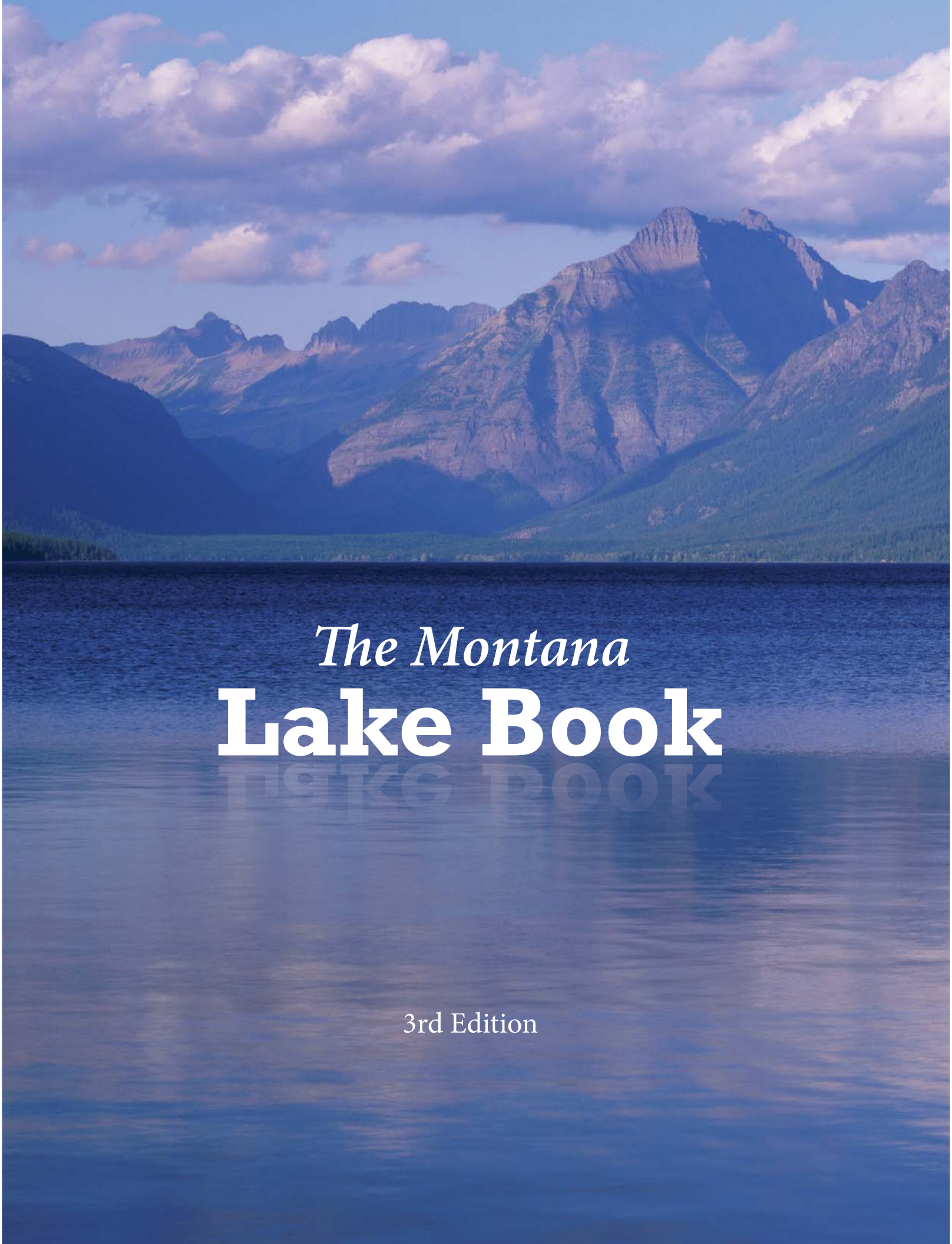

The Montana
Lake Book

3rd Edition

Bowman Lake, Glacier National Park. Photo courtesy gravityshots.com

What is a Lake?

A lake is an area of variable size filled with water, lying on the surface of a continent, localized in a basin that is surrounded by land, and unconnected with the ocean except indirectly by rivers. *Limnology* is the study of lakes, rivers and wetlands.

So lovely was the loneliness of a wild lake. – Edgar Allan Poe

A lake carries you into recesses of feeling otherwise impenetrable. – William Wordsworth

Perhaps the truth depends on a walk around the lake. – Wallace Stevens

Be calm like a calm lake, then you will look beautiful like a beautiful calm lake! – Mehmet Murat ildan

Time wasted at the lake is time well spent. – unknown

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The Montana Lake Book Third Edition

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Front and Back Cover Lake McDonald, Glacier National Park: Photo courtesy of spiritofamerica

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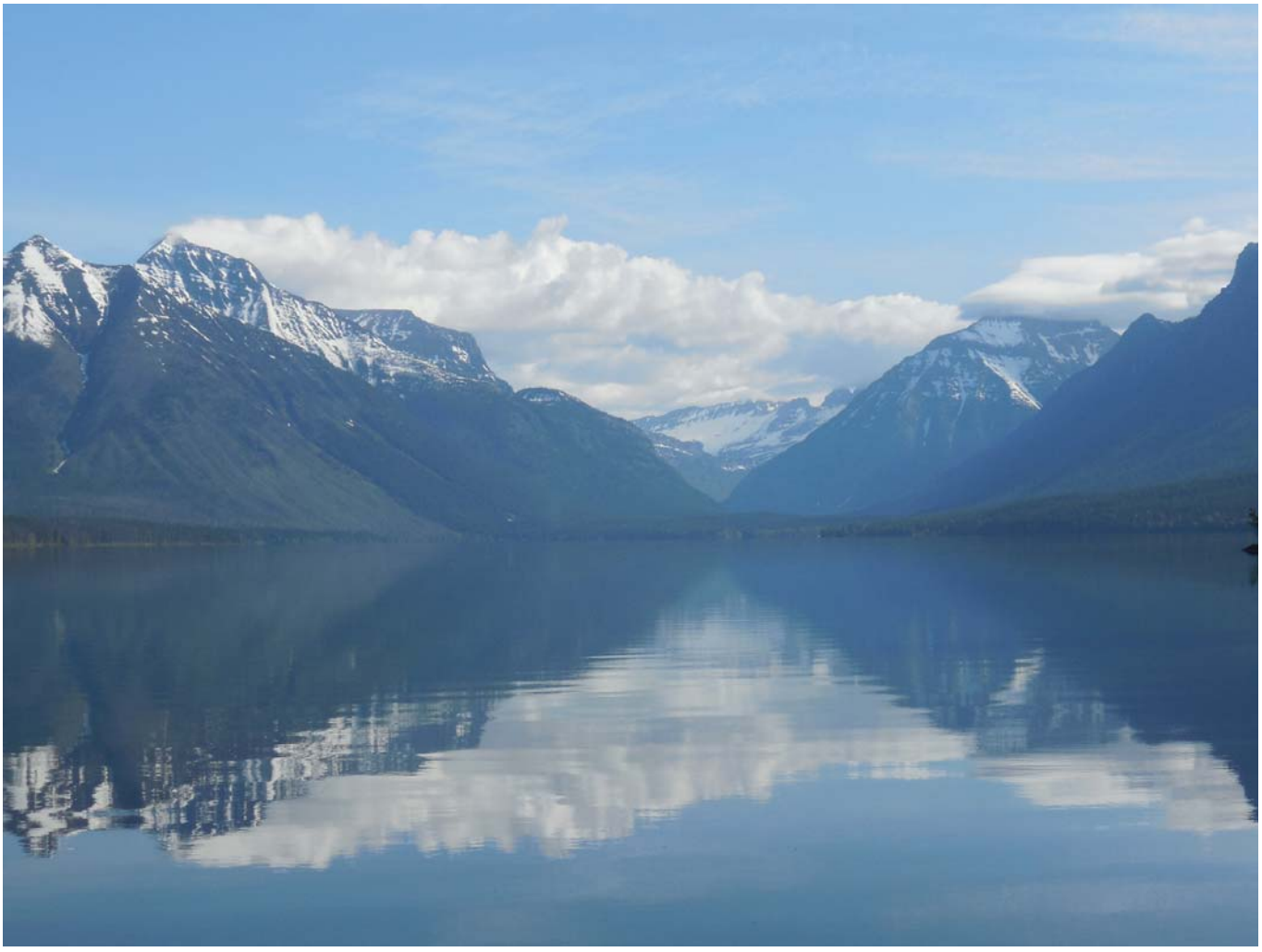
The Montana Lake Book, Third Edition, 2017

Welcome to the Third Edition of the Montana Lake Book.

The Montana Lake Book explains how lakes function, how they are threatened and how they can be protected. It also identifies simple actions we can all take to help protect and preserve the lakes of Montana.

Lakes are among our most valued – and most threatened – natural resources. They provide recreational and drinking water for people, and important habitat for fish and other wildlife. Despite these critical roles, few people understand how their daily activities can challenge the health of our lakes. Even those of us who live miles from a lake directly affect the lake's water quality. Learning to understand how simple changes in our behaviors can protect lake health is an investment in our future and in the legacy we leave for our children. Through these pages, you will learn how to protect our lakes while enjoying all they have to offer.

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



Lake McDonald, Glacier National Park. Photo courtesy Lori Curtis

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Bull Lake in Fall. Photo courtesy Whitefish Lake Institute

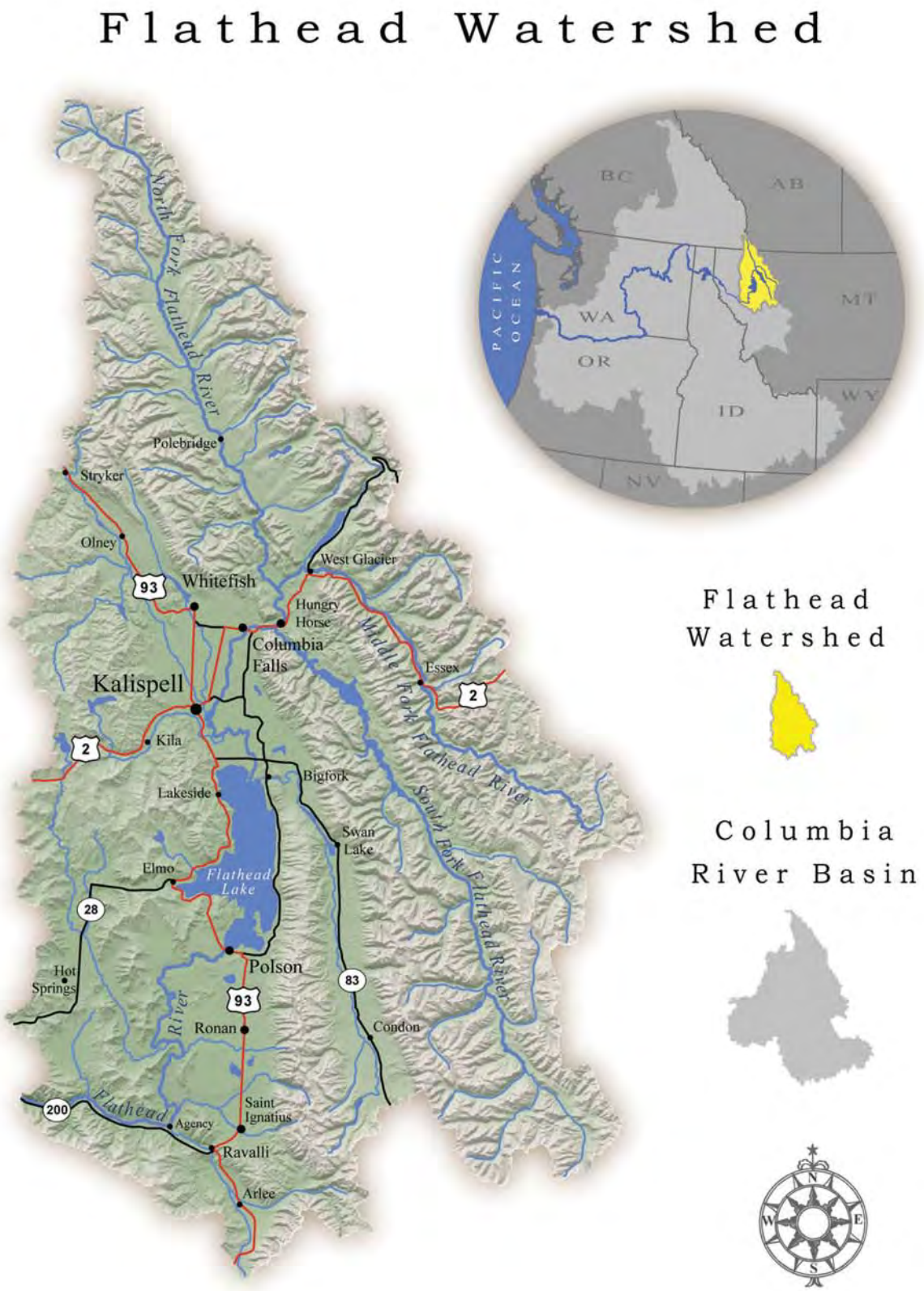


Figure 1. Sample Watershed: Flathead Watershed. Graphic courtesy Peter Petri/Mobile LoGIStics Mapping

What is a Watershed?

"…that area of land, a bounded hydrologic system, within which all things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community." – John Wesley Powell, American geologist, ethnologist, explorer and government administrator

We all live in a watershed—an area of land that captures, stores, and sheds water. The water that flows from the land eventually drains to waterbodies, from which most watersheds get their names.

Montana is home to some of the world's most interesting watersheds. For example, in Northwest Montana, the Flathead Watershed originates in Alberta, Canada in the north, flows through nearly six million acres of forests, farms, and cities, through the waters of the Flathead, Stillwater and Swan Rivers, and drains to Flathead Lake—the largest freshwater lake west of the Mississippi River. The Flathead River then serves as one of the headwater rivers of the Columbia River Basin, which drains to the Pacific Ocean in Astoria, Oregon. This international boundary-crossing watershed illustrates how upstream activities can affect downstream neighbors.

To outline a lake watershed boundary, one needs only to connect the highest points of elevation around a lake on a topographic map. Water falling within this area flows by gravity into streams and groundwater to the lake. Watershed boundaries can be quite large, so even if you can't see a lake or river from where you are, you can be sure that you are in a watershed. Imagine a drop of rainwater landing in your yard, a few miles from a lake. It flows downhill into the roadside ditch where it travels into a culvert under the road and empties into a stream that feeds the lake. Along the way it picks up phosphorus from lawn fertilizer, motor oil from the road, and sediment from the ditch.

All of these things end up in the lake, and they all contribute to declining water quality. Now imagine what happens when you multiply this one drop by the countless number of raindrops and snowflakes that fall within your watershed each year.

The Importance of Snowpack

Montana receives precipitation in the form of rain and snow. Runoff from rainwater and snowmelt may be captured and temporarily stored in one of Montana's many lakes and reservoirs.

West of the Continental Divide, the Clark Fork and Kootenai Basins have a Pacific Northwest climate, which is generally wetter and more temperate than the rest of the state. Higher elevations receive a heavy winter snowpack, and much of the area receives more rainfall than lands to the east.

The Water Cycle

Lakes are one part of the water cycle. Snowmelt and rainwater flow over the land and fill our lakes, rivers, streams and oceans. In a natural setting, water from rain and snow is cleansed and filtered by plants and soil. Some water penetrates deep into the ground to become groundwater, eventually discharging into lakes, rivers and oceans. Evaporation then starts the cycle over again. Lakes play an important role by containing, filtering and evaporating water and by recharging important underground aquifers.

