ENVIROTHON ALBERTA 2025

2025 AQUATIC ECOLOGY

STUDY RESOURCES

2025 NCF-ENVIROTHON ALBERTA

2025

Aquatic Ecology

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NCF-Envirothon 2025 Alberta
Aquatic Ecology Study Resources

Key Topic #1: Hydrology and Aquatic Environments

1. Identify and classify different types of wetlands in Alberta.
2. Explain how Alberta's geology and soils impact the water quality of lakes and streams in alpine and boreal forest ecosystems.
3. Describe the process of thermal stratification of lakes and how this impacts lake mixing, temperature, and oxygen dynamics.
4. Describe how wildfires can impact hydrology and aquatic ecosystems.
5. Analyze the benefits and challenges associated with beaver presence in an aquatic ecosystem and apply techniques for coexisting with beavers.

Study Resources

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Video - Wetland Ecosystems

https://www.youtube.com/watch?v=bYS941IqbcM

Hydrogeological Regions Of Alberta

Alberta Energy Regulator

April 15, 2021

Groundwater plays an important role in the water cycle in Alberta. It contributes to streamflow during dry periods and maintains ecosystems such as fish spawning areas and wetlands. Groundwater is also an important source of water for different sectors of Alberta's economy, including rural water supply, agriculture, and industry.

Groundwater conditions rely on hydrogeological characteristics which are a reflection of the unique physiography, geology, and climate of an area. Hydrogeological characteristics affect groundwater movement, availability, yield, quality, and response to changes from human use or climate change. Knowledge of regions in Alberta that are similar in their hydrogeological characteristics is important for developing policies for water resource management and building water security, sustainability and resilience for the future.

The Geological Survey of Canada defined nine broad hydrogeological regions for Canada. The vast majority of Alberta is covered by only one of these national-scale regions; the Plains Region. Small portions of Alberta are defined as the Precambrian Shield Region in the far northeast, and the Cordillera Region in the southwest. To more accurately represent the variability of physiography, geology, and climate across the province, the Alberta Geological Survey has defined ten provincial-scale hydrogeological regions.

- Mountains and Foothills
- Western Plains and Benchlands
- Central Plains
- Eastern Plains and Buried Valleys
- Province-Wide Buried Valleys
- Regional Uplands
- McMurray Lowlands
- Northwestern Lowlands
- Northeastern Lowlands
- Canadian Shield and Athabasca Basin

For the Province-Wide Buried Valleys (Region 5) and the Canadian Shield and Athabasca Basin (Region 10) regions, subdivisions are used to distinguish subregional differences.

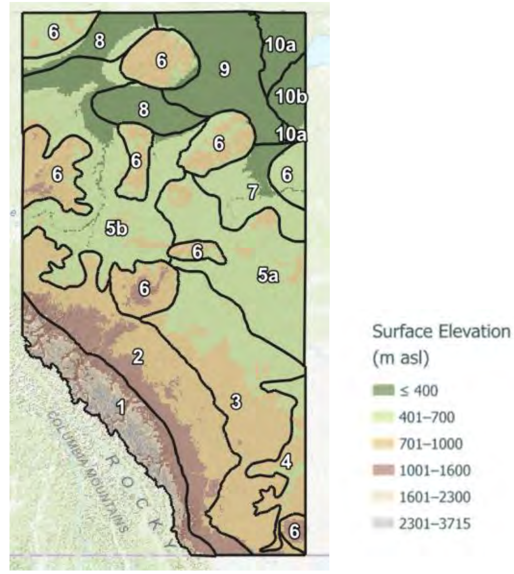
Alberta's hydrogeological regions provide context for water management planning and policy development based on the unique characteristics of each region. Descriptions and conceptual drawings of each region provide the overarching hydrogeological setting within each region. These descriptions can guide more localized studies of specific aquifers or aquifer systems.

Alberta's Hydrogeological Regions

Regional geology and physiography are important characteristics in defining Alberta's provincial-scale hydrogeological regions. Specifically, land position (elevation), the presence of buried bedrock valleys, the thickness of sediment overlying bedrock, and the bedrock type were considered. The following sections and maps describe how each of these characteristics contributes to the physical system through which groundwater moves.

Land Elevation

The elevation of an area relative to its surroundings plays an important role in driving groundwater flow. Groundwater typically flows from areas of high elevation to areas of low elevation. Elevation differences within a small area affect shallow groundwater movement and form local groundwater flow systems. Elevation differences across progressively larger areas affect movement of progressively deeper groundwater, forming subregional and regional flow systems. Groundwater enters the flow system in recharge areas and leaves it in discharge areas.

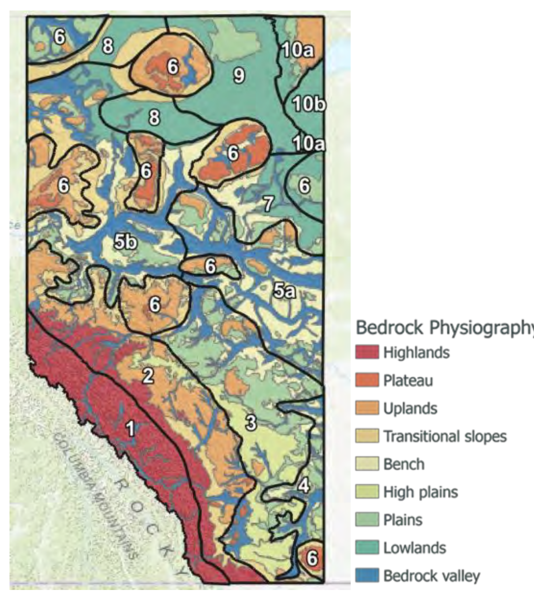


The hydrogeological regions do not define groundwater flow system boundaries explicitly; however, the high elevation of the Mountains and Foothills (Region 1) generally drives deep groundwater towards the north and east. Similarly, a defining characteristic of the Regional Uplands (Region 6) is that each upland rises significantly above the surrounding landscape and drives groundwater flow into neighbouring regions.

Within each of the hydrogeological regions, local-scale and subregional variation in ground elevation creates shallower groundwater flow systems that are nested within the larger regional system.

Bedrock Physiography

The topography of the present land surface is often a subdued reflection of the physiography of the underlying bedrock surface, with one major exception: ancient bedrock valleys that are buried by glacial sediments, making them indistinguishable from the present land surface. The buried valleys sometimes contain permeable sand and gravel along the valley floor, deposited by preglacial rivers or glacial meltwater. These deposits form so-called buried valley aquifers. Buried valley aquifers are an important groundwater source across the Prairie provinces of Canada.



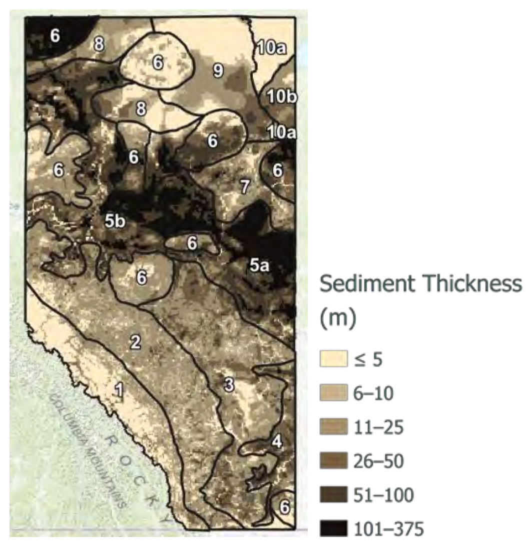
The physiography of the bedrock surface is mainly a result of millions of years of erosion by preglacial, eastward- to northeastward-flowing rivers. The rivers began in the Rocky Mountains and cut progressively downwards across the plains. In some areas, the bedrock was affected more recently by erosion by glacial meltwater and modern-day rivers.

Most, but not all of the bedrock valleys shown on the map (in dark blue) are buried. Some have never been buried, some were buried and later carved out again, and some are bedrock valleys carved by modern-day rivers. Although some bedrock valleys look connected, they may have been carved out at different times. Additionally, not all buried valleys contain buried valley aquifers.

An abundance of large buried valleys defines the Province-Wide Buried Valleys region (Region 5). These deep and wide valleys are filled with a substantial amount of sediment. In the eastern half of the region (Region 5a) the main source of groundwater is from aquifers within the sediment rather than the bedrock, which is unusual in Alberta. Buried valleys are also a defining feature of the Eastern Plains and Buried Valleys region (Region 4), where a higher proportion of groundwater comes from the thicker sediment filling the buried valleys, rather than the bedrock. In other regions, smaller buried valleys occur and may contain aquifers that can provide a local source of groundwater. In general, buried valleys become a more important source of groundwater eastwards from the mountains into Saskatchewan.

Sediment Thickness

The thickness of sediments above the bedrock can influence the hydrogeology in two ways: first, the sediments may contain permeable zones that form suitable aquifers, and second, groundwater recharge to the bedrock units below may be decreased by thick sediment. The sediment thickness also affects the minimum depth which a well needs to be drilled to obtain water from the bedrock, which can become cost-prohibitive for some users.



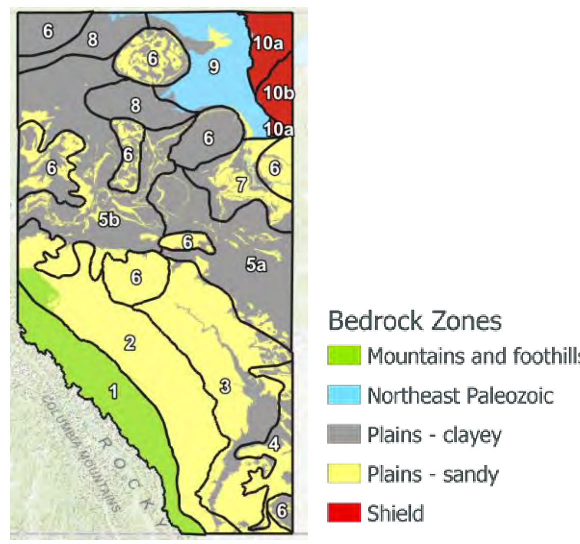
Much of the sediment that covers Alberta has been affected and deposited by glacial processes during the last continental glaciation. Most of this sediment can be categorized as diamicton, which is a mixture of particle sizes from clay to boulders. A common diamicton in Alberta is till, which is a sediment deposited by glacial ice. Till is often a poor aquifer material because it does not transmit water easily and the water quality is often poor. Sometimes the till contains zones of permeable sand and gravel which may function as local aquifers.

Thick sediments in Alberta are often associated with buried valleys, which may contain aquifers of preglacial fluvial sand and gravel at their base that are often confined by till above. Preglacial sand and gravel aquifers can also be found directly overlying bedrock at higher elevations, such as along bedrock terraces or even on top of the Regional Uplands (Region 6). Like the buried valley aquifers, these deposits mark the locations of the floors of ancient rivers. Modern sand and gravel deposits can be viewed along some major rivers and may form localized aquifers that are well connected to nearby rivers, lakes, and wetlands.

Sediments are generally thin across the Western Plains and Benchlands region (Region 2), and aquifers within these sediments are not a major source of groundwater. The sediments get thicker moving east to the Central Plains (Region 3), and Eastern Plains and Buried Valleys (Region 4) regions, especially along the buried valleys. In the north-central part of Alberta, the Province-Wide Buried Valleys region (Region 5) is characterized by very thick sediments which in the east contain aquifers within the till that are sometimes widespread and interconnected, in addition to buried valley aquifers. In the northern part of Alberta, sediments are generally thin and there is little information on the presence of aquifers in the sediments above bedrock. The exception is the McMurray Lowlands region (Region 7), where extensive, but narrow and discontinuous aquifers are present in the buried valley sediments.

Bedrock Geology

The type of bedrock affects where and how easily groundwater can move. There are over a hundred different geological formations in Alberta. The bedrock geology map of Alberta shows the shallowest bedrock formation in a given area. Outside of the Mountains and Foothills region (Region 1), most of the formations have a slight downward tilt, or dip, towards the Rocky Mountains. The formations at the bedrock surface consequently get older towards the east and north.



The formations on the bedrock geology map have been grouped based on the type of rock to show five bedrock zones. The type of bedrock affects the arrangement of aquifers and movement of groundwater through either small spaces between rock grains (pores) or fractures, faults, and large voids.

- The green area contains mainly hard, well-cemented, Precambrian, Cambrian and Paleozoic metamorphic and sedimentary rocks that form the Rocky Mountains and Foothills region (Region 1). Groundwater in this region will preferentially flow through fractures and faults in the deformed bedrock

- The yellow and grey areas cover a majority of the province and contain softer, less well-cemented, porous Mesozoic and Cenozoic sedimentary rocks. Groundwater movement depends on how easily water can move through pores in the bedrock. Sandstone-dominated formations (yellow on map) transmit groundwater more easily than more mudstone-dominated formations (grey on map). These areas contain aquifer systems, which are several geological layers that function as an aquifer when grouped together. The mudstone-dominated formations generally function as aquitards, although they can sometimes produce small amounts of water from localized aquifers. Although sandstone-dominated formations are found across the plains regions in southern

Alberta, differences in how these formations were deposited influence the extent of aquifer systems, groundwater availability, and water quality. These geological differences are a key differentiating factor between the Western Plains and Benchlands (Region 2) and Central Plains (Region 3) regions.

- The blue areas contain hard, well-cemented Paleozoic carbonates and evaporites. The Northeastern Lowlands region (Region 9) is dominated by these rocks and contains complex aquifer systems where permeability has been enhanced by fractures and voids created where groundwater has altered and dissolved the bedrock.
- The red area contains very hard, igneous, and metamorphic rocks and non-porous cemented sandstones of the Canadian Shield and Athabasca Basin in the far northeast and define the Canadian Shield and Athabasca Basin region (Region 10). Groundwater movement will typically only occur through fractures and faults.

How and Why Lakes Stratify and Turn Over: We explain the science behind the phenomena

By Paul Fafard, Field Sampling Technician
IISD Experimental Lakes Area
May 16, 2018

Have you ever been swimming and experienced a sudden drop in temperature in the water near your feet, while the surface water remains a comfortable temperature?

What you are experiencing is thermal stratification—when lakes “divide” into different layers of density due to differing temperatures.

When spring turns to summer, most Canadian lakes, including those at IISD Experimental Lakes Area, experience both thermal stratification and lake turnover. These phenomena are very important for many aquatic organisms and allow for lake ecosystems to thrive.

Before getting into the details of thermal stratification and lake turnover, there are two things we need to remember:

- Water density depends on its temperature. The warmer the water, the less dense it becomes. Water is at its densest closest to 4°C.
- Liquids of different densities often do not mix easily. The greater the difference in density, the harder it is to get the liquids to mix. Think about oil and vinegar in a salad dressing. This resistance to mixing also occurs in water of different temperatures

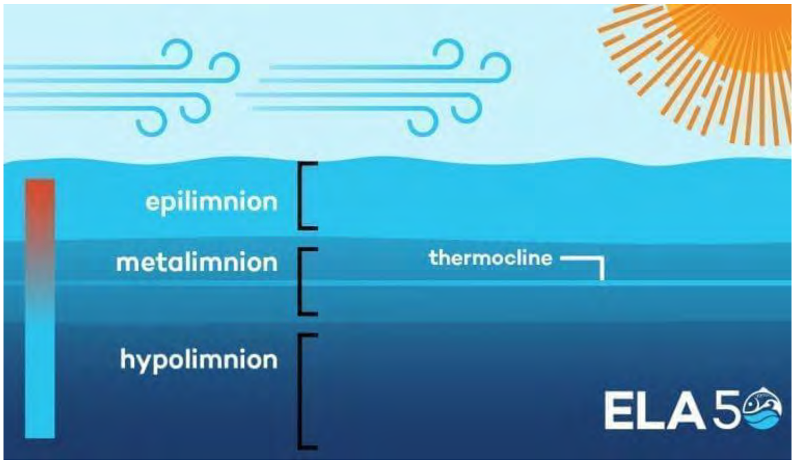
Spring to Summer: Lakes begin to stratify due to differences in temperature

Thermal stratification occurs when the water in a lake forms distinct layers through heating from the sun. When the ice has melted in the spring, solar radiation warms the water at the surface of the lake much faster than in deeper waters. In fact, sunlight often only penetrates a few metres into the lake, directly warming just the top few metres. As the water warms, it becomes less dense and remains at the surface, floating in a layer above the cooler, denser water below.

Lake turnover is extremely important in freshwater lakes, as it is the event that is responsible for replenishing dissolved oxygen levels in the deepest lake waters.

When a lake stratifies, three different layers typically form.

The shallowest layer is that warm surface layer, called the epilimnion. The epilimnion is the layer of water that interacts with the wind and sunlight, so it becomes the warmest and contains the most dissolved oxygen. Though dissolved oxygen doesn't play a direct role in lake stratification and turnover, it is important for all the aquatic organisms in a lake that require oxygen to survive.



The deepest layer is the cold, dense water at the lake bottom, called the hypolimnion. The hypolimnion often remains around 4°C throughout the year, rarely gets any direct warmth from the sun and is isolated from the air at the surface of the lake. The hypolimnion contains the lowest amount of dissolved oxygen and can often become anoxic (zero dissolved oxygen) while the lake is thermally stratified.

The middle layer is the transition zone of water between the warm epilimnion and cold hypolimnion, called the metalimnion. The metalimnion is a place where the shallowest of the cool waters in the hypolimnion gradually warm up until they mix into the epilimnion. The point of greatest temperature difference (and therefore density difference) is called the thermocline and occurs within the metalimnion.

Lakes stratify thanks to the heat of the sun and the movement of the wind.

Throughout the summer, wind and waves cause the warming water in the epilimnion to mix deeper and deeper, slowly incorporating hypolimnetic water through the metalimnion. The ability of a lake to mix through wind turbulence is determined by the "stability" of thermal stratification. Stratification becomes increasingly stable with heating from the sun. The larger the difference in temperature (and density) between the epilimnion and the hypolimnion, the more stable the thermal stratification.

When you are next swimming in a freshwater lake, impress all your friends by dipping your toes from the epilimnion, through the metalimnion and into the depths of the hypolimnion!

Eventually, the epilimnion warms to the point where the difference in density between the epilimnion and hypolimnion (at the thermocline) is so large that wind and waves can no longer generate enough energy to incorporate hypolimnetic water.

As the summer turns to fall, the surface waters cool and sink, mixing the epilimnion down towards the hypolimnion and weakening the thermocline; as the temperatures and densities of the epilimnion and hypolimnion become more similar, the water currents and wind can once again mix water between the two layers.

