Itasca Waters Shoreland Advisors

June 2019

ITASCA WATERS
Team Up for Clean Waters

UNIVERSITY OF MINNESOTA EXTENSION

Available online at: https://z.umn.edu/shorelandadvisors

We are Water MN is led by the Minnesota Humanities Center in partnership with the Minnesota Pollution Control Agency, the Minnesota Historical Society, the Minnesota Department of Health, the Minnesota Department of Natural Resources, and the Minnesota Department of Agriculture.

We are Water MN is funded in part by the National Endowment for the Humanities and with money from the Arts and Cultural Heritage Fund that was created with the vote of the people of Minnesota on November 4, 2008.

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HISTORY AND INTENT OF THE SHORELAND ADVISORS PROGRAM

Several years ago, Itasca Waters surveyed Itasca County lakeshore residents. From the survey we learned lakeshore owners wanted information about shoreland in two formats: a website and a printed guide. Over the past two years, Itasca Waters has accomplished both of those needs by providing a useful website, ItascaWaters.org, that contains information about the aquatic zone of a lake, shoreland buffers, erosion and runoff issues, septics, and private forest management. We are currently in the process of recording six episodes on ICTV that will cover these five areas and will be available on our website, on ICTV's website and on YouTube. In addition, we published a thirty page booklet, Itasca County Shoreland Guide to Lake Stewardship, which is available on our website and at County and State Agencies.

The survey also indicated lakeshore property owners were interested in getting information about their property from ordinary citizens. As a result, Itasca Waters decided to pioneer and pilot a unique program: the Shoreland Advisors program. This three-year program focuses on restoring and preserving shoreland in Itasca County, by using some helpful practices that can positively impact lake water quality.

The volunteer advisors complete an educational workshop and training session, understanding they are not experts on shoreland. They will make personal onsite visits with lakeshore owners who want information about managing shoreland property in an ecologically friendly way that helps water quality. We are asking Shoreland Advisors to commit to visiting three properties over two years. Itasca Waters will furnish the advisors with the name and contact information of the lakeshore owner who has requested a site visit. After the site visits, Itasca Waters will gather feedback from both the Shoreland Advisors and the property owners. Advisors will be trained to feel comfortable visiting shoreland owners.

We are also developing a guide Advisors can hand out to shoreland owners that will have a list of Itasca County experts/businesses that owners can contact for more information such as: State and County agencies, landscapers, septic providers, and native plant nurseries.

Our hope is the Shoreland Advisor's program will be a model that can be used across the state.

Shoreland Advisor
Visit Record

ITASCA WATERS
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Date:

Property Owner's Name:

Lake:

911 Address:

Email Address: Phone Number:

Reason for Consultation?
Next steps
Follow up information to send

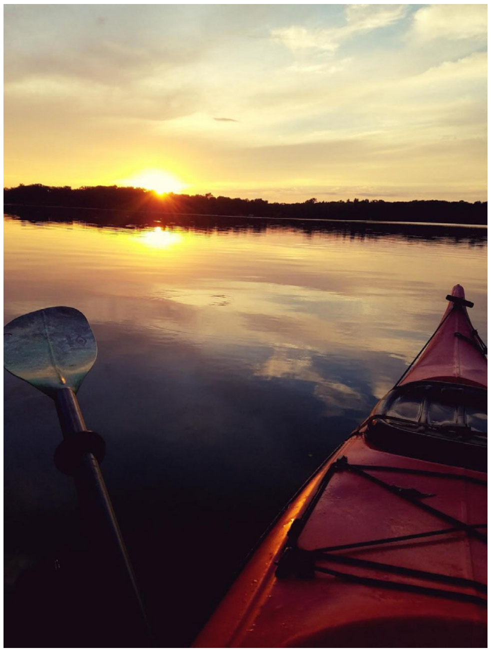
Share by: Email USPS Mail Phone Call

Lakeshore Property: Management Matters

Keeping excess water and pollutants out of the lake

When we build our homes on the shores of lakes and rivers, we inevitably change the path that water takes. We create impervious surfaces – any hard surface that does not allow water to soak into the ground – with our roofs, garages, driveways, and walkways. Less area for rainfall and snowmelt to soak into the ground creates the potential for more water flowing over the surface of the land into the nearest waterbody, and that flowing water can pick up pollutants that we don't want in our lakes and rivers.

photo credit: David Fluegel, Univ. of MN Extension



What you can do

There are ways to mitigate for these impacts. First, we can minimize the amount of impervious surface that we create. For example, consider using stepping stones instead of concrete paths. Second, rather than letting the rainfall and snowmelt run into the lake or river, we can design our landscapes to hold the water. Rain gardens, shoreline buffers, and rain barrels are a few examples of practices that you can adopt on your own waterfront property to help keep the lake clean.

Other ways you can be part of the solution

There are other important ways that you can be a good water steward on your property.

Septic systems can be a source of pollution: they need to be maintained and periodically inspected to ensure they are in good working condition. Similarly, we do not want pet waste to wash into the lake or river, so pick up after your pets and dispose of the waste with your household garbage.

It's important to protect your shoreline from eroding because eroding soil can increase sedimentation and decrease water clarity. Maintaining good vegetation both in the lake and on the shoreline is key to preventing erosion. Aquatic vegetation, such as bulrushes, is important for fish habitat, too.

Who doesn't love a nice campfire at the water's edge on a beautiful summer evening? Keep in mind, though, that the ashes left behind are full of pollutants that we don't want in the water. Once the fire has completely cooled, move the ashes to an area where they won't wash into the lake.

Resources to help you be a good shoreline steward

- Rain Gardens
  - Rain Gardens: A Homeowner's How-To Manual: https://dnr.wi.gov/topic/shorelandzoning/documents/rgmanual.pdf
  - Blue Thumb Guide to Rain gardens: http://www.blue-thumb.org/raingardens/
- Shoreline Landscaping
  - Restore Your Shore: https://www.dnr.state.mn.us/rys/index.html
  - University of Minnesota Water Resources Program: https://extension.umn.edu/water-resources/shoreland-property-owners
  - Score Your Shore: https://www.dnr.state.mn.us/scoreyourshore/index.html
- Septic Systems
  - University of Minnesota Water Resources Program: https://extension.umn.edu/water-resources/shoreland-property-owners
  - University of Minnesota Onsite Sewage Treatment Program: https://septic.umn.edu/

Who can help?

- Itasca Soil and Water Conservation District: https://www.itascaswcd.org/
- Itasca Waters: http://itascawaters.org/
- University of Minnesota Extension – Water Resources Program: Karen Terry, kterry@umn.edu, 218-770-9301

This newly-restored landscape, which includes a rain garden as well as shoreline plantings, allows for access to the water as well as natural areas.

Photo credit: Karen Terry, Univ. of MN Extension

Natural Shorelines

Keeping our lakes and rivers clean

WHY?

Healthy shorelines with native plants help keep sediment and other pollutants out of our lakes. Many native plant species grow dense vegetation and have deep roots that slow down rain water flowing over the surface of the land, allowing it – and the soil and pollutants that it's carrying – to settle out before reaching the lake. The plants' deep roots also help protect the shoreline against the erosive action of waves by anchoring deep into the soil. Native plants have evolved to withstand Minnesota's harsh winters so once they are established, they will require very little maintenance or care.

Short, mowed vegetation does little to hold water and pollutants from entering the lake.

Photo credit: Karen Terry, Univ. of MN Extension

HOW?

Make a plan

Think about the way you use your shoreline. You can restore part of it to a natural state and still maintain the features and access that you want. Consider what area you might want to restore, what you want it to look like (forest or grasses and flowers, for instance),and what your budget and timeline are.

Gather your resources and implement your plan

Will you be doing the work yourself or hiring a landscaper to do the job? If you will be doing it yourself, check out resources to help. The book "Lakescaping for Wildlife and Water Quality" and online tool "Restore Your Shore" (https://www.dnr.state.mn.us/rys) are both good DIY resources.

This restored shoreline matches the homeowners' preferences. There are many design options available.

Photo credit: Karen Terry, Univ. of MN Extension

Your local Soil and Water Conservation District, watershed district, and county Environmental Services or Land and Resources are all good places to talk to staff about your project. They may be able to offer technical or financial assistance, and they can help you understand what regulations apply to your project.

It's important to get your plants from a reputable native plant supplier. An online list of suppliers and landscapers can be found on the Department of Natural Resources website (https://www.dnr.state.mn.us/gardens/nativeplants/suppliers.html), or ask your local agency staff for recommendations.

Before you start installing your shoreland buffer, it's a good idea to think about your maintenance plan. In the short-term, your site will need to be watered and some weed removal might be necessary. In the long-term, it might need to be mowed or burned every few years and weeds kept in check.

Who can help?

- Itasca Soil and Water Conservation District: https://www.itascaswcd.org/ -- contact Tim Frits, Shoreland Specialist to explore possible cost-share and technical assistance (218-328-3093, Tim.Frits@itascaswcd.org. .
- Itasca Waters: http://itascawaters.org/
- University of Minnesota Extension – Water Resources Program: Karen Terry, kterry@umn.edu, 218-770-9301

This shoreline restoration project includes coco-fiber logs to stop erosion as well as native plants in the upland area.

Photo credit: Karen Terry, Univ. of MN Extension

Rain Gardens

Keeping our lakes and rivers clean

WHY?

Rain and melting snow running across your property pick up dirt and pollutants – a toxic concoction that we don't want in our lakes and rivers. Rain gardens, which are recessed a few inches into the ground, are designed to intercept runoff water and pollutants and hold it until it can either soak into the ground (recharging our groundwater supplies) or be taken up by plants, typically within less than 24 hours after the rain stops. This helps keep our lakes and rivers clean by keeping the water and pollutants out.

This large rain garden is at The Lodge in Detroit Lakes. It captures some of the water from the building's roof and parking lot and keeps it from going into Big Detroit Lake.

Photo credit: Karen Terry, Univ. of MN Extension

HOW?

Make a plan

Where does the water flow in your yard? Next time it's raining, put on your yellow slicker and go outside to observe. Odds are that water is coming off of your roofs and driveway so pay attention to what path it takes. Look for a place along that path that is 1) typically dry (not marshy), 2) not too close to your buildings, and 3) a place you'd enjoy a garden. Pay attention to where the water comes from: you will need to estimate runoff volume to design your rain garden. If the water comes from your roof, for example, measure the area that drains to your proposed site.

Before you dig your rain garden, make sure that it's a site where the water will soak in quickly. You can do a 'percolation test' to measure the rate of infiltration; the goal is for the standing water (typically a max of 6" deep) to be gone within 24 hours. If your chosen site does not pass the 'perc test', consider choosing a new site.

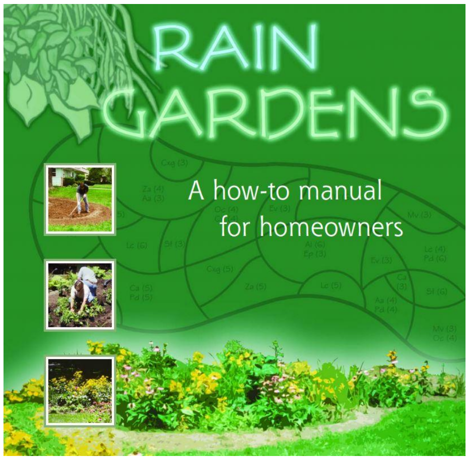
A volunteer crew planted this large rain garden in Fergus Falls in 2009. It captures some of the water from a network of neighborhood storm drains and prevents it from flowing into the Otter Tail River.

Photo credit: Karen Terry, Univ. of MN Extension

You can choose a variety of planting schemes, from shrubs to flowers to a mix of flowers and grasses, to achieve the look you want. There are several benefits to using native plants in your rain garden: they provide food and habitat for native pollinators and birds, their deep roots create pathways for water to travel down, they are easy to maintain, and they are tough enough to survive Minnesota winters.

Gather your resources and implement your plan

The booklet "Rain Gardens: A How-To Manual for Homeowners" (https://dnr.wi.gov/topic/shorelandzoning/documents/rgmanual.pdf) is a useful step-by-step guide to designing and installing your rain garden.



Your local Soil and Water Conservation District, watershed district, and county Environmental Services or Land and Resources are all good places to talk to staff about your project. They may be able to offer technical or financial assistance, and they can help you understand what regulations apply to your project.

It's important to get your plants from a reputable native plant supplier. An online list of suppliers and landscapers can be found on the Department of Natural Resources website (https://www.dnr.state.mn.us/gardens/nativeplants/suppliers.html), or ask your local agency staff for recommendations.

Before you start installing your rain garden, it's a good idea to think about your maintenance plan. In the short-term, your site may need to be watered, and some weed removal might be necessary. In the long-term, it might need to be mowed or burned every few years and weeds kept in check.

Who can help?

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There are native plants to fit any situation. These black-eyed Susans like sunshine. Choose your plants based on your soil type, amount of sun/shade, moisture level, plant height, and more.

Photo credit: Karen Terry, Univ. of MN Extension

Rain Barrels

Keeping our lakes and rivers clean

WHY?

Have you ever watched a river of rainwater run down your driveway into the lake or storm sewer? Or even worse, seep into your basement? Collecting roof runoff in rain barrels is a good solution to these problems and it also helps alleviate stressed water systems and conserve limited resources. Although rain barrels have been around for thousands of years, people are now encouraged more than ever to use them as a way to protect our lakes and rivers while saving money on water bills.

A rain barrel is any type of container used to catch water flowing from a downspout. Rain barrels reduce the amount of stormwater runoff by collecting rain off a roof and storing it for future use.

Rain barrels can blend into your home's design.

Photo credit: Cindy Johnson, Erhard, MN

HOW?

Make a plan

The rain barrel is placed underneath a shortened downspout, diverting the roof runoff into the rain barrel. Most rain barrels have an overflow hose near the top and are covered to keep mosquitoes and other insects out. They also typically have a spigot near the bottom to drain them; the water can be released slowly away from your buildings or used to water plants. Placing the rain barrel on a sturdy platform will allow for more clearance under the spigot, and it will also increase the rate of flow if you are attaching a hose to the barrel's spigot.

During a one-inch rain event, 0.6 gallons of water will fall on one square foot of roof and 54 gallons will fall on 90 square feet of roof—enough to fill a 55 gallon rain barrel. To collect twice this volume from the same downspout, connect the overflow hose from the first rain barrel to a second rain barrel.

A spigot near the bottom allows you to attach a garden hose to drain the barrel.

Photo credit: Karen Terry, Univ. of MN Extension

Gather your resources and implement your plan

Rain barrels can be purchased, or you can reduce your costs considerably by making your own. Plastic rain barrels may be painted – be creative! Google 'painted rain barrel photos' for inspiration. Be sure to use spray paint specially formulated to bond well to plastic surfaces.

Calculate the area of the roof that drains to the downspout to size your rain barrels appropriately.

Photo credit: Karen Terry, Univ. of MN Extension

Rain barrels require seasonal maintenance. During the rainy months, routinely inspect them and remove any debris that has accumulated on the lid that might block the screen at the inlet. You should also routinely clean the inside of your rain barrel. In the fall, remember to take your barrel out of operation. Turn it upside down or store it inside and redirect the downspout away from the foundation.

Your local Soil and Water Conservation District, watershed district, and county Environmental Services or Land and Resources are all good places to talk to staff about your project. They may offer classes on how to build your own rain barrel or make a bulk purchase for local residents, and they may be able to offer technical or financial assistance.

Who can help?

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Fertilizer and the Law

Don't add fertilizer to our lakes and rivers

Excess nutrients upset the balance

Lakes and rivers are ecosystems that have a point of being 'in balance' -- which means that the right things are present in the right amounts at the right time. If we add nutrients to the water, we risk throwing the system off balance. An abundance of nutrients can lead to excess aquatic plant growth and algae blooms.

When we work to make our lawns green, it's important to make sure that we are not making the lake green, too. Minnesota's Phosphorus Lawn Fertilizer Law makes it illegal to apply fertilizer containing phosphorus to lawns or turf with these very limited exceptions:

- A soil test or plant tissue test shows a need for phosphorus.
- A new lawn is being established by seeding or laying sod.
- Phosphorus fertilizer is being applied on a golf course by trained staff.
- Phosphorus fertilizer is being applied on farms growing sod for sale.

Excess nutrients in lakes often leads to algae blooms.

Photo credit: Karen Terry, Univ. of MN Extension

If you choose to fertilize your lawn, make sure that you use a fertilizer that does not contain phosphorus -- it's the middle number of the three shown on the packaging (e.g., 22-0-15).

Revised May 2019

Herbicides and Pesticides

Let's not kill the good stuff

Weed Killers

There are times when we need to use chemicals to kill tough weeds, but it's important that we don't harm our lakes and rivers in the process. Glyphosate is a common herbicide which often contains a surfactant that ensures that it sticks to the vegetation long enough to do its work. But that surfactant is not good for our aquatic ecosystems so when spraying close to the water's edge, make sure to use a mixture that is surfactant-free. A variety called Rodeo, for example, is labeled as safe for use in close proximity to water.

Weed killers can have unintended negative impacts on the fish and invertebrates in the lake.

Photo credit: Karen Terry, Univ. of MN Extension

Bug Killers

When we start thinking of our lawns as part of the ecosystem, we recognize that insects play an important role. As such, pesticides should be used sparingly to avoid killing the beneficial insects. In recent years, a large class of insecticides called neonicotinoids have come on the market. There is a growing body of evidence that suggests that these 'neonics' are causing harm to native pollinators and other insect groups. In addition to being in insecticide sprays, neonics are also in the plants that we buy. Be a savvy shopper: avoid insecticides and plants that have neonics!

Monarch butterfly on Joe-pye weed.

Photo credit: Linnea White, Univ. of MN Extension

Aquatic Plant Removal

Minimize to areas only needed for boating or swimming

What are aquatic plants?

Aquatic plants are an important part of a lake's ecosystem, and when we remove them, we change the balance of the system. Many fish, insects, and other animals depend on the aquatic plants for some or all of the life cycles. While there are circumstances that warrant the removal of aquatic plants, it should always be done sparingly and with caution.

Photo credit: Karen Terry, Univ. of MN Extension

There are four main categories of aquatic plants: submerged (e.g., coon tail), emergent (e.g., cattail), floating-leaf (e.g., water lily), and algae. Which plants grow where depends on factors such as water depth, water clarity, substrate type, and degree of wave action.

If you choose to remove ...

Aquatic plants in public waters are the property of the state. Although a permit is not always needed, it is best to contact the MN Department of Natural Resources prior to any aquatic plant removal. For Itasca County lakes and rivers, contact Aquatic Plant Management staff at the Brainerd office (218-203-4342).

No permit needed *(it's recommended that you always contact the DNR to verify)*:

- You may cut or pull submerged vegetation if the area to be cleared is not more than 2500ft^2 AND
- the area cleared must not extend more than 50' along the shoreline or ½ the length of your shoreline, whichever is less.
- A channel for boat access may also be cleared, up to 15' wide and as long as necessary to reach open water.
- Proper disposal of the removed plants is required.

Permit needed:

- Destruction of any emergent plants (e.g., cattails, bulrushes)
- Clearing an area larger than $2500 ft^2$
- Applying herbicides or fungicides
- Moving or removing a bog of any size
- Transplanting aquatic plants
- Use of automated aquatic plant control devices (e.g., weedrollers)
- Removal of floating-leaf plants outside of the allowable 15' boat channel

Not allowed:

- Excavating the lake bottom for vegetation control
- Using hydraulic jets
- Using lake bottom barriers to prevent aquatic plant growth
- Removing aquatic plants within posted fish spawning areas
- Removing aquatic plants from an undeveloped shoreline
- Removing aquatic plants where they do not interfere with swimming, boating, or other recreational uses

Aquatic plants are an integral part of lake ecosystems; many fish and invertebrates depend on plants for some part of their life cycle.

Photo credit: Karen Terry, Univ. of MN Extension

Source: https://www.dnr.state.mn.us/shorelandmgmt/apg/regulations.html

More Sustainable (and Beautiful) Alternatives to a Grass Lawn

Manicured turf grass lawns cover up to 50 million acres of land in America. But a new, no-mow movement is challenging this conformity—and helping the environment.

September 30, 2016 Mary Talbot

Source: https://www.nrdc.org/stories/more-sustainable-and-beautiful-alternatives-grass-lawn

Adams County PA Master Gardener, BBG Graduate, and NRDC Member; Audrey Hillman

In a case of taking "the grass is always greener" a bit too literally, American homeowners have long strived to make their lawns brighter, lusher, and more velvety than their neighbors'. But all that competition has a devastating environmental impact. Every year across the country, lawns consume nearly 3 trillion gallons of water a year, 200 million gallons of gas (for all that mowing), and 70 million pounds of pesticides.

You may also know that turf grass, however welcoming it looks for our bare feet, provides virtually no habitat for pollinators and other animals and plants that make up a healthy, diverse ecosystem. In fact, these lawns can do substantial harm to the environment and to both vertebrates and insects. Birds, for instance, may ingest berries and seeds that have absorbed pesticides from the ground. Likewise, rainwater runoff from lawns can carry pesticides and fertilizers into rivers, lakes, streams, and oceans via the sewer system. This can poison fish and other aquatic animals and harm humans who swim, surf, and eat seafood that may be contaminated. And then, of course, lawn mowers can pollute the air.

Luckily, today more Americans are ready for a change. "We're on the cusp of a transition that will likely take place over the next 10 to 15 years, away from the conformity of mowed turf," says Ed Osann, senior policy analyst and water efficiency project director with NRDC's Water program. He adds that eradication of all grass isn't the goal. "We're not declaring war on turf or suggesting that we remove every square foot of it. But we want to encourage people to think about whether there are places in their yards that can be converted to allow for a more diverse and sustainable landscape."

The No-Mow Movement

A growing number of homeowners are converting part or all of their lawns to a less thirsty form of landscape. These no-mow yards fall into four categories: 1) naturalized or unmowed turf grass that is left to grow wild; 2) low-growing turf grasses that require little grooming (most are a blend of fescues); 3) native or naturalized landscapes where turf is replaced with native plants as well as noninvasive, climate-friendly ones that can thrive in local conditions; and 4) yards where edible plants—vegetables and fruit-bearing trees and shrubs—replace a portion of turf. (According to the National Gardening Association, one in three families now grows some portion of the food they consume.)

Making the Change

A successful lawn conversion depends on climate, terrain, and of course individual taste. Of the four main no-mow strategies, Osann says, native or naturalized landscaping is likely your best option. It's adaptable to any part of the country and offers gardeners an infinite range of design possibilities. If you want to join the no-mow movement, here are some pointers to get you started:

- Get expert advice. Begin by talking with a landscaper who has experience with lawn conversions, or even a neighbor who has naturalized all or part of his yard. A landscaper can help remove existing grass and recommend native plants to use in its place. Depending on water and weather, a low-growing turf lawn will "green up" about two weeks after seeding. Another alternative is a wildflower garden grown from seed. (Just make sure you choose a wildflower mix that fits your climate, and weed out existing vegetation that would compete for moisture and sun.) After the seeds germinate and the flowers bloom (in 6 to 12 weeks), they don't require watering unless there's a prolonged drought.
- Do your weeding. Invasive plants like ragweed, thistle, and burdock can crowd out their native neighbors and may run afoul of local ordinances (as noted below). For most no-mow advocates, the payoff in natural beauty and habitat are well worth the effort.
- Check for incentives. Not surprisingly, western states such as Arizona and California, which have been in the throes of extreme drought for more than four years, have taken the lead in spurring homeowners to do lawn conversions. California, in fact, launched a turf replacement initiative that offers rebates of up to $500 per yard for homeowners who convert turf lawns to native, drought-resistant xeriscaping. On a more grass-roots level, organizations like the Surfriders Foundation, a national environmental group made up of surfing aficionados, have helped transform turf lawns in Southern California parks and homes into ocean-friendly gardens, using succulents and other indigenous plants along with hardscape materials like rocks and gravel that increase filtration, conserve water, and reduce runoff.

- Check the rule books. The no-mow movement may sound idyllic, but some practitioners have faced a surprising stumbling block: the law. In one example, Sarah Baker, a homeowner and scion of a family of horticulturalists in St. Albans Township, Ohio, decided to let her turf grass yard grow wild. Last year, she was forced to mow when authorities from her township deemed her garden, which had become a naturalized but well-tended landscape, a nuisance. Sandra Christos of Stone Harbor, New Jersey, says that after she replaced turf grass with native plants, she was delighted that cormorants, night herons, and kingfishers made themselves at home alongside "every kind of butterfly you can imagine." But since receiving a letter from the town clerk, Christos has had to tame the mallow, bayberry, clethra, and rosa rugosa along her walkway—or pay a fine.

Sarah Baker in her yard; Amanda Mae Taylor

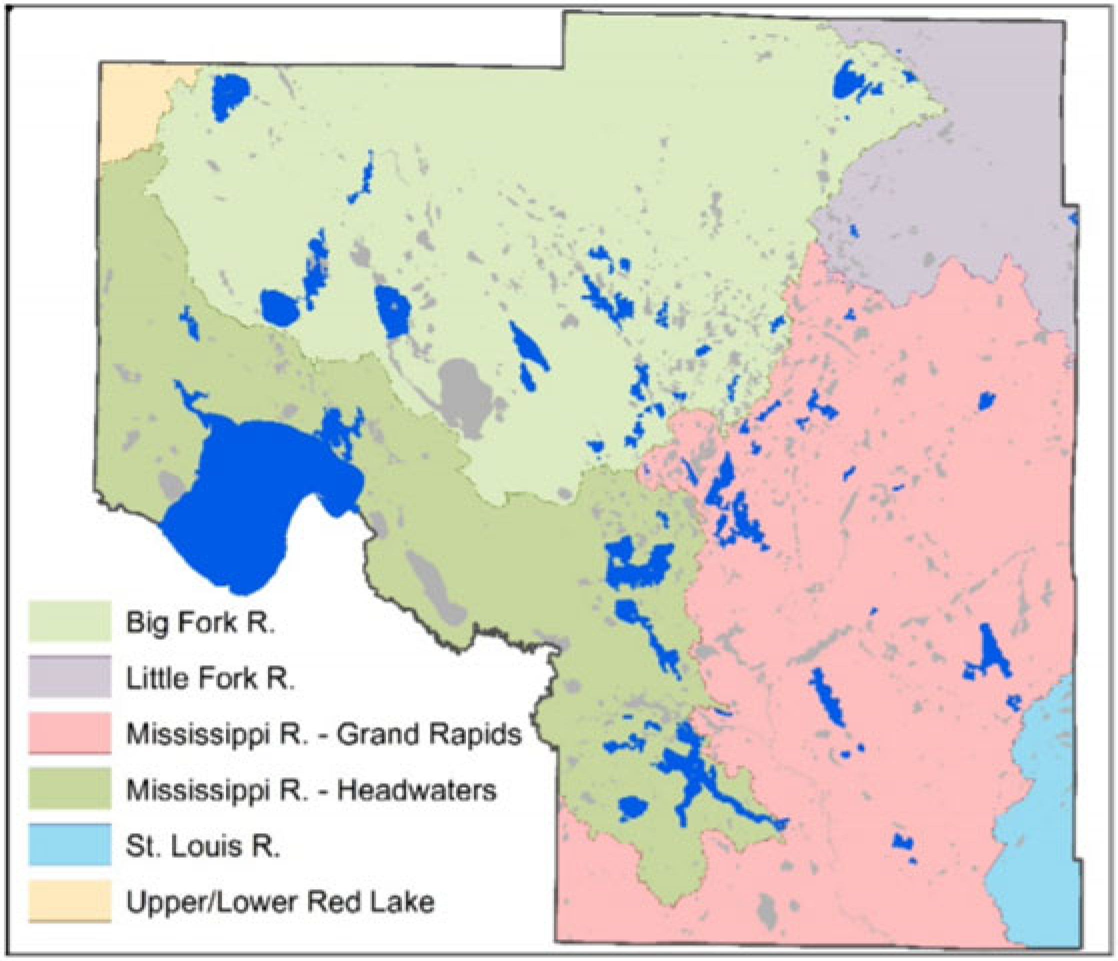
While local ordinances or homeowner association bans have emerged—mostly out of concern over fire safety, rodent control, and noxious weeds—they take on aesthetic concerns too, often proscribing grass over eight inches tall, vegetable gardens (especially in planned communities), or any kind of landscaping that deviates from clipped turf.

A recent white paper by students from Yale's forestry and law schools, in collaboration with NRDC, surveyed legal obstacles to various forms of no-mow and concluded that, for sustainable landscaping to achieve wider adoption, some municipalities will need to adjust their policies.

That change can happen if residents push for it. Montgomery County, Maryland, for example, amended its nuisance laws to allow for naturalized lawns after locals made the case that their wild gardens improved air and soil quality and reduced stormwater runoff.

Moving away from water-guzzling and chemical-hungry lawns and cultivating yards that are diverse and self-regulating is a matter of mounting urgency worthy of that kind of community organizing. As global temperatures rise and droughts drag on, the demands of turf grass are likely to become untenable.

"Our existing lawns are going to get thirstier and their water requirements will increase," Osann says. Fortunately, with an evolving toolkit of sustainable landscaping strategies, home gardeners can avoid such effects and help nurture the health of the planet—right in their own backyards.



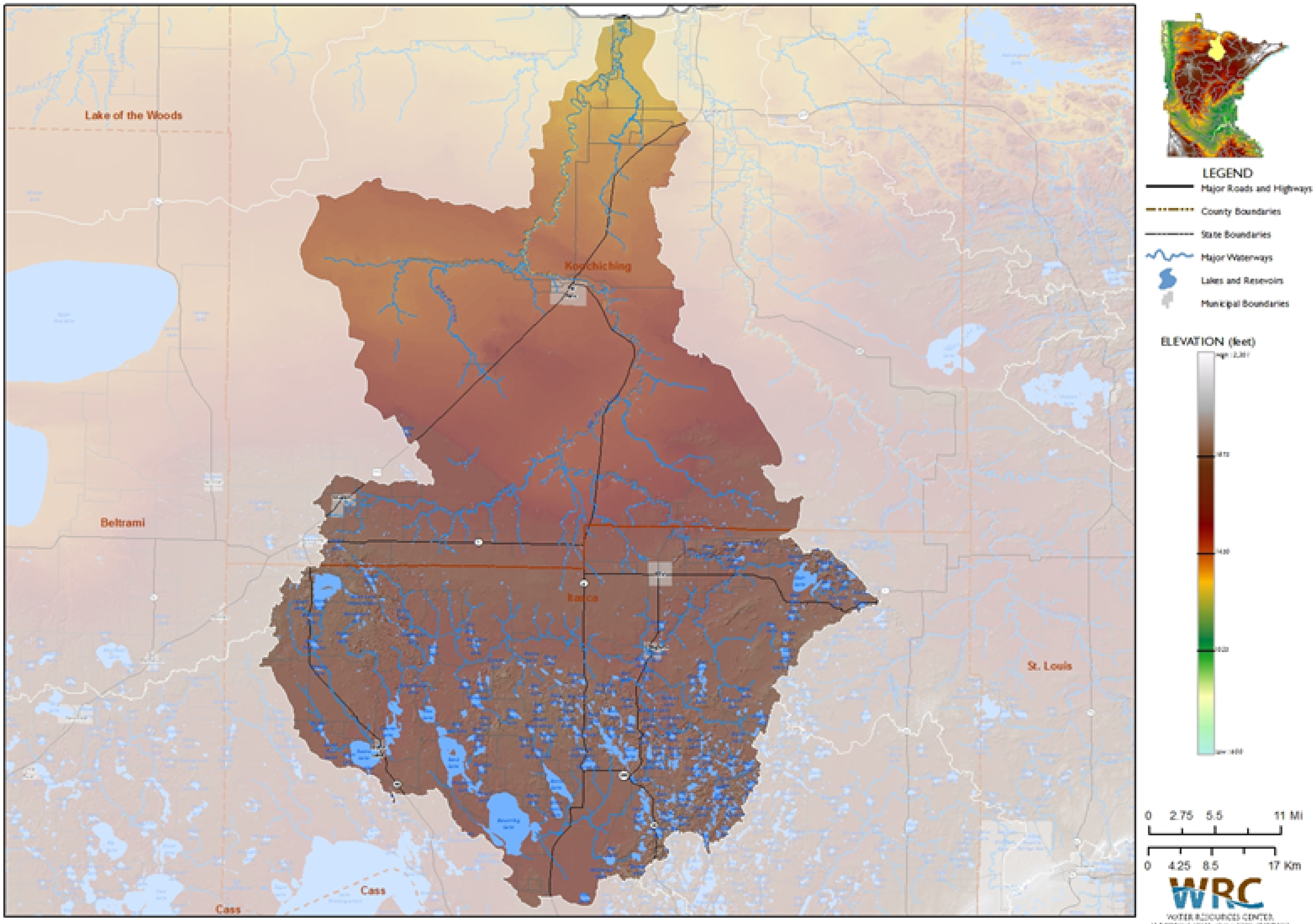
Itasca County is part of six major watersheds as shown in the graphic to the left.