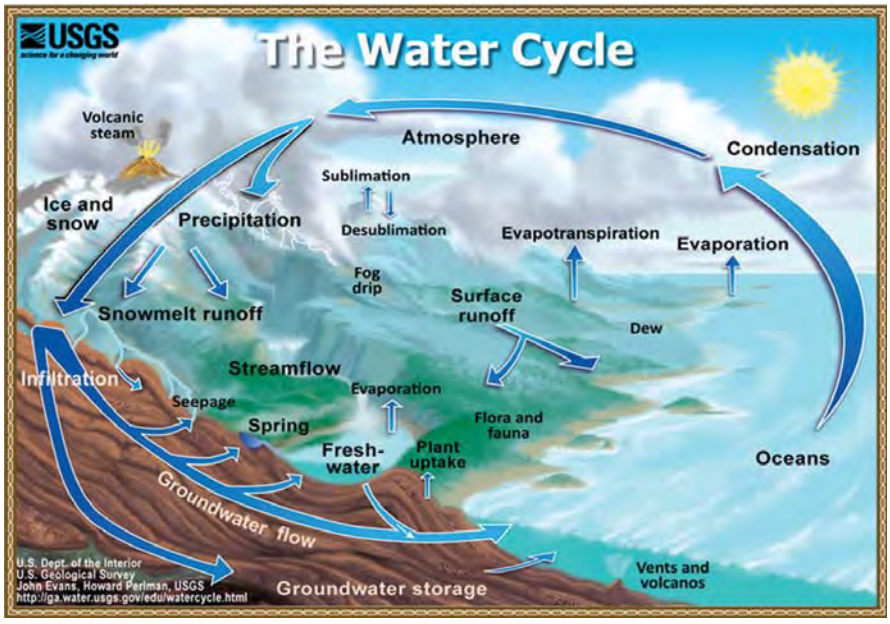


Figure 2. Watercycle. Graphic courtesy USGS

East of the divide, Montana is generally drier, windier, and experiences more extreme seasonal temperature fluctuations. Valley and prairie lands are arid to semi-arid, some receiving less than 10 inches of moisture a year. High elevations east of the divide can accumulate a heavy snowpack and also receive more rainfall than the lower elevations.

Montana's mountain snowpack serves as a natural reservoir for water that is released over the spring and summer months. The heaviest snowfall occurs between November and March, but heavy snowstorms can occur as early as mid-September or as late as early May. High elevation snowmelt runoff generally peaks in mid-June and trails off over the summer months. In the lower elevations, snow accumulation may runoff during February and March.

Adam Clark of USGS drilling snow on Sperry Glacier. Photo courtesy Dan Fagre USGS

Periods of drought may result in less winter snowfall and less water stored in the mountain snowpack. Periods of warmer temperatures may or may not decrease the overall amount of precipitation Montana receives. Warm temperatures may result in more of the state's precipitation falling as rain rather than snow. Warmer temperatures may also cause the snowpack to melt sooner and faster shifting the peak period of runoff to earlier in the season. *See Chapter 7 - A Changing Climate for more information.*

How Lakes Function

Lakes are essential elements of the landscape for several reasons. They provide important habitat for wildlife including fish and other aquatic species, many species of birds, and a multitude of mammals. People enjoy lakes for their beautiful scenery and use them for recreational activities such as fishing, hunting and boating.

Lakes also provide important ecosystem services. They act as natural regulators of river flow, trapping sediments and nutrients from rivers and streams that flow into them. The riparian plants that grow along the shorelines help to stabilize the sediments and provide complex habitats for terrestrial animals.

Lakes can be divided into two basic habitats: deep, open water (*pelagic zone*) and bottom areas (*benthic zone*). The deep, open water zone is where we find free-floating organisms like microscopic phytoplankton (algae) and zooplankton (animals); and larger organisms like our many different fish species. In contrast, the benthic zone is where we find attached algae (*periphyton*) on the surface of rocks and other

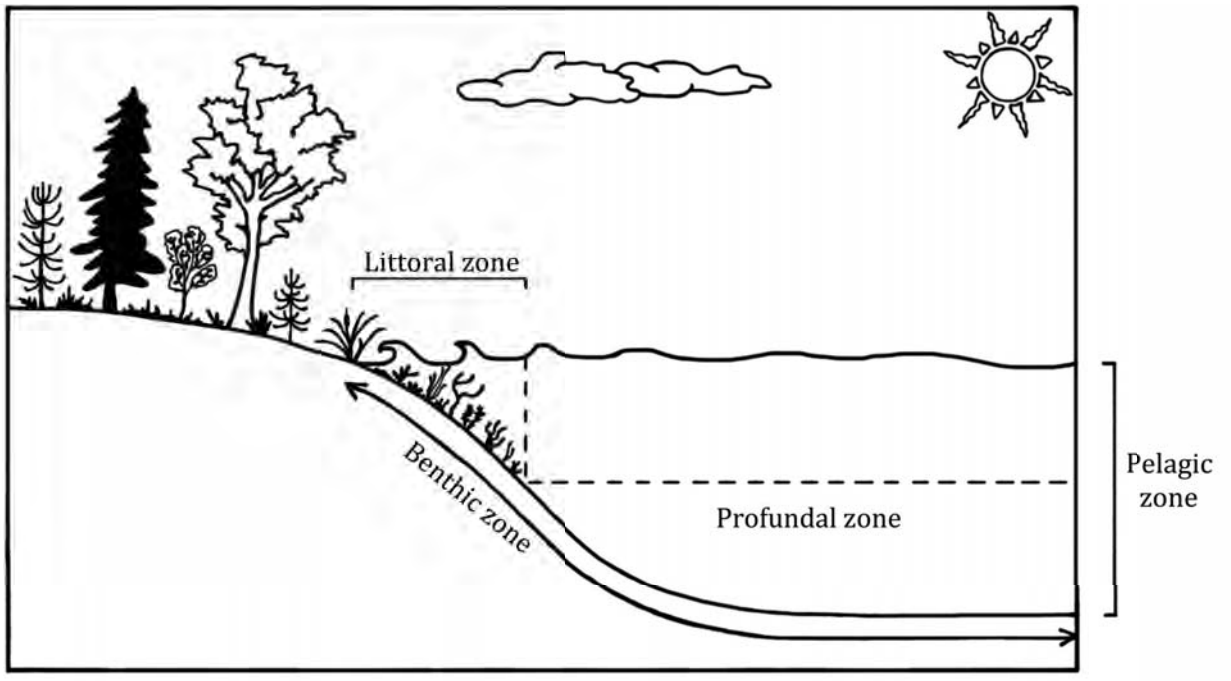


Figure 3. A cross-section of a lake depicting the zones that organisms inhabit. Diagram courtesy Flathead Lake Biological Station

substrates, larger macroalgae, macroinvertebrates (e.g. insect larvae, snails, amphipods, clams, etc.), and young fish.

The benthic zone can be further subdivided into illuminated areas (*littoral zone*) where the algae are able to grow, and dark areas generally lacking vegetation (*profundal zone*). The profundal zone is characterized by a lack of photosynthetic organisms, but that does not imply a complete lack of life. Life in this zone is dependent on the contribution of organic carbon from other areas of the lake or surrounding watershed, for example, dead leaves, macroalgae, or phytoplankton. As decomposers break down this organic material, they use oxygen from the surrounding water. The depletion of oxygen levels in some lakes can disrupt the lake's community of fish and other animals that depend on well-oxygenated water. Increased nutrient inputs from human activity can also cause greater than normal decreases in oxygen in this zone of the lake.

Knowing Lake Food Chains
Each organism found within the pelagic and benthic zones serves an important ecological role in the complex food chains that support all levels of life found within and around lakes. All organisms in those food chains are influenced by non-living (*abiotic*) factors and living (*biotic*) factors in their environment. Abiotic conditions (e.g., temperature, pH, clarity, dissolved oxygen, nutrients, etc.) and biotic conditions (e.g., predation, disease, etc.) of the lake impact organisms in the food chain and help to provide a natural balance to the aquatic ecosystems.

Clearly not all lakes are alike. Some lakes are shallow, warm and contain many species of aquatic algae, fish and other life. Other lakes are deep, with a large volume of cold, well-oxygenated water. These lakes support fewer varieties of plant life and usually provide habitat for trout.

Lakes of all sizes and depths are found across Montana. The biggest threat to these lakes is deteriorating water quality. Once good water quality is lost, it is extremely difficult, if not impossible, and expensive to restore.

Nutrients: The Green Machines
Excess nutrients, such as phosphorus and nitrogen, are a major threat to lake water quality. These nutrients occur naturally in the environment, but their concentrations can increase beyond natural levels due to human (*anthropogenic*) activity such as decreasing or eradicating natural lakeside and streamside vegetation, over-fertilizing lawns and raising livestock close to lakes and streams. These higher nutrient concentrations can quickly overload lakes and negatively impact their aquatic life.

Food Chains and Food Webs

Food Chains follow just one path of energy as animals find food.

A Simple Food Chain Example
Phytoplankton are eaten by zooplankton
Zooplankton are eaten by small fish
Small fish are eaten by large fish
Large fish are eaten by osprey

Food Webs consists of many food chains. They show how plants and animals are connected in many ways to help them all survive.

A Simple Food Web Example
Trees produce nuts which are food for insects and mice
Mice provide food for snakes and coyotes
Nuts and insects are also food for birds and skunks
Skunks and mice provide food for hawks and foxes

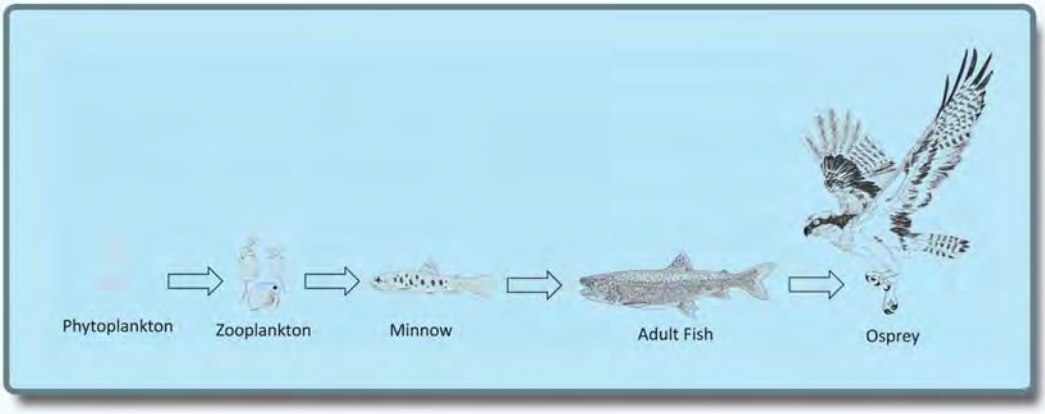


Figure 4. Typical Lake Food Chain. Diagram courtesy Flathead Lake Biological Station

Trophic State

Since the early 20th century, lakes have been classified according to their *trophic* state. Trophic means nutrition or growth. Although lakes are arranged into a few trophic classes, each lake has a unique set of attributes that contribute to its trophic status. The three main factors that regulate the trophic state of a lake are rate of nutrient supply, climate, and shape of the lake basin. Common trophic categories include:

- **Oligotrophic**: Deep clear lakes with low nutrients levels, little organic matter, and a high dissolved-oxygen level.
- **Mesotrophic**: Moderate nutrients levels and moderately productive in aquatic animal and plant life.
- **Eutrophic**: High nutrient levels and highly productive in aquatic animal and plant life.
- **Hypereutrophic**: Extremely rich in nutrients and minerals.
- **Dystrophic**: Brown or tea-colored water that is acidic due to organic matter input. Nutrient levels can vary but low dissolved oxygen levels affect aquatic life.

Nutrients feed microscopic plant-like organisms called *algae*. Algae are typically aquatic, photosynthetic organisms that lack true stems, roots, and leaves. Algae grow when they have adequate light, pH, temperature and nutrient conditions. Healthy lakes need algae since they are important primary producers for the lake. Algae are then eaten by zooplankton grazers, such as, daphnia (water fleas), copepods, and rotifers. The zooplankton are eaten by small fish, which are eaten by bigger fish, which again are eaten by animals higher in the food chain.

Blue green algae. Photo courtesy Flathead Lake Biological Station

A productive lake that provides food and habitat for wildlife and waterfowl starts with a solid base to the food web, in this case algae. However, excessive nutrients accelerate algal growth, which reduces water clarity and can lead to unpleasant odors. As algae die, they fall to the bottom of the lake and are decomposed by bacteria. As the bacteria consume the dead algae they deplete the oxygen levels in the surrounding water. Decreased oxygen levels make it difficult for fish and other aquatic animals to survive.

Many seemingly harmless activities added together can cause nutrient overloads. For example, disturbance of the natural landscape during the construction of a new home can increase nutrient concentrations in run-off. These high concentrations can continue if the surrounding landscape is not returned to its original condition. Removing natural vegetated buffers that filter and soak up nutrients allows an increase in nutrients of up to 10 times. Hard surfaces, such as sidewalks, driveways and rooftops, also increase nutrient loads by preventing run-off from soaking into the ground.

Checking Lake Water Quality

Montana has 1,417 named lakes, reservoirs, and ponds that are 5 acres or greater covering about 577,000 acres. These waterbodies include various natural lakes – alpine lakes and closed basin lakes (i.e., lakes with no surface outlet), as well as large reclamation and/or hydropower reservoirs. Protecting and restoring lake water quality and designated uses (primary contact recreation, drinking water, aquatic life and agriculture) is part of Montana state law and the federal Clean Water Act.

Knowledge and understanding of lake water quality and the pollutants affecting it helps to preserve our lake systems. Overall, nutrients and salinity are the most widespread pollutants in Montana lakes. Other pollutants of concern are metals, sediment, polychlorinated biphenyls (PCBs), pesticides and herbicides. Contaminants of emerging concern (e.g., pharmaceuticals and personal care products) are beginning to be studied to determine their ecological risk in lake systems and to human health.

Clarity

There are many measures of lake water quality, including clarity. Most people are concerned about how clear and clean lake water is, but clarity does not indicate lack of invisible toxic substances in the lake. Although clarity is often the most evident measure, other measures impact a lake's suitability for recreational activities, drinking, aquatic life, and agricultural activities. Expected levels of clarity are based on a lake's natural trophic state. Weather conditions, such as wind and rain, affect short term variability in clarity. Poor clarity may also indicate a nutrient overload because excess nutrients promote algal growth which decreases how far light can penetrate into the lake water.

One easy way to check water clarity is to use a Secchi disk. Scientists and volunteer citizen scientists use Secchi disks to monitor their lakes for possible changes in water quality.

Use of the Secchi Disk

By using this remarkably simple instrument, one can determine the general clarity of a lake. The observer lowers the disk into the water until it is no longer visible. At that point, the depth is recorded. By measuring Secchi disk depths regularly and over a period of years, historic changes in water quality can be determined and long-term trends established. Multiple measurements throughout the years tend to compensate for the variability caused by the observer and weather conditions. Examples of long-term Secchi depth data collection are shown in Figures 5 and 6.

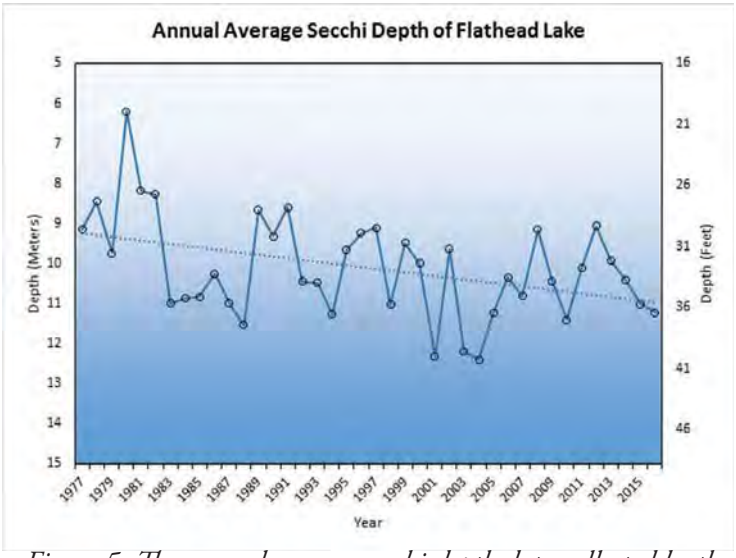


Figure 5. The annual average secchi depth data collected by the Flathead Lake Biological Station shows that the water clarity in Flathead Lake has improved slightly over time. Graphic courtesy Flathead Biological Station.