Eventually, the epilimnion cools until the entire lake is the same temperature (isothermal). This allows lake turnover to occur.

How wildfires impact a watershed

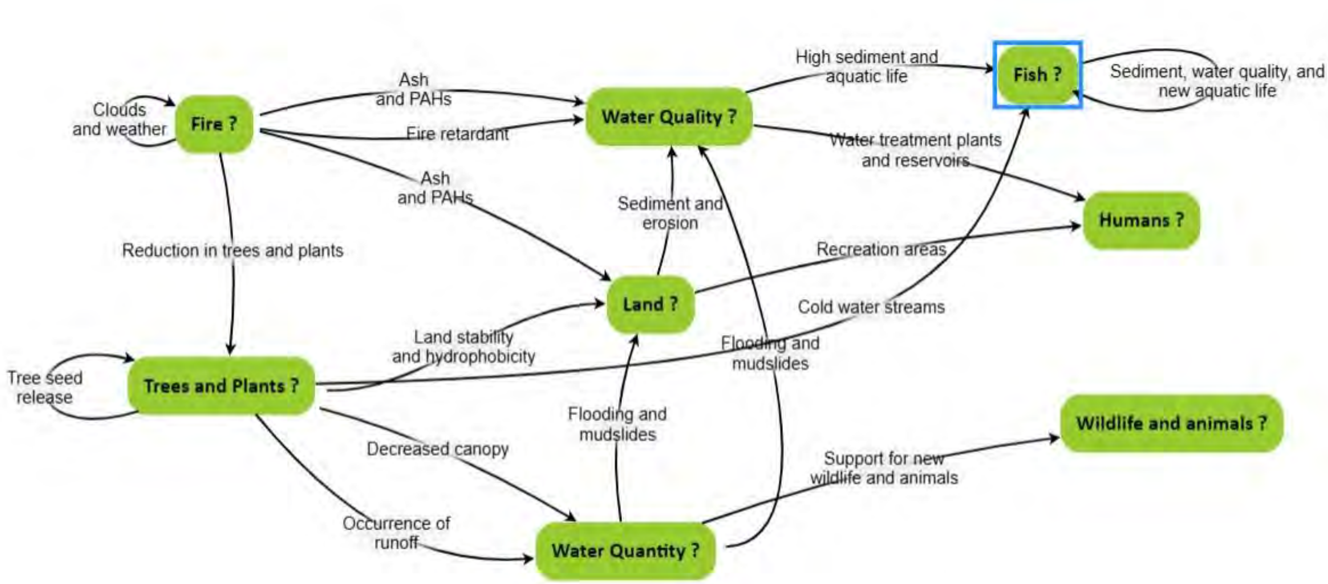
PUBLISHED: 14 July 2016

About 1,200 wildfires on average are reported in Alberta each year. Half of the wildfires are caused by humans and close to half are caused by lightning.

As we have seen dramatically over the last two decades, wildfires impact communities, people, wildlife and habitat as undergrowth burns, trees come down, and increased sediment enters streams. The specific impacts of a wildfire on a watershed can be unpredictable and depend on variables including existing (pre-fire) river or lake chemistry, topography and bedrock, and vegetation.

From a water quality perspective, wildfires can cause changes in a number of parameters of interest or concern including nutrients, sulfate, pH, total dissolved solids, turbidity, organic carbon, chloride, iron, color, taste, and odor.

Water quantity impacts are generally observed following intense rainfall or snowmelt in a watershed impacted by fire. Increased flooding and peak flows as well as debris flows are examples of wildfire impacts related to water quantity.



Wildfire-impacts: A complex web of nodes and edges where the nodes are issues(e.g. Fire, LAnd, Water Quality)and the edges are the wildfire impacts on other nodes (e.g. the effects of the fires retardant used on the wildfire on water quality)

Wildfire impacts

Clouds and weather

If the heat of a fire is lifted high enough it can create a water cycle of its own through pyrocumulus clouds. These clouds may rise above the smoke from a major wildfire and rain can fall from these clouds, which may help put out the fire or, in a worse scenario, cause lightning that creates another fire in the same or neighbouring watershed.

Ash and PAHs

Polycyclic Aromatic Hydrocarbons (PAHs) are a group of chemical compounds that show up after any sort of fire that involves organic matter. They appear after a wildfire and they can also appear within car exhaust fumes or cooking a burger on a BBQ. After a wildfire, if there is environmental monitoring nearby, the PAHs produced from the wildfire may interfere with those recordings.

Along with all the other ash and materials PAHs travel by air until they settle on the land and in water.

Fire retardant

Although fire retardant does have an environmental impact, in particular to fish and aquatic life, its impacts are dwarfed by the impacts of the ash and high temperatures from the fire. A study published in 2006 compiled data from post-fire surface water monitoring programs where fire retardant constituted ammonia, phosphorus, and cyanide was measured (data was available in the public domain). This study found these chemicals were also found in similar concentrations to streams in burned areas where retardant was not used.

Reduction in trees and plants

Following a wildfire the number of trees and plants in the impacted area can be dramatically reduced. The absence of trees and plants and a decreased canopy can contribute to mudslides and floods. However, over time a reduction in trees and plants can allow new growth to take root—fire can be an important contributor to natural regrowth and habitat change which contributes to overall diversity in a watershed.

Tree seed release

Although wildfire may kill off and remove some plants and trees there are some types of trees, such as the Lodgepole Pine (an evergreen conifer which is also the provincial tree of Alberta) whose pinecone scales are held closed by resin and only open from the heat of a wildfire or direct sunlight.

Decreased canopy

A decrease in trees and plants mean there is less, or in some cases no, interception of snowfall to the ground. This results in an increase in the amount of snow that reaches and stays on the ground, creating bigger snow pillows. Bigger snow pillows may result in higher peak flows as the snow melts or contribute to flooding or mudslides through the greater volume of snowmelt in specific areas.

Occurrence of runoff

Decreased trees and plants means there are fewer opportunities for precipitation to be trapped and soaked into the ground. This causes higher surface runoff and increased erosion, which increases water quantity and decreases water quality. Further, runoff during the first year after a wildfire can increase by as much as 30%.

Flooding and mudslides

Immediately after a wildfire occurs many of the services normally provided by trees and plants go missing. Intense rainfall and/or snowmelt (increasing water quantity) combined with the decreased tree canopy can contribute to flooding and mudslides. Flooding impacts after a wildfire can be exacerbated by debris flows with large amounts of soil, rocks, and trees from a burned area. The risk of flooding and debris flow in a watershed can be determined using a combination of slope (or ruggedness), road density, and other data. The more rugged a watershed is, the more susceptible it is to debris flows after a wildfire.

Land stability and hydrophobicity

Less trees and plants mean fewer roots holding together the soil. As a result soil and dirt in the burned area is less stable. Without the protective role of vegetation on soil there is potential for mudslides. Interestingly, in severe, slow-moving fires the combustion of vegetative materials creates a gas that penetrates the soil profile. As the soil cools, this gas condenses and forms a waxy coating. This causes the soil to repel water – a phenomena called hydrophobicity. Hydrophobicity can exacerbate runoff impacts.

Sediment and erosion

If rainfall occurs after a wildfire, the ash and soot that fell during the fire will be flushed through the watershed. Long term impacts of a fire and sediment depend on the characteristics of the watershed (lakes, rivers, or both), the severity, and the reoccurrence of rain events following the fire. Sediment can affect stream structure and function; headwater reaches will undergo erosion and can become unstable, while flatter downstream reaches will receive sediment and may become clogged with fine material.

High sediment and aquatic life

The large amount of sediment after the fire can overwhelm fish and aquatic habits. Since the 2003 Lost Creek fire in Alberta some of the aquatic ecology still has not recovered.

Water treatment plants and reservoirs

The proximity of the water treatment plant to the surface water source will affect how strongly the plant is affected by wildfire-related water quality changes.

Another consideration for water treatment plants after a wildfire is turbidity—which refers to the cloudiness of the water; clear water is not very turbid while muddy water is very turbid. A typical water treatment plant is prepared to deal with normal levels of turbidity and spikes in turbidity. However increased turbidity after a wildfire may require more treatment chemicals or cause additional wear and tear to water treatment filters. For example, membranes (ultrafiltration and microfiltration) can handle occasional turbidity spikes however over time productivity of the plant is impacted due to more frequent backwashes, which uses more water and increases 'downtime'.

Excess sediment and debris flows may fill or otherwise disrupt reservoirs, infiltration basins, or treatment works. In particular, mobilization of sediment can result in reservoir sedimentation, curtailing the useful life of a reservoir.

Recreation areas

The scars of a wildfire including singed vegetation, less trees and plants, flooding, or mudslides change public areas and may have a positive or negative impact on recreation and tourism. Areas may be closed for some time after a wildfire as burned trees can suddenly fall or lose limbs. Kootenay National Park, which borders Alberta's Banff National Park, has positioned the impacts of fire on landscapes as a visitor attraction, "The ghostly spindles of once-burned trees carpet many parts of Kootenay. The fresh green trees and plants among them are awe-inspiring evidence of the destructive and regenerative power of fire – vital to forest renewal and health."

Support for new wildlife and animals

During a wildfire many of the animals will find ways to escape, either by travel, or by burrowing underground. However the strategy of burrowing underground fails when the intensity of the fire is too great. Once a fire is over its remnants offer new scavenging opportunities for animals. Over time, as the forest returns, so do the wildlife, adding to the overall biodiversity of a watershed and its ecosystems.

Cold water streams

Fire can destroy vegetation that shades cold-water streams, which helps keep them cool. This impact on the watershed is not beneficial to favored angling species such as trout, which require a steady supply of clean, cold and silt-free water.

Sediment, water quality and new aquatic life

As the years pass after the wildfire, sediment is flushed downstream. This happens faster when a stream is undammed. Over time as the stream recovers the aquatic life will return.

Where Beavers Go, Surprises Follow

21 April 2021
BY GLYNNIS HOOD

Beaver - T. LePrieur

It's an usually warm day in January and my snowshoes are only partially necessary on the frozen ponds that aid my route through the Ministik Game Bird Sanctuary in east-central Alberta. Having studied beaver populations and their influence on wetland ecosystems for 20 years in the Beaver Hills moraine, this is my first serious exploration of the beaver ponds of Ministik. It is a world that defies explanation at times — towering lodges, beaver dams dropping in step-like formation to yet another perched wetland, and then to another, and another. As I rest against a beaver lodge to have my tea, I realize that after all these years, there is still so much more to learn about these rodents, which can engineer entire landscapes unlike any other mammal, other than humans.

Various researchers have found that beavers prefer to live in ponds with gentle slopes. However, in a recent study in Miquelon Lake Provincial Park, immediately south of Ministik, I determined that just the opposite happens in the Beaver Hills; the steeper the slope, the more likely beavers will occupy the pond. There are some beaver ponds in Ministik and Miquelon with slopes well exceeding 70%, complete with multigenerational foraging trails leading straight up the steepest banks. This winter, when my field assistant and I came across the top of a beaver foraging trail, we could see nothing but air below the ends of our snowshoes. The descent to the pond had a slope of about 75%; our enthusiasm tempered by a good dose of common sense, we chose another route down. This preference for steeper slopes in a landscape dominated by isolated ponds allows beavers closer access to preferred food sources, such as trembling aspen.

Beaver History: Collapse and Recovery

North American beaver populations, along with their Eurasian cousins, have made a remarkable comeback after collapsing from fur-trade overharvest. A great deal of this success is attributed to strict conservation policies and early reintroduction efforts, but the tenacity and adaptability of these large rodents have been central to their successful recovery. Their versatility makes beavers one of the most widespread mammals in North America, ranging from the Arctic Ocean to northern Mexico. With a warming climate, beavers are now moving from northern river systems and deltas directly onto the Arctic tundra as it becomes increasingly colonized by shrubs.

The history of beavers in the Beaver Hills has included both overexploitation and conservation. This area, known as Amiskwaciy ("beaver hills") in Cree, was an important hunting and resting area for many Indigenous peoples. The early fur trade brought heavy commercial trapping, and subsequent European settlement resulted in extensive deforestation through fire and logging. Beavers were completely trapped out in the Beaver Hills by the mid to late 1800s. Fortunately, this period of decline was followed by dedicated efforts to restore and conserve beavers and several other species that suffered a similar fate.

In 1899, the Federal Department of Interior established the Cooking Lake Forest Reserve, part of which is now the Cooking Lake-Blackfoot Provincial Recreation Area. Additional protected areas soon followed: Elk Island National Park in 1906, Ministik Game Bird Sanctuary in 1911, and Miquelon Lake Bird Sanctuary in 1920 (later Miquelon Lake Provincial Park in 1958). After the successful reintroduction of beavers from Banff National Park into Elk Island National Park in 1941, likely augmented with natural recolonization, the Beaver Hills again began to live up to their name. Beavers have now made their home throughout the moraine.

Beavers as Ecosystem Engineers

Because of the early conservation interest in the moraine, we have a well-established aerial photo record that dates back as far as the 1920s. Comprehensive aerial photo sets started in the 1940s. My analysis of these photos over a 54-year period (1948 to 2002) in Elk Island National Park showed that, even during the record-breaking drought of 2002, ponds with beavers had nine times more open water than those same ponds when beavers were absent. The presence of beavers explained over 80% of the annual variability in the extent of open water in the park. The results were so shocking that I reanalyzed the data and reviewed the aerial photographs several times before my PhD supervisor, Suzanne Bayley, and I sent the article for peer review.

My next question was why. Unlike what I have seen in Ministik, many of my study ponds in Elk Island lacked dams, and dams that did exist were usually associated with roadside culverts, or were relatively small. Permanent streams are uncommon, and there are no rivers in the 194-km2 park.

The answer began to reveal itself as I sat next to an occupied beaver pond during the drought of 2002. A series of open mudflats lay before me. But unlike the dry, flat-bottomed ponds elsewhere in the park, the bottoms of these occupied ponds had deep, water-filled channels, excavated by beavers in a complex branching pattern (see photo). They originated from the main entrance of the lodge and then radiated throughout the pond to key upland foraging areas. It seemed to me then that there was more to these channels than just access routes to favourite food sources.

Drought Pond

A few years later, in Miquelon Lake Provincial Park, I decided to quantify the often-cited description of beavers as ecosystem engineers. Although dams and lodges are the most recognized structures that beavers build, beaver channels along the bottom of the pond and extending perpendicular from the water's edge can be extensive. The longest channel I have measured is just under 500 m, likely excavated over several years. Most channels are much shorter, with many just under a metre deep and a metre wide. More than once, water lapping at the tops of our chest waders indicated that some channels are well over a metre deep. More fascinating than the length and depth of these channels is the impact they have on the configuration of riparian habitats and the increased volume of water in these ponds.

Through my studies, I determined that the creation of beaver channels increases the perimeter of a pond by an average of 575%. This is critical because riparian edges — those margins along water bodies where land and water meet — support high levels of biodiversity. Average surface area of these ponds also increased because of these channels. Most importantly, the volume of ponds with beavers was approximately 25% greater than ponds that were abandoned by beavers. Much of this increase in pond volume was directly related to increased depths of the ponds as beavers excavated and reconfigured the pond bottoms. Beaver channels appear to focus water from upland areas directly into the ponds.

The amount of effort required to create these channels is staggering. I calculated that in the excavation of channels, beavers moved over 1,700 m3 of soil for every square kilometre of park. A typical dump truck moves approximately 10 m3 of soil in one load. Now imagine beavers excavating the equivalent of over 17 dump trucks worth of soil for every square kilometre of park! These numbers reveal what ecosystem engineers can do, over and above the construction of dams and the flooding of adjacent areas. These channels are enduring, often lasting more than a decade after beavers are gone. Ponds with channels are the last to dry up in a drought, and the first to refill once it is over.

By modifying the shorelines and basins of ponds so dramatically, habitat complexity increases, which in turn influences habitat use and availability for other species. In a study with Dr. David Larson, we collected samples of aquatic invertebrates at three different habitats within occupied and unoccupied beaver ponds: along the vegetated shoreline, in the open water column, and in beaver channels. We fully expected that beaver channels would function much like the vegetated edges of the ponds, but were surprised to find that beaver channels served as "hunting hotspots" for predaceous aquatic invertebrates. Perhaps the regular movement of water in and out of the channel when beavers used them to access foraging areas, or the release of other food sources as beavers excavated the sides and bottoms of the channels, provided a regular influx of new prey. Whatever the reason, these tiny aquatic predators were found in higher abundance in these often-overlooked habitats. Other invertebrate species were also found exclusively in active beaver ponds, regardless of the type of habitat they used within the pond.

While sampling for invertebrates, we started to notice that other species appeared to be attracted to beaver channels as well. In a joint study with Nils Anderson and Cindy Paszkowski, we investigated the use of beaver ponds by wood frogs. These frogs mate in water, are born in water, and then disperse to upland areas as young frogs until they return to the ponds to mate as adults. We found that young and adult dispersing wood frogs were nine times more abundant in beaver channels than in regular shoreline habitats. We believe these channels serve as movement corridors for the dispersing frogs, providing additional protection from predation and injury as they move to upland habitats.

With all of these channels "reaching out" to the surrounding landscape, beaver channels can also help decrease the distance from one wetland to another quite dramatically. This is critical in the Beaver Hills, which is a landscape dominated by geographically isolated wetlands. Any connection between these water bodies provides ecological opportunities for species' movements across the landscape. Currently, my research team and I are using specially placed wildlife cameras, environmental DNA, and wildlife signs (e.g., beaver lodges, wildlife tracks, muskrat huts and push-ups) to assess how land use, aquatic connectivity, and species associations influence the distribution of a suite of semi-aquatic mammals across the Beaver Hills.

From the tiny American water shrew and northern bog lemming, to muskrat, beaver, and mink, to the possible presence of river otter, it takes a suite of clues to understand how ecosystem engineering and species interactions might influence entire ecological communities. Beavers are just part of the picture, but their tremendous influence on freshwater systems could play an important role in the presence of these other species, some of which have declining populations in Alberta.

Managing Beaver Conflicts

Despite their important ecological role, beavers continue to be a controversial species. People phone and email me regularly to ask where they can obtain beavers for their properties, or to ask how to get rid of them and reduce the damage associated with flooding and felled trees. There is a definite financial cost to living with beavers. To quantify this cost, Varghese Manaloor, Brendan Dzioba, and I surveyed 48 municipalities (including rural counties) and four provincial parks in Alberta. We estimated that beaver management (prevention, dam removals, and repairs) costs Alberta municipalities over $3 million per year. Given incomplete cost accounting by several municipalities, we considered these costs to be very conservative.