Two of the watersheds – Big Fork and Little Fork
– are part of the Rainy River Basin that eventually flows north into Canada, and a third
– Upper/Lower Red Lake (very little of which lies in Itasca County) – flows to Canada via the Red River of the North.

The Mississippi River – Grand Rapids and Mississippi River – Headwaters drain via the Mississippi River south to the Gulf of Mexico, and the small area of Itasca County land in the St. Louis watershed drains into Lake Superior.

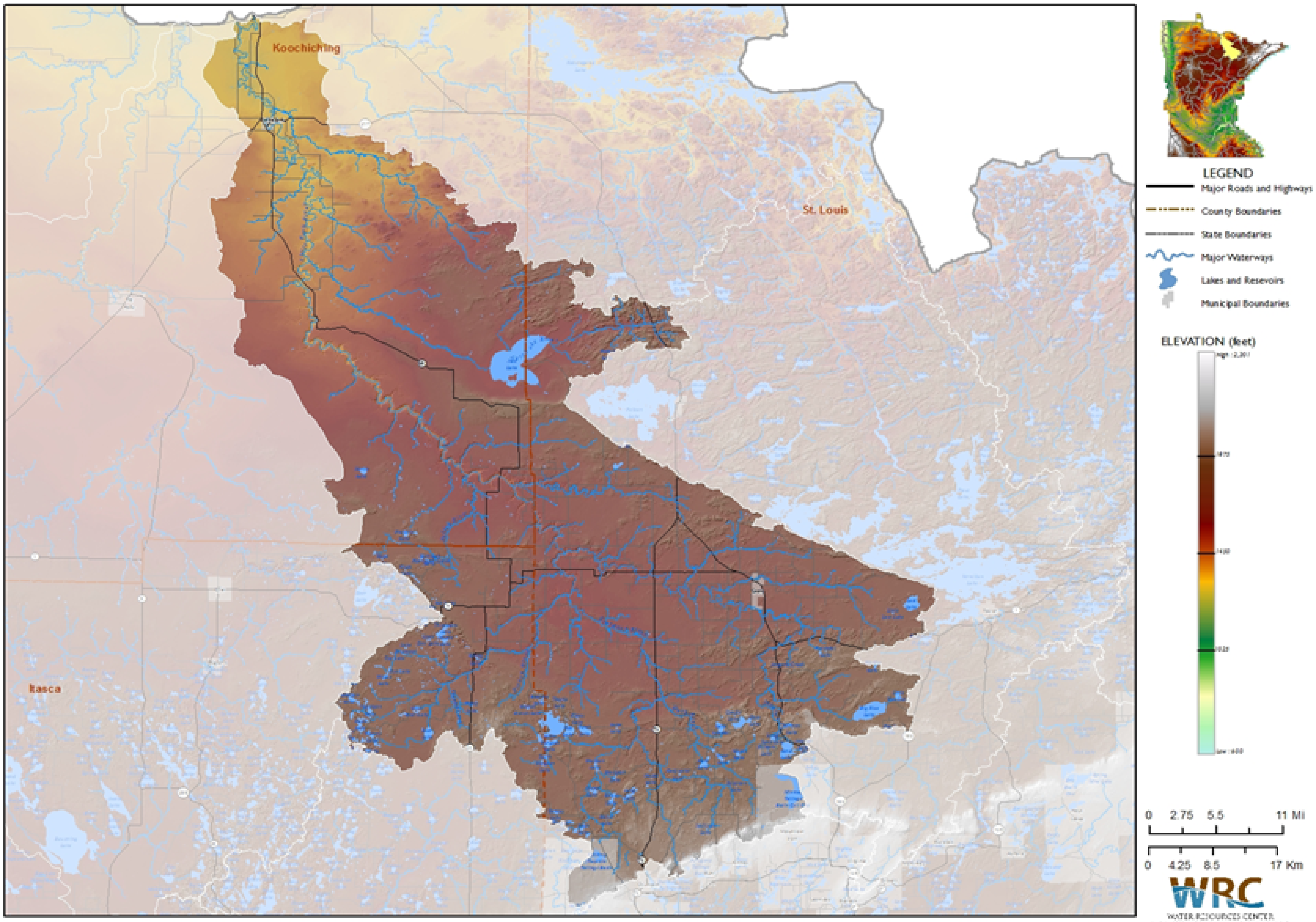
Source: Itasca County Lake Prioritization – Lake Prioritization and Protection Planning Document, 2017

https://www.itascaswcd.org/component/edocman/?task=document.viewdoc&id=83&Itemid=0



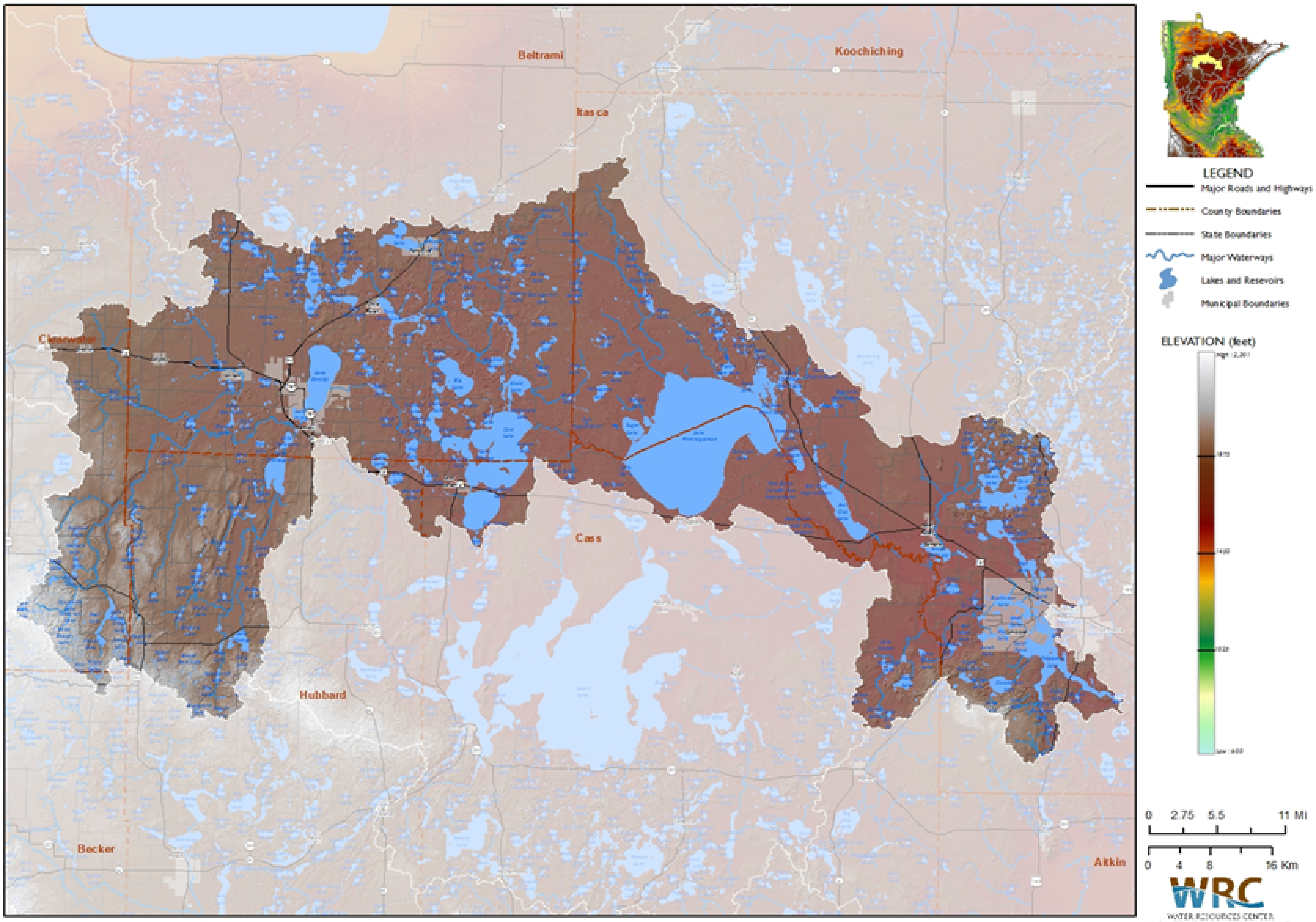
BIG FORK RIVER MAJOR WATERSHED

Source: https://mrbdc.mnsu.edu/mnnutrients/watersheds/big-fork-river-watershed



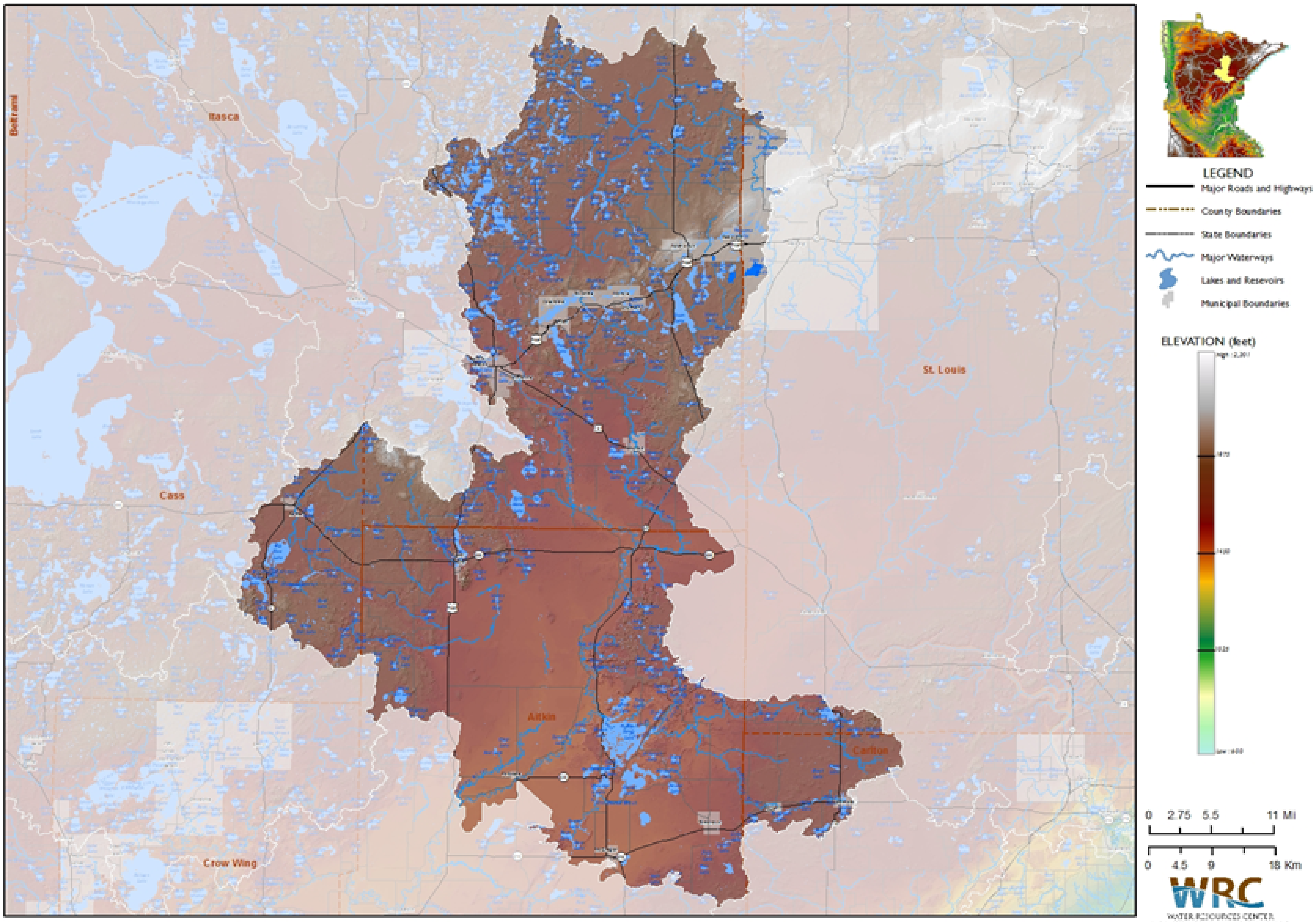
LITTLE FORK RIVER MAJOR WATERSHED

Source: https://mrbdc.mnsu.edu/mnnutrients/watersheds/little-fork-river-watershed



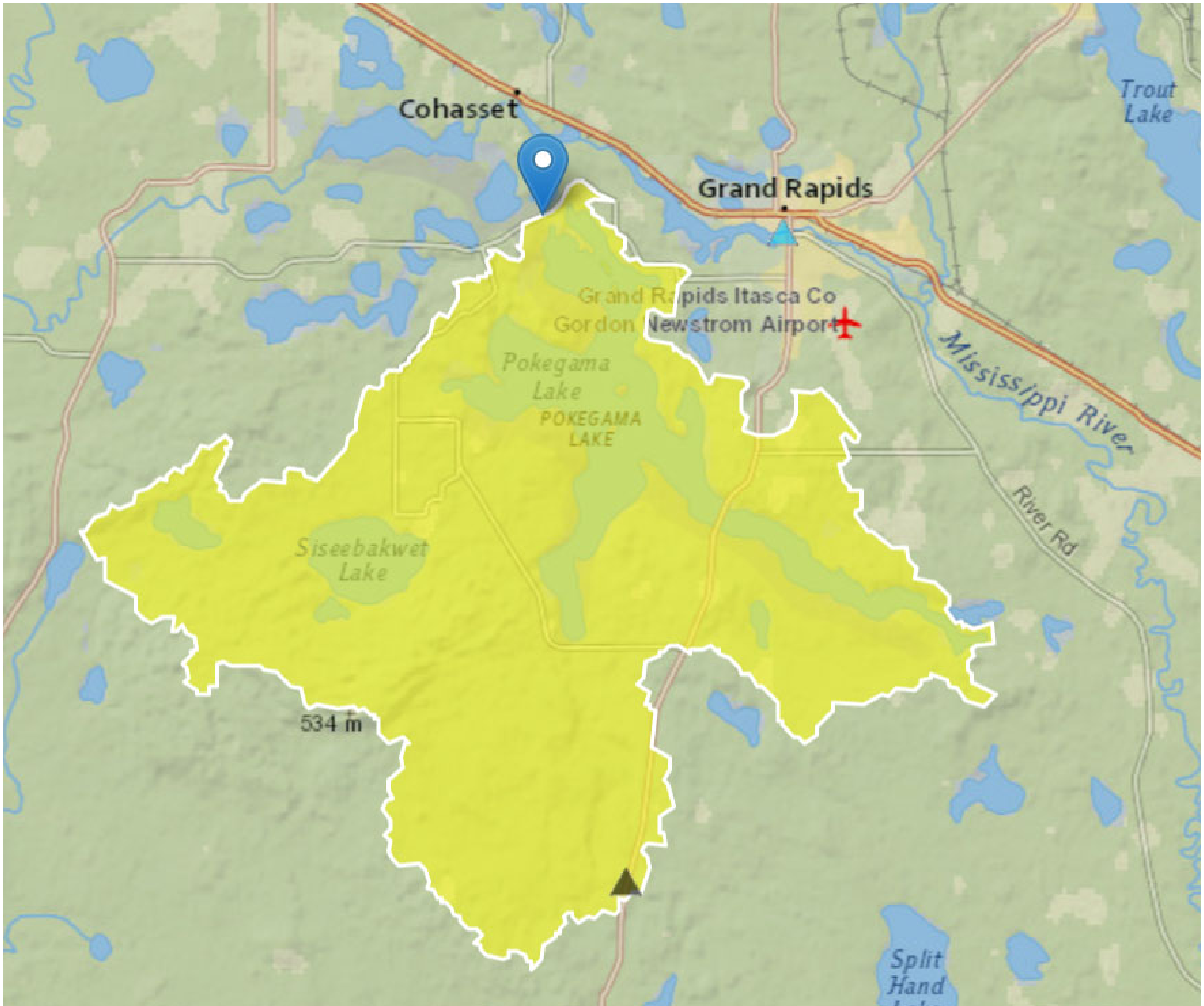
MISSISSIPPI RIVER - HEADWATERS MAJOR WATERSHED

Source: https://mrbdc.mnsu.edu/mnnutrients/watersheds/mississippi-river-headwaters



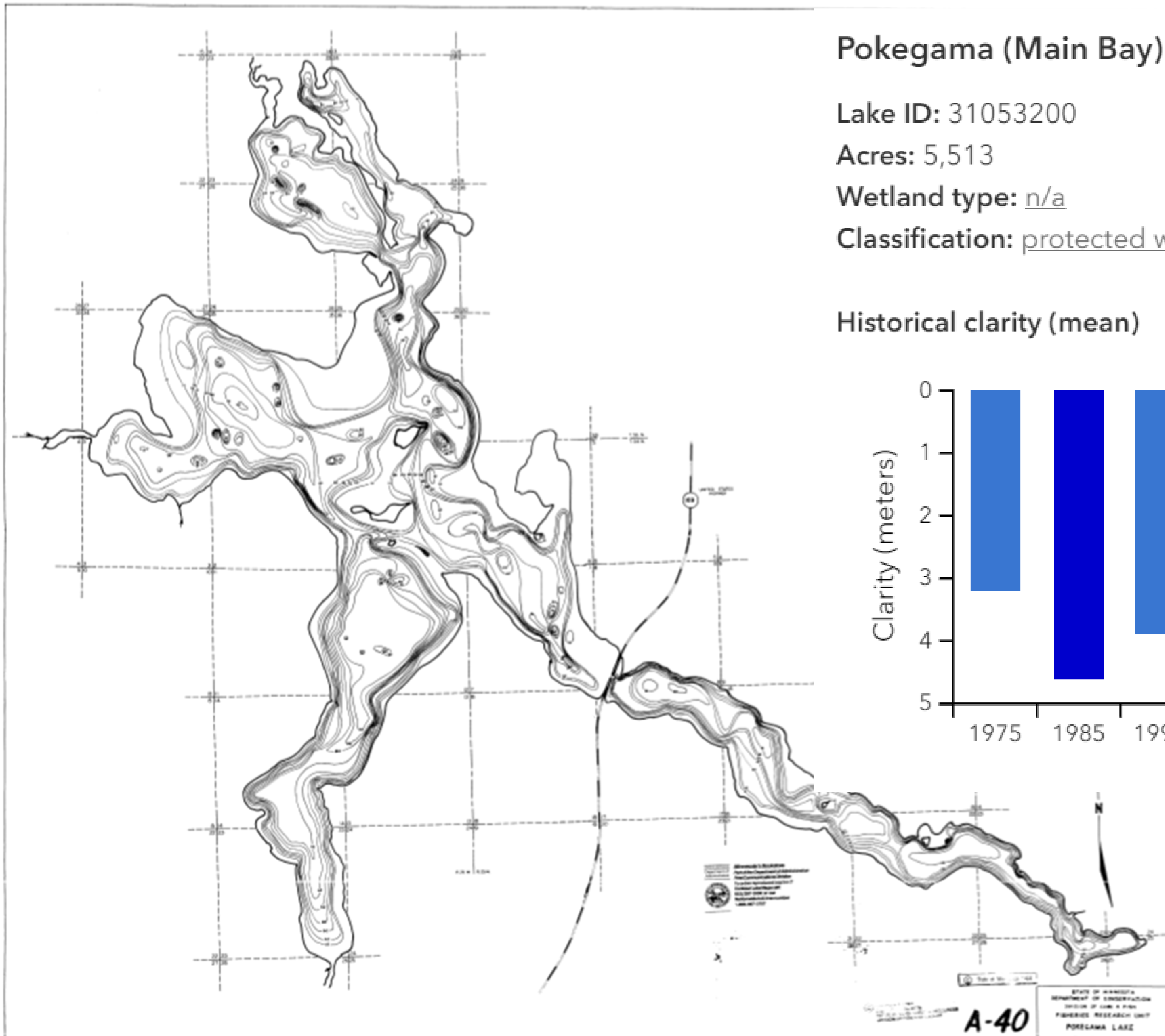
MISSISSIPPI RIVER - GRAND RAPIDS MAJOR WATERSHED

Source: https://mrbdc.mnsu.edu/mnnutrients/watersheds/mississippi-river-grand-rapids



Pokegama Lake and its lakeshed

Source: https://streamstats.usgs.gov



Pokegama (Main Bay) (Itasca County)

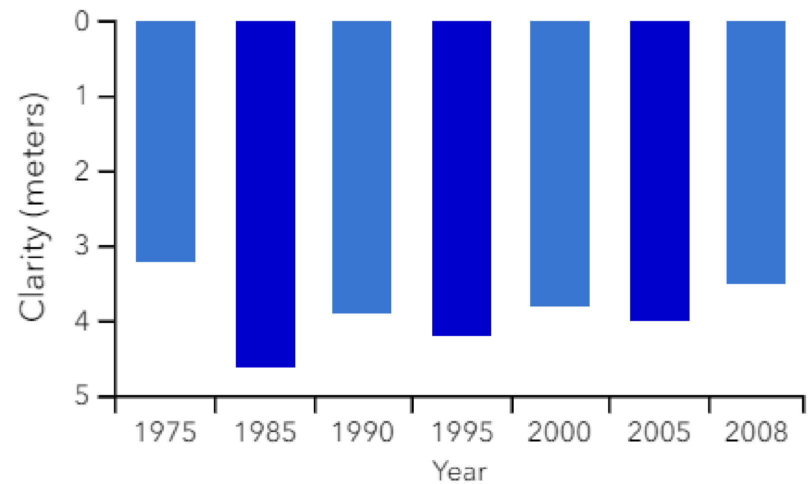
Lake ID: 31053200

Acres: 5,513

Wetland type: n/a

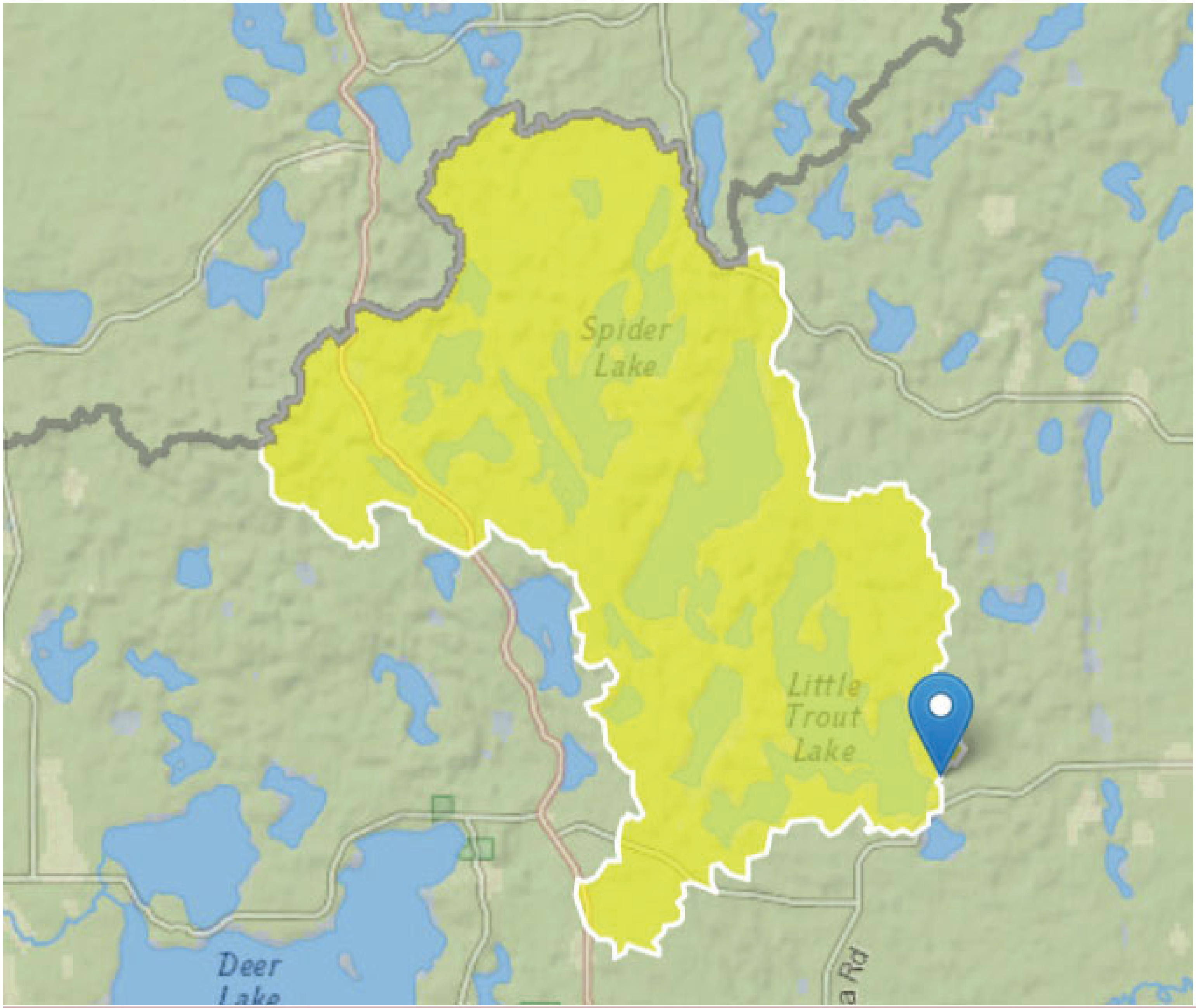
Classification: protected water

Historical clarity (mean)



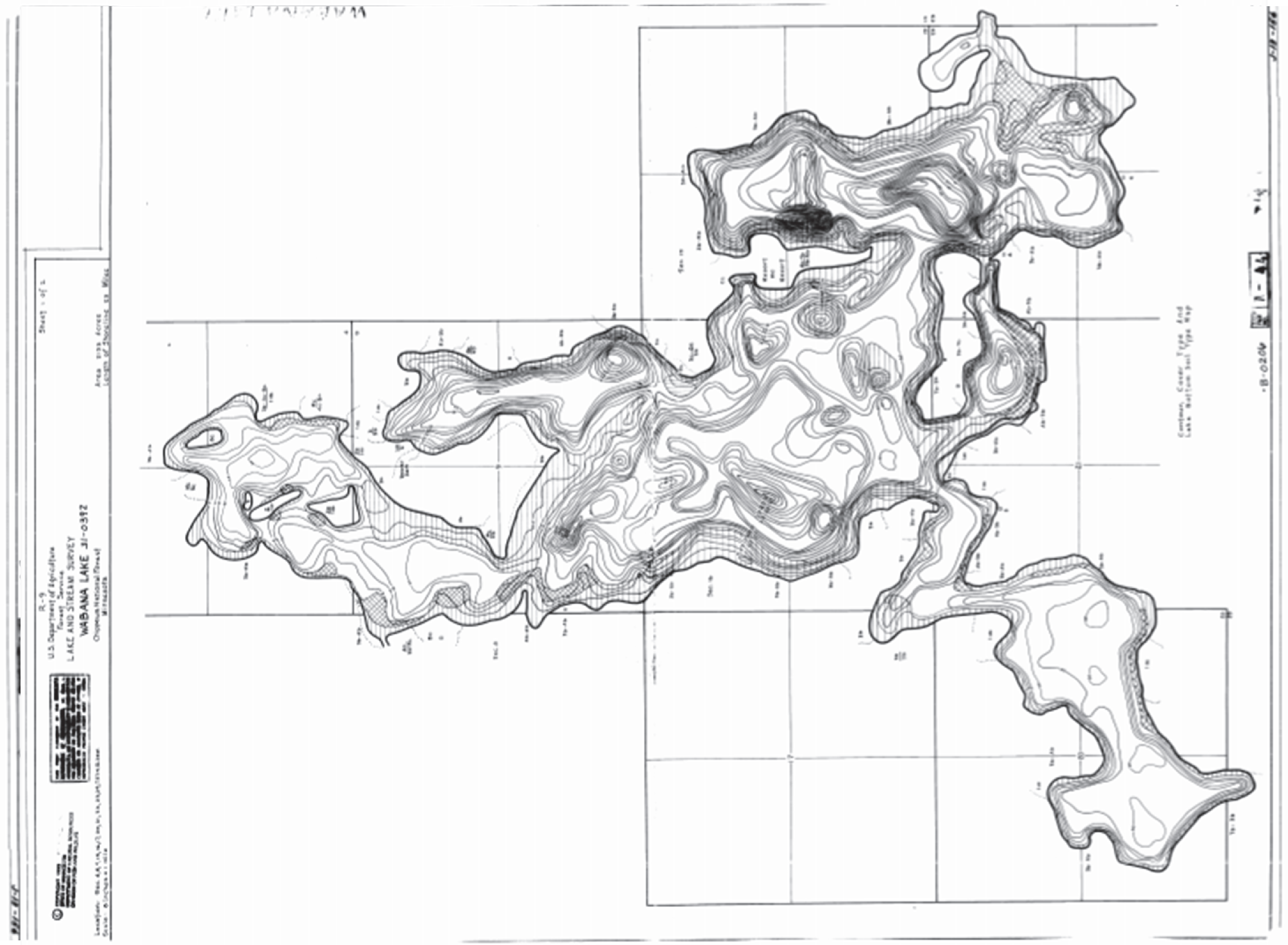
Source: https://lakes.rs.umn.edu/#31053200