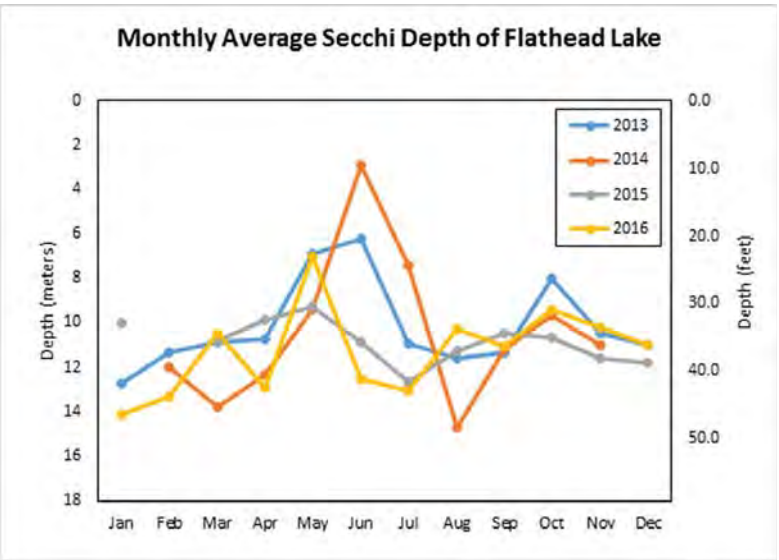
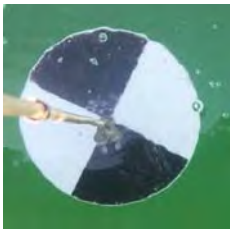


Figure 6. The monthly average Secchi depth data collected by the Flathead Lake Biological Station shows that there is great seasonality to the secchi depth in Flathead Lake throughout the year. For example, the graph depicts a large decline in clarity during the spring when there is peak flow in the river discharge from the spring snowmelt. Graphic courtesy Flathead Biological Station.

Water Clarity on Avalanche Lake. Photo courtesy Flathead Lake Biological Station



Secchi disk. Photo courtesy Flathead Lake Biological Station

The Secchi Disk

Father Pietro Secchi, an astrophysicist who was the scientific advisor to the Pope, invented the Secchi disk. In 1865, Secchi used white disks to measure the clarity of the water in the Mediterranean Sea. Various sizes of disks have been used since that time, but the most frequently used disk is an 8-inch diameter metal disk painted in alternate black and white quadrants.

Usage Suitability
In Montana, water quality is measured against established beneficial uses. These are the various ways that a water body is suitable for use by people, wildlife, and livestock. Montana's beneficial uses include **recreation**, **drinking water**, **aquatic life**, and **agriculture**. Water quality goals are based on the maximum amount of a pollutant a waterbody can have while still maintaining its designated beneficial uses. If a waterbody is determined to be "impaired," it means that its suitability for those beneficial uses are limited or harmed to some extent.

Suitability for Recreation
Lakes are valued for scenery, swimming, boating, and fishing, but under some circumstances these activities may not be desirable or safe. Algal blooms diminish recreation opportunities and might be toxic and potentially harmful. High fecal coliform bacteria counts at a local beach or in a bay can require temporarily closing an area to swimming. A day or two is usually sufficient to allow nature to lower bacteria counts, unless the source is a poorly maintained septic system or a break in a nearby sewer line.

Suitability for Drinking
Do not drink lake water without disinfecting it. Bacteria, viruses, parasites and toxic algae in the water can cause sickness. Bacteria may naturally occur or come from a malfunctioning septic system, a sewage treatment plant, or stormwater runoff.

Suitability for Aquatic Life
Wildlife including fish and other aquatic organisms rely on suitable water quality conditions for their habitat and survival. Pollutants may cause a decline or disappearance of some species and a dominance of others, shifting the lake food web, and altering the lake dynamics. Another path that is important to consider is the bioaccumulation and biomagnification of pollutants, such as heavy metals, in the food web. This poses a risk to humans consuming fish from contaminated lakes. The pathway of bioaccumulation and biomagnification is not always known and may vary between pollutants.

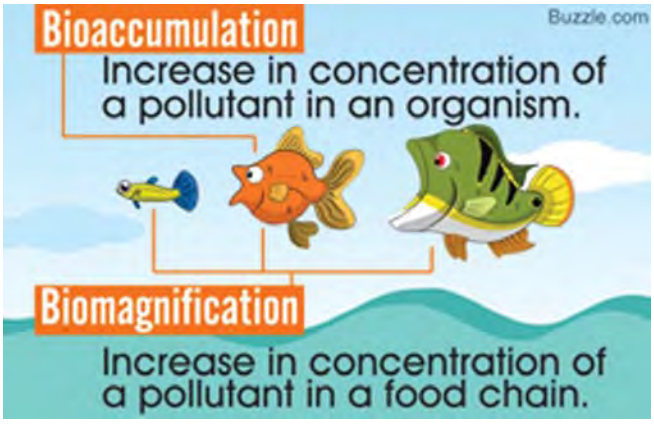


Figure 7. Bioaccumulation vs. Biomagnification, Graphic courtesy Buzzie.com

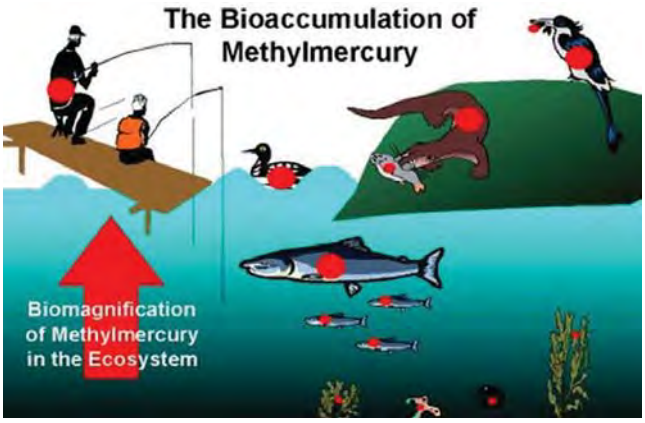


Figure 8. Bioaccumulation. Graphic courtesy Buzzie.com

Algal bloom. Photo courtesy Gallatin City-County Health Department

Lake Closure Sign. Photo courtesy San Jose Parks, Recreation & Neighborhood Services

Bighorn Lake - Investigating Biomagnification

Fish tissue samples obtained from Bighorn Lake contained some of the highest mercury concentrations (1.1 ppm average in walleye) measured in a nationwide assessment (U.S. Environmental Protection Agency, 2009). Very small amounts of mercury (Hg) (sub-parts-per-trillion levels) in combination with stagnant, low oxygen, is converted by microorganisms to methylmercury. Methylmercury is readily accumulated in aquatic organisms, resulting in biomagnification and bioaccumulation of Hg in organisms up the food chain. Reservoirs with stagnant side canyons, such as Bighorn Lake, could provide an ideal environment for microbial mercury methylation because of the flushing with fresh, oxygenated water that occurs in these areas.

The U.S. Geological Survey, in collaboration with Montana Fish Wildlife and Parks and Montana State University have begun to characterize the sources and concentrations of Hg in Bighorn Lake by collecting fish, water, sediment and microbial samples. The increased knowledge of biogeochemical cycling and transfer of Hg through the food web to top predators could identify management strategies that reduce metal concentrations in Bighorn Lake fish.

David Naftz and Elliott Barnhart of USGS collecting water from Bighorn Lake for mercury analysis.

U.S. Environmental Protection Agency, 2009, The National Study of Chemical Residues in Lake Fish Tissue, EPA-823-R-09-006, https://www.epa.gov/fish-tech/national-lake-fish-tissue-study-fish-tissue-analysis

Bighorn Canyon National Recreation Area in Southeast Montana. Photo courtesy National Park Service

Suitability for Agriculture
Many of Montana's lakes are used to irrigate pastures and crops or provide drinking water for livestock. High levels of salinity, a common pollutant, may make water unsuitable for irrigation depending on the salt tolerance of the crop. It is important that livestock have access to clean water, as water with high levels of salinity or other contaminants can cause ailments or inability to drink the water.

Citizen Science & Community Involvement
There are a numerous ways in which citizens contribute to water quality sciences. Volunteer monitoring, lake associations, school groups, and watershed groups all play a part in monitoring water quality.

Volunteer Lake Monitoring

There are many concerned citizens throughout Montana who participate as volunteers in water quality monitoring programs. A good example of such participation can be found in the *Northwest Montana Lakes Volunteer Monitoring Network* (NWMTLVMN). The NWMTLVMN is a citizen science program funded by Montana Fish, Wildlife & Parks, and managed by the Whitefish Lake Institute.

Currently, over fifty volunteers monitor over fifty locations on forty-one lakes in Flathead, Lake, Lincoln and Missoula counties. Program volunteers are trained to collect long-term water quality information for the lakes and to provide a front line of defense in early detection monitoring for aquatic invasive species (AIS).

NWMTLVMN Volunteer Kim Corette. Photo courtesy Whitefish Lake Institute

Create or Join a Lake Association

Creating a lake association or becoming a member of one has many benefits for the lake on which you live or recreate. Some of the benefits are:

- Increased public awareness about your lake, the recreational and ecological benefits it has to offer, and the issues which potentially impact the lake and its habitat;
- Better protection for your lake and its wetlands, wildlife and fish as the association works with elected officials and other non-profit organizations;
- Enforcement of environmental and safety laws;
- Support for legislation that protects your lake and other Montana waters;
- Improvement of your lake's public access sites;
- Improved water quality;
- Elimination or reduction of pollution in lakes;
- Being part of a community that shares your love and respect for your lake.

Please consider joining your local lake association or creating one if your lake doesn't already have one.

Lake Association Meeting. Photo courtesy Flathead Lakers

Student Engagement

Whitefish High School's **Project FREEFLOW** is an advanced high school field science program. Its purpose is to provide students with an opportunity to acquire and analyze water quality and habitat assessment data, develop an understanding of natural resource management and study current environmental issues.

FREEFLOW has been involved with aquatic field science work for the past 20 years. Projects include water quality sampling, bank rehabilitation projects, and GIS field mapping throughout the Northern Rocky Mountains.

Students participate in organizational meetings, conduct field studies, process and download data using GIS software, listen to professional presentations, perform technical writing, present research findings to the public, and participate in the Montana State Envirothon competition.

FREEFLOW students have the opportunity to work with professional scientists and participate in extended wilderness experiences every summer.

FREEFLOW Students recording water quality values. Photo courtesy Whitefish Lake Institute

Montana Watershed Coordination Council (MWCC)

The MWCC has been cultivating broad-based support for community driven approaches to managing complex land and water issues for over twenty years as the statewide organization representing each of more than 60 watershed groups. MWCC maintains a directory of Montana's watershed groups.

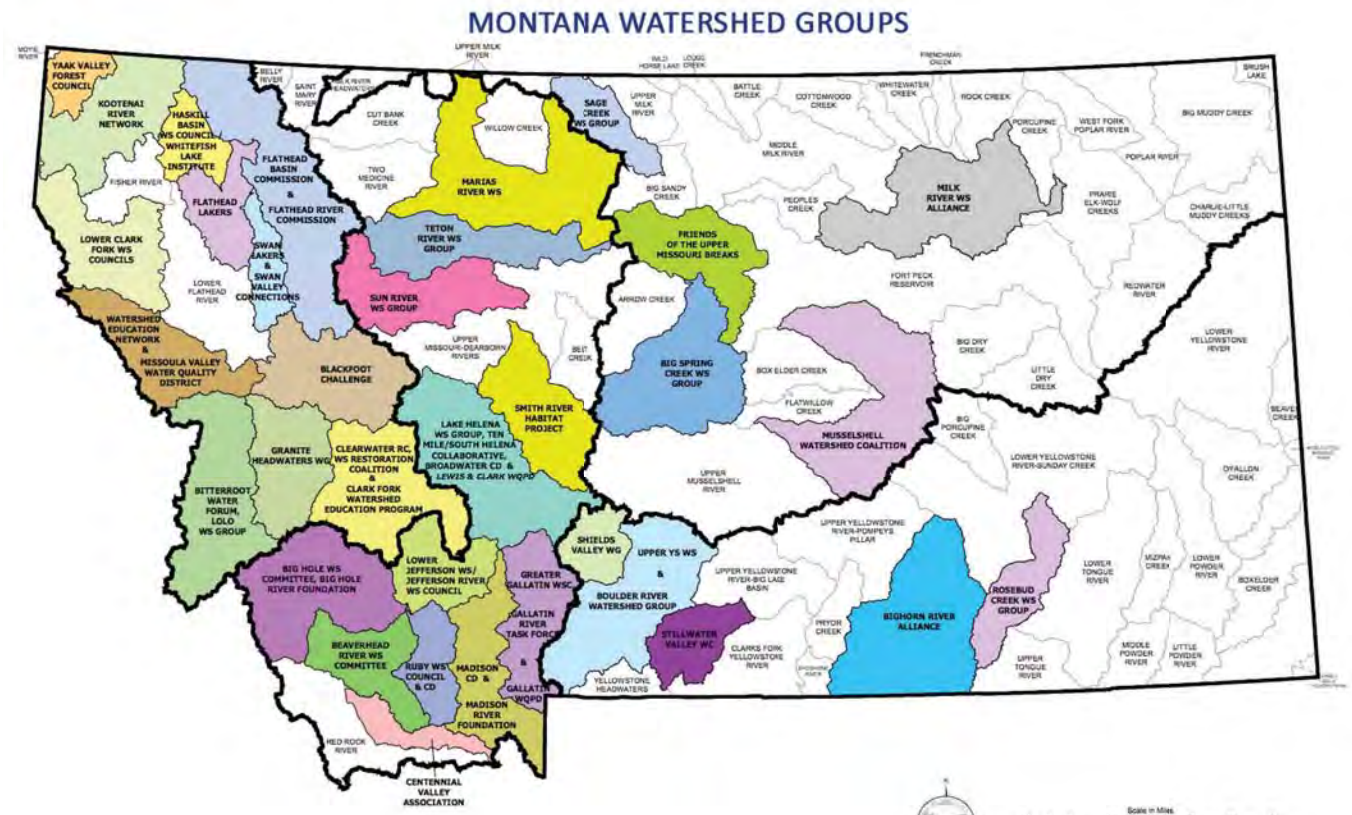


Figure 9. Montana Watershed Coordination Council (MWCC) Watershed Group Map. Graphic courtesy MWCC

Flathead Lake/Polson. Photo courtesy www.larrymayer.com

Chapter 1
LEARN MORE ABOUT

Montana Water Resources

Headwaters to a Continent: A Reference Guide to Montana Water Resources
http://mtwra.org/

Montana Watercourse
www.mtwatercourse.org/Publications

Who Does What With Montana's Water: A Directory
Montana State University
www.water.montana.edu

Lake Science

North American Lake Management Society (NALMS) www.nalms.org

Volunteer Lake Monitoring Programs

Northwest Montana Lakes Volunteer Monitoring Network www.nwmtlvmn.org

Watershed Groups and Lake Organizations

Montana Watershed Coordination Council
http://mtwatersheds.org/app/

Kintla Lake, Glacier National Park. Photo courtesy Walt Curtis

Waterfront Property
Living on or near a lake offers many benefits to homeowners, including a scenic viewshed, recreational access, and increased property value. However, these benefits come with responsibilities. One of the most important things lakefront homeowners can do is to become involved with their local lake associations to understand the most pressing issues of their lake. Joining with fellow citizens on collective lake protection efforts can yield the greatest benefits for both homeowners and for the lake.

The following considerations are applicable for everyone developing and maintaining property, particularly in areas near lakes, rivers and streams.

Designing and Maintaining Your Homesite with Care
Where on your property you build your home makes a big difference in protecting water quality. Start by checking with your local planning office to find out about waterfront building rules and codes.

When designing your site, set back all buildings at least 100 feet (or the greatest distance possible) from the high water mark and leave a minimum 100 foot buffer of natural vegetation along the lakeshore or streambank. Paths leading down to the water should be as narrow as possible and wind gently down to the water so that run-off does not have a direct route to the lake or stream. Locate buildings on slopes with less than a 20% grade. There is a greater likelihood of erosion on steeper slopes, which will cause water to run directly into the lake.

When designing or renovating your homesite, try to minimize areas of impervious surfaces like driveways, patios, or roofs, or choose alternative building materials that allow water to filter into the ground. Also, consider the area above your shoreline as the last opportunity to filter out harmful pollutants and sediments from stormwater runoff. Create, maintain or restore riparian buffer areas so that they can absorb and filter water from rooftops, driveways and other impermeable surfaces, thereby helping to protect your lake.