Pond Leveller Install G. Hood

Fortunately, management alternatives, such as pond levellers, exist to help reduce these costs. Pond levellers are made from a series of large plastic pipes and a protective cage that, once placed through a dam, maintain the pond at a constant level (see photo). Thus, the pond can remain (rather than being drained), nearby facilities are protected from flooding, and the ecological benefits of beaver ponds remain. Over the years, we have installed around 30 of these devices with a good deal of success. When we conducted a cost-benefit analysis of the levellers we had installed in the Cooking Lake-Blackfoot Provincial

Recreation Area, there was a net benefit of over $81,000 relative to traditional management approaches. Now organizations including Cows and Fish and the Miistakis Institute have taken the lead. Increasingly, pond levellers are seen as a cost-effective way to help humans and beavers coexist.

In many ways, beavers helped open up North America to European exploration and colonization. It was an era that almost resulted in the species' demise. Its return brings with it water, biodiversity, connectivity, and a bit of conflict requiring imaginative solutions for coexistence.

As my snowshoed feet pass by yet another beaver lodge, I cannot help but imagine what is yet to be discovered about this animal that transforms ecosystems in such dramatic ways, and enhances our understanding of how the loss of one species could affect the ecological health of so many others.

Dr. Glynnis Hood is an ecologist and Professor of Environmental Science at the University of Alberta's Augustana Campus in Camrose. Her research interests include aquatic ecology, wildlife management, and human-wildlife interactions. She is the author of Semi-Aquatic Mammals: Ecology and Biology and The Beaver Manifesto.

This article originally ran in *Nature Alberta Magazine* - Spring 2021.

NCF-Envirothon 2025 Alberta
Aquatic Ecology Study Resources

Key Topic #2: Aquatic Ecosystems

6. Describe the trophic system for classification of lakes based on productivity.
7. Identify common aquatic invasive species in Alberta (such as zebra and quagga mussels), explain their methods of introduction and spread, and describe their impacts to aquatic ecosystems.
8. Explain how riparian zones contribute to aquatic ecosystem health and water quality.
9. Explain the impacts of harmful algal blooms on aquatic ecosystems and human health, and identify strategies for their prevention and management.
10. Describe the effects of oil and gas development on water quality, including atmospheric deposition, spills, and tailings.
11. Explain the distinction between species at risk designations for aquatic organisms in Alberta and Canada (such as extirpated, endangered, threatened, species of concern) and provide examples of each type for Alberta along with strategies for management and recovery of these species.

Study Resources

Resource Title	Source	Located on Page
Lake Trophic State	*Brendan Wiltse, All About Lakes, 2025*	22
A Brief Introduction to Limnology, excerpt	*Alberta Lake Management Society, Factsheets, 2017*	26
Biodiversity and Riparian Areas: Life in the Green Zone	*Cows & Fish Riparian Management Society,*	28
Schedule A of the Alberta Fisheries Act	*Government of Alberta, 2000 Current as of December 15, 2022*	32
2021 Flowering Rush Herbicide Application at Lake Isle, *VIDEO*	*Alberta Environment and Protected Areas, YouTube, 2021*	34
Riparian Video Series - Where Land Meets Water, *VIDEO*	*Battle River Watershed, YouTube, 2022*	35
Lake and Watershed Management Options for the Control of Nuisance Blue-Green Algal Blooms in Pigeon Lake, Alberta, *pages 17 and 18*	*Chris Teichreb, M.Sc., P.Biol. Limnologist/Water Quality Specialist, Alberta Government, 2012*	36
Cyanobacteria (blue-green algae)	*Environmental Public Health, Alberta Health Services, 2023*	38
Fossil Fuels and Water Quality, Chapter 4 excerpt	*Lucy Allen, Michael J. Cohen, David Abelson, and Bart Miller, 2013*	42
Categories of Species at Risk	*Alberta Environmental Law 101, by abenvirolaws in Species Law*	46
Species at Risk Assessed in Alberta	*Government of Alberta, January 2024*	48

LAKE TROPHIC STATE

Brendan Wiltse, All About Lakes, 2025

Lakes are often classified based on their “trophic state,” a measure of the amount of algal growth or primary production in the lake. Primary production is a term used in lake ecology that refers to the amount of photosynthesis occurring in a waterbody. Free-floating algae, or phytoplankton, are responsible for the majority of primary production in a lake.

There are several reasons why organizing lakes based on their primary production is beneficial. Not the least of which is that many people prefer to swim and recreate on lakes with clear water, resulting from low primary production levels. Another is that as primary production increases, the amount of energy available to the rest of the food web increases. An increase in energy in the food web can affect fish and other organisms in the lake.

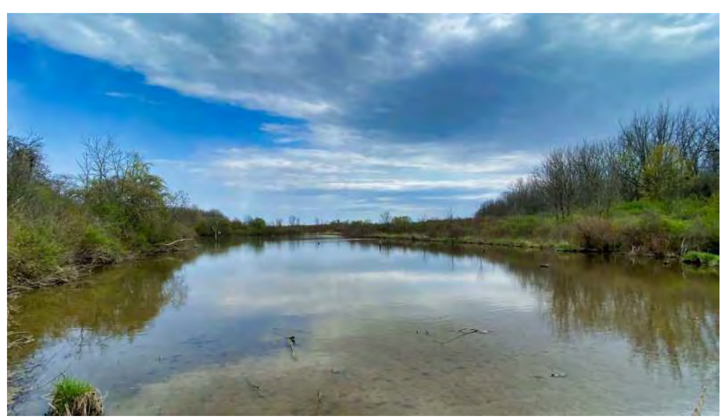
There are four trophic states that a lake can belong to; oligotrophic, mesotrophic, eutrophic, and hypereutrophic.

Oligotrophic Lakes

Oligotrophic lakes are the least productive. They characteristically have clear water, with water column transparency (Secchi depth) of over 13 feet (4 meters). The water column will also be well oxygenated, which, depending on temperature, may allow the lake to support cold-water fish like trout and salmon. These lakes are also often preferred for recreational activities such as swimming, paddling, water skiing, diving, and boating.

Mesotrophic Lakes

Mesotrophic lakes are moderately productive, and their water clarity is lower than oligotrophic lakes, typically 6.5 to 13 feet (2-4 meters). The higher primary production results in more algae, which decreases transparency. In addition, higher primary production results in increased bacterial decomposition of organic matter. Bacteria consume oxygen during decomposition, which results in decreased oxygen concentrations in the deeper waters of mesotrophic lakes. Lower oxygen concentrations in the deeper waters make it less likely that these lakes will support cold-water fish.



Mesotrophic lakes are often good for fishing for warm-water species such as yellow perch, bass, and northern pike.

Eutrophic Lakes

Eutrophic lakes are highly productive. The water clarity of eutrophic lakes tends to be very low, usually 1.5 to 6.5 feet (0.5-2 meters). Eutrophic lakes may have algal blooms problems and taste and odor issues. The high levels of primary production and decomposition will result in low levels of dissolved oxygen, affecting fish and other aquatic organisms. These lakes will have only warm-water fishes, predominantly bass.

Hypereutrophic Lakes

Hypereutrophic lakes are incredibly productive, they are typically dominated by algae scums at the surface, and their transparency is less than 1.5 feet (0.5 meters). These lakes are so productive that they may experience extremely low dissolved oxygen due to decomposition, even in the surface waters, resulting in summer fish kills.

It is essential to recognize that a lake's trophic state does not necessarily indicate whether that lake is polluted or has poor water quality. Lakes naturally occur in all of the trophic states described above. What is important is to determine whether a lake is moving from one trophic state to the other, and if so, why.

Factors That Influence Trophic State

Nutrient Supply

Nutrients, such as phosphorus and nitrogen, are necessary for algae and other phytoplankton to grow. Often, phosphorus is the limiting nutrient in lake ecosystems. Meaning, that if provided more phosphorus, more algae will grow. Bedrock geology, soils, and surrounding vegetation are natural sources of nutrients for lakes. Depending on the land and watershed around a lake, they will naturally fall into one of the trophic states described above.

Climate

Climate is another factor that will influence the trophic state of a lake. Temperature, cloud cover, and precipitation will all influence the trophic state of a lake. Algae and phytoplankton need sunlight and warm temperatures to grow and reproduce. In regions with warmer and sunnier climates, lakes will tend to be more productive. Precipitation also plays a role in nutrient inputs to a lake. Heavy rains can wash nutrients into a lake, while periods of drought can reduce lake flushing, trapping nutrients within the lake.

Lake & Watershed Shape

The lake's size, shape, and depth can all influence the trophic state. Small shallow lakes tend to be more eutrophic than big deep lakes because more water is near the surface, where nutrients, sunlight, and warm temperatures feed phytoplankton. The size and shape of the watershed are also important. This determines how much bedrock, soil, vegetation, and human influences contribute nutrients to the lake relative to the size of the lake.

Lake Aging

A general concept is that lakes naturally move from an oligotrophic to a eutrophic state over time. This gross generalization likely only applies to a limited number of water bodies. Certainly, a lake's trophic state can change over long-time scales due to changes in a lake's watershed and natural alterations to its size, shape, and depth.

Lakes can be studied over centuries or millennia using paleolimnology. Paleolimnologists study lake sediments to reconstruct the ecological past of a lake. Many paleolimnological studies of lakes show little change in a lake's trophic state over thousands of years. Similarly, other studies have demonstrated significant fluctuations in lake productivity due to entirely natural processes. Natural changes in climate and watershed vegetation can significantly influence the trophic state of a lake.

Cultural Eutrophication

The process of a lake becoming more productive is called eutrophication. Eutrophication can occur naturally as the lake and land around it change. Cultural eutrophication is the process of humans making a lake more productive through the addition of nutrients such as phosphorus. Lawn fertilizers, septic systems, wastewater treatment plants, and erosion from development can all add nutrients to a lake.

Excess nutrients have been a significant source of pollution to lakes worldwide over the past century. When lakes move toward a more eutrophic state, there are many undesirable consequences, such as harmful algal blooms, taste and odor issues, increased cost of water treatment, fish kills, and altered aesthetics. The Clean Water Act, passed in 1972, focused heavily on reducing point sources of pollution to waters in the United States. The federal government invested in upgrading municipal wastewater treatment facilities to reduce nutrient inputs to lakes and rivers while also regulating industrial pollution.

More recently, it has been recognized that non-point sources of nutrient pollution are also important. Agricultural runoff, lawn fertilizers, and stormwater are all examples of non-point sources of pollution. It is more challenging to regulate and manage these sources of pollution because they are difficult to quantify, come from a large number of sources, and vary depending on the landscape.

Brendan holds a Ph.D. in Biology from Queen's University. He studied how small boreal lakes at the Experimental Lakes Area have responded to recent climate change. After graduate school, he served as the Science & Stewardship Director at the Ausable River Association. During his time there, he worked extensively on road salt pollution in the Ausable River watershed, specifically studying its impact on Mirror Lake in Lake Placid, NY. Brendan currently works as a Senior Research Scientist at the Paul Smith's College Adirondack Watershed Institute. He is a Certified Lake Manager through the North American Lake Management Society and a member of the Global Lakes Ecological Observation Network.

A BRIEF INTRODUCTION TO LIMNOLOGY

Excerpt

2017

PHOSPHORUS AND NITROGEN Phosphorus and nitrogen are important nutrients limiting the growth of algae in Alberta lakes. While nitrogen usually limits agricultural plants, phosphorus is usually in shortest supply in lakes. Even a slight increase of phosphorus in a lake can, given the right conditions, promote algal blooms causing the water to turn green in the summer and impair recreational uses. When pollution originating from livestock manure and human sewage enters lakes not only are the concentrations of phosphorus and nitrogen increased but nitrogen can become a limiting nutrient which is thought to cause blooms of toxic algae belonging to the cyanobacteria. Not all cyanobacteria are toxic, however, the blooms can form decomposing mats that smell and impair dissolved oxygen concentrations in the lake.

CHLOROPHYLL-A Chlorophyll a is a photosynthetic pigment that green plants, including algae, possess enabling them to convert the sun's energy to living material. Chlorophyll a can be easily extracted from algae in the laboratory. Consequently, chlorophyll a is a good estimate of the amount of algae in the water. Some highly productive lakes are dominated by larger aquatic plants rather than suspended algae. In these lakes, chlorophyll a and nutrient values taken from water samples do not include productivity from large aquatic plants. The result, in lakes like Chestermere which are dominated by larger plants known as macrophytes, can be a lower trophic state than if macrophyte biomass was included. Unfortunately, the productivity and nutrient cycling contributions of macrophytes are difficult to sample accurately and are therefore not typically included in trophic state indices.

SECCHI DISK TRANSPARENCY Lakes that are clear are more attractive for recreation, whereas those that are turbid or murky are considered by lake users to have poor water quality. A measure of the transparency or clarity of the water is performed with a Secchi disk with an alternating black and white pattern. To measure the clarity of the water, the Secchi disk is lowered down into the water column and the depth where the disk disappears is recorded. The Secchi depth in lakes with a lot of algal growth will be small while the Secchi depth in lakes with little algal growth can be very deep. However, low Secchi depths are not caused by algal growth alone. High concentrations of suspended sediments, particularly fine clays or glacial till, are common in plains or mountain reservoirs of Alberta. Mountain reservoirs may have exceedingly low Secchi depths despite low algal growth and nutrient concentrations. The euphotic zone or the maximum depth that light can penetrate into the water column for actively growing plants is calculated as twice the Secchi depth. Murky waters, with shallow Secchi depths, can prevent aquatic plants from growing on the lake bottom. Conversely, aquatic plants can ensure lakes have clear water by reducing shoreline erosion and stabilizing lake bottom sediments. In Alberta, many lakes are shallow and bottom sediments contain high concentrations of nutrients. Without aquatic plants, water quality may decline in these lakes due to murky, sediment laden water and excessive algal blooms. Maintaining aquatic plants in certain areas of a lake is often essential for ensuring good water clarity and a healthy lake as many organisms, like aquatic invertebrates and insects, depend on aquatic plants for food and shelter

Table A - Trophic status classification based on lake water characteristics.

TROPHIC STATE	TOTAL PHOSPHORUS ($\mu g \cdot L^{-1}$)	TOTAL NITROGEN ($\mu g \cdot L^{-1}$)	CHLOROPHYLL A ($\mu g \cdot L^{-1}$)	SECCHI DEPTH (m)
Oligotrophic	< 10	< 350	< 3.5	> 4
Mesotrophic	10 – 30	350 - 650	3.5 - 9	4 - 2
Eutrophic	30 – 100	650 - 1200	9 - 25	2 - 1
Hypereutrophic	> 100	> 1200	> 25	< 1

Biodiversity and Riparian Areas

life in the green zone

Cows and Fish Fact Sheet

What is Biodiversity?

Biodiversity describes the variety and array of life on Earth. Variety (or diversity) is not only the spice of life, it is essential to life. The diversity of biological life (biodiversity) exists at three scales. These range from genes to species to ecosystems. Loss at any point in the scale ripples through the other scales of biodiversity, indicating the inter-related nature of the system. A common measurement of biodiversity is the total number of species found in an area.

Variety of Genes

Variety of Species

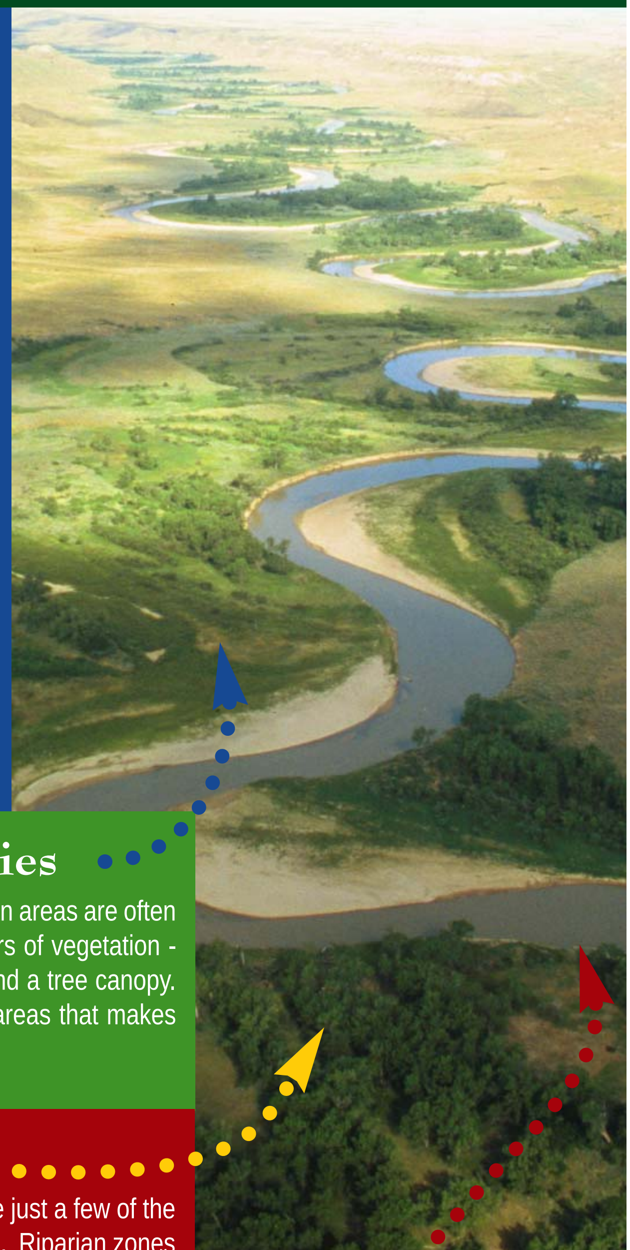
Variety of Ecosystems

Biodiversity

Why is Biodiversity Important?

- Biodiversity refers to the living pieces that shouldn't be discarded since we use the earth's resources to sustain us. Experience suggests to us that the first rule of intelligent tinkering is to keep all of the pieces. Because of the interconnected nature of ecosystems, the loss or addition of one species has the potential to change an ecosystem.
- High levels of biodiversity are associated with greater ecosystem stability. The more diverse a system is, the better able it is to cope with environmental stressors, such as floods or drought. Biodiversity gives us choices, options and flexibility to help us cope with variability, including long-term habitat changes.
- When a system is simplified, such as having only one species of crop or type of grass, it increases the odds that environmental stressors will have a more pronounced impact or that a disease or pest will be able to spread rapidly. Animal and plant populations with low genetic diversity are much more susceptible to stress and vulnerable to extinction.
- We all rely on the tremendous variety of species, genes and ecosystems in our world and the many benefits we receive from them - they deserve our respect and conservation.