Source: http://files.dnr.state.mn.us/lakefind/data/lakemaps/b0441010.pdf



Wabana Lake (Little Trout Lake) and its lakeshed

Source: https://streamstats.usgs.gov



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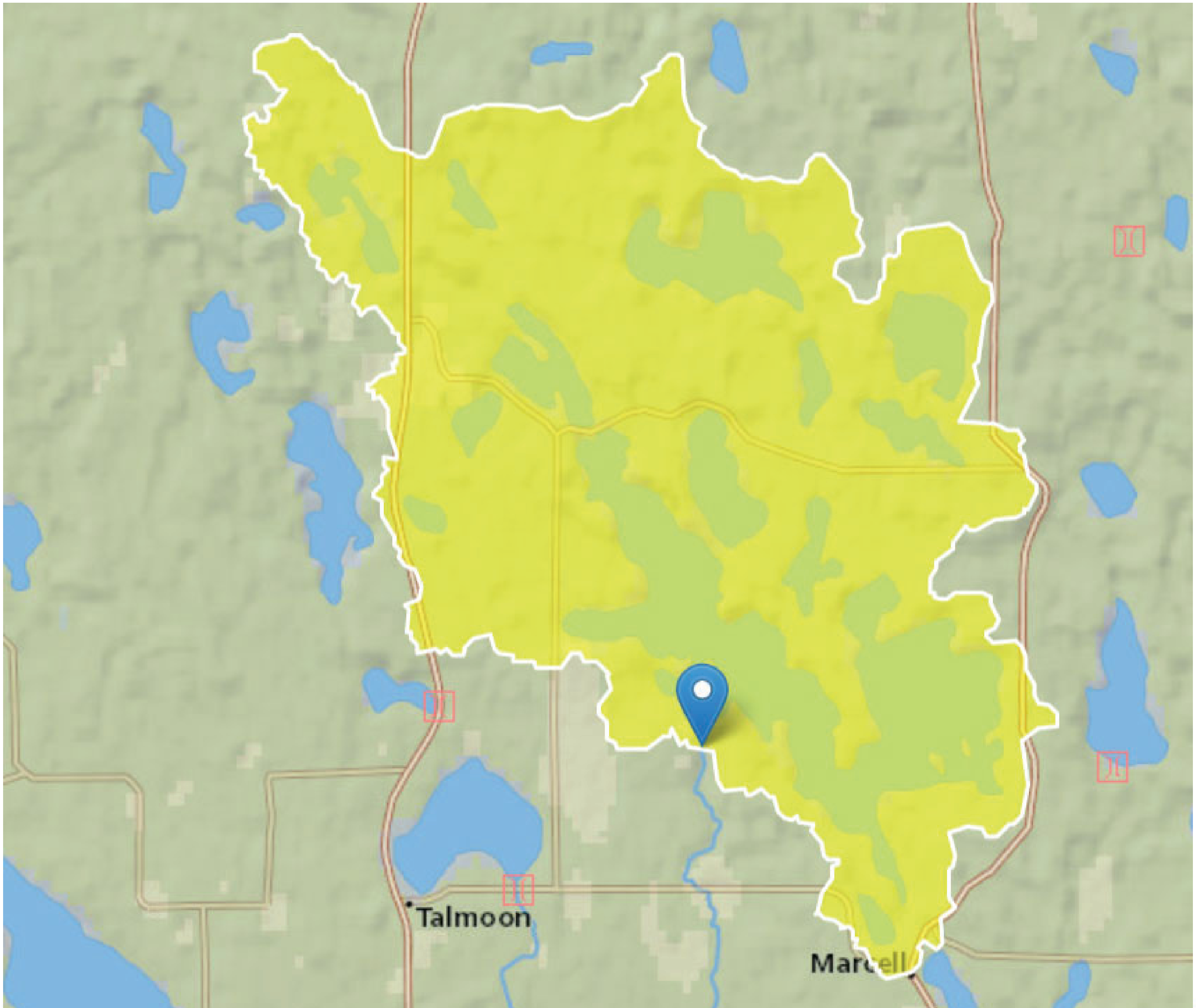
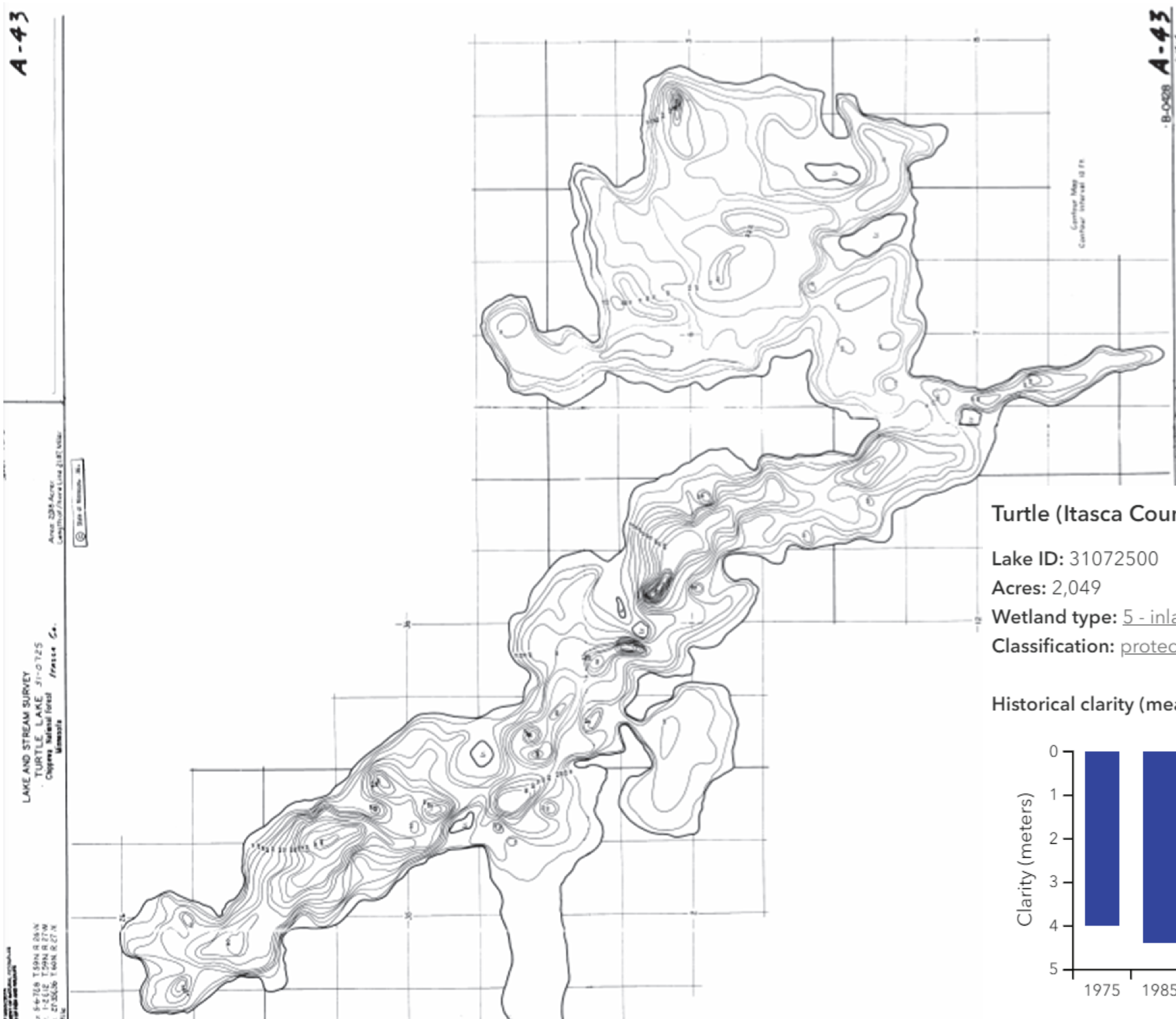
Source: http://files.dnr.state.mn.us/lakefind/data/lakemaps/b0206010.pdf



Turtle Lake and its lakeshed

Source:
https://streamstats.usgs.gov



Source: http://files.dnr.state.mn.us/lakefind/data/lakemaps/b0428010.pdf

Turtle (Itasca County)

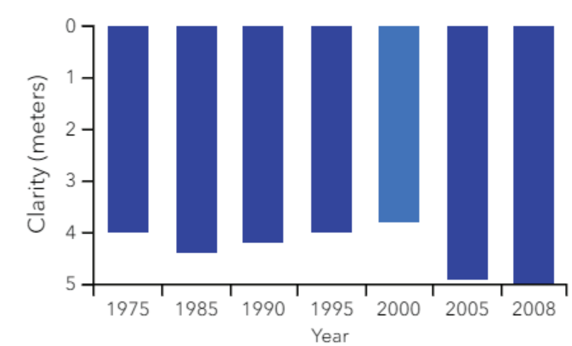
Lake ID: 31072500

Acres: 2,049

Wetland type: 5 - inland open fresh water, shallow pond, or reservoir

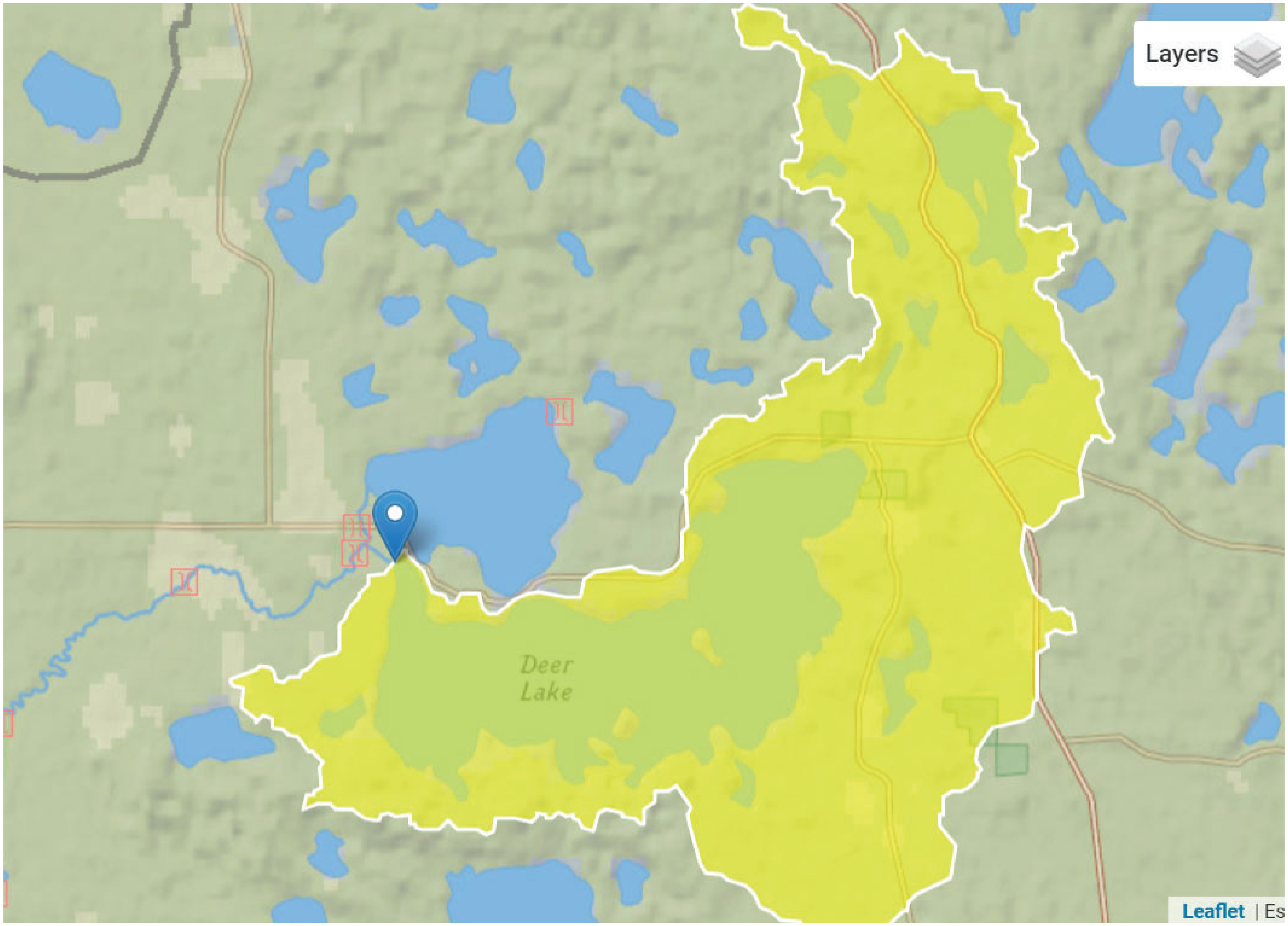
Classification: protected water

Historical clarity (mean)

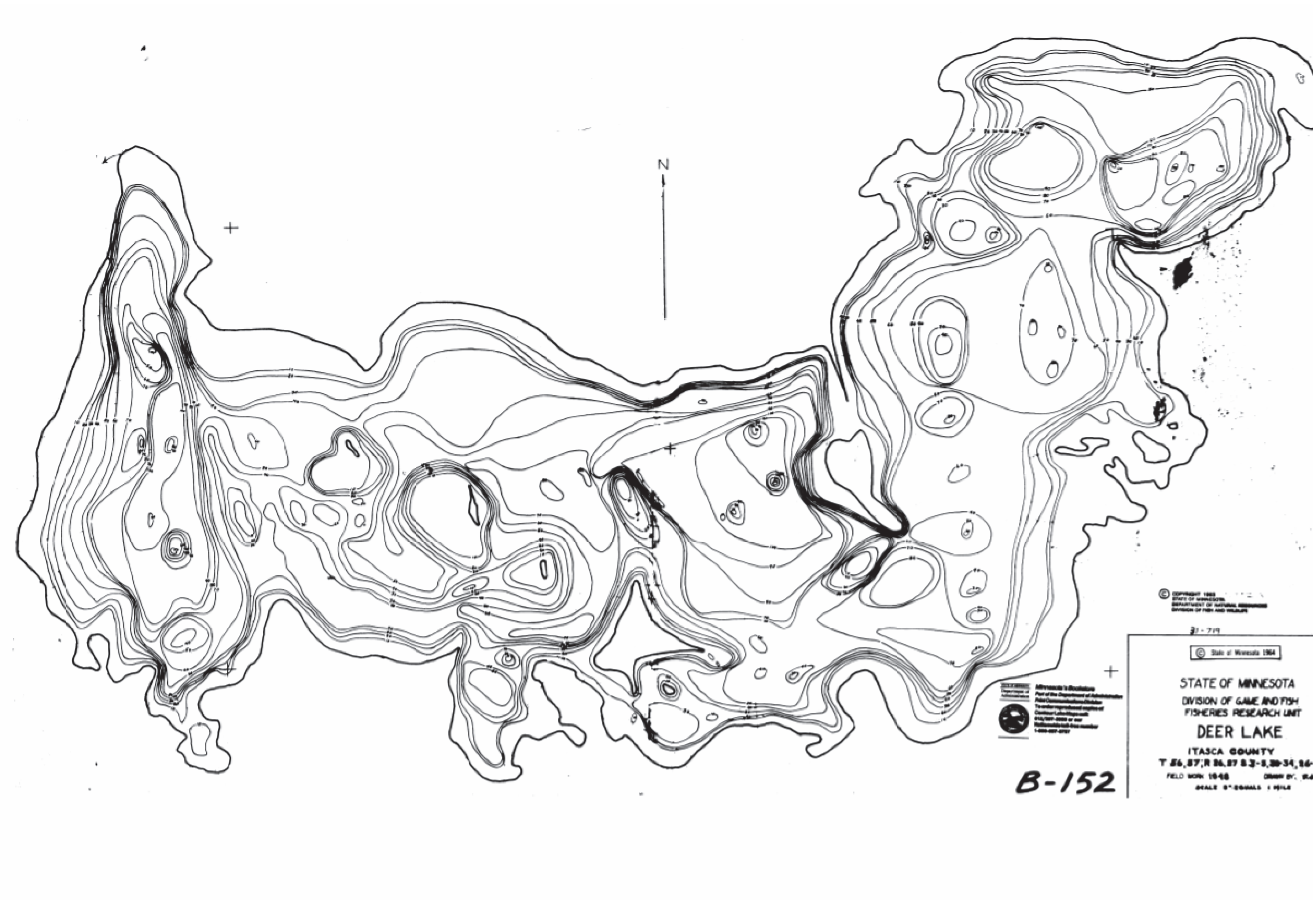


Source: https://lakes.rs.umn.edu/#31072500

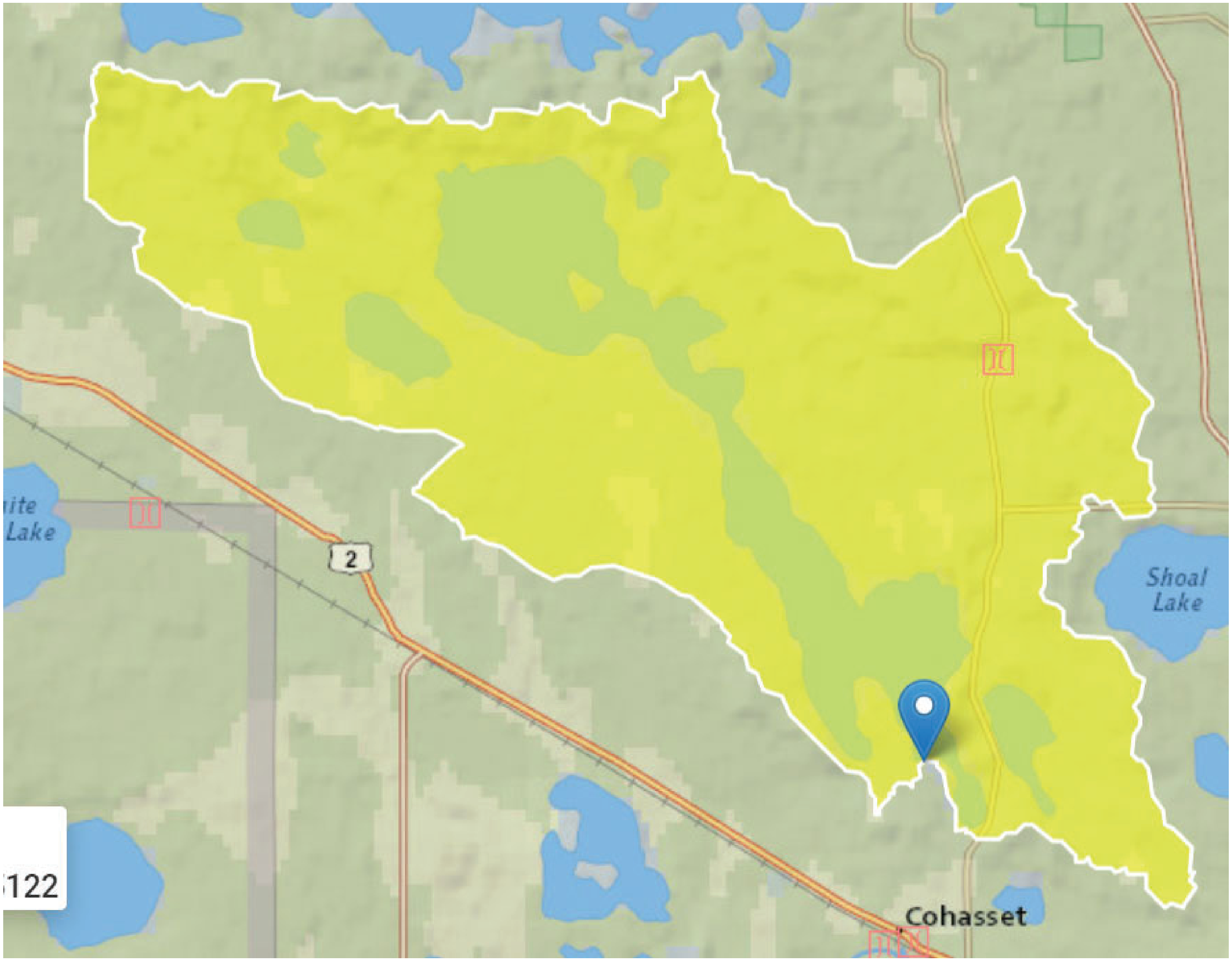
Deer Lake and its lakeshed



Source: https://streamstats.usgs.gov

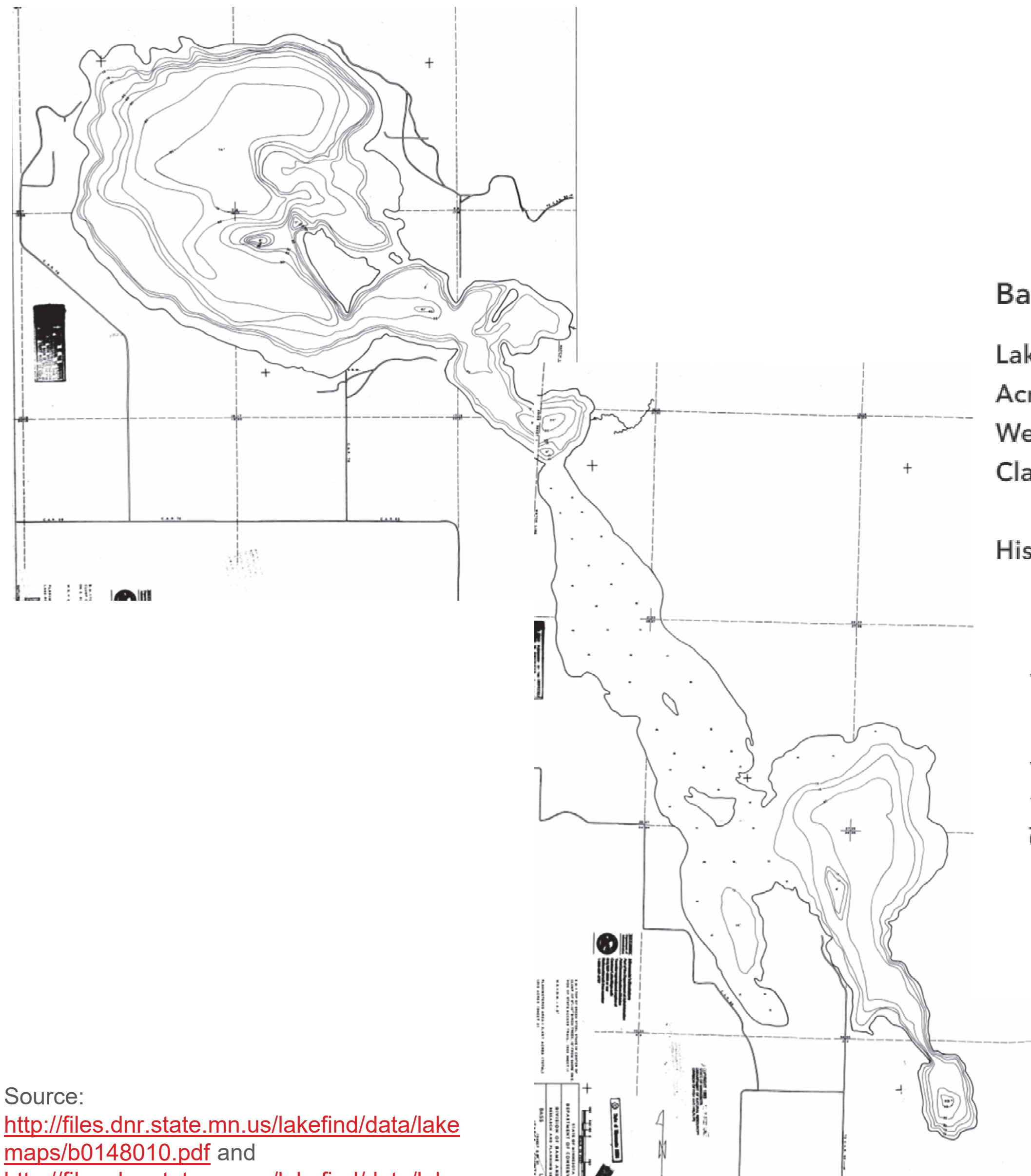


Source: http://files.dnr.state.mn.us/lakefind/data/lakemaps/b0152010.pdf



Bass Lake (near Cohasset) and its lakeshed

Source: https://streamstats.usgs.gov

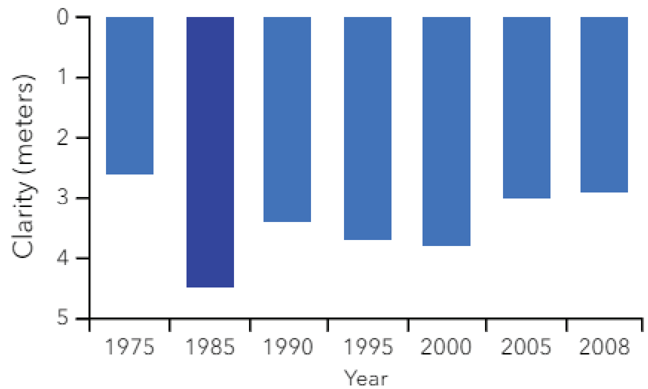


Source:
http://files.dnr.state.mn.us/lakefind/data/lakemaps/b0148010.pdf and
http://files.dnr.state.mn.us/lakefind/data/lakemaps/b0148020.pdf

Bass (Itasca County)

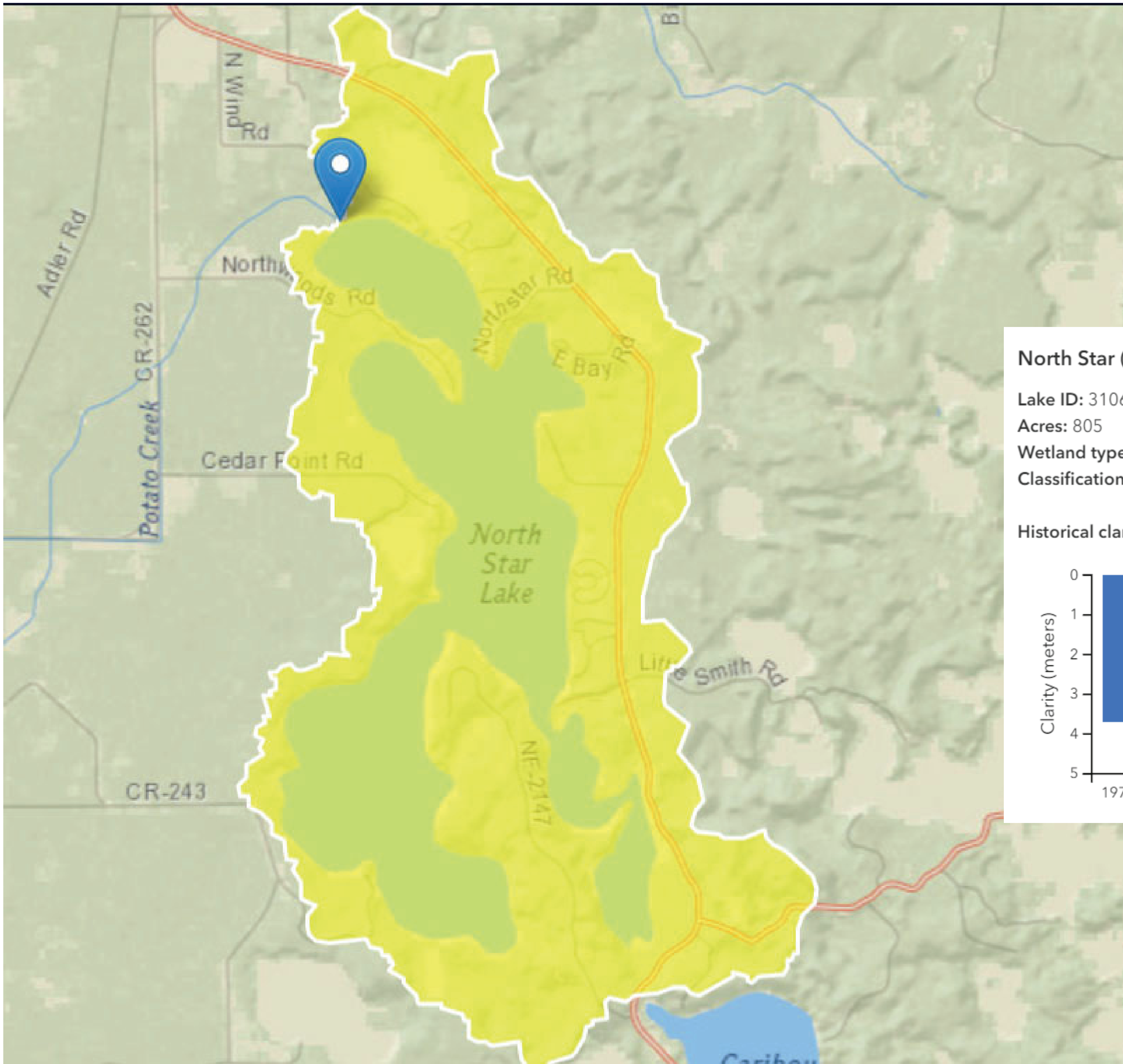
Lake ID: 31057600
Acres: 2,661
Wetland type: 5 - inland open fresh water, shallow pond, or reservoir
Classification: protected water

Historical clarity (mean)



Source: https://lakes.rs.umn.edu/#31057600

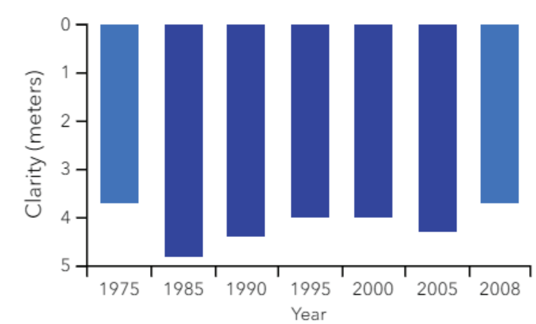
North Star Lake and its lakeshed



North Star (Itasca County)

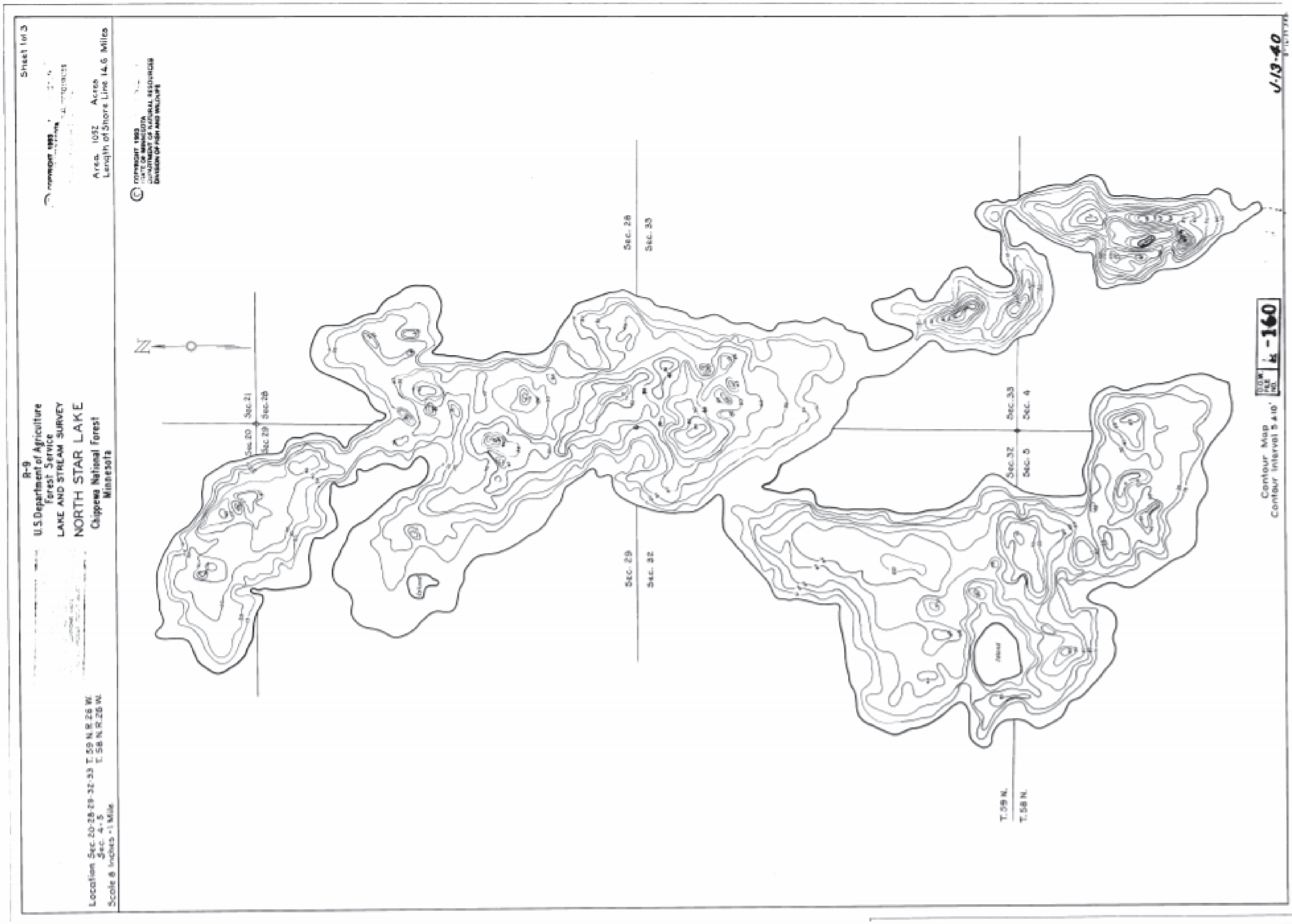
Lake ID: 31065300
Acres: 805
Wetland type: 5 - inland open fresh water, shallow pond, or reservoir
Classification: protected water

Historical clarity (mean)