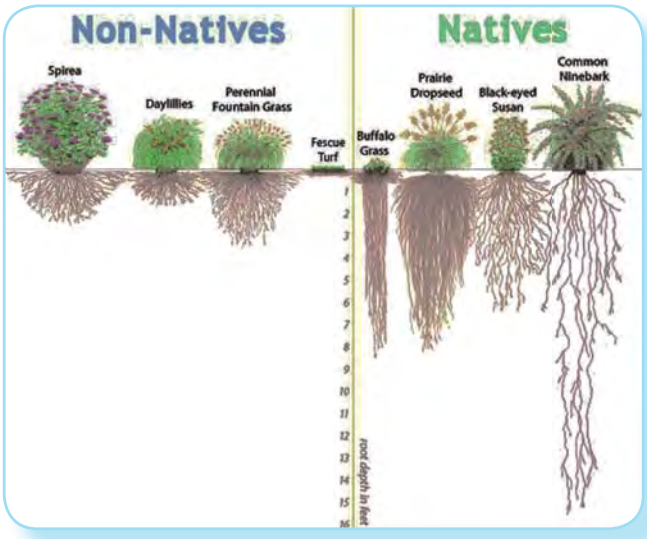


Figure 10. Non-native vs. native root growth. Graphic courtesy allianceforthebay.org

Riparian Buffers
Land adjacent to lakes, streams and rivers is called the riparian buffer. Properly functioning riparian buffers are areas of undisturbed native vegetation composed of trees, shrubs, wildflowers and a thick duff layer (pine needles, bark mulch, or ground cover). When left undisturbed or replanted with native species (not lawn grass or ornamental trees), riparian buffers help filter pollution from run-off coming from our homes, work and recreation areas.

The vegetation in the buffer soaks up excess nutrients and absorbs pesticides, herbicides and other pollutants before they reach a lake or stream. If these nutrients reach a water body, they may cause an algal bloom and degrade water quality. Riparian buffers also help contain sediment that is carried by run-off, another pollutant that can degrade water quality. Maintaining or enhancing a natural and functioning riparian buffer is the best way to keep our lakes and streams clean.

The Benefit of Native Plants

Native plants provide multiple benefits to people and contribute to maintaining healthy wildlife habitat. Once established, native plants seldom need watering, mulching, protection from frost or ongoing maintenance. They produce nectar, pollen, and seeds that serve as food for bees, birds, butterflies, and other wildlife. According to the USDA Natural Resources Conservation Service (NRCS), native plants provide the following benefits:

Economic
- Lower Water and Maintenance Costs
- Enhanced Real Estate Values
- Increased Survivability of Plantings
- Edible and/or Decorative Products

Environmental
- Improved Water and Soil Conservation
- Reduced Use of Petroleum Products
- Improved Air Quality/Carbon Sequestration
- Enhanced Urban Wildlife Habitat
- Reduced Water Contamination

Aesthetic
- Increased Year-Round Visual Interest
- Increased Urban Wildlife Viewing
- Encouraged Link with Nature
- Enhanced Quality of Life

Keeping It Natural and Sharing the Views
People value lakes because of their natural and scenic beauty, but no one person owns the view. Lakeshore property owners have a responsibility to protect views toward and from the lake. Think of yourself as a partner with others; keep your section of the lakeshore as close to its natural state as possible and encourage your neighbors to do the same. At the same time, you will protect water quality and wildlife habitat.

- Minimize your building area.
- Keep the shoreline free from permanent structures like boathouses and gazebos.
- Maintain a scenic shoreline by leaving an undisturbed and functioning vegetated riparian buffer.
- If you (or someone before you) removed the native vegetation, plant a new riparian buffer garden using beautiful Montana native plants and encourage other existing natives to flourish. Place new buildings far from the shore and paint them a dark color that blends with the landscape.
- Avoid bright outdoor lights.
- Limit pruning and clearing trees within 100 feet of the water.

How to Make a Beautiful Riparian Buffer Garden

Lakefront homeowners can create beautiful waterfront landscaping that also protects the lake.

- In areas where native vegetation exists, leave at least 100 feet (or the largest strip possible) of undisturbed vegetation between development and the water body.
- If vegetation has been previously removed, select a variety of native trees, shrubs, grasses and groundcover to replant the area. Use a thick layer of mulch to replace the natural duff layer. Consult your local agriculture extension agent or a native plant professional for a list of species that will work for your area.
- Leave the area as natural as possible, including slope, depressions and other irregularities.
- Limit hard surfaces such as patios, rooftops and driveways.
- Do not channel runoff. Where possible, direct excess runoff to flat, wet areas of your property. This adds an additional nutrient and sediment filter.

Waterfront Landscaping
Waterfront landscaping is important to consider whether you are maintaining a natural shoreline or enhancing or restoring your existing shoreline. Following a few lake-friendly tips and having a good landscape plan protects water quality, fish and wildlife, encourages native plants, and enhances the natural beauty of the area.

A sensible approach to waterfront landscaping improves natural habitat and reduces pollution and erosion, while also meeting your living and lake access needs.

- Enjoy the natural beauty and privacy of your site by maintaining large areas of native trees and vegetation. Native plants require less maintenance than other plants and are more likely to survive and provide better wildlife habitat.
- Keep lawns, vegetable gardens and other cleared areas small.
- Don't rake leaves or other forest floor debris; they help trap and filter water and prevent erosion.
- Never use fertilizers in riparian buffer areas and minimize their use in adjacent upland areas. If you must fertilize, apply small amounts over a period of weeks. Never apply fertilizer before or right after a heavy rain or when plants are dormant.
- Choose natural herbicides or pesticides for lawns and gardens. Chemical toxins are poisonous and are easily carried into nearby water bodies.

Protect the Natural Shoreline
A general rule of thumb is that no beach is a good beach – unless it was formed naturally over time. Sand and rocks dumped unnaturally are pollutants that will eventually wash away, requiring continual re-supply. They can also contain nutrients and destroy critical bird, amphibian and fish habitat.

- Leave existing rocks and aquatic plants to break the waves from boats and wind. These prevent erosion and stabilize the shoreline.
- Use temporary docks that are put in and removed seasonally. Don't build a permanent dock as these structures can disturb bottom habitat, alter wave patterns and cause erosion.
- Use the best products available. Avoid using creosote or pressure treated wood and white Styrofoam. New plastic and vinyl products offer good alternatives.
- Use a public beach, boat launch or marina for access to the lake. By concentrating recreational uses in one area, you protect the shoreline habitat elsewhere.

- If you must build along the shore, remember that any alterations to the shoreline require a permit. Tribal lands may require a separate permitting process. Check with your local planning and building department to determine what kind of permit you need.
- Seawalls and rip-rap: *Just Say No.* These changes to the shoreline increase wave energy in the lake and erode adjacent properties. They also change natural currents, alter beach dynamics and impact shallow water habitat that is important for invertebrates, fish and many other species of wildlife.
- Your local conservation district can provide information about waterfront landscaping and protecting natural shorelines.
- Your local lakeshore regulations will let you know what is allowed on your lake.

Understanding Your Septic System

Approximately 30% of U.S. households have on-site "septic systems." Septic systems consist of a **tank** that receives household effluent from toilets, sinks, showers, and washing machines; a **leachfield/drainfield**, and **plumbing pipes** to connect the system**.** Septic "leachate" is the liquid that remains after wastewater drains though septic solids. The liquid contains elevated concentrations of bacteria and organic compounds from waste and other household materials.

When properly placed, functioning, and maintained, septic systems are designed to collect wastewater and neutralize contaminants before they enter ground or surface water systems. This is particularly important where ground and surface water drain to water bodies such as lakes. Decomposition of waste begins in the septic tank and ends in a leachfield after undergoing a series of treatments whereby wastewater is chemically, physically, and biologically processed to remove contaminants.

Modern septic systems are considered cost-effective wastewater treatment, however improper initial system design, impermeability of soil, improper soil drainage, incorrect vertical distance between the absorption field and water table, unsuitable slope, or improper maintenance may lead to system failures.

Healthy shoreline development. Photo courtesy Whitefish Lake Institute

Even when properly installed and maintained, septic systems have a finite life expectancy.

Many of the septic systems around Montana lakes have remained in function long past their life expectancy, posing a great threat to lakes and other waterbodies. There are a number of steps you can take to ensure that your septic system does not contaminate your lake.

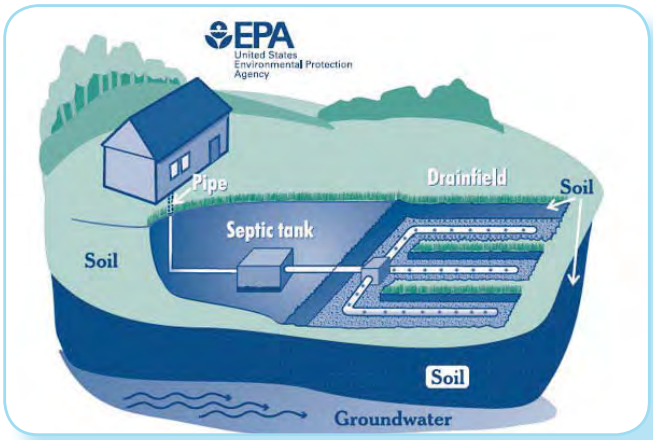


Figure 11. Typical Septic System. Graphic courtesy U.S. Environmental Protection Agency

Installing

- Be sure your professional installer follows the rules and codes in your area for proper septic system design and installation.
- Install a properly designed and approved septic system located as far as possible from water, at least 100 feet.

Operating and Knowing What to Flush

- Have the sludge level in your septic tank checked every one to three years. When checking the sludge level, also have them look at the tank to be sure the concrete is in good condition. A tank may last many years, but if you see signs of cracking or chipping, check with your county sanitarian.
- Conserve water. The less water you use, the better your septic system will work. Also give the system a rest after heavy use.
- DON'T use commercial products that claim to clean your septic tank without pumping. These products can clog your leach field and many contain chemicals that can contaminate groundwater.

Maintaining

- Have your septic system professionally inspected and pumped every 3-5 years depending on household size and use. If solids are

not removed, they can wash into and clog the leach field.
- Avoid using chemicals that kill microorganisms.
- Organize neighborhood septic tank pumping. Pumpers usually reduce the price for large volume jobs.

Septic System Facts
Nationally, over 28 thousand miles of streams are designated as "threatened or impaired" because of septic system failure and sewage pit waste, and lakes across the country are suffering eutrophication from septic leachate. Numerous studies show that septic leachate from household systems is transported by groundwater through lake bottom sediments into lake water, elevating nutrient concentrations and decreasing water quality and safety.

Septic leachate is a Nonpoint Source Pollution which comes from dispersed human activities such as septic systems, excess fertilization, high densities of livestock, domesticated pets, airborne deposition, and industrial runoff. Great strides have been made to deploy Best Management Practices in decreasing fertilization, protecting waterways from livestock and pets, installing wells at great distances from septic systems, and managing stormwater. However, decreasing septic leachate pollution is difficult because individuals are responsible for their own systems.

Although parasitic diseases, hormones, pharmaceutical compounds, and increased levels of nitrogen and phosphorus from these systems are compounding in our lakes and streams, there are no federal regulations for septic systems.

Pharmaceuticals and Personal Care Products: Chemical Cocktails
In the United States, pharmacists fill over three billion prescriptions a year. In addition to this, undocumented amounts of over-the-counter medications are purchased by consumers. Local and national studies have found prescription and over-the-counter pharmaceuticals in rivers, groundwater and municipal drinking water supplies. Unfortunately, septic systems, wastewater treatment plants and drinking water treatment facilities are not yet designed to treat these contaminants. It is critically important to lake water quality and human health that we prevent the transport of these contaminants into our water bodies. Although the federal government does not have a national policy on pharmaceutical disposal, here are some recommendations: Do not flush medicines down the sink or toilet unless disposal instructions indicate that this is the right mechanism. Contact a local waste management office for local options and guidelines. Many counties and cities in Montana have pharmaceutical collection locations where you can safely dispose of unwanted or expired pharmaceuticals.

If you have pharmaceuticals that cannot be otherwise disposed of, the most current advice is to mix the contents with kitty litter or coffee grounds, seal them in a container and dispose of them with your trash.

A 2008 *Montana Water Center Newsletter* reported that a joint study between the Montana Bureau of Mines & Geology and the Montana Department of Environmental Quality surveyed ground water beneath the Helena Valley on two occasions in 2005.
They tested 35 domestic water supplies, and found 22 compounds classified as "pharmaceuticals or personal-care products." These included antibiotics, painkillers, anti-inflammatory and seizure-control drugs, anti-depressants, estrogens and androgens, caffeine, plasticizers, insect repellent and an herbicide.

Pharmaceuticals. Photo courtesy Kewnj

Use and Dispose of Hazardous Materials Responsibly
- Pharmaceuticals often leach into groundwater and cause contamination of drinking water. Many counties and cities have a pharmaceutical and personal care product (PPCP) disposal program.
- Take advantage of your local landfill's hazardous material collection day. Check with your county to find out when the next collection day is scheduled.
- Reduce your use of toxic materials by replacing them with less hazardous products available at most home improvement stores.
- Store hazardous materials in contained, safe areas. Containment prevents contamination

of water supplies and protects lake water from undetected leaks.

- Dispose of paint thinners and other chemical products responsibly. Check the labels for proper disposal instructions. Do not pour them down the drain where they can damage water treatment systems, destroy septic systems and contaminate ground and surface waters.
- Allow unused latex paint to air dry in a well-ventilated place until it hardens, then put it in your garbage. This will help prevent toxic wastes from leaking into a landfill and eventually into groundwater.
- Allow used paint thinner and solvents to settle, then pour off the clear liquid and reuse. Air dry the sludge and put it in the garbage.
- Take used motor oils and petroleum products to a recycling or service station. These products and other toxic materials can usually be recycled. Never dispose of these products in drains or on driveways or roads.

Pet Waste and Water Quality

Pet waste poses a significant problem for water resources. Pet owners have the ability and responsibility to reduce the problem. Pollutants from improperly disposed pet waste is easily carried by stormwater from rain or melting snow. Stormwater in turn drains directly into lakes and streams. As this waste is broken down, it uses up oxygen and can release ammonia. Low oxygen levels, ammonia and warm temperatures combine to create a toxic environment that can kill fish and other aquatic species.

Pet waste also contains nutrients that encourage algae growth in waterbodies. Lastly, pet waste carries diseases, which can make water unsafe for swimming or drinking. Cleaning up after a pet is a simple task requiring only carrying a plastic bag (where they are not already provided) and/or scooper while walking pets.

After picking up pet waste, it can be flushed down the toilet or buried away from any water resources or wells. While cat litter should not be flushed down the toilet, cat feces can be scooped out and flushed. Used litter should be put in a securely closed bag in the trash. Be sure to check your local ordinances as putting pet waste in the trash is against the law in some communities.

Chapter 2

LEARN MORE ABOUT

Building & Landscaping

Montana Department of Environmental Quality
www.deq.state.mt.us
Local green building associations
Local Conservation Districts
Montana Native Plant Society
www.mtnativeplants.org
Local City or County Planning Offices

Septic Systems

Local City or County Health Departments
Local Water & Sewer Districts
Local Tribal Health Departments
U.S. Environmental Protection Agency
www.epa.gov/owm/septic

Disposing of Hazardous Materials

County Landfills
Local Solid Waste Programs

Hebgen Lake near West Yellowstone. Photo courtesy www.larrymayer.com

Farming and Fertilizers

In many lake watersheds, agriculture is a significant contributor to the economy, but also a source of nutrient pollution. One reason is that large expanses of bare or freshly tilled soil are prone to erosion. These soils are usually fertilized to enhance the growth of plants. Fertilizer ingredients typically include nitrogen, phosphorus and potassium in varying concentrations. If not carefully stored and applied, these fertilizers can also end up fertilizing our lakes. There are actions you can take to protect lake water quality and increase crop productivity.

- Plant winter cover crops, if needed, to reduce erosion. The roots stabilize soil during run-off and take up nutrients.
- Although Montana state Streamside Management Zones (SMZs) are less restrictive, we suggest a 100 ft. buffer best protects lake resources.
- Maintain or create riparian buffer strips of dense native vegetation at least 100 feet in width along all streams, rivers and lakes.
- Leave a filter strip of rough grass between the riparian area and crops.
- Strip crop and contour plow where appropriate to reduce the potential for erosion; these practices break up large expanses of tilled soil and slow the flow of run-off.
- Minimize use of chemical pesticides and herbicides. Use the least toxic options available to prevent polluting water.
- Apply proper amounts of fertilizer only during the growing season when it can be used by plants. More is not better!
- Store and apply commercial fertilizers carefully, according to recommendations.
- Use Best Management Practices (BMPs). Consult your county extension agent, Conservation District or Natural Resource Conservation Service (NRCS) representative for more information.