Riparian Areas
Overflowing with Biodiversity!

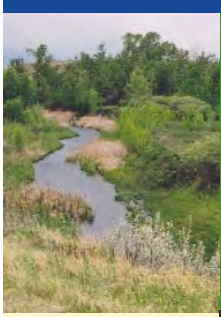


Biodiversity and Riparian Areas

Riparian describes the land immediately surrounding water sources where water strongly influences the immediate ecosystem. Examples of riparian areas include the dense cattails around a wetland and the cottonwood forests along a prairie river.

Riparian areas, especially those in prairie environments, support high levels of natural biodiversity. The combination of water, lush vegetation and connections to other landscapes provides opportunities for many species. Prairie riparian zones have been found to contain up to seven times more bird species than surrounding grassland communities.

Riparian areas create important corridors that link a variety of ecosystems together. Species and genetic material travel easily through these small, but unique, pieces of the landscape. Riparian corridors act like a network or web across the landscape, joining distant areas together.



Complex Plant Communities

As well as containing many different types of plants, riparian areas are often structurally very complex. That is, there are several layers of vegetation - often a low ground cover, several different shrub layers and a tree canopy. This structural diversity is one of the aspects of riparian areas that makes them attractive to so many wildlife species.

Mammals

Deer, cottontail rabbits and porcupines are just a few of the many mammals attracted to riparian areas. Riparian zones have been found to be critical roosting and foraging habitat for bats.

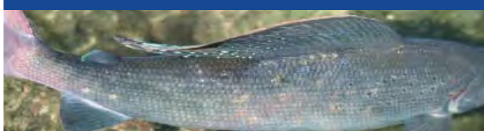
Reptiles & Amphibians

All frogs, salamanders and most toads rely on riparian areas for reproduction, shelter and food. Many snakes, such as bull snakes and garter snakes do most of their hunting in riparian areas.

Riparian Areas
Overflowing with Biodiversity!

Fish

Healthy riparian areas are critical to fish. Fish spend considerably more of their time along streambanks and shores than in the middle of waterbodies. Well-vegetated shores and banks provide cover, shade, clear water, a place for egg-laying and feeding opportunities.



Invertebrates

When we think of riparian insects, mosquitoes tend to come to mind! However these are a small part of overall insect diversity. Dragonflies, damselflies, caddisflies, as well as many butterflies and moths also depend on riparian areas.

Birds

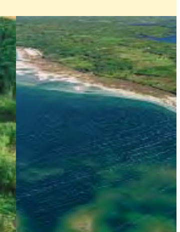
Do you want to see a lot of different birds in a short time period? Visit a riparian area! Riparian areas, especially cottonwood forests, support the highest breeding bird densities and diversities in North America. Over 80% of Alberta's bird species rely on riparian forests for all or part of their lifecycle. Riparian areas are particularly critical for forest birds as they migrate across the prairies; without riparian areas, where would they stop for rest and re-fuelling?

Rare Species

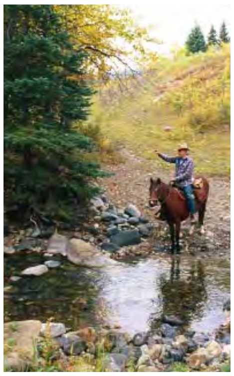
Almost two-thirds of Canada's rare and endangered species rely on riparian areas for at least part of their life cycle. An example is the Western Blue Flag Iris, a threatened species that is found only in riparian areas around lakes and large wetlands in southern Alberta.

Riparian areas contribute to the overall diversity of ecosystems. Here are just a few of the types of riparian ecosystems in Alberta:

- alder-lined mountain streams;
- cattail-rimmed wetlands and sloughs;
- spruce and shrubs along boreal creeks;
- lush cottonwood forests along prairie rivers;
- parkland potholes surrounded by aspen groves; and
- sedge and willow habitats bordering foothill creeks.



People and Riparian Biodiversity

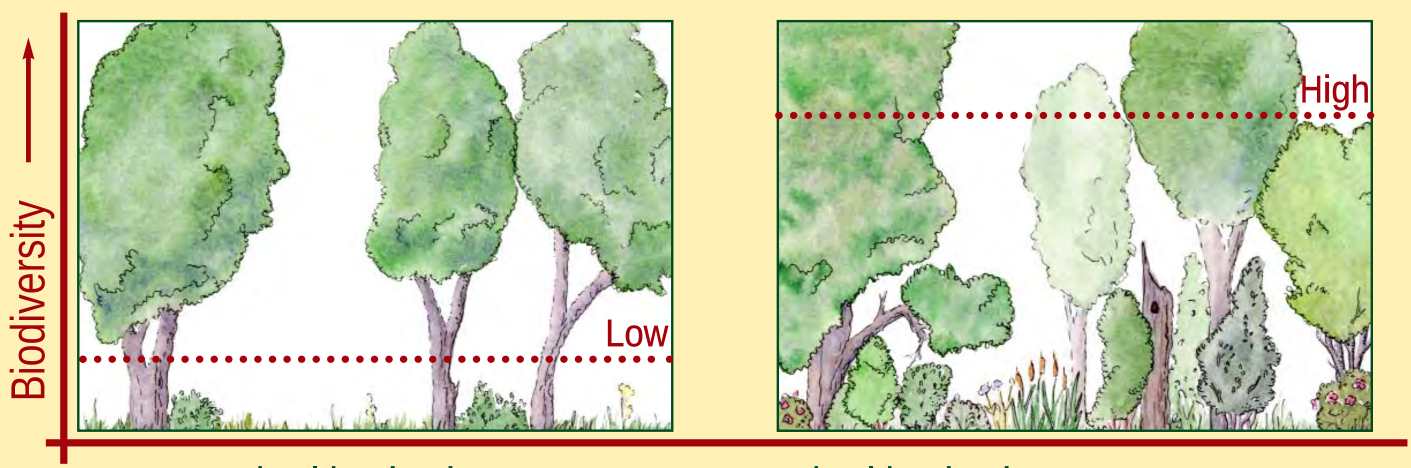


Riparian areas not only attract biodiversity, they also attract people. Historically, riparian areas were important for native peoples and early settlements. Typical disturbances included logging and along some river valleys, roads, highways, coal and gravel mining. Today, riparian areas attract a variety of urban, recreational, industrial and agricultural activities. The cumulative nature of these land uses affects biodiversity.

Recreational activities can impact riparian biodiversity in several ways. Intensive recreational facilities, such as campgrounds, often result in the removal of the riparian vegetation. Reduced vegetation diversity then leads to reduced wildlife abundance and a drop in the total number of species. Human noise and activity can result in reduced numbers of some sensitive wildlife species.

Recreational activities can result in the loss of understorey vegetation

Cattle grazing can also affect riparian biodiversity, depending on the intensity and duration of use. In heavily pastured riparian areas, vegetation becomes trampled and reduced by foraging livestock. Shrubs seem to be especially vulnerable. Several studies in Alberta have shown that there are fewer birds and fewer bird species in riparian areas that are intensively grazed by livestock through the entire growing season.



Although an **unhealthy riparian zone** may still support trees, there is usually a lack of structural diversity (i.e. few shrub layers). The result is lower biodiversity. Different management may restore this area and improve biodiversity.

A **healthy riparian zone** is a tangle of shrubs, trees and other lush vegetation. It is a structurally diverse community. Biodiversity is extremely high in healthy riparian areas.

Healthy riparian areas harbor much higher levels of natural biodiversity than unhealthy riparian areas. When riparian areas are properly cared for, their ability to support more species, or higher levels of biodiversity, is increased. Healthy biodiversity is in everyone's best interest as it means stability, productivity and reliability for the users and stewards of riparian areas.

Photo Credits: Lorne Fitch, Liz Saunders. Illustrations: Liz Saunders

Working with producers and communities on riparian awareness

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Funding Associates include
AESA, CARDF, CABIDF, Habitat Stewardship Program

Schedule 1 of the Alberta Fisheries Act

Item 1[1]
Invasive Species Fish

	Common Name	Scientific Name	Conditions for import and possession exemptions to apply
1	Bowfin	*Amia calva*	dead and eviscerated
2	Green sunfish	*Lepomis cyanellus*	dead
3	Pumpkin seed	*Lepomis gibbosus*	dead
4	Bluegill	*Lepomis macrochirus*	dead
5	Snakehead (whole family)	*Channidae spp.*	dead
6	Alewife	*Alosa pseudoharengus*	dead and eviscerated
7	Oriental weather loach	*Misgurnus anguillicaudatus*	dead
8	Red shiner	*Cyprinella lutrensis*	dead
9	Utah chub	*Gila atraria*	dead
10	Black carp	*Mylopharyngodon piceus*	dead and eviscerated
11	Largescale silver carp	*Hypophthalmichthys harnandi*	dead and eviscerated
12	Silver carp	*Hypophthalmichthys molitrix*	dead and eviscerated
13	Bighead carp	*Hypophthalmichthys nobilis*	dead and eviscerated
14	Orfe or ide	*Leuciscus idus*	dead
15	Common rudd	*Scardinius erythrophthalmus*	dead
16	Tench	*Tinca tinca*	dead
17	Round goby	*Neogobius melanostomus*	dead
18	Tubenose goby	*Proterorhinus marmoratus*	dead
19	Black bullhead	*Ameiurus melas*	dead
20	Yellow bullhead	*Ameiurus natalis*	dead
21	Brown bullhead	*Ameiurus nebulosus*	dead
22	White perch	*Morone americana*	dead
23	Ruffe	*Gymnocephalus cernuus*	dead
24	Zander	*Sander lucioperca*	dead
25	Western mosquitofish	*Gambusia affinis*	dead

Item 2[1]
Freshwater Dwelling Invasive Plants

	Common Name	Scientific Name
1	Flowering rush	*Butomus umbellatus*

2	Eurasian watermilfoil	*Myriophyllum spicatum*
3	Purple loosestrife	*Lythrum salicaria*
4	Himalayan balsam	*Impatiens glandulifera*
5	Yellow flag iris	*Iris pseudacorus*
6	European frog-bit	*Hydrocharis morsus-ranae*
7	Water soldier	*Stratiotes aloides*
8	Yellow floating heart	*Nymphoides peltata*
9	European water chestnut	*Trapa natans*
10	Hydrilla	*Hydrilla verticillata*
11	Phragmites	*Phragmites australis*
12	Curly leaf pondweed	*Potamogenton crispus*
13	Brazilian elodea	*Egeria densa*
14	Fanwort	*Cobomba caroliniana*
15	Variable-leaf watermilfoil	*Myriophyllum heterophyllum*
16	Giant salvina	*Salvinia molesta*

Item 3[1]
Freshwater Dwelling Invasive Species other than Plants or Fish

	Common Name	Scientific Name	Conditions for import and possession exemptions to apply
1	Zebra mussel	*Dreissena polymorpha*	
2	Quagga mussel	*Dreissena rostriformis bugensis*	
3	Golden mussel	*Limnoperna fortunei*	
4	Channeled applesnail	*Pomacea canaliculata*	dead
5	Facet snail	*Bithynia tentaculata*	dead
6	Asian tapeworm	*Bothriocephalus acheilognathi*	dead
7	Spiny water flea	*Bythotrephes cederstroemi*	dead
8	Fish hook water flea	*Cercopagis pengoi*	dead
9	Asian clam	*Corbicula fluminea*	dead
10	New Zealand mud snail	*Potamopyrgus antipodarum*	dead
11	Chinese mystery snail	*Cipangopaludina chinesis*	dead

1 Item 1, 2 or 3 also includes any hybrid offspring resulting from the crossing of 2 invasive organisms included in that Item or of one invasive organism included in that Item with another organism that is not an invasive organism.

2015 c7 s37;AR 45/2016 s14

Video - 2021 Flowering Rush Herbicide Application at Lake Isle

https://youtu.be/YoLiiHZRW8s?si=vS2ZfHkJMy7VP8qd

Video - Riparian Video Series - Video 2 - Where Land Meets Water

https://youtu.be/inncgnI_7eg?si=6dI-iMKqi-pHnFzy

Lake and Watershed Management Options for the Control of Nuisance Blue-Green Algal Blooms in Pigeon Lake, Alberta

pages 17-18

Table 2: Comparison of Watershed and In-Lake Controls of Nuisance Blooms

Watershed Controls	In-Lake Controls
Examples: Riparian restoration, fertilizer restriction, wastewater management	Examples: Chemicals/binding agents, dredging, addition/removal of water
Treats the source by preventing nutrients from entering lake	Treats internal source of nutrients and/or treats the issue (nuisance bloom)
Generally requires change in behaviour of watershed users	Generally does not require change in behaviour of users
Stakeholders are involved and engaged	Level of stakeholder involvement usually lower
Cost/benefit ratio usually low	Cost/benefit ration usually higher
Long-term strategy	Can be a long-term strategy or short-term response to nuisance bloom

3.1 Watershed Controls

As the name implies, watershed controls are strategies intended to prevent the delivery of nutrients to a lake. Incorporation of a variety of these options is essential to a program aimed at reducing frequency and intensity of nuisance blooms in lakes as this eliminates an external source of nutrients to the lake. Given that the turnover time (time in which it takes to replace the water in a lake through inflowing surface and groundwater) for Pigeon Lake exceeds 100 years, eliminating nutrient inputs to the lake prevents the risk of nutrients accumulating over a longer period. Even if the residence time was short, if the level of nutrients entering a lake basin continues to be elevated, the lake will be susceptible to nuisance blooms (as seen in Baptiste Lake).

Examples of watershed controls include fertilizer restrictions, enhanced stormwater treatment, development of regional wastewater lines, riparian restoration, agricultural bmp's (best management practises) and use of communal wastewater tanks. A number of watershed initiatives have either been incorporated or are underway at Pigeon Lake. Along with these initiatives is the need for a strong education and awareness campaign to encourage uptake and help lower the input of nutrients to the lake.

3.2 In-Lake Controls

In-lake controls for the management of nuisance blooms are broken-down into three major categories; physical, chemical and biological. Physical controls involve the physical modification of in-lake elements to remove accumulated nutrients or disrupt conditions favourable for algal or cyanobacterial growth. These can include such strategies as increased circulation, dilution and flushing, dredging, light-limiting dyes, surface covers and mechanical removal of blooms. While effective at smaller scales, large scale applications as would be needed at Pigeon Lake may prove too costly and interfere with recreational opportunities. In addition, several potential controls may have additional impacts to fish habitat or other beneficial species, which must be considered before pursuing. However, methods such as removing accumulated bloom material may provide some benefit if applied in local areas such as swimming beaches, removing both the biomass and the associated nutrients. In these cases, it must be ensured that removed material be deposited as far away from the lake as possible to ensure nutrients do not re-enter the lake in the future.

Chemical control involves the application of chemicals to kill nuisance algae or cyanobacteria or bind with the nuisance species and nutrients to prevent growth. Examples of chemical options include application of algaecides, binding agents, aeration/oxygenation of the water column, and phosphorus inactivation. Many chemical options are illegal to use in fish bearing waterbodies such as Pigeon Lake due to their potential impact to non-target organisms. Studies have shown that these chemicals may persist in the environment and impact lake ecosystems long after initial application (Schindler and Vallentyne 2008). Phosphorus inactivation through the application of ferric salts near the sediment water interface may be a potential option for Pigeon Lake, although current research needs to be fully evaluated to determine its effectiveness in well aerated systems like Pigeon Lake.

Biological controls involve modifying the biological components of a lake ecosystem to produce a less favourable environment for the growth of nuisance algae or cyanobacteria. Examples of biological control include enhanced grazing by stocking zooplankton species, bottom-feeding fish removal and pathogens. Biological control is based on the principle of modifying food webs to favour enhanced grazing and the growth of non-nuisance species of algae (see Carpenter and Kitchell 1993 for an overview of trophic cascade effects). It does require an excellent understanding of food web dynamics within a particular lake and would be strongly cautioned against in Pigeon Lake due to the potential disruption or alteration of a highly desirable fishery.

Cyanobacteria (blue-green algae)

Current as of: June 5, 2023
Author: Environmental Public Health, Alberta Health Services

What are cyanobacteria?

Large growth (bloom) of cyanobacteria on a lake.
Source: Ron Zurawell, Alberta Environment

Cyanobacteria (also called blue-green algae) are types of bacteria found in many lakes, ponds, and other bodies of water. Many types of cyanobacteria can control whether or not they float (buoyancy), which lets them to move up and down in the water.

Cyanobacteria can multiply a lot in the summer, which causes large growths called blooms. Cyanobacteria blooms can be blue-green, greenish-brown, or pinkish-red and can smell musty or grassy. Blooms often look like scum, streaks, or mats on the water surface or throughout the water. Cyanobacteria blooms often form when conditions are calm.

Cyanobacteria bloom on a lake.
Source: Ron Zurawell, Alberta Environment

How do cyanobacteria blooms affect human health?

Some types of cyanobacteria that form blooms also produce toxins that can affect your health. Most toxins break down within days, but they can stay in the water at low levels for weeks after a bloom disappears.

Some blooms don't contain toxins, but you can't tell if a bloom is harmful or not from how it looks. If you see a bloom, assume it is toxic and take precautions.

Cyanobacteria bloom at the shore of a lake
Source: Environmental Public Health, Alberta Health Services

Children might be more at risk for getting sick from cyanobacteria because they often spend more time in the water and may swallow contaminated water by accident.

If you have **contact** (like swimming) with water that has a cyanobacteria bloom, it can cause:

- skin irritation and rash
- sore throat
- sore, red eyes
- swelling of your lips
- hay fever symptoms, like stuffy nose

If you **drink** water with cyanobacteria, it can cause:

- headache
- diarrhea
- weakness
- liver damage
- fever (temperature over 38.5°C or 101.3°F)
- nausea and vomiting
- muscle and joint pain
- cramps in your abdomen (belly)

Treat all cyanobacteria blooms with caution. Call Health Link at 811 if you drink or have been in contact with water that has a cyanobacteria bloom and are having symptoms.

How do cyanobacteria blooms affect livestock and pets?

Some illnesses and deaths of livestock, pets, and wildlife have been linked to animals drinking water containing toxins from cyanobacteria blooms. Keep animals away from water sources with cyanobacteria blooms because animals aren't concerned with how water looks or smells before they drink it.