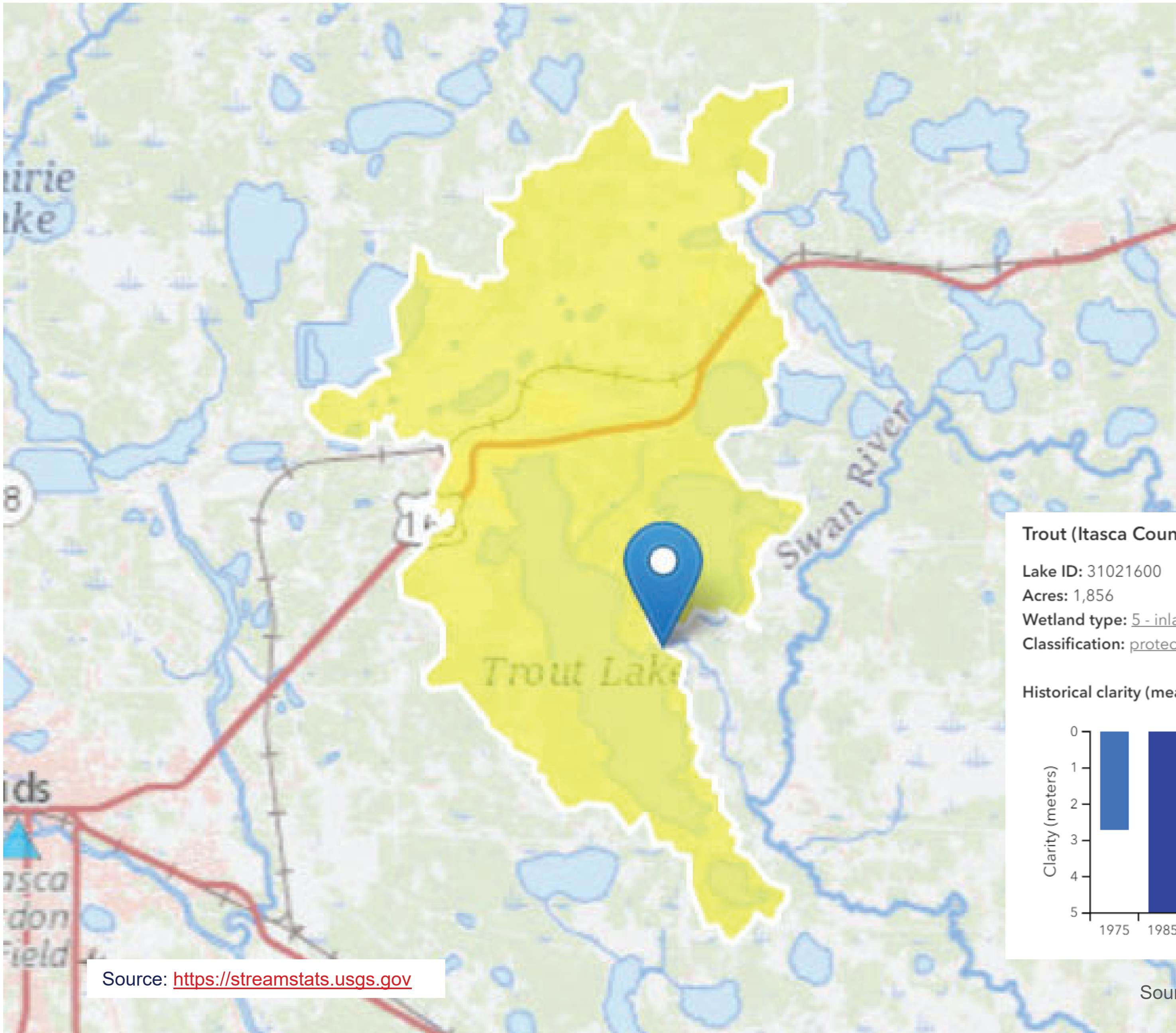
Source: https://lakes.rs.umn.edu/#31065300

Source: https://streamstats.usgs.gov

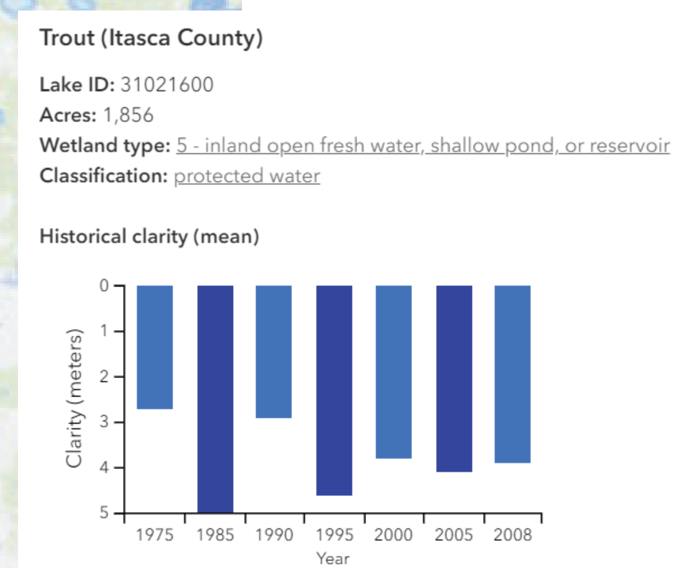


Source: http://files.dnr.state.mn.us/lakefind/data/lakemaps/b0159010.pdf

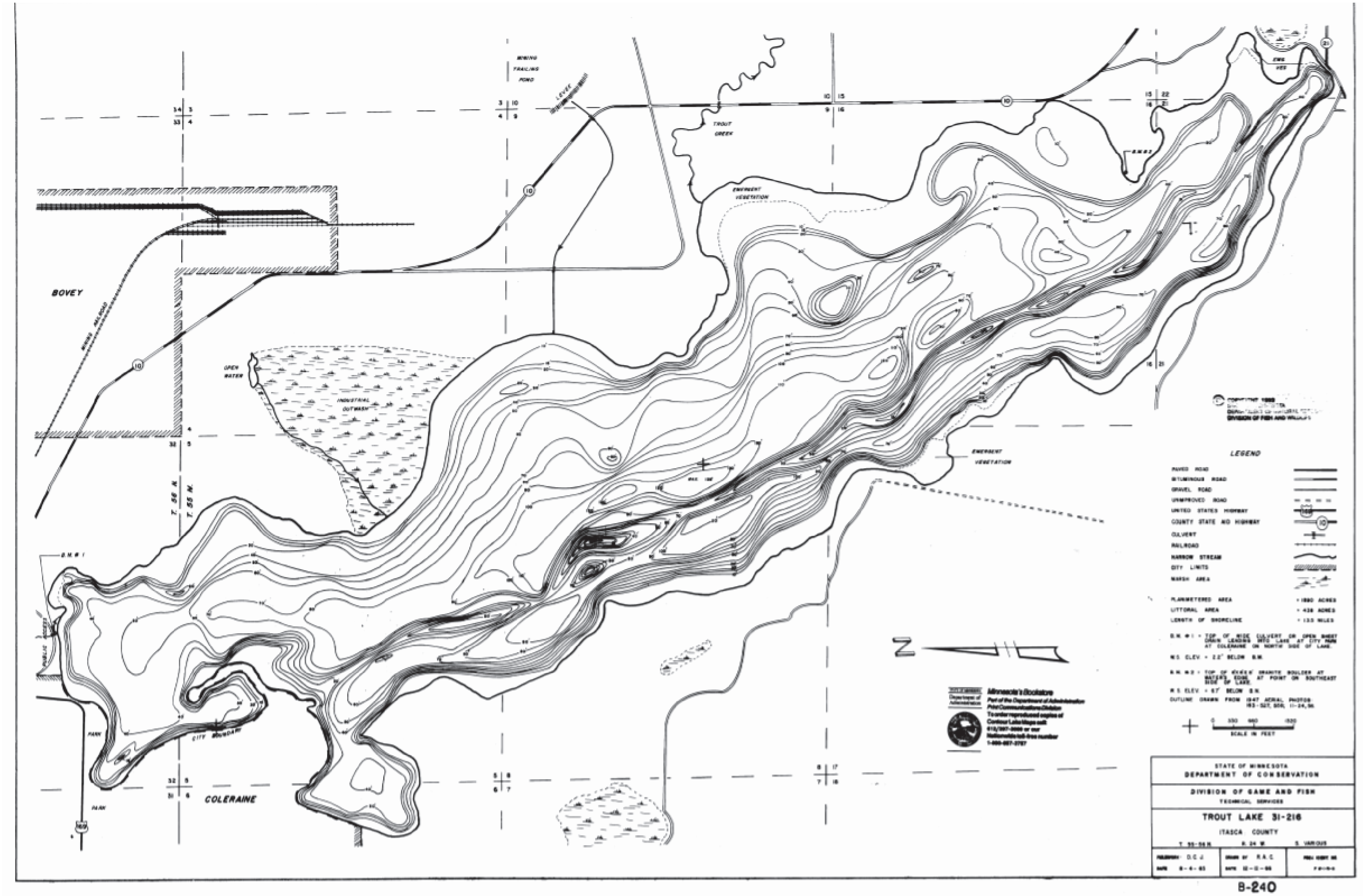
Trout Lake and its lakeshed



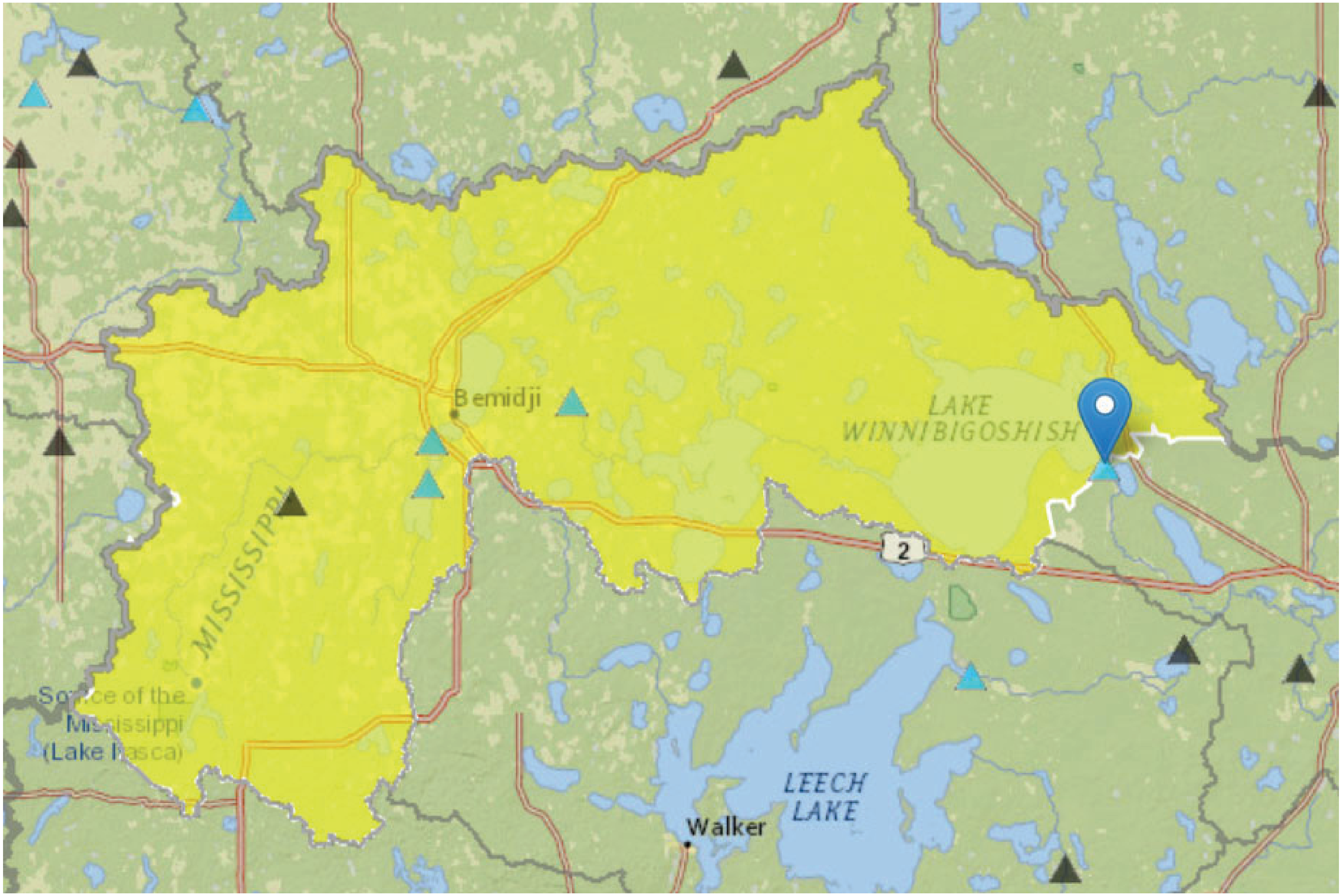
Source: https://streamstats.usgs.gov



Source: https://lakes.rs.umn.edu/#31021600



Source: http://files.dnr.state.mn.us/lakefind/data/lakemaps/b0240010.pdf



Lake Winnibigoshish and its lakeshed

Source: https://streamstats.usgs.gov

PUBLIC RELEASE: 26-MAR-2019

Sometimes it's not good to be green

Greening of lakes will significantly increase greenhouse gas emissions

UNIVERSITY OF MINNESOTA

IMAGE: JULY 10, 2014. WATER FLOWING INTO A EUTROPHIC LAKE FROM AGRICULTURAL FIELDS. ALGAE IS ALREADY ABUNDANT IN THE STREAM WHERE IT HAS GROWN DUE TO HIGH NUTRIENTS AND TEMPERATURES. CREDIT:... **view more ›**

CREDIT: JOHN A. DOWNING/MINNESOTA SEA GRANT

The good news is global and local. Keeping inland lakes from turning green means less greenhouse gases entering the atmosphere and contributing to climate change. Healthy drinking water, shing and recreation opportunities are also increased when waters are not green.

What's wrong with being green? Toxins released by algal blooms can ruin drinking water. When dense algae blooms die, the bacteria that decompose the algae also deplete oxygen in the water. Without oxygen, sh and other animals suffocate. Globally, such green waters are also an important contributor to atmospheric methane -- a greenhouse gas that is up to 34 times more potent than carbon dioxide.

"We estimate that the greening of the world's lakes will increase the emission of methane into the atmosphere by 30 to 90 percent during the next 100 years," said Jake Beaulieu of the United States Environmental Protection Agency and lead author of a paper on lake greening and greenhouse gas emissions published March 26, 2019 in the journal *Nature Communications*.

According to the authors, three distinct mechanisms are expected to induce increases in lake greening or eutrophication during the next 100 years. First, human populations are expected to increase by 50 percent by 2100. More people means more sewage and more fertilizers that runoff land. At current rates of population **growth and climate change, eutrophication in lakes will increase by 25 to 200 percent by 2050 and double or quadruple by 2100. Second, increased storms and stormwater runo will increase the nutrient losses from land to inland waters. Third, as the climate warms, lakes will warm. Warmer waters produce more algae. Additionally, the area of the planet covered in water is expected to increase, which will result in more methane-emitting surface waters.**

"It is really surprising how much eutrophication could increase in the next 50 to 100 years," said co-author John A. Downing of the University of Minnesota Sea Grant program. "People do four important things that a ect eutrophication: they eat, they excrete, they make more people who eat and excrete, and they alter landscapes and climate," said Downing.

Using projected population growth and climate change, the authors simulated the eutrophication of lakes under four different and conservative scenarios of future phosphorus loading from low to high: 80, 130, 170, 200, and 220 percent of current levels.

"We used phosphorus because the relationship between phosphorus and plant or algae growth is well established," said co-author Tonya DelSontro of the University of Geneva. "Currently, the single largest source of atmospheric methane is wetlands. If the phosphorus in lakes triples, then methane emissions from lakes could be twice that of wetlands."

The authors used a statistical model they created in 2018 that correlates methane emissions with lake size and chlorophyll, which is a measure of high algal biomass stimulated by phosphorus. By using global distribution of lake size and total lake area, climatic heating of lakes, future phosphorus concentrations and storm-driven nutrient runoff they were able to estimate future lake methane emissions, which the authors say has not been done before.

The optimistic outcome is that improved nutrient management practices could reverse the greening or eutrophication of lakes and thereby reduce methane emissions. Additionally, local action to improve water quality could have important global consequences.

"In keeping and improving the quality of our fresh water we win twice," said Downing. "Once in the atmosphere and once back down here on Earth."

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John A. Downing, Director, Minnesota Sea Grant; Professor of Biology, Department of Biology and Scientist, Large Lakes Observatory, University of Minnesota Duluth; downing@d.umn.edu, 218.726.8715.

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"LAKESHORE PROPERTY VALUES AND WATER QUALITY: EVIDENCE FROM PROPERTY SALES IN THE MISSISSIPPI HEADWATERS REGION."

Submitted to the Legislative Commission on Minnesota Resources

By the Mississippi Headwaters Board

and Bemidji State University

(May14, 2003)

BY

Charles Krysel

Elizabeth Marsh Boyer

Charles Parson, Ph D.

And

Patrick Welle, Ph. D

Full report is available online at: https://z.umn.edu/shorelandadvisors in the "Articles" folder.

Forward Forward

The Legislative Commission of Minnesota Resources (LCMR) provides grants on a competitive basis to proposals that best protect the State's natural resources. The Mississippi Headwaters Board (MHB), a joint powers board of eight counties, joined in the mission under Minnesota Statute 103F. 361-377 in 1980. The mission is to protect and enhance the values of the first 400 miles of the River. This pristine stretch of River runs through eight rural counties from the Headwaters at Lake Itasca in Clearwater County to the southern border at Royalton in Morrison County. MHB is responsible for the initiation of this project

The First City on the Mississippi River is Bemidji, located on beautiful Lake Bemidji. The location, scholarly reputation of the researchers and cooperation of the lake associations made Bemidji State University (BSU) the best choice to implement MHB's proposal to the LCMR. The River runs through many lakes and is the sink into which other lakes contribute runoff. As the contributing watershed to the Mississippi River, the lakes data were included in creating this tool for wise decision-making that may aid in preserving the integrity of the Upper Mississippi River basin for posterity. "We do not own our land (or water), we borrow it from our children".

For the first time, this study defines the dollar value of water quality to the northern Minnesota economy. The State of Minnesota consists of a well-educated population, aware of the value of the State's most valuable resource, clean water. In today's political/budgetary climate, support of the environment that maintains water quality has been viewed as frivolous, anti-business, or an unnecessary expense. Through objective scientific method and hedonic modeling, this study attaches tremendous economic value to investing in a clean environment. Thank you for using the information to the best advantage for all people.

In Public Service,
Jane E. Van Hunnik-Ekholm, MS
MHB Executive Director
May 15, 2003

EXECUTIVE SUMMARY

PURPOSE OF STUDY

The purpose of this study was to conduct research (similar in design and format to the above mentioned Maine studies) to determine if water quality of Minnesota lakes located in the Mississippi Headwaters Board jurisdiction affects lakeshore property prices. The hypothesis is that it does.

Like most environmental amenities, water quality is a non-market good that is not bought and sold outright as its own product on the marketplace. Instead, water quality is exchanged in the market, albeit implicitly, as an inherently attached characteristic or feature of some differentiated product. Differentiated products are those that consist of different or varying characteristics and exchanged on the market as a packaged good. Residential lakeshore properties are these kind of differentiated products because each one is unique in the quantity and quality of characteristics attached to it---the property, structural, locational and environmental quality variables that make it distinct.

METHOD

The price contribution of an attached environmental amenity must be determined indirectly. In the case of lakeshore property, the value of water quality is capitalized in the value of the land (Boyle et al 1998; Steinnes 1992) and its share of a property's price can be determined "through the price differentials between properties on lakes with differing levels of water quality, while controlling for other property characteristics"

(Michael et al 1996). Hedonic regression analysis is used to determine the implicit price of environmental amenities for differentiated products.

Available water quality data were obtained from the Minnesota Pollution Control Agency and data on lakeshore properties were collected from county assessors. A property site-quality rating inventory was also included. From these data, explanatory variables were selected for use in hedonic models. Lakes were assigned into groups, as a proxy for real estate market areas. From these lakes, 1205 residential lakeshore property sales that occurred in 1996 through 2001 were used. A hedonic equation was determined for each of the lake groups with a water quality variable used to explain variation in sales prices. Using these equations, the implicit prices of water quality---the effects on lakeshore property prices---are estimated for lake groups and for individual lakes. Combined data from the lake groups were then used to calculate the marginal amounts that people are willing to pay for lake water quality.

FINDINGS AND IMPLICATIONS

Water quality was shown to be a significant explanatory variable of lakeshore property prices in all lake groups in both versions of the model. Water quality has a positive relationship with property prices. Site quality, the other environmental variable used in the MN model, was found to be significant in four of the six lake groups with a positive relationship with property prices in one lake group and negative in three.

Using the estimated hedonic equations from the MN model, the implicit prices of water quality was determined and calculations were made to illustrate the changes in property prices on the study lakes if a one-meter change in water clarity would occur. Expected property price changes for these lakes are in the magnitude of tens of thousands to millions of dollars. The evidence shows that management of the quality of lakes is important to maintaining the natural and economic assets of this region.

SECTION 1
INTRODUCTION AND PURPOSE OF STUDY

Minnesota's lakes are essential to the ecological, economic and cultural health and well being of the State of Minnesota. The more than 10,000 freshwater lakes that the State is known for provide essential benefits that must be wisely managed if they are to be sustained. Aside from their ecological importance, Minnesota's lakes are extremely important to the state's recreation and tourism industry, as well as to many local economies. According to the Minnesota Department of Natural Resources (MNDNR hereafter): "High-quality water is essential for a healthy state economy" (1998). Clearly, Minnesota lakes are an extremely valuable resource, assets worthy of protection if their benefits are to continue.

The challenge to maintain and protect lake water quality will become increasingly difficult if population and development trends continue at the present rate. In the last 50 years, lakeshore development on Minnesota's lakes has increased dramatically (Minnesota Planning 1998) and during the 1990s---in much of the area where the Mississippi Headwaters Board has jurisdiction---"growth has exploded…as demand for lakefront property has increased" (Minnesota PCA 2000). Lakeshore property is in demand because of the amenities or benefits they provide its owners, such as water-

An Economic Assessment of the Value of Lakes and Lake Water Quality in Itasca County, Minnesota[^]

prepared by

Dr. Daniel J. Phaneuf
University of Wisconsin-Madison

for the

Itasca Water Legacy Partnership

with funding from

The Blandin Foundation

[^] I would like to acknowledge the help and participation of members of the IWLP in conducting this study. The contributions and suggestions from Dr. Harold Dziuk have been particularly important.

Full report is available online at: https://z.umn.edu/shorelandadvisors in the "Articles" folder.

EXECUTIVE SUMMARY

Itasca County, Minnesota, is home to approximately 1000 lakes, which constitute the economic and cultural center of the county. The water quality in these lakes ranks among the highest in the state, and county residents have nurtured a legacy of high environmental quality and a commitment to sustainability. Maintenance of the county's high quality lakes requires careful monitoring and management decisions, as well as an understanding of the economic value generated by the resource base. This study is focused on the latter of these needs.

The lakes in the county provide recreation and aesthetic services to both Itasca County residents and visitors. The economic value provided by these services is reflected in the trips residents and visitors make to the county's lakes, the income earning opportunities the lakes provide, and the desire among county residents to provide future generations with access to the same high quality resource. Measurement of this economic value requires an understanding of the willingness to pay by residents and nonresidents for the continued maintenance of a high quality resource. A mail survey of county residents, along with an intercept survey of visitors to the county, provided the basis for estimating the willingness to pay for characteristics of the lakes related to (a) recreation access; and (b) water quality maintenance.

The travel cost method was used to measure the economic value of the recreation use of the county's major lakes. This approach infers visitors' willingness to pay for a visit to a lake by measuring the implicit costs of a visit, which includes the money and time commitments needed for travel. Application of this method suggests that county residents value the county's lakes for recreation purposes at a rate of $49 million annually. Visitors to the county enjoy an additional $34 million worth of benefits from their recreation visits. Together the recreation services provided by the county's major lakes are worth nearly $85 million per year, which is equivalent to approximately 12 percent of aggregate county income per year.

The contingent valuation method was used to measure the economic value of changes in lake water quality across the extent of the county. Lake water quality is potentially valuable both as a quality dimension of lake recreation and as a vehicle for providing more general environmental services. Application of the method in the Itasca County context shows that county residents are willing to pay at least $10 million per year (nearly 1.5 percent of total county income) to prevent a 20 percent decrease in future water quality, relative to today's high level. This number is notable in that it does not reflect changes in the existence or availability of lakes for recreation; rather, it suggests that high water quality in the county provides substantial economic value by augmenting the appeal of recreation access and through more general channels such as preservation and bequest motives.

Overall the findings from this study show that Itasca County residents attach significant value to their endowment of high quality lakes, and that the lakes provide economic benefits at a magnitude that ranks them among the major sources of well-being in the county. Care needs to be taken to ensure that this unique resource is managed in a way that allows these large and widely distributed economic benefit flows to continue unabated in the future.

VALUING ITASCA COUNTY'S LAKES

Itasca County is home to over 1,000 lakes with water quality that ranks among the highest in Minnesota. Maintenance of the county's high quality lakes requires careful monitoring and management decisions, as well as understanding of the economic value generated by the resource base. With funds awarded by the Blandin Foundation, the Itasca Water Legacy Partnership proposed a study using well-accepted methods developed in the field of environmental economics to focus on the latter of these needs.

University of Wisconsin-Madison economist Dr. Daniel Phaneuf agreed to direct a study that would quantify the contribution of Itasca County's lakes and lake water quality to residents and non-residents well-being. He used a survey of Itasca County residents to measure residents' recreation use of the county's lakes, their knowledge of water quality issues, and the importance they place on preserving the county's high water quality. Dr. Phaneuf received 901 completed surveys with a response rate of 48.4 percent.

Dr. Phaneuf's results demonstrate that lakes in Itasca County provide recreation and aesthetic services to residents and visitors alike. The economic value provided by these services is reflected in the trips residents and visitors make to the county's lakes, the income earning opportunities the lakes provide, and the desire among county residents to provide future generations with access to the same high quality resource. Measurement of this economic value requires an understanding of the 'willingness to pay' by residents and nonresidents for the continued maintenance of a high quality resource.

Willingness to pay (WTP) is a concept economists use to translate abstract concepts such as preference, attitudes, and beliefs into a concrete and comparable figure. It provides a measure of what a person would give up (expressed in terms of money that cannot be spent on other things) in order to have the item under study. Importantly, the concept of WTP is distinct from who actually pays. The survey was used to measure peoples' WTP for (a) recreation access to lakes in the county; and (b) maintenance of water quality in the county.

Lake Usage

The first part of the survey focused on gathering information on respondents' use of lakes in the county. To begin, individuals indicated if they had made any day trip visits to lakes in Itasca County during 2012 and 2013. The survey described a day trip as involving travel of at least 10 minutes to reach the destination, meaning lakefront property owners were not to count uses of their home lake as trips.

Respondents were then asked to report the visits that they made in 2012 and 2013 to a list of 69 of the major water bodies in the county. They were also given the chance to write in the names of non-listed lakes that they had visited. As summarized in table 1, the data show that Itasca County residents are avid lake users, with three quarters of respondents reporting a lake visit. By way of comparison the 2009, the National Survey of Recreation and the Environment, a nationally representative survey, found that 36 percent of respondents went fishing, 42 percent went boating, 21 percent used a personal watercraft, and 13 percent hunted. Thus by national standards residents of Itasca County are unusual in their high rate of water-based, and more generally outdoor, recreation

Table 1: Lake visits by Itasca County residents

year	mean	std. dev.	median	percent > 0
trips in 2012	16.25	35.81	5	76%
trips in 2013	14.14	33.49	4	73%

Full report is available online at: https://z.umn.edu/shorelandadvisors in the "Articles" folder.

Among the lakes listed in the survey, Pokegama Lake received the highest frequency of visitation in 2013, with 36 percent of respondents reporting having made a trip to the lake. Other lakes receiving a high percent of respondent visits include Trout Lake (Coleraine) at 14 percent, Cut Foot Sioux Lake at 12 percent, Deer Lake (Deer River) at 11 percent, and Bowstring Lake at 11 percent.

The survey also asked people to report on their activities and group composition when visiting lakes in the county. Table 2 reports participation levels in the various activities. Since people could select more than one activity, the percentages do not add to one hundred. In terms of group composition, nearly half (45 percent) of respondents reported that a typical visit included other adults but no children, eight percent reported visiting alone, and 47 percent typically visited with both children and other adults.

Table 2: Activities by Itasca County residents on lake visits

Activity	percent yes
Swimming or playing in the water	46%
Fishing or hunting	57%
Motorized boating activities such as waterskiing, jet skiing, or tubing	27%
Non-motorized boating activities such as sailing, canoeing, or kayaking	21%
Nature appreciation of wildlife viewing	53%
Relaxing on or near the water	62%
Using walking trails or other near-shore facilities	33%

Attitudes and Beliefs

Following the recreation trip section the survey solicited information on residents' attitudes and beliefs about water quality in the county. These questions revealed that the population is relatively familiar with water quality issues and that there is an appreciation for the fact that water quality in the area is currently high. For example, table 3 shows that a high percentage of respondents are at least somewhat familiar with water quality issues, while table 4 on the next page provides a listing of the water quality dimensions that people thought were most important.

In order to value a change in water quality it is necessary to establish a consistent baseline. As part of this the survey asked people to rate the water quality in the lake they most recently visited according to three qualitative levels. Table 5 on the next page summarizes answers to this question. The figures support the supposition that county residents have a good appreciation for the area's high lake water quality.

Table 3: Water quality in northern Minnesota

How familiar are you with water quality issues in northern Minnesota lakes?	Percent selecting
Very familiar	20%
Somewhat familiar	62%
Not familiar	18%

Table 4: Importance of water quality attributes

Which of the water quality indicators listed above is most important to you?	Percent selecting
Water clarity	23%
Invasive species	30%
Health of fish populations	29%
Weed/algae growth	18%

Table 5: Water quality rating at lake most recently visited

How would you rate the quality of water in the lake you most recently visited ?	Percent selecting
Good	62%
Fair	35%
Poor	3%

Recreation Analysis
A common way to measure the willingness to pay for recreation resources is to examine the travel costs that people bear when driving to a recreation destination. The travel costs include out of pocket expenses such as fuel and vehicle depreciation, as well as the implicit value of travel time. The survey data on residents' visits to the county's lakes was matched to the travel distance and time from each respondent's home to each of the 69 major lakes named in the survey. Analysis of these matched variables suggests that Itasca residents value the county's lakes for recreation purposes at a rate of $49 million annually. An auxiliary intercept survey of visitors to the county conducted in 2012 suggests that visitors enjoy an additional $34 million worth of benefits from their recreation visits. Together the recreation services provided by the county's major lakes are worth nearly $85 million per year, which is equivalent to approximately 12 percent of aggregate county income per year.

Water Quality Changes
To understand residents' willingness to support efforts to preserve water quality in the county the survey used the 'contingent valuation' method. Respondents were reminded that the county currently enjoys high water quality levels, and given a baseline distribution. They were then asked to consider that water quality could deteriorate in the future without additional actions. Figure 1 shows the information that was presented to respondents.

Figure 1: Baseline and changed water quality

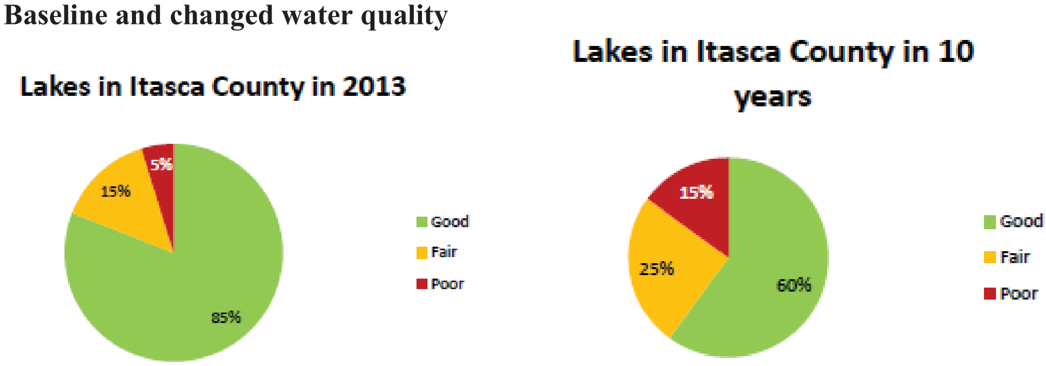

Table 6: Rating the effectiveness of different policies and practice

Which of the following rules/plans would most effectively protect water quality?	Percent selecting
New construction rules	12%
Septic tank maintenance	36%
Lake smart landscapes	21%
Invasive species outreach	31%

Respondents were then asked to consider a public initiative that would maintain today's high water quality using conservation methods of the types listed in table 6. To familiarize people with the possible methods they were asked to report their beliefs about the potential effectiveness of each option.

Contingent Valuation

The contingent valuation method uses a hypothetical referendum format to understand if a sample of people would support a new program in exchange for some addition to their cost of living. In the Itasca County survey respondents were asked if they would vote yes or no on the initiative described above, conditional on knowing that their utility bills would rise by a specified amount in order to pay for the initiative. The method is based on the notion that people will only vote 'yes' for the program if they perceive the benefits it provides to be greater than their personal cost. Thus a yes vote signals that their WTP for the program is larger than the increase in their utility bill. Table 7 provides a summary of how the sample voted in the hypothetical referendum.

