if they have received proper training.*
- *Use the phosphorous index (PI) standard to ensure that their NMP adequately controls phosphorous runoff over the accounting period.*
- *Avoid tilling within 5 feet of the edge of the bank of surface waters. This setback may be extended up to 20 feet to ensure bank integrity and prevent soil deposition.*

► Additional Standards:

FARMERS WITH LIVESTOCK MUST:

- *Prevent direct runoff from feedlots or stored manure from entering lakes, streams, wetlands and groundwater.*
- *Limit access or otherwise manage livestock along lakes, streams and wetlands to maintain vegetative cover and prevent erosion.*
- *Prevent significant discharges of process wastewater (milkhouse waste, feed leachate, etc.) into lakes, streams, wetlands, or groundwater.*

FARMERS WHO HAVE, OR PLAN TO BUILD, MANURE STORAGE STRUCTURES MUST:

- *Maintain structures to prevent overflow and maintain contents at or below the specified margin of safety.*
- *Repair or upgrade any failing or leaking structures to prevent negative impacts to public health, aquatic life and groundwater.*
- *Close idle structures according to accepted standards.*
- *Meet technical standards for newly constructed or significantly altered structures.*

FARMERS WITH LAND IN A WATER QUALITY MANAGEMENT AREA *(300 feet from streams, 1,000 feet from a lake, or in areas susceptible to groundwater contamination)* MUST:

- *Avoid stacking manure in unconfined piles.*
- *Divert clean water away from feedlots, manure storage areas, and barnyards located within this area.*

Photos: Jeffrey J. Strobel, Duane Popple and Lynda Schweikert

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► Farmland Preservation Tax Credit:

A farmer must comply with applicable state standards to receive the Farmland Preservation Tax Credit, even if cost sharing is not available. Farmers may be considered in compliance by entering into a schedule of compliance.

This requirement applies to farmers whose land is located in a certified farmland preservation zoning district (i.e. exclusive agriculture), or for farmers who signed a farmland preservation agreement after standards were in effect for that county. Farmers should contact their county land conservation staff for more information regarding applicable standards and compliance documentation.

► Implementation and Financial Assistance:

Under DNR rules, a landowner is normally entitled to cost sharing if the landowner is required to implement best management practices on "existing cropland" or an "existing" livestock facility or operation in order to comply with a DNR performance standard. Cropland or livestock facilities brought into service after the effective date of the standard are considered "new" and must meet standards and prohibitions without cost-share funding. Farmers with existing cropland or livestock facilities may be eligible for state or federal cost sharing and are encouraged to contact their county land conservation staff or USDA Natural Resources Conservation Service (NRCS) office for information about current funding sources, rates and practices eligible for cost sharing.

Farmers also should work with their land conservation staff to determine how these performance standards and prohibitions may affect their participation in various federal, state and local programs, such as Farmland Preservation. You can find a directory of land conservation offices and related agencies at http://datcp.wi.gov/Environment under "Land and Water Conservation."

► Permits and Licensing:

Farmers may be required to meet NR 151 Standards in order to obtain local and state permits. For livestock siting and manure storage ordinance permits, for example, nutrient management plans and other requirements may be imposed on livestock operations without providing cost sharing. Contact your local officials for additional information.

Farmers with 1,000 or more animal units must operate under a Wisconsin Pollutant Discharge Elimination System (WPDES) permit and do not qualify for state cost sharing to meet permit requirements. Contact your DNR Service Center for more information about WPDES permits.

For more information about runoff management in Wisconsin and topics found in this brochure please visit:

runoffinfo.uwex.edu

Wisconsin Department of Natural Resources (WDNR), Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP), in cooperation with: USDA Natural Resources Conservation Service (NRCS), University of Wisconsin-Extension (UWEX), County Land Conservation Departments (LCD).

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