Don't let animals eat whole fish or trimmings (any waste from cutting up a fish, including the head, bones, intestines, or skin) from affected lakes.

Can I water my vegetable garden with lake water that has a cyanobacteria bloom?

Don't use water sources with cyanobacteria blooms to water plants you can eat. Toxins from cyanobacteria can contaminate fruits and vegetables, including lettuce, carrots, and tomatoes.

Is it safe to cook with water from a water source with a cyanobacteria bloom?

No. Don't cook with water that might have a cyanobacteria bloom. Boiling water doesn't remove cyanobacteria toxins.

Is it safe to eat fish from water with a cyanobacteria bloom?

You can safely eat fish fillets (boneless pieces of fish meat) from lakes with a cyanobacteria bloom. You might want to limit how much whole fish and trimmings (any waste from cutting up a fish, including head, bones, intestines, or skin) you eat, because fish store toxins in their livers.

What can I do to help prevent cyanobacteria blooms?

The best way to help prevent cyanobacteria blooms is good watershed management. Watershed management means thinking about the interaction of land, water, plants, animals, and people across many areas that are connected by water. Watershed management looks at the impact of a variety of land uses on water.

You can help control cyanobacteria blooms by limiting the nutrients that go into water systems, like from wastewater or runoff from agriculture. You can limit nutrients by not using lawn fertilizers and by properly maintaining your private sewage systems.

What else do I need to think about?

Treat any cyanobacteria bloom as if it is contaminated with toxins.

- Don’t swim or wade in water with scum on the surface.
- Don’t drink water if it might have cyanobacteria.
- Have another source of drinking water for pets and livestock.
- If you see a bloom, call Environmental Public Health at 1-833-476-4743 or report it online.
- Call Health Link at 811 if you drink or have been in contact with contaminated water and have any symptoms.
- Call a veterinarian if your pet drinks or has been in contact with contaminated water.

If you have any questions, contact Environmental Public Health.

Fossil Fuels and Water Quality

Chapter 4 Excerpt

Lucy Allen, Michael J. Cohen, David Abelson, and Bart Miller

Impacts on Freshwater Ecosystems

Freshwater ecosystems are affected in a variety of ways by the direct impacts of fossil-fuel extraction and mining outlined earlier. These ecosystem impacts fall into four basic categories: (1) impacts related to climate change, (2) physical impacts, (3) chemical impacts, and (4) biological impacts.

Climate Change

Fossil-fuel production and combustion generates some 90 percent of total U.S. green- house gas emissions; lower fossil-fuel use rates and higher rates of land-use changes in other parts of the world suggest that fossil fuels contribute a slightly lower, though still disproportionately large, share of global greenhouse gas emissions. These emissions are already changing the global climate, including temperature and precipitation, and risk dramatically altering the hydrologic cycle. The extraction and use of carbon-intensive fossil fuels generates fundamental changes in the global distribution of water, in turn affecting a host of water-quality parameters, including sedimentation, temperature, and dissolved oxygen concentrations (Fischlin et al. 2007). Projected increases in storm intensity will amplify runoff from contaminated surfaces, both in urban areas and from tailings piles, and could overwhelm efforts to retain and manage such contaminated runoff. Increased storm intensity could also affect coal ash and other retention ponds, increasing the risk of pond failure and subsequent release of contaminated materials into downstream waterways.

Decisions about current and future energy supplies present critical opportunities. Retiring aging thermoelectric power plants may create “new” water supplies that can meet growing urban demands or environmental needs while reducing greenhouse gas emissions, if their generation capacity can be offset through energy-efficiency improvements or less water-intensive energy sources. For example, recent legislation in Colorado directed Xcel Energy to replace 900 megawatts of coal-fired power plants in the Denver metropolitan region with natural gas units, energy efficiency, and other resources. This legislation will provide important (though incidental) benefits to water resources. As other plants near the end of their design life span, additional opportunities for advancing an integrated energy, climate, and water policy may arise.

Physical Impacts

Fossil-fuel production and use can create a variety of physical changes in water resources, including changes in channel structure, sediment-transport dynamics, ground-water–surface water connectivity, and subsurface water connectivity and mobility, as well as temperature changes in surface and groundwater. The most dramatic change in channel structure comes from the surface-mining method known as mountaintop removal and valley fill, in which streams are completely buried by tailings, as described earlier. Figure 4.1 shows a mining and valley fill operation in West Virginia, U.S., in 2009. Underground coal mines and surface-mining operations for coal and tar sands all generate large volumes of tailings that can wash into and choke streams, burying fish eggs and aquatic insects. Fracking can also increase groundwater mobility, connecting pockets of highly saline or otherwise contaminated groundwater with drinking-water wells and alluvial aquifers, permitting the migration of hydrocarbons, benzene, arsenic, and other contaminants into drinking water supplies and into surface waterways. Similarly, in situ methods for extracting petroleum and tar sands, such as the injection of steam or lubricants and surfactants, can increase the mobility of underground contaminants and contaminate groundwater resources. Thermal pollution occurs at a much larger scale at power plants burning fossil fuels, where cooling water absorbs excess heat from the plant and is then discharged into streams or lakes, typically increasing the chemical and biological oxygen demand in the receiving water.

FIGURE 4.1 SEDIMENT PONDS, VALLEY FILL, AND EDGE OF COAL MINE NEAR BOB WHITE, WEST VIRGINIA, UNITED STATES.
Source: Vivian Stockman, http://www.ohvec.org

Chemical Impacts

At every stage of their production and use, fossil fuels can create a host of adverse chemical impacts on water quality. Fossil-fuel production, transmission, and use can contaminate water resources with hydrocarbons, heavy metals, increased nutrient and salt loads, and a host of toxic compounds, including benzene, toluene, and hexavalent chromium. The ubiquity of pipelines and tanker trucks, not to mention personal and commercial vehicles, makes fuel leaks and spills a statistical certainty, as noted earlier. Coal mine tailings often leach heavy metals and acids into nearby streams, dramatically lowering pH (often to levels of 2 to 3) and decimating or even extirpating entire aquatic communities (Swer and Singh 2004). Abandoned mines themselves, common throughout many areas of the world, pose their own long-term threats to water quality: such mines often contain heavy metals and sulfur compounds and can fill and spill from surface precipitation and groundwater, generating acid mine drainage (Banks et al. 1997).

Produced water from oil, gas, and coal extraction typically contains hydrocarbon residues, heavy metals, hydrogen sulfide, and boron, as well as elevated concentrations of salts. Although most produced water is re-injected or discharged to the ocean, more than 300 million m^3 per year of such water stays on the planet's surface, stored in retention ponds or discharged generally to the land or water, where it can contaminate groundwater and surface-water resources. Processing and refining fossil fuels also generate chemical wastes that, if not properly managed, can contaminate water with petroleum wastes, heavy metals, selenium, and other contaminants. In 2008, a Texas petroleum refinery was fined for more than 2,000 unlawful discharges between 1999 and 2006 ("Refinery Water Pollution" 2008). Combustion of coal and petroleum products generates large quantities of sulfur and nitrous oxides that can generate acid precipitation and excess nutrient loadings on land and water surfaces. Coal combustion leaves coal ash, which is often stored wet in retention ponds, though such ponds have failed, discharging selenium, arsenic, and other contaminants into nearby streams. Fuel spills from personal and commercial vehicles are widespread, leaving residues on impervious surfaces that can wash into streams or lakes or percolate into the ground after precipitation events.

Ecological Impacts

Many aspects of fossil-fuel production directly affect aquatic resources and can cause mortality events or otherwise degrade ecological resilience. At the global level, the clear link between fossil-fuel combustion and climate change means that the ecological impacts of climate change can be largely attributed to fossil fuels. The scientific literature robustly describes the intersection of climate change, water quality, and eco- systems (see Fischlin et al. 2007, Meyer et al. 1999). Impacts include direct changes, such as increased temperature and carbon dioxide concentrations and habitat loss, and increased internal nutrient loadings and decreased oxygen concentrations. These in turn affect primary production, species composition, and foodwebs and likely will increase the risk of extinctions from freshwater ecosystems.

Physical and chemical impacts lead to widespread ecological impacts in aquatic com- munities, ranging from complete extirpation of entire aquatic communities to periodic mortality events in response to spills and leaks, to degraded ecosystems left more susceptible to other disturbances. In the U.S., more than 1,200 kilometers of streams have been buried by coal mine operations; the total length of streams lost worldwide due to fossil-fuel production is not known. Fisheries in another 13,000 kilometers of streams in the eastern U.S. alone have been degraded by coal mining operations, hinting at the scale of the problem globally.

Morbidity and mortality resulting from direct oil spills and leaks have attracted considerable media attention over the years, but they are not the only source of petroleum- related mortality for waterbirds and aquatic organisms. Retention ponds for produced water and other wastewater discharges, such as processing, refinery, and thermal generation plant liquid wastes, can become attractive nuisances for migratory birds and other wildlife. Ducks and other birds have landed on such retention ponds, only to die in large numbers due to oil fouling or acute toxicity. Gosselin et al. (2010) provide a historical overview of environmental incidents generated by Alberta tar sands, noting that natural bitumen discharge had been recorded along a river bank in Alberta as far back as 1719. Large-scale commercial operations began more than 40 years ago, leading to spills and releases from pipelines and tailings ponds. A 1970 pipeline spill released more than 3,000 m^3 of oil, creating an oil slick that reached more than 250 kilometers down the Athabasca River, contaminating water supplies for several communities, and likely harming aquatic organisms (though such impacts were not well monitored or reported). Subsequent sampling found that drainage from tailings ponds was acutely toxic to fish. In 2008, some 1,600 ducks died after landing in a tar sands tailings pond and becoming fouled by bitumen on the water surface (Gosselin et al. 2010).

Acid precipitation causes a host of ecological impacts, especially to aquatic resources. Acid precipitation—primarily generated by coal combustion—can increase the mobility of aluminum and other metals in aquatic systems, leading to mortality of fish and aquatic invertebrates, in turn diminishing the prey base for birds and other animals. Acid precipitation—and its degradation of water quality and dependent ecosystems— occurs downwind of coal-fired power plants; adverse impacts have been reported in China, Europe, and North America (Larssen 1999, Menz and Seip 2004).

Categories of Species at Risk

by abenvirolaws in Species Law

A PROJECT OF THE ENVIRONMENTAL LAW CENTRE

Now that you know what a 'species' is, let's figure out what it means when they are considered 'at risk'…

In Alberta, the Wildlife Act defines an endangered species in Section 1(i) of the Act, as, "a kind of endangered animal, a kind of invertebrate prescribed as an endangered invertebrate, a kind of plant, alga or fungus prescribed as an endangered plant, alga or fungus, a kind of fish prescribed as an endangered fish, or any combination of any of those kinds of organisms."[1]

Once something is determined to be a species, it can be defined as either at risk, secure, or undetermined. If a species is secure, it does not require management to prevent it from becoming extinct – its population is stable and/or growing. If a species is undetermined, it may be because there is not sufficient data to properly classify the species as either secure or at risk. If a species is considered to be at risk, then that particular species will be further studied to classify it in one of the following sub-categories:

<u>1. Extinct</u>: A species that no longer exists anywhere in the world.

> **Example: Passenger pigeons which used to live in huge flocks across Canada, are now extinct [2]**

<u>2. Extirpated</u>: A species that no longer exists in the wild in a specific geographical region but continues to exist elsewhere in the wild.

> **Example: Prior to the Atlantic grey whale's extirpation from Canada's Atlantic coast, the grey whale lived in waters off both the Atlantic and Pacific coasts of Canada. Today, the grey whale can only be found off the Pacific coast [3]**

<u>3. Endangered</u>: A species that is at immediate risk of extirpation or extinction.

> **Example: The Atlantic Bluefin Tuna has been listed as endangered since 2011. Its population has been steadily declining, in large part due to overfishing [4]**

<u>4. Threatened</u>: A species likely to become endangered if limiting factors are not reversed.

> **Example: The Barn Swallow, a songbird that used to be found in nearly every province and territory in Canada has been listed as threatened since 2011, due to changes in their habitat, climate change, and other health factors [5]**

<u>5. Species of Special Concern</u>: A species that is particularly sensitive to human activities or natural events.

> **Example: The beluga whale population that can be found off the coast of Nunavut and throughout the Arctic Ocean has been listed as a special concern since 2004. Over-exploitation is the main cause of these beluga's decline.[6] Notably, other beluga populations have already been upgraded to threatened or endangered.**

<u>6. Data Deficient</u>: A species for which there is insufficient information to support status designation.[7]

This initial classification step is crucial because, under the current legislative process, a species' classification will significantly affect both how it is treated and how well it is protected. In a later section on this page, we will explain how the Alberta government has left this classification process up to government policy rather than including classification in the legislation. As you may already know, government policy, unlike legislation, is unenforceable and potential enforcement depends entirely on the government's discretion.

[1] Wildlife Act, RSA 2000, c W-10 s 1(i).

[2] David Biello, "3 Billion to Zero: What Happened to the Passenger Pigeon?" Scientific American (27 June 2014), online: https://www.scientificamerican.com/article/3-billion-to-zero-what-happened-to-the-passenger-pigeon/.

[3] Species at Risk Public Registry, "Response Statement – Grey Whale, Atlantic Population" Government of Canada (2 December 2010), online: https://wildlife-species.canada.ca/species-risk-registry/species/speciesDetails_e.cfm?sid=129.

[4] Species at Risk Public Registry, "Species Profile: Atlantic Bluefin Tuna" (15 November 2017), online: https://wildlife-species.canada.ca/species-risk-registry/species/speciesDetails_e.cfm?sid=114.

[5] Species at Risk Public Registry, "Species Profile: Barn Swallow" (15 November 2017), online: https://wildlife-species.canada.ca/species-risk-registry/species/speciesDetails_e.cfm?sid=1147.

[6] Species at Risk Public Registry, "Species Profile: Beluga Whale Eastern High Arctic – Baffin Bay Population" (15 November 2017) online: https://wildlife-species.canada.ca/species-risk-registry/species/speciesDetails_e.cfm?sid=150.

[7] Species at Risk Alberta, "A Guide to Endangered and Threatened Species and Species of Special Concern in Alberta", Alberta Environment and Sustainable Resource Development 2 (2016) at 1.

Species at Risk Assessed in Alberta

Endangered and Threatened species currently listed under Alberta's *Wildlife Act* and other species assessed by the scientific sub-committee of the endangered species conservation committee.

Endangered Species (listed under *Wildlife Act*[1])

1. Swift fox (*Vulpes velox*)
2. Sage grouse (*Centrocercus urophasianus*)
3. Piping plover (*Charadrius melodus*)
4. Ord's kangaroo rat (*Dipodomys ordii*)
5. Whooping crane (*Grus americana*)
6. Mountain plover (*Charadrius montanus*)
7. Short-horned lizard (*Phrynosoma hernandesi*)
8. Burrowing owl (*Athene cunicularia*)
9. Ferruginous hawk (*Buteo regalis*)
10. Tiny cryptantha (*Cryptantha minima*)
11. Soapweed (*Yucca glauca*)
12. Western spiderwort (*Tradescantia occidentalis*)
13. Porsild's bryum (*Bryum porsildii*)
14. Limber pine (*Pinus flexilis*)
15. Whitebark pine (*Pinus albicaulis*)
16. Slender mouse-ear-cress (*Halimolobos virgata*)
17. Little brown myotis (*Myotis lucifugus*)
18. Northern myotis (*Myotis septentrionalis*)

Threatened Species (listed under *Wildlife Act*[1])

1. Peregrine falcon (*Falco peregrinus*)
2. Woodland caribou (*Rangifer tarandus caribou*)
3. Barren ground caribou (*Rangifer tarandus groenlandicus*)
4. Northern leopard frog (*Rana pipiens*)
5. St. Mary sculpin (*Cottus bairdi punctulatus*)
6. Stonecat (*Noturus flavus*)
7. Shortjaw cisco (*Coregonus zenithicus*)
8. Western silvery minnow (*Hybognathus argyritis*)
9. Lake sturgeon (*Acipenser fulvescens*)
10. Small-flowered sand verbena (*Trypterocalyx micranthus*)
11. Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*)[2]
12. Grizzly bear (*Ursus arctos*)
13. Athabasca rainbow trout (*Oncorhynchus mykiss*)[3]
14. Bull trout (*Salvelinus confluentus*)
15. Pygmy whitefish (*Prosopium coulteri*)
16. Western grebe (*Aechmophorus occidentalis*)
17. Wood Bison (*Bison bison athabascae*)[4]
18. Brassy Minnow (*Hybognathus hankinsoni*)

Special Concern Species

1. Sprague's pipit (*Anthus spragueii*)
2. Long-toed salamander (*Ambystoma macrodactylum*)
3. Long-billed curlew (*Numenius americanus*)
4. Loggerhead shrike (*Lanius ludovicianus*)
5. Black-throated green warbler (*Dendroica virens*)
6. Harlequin duck (*Histrionicus histrionicus*)
7. White-winged scoter (*Melanitta fusca*)
8. Prairie falcon (*Falco mexicanus*)
9. Barred owl (*Strix varia*)
10. Western blue flag (*Iris missouriensis*)
11. Arctic grayling (*Thymallus arcticus*)
12. Weidemeyer's admiral (*Limenitis weidemeyerii*)
13. Western small-footed myotis (*Myotis ciliolabrum*)
14. Great Plains toad (*Anaxyrus cognatus*)
15. Prairie rattlesnake (*Crotalis viridis*)
16. Hare-footed locoweed (*Oxytropis lagopus*)
17. Trumpeter swan (*Cygnus buccinator*)
18. Canada Warbler (*Cardellina canadensis*)

Data Deficient Species

1. Wolverine (*Gulo gulo*)
2. Canadian toad (*Anaxyrus hemiophrys*)
3. American badger (*Taxidea taxus*)
4. Verna's Flower Moth (*Schinia verna*)

Species Status Approved

1. Yucca moth (*Tegeticula yuccasella*) – Endangered
2. Banff Springs snail (*Physella johnsoni*) – Endangered

Species Status Recommendations

1. Cape May warbler (*Dendroica tigrina*) – Special Concern
2. Bay-breasted warbler (*Dendroica castanea*) – Special Concern
3. Woodland caribou (*Rangifer tarandus caribou*) – Endangered
4. Plains Bison (*Bison bison bison*) – Threatened
5. Chestnut-collared Longspur (*Calcarius ornatus*) – Endangered
6. Thick-billed Longspur (*Rhynchophanes mccownii*) – Endangered
7. Hoary Bat (*Lasiurus cinereus*) – Endangered

1. List of Endangered and Threatened species prescribed under Alberta's *Wildlife Act* is available in Schedule 6 of the Wildlife Regulation; see http://www.qp.alberta.ca, "Laws Online/Catalogue".
2. The only threatened stocks of westslope cutthroat trout are genetically pure native stocks that are found, killed or captured from flowing waters in parts of the Oldman River and Bow River watersheds and Picklejar Lakes.
3. The only threatened stocks of Athabasca rainbow trout are genetically pure native stocks that are found, killed or captured from flowing waters in the Athabasca River or Freeman River watersheds, or from Rock, Mystery or Sphinx lakes.
4. The only threatened wood bison are those that are not domestic bison and that are found or killed on or captured from within the wildlife management units or portions of wildlife management units that are outlined in Schedule 6 of the Wildlife Regulation.