Table 7: Percentage of sample voting yes by cost amounts

Annual Increase in Utility Bill	Percent voting 'yes'
$36	68%
$72	68%
$120	57%
$216	52%
$360	39%

Analysis of the voting data shows that county residents are willing to pay at least $10 million per year (nearly 1.5 percent of total county income) to prevent a 20 percent decrease in future water quality, relative to today's high level. This number is notable in that it does not reflect changes in the existence or availability of lakes for recreation; rather, it suggests that high water quality in the county provides substantial economic value by augmenting the appeal of recreation access and through more general channels such as preservation and bequest motives.

Implications

Overall the findings from this study show that Itasca County residents attach significant value to their endowment of high quality lakes, and that the lakes provide economic benefits at a magnitude that ranks them among the major sources of well-being in the county. Care needs to be taken to ensure that this unique resource is managed in a way that allows these large and widely distributed economic benefit flows to continue unabated in the future.

The Effects of Aquatic Invasive Species on Property Values: Evidence from a Quasi-Experiment

Eric J. Horsch and David J. Lewis

ABSTRACT. *This study uses hedonic analysis to estimate the effects of a common aquatic invasive species—Eurasian watermilfoil (milfoil)—on property values across an extensive system of over 170 lakes in the northern forest region of Wisconsin. Since milfoil is inadvertently spread by recreational boaters, and since boaters are more likely to visit attractive lakes, variables indicating the presence of milfoil are endogenous in a hedonic model. Using an identification strategy based on a spatial difference-in-differences specification, results indicate that lakes invaded with milfoil experienced an average 13% decrease in land values* after *invasion.* (JEL Q51, Q57)

I. INTRODUCTION

The invasion of ecosystems by nonnative species is considered to be second only to habitat loss as the greatest threat to biological diversity (Wilcove et al. 1998). Freshwater rivers and lakes have been particularly susceptible to species invasions and have recently attracted the attention of large environmental regulatory bodies.[1] Invasive species can (1) alter ecological communities by competing with or preying on native species, (2) affect market-related enterprises such as agriculture, forestry, fisheries, and electric power production, and (3) affect nonmarket resources such as recreational fisheries. Despite significant advances in understanding the ecology of invasive species, the economic costs of invasive species are not generally understood (Lovell and Stone 2006). The most commonly cited estimate of the costs of invasive species for the United States is $120 billion per year (Pimentel, Zuniga, and Morrison 2005), which is derived from estimates of the costs of managing species invasions, including the amount that must be spent to repair infrastructure damage. However, such cost estimates tend to be more anecdotal and not based on empirical methods grounded in economic theory (Lovell and Stone 2006). Developing a greater understanding of the relationship between invasive species and welfare is central to understanding the appropriate role of public policy.

The purpose of this study is to estimate a hedonic model of lakeshore property values to quantify the effects of a common aquatic invasive species—Eurasian watermilfoil (*Myriophyllum spicatum*, hereafter, milfoil)—on property values across an extensive system of over 170 lakes in the northern forest region of Wisconsin. Milfoil has been labeled as "among the most troublesome submersed aquatic plants in North America" (Smith and Barko 1990, 55) and is characterized by dense stands that (1) block sunlight and limit the ability of native plant

[1] For example, the discharge of ballast water by ships into a different body of water from where the ship originates is thought to be a primary avenue of aquatic species invasions. In response, the U.S. Environmental Protection Agency is currently proposing extensive regulations governing the discharge of ballast water.

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Full report is available online at: https://z.umn.edu/shorelandadvisors in the "Articles" folder.

approach, the fixed-effects model has the least restrictive identification assumptions across all estimated models and, combined with our use of cluster-robust standard errors, appears to resolve the issues of bias and inefficiency brought about by the presence of milfoil on a lake being correlated with unobserved neighborhood effects.

Marginal Willingness to Pay to Avoid Milfoil Invasions

Using the results from the spatial difference-in-differences hedonic model, insights can be made concerning the marginal willingness to pay to prevent an additional milfoil infestation on a lake. The hedonic price function can be used to approximate welfare effects for *localized* amenity changes when the number of parcels affected by a change in environmental quality is small relative to the land market (Palmquist 1992). Given our use of a presence/absence dummy variable indicating a lake's milfoil status, the localized amenity change in this paper is the invasion of one additional lake with milfoil.[28] Given our set of 172 lakes in the same land market, evaluating the costs of one additional infested lake reasonably fits the criteria of a localized amenity change.

The results from Tables 4 and 5 indicate that lakefront property owners are willing to pay, on average, more than $28,000 for a property on a lake free of milfoil, all else equal (depending on specification, results range from $28,000 to $32,087). With the nonlinear model, the estimated marginal willingness-to-pay depends on the value of the other exogenous variables, and the average varies across milfoil lakes from a low of approximately $13,700 to a high of $48,400.[29] Since the price of land is a stream of rents in perpetuity, we can calculate the average annual marginal willingness to pay as approximately $1,400 (assuming a 5% discount rate). Multiplying the average marginal willingness to pay by the number of affected parcels on the average lake, we arrive at an aggregate cost of milfoil of about $187,600/year, on average, for one additional infested lake. This amounts to approximately 8% of total *property value*, or 13% of total *land value*, net of the value of any structure. For further perspective, consider that there are approximately 500 lakes in Wisconsin affected by milfoil, and the state's DNR allocates approximately $4 million dollars annually for the management of *all* aquatic invasive species across the entire state (including prevention efforts on lakes not yet invaded). While the results of our analysis for marginal changes in milfoil invasions cannot be aggregated to examine the economic cost of milfoil on all 500 lakes, the marginal willingness-to-pay estimates for preventing an additional lake from being infested are nevertheless useful for examining policies aimed at preventing the spread of milfoil.

VII. CONCLUSIONS

The findings of this paper reveal that lakes invaded with the aquatic species Eurasian watermilfoil experienced an average 13% decrease in land values *after* invasion. Therefore, we document a unique phenomenon in the environmental economics literature: aquatic invasive species can depress land values. This result complements prior analyses that quantify the effects of fecal coliform counts and water clarity on the values of shoreline property (Leggett and Bockstael 2000; Poor et al. 2001). Government agencies are spending significant dollars on invasive species management, despite the general lack of estimates on the costs of invasions derived from a rigorous economic framework. Our results provide some evidence as to the potential benefits derived from preventing the spread of Eurasian watermilfoil, one of the most widespread and common aquatic invasive species in North America.

[28] Our results can only be used to derive the implicit price of being on a lake infested with milfoil, not the implicit price of reducing the abundance of milfoil on an already-infested lake.

[29] The average willingness to pay for each milfoil lake is significantly different from zero at the 5% level and is calculated with the lake-specific sample mean values of the exogenous variables.

In addition to providing empirical evidence as to the potential benefits from reducing the spread of invasive species, this paper also develops a quasi-experimental specification to identify the effects of changes in endogenous neighborhood amenities within the commonly estimated hedonic framework. In our application, a lake is more likely to be invaded with milfoil if it is more popular with recreational boaters. Therefore, since lakes popular with recreational boaters are also likely to be popular with potential residents, and since many aspects of a lake's amenities may be difficult to quantify, the presence of milfoil on a lake is an endogenous variable in the hedonic price equation. Our identification strategy is based on a spatial difference-in-differences specification and isolates the source of endogeneity bias as arising from unobserved neighborhood effects. Although typically treated as an econometric efficiency issue in the literature, we highlight the estimation bias that ensues when a measurable neighborhood amenity is correlated with unobservable neighborhood effects. Our spatial difference-in-differences specification defines distinct neighborhood fixed effects to control for both observable and unobservable neighborhood effects, while exploiting the fact that the environmental amenity of interest (a lake free of milfoil) varies over the 10 years of property transactions used in our dataset. In addition, the neighborhood clustering aspect of properties allows us to estimate cluster-robust standard errors with no restriction on spatial correlation within neighborhoods.

Given the potential for correlation between observed and unobserved neighborhood amenities in hedonic property value models, the identification strategy employed in this study could potentially be used in other settings. The most obvious example would be hedonic analyses of the many other aquatic invasive species that are readily spread by the movement of recreational boaters and anglers (e.g., zebra mussels, rusty crayfish), as the same endogeneity problems highlighted in this paper may also plague other hedonic analyses of aquatic invasive species. The fixed-effects approach works best with clearly defined spatial neighborhoods. In this study, lakes give rise to natural neighborhoods, though such a clear definition of neighborhoods may not always exist for landscapes with less development fragmentation. However, it should be noted that all spatial econometric models face the problem of defining the relevant spatial neighborhood. Some studies use a distance-decay approach, others define neighbors by concentric rings of varying radius around a particular parcel, while others subjectively define a neighborhood to share a common error term. While specific applications may naturally lend themselves to particular spatial structures, this paper demonstrates the potential of specifying fixed neighborhood effects jointly within a difference-and-differences framework as a strategy for identifying the effects of an endogenous neighborhood amenity on property values.

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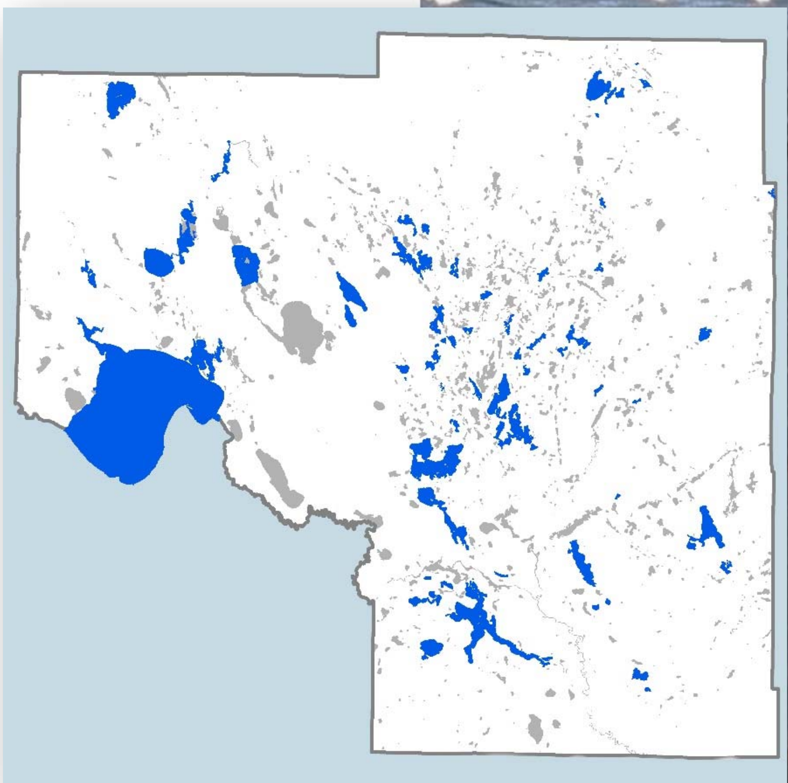
Itasca County Lake Prioritization



Lake Prioritization and Protection Planning Document

2017

"Managing natural resources through technical assistance and education."

CLEAN WATER LAND & LEGACY AMENDMENT

Minnesota Board of Water & Soil Resources

Prepared by:

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Date: November 20, 2017

To: Itasca County Soil & Water Conservation District
1889 US-2
Grand Rapids, MN 55744

Subject: Itasca County Lake Prioritization and Planning Document

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Itasca County Soil and Water Conservation District (SWCD)
Lake Associations

Table of Contents

Itasca County Data Assessment Summary Report

Introduction

Itasca County is located in the lakes country of northern Minnesota. There are over 1,000 lakes in the county, with about 950 lakes over ten acres in size. Scenic lakes, rivers and streams cover 8% of the surface area of Itasca County - and an additional 31% of the county is covered by wetlands. These resources are valued for their excellent recreation opportunities and water quality.

In 2015, for the purpose of their water plan update, the Itasca Soil and Water Conservation District (SWCD) decided to evaluate the water quality of 38 lakes in Itasca County. In 2016, 34 additional lakes were evaluated using the same process. Lakes evaluated in this report are indicated in dark blue in Figure 1 and listed in Table 1; there are 72 total lakes evaluated.

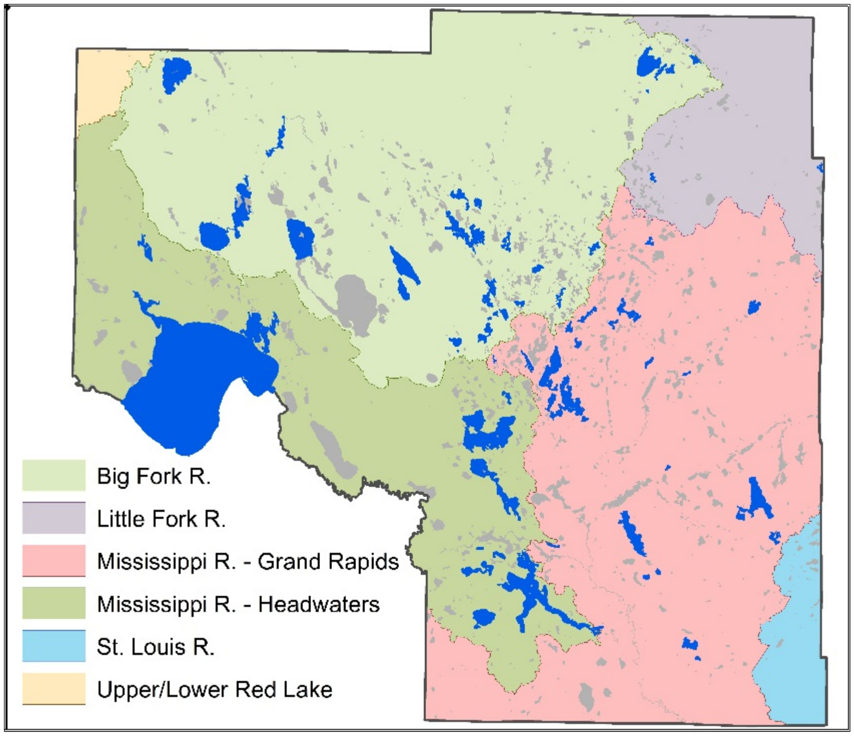


Figure 1. Lakes of Itasca County. Lakes evaluated in this report are in dark blue, while each major basin is highlighted in a different color.

Itasca County lakes have been monitored off and on between the 1970s and 2017. This monitoring has been completed by numerous organizations including Lake Associations, Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, Itasca SWCD, Itasca Water Legacy Partnership (IWLP), and the Itasca Community College Laboratory.

The purposes of this report were to compile all available data for these lakes from all the different sources, evaluate the data quality, identify data gaps, assess the data, and look for water quality trends, and prioritize lakes for management. This report contains a summary of the current state of selected Itasca County lakes and recommendations for future monitoring. Individual lake reports follow with more in-depth assessments and recommendations.

Table 1. Data availability for Itasca County Lakes.

Data Availability

Transparency data		Secchi disk data have been collected extensively and should continue annually since it is relatively easy and inexpensive.
Chemical data (phosphorus)		Most large Itasca County lakes have at least two years of water quality data in the past 10 years. They don't have long-term data sets for trend analysis.
Inlet/Outlet data		Inlet/outlet data are sparse, and could be collected on lakes with declining transparency trends to investigate the cause in water quality decline.

Table 2. Lakes assessed in the 2015-2016 lakes assessments.

Lake Name	Lake ID	Lake Size (acres)
Adele	31-0642-00	22
Amen	31-0597-00	215
Balsam	31-0259-00	714
Bass	31-0576-00	2,765
Battle	31-0197-00	243
Beatrice	31-0058-00	124
Beaver	31-0638-00	13
Bello	31-0726-00	530
Bluewater	31-0395-00	359
Boy	31-0623-00	43
Buck	31-0069-00	495
Burnt Shanty	31-0424-00	198
Burrows	31-0413-00	306
Caribou	31-0620-00	247
Clearwater (Round)	31-0214-00	132
Crum	31-0171-00	19
Cut Foot Sioux	31-0857-01	2,378
Deer (0334)	31-0334-00	1,853
Deer (0719)	31-0719-00	4,163
Dixon	31-0921-00	622
Dora	31-0882-00	430
Dunning	31-0221-00	67
Eagle	31-0454-00	285
East Smith	31-0616-00	152
Erskine	31-0311-00	40
Fifth Chain	31-0497-00	104
Five Island	31-0183-00	214
Grave	31-0624-00	525
Guile	31-0569-00	88
Gum	31-0492-00	32
Gunn	31-0452-00	108
Hale	31-0361-00	126
Hale	31-0373-00	130
Hart	31-0020-00	328
Horseshoe	31-0696-00	260
Island	31-0913-00	3,108
Jack the Horse	31-0657-02	260
Jessie	31-0786-00	1,740
Little Bowstring	31-0758-00	327
Little Dead Horse	31-0621-00	79
Little Jessie	31-0784-00	628
Little Long	31-0613-00	305
Little Trout	31-0394-00	86
Little Wabana	31-0399-00	116
Loon	31-0571-00	231
Maki	31-0759-00	16
McGuire	31-0078-00	79
Moose	31-0722-00	1,274

Lake Name	Lake ID	Lake Size (acres)
Napoleon	31-0290-00	138
Natures	31-0877-00	2,250
North Star	31-0653-00	821
Pickerel	31-0339-00	241
Pokegama	31-0532-00	1,123
Rice	31-0717-00	863
Round (Clear)	31-0209-00	126
Round	31-0896-00	2,860
Sand (0438)	31-0438-00	195
Sand (0826)	31-0826-00	4,225
Scrapper	31-0345-00	172
Shallow	31-0084-00	539
Siseebakwet	31-0554-00	1,210
Snaptail	31-0255-00	177
South Sugar	31-0555-00	91
Swan	31-0067-00	2,116
Three Island	31-0542-00	250
Trestle	31-0127-00	88
Trout	31-0410-00	1,736
Trout	31-0216-00	1862
Turtle	31-0725-00	2,156
Wabana	31-0392-00	2,221
White Swan	31-0260-00	165
Winnibigoshish	11-0147-00	53,425

Trophic State Index (TSI)

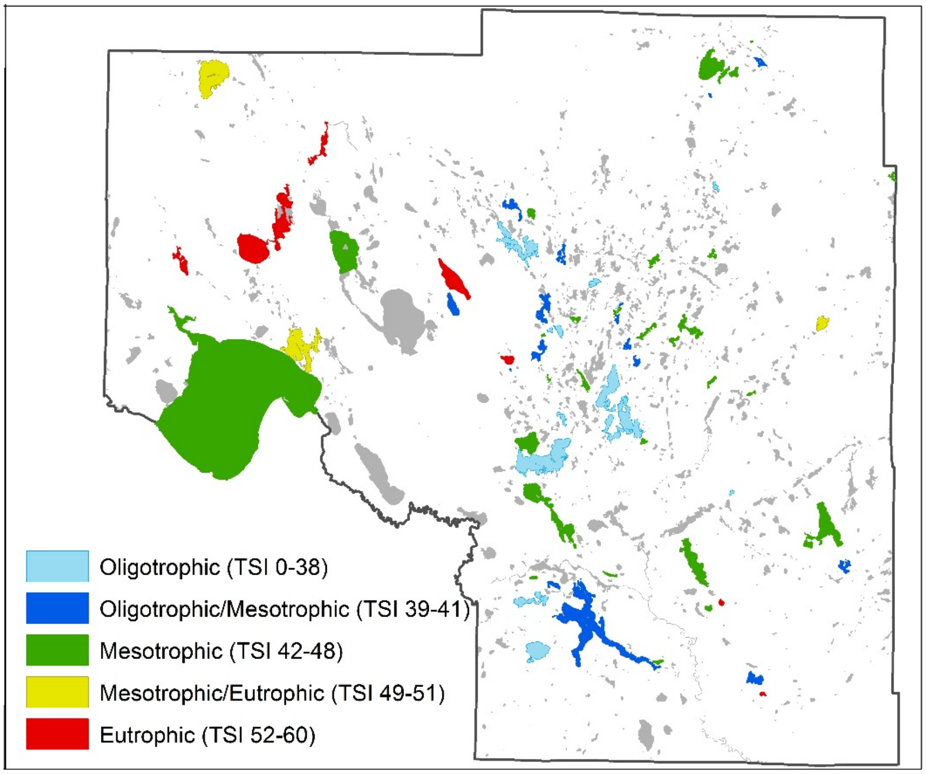


Figure 1. Trophic state index of assessed lakes in Itasca County .

Trophic State Index (TSI) is a standard measure or means for estimating the amount of algae in a lake. The TSI is used to classify the "trophic state" of a lake, which broadly includes three categories: oligotrophic (little algae), mesotrophic (moderate algae), and eutrophic (high algae).

Many lakes, over long periods of time naturally "age" as runoff from adjacent lands adds nutrients into a lake. Young lakes start off oligotrophic and become eutrophic as they age, a process called "eutrophication". When human use of lakes increases the rate of nutrients into lakes, above background rates, for example through agriculture, sewage leakage, lawn fertilization, or more, lakes are said to undergo "cultural eutrophication". While preventing natural eutrophication is difficult, through modifying behavior and lake use, people can slow the rate of cultural eutrophication. Typical characteristics of these trophic states as well as some finer trophic state divisions are given in Table 4. Phosphorus (a nutrient), chlorophyll *a* (an indication of algal concentration) and Secchi depth (transparency measure of water transparency/clarity) are usually related and are the primary measurements used to determine a lake's TSI. The more phosphorus that is available, the more algae that can grow. As algal concentrations increase, it causes water to become turbid or murky, which results in the water becoming less transparent and subsequently, the Secchi depth decreases.

The TSI is unitless but can range from 0 (as oligotrophic as possible) to 100 (as eutrophic as possible). In real terms, a TSI of 0 would have a Secchi depth of approximately 210 feet while a TSI of 100 would have a TSI of approximately 3 inches. For every increase of 10 units in the TSI, the Secchi depth halves and the phosphorus doubles. Most of the large Itasca County lakes fall into the mesotrophic category (Table 3, Figure 2).

Table 3. Trophic state and trophic state index for large lakes in Itasca County.

Lake	Mean TSI	Trophic State	Mean TSI Secchi	Mean TSI Phosphorus	Mean TSI Chlorophyll *a*
Caribou	30	Oligotrophic	27	29	32
Dunning	35	Oligotrophic	35	NA	NA
Amen	36	Oligotrophic	37	37	35
Bluewater	36	Oligotrophic	36	36	37
Little Dead Horse	36	Oligotrophic	39	37	33
Three Island	36	Oligotrophic	32	35	40
Trout (410)	36	Oligotrophic	37	37	36
Wabana	36	Oligotrophic	35	36	37
Deer (0719)	37	Oligotrophic	35	39	37
Little Trout	37	Oligotrophic	34	40	38
Siseebakwet	37	Oligotrophic	38	39	36
Napoleon	38	Oligotrophic	37	38	38
Rice	38	Oligotrophic	40	36	37
Turtle	38	Oligotrophic	37	36	40
South Sugar	39	Oligotrophic/Mesotrophic	38	40	39
Jack the Horse	39	Oligotrophic/Mesotrophic	42	37	39
Little Jessie	39	Oligotrophic/Mesotrophic	38	37	41
Maki	39	Oligotrophic/Mesotrophic	39	NA	NA
Hale	40	Oligotrophic/Mesotrophic	37	41	40
Little Wabana	40	Oligotrophic/Mesotrophic	35	40	40
Bello	40	Oligotrophic/Mesotrophic	43	37	38
Erskine	40	Oligotrophic/Mesotrophic	38	42	39
Five Island	40	Oligotrophic/Mesotrophic	42	37	42
Grave	40	Oligotrophic/Mesotrophic	40	40	41
Gum	40	Oligotrophic/Mesotrophic	40	NA	NA
Gun	40	Oligotrophic/Mesotrophic	36	41	43
Loon	40	Oligotrophic/Mesotrophic	40	37	41
North Star	40	Oligotrophic/Mesotrophic	40	39	40
Shallow	40	Oligotrophic/Mesotrophic	38	38	40
Boy	41	Oligotrophic/Mesotrophic	37	42	44
Moose	41	Oligotrophic/Mesotrophic	39	44	42
Burnt Shanty	41	Oligotrophic/Mesotrophic	36	45	42
Hart	41	Oligotrophic/Mesotrophic	44	40	40

Table 3 continued on next page…

Table 3 continued. Trophic state and trophic state index for large lakes in Itasca County.

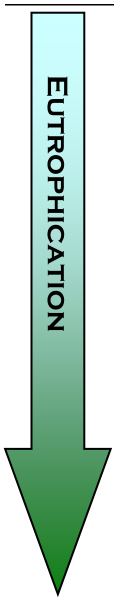
Lake	Mean TSI	Trophic State	Mean TSI Secchi	Mean TSI Phosphorus	Mean TSI Chlorophyll *a*
Pokegama	41	Oligotrophic/Mesotrophic	38	42	42
Sand (0438)	41	Oligotrophic/Mesotrophic	36	44	42
Trestle	40	Oligotrophic/Mesotrophic	41	NA	NA
Beatrice	42	Mesotrophic	42	40	44
East Smith	42	Mesotrophic	41	42	43
Fifth Chain	42	Mesotrophic	42	41	44
Guile	42	Mesotrophic	36	43	48
Trout	42	Mesotrophic	38	45	44
Deer (0334)	43	Mesotrophic	44	40	45
Little Long	43	Mesotrophic	37	44	47
Snaptail	43	Mesotrophic	43	42	43
Adele	44	Mesotrophic	43	44	44
Balsam	44	Mesotrophic	43	43	45
Bass	44	Mesotrophic	37	46	47
Burrows	44	Mesotrophic	41	43	47
Hale	44	Mesotrophic	42	48	42
Pickerel	44	Mesotrophic	45	41	47
Battle	45	Mesotrophic	45	42	46
Beaver	45	Mesotrophic	41	46	49
Crum	45	Mesotrophic	43	47	46
Horseshoe	45	Mesotrophic	42	46	45
Sand (0826) S Bay	45	Mesotrophic	44	45	46
White Swan	45	Mesotrophic	44	47	45
Eagle	46	Mesotrophic	44	45	49
Swan	46	Mesotrophic	39	48	51
Scrapper	NA	Mesotrophic	46	NA	NA
Clearwater (Round)	47	Mesotrophic	48	46	46
Winnibigoshish	47	Mesotrophic	42	48	50
Buck	49	Mesotrophic/Eutrophic	44	52	52
McGuire	50	Mesotrophic/Eutrophic	50	49	NA
Cut Foot Sioux	50	Mesotrophic/Eutrophic	47	52	52
Little Bowstring	51	Mesotrophic/Eutrophic	47	53	53
Natures	51	Mesotrophic/Eutrophic	54	56	43

Table 3 continued on next page…

Table 3 continued. Trophic state and trophic state index for large lakes in Itasca County.

Lake	Mean TSI	Trophic State	Mean TSI Secchi	Mean TSI Phosphorus	Mean TSI Chlorophyll *a*
Island	51	Mesotrophic/Eutrophic	45	53	56
Dora	52	Eutrophic	49	57	52
Jessie	52	Eutrophic	47	55	55
Round (Clear)	52	Eutrophic	46	53	56
Sand (0826) N Bay	53	Eutrophic	49	54	56
Dixon	56	Eutrophic	52	57	58
Round	56	Eutrophic	56	59	58

Table 4. Trophic states and corresponding lake and fisheries conditions.



TSI	Attributes	Fisheries & Recreation
<30	**Oligotrophy:** Clear water, oxygen throughout the year at the bottom of the lake, very deep cold water.	Trout fisheries dominate.
30-40	Bottom of shallower lakes may become anoxic (no oxygen).	Trout fisheries in deep lakes only. Walleye, Tullibee present.
40-50	**Mesotrophy:** Water moderately clear most of the summer. May be "greener" in late summer.	No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate.
50-60	**Eutrophy:** Algae and aquatic plant problems possible. "Green" water most of the year.	Warm-water fisheries only. Bass may dominate.
60-70	Blue-green algae dominate, algal scums and aquatic plant problems.	Dense algae and aquatic plants. Low water clarity may discourage swimming and boating.
70-80	**Hypereutrophy:** Dense algae and aquatic plants.	Water is not suitable for recreation.
>80	Algal scums, few aquatic plants.	Rough fish (carp) dominate; summer fish kills possible.

Source: Carlson, R.E. 1997. A trophic state index for lakes. *Limnology and Oceanography*. 22:361-369.

Water Quality Trends

In assessing water quality, agencies and other lake data users want to know if the amount of algae has been changing over time. Scientists test hypotheses using statistics, and the hypothesis used in a trend analysis is that no trend exists. In other words, we begin with the assumption that there is no trend. We collect data and use statistics to determine the probability of collecting our data if this hypothesis of no trend is indeed true. The output from a statistical test is called the probability value (or p-value for short) of collecting data given the hypothesis of no trend is true. The smaller this probability value, the more likely the null hypothesis of no trend can be rejected. The MPCA has set the acceptable p-value to be less than 10%. In other words, if $p < 0.10$ we reject the hypothesis of no trend and accept that a trend likely exists. Another way to think of this is to say that there is in reality an existing trend, there is a 90% chance we would have collected the data we collected and that a 10% chance that the trend is a random result of the data.

For detecting trends, a minimum of 8-10 years of data with four or more readings per season are recommended by the MPCA. Where data does not cover at least eight years or where there are only few samples within a year, trends can be misidentified because there can be different wet years and dry years, water levels, weather, and etc., that affect the water quality naturally.

All of the lakes evaluated had sufficient transparency data to perform a statistical trend analysis (Tables 5-7). The data were analyzed using the Mann Kendall Trend Analysis (Tables 6-8).

Table 5. Itasca County Lakes with improving trends in transparency.

Lake	Parameter	Date Range	Trend	Probability
Bass	Transparency	1994-2014	Improving	95%
Boy	Transparency	1994-2010	Improving	99.9%
Buck	Transparency	1998-2013	Improving	99%
Deer 0719	Transparency	2001-2014	Improving	99%
Dixon	Transparency	1990-2014	Improving	90%
Dunning	Transparency	1989-2015	Improving	93%
Erskine	Transparency	2003-2010	Improving	95%
Hale (373)	Transparency	1995-2013, 2015	Improving	97%
Jessie	Transparency	1995-2014	Improving	95%
Little Wabana	Transparency	1999-2015	Improving	99.9%
Sand	Transparency	1988-2008, 2012-2014	Improving	99.9%
Shallow	Transparency	2008-2017	Improving	95%
Siseebakwet	Transparency	1989-2015	Improving	99.9%
Swan (main bay)	Transparency	1996-2014	Improving	80%
Turtle	Transparency	1990-2014	Improving	95%
Wabana	Transparency	1999-2015	Improving	99.9%
White Swan	Transparency	1986-2002, 2005-2015	Improving	99.9%

Table 6. Itasca County Lakes with declining water quality trends.

Lake	Parameter	Date Range	Trend	Probability
Battle	Transparency	2003-2014	Declining	95%
Beatrice	Transparency	1991-2016	Declining	99.9%
Caribou	Transparency	2001-2014	Declining	99%
Gum	Transparency	2003-2014	Declining	90%
Jack the Horse	Transparency	1997-2004, 2006-2011	Declining	96%
Pickerel	Transparency	2003-2015	Declining	93%
Round (Clear)	Transparency	1991-2014	Declining	99%

Table 7. Itasca County Lakes with no evidence of water quality trends.

Lake	Parameter	Date Range	Trend
Adele	Transparency	2001-2010	No Trend
Amen	Transparency	1999-2015	No Trend
Balsam	Transparency	1992-2014	No Trend
Beaver	Transparency	2004-2010	No Trend
Bello	Transparency	1997-2013	No Trend
Bluewater	Transparency	1992-2015	No Trend
Burnt Shanty	Transparency	1999-2013	No Trend
Burrows	Transparency	2001-2015	No Trend
Clearwater (Round)	Transparency	1995-2013, 2015	No Trend
Crum	Transparency	2003-2010	No Trend
Cut Foot Sioux	Transparency	2005-2014	No Trend
Deer 0334	Transparency	1995-2014	No Trend
Dora	Transparency	1999-2014	No Trend
Eagle	Transparency	1988-2013	No Trend
East Smith	Transparency	1998-2015	No Trend
Fifth Chain	Transparency	2001-2014	No Trend
Five Island (Ball)	Transparency	2003-2014	No Trend
Grave	Transparency	1993-2010	No Trend
Guile	Transparency	2006-2015	No Trend
Horseshoe	Transparency	2000-2014	No Trend
Island	Transparency	2007-2014	No Trend
Little Bowstring	Transparency	1998-1999, 2001-2015	No Trend
Little Dead Horse	Transparency	1997-2015	No Trend
Little Jessie	Transparency	1999-2013	No Trend
Little Jessie	Transparency	1999-2013	No Trend
Little Long	Transparency	2010-2011	No Trend
Little Trout	Transparency	1988, 1991, 2005-2015	No Trend
Loon	Transparency	1991-1992, 1994-2014	No Trend
Maki	Transparency	1997-2015	No Trend
McGuire	Transparency	1991-2015	No Trend
Moose	Transparency	1999-2015	No Trend
Napoleon	Transparency	2005-2015	No Trend
Natures	Transparency	2005-2015	No Trend

Table 7 continued on next page.