Poor grazing practices. Photo courtesy Whitefish Lake Institute

Good grazing practices. Photo courtesy Flathead Conservation District

Cattle & Critters

Livestock that are allowed unrestricted access to water bodies can cause erosion by consuming bank-stabilizing vegetation, trampling stream banks and lake shores, and depositing manure that can contaminate the water. Here are some options to help reduce livestock's negative impacts:

- Install a fence to keep animals from unrestricted access to water and riparian vegetation.
- Install a water gap or off-source watering device such as a nose pump to provide drinking water.
- Lure livestock away from water by placing salt blocks far from the water.
- Store manure in properly designed pits or stacking sites to reduce nutrient rich run-off that can contaminate groundwater and lakes.
- If you must graze livestock in a riparian area, follow a well developed, site specific management plan that limits time of year and duration of grazing.
- Take an active role in management by checking the condition of fences and vegetation at least once a year.

Forestry and Timber Harvesting
The forest products industry plays an important role in Montana, contributing to the economy and to the health of our land and water resources. Properly managed forests balance the wood products industry with conservation of wildlife and human habitats. However, poorly managed forestry operations can be a significant source of sedimentation and subsequent nutrient pollution. Timber harvesting operations can be a problem when logging roads, stream crossings, skid trails and log landings are improperly built, poorly located or are not maintained to the appropriate level of use.

Well managed forestry. Photo courtesy Holly McKenzie

Avoid Erosion on Logging Jobs

- Consult with Montana Department of Natural Resources and Conservation personnel before you plan your timber harvest. They can provide information about professional logging contractors, forestry consultants and information on streamside management zone (SMZ) laws.
- Use Forestry Best Management Practices (BMPs) to prevent erosion during and after timber harvest and road construction operations. Contact your local planning department or Montana's DNRC for BMPs.
- Follow the stream management zone (SMZ) law requirements to help filter run-off. Riparian buffer strips wider than the minimum may be necessary to adequately protect streams and lakes.
- Check with your local conservation district to find out if you need a permit for crossing streams or wetlands on your property. Not all activities require permits and some crossings are permitted without review. Both the landowner and contractor may be legally responsible for obtaining permits.
- Avoid working in wet areas and during wet weather. The soil's ability to hold and filter water can be damaged by heavy equipment.
- Logging equipment can spread noxious weeds and should be washed before the timber harvest and when the job is completed.
- To reduce erosion and combat the spread of noxious weeds, replant bare disturbed soil with native grasses that promote existing vegetation.
- Closely monitor and treat (as necessary) disturbed areas such as skid trails, landings or burn piles for noxious weeds.

Roads, Driveways & Ditches
Paved, dirt or gravel roads; ATV trails; new roads and driveways close to the shore; culverts and roadside ditches—even worn footpaths—are all highways for sediment, nutrients and other pollutants to reach a stream or lake. Vehicles compact soil, reducing its ability to absorb and retain water. Compacted soil results in increased water flow across the ground, concentrating water and pollutants and increasing soil erosion.

It doesn't take much to start the process. Water from a heavy thunderstorm will concentrate on roads and trails, picking up speed and energy. This water can scour open ground on a construction site, erode a sloping path or wash out a newly constructed roadside ditch. An erosion site located miles from the lake, but still in the watershed, can alter lake water quality because the sediment from the eroded site flows downhill until it reaches the lake. Numerous erosion sites along miles of roads and ditches have a severe, cumulative impact on water quality – especially during a downpour.

Flowing water scours erosion channels and picks up sediments, nutrients and other pollutants. The faster the water flows, the more pollution ends up in the lake. Roads also function as super highways for terrestrial weeds that can spread to the banks of lakes, rivers and streams. Once weeds become established along lakes, bank stability is compromised because weeds do not provide the same soil stabilizing root system as native plants. The deep root systems of native plant communities prevent erosion and sedimentation and should therefore be maintained.

Building Driveways and Roads Responsibly

- Reduce the amount of roads, and keep road and driveway lengths to a minimum by clustering development. The longer the paved surface, the higher the velocity of water flowing over that surface and the more erosion and sedimentation. Reducing the length of roads and driveways lessens soil compaction and the flow of nutrients to nearby water-

ways.

- Design and build new roads and driveways with culverts, drainage diversions, ditches and roadside buffers to deal with run-off from major storms. Ask your local conservation district for help.
- Avoid construction on slopes greater than 20%. On all slopes use water bars and diversions to help reduce erosion.
- Divert water flowing in roadside ditches that are U-shaped not V-shaped and have long sloping runs into flat wooded areas where sediments, nutrients and pollutants are filtered out. Use frequent ditch turn-outs to slow water flow.
- Grade/crown roads and driveways to shed water to desired areas.
- Retain or plant native plants/buffer strips along roads and uphill from ditches to intercept and filter nutrient rich run-off before it gets into the ditch.
- Limit the clearing of vegetation and reduce disturbing the duff layer which stores nutrients. The duff layer is the organic material layer between the uppermost soil mineral horizon and the litter layer. It is organic material that has decomposed to the point at which there is no identifiable materials such as leaves or twigs.
- Work with your county to adopt local road standards that will reduce nutrient run-off.
- Organize volunteers to go out during or right after a heavy rainstorm to identify and trace sources of erosion. Determine which streams and rivulets are brown with silt to find out where erosion occurs. Then work with landowners to correct the problems.

Poor road building practices. Photo courtesy Whitefish Lake Institute

Conservation Districts

MONTANA ASSOCIATION of CONSERVATION DISTRICTS
We're growing Montana's future.

What's a Conservation District?

Conservation districts (CDs) are units of local government designed to help citizens conserve their soil, water, and other renewable natural resources. They conduct local activities to promote natural resources, including education and on-the-ground conservation projects. In Montana, CDs have the additional responsibility of implementing the Natural Streambed and Land Preservation Act, also known as the 310 law. This law requires any individual or corporation proposing work in or near a perennial stream, on private or public land, to apply for a 310 permit through their local conservation district. If you are planning to work in or near a stream, you must first get a 310 permit. It's free and it's the law.

History

Conservation districts were organized in the 1930s as a response to the "Dust Bowl" days. Today, there are almost 3000 conservation districts nationwide, and their conservation activities encompass a wide spectrum of natural resource issues. In 1937, President Roosevelt encouraged Montana to adopt legislation enabling the creation of local soil conservation districts. The State of Montana passed legislation creating its conservation districts in 1939 to provide for local control of natural resource management programs and activities. Montana's 58 conservation districts cover all counties and include more than 70 municipalities included within district boundaries.

Because of their unique characteristics and proven track record, CDs have been entrusted by the state with mandated activities such as water reservations, stream access portage routes, county planning board participation, and local Total Maximum Daily Load (TMDL) consultation. Also, CDs serve as the local point of contact for numerous federal programs. This is all in addition to the long-standing CD roles such as educating landowners about sound conservation practices, tree planting, and organizing outdoor classroom educational activities for school children.

Funding

Local funding for the operation and conservation activities of each district comes from mills levied on real property within the boundaries of the district. In almost all districts, the amount generated locally is inadequate to meet the expectations of the citizens living in the CD. The State of Montana, through the Department of Natural Resources and Conservation, provides a grant to allow the district to operate at a minimal level. In all cases, each district must think creatively about how to secure additional funding and seek out state and federal grant opportunities in order to meet the needs of their constituents.

Partners

Districts have two main partners; the State of Montana participates through the Department of Natural Resources and Conservation (DNRC), and the federal government participates through the Natural Resources Conservation Service.

The **Conservation and Resource Development Division** (CARDD) of the Montana DNRC has duties specifically established in state statute to: assist CD supervisors in carrying out their authorities and programs, facilitate an interchange of information, activities, and cooperation among districts; coordinate programs among districts through advice and consultation; secure the cooperation and assistance of federal and other state agencies in the work of districts; disseminate information concerning the activities and programs of districts; and administer financial assistance programs for districts. This division provides a link to state government for the continued successful operations of CDs.

The **Natural Resource Conservation Service (NRCS)**–formerly the Soil Conservation Service–of the U.S. Department of Agriculture provides technical assistance to the nation's private land managers. Conservation districts were established as a link between the NRCS and these land managers. Generally located in the same local field offices as NRCS employees, CDs set local priorities for federal conservation programs.

Chapter 3

LEARN MORE ABOUT

Agricultural Practices
Local Conservation Districts

MSU Extension
https://www.msuextension.org/

Natural Resources Conservation Service (NRCS)
www.nrcs.usda.gov

Timber Harvest
Montana Dept. of Natural Resources and Conservation www.dnrc.mt.gov

Montana Logging Association
www.logging.org

MSU Extension, Forestry
www.cfc.umt.edu/extensionforestry/

Weed Control
County Weed Departments

Montana Noxious Weeds Program
http://agr.mt.gov/weedpest/

Road Construction
Local Conservation Districts

Stream Permitting
Local Conservation Districts

Boat heading toward Conrad Point on Flathead Lake. Photo courtesy gravityshots.com

Recreation in Montana brings millions of dollars to our local economies each year. Fishing, boating, water skiing and swimming bring tens of thousands of visitors to our state for their vacations of a lifetime. With so many visitors, it is particularly important to use caution when recreating on the water.

Boating Boom...erang
Many lakes suffer from a "boomerang" affliction: they attract boaters and personal watercraft because of their beauty, but too many watercraft and careless boating decreases their attractiveness. Boating has always been part of the Montana lake experience. However, as use of motorized watercraft has grown, problems have increased. The most serious boating problems are safety, congestion, noise pollution, accelerated shoreline erosion and sedimentation from larger wakes. Air and water pollution can also result from poorly tuned engines, and wildlife harassment, gas spills and human waste add to the problems related to boating. It is important to take responsibility for our actions and work together to ensure the safety of all recreationists.

Motorized Watercraft: It's a Gas
Gasoline constituents, in the form of volatile organic compounds (VOCs), include BTEX (benzene, toluene, ethylbenzene and xylene). Studies conducted on lakes such as Lake Tahoe in California and Whitefish Lake in Montana indicate that BTEX and other compounds found in water bodies are directly related to motorized watercraft activity.

BTEX are known to cause a myriad of human health concerns, including cancer, birth defects and damage to the nervous system, liver, and kidneys. BTEX exposure can result from inhalation, ingestion and/or contact absorption through the skin. BTEX also has an adverse effect on aquatic plants and animals.

Boat Wake. Photo courtesy Whitefish Lake Institute

Practice Responsible Boating

- Drive at safe, fuel-efficient speeds.
- Watch your wake and slow down if it gets too big. Large wakes erode the shoreline and damage wildlife habitat.
- Observe no wake speeds within 200 feet of all shorelines.
- Stay away from shallow areas. Motors churn up bottom areas and re-suspend nutrient rich sediments.
- Keep a trash bag handy to collect and store all trash, including cut fishing line.
- NEVER dispose of sewage overboard – it is ILLEGAL. Keep all sewage sealed in a holding tank for appropriate disposal at a marina.
- Plan ahead; sewage-dumping stations near lakes are extremely limited.
- Enjoy the natural quiet of the lake. Consider canoeing, rowing sailing or paddleboarding. Avoid playing loud music because sound carries easily over water.
- Stay away from birds and their nests, as well as other animals. It is illegal to harass wildlife and your actions may separate the young from their parents or chase them out of their natural habitat.
- Operate watercraft safely and courteously. Avoid congested areas when possible.
- Obtain a copy of and abide by Montana's boating laws.

2-Stroke vs. 4-Stroke

A 1996 EPA report found that 4-stroke engines are 75- 95% cleaner than carbureted two-stroke engines. Scientific reports indicate that engine inefficiencies in carbureted 2-stroke engines can affect water quality: 30% of 2-stroke watercraft fuel is released unburned directly into the water via the exhaust system.

The California Air Resources Board found that a typical personal watercraft (carbureted 2-stroke) that consumed five gallons of gasoline per hour and operated 41 hours per year discharged between 50 and 60 gallons of unburned fuel into the environment.

The watercraft industry is responding by improving technology. However, if you're in the market to purchase a personal watercraft or outboard motor, make sure the model you are looking at is not the carbureted 2-stroke type. For all outboard motors, make sure your engine is tuned so that it operates at maximum efficiency. Take care not to spill oil or gas while refueling.

Benefits of 4-stroke:

- Quiet and smooth;
- More fuel efficient;
- Less polluting;
- More reliable;
- Gasoline ready – no mixing oil and gas;
- Smooth idling;
- Great trolling motors;
- Accepted at any body of water that allows motorized boats, some areas have banned 2-stroke boat engines;
- Readily available, almost all new production is 4-stroke.

Diagnosing UFOs: Unidentified Floating Objects

Murky, Green-Colored Water
Description: Murky, green-colored water that looks like green paint on the windward shore; unpleasant odor

Analysis: Algae. Algae are microscopic plant-like organisms that are natural components of lakes and streams. When high nutrient concentrations occur, algae become so abundant that the water becomes murky. People should avoid swimming in algae blooms because toxins in some algae cause skin irritation. Consumption of water by livestock and other animals such as pets during an algal bloom can result in intestinal distress and, in extreme cases, death.

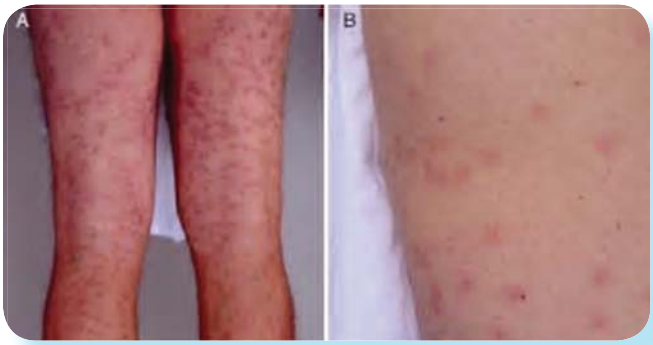
Algal bloom on lake. Photo courtesy circleofblue.org

Yellow-Green Dust
Description: Yellow-green dust on the lake in early summer

Analysis: Pollen from nearby trees. The pollen might look similar to algae, but pollen is more yellow and dust-like and floats on the surface. Over time the pollen will become waterlogged and sink from sight. Pollen usually has little effect on water quality.

Pollen accumulation on lake. Photo courtesy Andy Fuery

Red, Itchy Rash
Description: Red, itchy rash on swimmers soon after coming out of the water



Swimmer's Itch. Photo courtesy Mayo Clinic

Analysis: Swimmer's itch. Swimmer's itch is caused by a parasite that typically uses waterfowl and snails as hosts, but can irritate humans. The swimmer may notice a prickling sensation after getting out of the water and may develop red spots and swelling that can last a week or more. To prevent swimmer's itch, towel off vigorously or take a shower immediately after coming out of the water– especially in mid to late summer when the parasite is most prevalent. It is not dangerous or contagious, but can be very uncomfortable.

Dead Fish
Description: Dead fish in the water or on the shore

Analysis: A few dead fish along the shore is not significant and may result from natural causes, such as spawning, or bacterial infection from warm summer water. Numerous dead fish (dozens or more) or dead fish of more than one species is a cause for concern. Contact your regional Montana Fish, Wildlife & Parks office immediately to report the problem.

Dead fish on lake. Photo courtesy Rolf Kenneth Myhre

Foam
Description: Foam "soap suds" along the shore

Foam on lake. Photo courtesy Orion2

Analysis: Foam along the shore does not necessarily indicate pollution from laundry waste. Foam is created when the surface tension of water is reduced and air is introduced. This causes bubbles. Many natural organic compounds will reduce surface tension and when these compounds are mixed with air by wind and currents, they produce foam. Natural foam has a somewhat earthy or fishy smell while detergent foam will smell of perfume.