NCF-Envirothon 2025 Alberta
Aquatic Ecology Study Resources

Key Topic #3: People, Stewardship, Conservation and Aquatic Environments

12. Describe the effects of anthropogenic impacts to aquatic ecosystems in Alberta (including angling, development, recreation, agriculture, and industrial uses) and explain how these uses interact.
13. Describe the role that watershed stewardship groups play in advocacy for streams, lakes, and the aquatic organisms that rely on them.
14. Identify tools and management practices used by agricultural producers to protect aquatic environments and their watersheds.
15. Identify organizations and agencies involved in the protection, conservation, and management of aquatic ecosystems in Alberta.
16. Identify the legislation at all levels of government that protects aquatic resources and ecosystems in Alberta.

Study Resources

11.2 Anthropogenic Effects on Water Quality

Human activities are common causes of water-supply problems, and, in this regard, the most important activities are agriculture, industry, landfills, sewage, and anything that can lead to elevated turbidity. Anthropogenic sources are divided into two types, nonpoint sources where the effect is distributed over a large area such as agriculture or logging, and point sources, like factories, landfills or mines, where the effect is localized to a specific site.

By a wide margin, agriculture represents the greatest threat to water quality. Agriculture is everywhere, and it occupies more land than all other uses combined. There is currently 30% more agricultural land than forested land. Modern agriculture, while very efficient in terms of production per input dollar, is also intensively dependent on the use of chemicals (fertilizers and pesticides) and a significant proportion of the chemicals applied either run off the surface into streams and lakes, or seep into aquifers.

Large amounts of nitrogen, phosphorous and potassium fertilizers are applied to fields all over the world. These nutrients help the crops to grow, but if more fertilizer is applied that is really needed, then the excess will end up making its way into the environment. Nitrogen from fertilizers can volatilize into the air, to come down within rainfall somewhere else. Nitrogen, phosphorous and potassium can run off fields into surface water bodies. They can also infiltrate down into the soil, and move downwards out of reach of the plant roots where they are added to the groundwater. That groundwater may discharge to a surface water body. In lakes and streams these excess nutrients help algae to thrive, and that can create significant problems for aquatic life and human water supplies and is also an issue for anyone who likes to be in or near the water.

Agriculture is a major source of the phosphorous that leads to excess algal growth in lakes, but not the only one. Other important sources include municipal sewage effluent, industrial effluent, urban storm water runoff, and atmospheric deposition.
Runoff from fields is not only laced with excess nutrients and pesticides, it is also rich in suspended matter that contributes to the turbidity of surface water, degrading aquatic

ecosystems, and potentially endangering human water supplies (Figure 11.2.3). The risk of turbid runoff is greatest when fields have been left unprotected by vegetation following harvesting or tillage.

Figure 11.2.3 Turbid Runoff From a Field in Iowa Following a Rainstorm

Nearly 80% of global farmland is dedicated to livestock, either for grazing or for growing animal feed (although livestock farming accounts for only 18% of the caloric output from farming) and farm animals produce manure—lots of it. Manure from all livestock is rich in nitrogen, potassium and phosphorous, and so contributes to the surface water algae problem described above, and to elevated levels of nitrogen in groundwater. In addition to nitrates and other nutrients, animal manure also contains bacteria, and while most of those bacteria are harmless to humans, some present a serious risk..

Logging, like agriculture, is a nonpoint source of pollution because it is carried out over wide areas, and it involves the application of fertilizers and pesticides and the removal of vegetation. But logging differs because it is often carried out on steep slopes—in the remaining forested areas that are too rugged for farming or urbanization—(Figure 11.2.5) and so the issue with erosion and turbid runoff is exacerbated. Most logging operations also involve the construction of temporary roads on steep terrain. Road construction amplifies the risk of slope failure and that increases the likelihood of damage to surface water habitat and supplies.

Figure 11.2.5 A Clear Cut in the Coquille River Basin of Southwestern Oregon

Point sources of pollution include mines, petroleum extraction operations, plants for extracting and refining ores and petroleum, chemical works, manufacturing plants, sewage treatment systems, landfills and underground storage tanks (USTs) at filling stations.

Throughout the history of industrialization, owners and operators of all of these types of facilities have failed catastrophically and repeatedly to protect the environment, water supplies, ecosystems and the lives and health of workers and innocent people. One of the most notorious examples was in the city of Niagara Falls, New York. In the 1920s the city set aside an abandoned canal—Love Canal—as a dump site for municipal waste. In 1942 the Hooker Chemical Company was given permission to dispose of chemical by-products from the manufacture of dyes, perfumes and rubber goods into the dump. From then until 1952 Hooker dumped nearly 20,000 tonnes of chemical wastes at the site, most of it in 200-litre metal drums, which they eventually covered up with clay. In 1952 they sold the site (which they had purchased from the city in 1947), along with the liability for the dumped chemicals, to the Niagara Falls Board of Education. A 400-student elementary school was built on top of the old dump and it was in use from 1955 to 1978. Soon after construction of the school, toxic chemicals started coming to surface, parts of the clay cover collapsed, and some of the metal drums were exposed at surface.[8] During heavy storms contaminated surface water ran off the site and into the Niagara River (and then over the falls). Contaminated groundwater also migrated offsite and into the basements of neighbouring homes. The Love Canal site was eventually cleaned up, and the school and surrounding homes abandoned, but there are lingering health issues amongst those who lived in the area.

There are industrial sites like Love Canal all over the world and their contamination legacies will be with us for decades, even centuries. Increasingly however, corporations and individuals are being held to account for making the assumption that they can dump whatever waste they need to get rid of onto the ground and into water and the air.

But it isn’t just large operations that are problematic. In virtually every village, town and neighbourhood in North America (and elsewhere as well) there are abandoned sites surrounded by chain link fences and dotted with the plastic pipes of monitoring wells. Many of these are the remains of gas stations with underground storage tanks (USTs) that had leaked so badly that the operation was forced to close. If you think you haven’t seen one, you probably just haven’t realized what they are. Some UST sites have been cleaned up and rehabilitated. The one illustrated on Figure 11.2.6 has been vacant for over 20 years, possibly because the value of the land is less than the cost of removing the contamination and making the site usable for some other purpose.

Figure 11.2.6 The Site of a Filling Station With Leaking Underground Storage Tanks. The white pipes are groundwater monitoring wells.

A leaking fuel UST is at least three problems in one (Figure 11.2.7). Some components of the fuel are volatile, and so will form a vapour phase that rises to surface and may enter nearby buildings. Most fuels used for vehicles like cars, trucks and planes are lighter than water and so will float along the surface of the saturated zone (the water table). Some components of the fuel are soluble in water and so will mix with groundwater and be dispersed in that way. Some components of the fuel may be heavier than water so will sink through the saturated zone. The aquifer water will eventually come to surface somewhere and will bring some of those dissolved and heavy constituents with it.

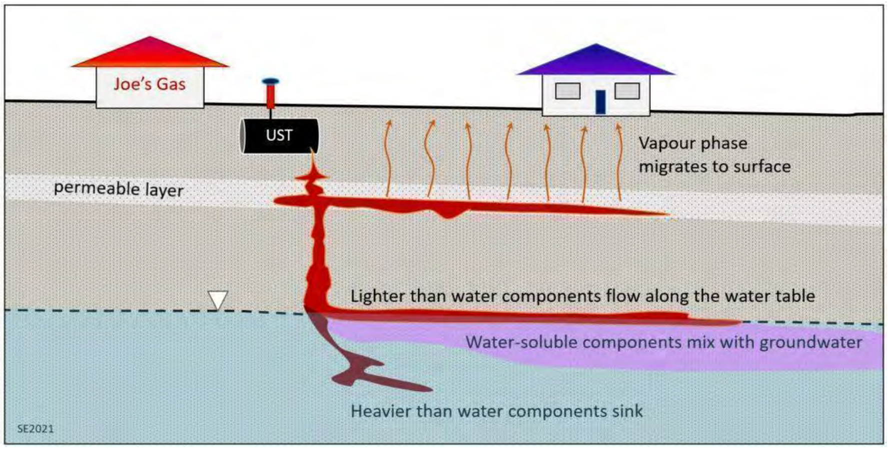


Figure 11.2.7 Illustration of the Fate of Petroleum That Has Leaked from a UST

Potential Effects of Fisheries on Aquatic Ecosystems

2007

Fishing can have both direct and indirect impacts on target species and aquatic ecosystems. Direct impacts include overfishing that leads to population declines, while indirect impacts can include disruption of aquatic food webs, when predator/prey interactions are affected by changes in fish populations.

The impacts of fishing on a fish population and the aquatic ecosystem depend on the biological and chemical characteristics (the productivity) of the waterbody, fishing pressure, the amount of fish biomass, and the biology of the fish population, including the age and size distribution, growth rates, spawning success, reproduction rates, and the role of the species within the aquatic ecosystem (Joynt and Sullivan 2003). Management strategies are therefore waterbody- and species-specific. In order to protect fish stocks, managers must determine the **maximum yield**—the maximum catch that can be taken while leaving a self-sustaining population—and allocate it between user groups (i.e., the sport, commercial, and domestic fisheries).

Due to the cold climate in Alberta, fish grow slowly and reach reproductive maturity late. High fishing pressure on species with low biological productivity can lead to collapse of the fish population over time. Lake trout, bull trout, cutthroat trout, walleye, lake sturgeon, northern pike and yellow perch populations have experienced significant collapses in Alberta waters. Some populations, including lake trout in Lesser Slave Lake, walleye in North Buck Lake, and native cutthroat trout in many streams, have been completely eliminated by overfishing (Joynt and Sullivan 2003).

Fisheries management aims to control fishing pressure so that fish are not harvested faster than they can reproduce. Three indications that a fishery has influenced a fish population include (Joynt and Sullivan 2003):

- **A decrease in the size of fish being caught,** indicating that fish are being harvested before they reach their full size.
- **A decrease in the number of adult fish caught,** indicating that fish are being caught before they can spawn. This reduces the rate at which the population can be replaced.
- **Complete elimination of a species** in a waterbody due to harvesting.

Twelve species of fish in Alberta waters have been classified by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as threatened, vulnerable or undetermined status due to fishing pressure, habitat loss or other human disturbances. Native species in the boreal region identified as threatened or vulnerable include the shortjaw cisco, the brassy minnow, bull trout, and Arctic grayling (Joynt and Sullivan 2003).

In addition to direct impacts on the targeted fish species, fishing pressure also affects interactions in an aquatic food chain. The balance in a food chain is disrupted when the fishing reduces the number of predator or prey fish. A decrease in the number of individuals in one link of a food chain can affect prey-predator relationships throughout the entire ecosystem.

3.0 Watershed Planning in Alberta

The intent of the following sections is to provide a solid understanding of the current regulatory and policy frameworks that affect the creation and implementation of lake watershed management plans. Existing legislation and planning activities need to be examined to ensure that management plans reflect and are consistent with municipal and provincial land use plans; that they are achievable, and that lake outcomes can be realized during the plan implementation phase.

The approach to watershed management in Alberta mirrors a general trend in Canada, which places a very strong emphasis on the creation of partnerships, multi-stakeholder councils and other forms of collaborative or adaptive co-management in environmental governance. While there has not been any change in the constitutional powers held by either of the provincial or federal governments (see Table 2 for a list of regulations), there is a trending shift from historical top down government regulatory approaches to adaptive co-management of natural resources. The traditional regulatory system has not been effective in preventing degradation of natural resources anywhere around the world.

The link between land use (e.g. agriculture, roads, residential development) within a watershed and water quality and aquatic health has been clearly identified. For that reason, watersheds are considered an appropriate unit for bringing together different stakeholders in collaborative, watershed management processes. Collaborative planning wherein the province, municipalities, private businesses, land owners and other interested parties form interactive networks to address common resource issues is neither easy nor straightforward.

Lake watershed management plans relate directly to other types and scales of planning initiatives already underway across Alberta. Some of the governance tools applicable in Alberta of

Water vs. Watershed Management Planning

Enabled by Alberta's Water Act, water management planning sets clear and strategic direction regarding how water should be managed. Typically led by the provincial government, water management planning focuses primarily on water licensing and allocations, although land use practices and other issues of watershed management can be addressed through water management plans.

In comparison, watershed management planning broadens the scope of management to consider all activities that potentially impact water quality and quantity, thus considering the inter-connectedness of ecosystem components. In fact, a completed water management plan can complement, or be considered a key component, of a watershed management plan, and vice versa. Unlike a water management plan however, a watershed management plan carries no regulatory authority; **being advisory in nature, its potential comes only from each of the associated authorities approving and adopting the recommendations and enacting them into their own policies and practices.**

This expansion from water to watershed management acknowledges that many decisions concerning land use that affect water quality, quantity, and aquatic ecosystems are outside the jurisdiction of the Water Act and other legislation. As such, watershed management planning requires collaboration and cooperation between all stakeholders who have an interest in or responsibility for these matters.

WATERSHED MANAGEMENT PLANNING PROCESS

Figure 5. Watershed Management Planning Process showing six stages and 16 detailed steps of planning. (From: Guide to Watershed Management Planning in Alberta, ESRD 2013.

START HERE:

Understand

Step 1: Prepare a state of watershed report.

Collaborate

Step 2: Identify who should be involved in developing a watershed management plan.

Step 3: Determine how participants will work together.

Step 4: Establish the structure under which participants will contribute.

Plan

Step 5: Identify priorities and the scope and scale of planning activities.

Step 6: Prepare and confirm support for the terms of reference.

Step 7: Develop a communications and engagement strategy.

Step 8: Identify outcomes, objectives, and indicators.

Step 9: Develop, evaluate and select preferred management actions.

Step 10: Draft and confirm support for the plan.

Implement

Step 11: Build the foundation for successful implementation.

Step 12: Establish an implementation committee.

Step 13: Implement the plan.

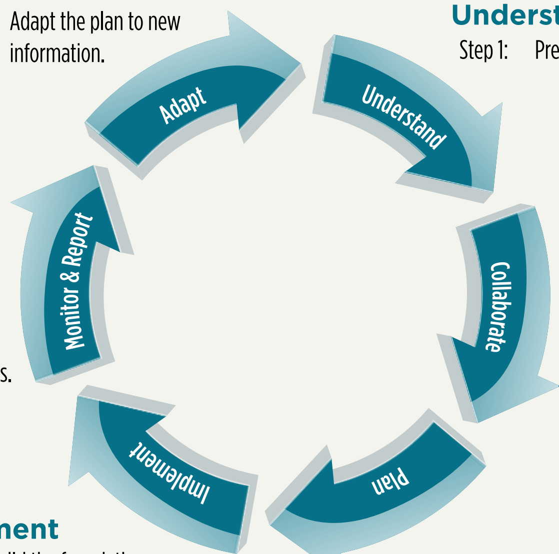
Monitor & Report

Step 14: Monitor implementation and outcomes.

Step 15: Report on implementation and outcomes.

Adapt

Step 16: Adapt the plan to new information.



FOOD FOR THOUGHT

In a discussion paper prepared for the Pigeon Lake Watershed Association the Environmental Law Centre recommended four ways to improve consistency in regulation of activities affecting lake watersheds. These options include:

- Amalgamating watershed municipalities;
- Pursuing an inter-municipal development plan and creating an inter-municipal planning commission and inter-municipal subdivision and development appeals board under the Municipal Government Act (MGA);

Entering into a memorandum of understanding among all municipal bodies, provincial, federal and first nations governments, or

- Advocating for a substantive watershed plan to be incorporated into the regional plan under the Alberta Land Stewardship Act (ALSA).

To read the report visit: pigeon lake watershed stewardship society webpage www.plwa.ca

Watershed Planning and Advisory Councils

These independent, non-profit organizations report on watershed health, and facilitate collaborative planning, education, and stewardship.

Overview

Watershed Planning and Advisory Councils (WPACs) are important stewards of Alberta's major watersheds. They are independent, non-profit organizations that are designated by the Alberta government to report on the health of our watersheds, lead collaborative planning, and facilitate education and stewardship activities.

WPACs engage representatives of key stakeholders in the river basin area, including:

- municipal, provincial and federal governments
- industrial sectors
- conservation groups
- aboriginal communities
- academia
- the public

In their work, they seek consensus on land and water resource management strategies that support the achievement of shared environmental, social, and economic outcomes for the watershed.

Within Alberta there are currently 11 WPACs representing the major river basins:

- Athabasca Watershed Council
- Battle River Watershed Alliance
- Bow River Basin Council
- Lesser Slave Watershed Council
- LICA – Beaver River Watershed
- Mighty Peace Watershed Alliance
- Milk River Watershed Council Canada
- North Saskatchewan Watershed Alliance
- Oldman Watershed Council
- Red Deer River Watershed Alliance
- South East Alberta Watershed Alliance

Collaborative approach

The Water for Life strategy marked a shift in the management of Alberta's water resources to better enable shared responsibility and environmental stewardship. WPACs are the main mechanism to foster this collaboration at the watershed level, creating opportunities for stakeholders to come together, share resources, and explore innovative solutions to water management challenges. This provides a strong basis for collaborative action and shared ownership in the work of the council.

Program areas

Water for Life provided WPACs with a mandate to support multi-stakeholder collaboration and community engagement within four main program areas:

- Education and Outreach
- Environmental Stewardship
- Watershed Evaluation and Reporting

- Watershed Management Planning

Education and outreach

Through their education and outreach programs, WPACs aim to raise public awareness about issues and stewardship options within the watershed, and encourage public involvement in watershed management. Education and outreach activities vary across each WPAC according to their priorities and objectives. Below are a few examples of the types of activities that may be underway.