Table 7 continued. Itasca County Lakes with no evidence of water quality trends.

Lake	Parameter	Date Range	Trend
North Star	Transparency	2005-2014	No Trend
Pokegama	Transparency	1996-2014	No Trend
Prairie	Transparency	1991-2015	No Trend
Rice	Transparency	2005-2014	No Trend
Round	Transparency	2001-2010	No Trend
Sand 0826	Transparency	1991-2014	No Trend
Scrapper	Transparency	1999-2015	No Trend
Snaptail	Transparency	1991-2015	No Trend
South Sugar	Transparency	1997-2015	No Trend
Three Island	Transparency	2006-2015	No Trend
Trestle	Transparency	2001-2015	No Trend
Trout	Transparency	1993-2014	No Trend
Trout (410)	Transparency	1992-2014	No Trend

Ecoregion Comparisons

Minnesota is divided into 7 ecoregions based on land use, vegetation, precipitation and geology. The MPCA has developed a way to determine the "average range" of water quality expected for lakes in each ecoregion. The MPCA evaluated the lake water quality for reference lakes. These reference lakes are not considered pristine, but are considered to have little human impact and therefore are representative of the typical lakes within the ecoregion. The "average range" refers to the 25th - 75th percentile range for data within each ecoregion.

Figure 3. Minnesota Ecoregions. Itasca County is indicated in black.

All of Itasca County is in the Northern Lakes and Forests (NLF) Ecoregion (Figure 3). This heavily forested ecoregion is made up of steep, rolling hills interspersed with pockets of wetlands, bogs, lakes and ponds. Lakes are typically deep and clear, with good gamefish populations. These lakes are very sensitive to damage from atmospheric deposition of pollutants (mercury), storm water runoff from logging operations, urban and shoreland development, mining, inadequate wastewater treatment, and failing septic systems. Agriculture is somewhat limited by the hilly terrain and lack of nutrients in the soil, though there are some beef and dairy cattle farms.

Most of the lakes evaluated in this report fall within the expected ecoregion ranges for the Northern Lakes and Forests Ecoregion (Table 8).

Table 8. Ecoregion ranges.

Ecoregion	Total Phosphorus (ug/L)	Chlorophyll *a* (ug/L)	Secchi Depth (ft)
Northern Lakes and Forest (NLF)	14 - 27	<10	8 - 15

Statewide Assessments

Lake monitoring should be designed and accomplished for achieving specific goals. There are two main purposes for lake monitoring in Minnesota. The first is the MPCA statewide 303(d) and 305(b) assessments that occur every two years. Statewide MPCA Assessments are performed with a minimum data set of 8 data points each of total phosphorus, chlorophyll *a*, and secchi depth over a two-year period in the past 10 years. This assessment can be considered the first step to understanding a lake.

The second purpose for lake monitoring is ongoing education, awareness and lake condition. After the lake's current condition is determined, associations can monitor water quality each year to learn about seasonal variability, year-to-year variability, and if the water quality is improving, declining or staying the same (trend analysis). Condition monitoring involves collecting at least 5 samples during the growing season (the typical program involves monitoring once a month May-September) each year.

Impaired Waters Assessment 303(d) List

There are two main types of Impaired Waters Assessment for lakes: eutrophication (phosphorus) for aquatic recreation and mercury in fish tissue for aquatic consumption.

Many of the Itasca County Lakes are listed as impaired for mercury; however, they are part of the statewide mercury TMDL (Figure 4). The remaining lakes in the county most likely are not listed due to lack of fish tissue data. There are statewide fish consumption guidelines available from the Minnesota Department of Health: http://www.health.state.mn.us/divs/eh/fish/index.html.

Most Mercury comes from the air. Mercury gets into the air through emissions from coal-burning plants and taconite processing and moves long distances in the wind currents. From there, it settles into our lakes and streams and bacteria convert it to a toxic form, methylmercury. The problem is that 90% of the mercury in our waters comes from other states and countries, which is why it is so hard to regulate. In turn, 90% of the mercury emitted in Minnesota goes to other states and countries.

The mercury that settles into our lakes and streams gets filtered by zooplankton, the tiny animals that get eaten by small fish. The larger the small fish gets, the more mercury builds up in its tissue from all the zooplankton eaten. Mercury bioaccumulates, which means that at each step in the food chain the mercury builds to higher levels, especially in large predatory fish such as walleye, northern pike and muskies.

The lakes in Table 9 are currently listed as impaired for eutrophication as of the 2018 Impaired Waters List (Figure 4). Total Maximum Daily Load (TMDL) Studies are scheduled for these lakes in the next decade.

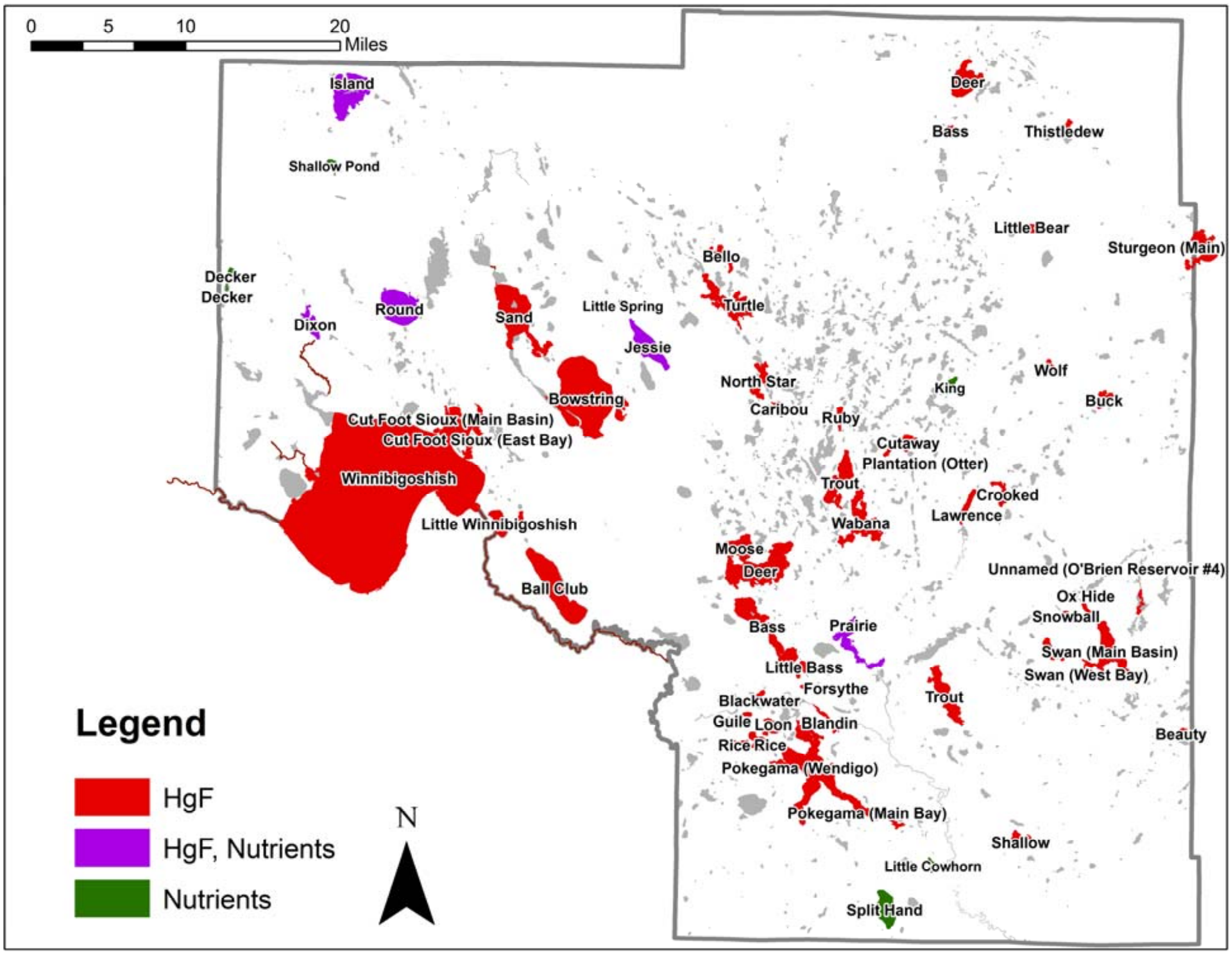


Figure 4. Itasca County lakes illustrating impaired waters status, 2018 Draft Impaired Waters List (as of 11/15/2017) . HgF stands for Mercury in Fish Tissue.

Table 9. Lakes in Itasca County that are impaired for excess nutrients and eutrophication, 2018 MPCA Draft Impaired Waters List (as of 11/15/2017).

DOW	Lake	Year added to List	TMDL Target completion
31-0813-00	Bowstring	2014	2016
31-0913-00	Island	2010	2017
31-0797-00	Little Spring	2014	2017
31-0896-00	Round	2008	2023
31-0910-00	Shallow Pond	2014	2017
31-0934-00	Decker	2006	2027
31-0921-00	Dixon	2008	2027
31-0384-00	Prairie	2010	2019
31-0353-00	Split Hand	2010	2019
31-0258-00	King	2018	2019
31-0198-00	Little Cowhorn	2018	2019

DNR Fisheries approach for lake protection and restoration

Credit: Peter Jacobson and Michael Duval, Minnesota DNR Fisheries

In an effort to prioritize protection and restoration efforts of fishery lakes, the MN DNR has developed a ranking system by separating lakes into two categories, those needing protection and those needing restoration. Modeling by the DNR Fisheries Research Unit suggests that total phosphorus concentrations increase significantly over natural concentrations in lakes that have watershed with disturbance greater than 25%. Therefore, lakes with watersheds that have less than 25% disturbance need protection and lakes with more than 25% disturbance need restoration (Table 10). Watershed disturbance was defined as having urban, agricultural and mining land uses. Watershed protection is defined as publicly owned land or conservation easement.

Table 10. Suggested approaches for watershed protection and restoration of DNR-managed fish lakes in Minnesota.

Watershed Disturbance (%)	Watershed Protected (%)	Management Type	Comments
< 25%	> 75%	Vigilance	Sufficiently protected -- Water quality supports healthy and diverse native fish communities. Keep public lands protected.
	< 75%	Protection	Excellent candidates for protection -- Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%.
25-60%	n/a	Full Restoration	Realistic chance for full restoration of water quality and improve quality of fish communities. Disturbed land percentage should be reduced and BMPs implemented.
> 60%	n/a	Partial Restoration	Restoration will be very expensive and probably will not achieve water quality conditions necessary to sustain healthy fish communities. Restoration opportunities must be critically evaluated to assure feasible positive outcomes.

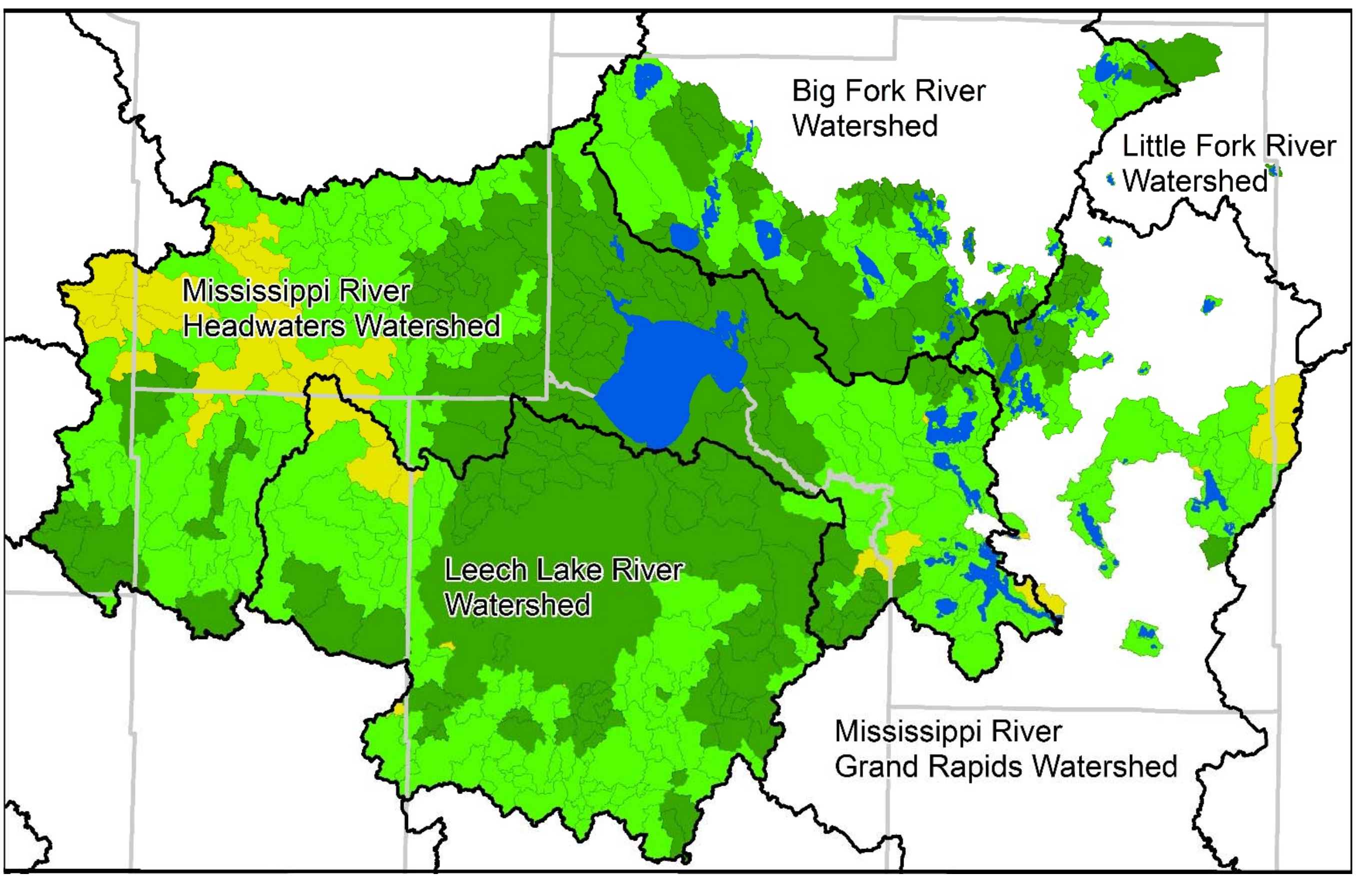


Figure 5. Map of lakesheds color-coded with management focus (Table 9).

Most of the lakes evaluated in this report have a protection management focus (light green, Figure 5, Table 11).

The next step was to prioritize lakes within each of these management categories. DNR Fisheries identified high value fishery lakes, such as cisco refuge lakes. Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. These watersheds with low disturbance and high value fishery lakes are excellent candidates for priority protection measures, especially those that are related to forestry and minimizing the effects of landscape disturbance. Forest stewardship planning, harvest coordination to reduce hydrology impacts and forest conservation easements are some potential tools that can protect these high value resources for the long term. There are eleven Itasca County Lakes evaluated in this report that are listed as Cisco refuge lakes (Table 11).

Table 11. Itasca County Lakes evaluation of watershed protection and disturbance.

Lake Name	Management Focus	Cisco Refuge Lakes	Lake Name	Management Focus	Cisco Refuge Lakes
Amen	Vigilance		Little Bowstring	Protection	
Battle	Vigilance		Little Jessie	Protection	
Beatrice	Vigilance		Little Long	Protection	
Bello	Vigilance		Little Trout	Protection	
Boy	Vigilance		Little Wabana	Protection	x
Burnt Shanty	Vigilance		Loon	Protection	x
Burrows	Vigilance		Maki	Protection	
Crum	Vigilance		McGuire	Protection	
Cut Foot Sioux	Vigilance		Moose	Protection	
Dixon	Vigilance		Napoleon	Protection	
East Smith	Vigilance		Natures	Protection	
Grave	Vigilance		North Star	Protection	x
Gunn	Vigilance		Pickerel	Protection	
Jack the Horse	Vigilance		Pokegama	Protection	
Little Dead Horse	Vigilance		Rice	Protection	
Round	Vigilance		Round (Clear)	Protection	
Sand (0438)	Vigilance		Sand (0826)	Protection	
Trout (0410)	Vigilance	x	Scrapper	Protection	
Winnibigoshish	Vigilance		Shallow	Protection	x
Balsam	Protection		Siseebakwet	Protection	x
Bass	Protection		Snaptail	Protection	
Beaver and Adele	Protection		South Sugar	Protection	
Bluewater	Protection	x	Swan	Protection	
Buck	Protection		Three Island	Protection	
Caribou	Protection		Trestle	Protection	
Clearwater (Round)	Protection		Trout (0216)	Protection	x
Deer (0334)	Protection		Turtle	Protection	x
Deer (0719)	Protection		Wabana	Protection	x
Dora	Protection		White Swan	Protection	
Dunning	Protection		Hale (0373)	Restoration	x
Eagle	Protection		Hale (0361)	Restoration	
Erskine	Protection				
Fifth Chain	Protection				
Five Island	Protection				
Guile	Protection				
Gum (Gunn)	Protection				
Hart	Protection				
Horseshoe	Protection				
Island	Protection				
Jessie	Protection				

Aquatic Invasive Species

Invasive species are a large threat to Minnesota's lakes. Invasive species can get out of control because there is nothing in the ecosystem naturally to keep the population in check. They can also replace native beneficial species and change the lake's ecosystem.

As of 2017, Itasca County has numerous infestations (Figure 6). The most difficult infestation to deal with is zebra mussels, since there is currently no method of controlling them.

At boat landings, there are usually DNR signs telling which invasive species are present in the waterbody and how to prevent their spread. Boaters should be educated about how to check for invasive species before moving from lake to lake. Care should be taken to protect Itasca County's water resources from future aquatic invasive species infestations.

For a current list of the infested waters in Minnesota, visit the DNR's website: http://www.dnr.state.mn.us/invasives/index_aquatic.html.

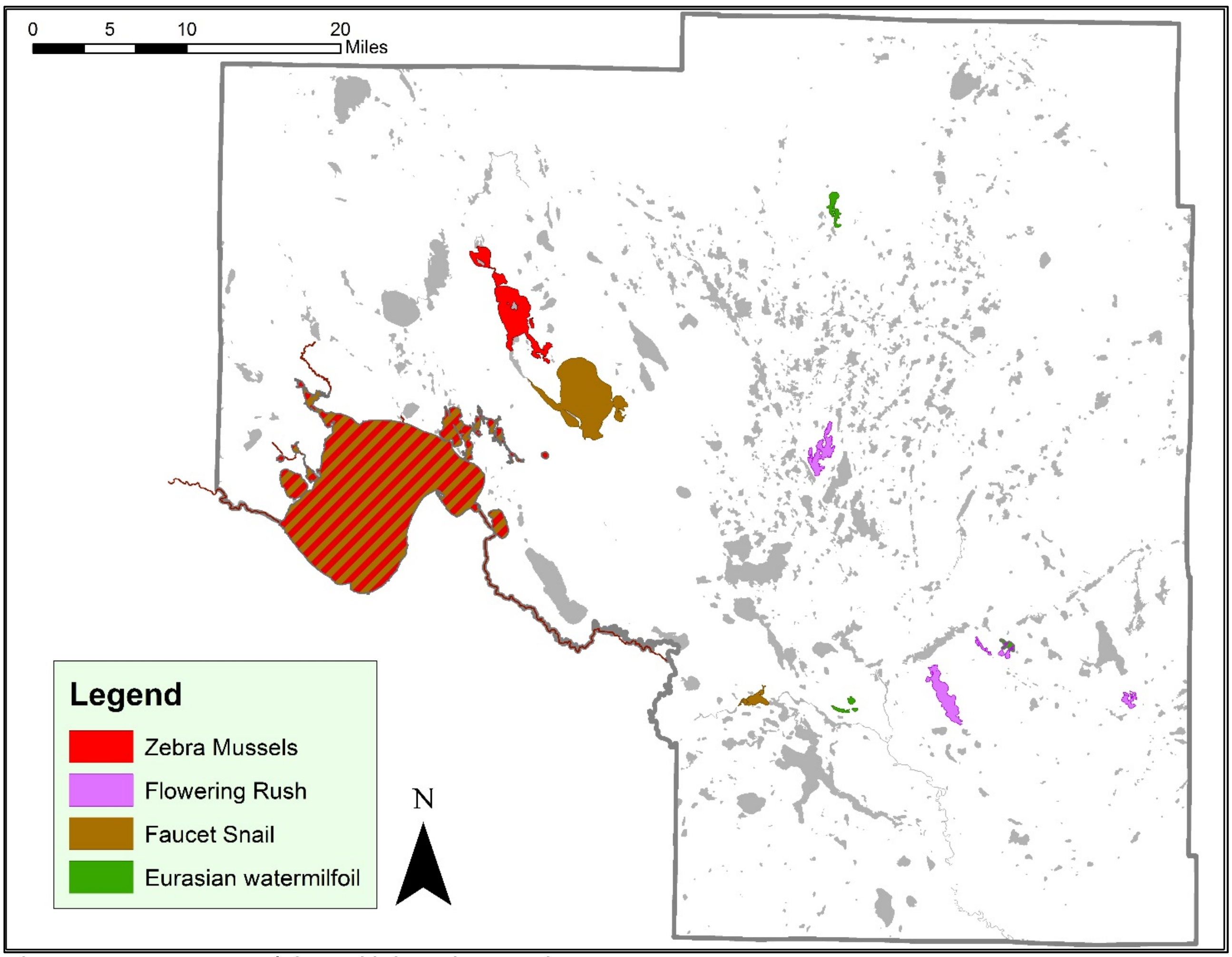


Figure 6. Itasca County lakes with invasive species.

Prioritization and Potential Lake Impacts

Prioritization Methods

The lakes in this report were prioritized for future management. This ensures the water plan is targeted to the greatest needs and value. For prioritization, each lake's trends, property values, phosphorus sensitivity, and percent protection of the lakeshed was considered in one large matrix. Categories were formed by comparing all the characteristics mentioned above (Figure 7). For details see Tables 13-19.

Lakes that are high value to the county and sensitive to decline should be part of the county's focus for management and implementation grant projects. Lakes that are low value to the county and low risk should have a landowner and lake association focus for projects.

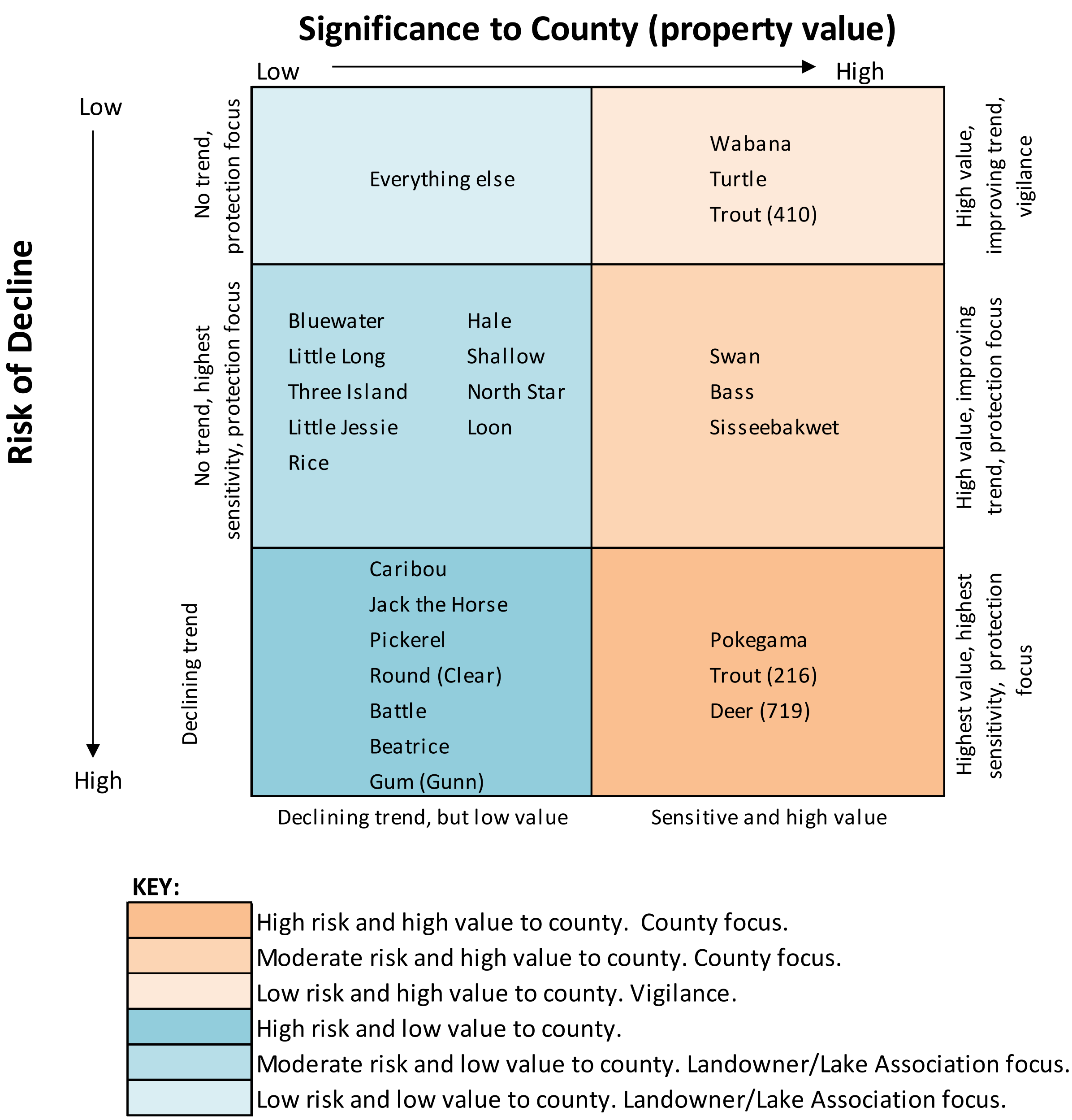


Figure 7. Prioritization matrix of lake significance to the county versus the risk of decline.

Table 12. Definitions of potential lake impacts from Tables 13-19.

Potential Lake Impact*	Definition
Agriculture (Ag.)	Agriculture is present near the lakeshore and there may not be sufficient buffers to protect the lake from runoff.
Development	Over two thirds of the lakeshore is developed (impervious surface, septic systems), and additional development is possible.
Shallow	The majority of the lake is 20 feet deep or less. Aquatic plants and sediments must be protected to prevent a switch to the turbid state.
Internal Loading	Internal loading could be occurring due to lake depth and frequent mixing in the summer. The internal loading shows as increasing phosphorus toward the end of the summer and nuisance algae blooms.
Inlet Loading	Phosphorus could be impacting the lake through inlet loading.
Large Watershed	The large watershed of the lake contributes nutrients cumulatively to the lake.
City Stormwater	There is a city located on the lake shore and city stormwater can carry nutrients into the lake that fuels plant and algae growth.

These lake impacts are not quantified as to how much loading they are providing to the lake.

First Priority Lakes to Watch

This category is defined as lakes with the highest economic value to the county, the highest phosphorus sensitivity, heavy development, good water quality, and less than 75% protected land (Table 13). Currently, these lakes all have stable or improving water quality. Being in the highest category for phosphorus sensitivity means that additional phosphorus has the potential to impact the water quality. These lakes should be a high priority for the county to continue monitoring annually to detect any changes or potential declines in water quality. More specifically, Trout Lake is recovering from past nutrient inputs from mining and city sewage pre-1970s. It has improved remarkably since the 1970s, and should continue to improve as long as it is taken care of. The city of Grand Rapids is adjacent to Pokegama, which has the potential to contribute stormwater runoff to the lake. Stormwater mitigation projects can go a long way in assisting in lake protection.

Table 13. First priority watch lakes in Itasca County.

ID	Lake	Development	Shallow	Internal Loading	Inlet loading	Large Watershed	City Stormwater	Total Impacts	Trend	Mean TSI	Phosphorus Sensitivity	Protected Land
31-0719-00	Deer	x						1	Improving	37	Highest	57.0%
31-0532-01	Pokegama	x			x		x	3	No Trend	41	Highest	34.0%
31-0216-00	Trout	x					x	2	No Trend	42	Highest	26.6%

These lake impacts are not quantified as to how much loading they are providing to the lake.

Second Priority Lakes to Watch

This category is defined as lakes with high economic value to the county, improving trends, heavy development, and less than 75% of the lakeshed protected (Table 14). Potential for impacts on each lake are noted in the table and can inform future projects. Like Trout in Table 13, Swan is recovering from past mining and city sewage inputs. The focus for these lakes should be to increase the amount of protected land in the lakeshed and/or implement forest preservation such as Forest Stewardship Planning.

Table 14. Second priority lakes to watch in Itasca County.

ID	Lake	Development	Shallow	Internal Loading	Inlet loading	Large Watershed	City Stormwater	Total Impacts	Trend	Mean TSI	Phosphorus Sensitivity	Protected Land
31-0576-00	Bass	x			x			2	Improving	44	Higher	38.0%
31-0067-02	Swan	x			x	x	x	4	Improving	46	High	36.6%
31-0554-00	Siseebakwet	x						1	Improving	37	Higher	28.0%

These lake impacts are not quantified as to how much loading they are providing to the lake.

Outstanding Resources

This category is defined as lakes with high economic value to the county, oligotrophic productivity, Cisco refuge lakes, outstanding biodiversity significance (DNR), good lakeshed protection (near or over 75%) and low lakeshed disturbance (<3%) (Table 15). These lakes are already well protected, and therefore can be considered “vigilance lakes” (Table 10). These lakes are some of the best water quality in the state (and even the nation) and are really jewels to treasured.

Table 15. Third priority lakes to watch and outstanding resources.

ID	Lake	Development	Shallow	Internal Loading	Inlet loading	Large Watershed	City Stormwater	Total Impacts	Trend	Mean TSI	Phosphorus Sensitivity	Protected Land
31-0392-00	Wabana	x						1	Improving	36	Higher	72.0%
31-0725-00	Turtle	x						1	Improving	38	Higher	65.6%
31-0410-00	Trout							0	No Trend	36	Higher	93.0%

These lake impacts are not quantified as to how much loading they are providing to the lake.

Declining trends

These lakes are showing declining trends in transparency (Table 16). Human-causes are not apparent for these trends, as these lakes are not very developed. These trends could be caused by natural phenomena like nutrient rich watersheds, groundwater and precipitation. Caribou has very low phosphorus and is very sensitive to any additional phosphorus inputs. It shows a declining trend in transparency at two different monitoring sites from 2001-2014. Over the long-term, from 1989-2014, there is no trend. There are no immediate human-caused impacts apparent, except for possibly a gravel pit to the west of the lake. This area should be visually inspected and monitored during storm events for runoff to the lake. It is possible that the trend could be from natural nutrient inputs from the groundwater or precipitation. Beatrice has a declining trend in transparency in the long-term, but stable in the short-term (2004-2014). The lakeshed is well-protected and there is very little development, so the trend could be due to natural causes. No imminent water quality threats stand out around the shoreline.

Table 16. Lakes in Itasca County with declining trends.

ID	Lake	Development	Shallow	Internal Loading	Inlet loading	Large Watershed	City Stormwater	Total Impacts	Trend	Mean TSI	Phosphorus Sensitivity	Protected Land
31-0620-00	Caribou							0	Declining	30	Highest	65.2%
31-0657-02	Jack the Horse							0	Declining	39	Highest	78.0%
31-0339-00	Pickerel							0	Declining	44	Higher	57.0%
31-0209-00	Round (Clear)		x	x				3	Declining	52	Higher	42.8%
31-0197-00	Battle		x					1	Declining	45	Highest	81.4%
31-0492-00	Gum (Gunn)				x	x		2	Declining	40	NA	67.8%
31-0058-00	Beatrice		x					1	Declining	42	Highest	78.9%

These lake impacts are not quantified as to how much loading they are providing to the lake.