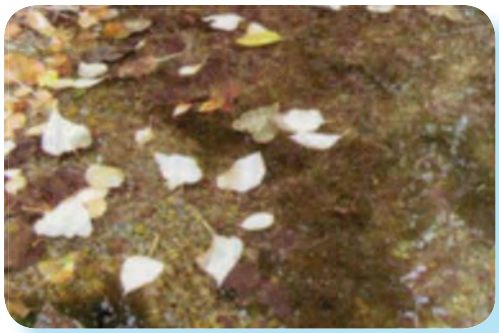
Green Cotton Candy
Description: Green, cotton candy-like clouds in shallow waters

Filamentous Algae. Photo courtesy aquaplant.tamu.edu

Analysis: Filamentous algae. It is common in some lakes and may not indicate a water quality problem. These clouds may appear after heavy run-off in the spring or following a long, hot spell in the summer. However, localized concentrations may indicate a pollution source nearby.

Dark Cloud
Description: Dark cloud in the water accompanied by an oily sheen.

Analysis: The cloud may be insect cases left behind from a hatch of aquatic insects, which hatch any time during the open water season. Wind often concentrates the cases along the shore, and as they decompose, an oily film can form on the water's surface. Dark oily clouds can also occur near decomposing leaves, typically in the fall.



Dark cloud of insect cases. Photo courtesy of Whitefish Lake Institute

Worm-like animals
Description: Flat, worm-like animals attached to skin.

Analysis: Leeches. Leeches are found in shallow, protected waters and are active on hot summer days and at night. They are attracted to water disturbance around docks and swimming areas. The best way to avoid leeches is to swim in deep waters.

Leech. Photo courtesy The Guardian

Montana's Native Fish

Adapted from Montana Fish, Wildlife & Parks

As a group, all 56 native Montana fish still inhabit state waters, but some are facing a long fight for survival. Most of our best-known fish - rainbow trout, brown trout, largemouth bass, and walleye - are not native to Montana, but were introduced by newcomers as sport fish.

Montana's native fish adapted to a life in mountain and prairie streams over thousands of years - enduring wild spring floods, summer droughts, and long, cold winters.

As new settlers changed Montana's landscape, the cycle of life changed for Montana's native fish as well. The eventual planned and unplanned introductions of non-native fish also added new challenges to our native fishes' struggle to survive in Montana waters.

Like a family heirloom passed from generation to generation, Montana's native cutthroat trout are among the treasures that make Montana such a special place. Montana's native fish are Nature's Keepers and it's up to all of us to keep it that way.

Chapter 4

LEARN MORE ABOUT

Safe Boating on Montana Waters
http://fwp.mt.gov/recreation/safety/boating/default.html

Swimmer's Itch
Mayo Clinic http://www.mayoclinic.org

Montana's Native Fish
http://fwp.mt.gov/fishing/planAFishingTrip/ethics/illegalintro.html

Western larch needles change color in the Fall along the shoreline of Tally Lake in Northwestern Montana. Photo courtesy Lori Curtis

CHAPTER 5 - PROTECTING OUR FISHERIES

Holter Lake near Helena. Photo courtesy www.larrymayer.com

The lakes of Montana are diverse and teeming with life. The variety of fish species and other aquatic organisms make our lakes, rivers and streams an angler's paradise and provide a multi-million dollar boost to the local economy.

Different Fish for Different Lakes
Some lakes are shallow, warm and have numerous aquatic plants. Species such as bass, perch and pike like these warm-water lakes. Other lakes are deep, with large volumes of cold water. These lakes support trout and other salmonid species. Not every lake is suitable for every kind of fish. Temperature and oxygen levels are the two major factors that control whether or not certain fish species are present. Other factors such as available habitat, competing species and stocking practices also influence fish species.

Declining water quality may result in the loss of a cold-water fishery. Increased nutrients, for example, can ultimately lead to the loss of oxygen in the deeper regions of the lake. Once cold-water fish habitat is lost, it usually cannot be restored – and rarely can it be restored to support trout.

Although we associate fishing with lakes and streams, some lakes and streams have no fish. These areas provide habitat for frogs and salamanders, critical species for many ecosystems. It is very important to protect remaining amphibian habitat.

The Lives of Native Trout
Native trout species such as bull trout, westslope and Yellowstone cutthroat trout may exhibit three distinct life history patterns that can encompass sizeable geographic areas. Resident fish reside entirely in natal streams, while *fluvial* and *adfluvial* fishes out-migrate from natal streams as juveniles to larger rivers (*fluvial*), or lake environments (*adfluvial*) growing to maturity before returning to spawn.

Fish can reach sexual maturity faster in lakes than rivers and streams due to increased productivity. The *spatial* distribution and diverse habitat needs of native fluvial and adfluvial fishes emphasize the importance of sustaining watershed health and habitat connectivity. It also highlights the vulnerabilities of migratory fishes to *anthropogenic* influences throughout their habitat range. Influences affecting habitat, access to habitat, water quality and species composition (competition, *hybridization* or *predation* with non-native species) throughout a watershed ultimately affect the health and viability of native fish populations in streams, rivers and lakes.

Native and Non-Native Species
Many non-native fish and aquatic species have been legally introduced by agencies into our lakes and rivers to enhance angling opportunities. In fact, early fisheries management in the United States centered on the introduction of non-native game fish. Some planned introductions have benefited angling opportunities in certain waters, while others have had unexpected and damaging results. Introduced non-native species can cause problems because they are often more aggressive and more adaptable to ecosystem changes. Often, they reproduce more rapidly than native species giving them a competitive edge.

Westslope Cutthroat Trout. Photo courtesy Montana Fish, Wildlife & Parks

The introduction of Mysis shrimp into the Flathead Watershed is one example of an unexpected and drastic food web change caused by an introduction. This introduction was intended to provide a better food source for kokanee salmon—a popular fish amongst anglers. Instead of boosting kokanee salmon, Mysis shrimp are the primary cause for the collapse of that salmon population in Flathead Lake and gave rise to a fish community dominated by non-native lake trout and non-native whitefish.

Our understanding of the ecological impacts of introduced species has continuously advanced. Legislation, like the Endangered Species Act, now places a high value on native species and mandates their protection. Today, fisheries managers carefully weigh the costs and benefits associated with new species introduction or the continued stocking of non-native fishes to our waters.

In Montana, fisheries managers emphasize preserving and enhancing wild fish populations. They also give special consideration to populations of native fish. Montana is home to many valuable native species, including white sturgeon, mountain whitefish, grayling, bull trout and Montana's State Fish—the black spotted (westlsope) cutthroat trout.

Illegal Fish Introductions
Illegal introduction of non-native species is also of great concern. Fish like carp, yellow perch, suckers, shiners, sunfish and even certain game fish can severely affect sport fisheries. When people move live fish from one body of water to another, the future of their own fishing is at stake. Anglers illegally introduce species by using live bait, dumping bait buckets and even intentionally stocking rivers and lakes.

Bucket biology – the practice of transporting live fish from one water body to another to artificially stock the second water body – IS A CRIME. You can be arrested and fined heavily in Montana and you can cause significant damage to a fishery. Introduced fish may:

- Cause the decline of many threatened and endangered species;
- Reproduce rapidly and outcompete native species;
- Interbreed with native or established species, thereby reducing the long-term survival of native species;
- Carry and spread new diseases and parasites;
- Directly alter the existing habitat;
- Require difficult and costly management decisions that may or may not be successful in restoring native fishes.

Since the discovery of Walleye in Swan Lake, Montana Fish, Wildlife & Parks, Montana Trout Unlimited and the Fishing Outfitters Association of Montana joined together to offer rewards for information leading to the prosecution of persons illegally introducing fish into any Montana waters.

Walleye in Swan Lake

In 2015, illegally introduced non-native walleye were discovered in Swan Lake during a Montana Fish, Wildlife & Parks contracted netting operation. The professionals are hired to remove lake trout from Swan Lake three times a year in an effort to protect populations of native bull trout and kokanee salmon. The fall netting targets lake trout spawning areas during a time when bull trout have migrated from the lake to their spawning streams. Non-native lake trout eat bull trout and other species and have few predators to keep them in check.

Lake trout were introduced to Flathead Lake as a sport fish in the early 1900s. They took off in the 1960s after mysis shrimp were introduced to Swan Lake and Whitefish Lake and later drifted downstream to Flathead Lake. They became food for lake trout which quickly grew to the dominant species in the 1980s. Flathead Lake's kokanee population was nearly wiped out within three years. Lake trout appeared in Swan Lake in 1998. That same year, bull trout were listed as "threatened" under the U.S. Endangered Species Act.

According to Montana Fish, Wildlife and Parks Region 1 fisheries manager, Mark Deleray, "bucket biologists" have cost the state hundreds of thousands of dollars in attempts to remove the predators and preserve existing fish populations. It is illegal to move any live fish from the water in which the fish are caught. Montana Trout Unlimited Past-Executive Director Bruce Farling said "There have been over 600 documented, illegal introductions of unwanted species in the waters of this state in recent years, and in all cases, either the fisheries were damaged or no better fishery was created. This introduction puts a multimillion-dollar fishery at risk."

Swan Lake. Photo courtesy Lori Curtis

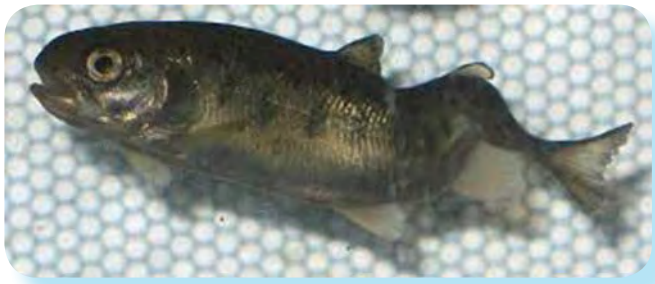
Aquatic Habitat
Rooted native aquatic plants grow in shallow, protected waters. Although they may seem like nothing more than weeds at times, their overall benefit is immense. Native aquatic plants:

- Provide spawning habitat for certain fish species and nursery areas for virtually all fish;
- Create habitat for many small insects and crustaceans, which in turn are important food sources for fish;
- Stabilize lake sediments by absorbing the force of waves and reducing shoreline erosion. Their roots trap sediment particles and hold them in place;
- Absorb nutrients and thus reduce undesirable algae growth

The presence of aquatic plants does not necessarily indicate a pollution problem. However, they may thrive where shoreline tree removal, landscaping alterations from construction and shoreline erosion have occurred.

Beneficial Aquatic Habitat. Photo courtesy Lori Curtis

Whirling Disease in Montana
Whirling disease is a parasitic infection that affects salmonid fishes (trout, salmon, char, whitefish, grayling). The disease is named for one of the symptoms of infection: erratic, tail chasing, "whirling" behavior. Infection can lead to physical deformities of the head, spine and cartilage and a blackening of the tail. Severe infection can lead to death as these deformities reduce a fish's ability to feed and avoid predators. In some cases, whirling disease has caused major fishery losses and associated economic costs. There is no known cure or vaccine for whirling disease.



Fish with Whirling Disease. Photo courtesy State of Colorado

Whirling disease is caused by the microscopic parasite *Myxobolus cerebralis*, which was introduced from Europe to the US in 1956. The disease-causing parasite has a complex, two host life cycle that depends upon salmonid fishes and a small, common aquatic worm called *Tubifex tubifex*. Whirling disease cannot infect humans, mammals or non-salmonid fishes.

Whirling disease is spread through the movement of infected fish or fish parts, and by the movement of water or mud that contains parasites. This can happen naturally within a watershed, but the spread into new watersheds is typically done inadvertently by humans. Whirling disease was first discovered in Montana in 1994 and has spread throughout much of Western and Central Montana.

Tubiflex tubiflex. Photo courtesy The fish guide

Combat Whirling Disease

- Know whether you are fishing or recreating in waters infected by whirling disease. Whirling disease has been detected in most major watersheds of Western and Central Montana.
- After leaving a stream or lake, be sure to thoroughly clean, drain and dry all of your fishing and boating equipment, including your waders. Mud and water may hold tubifex worms, whirling disease spores, and other invasive species.
- Never transport live fish, live bait, insects or plants from one water body to another. It is illegal in Montana.
- Don't use salmonid (trout, char, salmon, whitefish, grayling) parts as cut bait. It is illegal.
- Don't collect sculpins or use them as bait. It is illegal.
- When cleaning fish, either sink the entrails in the water body where the fish was caught or put them in garbage cans. Whirling disease may be able to survive wastewater treatment systems, so do not put fish parts down the kitchen disposal. Fish parts should be disposed of in the garbage, by burying, or by burning.
- Talk to your friends and colleagues about this issue. Share what you know about whirling disease.
- If you see fish with whirling disease symptoms in an area where whirling disease has not been reported, contact your regional Montana Fish, Wildlife & Parks office.

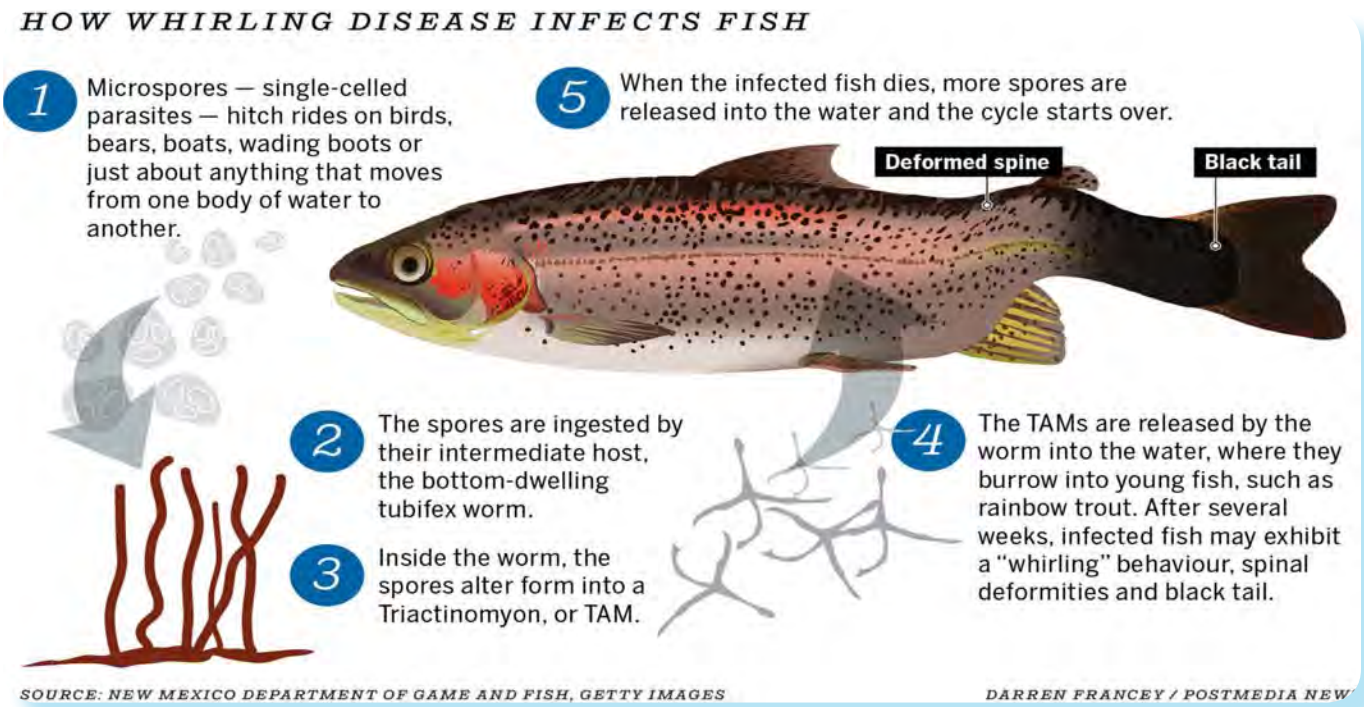


Figure 12. How Whirling Disease Infects Fish. Graphic courtesy New Mexico Department of Game and Fish. Getty Images.