Workshops and educational forums:

Workshops and educational forums are regularly held by various WPACs, providing the general public with an opportunity to learn more about issues in the watershed, to network with various stakeholders and to discuss ongoing initiatives.

Classroom programs:

Several WPACs have also developed classroom programs as part of their education activities. These include school presentations and field trip opportunities, as well as working with schools to develop programs that build environmental awareness and stewardship within the curriculum.

Community events:

Participation in community events allows WPACs to celebrate successes and engage with the public while raising awareness in a more festive setting.

Communication initiatives:

Many WPACs have developed a number of communication initiatives to support their education and outreach work. Most WPACs regularly send out a newsletter to their members and provide a wealth of information through their website, social media and publications.

Environmental stewardship

Environmental stewardship recognizes a collective responsibility to retain the quality and abundance of land, air, water and biodiversity, and to manage this natural capital in a way that conserves all of its environmental, economic, social and cultural values.

WPACs work with communities and stakeholders in the watershed to promote environmental awareness and a shared responsibility for practices that support a healthy watershed. The commitment to action made by individual WPAC partners and the resulting tangible improvements to watershed health serve as a testament of environmental stewardship. The stewardship work undertaken by WPACs has included water conservation initiatives, shoreline cleanups, installation of off-site livestock watering systems, and riparian and wetland restoration programs.

WPACs also provide advice and support to Watershed Stewardship Groups (WSGs) that encourage local actions to promote watershed health.

Evaluation and reporting

State of the watershed report

The state of the watershed report is one of the 2 key deliverables produced by Watershed Planning and Advisory Councils (WPACs). It describes the history of the watershed, its natural and built features, the condition of the resources, and the impact of human activity on the watershed. State of the watershed reports are expected to inform the development of Integrated Watershed Management Plans (IWMP), providing a foundation of information for developing effective management strategies to meet watershed goals.

Developed in 2008, the Handbook for State of the Watershed Reporting is intended to serve as an informative reference guide to "non-technical audiences" interested in assessing and reporting on the state of their local watershed. It supports the work of WPACs and Watershed Stewardship Groups (WSGs) pursuing similar activities.

Watershed management planning

Integrated Watershed Management Plans (IWMPs)

IWMPs are the second key deliverable produced by Watershed Planning and Advisory Councils (WPACs). These plans provide advice to governments and agencies that have policy and regulatory decision-making authority for land and resource management. Collaboration is central to the development of IWMPs, which are based on consensus agreement and inclusive participation of stakeholders and community representatives from within the watershed.

Finalized in 2015, the Guide to Watershed Management Planning in Alberta provides advice on the steps to develop and implement a watershed management plan. The guide is based on the iterative process of adaptive management, from planning through to implementation and evaluation, and back to planning.

Water management plans versus watershed management plans

Unlike watershed management plans, water management plans are statutory plans developed under the Water Act. They provide guidance for regulatory decisions made under the Water Act, including the establishment of minimum in-stream flows, conditions on diversions, and strategies for the protection of the aquatic environment. When a water management plan is approved by the Lieutenant Governor in Council, it becomes an "Approved Water Management Plan" and must be considered when making water approval decisions.

Alberta

Water for Life strategy

Water for Life is the overarching government-wide strategy for water in Alberta.

Overview

Water is not only a resource, it is a life source. We all share the responsibility to ensure a healthy, secure and sustainable water supply for our communities, environment and economy.

The Water for Life strategy outlines the Government of Alberta's commitments to manage and safeguard Alberta's water resources. The strategy has been the vehicle for managing Alberta's water resources since its release in 2003.

Renewed strategy

Released in 2008, the renewed Water for Life strategy better reflects the population increase and economic growth Alberta has seen over the past years, and Albertans' changing water needs. As in the original, the renewed strategy has 3 main goals:

- safe, secure drinking water supply
- healthy aquatic ecosystems`
- reliable, quality water supplies for a sustainable economy

These goals will be met through 3 key directions:

- knowledge and research
- partwater conservationnerships
-

For more details, read the Water for Life fact sheet.

Action plan

Water for Life goals and key directions will be achieved through the Water for Life action plan, which is designed to ensure achievable and timely outcomes that reflect growing pressures on our province's water supplies.

Progress report

- Water for Life: Progress Report (December 1, 2008 to March 31, 2011)

Government of Canada Gouvernement du Canada

Sustainable Agricultural Land Management around Wetlands on the Canadian Prairies

Introduction

Before the prairies were developed for agricultural crop production, an abundance of natural wetlands were an integral part of the prairie grassland and parkland ecosystems. While there is considerable uncertainty about wetland loss, up to 70% is estimated in settled areas across Canada (Source: Canadian Wetland Inventory, 2008), and 84% of this loss is attributed to drainage for agricultural crop production (Source: Canadian Wildlife Service, 1991).

Remaining wetlands within fields used for agricultural production often pose significant challenges for farmers. At the same time these wetlands provide many important ecosystem functions. Over the past several decades a growing number of environmental programs have encourag ed farmers to restore and/or maintain natural wetlands. These programs have been somewhat successful in some areas, but in other areas wetland drainage continues.

Wetland management is a prime example of where ecological and agricultural perspectives are often widely divergent. However, the reality is that ecosystem function and agricultural production have coexisted on the prairie landscape since cultivation began, and will continue to do so in the future. The challenge is to design land management systems that allow both of these outcomes to flourish.

Understanding Natural Wetlands

Wetlands are typically low lying areas impacted significantly by water at or near the surface. They include not only open water bodies such as sloughs and springs, but also the riparian area immediately upslope of water bodies.

The riparian area, simply defined as the interface between land and water, consists of different zones characterized by varying degrees and persistence of water ponding or soil saturation. A common feature of these zones is that they support water loving organisms. These zones are typically organized as concentric circles or bands, each with a unique set of organisms adapted for their specific environment. Plant species include both vegetative and woody types, and most are perennial.

Natural wetland in an agricultural landscape

The size of the wetland pond and its surrounding vegetation zones fluctuate over seasons and year to year due to wet and dry cycles. However, organisms adapted to wetlands have the capacity to move laterally up or down the slope as required. Many are also able to create "seed banks" that remain dormant when conditions are not conducive to growth, but flourish when conditions improve (Source: Leck, 1989). As a result natural wetlands, while never static, are able to remain healthy under changing environmental conditions.

Natural wetlands provide a number of valuable ecological functions. Most obviously these areas have tremendous biodiversity, as they typically contain the greatest number and populations of species in the landscape. They also provide habitat for a large number of animal species that move in and out of wetland areas from surrounding uplands. In addition wetlands also help to:

- maintain water quality by filtering nutrients and pesticides, trapping sediment, and stabilizing shorelines and stream banks from erosion
- buffer water supplies by holding water during droughts, releasing water slowly to avert flood damage and recharging ground water aquifers.
- reduce greenhouse gases by building and storing soil carbon

Upland Management Impacts on Wetlands

The impact of upland management primarily involves the effect of different vegetation types and their management on hydrologic processes that influence the amount and quality of water entering wetlands. Wetlands are recharged with water primarily through surface runoff, but also through groundwater discharge, wind blown snow deposited into the wetland, and by direct precipitation on the wetlands. Across the Canadian prairies typically 80% of annual runoff is generated from snowmelt, even though snowfall accounts for only one-third of annual precipitation. (Source: Fang, 2007). The higher tendency for snowmelt to runoff is due to reduced infiltration associated with frozen soils, which usually stay frozen until after most of the snow has melted. Prairie wetlands would not exist without the addition of water from the surrounding uplands.

1. Type and Amount of Vegetation

There are a number of ways that vegetation impacts hydrologic processes. First of all, the increasing amount and roughness of surface cover will reduce snow drifting and water runoff, and increase the infiltration rate of precipitation and snowmelt at the soil surface. Secondly, the type of vegetation may influence the amount of cracks and macro pores that allow for increased infiltration. Thirdly, different types of vegetation have varying abilities to extract soil moisture. Perennial forages extract more moisture than annual crops in fall prior to winter freeze up. The net result of macropores and less soil moisture is increased infiltration and reduced runoff the subsequent spring compared to annual crop stubble. Long-term studies of wetlands at the St Denis National Wildlife Area in Saskatchewan showed that conversion of uplands to undisturbed grass resulted in almost complete drying out of small wetlands within the grassed fields (van der Kamp et al., 1998).

2. Fallow

The greatest land management impact on the fate of snow is the practice of fallow. Typically on fallow land, a much higher percentage of snowmelt succumbs to runoff than infiltration. Fallow soils tend to be moist or saturated entering the winter period, making them highly impermeable, particularly when frozen.

Fallow fields also experience the greatest amount of snow transport via wind drifting. Snow tends to accumulate in low lying areas or around shelterbelts, but a considerable amount may be lost to sublimation before it gets there. Sublimation involves the transformation of solid snow crystals directly to water vapour in the atmosphere, without an intermediate liquid phase.

Since the early 1970's, the amount of fallow has gradually decreased, so these impacts are declining over time (Source: Statistics Canada)

3. Conservation Tillage

No Till Seeding maintains standing stubble and crop residue cover

In semi arid regions conservation tillage on annual cropland will result in improved infiltration and reduced runoff due to increased crop residue, soil organic matter and formation of macro pores. Eliminating fall tillage helps to maintain standing stubble which reduces snow drift. These practices also result in lower water erosion and reduced infilling of wetlands by sediment. Reduced runoff and sedimentation will also help to reduce movement and deposition of dissolved and sediment bound nutrients, pathogens, and pesticides into water bodies.

However, greater concentration of nutrients close to the soil surface due to lower soil disturbance and crop residue conservation may result in increased amounts of soluble phosphorus in runoff. Also, in more humid environments conservation tillage may result in higher soil moisture levels entering the winter period, resulting in slower infiltration and increased snowmelt runoff in spring.

4. Nutrient Management

The timing, rate, and method of application of manure and fertilizer can have a significant impact on the risk of nutrient movement from upland areas into water bodies. In most cases practices that maximize efficiency of crop nutrient uptake also result in the lowest risk to the environment.

However, there are some current practices that may result in high nutrient loadings in upland areas.

- manure application rates in excess of crop requirement, often adjacent to intensive livestock operations
- fall application of fertilizer or manure
- high density winter feeding of livestock in open fields

Depending on hydrologic factors relating to soil, landscape, and climate features these excess nutrients may end up in wetland areas. Increased nutrient levels in wetlands do not usually threaten its survival, but may impact its function such as its usefulness as a source of drinking water for many species.

5. Upland Management Impacts on Waterfowl Habitat

In addition to the hydrologic impacts already discussed, upland management also affects waterfowl habitat directly through impact on nesting success. Spring tillage has the greatest negative impact in disturbing nests before young birds have left. This disturbance progressively decreases as one moves to annual crop systems that involve conservation tillage and fall seeded crops, then to delayed cut hay and grazed pasture, and finally idle perennial vegetation.

Specific Land Management Practices Near Natural Wetlands

As a general rule wetlands should be maintained or restored as natural wetlands, and the surrounding upland should be managed as perennial pasture or hay, or annual crop production. However, more careful consideration is needed for areas that transition between wetland and upland.

1. Restoration of Natural Wetlands

Wetlands that have been drained and used for crop or forage production often still have viable "seed banks" of native species, even after years of cultivation (Source: Rosberg, 2001). Therefore, if the area has not been earth filled, one may only need to restore the original water level. This may be as simple as raising or plugging the surface outlet.

Natural re-establishment of native species may take some time, and may involve a transition period where certain undesirable plant species may have negative impacts on surrounding upland, such as increased weed control costs. Over time there should be a shift to a more stable species composition that has fewer upland impacts.

2. Perennial Forages

Annual crop production should be limited to areas that dry up in time for spring seeding most years, and are not susceptible to ponded water after seeding. Areas too wet for annual crops may be suited to flood tolerant perennial forages.

Unfortunately, species with highest flood tolerance generally have lower forage value and also lower drought tolerance. These forages, even though able to tolerate lower levels of flooding, are not recommended for areas that flood for less than 2 weeks because there are other species more suited to these areas.

Forage stands in areas with frequent or long duration flooding or soil saturation are often too wet to be accessible for livestock grazing or haying operations. When they are accessible, the forage has often matured to the point that its feed value has significantly deteriorated. Therefore, even though there is potential to grow forages for agricultural production on lands with long duration flooding, practically these areas are more suitably managed as natural wetlands.

Nevertheless, areas susceptible to moderate flooding may be suited for perennial forage, and in fact be an important source of hay or pasture especially during drought years when upland production is minimal.

3. Salt Tolerant Forages

The degree of salinity also impacts the types of vegetation that can grow. Most annual crops tolerate only slight salinity. Some perennial forages have considerably more salt tolerance. As with flooding, species with high salt tolerance generally have lower forage value.

There are relatively few forage species with both flood and salinity tolerance. Therefore, it is recommended that areas with moderate to high flood duration and salinity be restored and managed as natural wetlands.

4. Grassed Waterways

Grassed Waterway harvested for hay

Often much of the surface runoff entering wetlands is through channelized flow. This type of flow also occurs when one wetland overflows resulting in runoff to another wetland downstream. These areas should have a flat bottom with gentle side slopes, stabilized with a sod forming perennial grass. This will ensure that the flow remains in the waterway and does not cause gully erosion and deposition of sediments in wetlands.

5. Forage Buffer Strips

Natural wetlands contain a variety of perennial plant species in the riparian zone. If the surrounding upland is in annual crop it is often desirable to establish an additional band of perennial forage outside the wetland area. Part of the reason relates to the fact that the outer edge of the riparian zone may vary over time between wet and dry cycles. Therefore, adding a perennial forage buffer helps to ensure that the entire riparian zone remains in perennial vegetation and provides good ecosystem functions. Of the entire wetland area this outermost zone will be the most feasibly used for forage production, because it will be least susceptible to flooding.

The width of this outermost band may vary considerably depending on many factors. In the prairie region forage buffer widths of 10 to 30 meters have been recommended (Source: Huel, 1998). Wider buffers could be rationalized for the following situations or functions:

a. gently sloping wetlands that have greater variability in land area susceptible to having excess moisture.
b. where grassed waterways or channelized water widens or fans out before entering a riparian area
c. increasing the buffers ability to enhance wildlife habitat and biodiversity
d. increasing the buffers ability to filter sediment, nutrients, and pesticides

The use of this forage buffer could be hay or pasture, although pasture will be limited to early spring or late fall if the surrounding upland is in annual crop. If high nutrient levels are threatening the wetland area, harvested hay or silage that is transported and fed off site also provides an extra advantage in helping remove some of these nutrients.

6. Set Back Distances for Crop Inputs

It is generally recommended to keep a setback distance between the edge of a wetland and applications of manure, fertilizer, or pesticides. This reduces the risk of nutrient, pesticide, and pathogen loadings into water bodies. A forage buffer strip is a good land use for a set back area, because it generally does not require nutrient or pesticide inputs to remain productive.

7. Squaring Off Forage / Annual Crop Boundaries

A major consideration in the design of forage buffers and set back distances is to create an annual cropped field that is not fragmented and subject to inefficient field operations through excessive overlap. This can be achieved by including small, irregularly shaped parcels of land adjacent to the wetland in the forage buffer (Source: Gregg). In a field with several wetlands connected by grassed waterways, it may be prudent to expand the forage to the area between the wetlands as well. The feasibility of this practice is also dependant on the ability to utilize the increased forage production.

8. Wetland Consolidation

Some farmers have effectively addressed the field fragmentation issue by draining a number of smaller wetlands into one larger one. The remaining wetland will experience an increase in area and volume roughly equal to the total area of the drained wetlands. However there is usually still a loss of wetland function primarily due to a reduction in wetland shoreline perimeter. Nevertheless, wetland consolidation may be more acceptable if it focuses on draining wetlands with very infrequent flooding, in other words those with minimal wetland function and maximum agricultural production potential. It should be noted that wetlands with short duration spring time flooding have significant function for nesting waterfowl.

9. Converting Entire Fields to Perennial Forage

For fields with excessive fragmentation, it may be more feasible to convert the entire field to perennial forage than establish forage in smaller areas like buffers and waterways. This has already been identified as a priority for hummocky landscapes, but may also be suitable in certain situations for other landscapes. A major factor in this decision is the interest and ability of the producer to make a significant management change from annual crop to livestock production. Often these conversions are most evident when accompanied by changes in land ownership or tenure.

10. Grazing Management

Wetlands can provide significant benefits for livestock production through the provision of forage, water, and shelter. However, without limited or restricted livestock access these areas can become negatively impacted by excessive nutrient and pathogen loadings, and excessive hoof disturbance in saturated zones. A proper grazing management plan which includes practices such as remote offsite watering systems, controlled riparian grazing, and upland portable windbreaks or shelters can help minimize these problems.

11. Trees and Shrubs

Trees and shrubs are a natural part of prairie wetlands. Species like willow and aspen are often found in the riparian zone. These species have considerable flood tolerance. This tolerance is exhibited not only in the ability of individual trees to survive a certain amount of flooding, but also the ability of these species to generate new trees through root suckering. For example, while prolonged flooding lasting for one year or more can kill a stand of aspen within a wetland area, new tree shoots will often emerge upslope of the flooded area.

Trees and shrubs also provide excellent nesting and foraging habitat for many resident and migrating songbirds. In addition other forms of wildlife use these areas as cover and shelter habitat. Beneficial insects such as bees and other pollinators are attracted to these sites.

The use of trees for commercial biomass production has recently gained interest on agricultural land (ie. agroforestry). Planting trees for agroforestry around wetlands may help to extract and remove excess nutrients. Trees may be even more effective than some forages, by using more extensive and deeper root systems to recapture deep leached nutrients.

A major concern with growing trees in this part of the landscape is the risk of flood damage. This depends on the risk of a flood event, the duration of flooding and soil saturation, the flood tolerance of the tree species, and the expected harvest interval of the tree crop. For example, species such as willow that are harvested on a frequent time interval would be considerably less risky than hybrid poplar harvested only after reaching a mature age.

Sustainable Management in the Midst of Variable and Changing Climate

Due to the high proportion of runoff that occurs during snowmelt, wetland water levels typically peak in the spring. Water levels then gradually subside throughout the summer as evaporation and water use by the riparian vegetation become more dominant hydrologic processes. However, intensive summer thunderstorms can quickly refill wetlands.

In addition to annual cycles, there are also multi year cycles that impact water levels in wetlands. Sometimes these cycles can last for a number of years. These wet and dry cycles pose special challenges for agricultural producers, especially because they are unpredictable. Add to this the risk of climate change and increased climate variability, and these challenges intensify.