Impaired Waters

These lakes are on the MPCA's Impaired Waters List for excess nutrients (eutrophication) (Table 17). Dixon and Jessie Lakes are showing improving trends. A TMDL was completed for Jessie Lake in 2009. For Jessie Lake to make more improvements in phosphorus reduction, the internal loading would need to be mitigated by an alum treatment or aeration as recommended in the TMDL report. Prairie Lake has a very large watershed and is heavily developed, as the City of Coleraine is adjacent to the lake. It is a fairly shallow lake though and has no trend, so it could be naturally more eutrophic. These lakes are very small and undeveloped and could be a lesser priority for the county for implementation projects. They all have multiple potential impacts as noted in Table 17.

Table 17. Lakes that are on the MPCA Impaired Waters List for excess nutrients in Itasca County.

Lake	ID	Development	Shallow	Internal Loading, Algae Blooms	Inlet loading	Large Watershed	City Stormwater	Total Impacts	Trend
31-0921-00	Dixon			x	x	x		3	Improving
31-0882-00	Dora		x		x	x		3	No Trend
31-0896-00	Round		x	x	x			3	No Trend
31-0786-00	Jessie	x		x	x	x		4	Improving
31-0384-00	Prairie	x				x	x	3	No Trend
31-0913-00	Island	x		x	x			3	No Trend

These lake impacts are not quantified as to how much loading they are providing to the lake.

Protection Lakes

These lakes have no statistical trends or improving trends, are not highly developed, and less than 75% of the lakeshed area is protected (Table 18). The cutoff used by DNR Fisheries for sufficient protection is 75% (Table 10), and many of the lakes in this table are near that number. The table is sorted by the percentage of protected land in the lakeshed. The other lakes should have a management focus of increasing protected lands and forests in the lakeshed. This protection can be accomplished by Forest Stewardship Plans on private forests, conservation easements, and aquatic management areas.

Table 18. Itasca County lakes with no trend or improving trends and have a protection focus.

ID	Lake	Development	Shallow	Internal Loading	Inlet loading	Large Watershed	City Stormwater	Total Impacts	Trend	Mean TSI	Phosphorus Sensitivity	Protected Land
31-0638-00	Beaver							0	No Trend	45	High	72.9%
31-0642-00	Adele		x					1	No Trend	44	High	72.9%
31-0653-00	North Star							0	No Trend	40	Highest	72.4%
31-0826-00	Sand			x	x	x		4	No Trend	45	High	72.3%
31-0394-00	Little Trout							0	No Trend	37	High	72.0%
31-0877-00	Natures		x					1	No Trend	51	Higher	71.0%
31-0069-00	Buck							1	Improving	49	Higher	67.7%
31-0758-00	Little Bowstring	x						1	No Trend	51	Higher	63.0%
31-0759-00	Maki	x						1	No Trend	39	NA	63.0%
31-0454-00	Eagle							0	No Trend	46	High	62.3%
31-0613-00	Little Long							0	No Trend	43	Highest	61.0%
31-0542-00	Three Island							0	No Trend	36	Highest	59.0%
31-0345-00	Scrapper							0	No Trend	46	NA	59.0%
31-0722-00	Moose	x						1	No Trend	41	Higher	58.0%
31-0913-00	Island	x		x	x			3	No Trend	51	NA	57.8%
31-0497-00	Fifth Chain				x			1	No Trend	42	NA	57.8%
31-0020-00	Hart	x						1	No Trend	41	High	54.0%
31-0784-00	Little Jessie	x						1	No Trend	39	Highest	51.0%
31-0717-00	Rice							0	No Trend	38	Highest	46.9%
31-0259-00	Balsam				x			1	No Trend	44	High	43.0%
31-0078-00	McGuire							0	No Trend	50	NA	42.0%
31-0084-00	Shallow	x	x					2	No Trend	40	Highest	41.6%
31-0571-00	Loon	x						2	No Trend	40	Highest	38.7%
31-0311-00	Erskine							0	Improving	40	High	38.2%
31-0399-00	Little Wabana							0	Improving	40	Highest	38.0%
31-0569-00	Guile							0	No Trend	42	High	32.0%
31-0127-00	Trestle							0	No Trend	40	Higher	31.0%

Table 18 continued on the next page.

Table 18 continued. Itasca County lakes with no trend or improving trends and have a protection focus.

ID	Lake	Development	Shallow	Internal Loading	Inlet loading	Large Watershed	City Stormwater	Total Impacts	Trend	Mean TSI	Phosphorus Sensitivity	Protected Land
31-0555-00	South Sugar	x						1	No Trend	39	High	28.0%
31-0214-00	Clearwater (Rd)		X					1	No Trend	47	Higher	14.0%
31-0255-00	Snaptail	x						1	No Trend	43	Higher	10.0%
31-0221-00	Dunning							0	Improving	35	NA	10.0%
31-0361-00	Hale	x						1	No Trend	44	Highest	8.0%

These lake impacts are not quantified as to how much loading they are providing to the lake.

Vigilance Lakes

These lakes' lakesheds are over 75% protected (Table 19). Therefore, they are vigilance lakes as defined by the DNR (Table 10). The management focus is to maintain the current protection levels.

Table 19. Itasca County lakes that have excellent lakeshed protection and are vigilance lakes.

ID	Lake	Development	Shallow	Internal Loading	Inlet loading	Large Watershed	City Stormwater	Total Impacts	Trend	Mean TSI	Phosphorus Sensitivity	Protected Land
31-0857-01	Cut Foot Sioux				x			1	No Trend	50	High	96.5%
31-0438-00	Sand							1	Improving	41	High	90.1%
31-0597-00	Amen	x						1	No Trend	36	High	87.0%
31-0621-00	Little Dead Horse							0	No Trend	36	Higher	84.0%
31-0452-00	Gunn							0	No Trend	40	High	83.0%
31-0616-00	East Smith							0	No Trend	42	Higher	82.0%
31-0424-00	Burnt Shanty							0	No Trend	41	Higher	80.2%
31-0623-00	Boy							1	Improving	41	High	80.0%
31-0624-00	Grave		x					1	No Trend	40	Highest	79.7%
11-0147-00	Winnibigoshish				x	x		2	NA	47	Higher	78.0%
31-0726-00	Bello							0	No Trend	40	Highest	77.1%
31-0171-00	Crum		x			x		2	No Trend	45	High	76.9%
31-0413-00	Burrows							0	No Trend	44	Higher	75.0%
31-0183-00	Five Island (Ball)							0	No Trend	40	Higher	75.0%

These lake impacts are not quantified as to how much loading they are providing to the lake.

Summary and Recommendations

Overall Conclusions

Overall, the lakes in Itasca County that were evaluated in this report have good water quality and are in good condition. Some lakes, such as Trout and Swan, are recovering from past impacts of mining and city sewage, and are almost back to where they were before the impacts.

The water quality in the lakes of Itasca County has a lot to do with how the glaciers left the area. The lakes around Jessie, Bowstring, Sand, and Winnibigoshish are large and shallow with more nutrients naturally. The deep lakes near Marcell and Grand Rapids, such as Deer and Pokegama, are naturally very low in nutrients.

All of the lakes evaluated had enough transparency data to perform a trend analysis. Overall, 17 lakes had improving water quality trends, seven lakes had declining trends, and the majoryt had no trends (Tables 5-7). The declining trends could be due to natural causes such as precipitation and groundwater, as they are occurring on lakes without apparent human impacts (Table 6).

Eleven Lakes in Itasca County are currently listed as impaired for eutrophication as of the 2018 Draft Impaired Waters List: Bowstring, Island, Little Spring, Round, Shallow Pond, Decker, Dixon, Prairie, Split Hand, King, and Little Cowhorn. A Total Maximum Daily Load (TMDL) study will be conducted on these lakes to determine how to reduce phosphorus levels. The TMDL for Jessie Lake is completed and can be found on the MPCA website. The TMDL schedule can be found in Table 9. Most of these lakes are shallow, and naturally have higher nutrient levels.

Eleven of the lakes evaluated in this report are designated as Cisco refuge lakes by the DNR: Bluewater, Hale (0373), Little Wabana, Loon, North Star, Shallow, Siseebakwet, Trout (0216), Trout (0410), Turtle, and Wabana (Table 11). Ciscos (*Coregonus artedi)* can be an early indicator of eutrophication in a lake because they require cold hypolimnetic temperatures and high dissolved oxygen levels. Cisco refuge lakes are usually deep and have good oxygen levels. Protecting the water quality and lakesheds of these lakes will help ensure the Cisco's survival.

Shoreline development seems to be the largest overall human-caused impact and risk to the lakes in Itasca County. From looking at GIS mapping layers over time, it appears that development on lakes in Itasca County has increased significantly since 1980. Demographic projections show anticipated population growth in Itasca County in the next ten years. Once the second tier around the lake is developed, the drainage in the lakeshed changes and more runoff reaches the lake from impervious surface and lawns. Project ideas include protecting land with conservation easements, enforcing county shoreline ordinances, smart development, shoreline restoration, rain gardens, and septic system maintenance. Forestry practices should follow the Minnesota Forest Resources Council guidelines for proper buffers between cutting and the lake. Past mining practices has also impacted lakes in central and eastern Itasca County. Future mining operations should consider avoiding runoff into area lakes.

Monitoring Recommendations

Some of the lakes in Itasca County had disjointed data with many gaps. Monitoring is most effective when done at one primary site in the lake over many consecutive years. Some of the lakes in this report jumped around and monitored one site one year and a different site the next year, which makes it hard to compare conditions year-to-year.

At a minimum, every lake should have one primary site (recommended in each individual report) that should be monitored for transparency with a Secchi disk weekly or bimonthly every summer. This monitoring is free and is tracked through the Minnesota Pollution Control Agency's Citizen Lake

Monitoring Program (CLMP, http://www.pca.state.mn.us/wfhyac7). After 8-10 years of consecutive data, a trend analysis can be completed for each lake.

Lakes that have declining trends and nuisance algae blooms should be monitored for internal loading and inlet loading. To confirm if internal loading is occurring, hypolimnion water samples (water samples taken 1 foot above the lake's bottom) and corresponding dissolved oxygen profiles could be monitored for a summer or two.

To determine the phosphorus loading from the watershed, the inlets could be monitored during baseline and peak flow events (spring thaw and heavy rains). Lakes with possible inlet loading are identified in Tables 13-19.

Lake Winnibigoshish

Lake Winnibigoshish is a difficult lake to monitor because there are so many different agencies and groups involved, and because it is so large. Implementing an annual monitoring program on this lake that shares data with all interested groups would greatly benefit the understanding of this lake. This monitoring program could include a few sites of transparency monitoring and one or two sites of chemical monitoring. This monitoring can also help determine if there are any effects on water quality from the Zebra mussel population. Transparency should be monitored weekly or every other week, and chemical monitoring should occur on at least 4-5 dates evenly spread throughout the summer to get a good average.

Shallow Lakes

Shallow lakes usually have a maximum depth around 20 feet deep or less and don't completely stratify all summer. A healthy shallow lake should have clear water and abundant aquatic plants. Native aquatic plants stabilize the lake's sediments and tie up phosphorus in their tissues. When aquatic plants are uprooted from a shallow lake, the lake bottom is disturbed, and the phosphorus in the water column gets used by algae instead of plants. This contributes to "greener" water and more algae blooms. Protecting native aquatic plant beds will ensure a healthy lake and healthy fishery.

Studies have shown that large boat motors can re-suspend the phosphorus from the lake's sediment and cause algae blooms. Boaters should be encouraged to drive slowly through areas shallower than 10 feet.

The shallow lakes evaluated in this report include Shallow, Adele, Crum, Deer (0334), Horseshoe, Beatrice, Grave, Battle, Dora, Natures, Deer (0334), Horseshoe, Round (Clear) and Round.

Stormwater Management.

Stormwater management is an issue anywhere there is concentrated development, therefore all the lakes in this report with an "x" in the Development or City Stormwater impact categories (Tables 13-19). Any impervious surface, including driveways, roads, roofs and patios cause the rain to run off of them instead of soaking into the ground. Turf grass does not sufficiently infiltrate rainwater either. Rain gardens and wetlands can be good areas for storm water storage and infiltration. For lakes located adjacent to a town, such as Pokegama and Trout, investigate specifically where storm water drains so that it is not impacting the lake. Towns have a high density of impervious surface. It is not possible to remove this impervious surface, but it is possible to install stormwater management practices to prevent the stormwater from running into the lakes.

Future Studies
Future studies that would better pinpoint the impacts on the lake include a shoreline inventory, monitoring stream inlets, monitoring for internal loading, and a watershed flow analysis. The shoreline inventory would consist of driving around the lake and rating each parcel as to how much of the frontage has a vegetative buffer.

To determine the phosphorus loading from the watershed, the inlets could be monitored during baseline and peak flow events (spring thaw and heavy rains). The inlets could also be ground-truthed, which entails walking them to look for erosion and insufficient vegetative buffers.

Monitoring for internal loading involves collecting hypolimnion water samples (water samples taken 1 foot above the lake's bottom) and corresponding dissolved oxygen profiles.

A watershed flow analysis would be done using GIS software to see the areas of heaviest runoff into the lake. This analysis would also help where stormwater mitigation, rain gardens and shoreline restoration would have the most positive impact on the lake.

Project Implementation
The best management practices above can be implemented by a variety of entities. Some possibilities are listed below.

Individual property owners
- Shoreline restoration
- Rain gardens
- Aquatic plant bed protection (only remove a small area for swimming)
- Forest Stewardship Planning
- Conservation Easements

Lake Associations
- Lake condition monitoring
- Ground truthing – visual inspection upstream on stream inlets
- Shoreline inventory study by a consultant
- Forest Stewardship Planning
- Conservation Easements

Soil and Water Conservation District (SWCD) and Natural Resources Conservation Service (NRCS)
- Shoreline restoration
- Stream buffers
- Forest Stewardship Planning
- Conservation Easements

County-wide Recommendation
In order to better manage the impact of septic systems on lake water quality, it is recommended that the county implement a lake-wide septic inspection program. In a program such as this, the county would focus on one to three lakes a year, pull septic system records on those lakes, and require old systems to be inspected. This program can rotate through the county doing a few lakes each year.

Since conversion of small cabins to large lake homes could be a future issue, strengthening county shoreline ordinances such as set-backs, impervious surface limits and shoreline alteration (installation of retaining walls and removing trees) will help to protect water quality.

Grant and Cost Share Possibilities

BWSR Clean Water Grants: These grants can be used for a variety of "on-the-ground" projects, where citizens and local governments are installing conservation practices to improve the quality in lakes, rivers and wetlands.
http://www.bwsr.state.mn.us/grants/index.html

DNR Conservation Partners Legacy Grant Program: These grants can be used for projects that restore, enhance and/or protect habitats for MN's fish, game, and wildlife.
http://www.dnr.state.mn.us/grants/habitat/cpl/index.html

DNR Shoreline Habitat Restoration Grants: Shoreland and Aquatic Habitat Block Grants are designed to provide cost share funding to counties, cities, watershed districts, other local units of government, conservation groups, and lake associations. It allows participants to conduct shoreline and watershed enhancement projects with native plants, while improving aquatic habitat and water quality for fish and wildlife.
http://www.dnr.state.mn.us/grants/habitat/shoreland.html

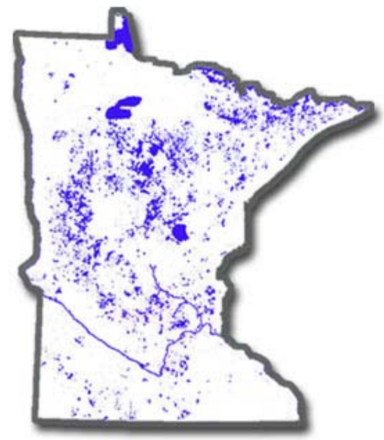
DNR Forest Stewardship Program: This program has a cost share for landowners to protect and manage forests on private lands.
http://www.dnr.state.mn.us/woodlands/cost-share.html

Minnesota Land Trust Conservation Easements: This program is for landowners to donate land into conservation easements, which protects them perpetually.
http://www.mnland.org/conservation-options

Appendix I: Limnology Educational Summary

Lake Water Quality: the natural factors and the human factors

There are many factors that contribute to a lake's current condition, including natural factors and human factors. Once these factors are understood, a better understanding of past, present and future lake water quality is possible.



Most of the lakes in Minnesota were formed as glaciers receded during the last ice age. Approximately 15,000 years ago to about 9,000 years ago, glaciers alternately retreated and advanced over the landscape, carving out holes and leaving behind ice chunks. As these ice chunks melted in the holes left behind, lakes were formed. Northern Minnesota was scraped fairly clean down to the bedrock, with boulders, sand and clay left behind, while southern Minnesota was left with a rich, fine prairie (now agricultural) soil.

The first thing that goes into understanding a lake is what sort of geological area it is in. Northern Minnesota lakes are commonly very deep, rocky lakes in forested areas. These lakes have very clear water and characteristically low phosphorus and algae concentrations due to the abundance of sandy, relatively infertile soil. The lakes in southwestern Minnesota are shallower prairie lakes surrounded by fertile soil. Lakes in this area tend to have more nutrients available for plants and algae to grow, and therefore get "greener" in the summer.

The geology and glacial formation of a lake usually determines its shape, size and depth. These factors contribute to nearly all physical, chemical and biological properties of a lake. Lake users such as fishermen are probably aware of these characteristics already because they also determine where the fish are. A lake that is one large round hole is different than a lake that has a lot of bays, points and bottom structure. A long narrow lake is more affected by wind (which mixes the lake) than a round lake. Deep lakes have different dynamics than shallow lakes, and most of all, deep lakes have more water. The more water a lake has (volume), the better it is able to dilute what runs into it.

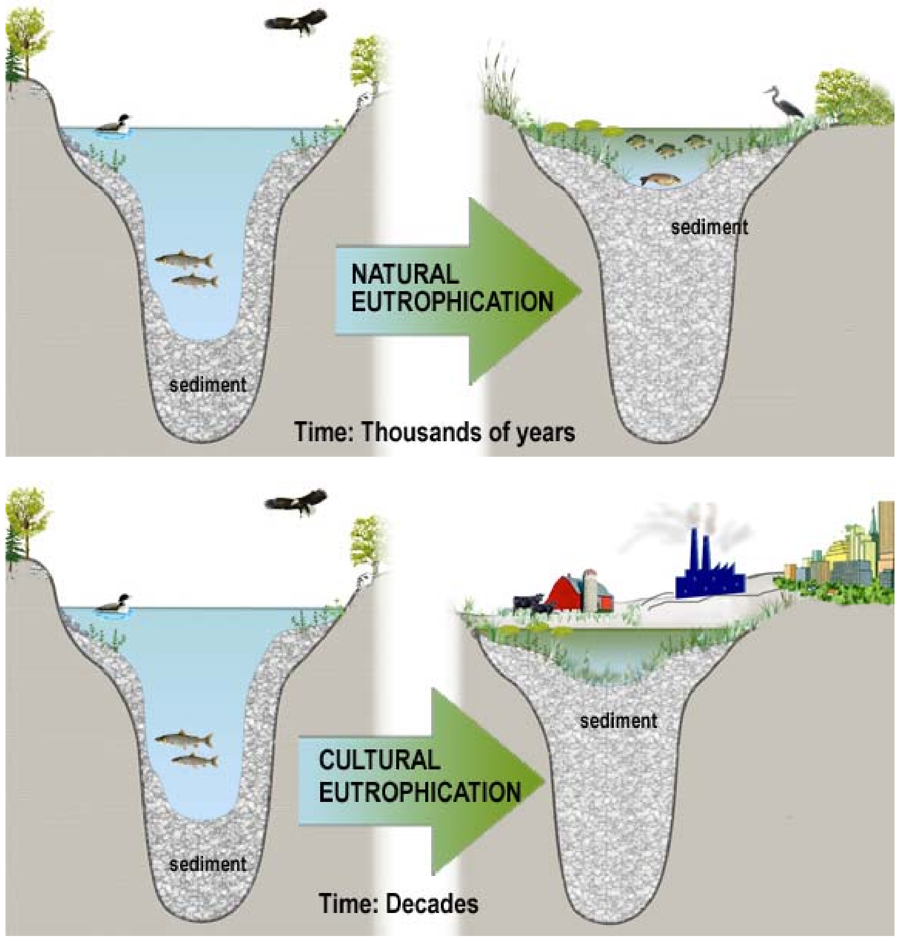
Shallow lakes are lakes where the sunlight can reach the entire bottom. Generally, this corresponds to about 15 feet deep or less. Since the sunlight can reach the bottom, aquatic plants are able to grow there. In deep lakes, the bottom does not receive sunlight, so no plants grow there and it stays dark and cold.

Another major factor affecting lake condition is the size of its watershed and where the lake sits within the watershed. A watershed is an area of land where all the water drains into the same river system. These watershed areas are defined by topography, or ridges of elevation. Therefore, watersheds are mainly driven by gravity – water runs down hill.

If a lake has a very small watershed or is at the top of a watershed (in topography terms), the lake usually has better water clarity than a lake at the bottom of a large watershed. As water flows downhill through a watershed it picks up sediment from erosion and nutrients from runoff. This sediment and nutrients can feed algae and cause the lake to become "greener".

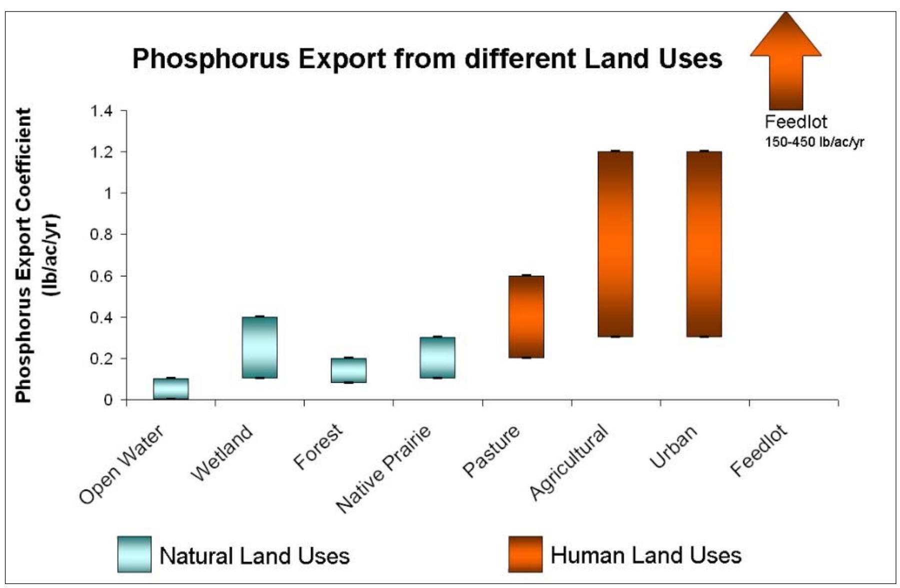
Lakes go through a natural ageing process where they gradually receive nutrients (phosphorus and nitrogen) and sediment from erosion in the surrounding watershed and become more fertile and shallow. This process is called eutrophication. Eutrophication is a natural process that a lake goes through over thousands of years.

Humans can speed up the process of eutrophication by adding excess nutrients and sediment quickly, where the lake will change trophic states in a matter of decades instead of centuries. This type of eutrophication is called cultural eutrophication because humans cause it. We have changed the landscape around lakes, which changes their water quality and speeds up eutrophication.



Around lakes, we have added a lot of impervious surface. Impervious surface is any surface on land that is impenetrable to water and prevents its absorption into the ground. Examples include rooftops, sidewalks, parking lots, and roads. The more impervious surface in a concentrated area, the less surface there is for rain to be absorbed into the ground. Instead, it ends up running into lakes and streams and carrying nutrients and sediment from the land it flows over.

Land practices such as urban areas, factories, agriculture, animal feedlots contain very concentrated amounts of nutrients. These nutrients wash into lakes and streams during heavy rains or through storm sewers. The additional nutrients that run into lakes and streams cause algal blooms and additional plant growth.



When erosion occurs along a lakeshore or a stream bank of a lake inlet, that extra soil can get washed into the lake. The extra soil particles cause cloudier water and eventually settle on the bottom of the lake making it mucky and less stable. The soil also carries with it nutrients such as phosphorus and nitrogen.

Eutrophication can be slowed if the inputs of nutrients (especially phosphorus) and sediment are slowed. Creating natural vegetation buffers along lakeshores and streams soak up nutrients and filter runoff. When planning new construction near water, make sure erosion is prevented by silt fences and minimize creating more impervious surface.

So how can one tell if the lake's water quality is declining or improving? The best way to determine long-term trends is to have 8-10 years of lake water quality data such as clarity (secchi disk), phosphorus, and chlorophyll-a (algae concentration). Only short-term trends can be determined with just a few years of data, because there can be different wet years, dry years, weather, water levels, etc. that affect the water quality naturally. The data needs to be analyzed with a statistical test (i.e.: Mann Kendall Trend Analysis) to be confident in a true trend.

In summary, lakes start out with a certain natural condition that depends on their location, their watershed size, and their area, depth and shape. Then we humans add to that by what type of land practices we implement near the lake and upstream from the lake. Lakes that are in more heavily populated areas usually have had more cultural eutrophication than lakes that are in sparsely populated areas.

When it comes to protecting our lakes, stewardship is an attitude. It is the understanding that what we do on land and in the water affects the lake. It is recognition that lakes are vulnerable and that in order to make them thrive, citizens, both individually and collectively, must assume responsibility for their care. Once you learn more about all the factors that potentially affect your lake, you can practice preventative care of your lake, and hopefully avoid costly problems.

"In the end, we will conserve only what we love; we will love only what we understand; and we will understand only what we have been taught." - Baba Dioum, a Senegalese ecologist.

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Appendix II: Phosphorus Export Educational Summary

Introduction

The purpose of lakeshed assessment is to develop an inventory and assess the resources within each lakeshed. The assessment can then be used as a tool to evaluate issues and create a framework of goals and strategies for citizens, as well as representatives from local units of government and resources agencies in the region. This information helps support the continued commitment to a collaborative effort to protect and improve water quality of Minnesota lakes and manage our limited resources.

Understanding a lakeshed requires the understanding of basic hydrology. A watershed is the area of land that drains into a surface water body such as a stream, river, or lake and contributes to the recharge of groundwater. There are three categories of watersheds: 1) basins, 2) major watersheds, and 3) minor watersheds.

Within this watershed hierarchy, lakesheds also exist. A lakeshed is defined simply as the land area that drains to a lake. While some lakes may have only one or two minor watersheds draining into them, others may be connected to a large number of minor watersheds, reflecting a larger drainage area via stream or river networks.

This summary includes educational information about phosphorus and nutrient transport in watersheds and lakesheds. For each individual lakeshed assessment, conclusions can be drawn as to the best way to protect and conserve land within the lakeshed. See individual lake reports for specific recommendations. Overall recommendations include:

- Continue to follow BMPs (Best Management Practices) in the lakeshed:
  - Plant natural vegetation along the shoreline
  - Protect and extend low phosphorus land covers wherever possible (forest/wetland)
  - Surface water onsite management (rain gardens, drainage, etc.)

- For lakes located near a town, investigate where storm water drains so that it is not impacting the lake. Rain gardens and wetlands can be good areas for storm water storage and infiltration.

Phosphorus

Phosphorus is a nutrient important for plant growth. In most lakes, phosphorus is the limiting nutrient, which means that everything that plants and algae need to grow is available in excess (sunlight, warmth, water, nitrogen, etc.), except phosphorus. This means that phosphorus has a direct effect on plant and algal growth in lakes – the more phosphorus that is available, the more plants and algae there are in the lake. Phosphorus originates from a variety of sources, many of which are related to human activities. Major sources include human and animal wastes, soil erosion, detergents, septic systems and runoff from farmland or fertilized lawns.

Phosphorus is usually measured in two ways in lakes, ortho-phosphate (soluble reactive phosphorus) and total phosphorus. Ortho-phosphate (soluble reactive phosphorus) is the chemically active, dissolved form of phosphorus that is taken up directly by plants. Ortho-phosphate levels fluctuate daily, and in lakes there usually isn't a lot of ortho-phosphate because it is incorporated into plants quickly. Total phosphorus (TP) is a better way to measure phosphorus in lakes because it includes both ortho-phosphate and the phosphorus in plant and animal fragments suspended in lake water. TP levels are more stable and an annual mean can tell you a lot about the lake's water quality and trophic state, as shown in Figure 1.

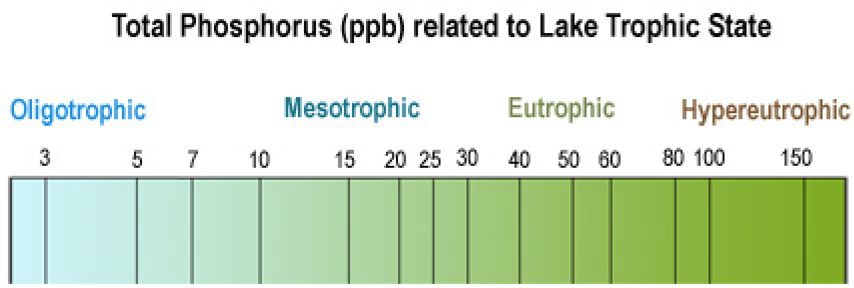

Figure 1. Phosphorus concentration (ppb) related to lake trophic state.

If phosphorus inputs are decreased or eliminated, less plants and algae are able to grow and water quality can improve.

Nutrient export to lakes

Phosphorus export, which is the main cause of lake eutrophication, depends on the type of land use occurring in the lakeshed. Phosphorus export (in lbs/acre/year) can be estimated from different land uses using the phosphorus export coefficient. Figure 2 shows the phosphorus export from the natural landscape versus human land uses. Humans alter the landscape, thereby adding more phosphorus to the lake than would occur naturally.

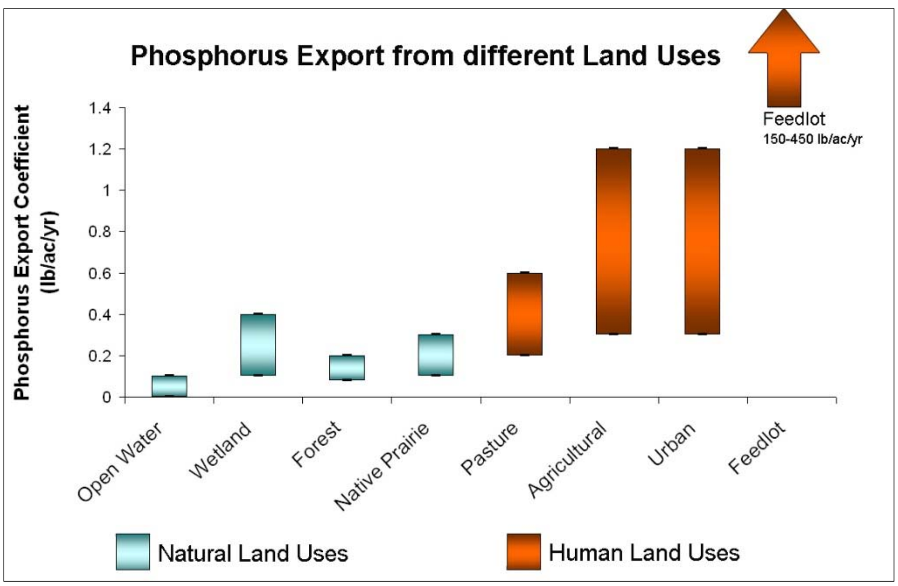

Figure 2. Phosphorus export coefficient for natural vs human land uses.

Stormwater is an all-inclusive term that refers to any of the water running off of the land's surface after a rainfall or snowmelt event. Stormwater carries nutrients and other pollutants, the largest being phosphorus. Around lakes, urban development is one of the largest contributors of phosphorus. Prior to development, stormwater is a small component of the annual water balance. However, as development increases, the paving of pervious surfaces (that is, surfaces able to soak water into the ground) with new roads, shopping centers, driveways and rooftops all adds up to mean less water soaks into the ground and more water runs off. Figure 2 is a variation on a classic diagram that has appeared in many documents describing the effects of urbanization. This adaptation from the University of Washington shows how the relative percentages of water soaking into the ground change once development begins in a forested area. Note that the numbers assigned to the arrows depicting the movement of water will vary depending upon location within Minnesota (MPCA 2008).