Actions you can take to protect your local fishery

- Obtain a copy of Montana Fishing Regulations and abide by them.
- Become proficient at identifying different species of fish so that you don't accidentally hurt endangered species.
- Do not release any fish into your lake that were not caught there. IT IS ILLEGAL. Introduced species may out-compete native species for food and habitat, may introduce diseases, and may degrade water quality.
- Keep sediments from entering streams, rivers and lakes. Sediments can smother lake spawning areas, aquatic plants and fish food such as crayfish, insects, etc.
- Prevent nutrients and pollutants from getting into the lake by reducing your use of chemical fertilizers and maintaining your septic system.
- Do not remove cover over the water such as trees, logs or aquatic plants. These materials provide critical habitat, protect bank stability and prevent rapid increase in water temperatures that harm cold-water fish.
- Guard against the introduction of aquatic plants, invertebrates and fish species not naturally found in your lake.
- Don't leave cut fishing line in the water and clean up any line that you may find in the water.
- When cleaning fish, either sink the entrails in the water body where the fish was caught, or put them in garbage cans.
- Clean, drain & dry live wells, transom wells, and bilges thoroughly and away from any river, lake or water body.

Proliferative Kidney Disease in Yellowstone River

In August of 2016, water-based recreation was banned along a 183-mile stretch of the Yellowstone River and all of its tributaries to help limit the spread of a microscopic fish-killing parasite. Montana Fish, Wildlife and Parks enacted the closure from Yellowstone National Park's northern boundary at Gardiner to the Highway 212 bridge in Laurel. The parasite causes Proliferative Kidney Disease (PKD) in fish, but does not pose a danger to humans. The disease is compounded by other conditions in the river such as low flow, consistent high temperatures, and the impact of recreational activities.

Although it has been found in only two isolated parts of Montana in the past 20 years, outbreaks have been documented in other northwestern states such as Washington, Oregon and Idaho. Regarding the closure and its impact to the recreational economy, Governor Steve Bullock said, "A threat to the health of Montana's fish populations is a threat to Montana's entire outdoor economy and the tens of thousands of jobs it sustains."

Chapter 5

LEARN MORE ABOUT

Montana's Native Fish
http://fwp.mt.gov/fishAndWildlife/management/nativeFish.htmland Non-Native Fish

Illegal Fish Introductions
http://fwp.mt.gov/fishing/planAFishingTrip/ethics/illegalintro.html

Whirling Disease Initiative
http://whirlingdisease.montana.edu/initiative

CHAPTER 6 - AQUATIC INVASIVE SPECIES (AIS) IN MONTANA

Tiber Reservoir and Dam. Photo courtesy www.larrymayer.com

The Threat of Aquatic Invasive Species
One of the biggest threats to our lakes comes in the form of small organisms and weeds that are invasive species. Montana lakes provide prime habitat and food for many non-native species to thrive and take over, limiting habitat for local, native species. It is extremely important to pay attention to these aquatic "hitchhikers" especially when boating in many different lakes throughout the state or country.

Zebra Mussels in Montana
Since their introduction to the Great Lakes in 1986 from ships' ballast water, zebra and quagga mussels have quickly spread and are now found in over 40 states and 3 Canadian provinces. Alaska, Hawaii, Washington, Oregon, Idaho, and Wyoming are the only states to remain free of these invasive mussels.

In the fall of 2016, invasive mussel larvae were detected in Montana water bodies east of the Continental Divide. When established, zebra and quagga mussels often cause crashes in fish populations, reduce water quality, cause toxic algae blooms, cover the beaches with sharp shells, and impact native species.

Zebra and quagga mussels greatly reduce ecotourism and property values near the water, increase personal costs to clean and maintain fishing boats and gear, clog pipes (in domestic, municipal, agricultural, and hydroelectric facilities), as well as increase the costs of electricity and water due to service providers' annual maintenance costs.

The primary cause for zebra and quagga mussel's movement westward is boats trailered by the public or by commercial haulers. Zebra and quagga mussels can spread on boat hulls, in water (as microscopic larvae) and on aquatic plants. A female zebra mussel can release up to one million eggs each season so transporting just one zebra mussel can spell trouble for Montana waters and your watercraft. And remember, IT IS ILLEGAL to transport zebra mussels and other invasive species into any Montana waterbody – even if it is by accident.

Zebra mussels. Photo courtesy U.S. Fish & Wildlife Service

Invasive mussels on boat motor. Photo courtesy National Park Service

AIS Watercraft Inspection Sign at Whitefish Lake. Photo courtesy Nicky Ouellet, Montana Public Radio

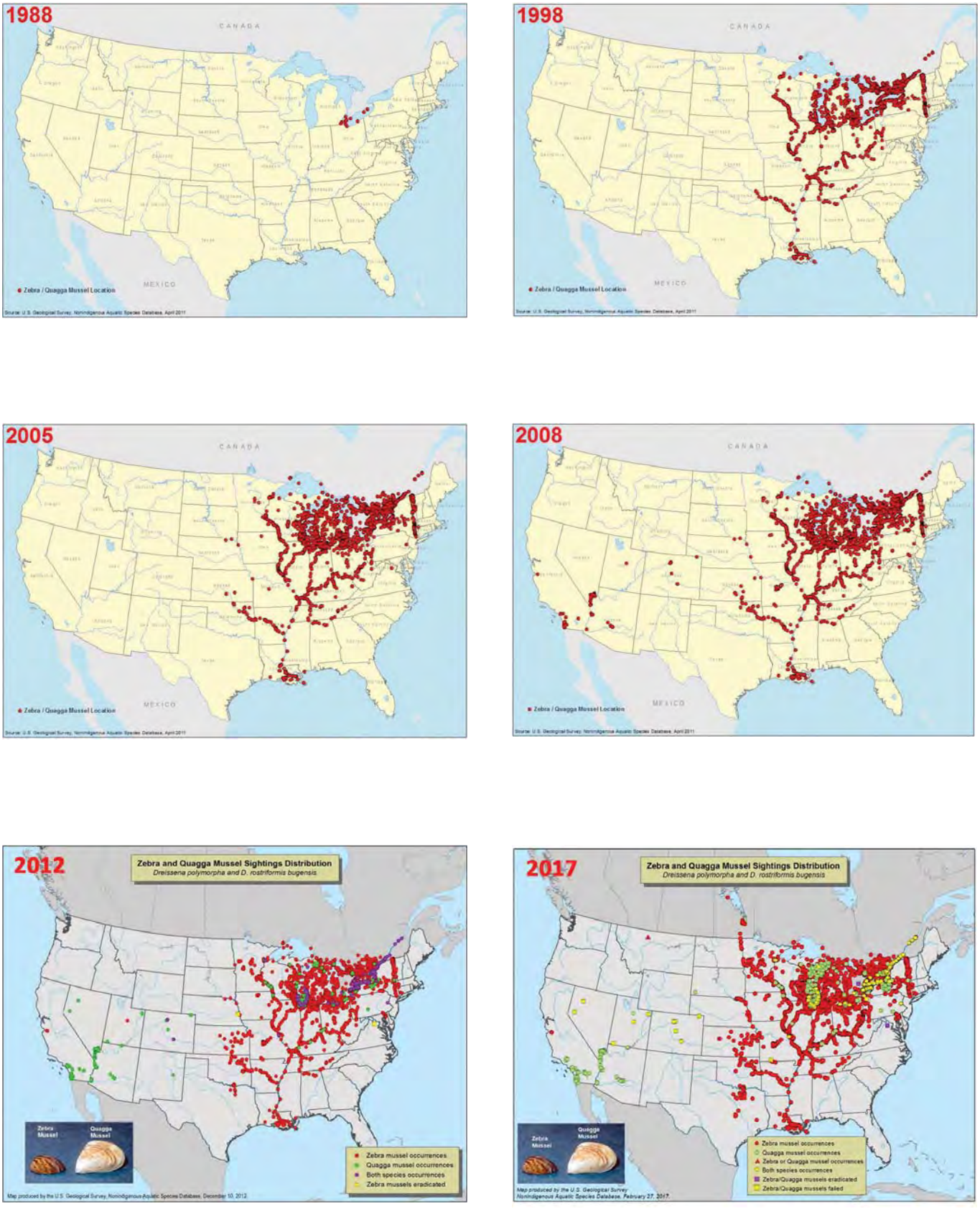


Figure 13. Progression of zebra mussel distribution in the U.S. Maps courtesy United States Geological Survey

New Zealand Mudsnails
New Zealand mudsnails (NZMS) are native only to New Zealand, but spread to North America in the late 1980s. This small invader quickly spread to waters in Yellowstone National Park and is now found in many waters across the West. People spread NZMS attached to waders and fishing gear or by moving fish or bait.

- NZMS average 1/8 inch in size but may be as small as a grain of sand. They have a gray, brown or black cone-shaped shell with 5 or 6 whorls.
- They live in all types of waters, from silted river bottoms to clear mountain streams to estuaries.
- Temperature tolerance is 32º - 77° F (66° F optimum).
- They reproduce by cloning, so it only takes ONE.
- Densities of over 500,000 per square yard have been reported in rivers in Yellowstone National Park.
- They can survive for days out of water on moist gear.

At high densities, NZMS alter aquatic habitats and food webs by eating algae and out-competing native bottom-dwelling organisms. These ecosystem impacts can reduce trout and other recreational fisheries FOREVER. Prevent the spread of New Zealand mudsnails by taking at least one of the following actions after using gear:

New Zealand Mudsnails. Photo courtesy biologicalexception.blogspot.com

- Rinse waders and other gear with disinfectant and scrub with a stiff brush to remove mud and debris.
- Remove snails from nooks and crannies (e.g. boot laces).
- Use separate sets of gear for infested and non-infested waters.
- Freeze gear for 6 to 8 hours (preferably overnight).
- Place gear in a hot water bath of at least 130º F for a minimum of 5 minutes.
- Dry gear completely for at least several days.
- Clean boats and trailers after each use.

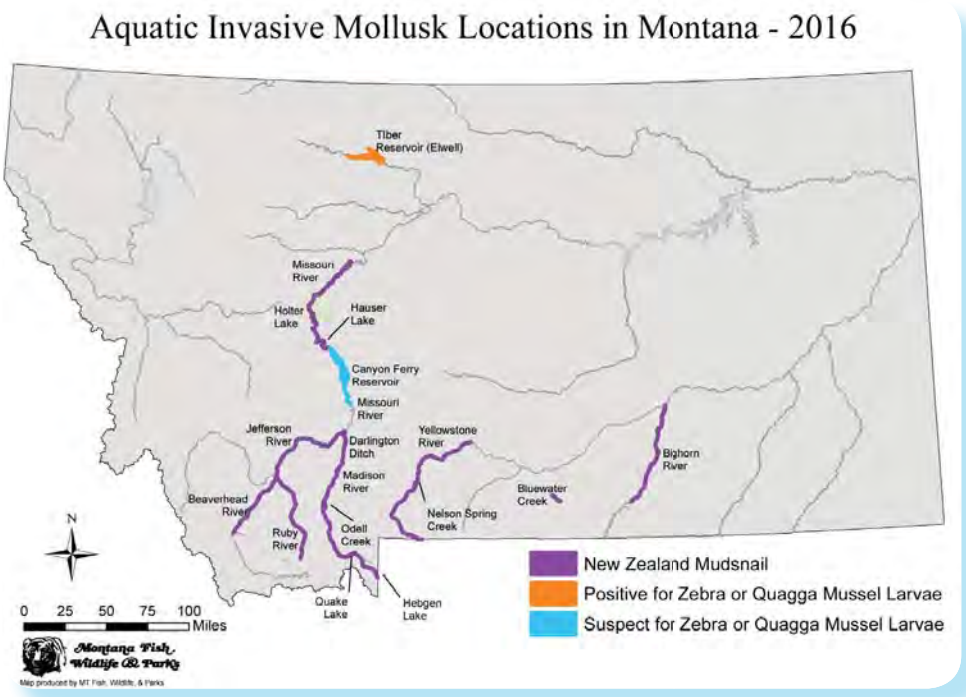


Figure 14. 2016 Map of "Aquatic Invasive Mollusk Locations in Montana". Graphic courtesy Montana Fish, Wildlife & Parks

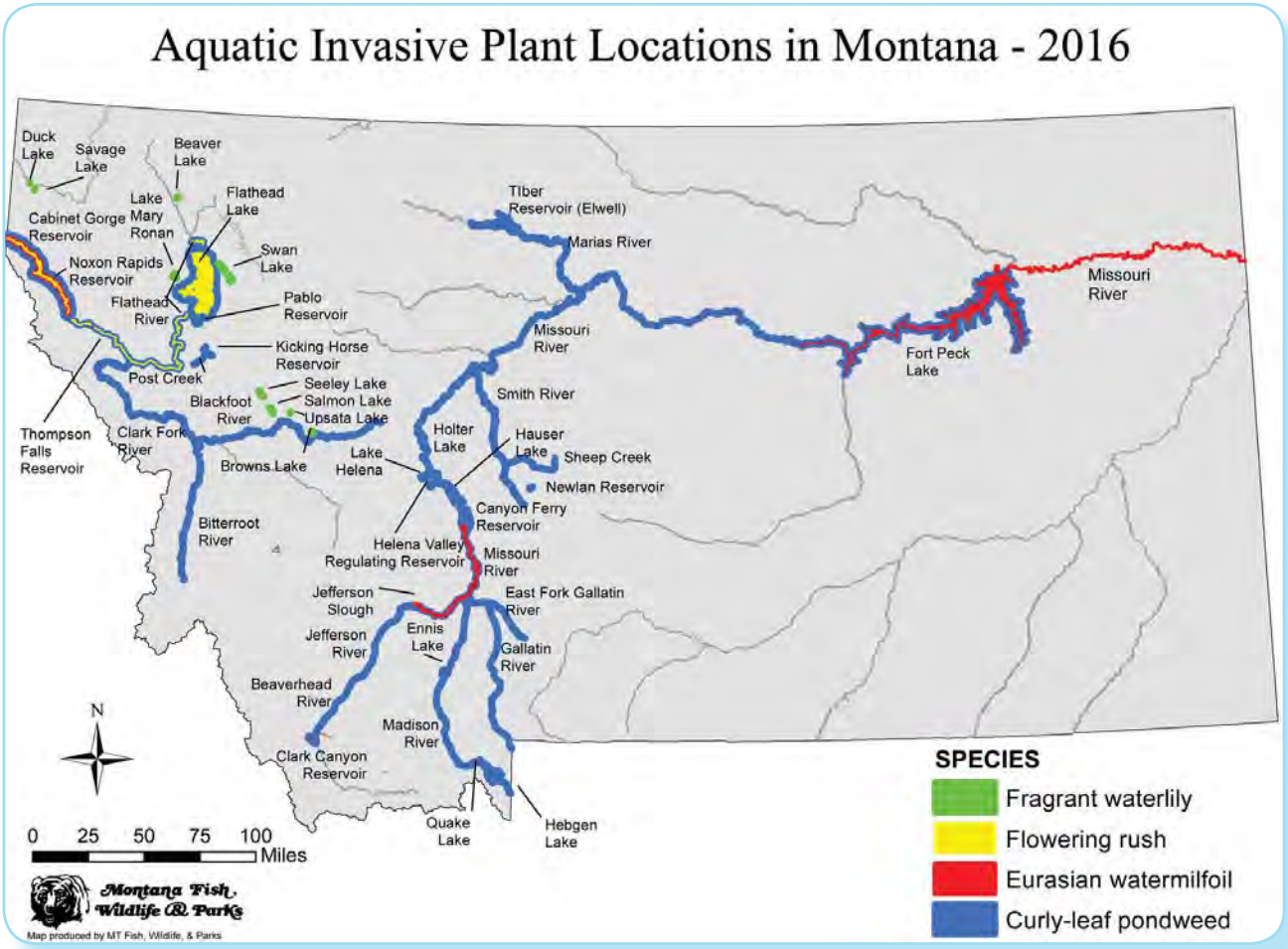


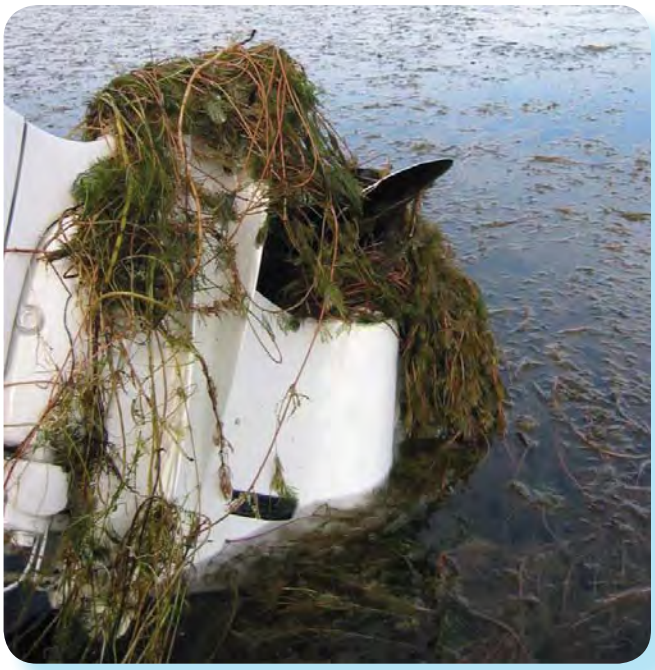
Figure 15. 2016 map of "Aquatic Invasive Plant Locations in Montana." Graphic courtesy Montana Fish, Wildlife and Parks

Living with Aquatic Weeds

Native aquatic plants play many vital roles in natural ecosystems. One of their most important functions is helping to prevent the spread of harmful invasive plants. Unfortunately, plant fragments—like other organisms—can travel with watercraft and gear from one lake to another where they can take hold and spread. A plant that lives harmoniously with other plants and animals in one environment may have no natural predators or other controls in a new location. To prevent the movement of plants from one water-body to another, be sure to remove plant fragments from boats, trailers and gear before leaving a lake. It is critical that all boaters and anglers inspect, clean, drain, and dry watercraft, waders, and other gear after EVERY visit to a water body.