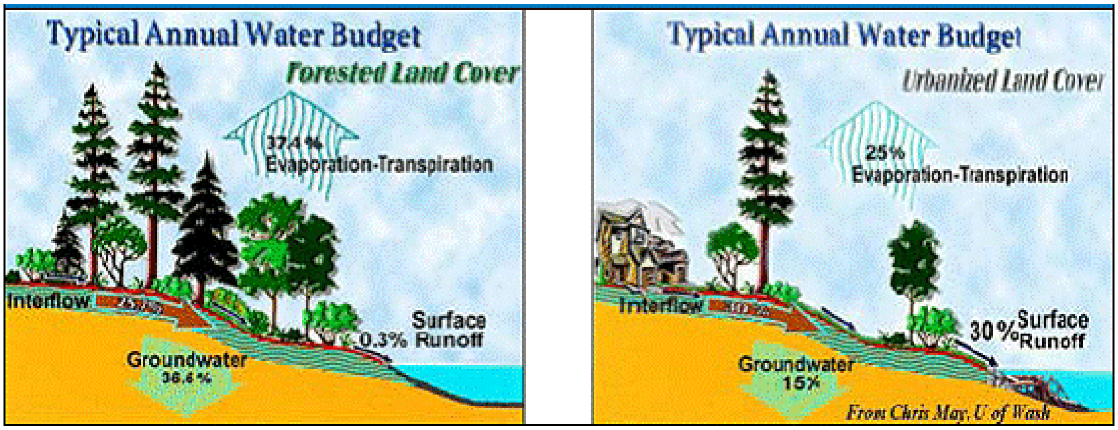

Figure 3. Differences in annual water budget from natural land cover to urbanized land cover (Source: May, University of Washington).

The changes in the landscape that occur during the transition from rural and open space to urbanized land use have a profound effect on the movement of water off of the land. The problems associated with urbanization originate in the changes in landscape, the increased volume of runoff, and the quickened manner in which it moves (Figure 3). Urban development within a watershed has a number of direct impacts on downstream waters and waterways, including changes to stream flow behavior and stream geometry, degradation of aquatic habitat, and extreme water level fluctuation. The cumulative impact of these changes should be recognized as a stormwater management approach is assembled (MPCA 2008).

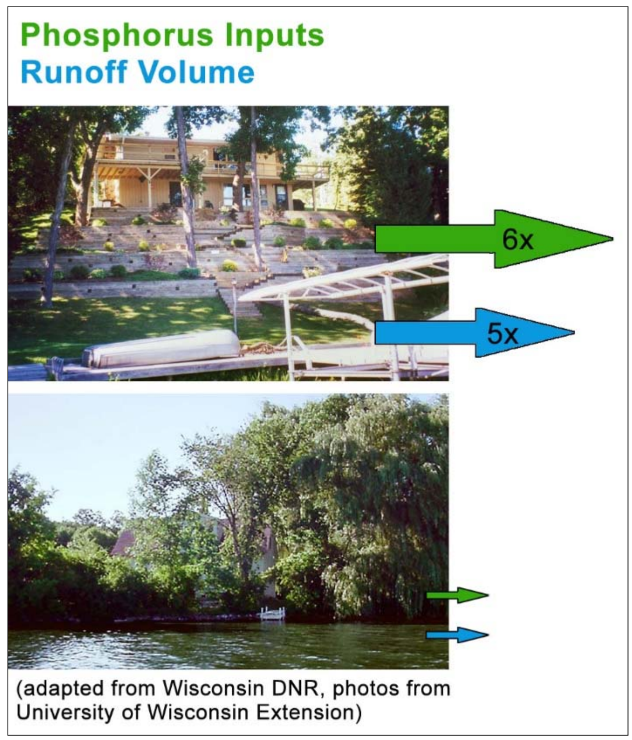

Figure 4. The effects of development on the amount of phosphorus and total runoff from a shoreland property. A large landscaped lot with a manicured lawn, a beach, and a retaining wall can increase total runoff volume by 500% and the phosphorus inputs to the lake by 600% (University of Wisconsin–Extension and Wisconsin Department of Natural Resources. 2002).

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Appendix 3: Glossary of terms

Glossary

Anoxic: without oxygen. Organisms cannot survive in prolonged periods of anoxia.

Chlorophyll-a: the pigment that makes plants and algae green. Chlorophyll-a is measured in lakes to determine algal concentration.

Dissolved oxygen: oxygen that is dissolved in the water column. Aquatic organisms (zooplankton, aquatic invertebrates and fish) need this oxygen to survive.

Epilimnion: The top layer of a lake where the sunlight penetrates and provides energy for plants and algae to grow.

Eutrophic: A lake that has low water clarity and high productivity (phosphorus and chlorophyll-1). Eutrophic lakes have a Trophic State Index between 50 and 70, an anoxic hypolimnion in the summer, algal and aquatic plants are prevalent, and can only support warm water fish.

Fall turnover: when the summer stratification layers of a lake mix due to the cooling epilimnion (upper layer of the lake). This mixing distributes all the nutrients evenly through the water column.

Fertility: the amount of plant and animal life that can be produced within a lake. Fertility is directly related to the amount of nutrients present in the lake to "feed" plants and animals (phosphorus, nitrogen).

Hypereutrophic: A lake that has very low water clarity and very high productivity (phosphorus and chlorophyll-a). Hypereutrophic lakes have a Trophic State Index over 70, and usually have heavy algal blooms and very dense aquatic plants.

Hypolimnion: The deep part of a lake that is cold and dark due to no sunlight penetration. This area of a lake can be anoxic in the summer due to stratification and decomposition.

Littoral area: the area around a lake that is shallow enough to support plant growth (usually less than 15 feet). This part of the lake also provides the essential spawning habitat for most warm water fishes (e.g. bass, walleye, and panfish).

Mesotrophic: A lake that has moderate water clarity and productivity (phosphorus and chlorophyll-a). Mesotrophic lakes have a Trophic State Index between 30 and 50, and the hypolimnion can become anoxic during the summer.

Nitrogen: a nutrient important for plant growth. Nitrogen can enter a lake through groundwater, surface runoff and manure.

Oligotrophic: A lake that has very clear water and very low productivity (phosphorus and chlorophyll-a). Oligotrophic lakes have a Trophic State Index under 30, the hypolimnion contains oxygen throughout the year and can support trout.

OP (Ortho Phosphate): the amount of inorganic phosphorus within a lake. Inorganic phosphorus is readily usable by algae and plants for growth.

Phosphorus: a nutrient needed for plant growth. Phosphorus can enter a lake through runoff from manure and fertilizer or through seepage from leaking septic and holding tanks.

Productivity: the amount of plant and animal life that can be produced within a lake. Productivity is directly related to the amount of nutrients present in the lake to "feed" plants and animals (phosphorus, nitrogen).

Secchi Depth: a measure of water clarity that can indicate the overall health of a lake. A black and white metal disc is lowered into the water on a rope until it can't be seen anymore and raised to the point it can be seen. The depth of the disk to the surface of the water is the Secchi Depth.

Spring turnover: when the ice melts off the lake in the spring and cold water on the top of the lake sinks. This mixing distributes all the nutrients evenly through the water column.

Stratification: The process in which most Minnesota lakes separate into three layers during the summer. The upper layer (epilimnion) becomes warm and is penetrated by sunlight, the lower layer (hypolimnion) is cold and dark and the middle area (thermocline) separates the top and bottom layers. Warm water is less dense than cold water, which is why the upper layer floats on top of the bottom layer and does not mix in the summer. Minnesota lakes mix in the spring and the fall, when the top layer of the lake cools off.

Thermocline: The area between the warm top layer of a lake and the cold bottom part of the lake. The thermocline is characterized by a sharp drop in temperature.

TP (Total Phosphorus): the total amount of organic and inorganic phosphorus within a lake. Organic phosphorus includes detritus, feces, dead leaves and other organic matter.

TMDL (Total Maximum Daily Load): the amount of a particular pollutant that a body of water can handle without violating state water quality standards.

Trend Analysis (Mann Kendall statistic): a way to test the probability of a trend being real versus just happening by chance. A trend probability of 90% (minimum probability used by MPCA) means that there is a 90% probability that the observed trend is real and a 10% probability that the observed trend is just from random chance.

Trophic State: Trophic states are defined divisions of a continuum in water quality. The continuum is Total Phosphorus concentration, Chlorophyll a concentration and Secchi depth. Scientists define certain ranges in the above lake measures as different trophic states so they can be easily referred to. See Oligotrophic, Mesotrophic, Eutrophic, Hypereutrophic.

TSI: Trophic State Index is a measurement of overall lake productivity (nutrient enrichment). The overall TSI of a lake is the average of the TSI for phosphorus, chlorophyll-a and secchi depth.

Turbidity: refers to how clear the water is. Cloudiness (turbidity) in the water can be due to suspended matter such as silt, clay, plankton and other organic matter. The more turbid the water is, the less sunlight can pass through.

Watershed: the area of land that drains into a lake directly or by way of a stream that flows into the lake. The land use practices of an entire watershed can affect the water quality of a lake.

Final Report
Sensitive Lakeshore Survey
Bass Lake
Itasca County, Minnesota

January 2014

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ECOLOGICAL AND WATER RESOURCES

Full report is available online at: https://z.umn.edu/shorelandadvisors in the "Articles" folder.

A Product of the Intra-Lake Zoning to Protect Sensitive Lakeshores Project

Application of ***Minnesota's Sensitive Lakeshore Identification Manual:*** *A Conservation Strategy for Minnesota's Lakeshores*

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Loon Nest Surveys
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Carlson, K., S. Simon, S., and D. Perleberg. 2014. Final report on the sensitive lakeshore survey for Bass Lake, Itasca County, MN. Division of Ecological and Water Resources, Minnesota Department of Natural Resources. 70 pp.

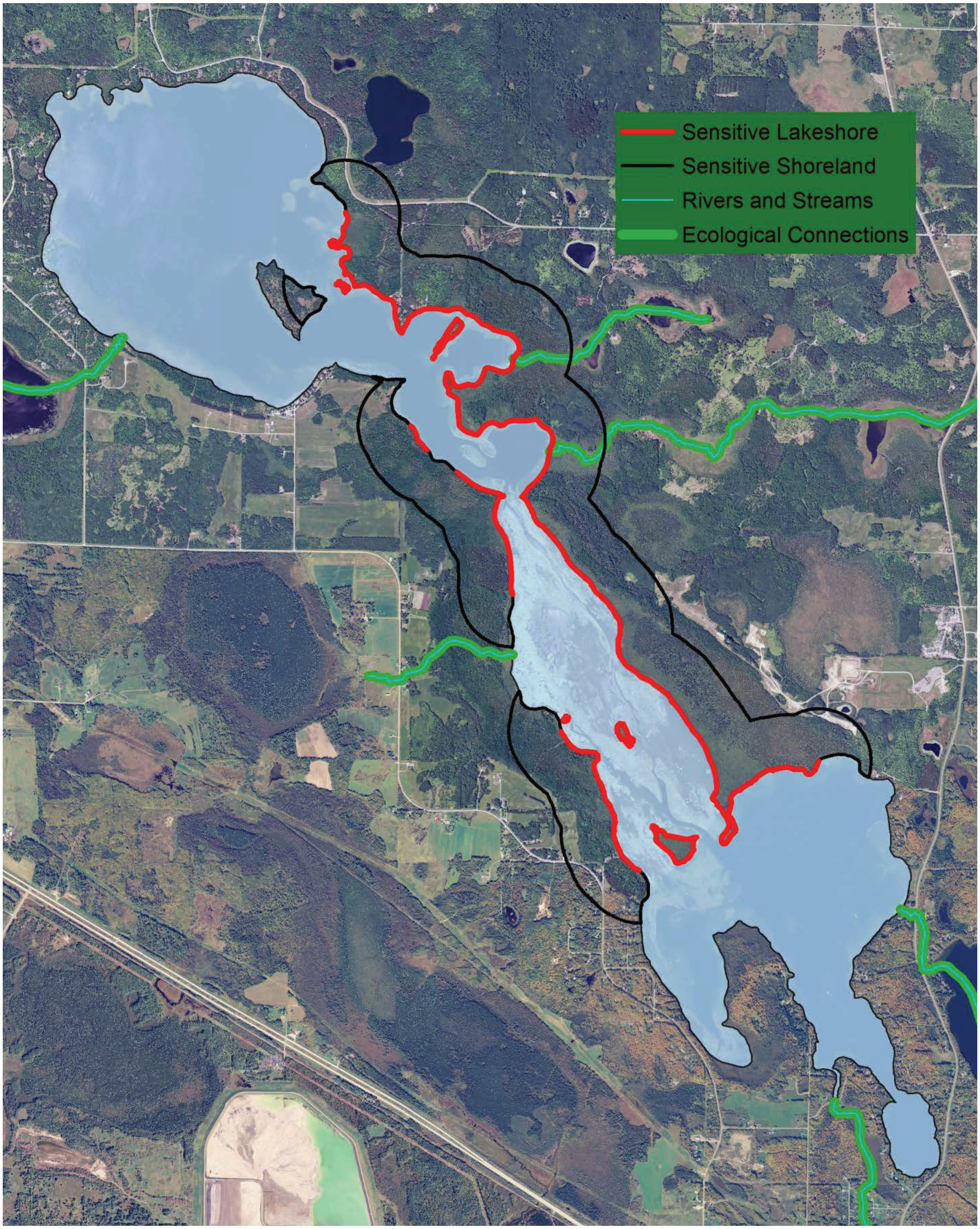
Executive Summary

Thirteen biological and physical attributes of the Bass Lake lakeshore area were assessed using the Minnesota Department of Natural Resources' sensitive lakeshore identification protocol. These attributes were scored and analyzed, and the results were incorporated into maps that delineate sensitive shoreline and sensitive shoreland. Approximately 9.5 miles, or 40% of the shoreline of Bass Lake was identified as sensitive.

Forty-four native aquatic plant taxa were documented in Bass Lake, including 25 submerged, three free-floating, six floating-leaved and 10 emergent taxa. Submerged aquatic plants occurred around the entire perimeter of Bass Lake and plants were found to a depth of 20 feet. Common submerged plants included muskgrass, coontail, flat-stem pondweed, Canada waterweed and northern watermilfoil. Approximately 1,005 acres of the lake were occupied by emergent or floating-leaved plant beds, including wild rice, bulrush, white waterlily, yellow waterlily and floating-leaf pondweed. Five unique plant species were also recorded in Bass Lake.

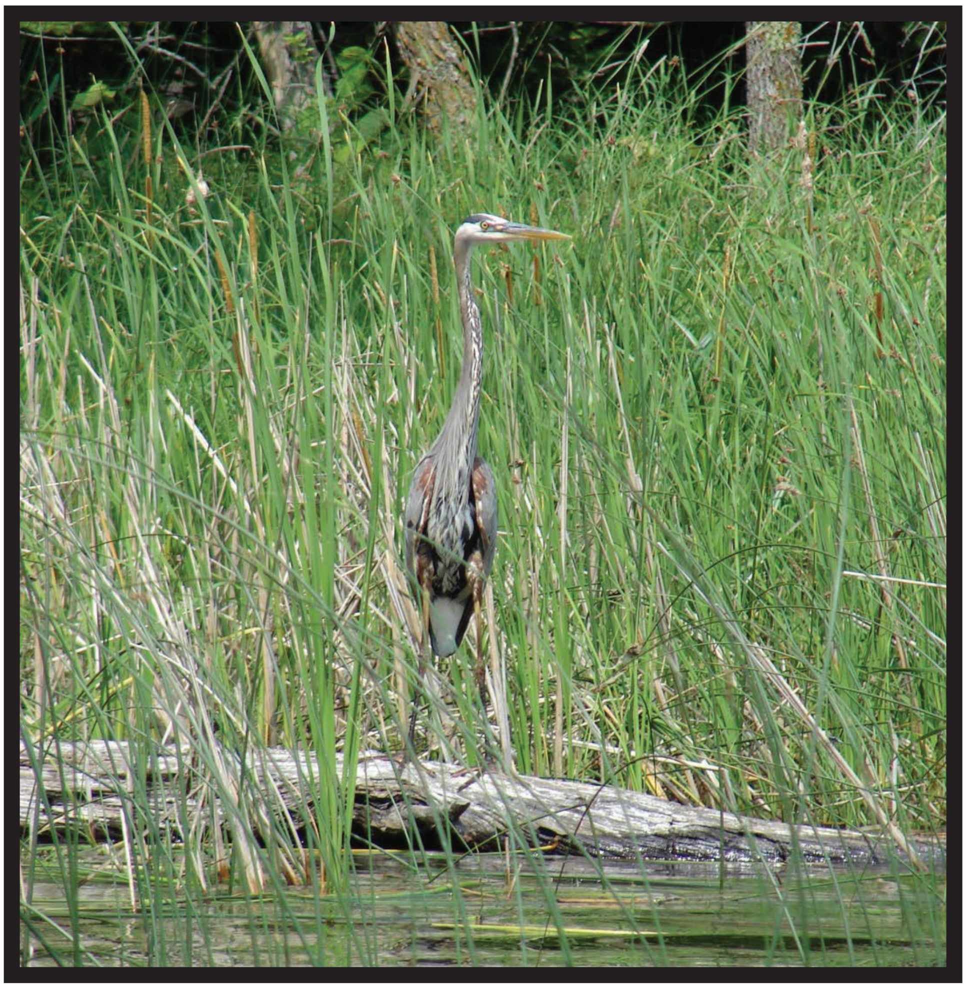
Four loon nesting areas were identified on Bass Lake in 2012. All documented nests were natural nests, and no active artificial nest platforms were recorded. Both mink and green frogs were recorded during the Bass Lake frog surveys, and frogs were heard along essentially the entire shoreline of Bass Lake. Surveyors documented one fish species of greatest conservation need, the longear sunfish, at Bass Lake. In addition, all three proxy species (blackchin shiner, blacknose shiner, banded killifish) were found at various survey stations within the lake. In total, surveyors identified 21 fish species in Bass Lake in 2012.

The ecological model identified the channel and nearby areas to be considered for potential resource protection districts by Itasca County. These stretches supported the greatest diversity of plant and wildlife species, including species of greatest conservation need. The ecological model displays these areas both as sensitive shoreline and as high priority shorelands. The rivers and streams connected to Bass Lake are also an important part of the ecosystem. They provide valuable connectivity between the lakes and nearby habitat. The county may use this objective, science-based information in making decisions about districting and reclassification of lakeshore areas. The most probable highly sensitive lakeshore areas and the recommended resource protection districts are:


Sensitive Lakeshore
Sensitive Shoreland
Rivers and Streams
Ecological Connections

Final Report
Sensitive Lakeshore Survey
Sand Chain of Lakes
Itasca County, Minnesota

October 2013



STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ECOLOGICAL AND WATER RESOURCES

Full report is available online at: https://z.umn.edu/shorelandadvisors in the "Articles" folder.

A Product of the
Intra-Lake Zoning to Protect Sensitive Lakeshores Project

Application of
Minnesota's Sensitive Lakeshore Identification Manual: *A Conservation Strategy for Minnesota's Lakeshores*

Prepared by
Stephanie Simon
Kristin Carlson
Donna Perleberg

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Paul Radomski

Surveys conducted by
Fish Surveys
Paul Radomski, Project Manager
Kevin Woizeschke, Nongame Wildlife Ecologist
Kent Montgomery, Bird Survey Specialist

Loon Nest Surveys
Kristin Carlson, Ecologist
Kevin Woizeschke, Nongame Wildlife Ecologist
Kent Montgomery, Bird Survey Specialist

Vegetation Surveys
Stephanie Simon, Aquatic Biologist
Donna Perleberg, Aquatic Plant Ecologist
Aaron Johnson, Intern
Kyle Walker-O'Beirne, Intern

Sand Chain of Lakes
Sand Lake (31-0826-00)
Little Sand Lake (31-0853-00)
Portage Lake (31-0824-00)
Bird's Eye Lake (31-0834-00)

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Funding for this report was provided by the State Wildlife Grants Program, Game and Fish Funds, Heritage Enhancement Funds, and by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR).

How to cite this document:
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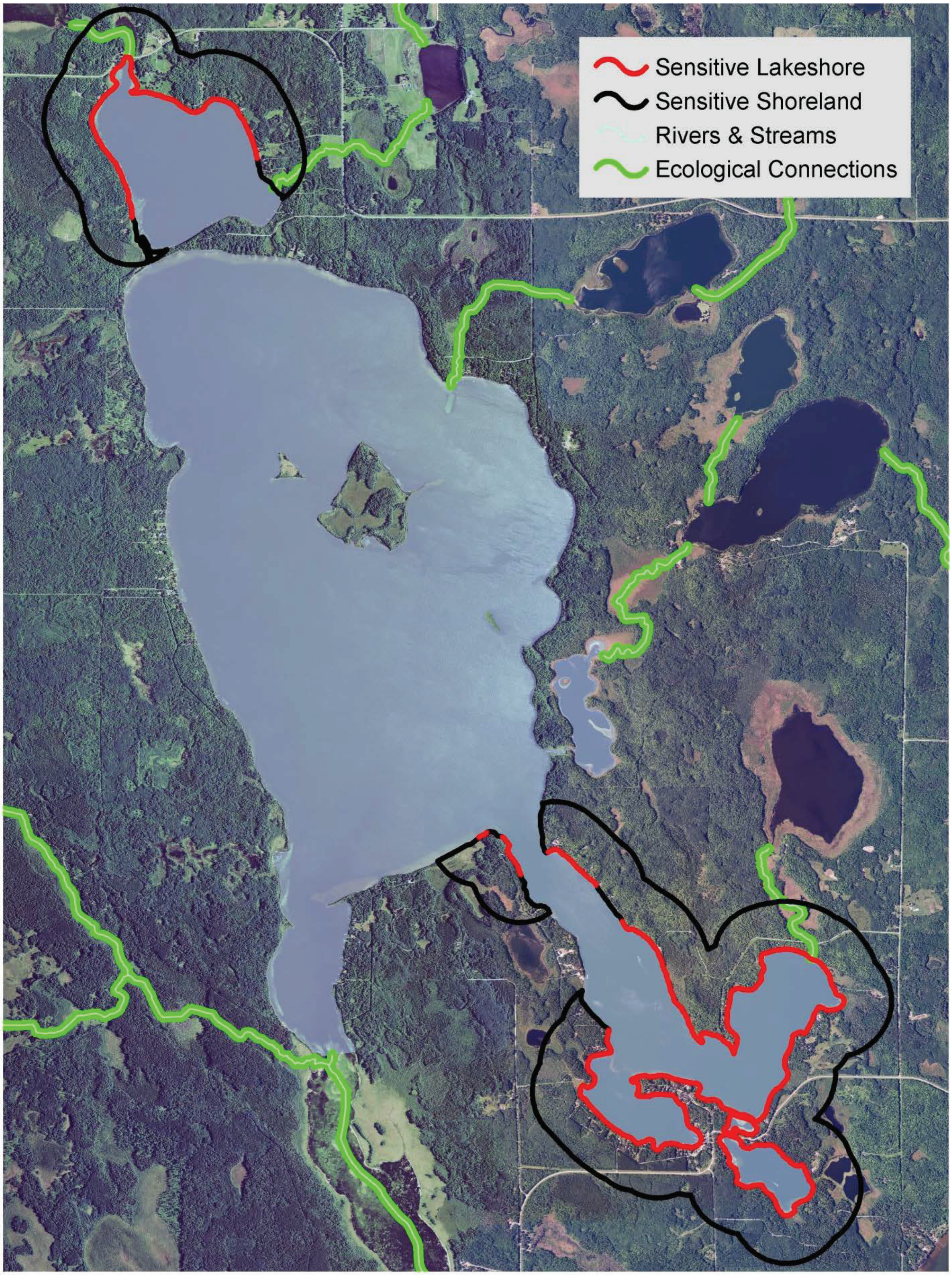
Executive Summary

Aquatic plants occurred around the entire perimeter of the Sand Chain of Lakes. Surveyors recorded 44 native aquatic plant species in the Sand Chain. The plant community included 26 submerged, four free-floating, five floating-leaf, and nine emergent species. Since 1957, this brings the total number of plant species that have been documented in these lakes to 46, making the Sand Chain among the richest in the state. Maximum depth of plant growth was to 20 feet in Sand Lake. Floating-leaf and emergent plant beds covered 388 acres. Bird's Eye and Portage lakes had the greatest percent of shallow water occupied by emergent and floating-leaf plants. In addition, two unique submerged aquatic plant species were located within the Sand Chain of Lakes.

Three proxy fish species (blackchin shiner, blacknose shiner, and banded killifish) were documented in the Sand Chain of Lakes in 2012. In total, surveyors identified 29 fish species in the Sand Chain of Lakes. Green frogs were not documented during the frog surveys, but mink frogs were recorded at various locations along the lake shorelines. Four loon nesting areas were identified on the Sand Chain of Lakes in 2012.

The ecological model identified two primary sensitive lakeshore areas to be considered for potential resource protection districts by Itasca County. These stretches supported the greatest diversity of plant and wildlife species, including species of greatest conservation need. The ecological model displays these areas both as sensitive shoreline and as high priority shorelands. The rivers and streams connected to the Sand Chain of Lakes are also an important part of the ecosystem. They provide valuable connectivity between the lakes and nearby habitat. The county may use this objective, science-based information in making decisions about districting and reclassification of lakeshore areas. The most probable highly sensitive lakeshore areas and the recommended resource protection districts are: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Sensitive Shoreland
Rivers & Streams
Ecological Connections

Final Report
Sensitive Lakeshore Survey
Turtle Lake (31-0725-00)
Itasca County, Minnesota

January 2014

STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF ECOLOGICAL AND WATER RESOURCES

Full report is available online at: https://z.umn.edu/shorelandadvisors in the "Articles" folder.

A Product of the Intra-Lake Zoning to Protect Sensitive Lakeshores Project

Application of Minnesota's Sensitive Lakeshore Identification Manual: *A Conservation Strategy for Minnesota's Lakeshores*

Prepared by
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Loon Nest Surveys
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Funding Support:
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Alternative format available upon request.

Executive Summary

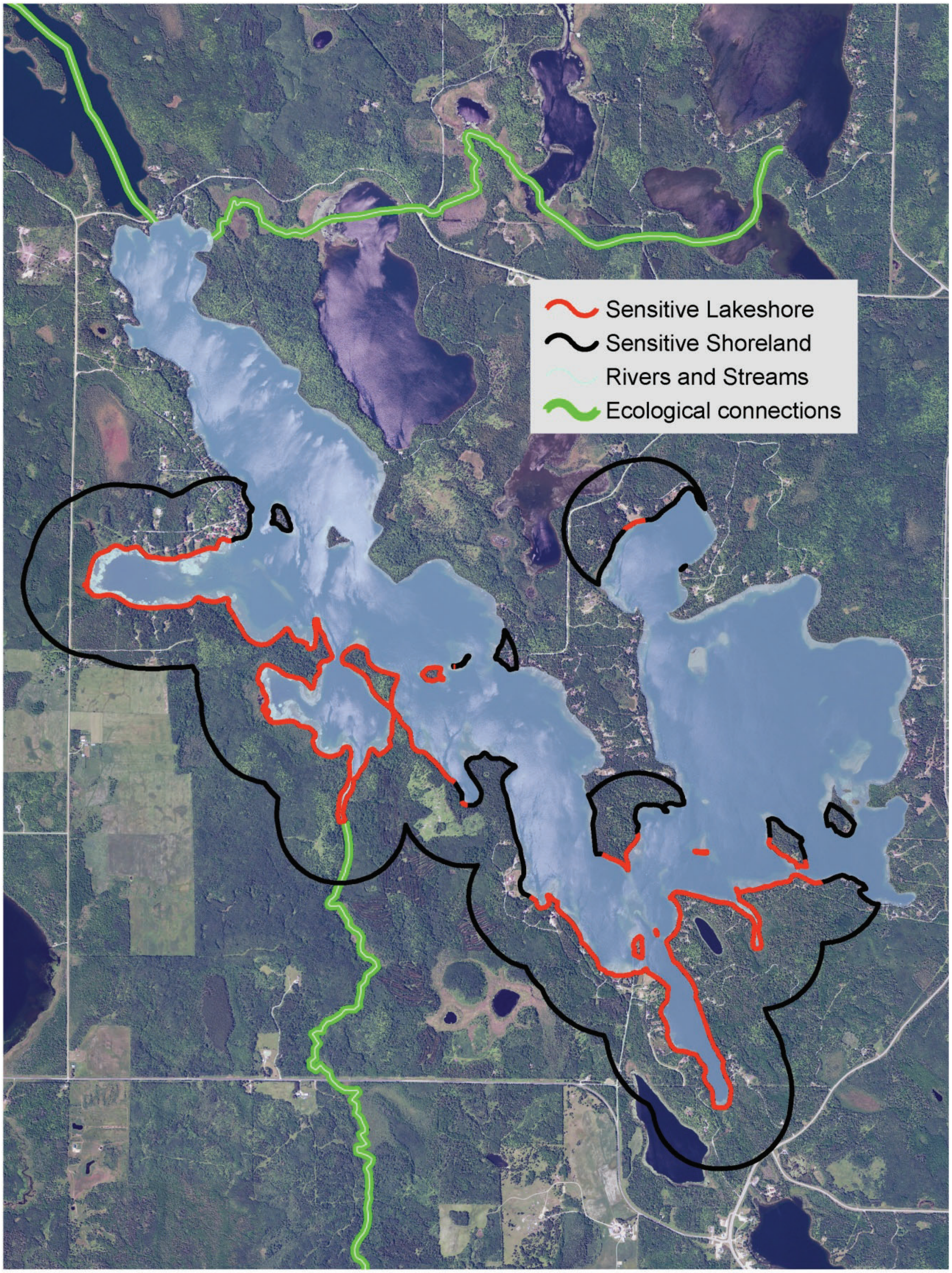
Key attributes of the flora, fauna, and physical habitat throughout the shoreline of Turtle Lake were comprehensively assessed using the Minnesota Department of Natural Resource's sensitive lakeshore identification procedures and incorporated into GIS maps. Each of the thirteen attributes was scored and combined using a standardized procedure to identify three sensitive lakeshore zones. In total, about 10 miles of lakeshore in Turtle Lake was identified as sensitive and included Moose, Sager and Newberg Bays, a significant stretch of the lake's western shore, and four islands.

A total of forty-four native aquatic plant taxa were documented in Turtle Lake, including 27 submerged, six floating-leaf and 11 emergent taxa. Submerged aquatic plants occurred around the entire perimeter of Turtle Lake and plants were found to a depth of 25 feet. Plant occurrence was greatest in depths from 0 to 15 feet, where 94% of the sites were vegetated. Common submerged plants included muskgrass, stonewort, greater bladderworts, narrow-leaf pondweeds, flat-stem pondweed, watermilfoils, and naiads. Floating-leaf plants, including white waterlily, yellow waterlily, watershield and floating-leaf pondweed, occupied about 81 acres. About 229 acres of bulrush were mapped. Six unique plant taxa were also documented in Turtle Lake.

One near-shore fish species of greatest conservation need, the pugnose shiner, was detected at several locations during the 2013 nongame fish surveys on Turtle Lake. Three proxy species, the blacknose shiner, blackchin shiner, and banded killifish, were noted at multiple survey sites. Total fish species diversity recorded during the nongame fish surveys was 19 species.

Both green frogs and mink frogs were documented during the Turtle Lake frog surveys. Green frogs were recorded more frequently than mink frogs, and were heard at approximately 36% of the survey sites. Frog locations were primarily within the protected bays and shallow non-windswept shorelines around Turtle Lake. Other anuran species documented at Turtle Lake included gray tree frogs.

The ecological model identified three primary sensitive lakeshore areas to be considered for potential resource protection districting by Itasca County. These stretches supported the greatest diversity of plant and wildlife species, including species of greatest conservation need. The ecological model displays these areas both as sensitive shoreline and as high priority shorelands. The rivers and streams connected to Turtle Lake are also an important part of the ecosystem. They provide valuable connectivity between the lakes and nearby habitat. The county may use this objective, science-based information in making decisions about districting and reclassification of lakeshore areas. The most probable highly sensitive lakeshore areas and the recommended resource protection districts are highlighted on the map: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