Eurasian Watermilfoil

Eurasian Watermilfoil (EWM) is perhaps the most dangerous unwanted aquatic weed because it is extremely aggressive. Its dense weed beds grow rapidly, choke native plants and spread easily to new areas. In the northwest, EWM currently flourishes in Idaho,



Eurasian Watermilfoil. Photo courtesy Kate Wilson

Washington, and British Columbia. In Montana EWM is found in Broadwater, Flathead, Gallatin, Jefferson, Lake, Sanders, and Valley counties. On some stretches of the Pend Oreille River in Washington, navigation and recreation have become virtually impossible due to EWM.

EWM reproduces successfully and very rapidly by a process called "fragmentation." The plants easily break into small pieces and each piece can form roots. It can easily spread between lakes and rivers by boaters unwittingly carrying plant fragments in their hulls and on their trailers. If left untreated, EWM forms dense mats of vegetation on the surface of the water that can interfere with recreational activities such as fishing, swimming, and boating, and that threatens the health of the water body. The resulting effect can be the loss of recreational use, decline in ecosystem health, and a decrease in lakefront property values.

The Beaver Lake Story

In October 2011, Eurasian Watermilfoil (EWM) was discovered by the Montana Department of Natural Resources and Conservation near the boat ramp on Beaver Lake near Whitefish in Northwestern Montana. Beaver Lake is hydrologically connected to Whitefish Lake and there are numerous methods for the plant to be spread from Beaver Lake to Whitefish Lake. An AIS response team responded to the discovery for further investigation. Bottom barriers were placed over the identified patch and a control/eradication plan was developed by a multiple agency workgroup in which the City of Whitefish and the Whitefish Lake Institute participated.

Since 2012, WLI and the City of Whitefish have taken the lead in addressing the EWM issue at Beaver Lake. As part of the Whitefish AIS Management Plan, WLI coordinated a suction dredging operation to eradicate plants. In 2012, 23.5 pounds of EWM were removed.

The program has proven successful and in 2016, <0.25 pound of EWM was removed from 5 plants hidden under a submerged tree. This atypical AIS success story is the result of very early detection coupled with rapid and aggressive eradication techniques. Because of the real threat to Whitefish Lake and the watershed, suction dredging will continue indefinitely until there is confidence that the EWM has been eradicated.

Clean.Drain.Dry. Graphic courtesy Montana Fish, Wildlife & Parks

Clean, Drain, and Dry. Graphic courtesy Sharilyn Fairweather. Flathead Beacon

Whitefish Lake Staff working at Beaver Lake. Photo courtesy Whitefish Lake Institute

Chapter 6

LEARN MORE ABOUT AQUATIC INVASIVE SPECIES

100 Meridian Initiative
www.100thmeridian.org

100 Meridian Video Library
"Don't Move a Mussel" - Part I
http://100thmeridian.org/Video/DMAM2008_WM.asp
"Don't Move a Mussel" - Part II
http://100thmeridian.org/Video/DMAMP2_2008_WM.asp

AIS Crown of the Continent Report

Aquatic Nuisance Taskforce
www.anstaskforce.gov

Confederated Salish & Kootenai Tribes
http://csktnomussels.org

Don't Let it Loose
http://www.dontletitloose.com

Inspect • Clean • Dry
http://fwp.mt.gov/fishing/guide/ANS/default.html

Montana Fish, Wildlife & Parks
http://fwp.mt.gov/fishAndWildlife/species/ais/prevention.html

NOAA Research Aquatic Invasive Species
http://www.research.noaa.gov/oceans/t_Invasivespecies.html

Pacific States Marine Fisheries Commission
psmfc.org

Stop Aquatic Hitchhikers
http://www.protectyourwaters.net

USGS - Nonindigenenous Aquatic Species
http://nas.er.usgs.gov/default.aspx

Dickey Lake. Photo courtesy Senhit

Late Winter on Whitefish Lake. Photo courtesy Whitefish Lake Institute

Aquatic ecosystems are highly sensitive to climate change. Warming temperatures and precipitation variability can have far reaching implications to water supply, water quality, and the aquatic food web that will affect us all—from ranchers to anglers. As the amount, seasonality, intensity, and distribution of precipitation changes, we can expect more drought and lower lake levels in some Montana watersheds as well as higher localized precipitation and flooding in others.

The discharge regimes of mountain streams and rivers that supply water to many Montana lakes will become more variable. In Montana, we are likely to experience earlier peak flows in spring and lower summer flows that will affect the transport rate of sediments and nutrients downstream. Warmer stream temperatures will also stress native fish species and give a competitive edge to more warm-water-tolerant introduced species.

A changing climate will mean that Montana lakes could experience a shift in their heat balance, temperature profiles and vertical mixing regimes. Warming atmospheric and stream temperatures will increase lake surface temperatures and decrease ice-cover, affect nutrient fluxes, alter the productivity and composition of lake *plankton*, and decrease dissolved oxygen levels for all aquatic life.

It will take the active partnerships of government agencies, universities, NGOs, and private citizens to protect our Montana water resources in a changing climate and to create resilience strategies for the future.

Lake Ice

The maximum density of water is 39.2 Fahrenheit at sea level. Any water that is warmer or cooler than the temperature of maximum density will float on top. In early winter as surface water temperatures reach the freezing point, ice will begin to form on top of the lake. The onset of ice formation can depend on the size and depth of the lake, along with local meteorological conditions. Lakes with larger volumes take longer to lose their heat and oftentimes have longer fetch distances than smaller lakes. Fetch is the unimpeded wind flowing over the lake that causes waves that can break up thin ice that initially forms around the edges of the lake. Ice forms most efficiently during very cold and windless conditions.

Years with more extreme weather conditions and shorter ice cover duration have become more common. Lake ice trend data from around the world is showing later ice on dates and earlier ice off dates. In addition, lakes known to historically freeze every year are now displaying higher variability in ice cover. From 1914 to 1962 Whitefish Lake completely froze in the winter 92% of the time. No data exists for 1963 to 1995. From 1996 to 2016 the rate at which Whitefish Lake completely froze decreased to 75% of the time.

The photo below shows Whitefish Lake in early winter as lake surface temperatures cool. Very cold temperatures coupled with calm conditions drive ice formation.

Whitefish Lake cooling down. Photo courtesy gravityshots.com

"Ice Breakup on Whitefish Lake." Photo courtesy gravityshots.com

Chapter 7

LEARN MORE ABOUT

Montana Climate Action Plans or activities related to addressing climate change:

Bozeman
http://bozemanclimatepartners.net/climate/climate-action-plans-policies-2/

Helena
http://aeromt.org/PDFs/ClimateChangeTaskForce.pdf

Climate Smart Glacier Country
http://climatesmartglaciercountry.org/

Climate Smart Missoula
http://www.missoulaclimate.org/action-plan--buckets.html

Red Lodge
http://cityofredlodge.net/

Missoula
http://www.ci.missoula.mt.us/1709/Conservation-Climate-Action-Plan

State of Montana
https://deq.mt.gov/Portals/112/Energy/ClimateChange/Documents/FinalReportChapters.pdf

The University of Montana
http://www.umt.edu/sustainability/documents/CAPFinal.pdf

Whitefish
(Climate Action Plan in progress as of 2017)
http://www.cityofwhitefish.org/

MSU/UM Montana Climate Assessment
http://montanaioe.org/mca

Montana Climate Office based at UM in Missoula
http://climate.umt.edu/default.php

U.S. Global Change Research Program Natural Climate Assessment
nca2014.globalchange.gov

APPENDIX A - MONTANA AND U.S. LAKE-RELATED AGENCIES

GOVERNMENT ORGANIZATIONS

Montana Department of Environmental Quality
www.deq.mt.gov

Montana Department of Fish, Wildlife & Parks
www.fwp.mt.gov

Montana Department of Natural Resources and Conservation
www.dnrc.mt.gov

Montana Natural Resources Conservation Service
https://www.nrcs.usda.gov/wps/portal/nrcs/site/mt/home/

United States Army Corps of Engineers
http://www.usace.army.mil/

United States Environmental Protection Agency
www.epa.gov

United States Fish & Wildlife Service
https://www.fws.gov/

United States Forest Service
https://www.fs.fed.us/

NATIONAL PROFESSIONAL ORGANIZATIONS

American Fisheries Society (AFS), Montana Chapter
www.montanaafs.org/

Association for the Sciences of Limnology and Oceanography (ASLO)
https://aslo.org/

American Water Resources Association (AWRA), Montana Chapter
www.montanaawra.org/

North American Lake Management Society (NALMS)
https://www.nalms.org/

Dr. Jim Elser serves as Past-President of the Association for the Sciences of Limnology and Oceanography (ASLO), the world's largest and most important aquatic sciences professional association. An internationally renowned and highly published freshwater ecologist, Dr. Elser took the reins at the Flathead Lake Biological Station (FLBS) in December of 2015. His research expertise lies in the integrative field of biological stoichiometry, the study of balance of energy and multiple chemical elements in living systems. Ecological in focus, stoichiometry uses an evolutionary viewpoint to integrate organizational levels from the molecule and cell to the ecosystem. He has conducted observational and experimental studies at various scales from laboratory cultures and short-term field experiments to sustained whole-ecosystem manipulations.

His more recent work has investigated the connections among Carbon:Nitrogen:Phosphorus stoichiometry, growth rate, rRNA physiology and genetics, and ecological dynamics in diverse biota and ecosystems, including the application of these ideas to tumor dynamics. Jim is an active member of the Arizona State University's NASA-funded Astrobiology project "Follow the Elements" and a co-organizer of ASU's Sustainable Phosphorus Initiative.

APPENDIX B - LAKE TERMINOLOGY

Abiotic
Not associated with or derived from living organisms. Abiotic factors in an environment include such items as sunlight, temperature, wind patterns, and precipitation.

Adfluvial
Migrating between lakes and rivers or streams.

Algae
Algae are simple plants that can range from the microscopic (microalgae), to large plants (macroalgae). Microalgae include both cyanobacteria, (similar to bacteria, and formerly called "blue-green algae") as well as green, brown and red algae.

Anthropogenic
Anthropogenic is an adjective that describes changes in nature made by people.

Benthic Zone
The benthic zone is the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers.

Bioaccumulate
Bioaccumulation is the accumulation of substances, such as pesticides, or other chemicals in an organism. Bioaccumulation occurs when an organism absorbs a substance at a rate faster than that at which the substance is lost by catabolism and excretion.

Biotic
Associated with or derived from living organisms. The biotic factors in an environment include the organisms themselves as well as such items as predation, competition for food resources, and symbiotic relationships.

Biomagnification
Biomagnification, also known as bioamplification or biological magnification, is the increasing concentration of a substance, such as a toxic chemical, in the tissues of organisms at successively higher levels in a food chain.

Dystrophic
Brown or tea-colored lake water that is acidic due to organic matter input. Nutrient levels can vary but low dissolved oxygen levels affect aquatic life.

Eutrophic
A lake with high nutrient levels and highly productive in aquatic animal and plant life. Eutrophic literally means true nutrients or truly nutrient rich (Phosphorus and Nitrogen).

Fluvial
From or found in a river.

Hybridization
The process of mating organisms—animals or plant—of different breeds, varieties, species or genera to create a hybrid.

Hypereutrophic
A lake that is extremely rich in nutrients and minerals.

Littoral zone
The part of a sea, lake or river that is close to the shore. In coastal environments the littoral zone extends from the high water mark, which is rarely inundated, to shoreline areas that are permanently submerged.

Mesotrophic
A lake with moderate nutrients levels and moderately productive in aquatic animal and plant life.

Nutrients
A component in foods that an organism uses to survive and grow. Macronutrients provide the bulk energy an organism's metabolic system needs to function while micronutrients provide the necessary cofactors for metabolism to be carried out. Both types of nutrients can be acquired from the environment.

Oligotrophic
Lakes that are deep and clear with low nutrients levels, little organic matter, and a high dissolved-oxygen level.

Pelagic Zone
Any water in a sea or lake that is neither close to the bottom nor near the shore can be said to be in the pelagic zone.

Photosynthesis
The process by which green plants and some other organisms use sunlight to synthesize foods from carbon dioxide and water. Photosynthesis in plants generally involves the green pigment chlorophyll and generates oxygen as a byproduct.

Phytoplankton
Photosynthesizing microscopic plant-like organisms at the base of the aquatic food web that inhabit the upper sunlit layer of almost all fresh waterbodies on Earth.

Plankton
Microscopic organisms that drift or swim weakly in a body of water, including bacteria, diatoms, and various larvae. Plankton is an important food source for fish and other larger organisms. (See phytoplankton and zooplankton)

Polychlorinated Biphenyls (PCBs)
An organic chlorine compound with the formula $C_{12}H_{10-x}Cl_x$. Polychlorinated biphenyls were once widely deployed as dielectric and coolant fluids in electrical apparatus, carbonless copy paper and in heat transfer fluids.

Predation
In an ecosystem, predation is a biological interaction where a predator (an organism that is hunting) feeds on its prey (the organism that is attacked).

Profundal Zone
The profundal zone is a deep zone of an inland body of freestanding water, such as a lake or pond, located below the range of effective light penetration. This is typically below the thermocline, the vertical zone in the water through which temperature drops rapidly.

Secchi Disk
The Secchi disk, as created in 1865 by Angelo Secchi, is a plain white, circular disk 30 cm (12 in.) in diameter used to measure water transparency in bodies of water.

Spatial
Having to do with "where" things are and why they occur there.

Trophic State
A method of classifying lakes. Trophic means nutrition or growth. Although lakes are arranged into a few trophic classes, each lake has a unique set of attributes that contribute to its trophic status. The three main factors that regulate the trophic state of a lake are rate of nutrient supply, climate, and shape of the lake basin.

Watershed
A watershed is the area of land where all of the water that falls in it and drains off of it goes to a common outlet. Watersheds can be as small as a footprint or large enough to encompass all the land that drains water into rivers that drain into Chesapeake Bay, where it enters the Atlantic Ocean.

Zooplankton
Zooplankton is a range of small and large animal-like organisms drifting in fresh waterbodies. Individual zooplankton are usually microscopic, but some are larger and visible with the naked eye.

Nature's Wonder: Pine Needle Balls

In 2015, WLI discovered perfectly formed larch needle balls along a small shoreline reach of Whitefish Lake in about two feet of water. Although balls comprised of organic matter (in this case larch needles) are uncommon, they have been reported worldwide and are often called surf balls or beach balls. Gift shops are known to sell these oddities as whale burps, whale barf balls, whale fur balls and moose balls.

Unique conditions are needed to form these balls. It is suspected that they are formed from surf action along the shoreline where as waves approach; they drag on the lake bottom, causing the wave crest to curl and crash onto the beach. The curling action may roll materials into a ball. However, the balls found in 2015 were within five feet on one another, suggesting other specific local conditions. These unique creations from Mother Nature are on display at the Whitefish Lake Institute office in Whitefish. Pine balls from Lindbergh Lake can be found at the Stumptown Historical Society in Whitefish, and from Kintla Lake at the Polebridge Mercantile in Polebridge.

Pineballs. Photo courtesy Whitefish Lake Institute

NOTES