Most crops and perennial forage species do not exhibit good tolerance for both flooding and drought. Therefore, there is always a risk of crop failure or forage die back. During longer drying or wetting trends there may be a need to make some land use and management changes to adapt. Decisions to change or not to change involve significant risk as one never knows how long a current trend will last.

The preferred goal is to find an appropriate balance in managing landscapes sustainably for agricultural production while maintaining the landscape's ecosystem functions. The specific practices to achieve this will vary from region to region, farm to farm, and even field to field depending on many factors. Making good management decisions requires a thorough knowledge of these factors, sufficient advance planning, and a patient commitment to carry through despite changing seasonal and year to year circumstances. A degree of flexibility is also required to adapt to longer wetting or drying trends that may require changes in land use or management for a period of years.

What laws exist to manage and protect our water?

Environmental Law Centre

Water Act

The Water Act is Alberta's current water management legislation. This Act came into force on January 1, 1999, and focuses primarily on the planning for and enforcement of water use in Alberta. Some of the main features of the Water Act are outlined below:

It vests ownership of all water in the Province with the Crown. This includes the right to use and divert water.

It defines a 'body of water' as "any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood, and includes but is not limited to wetlands and aquifers but does not include a water body that is part of an irrigation work." This is a good definition to use when thinking about water in Alberta. It is widely used and is relied on by other government bodies, such as the Alberta Energy Regulator as a fallback definition for pieces of legislation where water is not specifically defined.

It distinguishes between, and defines, three main forms of water use in Alberta:

Household use: when a person owns or occupies land above groundwater or beside a lake, river, or stream and uses the water available to them for their household needs. This does not apply to water that comes out of your tap when you live in a municipality (such as a city or town);

Licensable use: Albertans can apply for, and receive, licenses which allow them to use and divert water, for purposes such as irrigation or industry. The Act also allows license transfers between individuals, under certain circumstances; and

Exceptions: there are other exceptions to the licensing requirements under the Water Act, such as when you need water for firefighting.

It regulates proposed activities that may impact surface and ground water. For example, if you are planning to do something that may affect the quality of the water or the land or vegetation on a river bank, you may require prior authorization from Alberta Environment and Parks. This authorization may take the form of a Water Act approval, a water licence, or both.

The Water Act gives Alberta Environment and Parks and the Alberta Energy Regulator the authority to determine when and how a water licence will be issued. Before getting a licence, individuals need to apply, specifying the amount of water needed and where it will be used.

The government will then decide whether they should issue the license as requested, determine whether it should be altered, or even denied.

It provides for a recovery plan in the event of a spill – such as oil being spilled into one of our water bodies.

Public Lands Act

The Alberta Public Lands Act manages the use of crown land, which is land that is owned by the provincial government. This is a big job because most land in Alberta is public or crown land, meaning that it is neither privately owned nor is it a provincial or national park. The Public Lands Act governs the activities that can be conducted on this land and includes enforcement and compliance provisions when the land is harmed or improperly used.

This Act also plays a role in the governance of any water on these lands. In Alberta, the beds and shores of permanent and naturally occurring bodies of water (such as permanent wetlands) and the beds and shores of rivers and lakes are owned by the Crown, just like ownership of water is vested in the Crown under the Water Act. Section 3(2) identifies some exceptions to this crown control and ownership, however the provincial government still holds a significant amount of power when it comes to deciding how, and by whom, our water bodies, and the land surrounding them, are used.

Environmental Protection and Enhancement Act

The Environmental Protection and Enhancement Act (EPEA) is the primary provincial statute dealing with pollution. In this regard, the EPEA also plays an important role in managing and preventing water pollution.

For example, Part 7 of the EPEA is focused on managing potable water and prohibits anyone from releasing a substance into any part of a waterworks system that causes (or may cause) potable water to be unfit for use. Part 8 also states that hazardous substances must be stored and transported so as to ensure that they do not contaminate water. If contamination occurs, the EPEA enables the Director to issue an environmental protection order to prevent or manage the contamination. The EPEA also prevents waste from being disposed of into or under water or ice, unless the specific disposal falls under an approved exemption.

The EPEA is also the Act that sets out the environmental assessment process required for some large scale projects in the province.

Both the pollution prevention and environmental assessment provisions of the EPEA enable the Act to protect and manage water.

Species at Risk Act

The Species at Risk Act or SARA is federal legislation whose overarching purposes include the prevention of animal, plant, and insect species from becoming extinct or extirpated, providing for the recovery of species at risk, and ensuring that species of special concern (a lower designation) do not become threatened or endangered.

If species at risk are present, SARA may affect how a water body can be used and what human activity can occur near or on the water.

In Canada, the federal government has jurisdiction over certain aspects of water when it is related to fisheries, navigation, international relations such as boundary waters, and federal lands such as national parks. Much of the protection for aquatic species and their habitat comes from the Fisheries Act, however this protection regime is echoed in Section 34(1) of SARA.

Fisheries Act

The Fisheries Act is the federal statute that manages Canadian fisheries. The four fundamental subject matters dealt with in this legislation include: the proper management and control of fisheries; the conservation and protection of fish; the protection of fish habitat; and the prevention of pollution. In summer 2019, the federal government amended the Fisheries Act and brought back some increased protections for fish habitat, improving the conservation aspect of this Act.

In Alberta, the Fisheries Act is the Act that dictates how water bodies where fish live, reproduce in, or otherwise occupy, are managed. The Constitution awards the federal government with control over fisheries which means that federal jurisdiction over fisheries and fishing licences must be weighed alongside provincial control over the management of water, public lands or property, and civil rights. Additionally, both federal and provincial powers have to take Indigenous rights, protected under Section 35 of the Constitution, into consideration.

To learn more about the Canadian constitution and to better understand how federalism works, check out our section on Constitutional Law here.

Municipal Government Act

The Municipal Government Act (MGA) is the Act that puts in place the legislative framework for all municipalities and municipal entities across the province of Alberta. This means that it provides the governance model for local governments and lays the foundation for how municipalities operate, how municipal councils function, and how citizens can work with their municipalities. It also has a role to play in the governance of Alberta’s water.

The MGA defines a water body as, "a permanent and naturally occurring water body or a naturally occurring river, stream, watercourse or lake". Following this definition, in Section 60, the MGA states that a municipality has the direction, control and management of the bodies of water within the municipality, including the air space above and the ground below, subject to other enactments including in the Water Act. As you may have already been able to tell, governing and legislating for water is a complex feat that involves every level of government.

So, what control do municipalities have? Among other things, the MGA gives them the authority to choose whether development permits will be issued beside a body of water or on land subject to flooding or near a wetland; to award budget allocations to water treatment and/or water storage; to mandate that the owners of proposed subdivisions designate a portion of the proposed land as an environmental reserve – including land use around waterbodies and to choose to do so as a means of preventing water pollution. The MGA awards municipalities more control over day to day governance, which, in turn, awards them more power and control over the environment including our water.

Canada National Parks Act

The Canada National Parks Act begins by dedicating the national parks of Canada to the people of Canada for their benefit, education, and enjoyment and states that the parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations.

In Alberta, there are five national parks: Banff National Park, Jasper National Park, Elk Island National Park, Waterton Lakes National Park and Wood Buffalo National Park. This land base is widely used for numerous outdoor activities including skiing, hiking, camping and other outdoor enjoyment.

National Parks are federal land, which means that other federal legislation such as the Species at Risk Act applies. The SARA can place certain restrictions on national parks if species at risk are present.

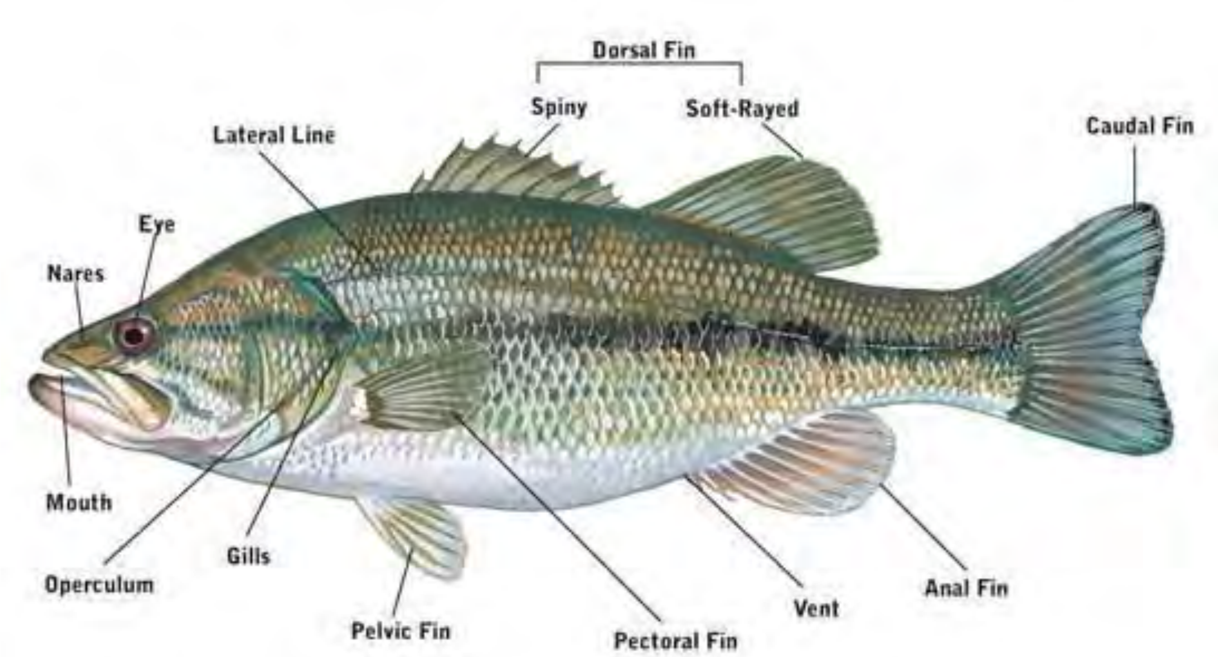
Key Topic #4: Applied Field Techniques

17. Identify native freshwater fish, macroinvertebrates, aquatic plants, and riparian plants (including common species and invasive species) in Alberta using a field guide.
18. Assess water quality based on macroinvertebrate species surveys and describe the tools and methods used to conduct these assessments.
19. Understand common water quality parameters and why their assessment is useful for determining overall water quality.
20. Explain the process and importance of properly calibrating aquatic monitoring tools.
21. Apply appropriate preservation methods for various types of water quality samples including: phytoplankton, zooplankton, chlorophyll-a, total phosphorus, and total dissolved phosphorus.

Study Resources

Fish - Anatomy

Fish are vertebrates, meaning they have a backbone. All fish have fins and most have scales (with a few exceptions, like catfish which do not). Fish are cold blooded animals that lay eggs and are well suited for living in water. Learn about the different fish adaptations below that allow a fish to survive in water.



External Anatomy

Eyes: Used for sight, fish can detect colors and see short distance with their eyes. They use their vision to escape predators and find food.

Nares: Similar to nostrils, except nares are used for smelling only (nostrils are used for both smelling and breathing).

Mouth: The mouth is used to consume food.

Operculum: The operculum is the bony flap that protects the gills from harm. It opens and closes to allow water to pass over the gills.

Pectoral Fin: The pectoral fin allows for abrupt changes in side-to-side direction and speed. It also acts as a brake to decrease speed while swimming.

Pelvic Fin: The pelvic fin stabilizes the fish while swimming and allows for up-and-down movement in the water.

Vent: The vent removes waste and extra water. It is also the outlet for eggs or milt (sperm) during spawning.

Anal Fin: The anal fin stabilizes the fish while swimming.

Caudal Fin: The caudal fin moves, propels or pushes the fish through the water.

Adipose Fin: The adipose fin is not pictured; it is not present on a lot of fish species. Its purpose is unknown. Trout, salmon and catfish have an adipose fin. It is the small, thick, fleshy fin located between the dorsal and caudal fins.

Dorsal Fin: The dorsal fin helps maintain balance while swimming.

Scales: Scales protect the fish from injury.

Barbels: Barbels are not pictured. They are the "whiskers" found on the head area of fish such as catfish or bullheads. On the catfish and bullheads, barbels are thought to be a sensory organ to help track down prey or food. Sturgeon also have barbels.

Internal Anatomy

Gills: Gills are the feathery tissue structure that allows fish to breathe in water. Water flows in through their mouth and over their gills where oxygen is extracted and passed into the bloodstream.

Swim Bladder: The swim bladder is a long, skinny organ that can inflate/deflate with air allowing fish to float at different levels in the water column.

Fish Senses

Eyesight: Fish can see in two directions (one eye focusing on an object independent of the other whereas human's eyes can only focus on one object at a time).

Hearing: Fish have ears but not external ear openings like humans do. Their ears lack a middle and outer ear because sound travels faster in water than in air. Fish have internal ears with pairs of inner ear bones called otoliths. The otoliths allow fish to sense sounds in the water. Fisheries biologists can also use these bones (otoliths) to age fish and determine the health of fish populations.

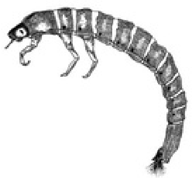
Smell: Fish use their sense of smell to locate food and to aid in migrating.

Taste: Some fish have taste buds, however, these taste buds are located on the outside of the fish's head and fins in small pores. Some fish like catfish have a very developed sense of taste.

Lateral Line: The lateral line, found alongside a fish's body from the operculum to the tail (caudal fin), senses vibrations or movements in the water. It allows fish to locate predators and find prey. This system is made up of a series of fluid-filled canals just below the skin of the fish's head and alongside the body. The canals are filled with tiny hair-like structures that detect changes in the water pressure via tiny pores connected to the system.

Guide to Aquatic Macroinvertebrates: The Basics

Riffle Beetle Larva

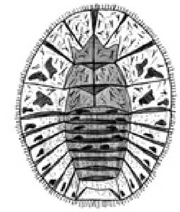



- Small crunchy, comma shaped body, up to 1/2 inch
- 3 pairs of segmented legs
- Gills and 2 hooks on posterior end

Riffle Beetle Adult


- Oblong beetle shape, long antennae
- Small, 1/16 - 1/8 of an inch
- Walks slowly underwater, doesn't swim on surface

Water Penny

- Flat saucer-shaped body
- 3 tiny pairs of legs on the underside
- Up to 1/2 inch

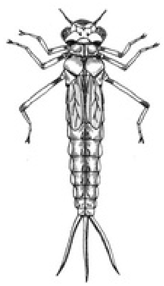
Mayfly


- Feather or leaf-like gills on the abdomen
- Typically has 3 tails (can have 2)
- 3 pairs of segmented legs

Stonefly

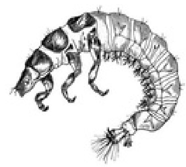

- Long antennae
- 2 tails
- No gills on abdomen
- 3 pairs of segmented legs

Damselfly




- 3 broad oar-shaped tails
- Long, narrow body with no gills on abdomen
- 3 pairs of spindly segmented legs

Common Net Spinning Caddisfly

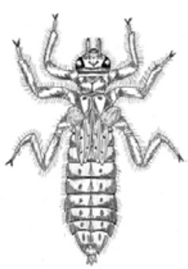



- Head and first three thoraxes are hardened
- 2 fleshy, hairy hooks on the posterior
- 3 pairs of segmented legs
- Gill tufts on abdomen

Case-making/Free living Caddisfly


- May have a case constructed of sand, gravel, leaves or twigs
- Hardened head with grub-like soft body
- 3 pairs of segmented legs with hooks on the posterior

Dragonfly

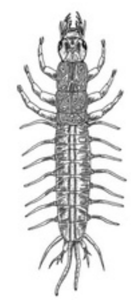



- Oval/round abdomen (may be wider than it is tall)
- Large eyes
- 3 pairs of segment legs

Dobsonfly (Hellgrammite)


- 8 pairs of fleshy appendages on abdomen
- Cotton-like gill tufts between appendages
- Large pinching jaw

Fishfly

- 8 pairs of fleshy appendages on abdomen
- No gill tufts
- Forked posterior with 2 fleshly tails

Alderfly


- 7 pairs of fleshy appendages on abdomen, no gill tufts
- One long thin branched tail

Guide to Aquatic Macroinvertebrates: The Basics

Midge


- Uniformly wide, segmented body
- Distinct head
- Pair of prolegs behind the head and at the posterior
- Up to 1/4 inch

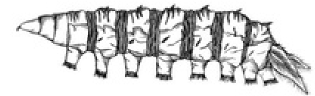
Crane Fly


- Plump, caterpillar-like, segmented body
- 4 fingerlike lobes at the posterior
- 1/2 - 1 inch

Black Fly


- Bowling pin shaped body
- Distinct head with one proleg directly underneath
- Up to 1/4 inch

Water Snipe




- Soft, fleshy body with tapered ends
- Caterpillar-like legs
- 2 feathery ‘horns’ at the posterior

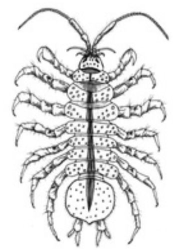
Crayfish


- Lobster-like body
- Two large claws near the head
- 1/2 - 5 inches

Scud


- Shrimp-like body, no hard covering
- Long antennae
- 7 pairs of legs
- Swims quickly on its side

Sowbug

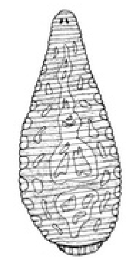



- Oblong body
- 2 pairs of antennae, one longer than the other
- Armor-like appearance

Clams & Mussels

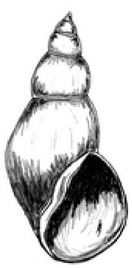

- Fleshy body enclosed between two-hinged shells
- 1/8 - 5 inches

Leech

- Worm-like segmented body
- Both ends have suckers
- 1/4 - 2 inches

Gilled Snail

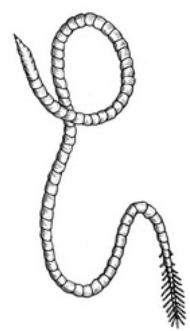



- Shell opens to the right when holding the shell with the narrow end pointing up and the opening facing you
- Has an operculum (thin plate covering the shell opening)

Lunged Snail


- Shell opens to the left when holding the shell with the narrow end pointing up and the opening facing you
- No operculum
- Shell might be in a coiled shape

Aquatic Worm

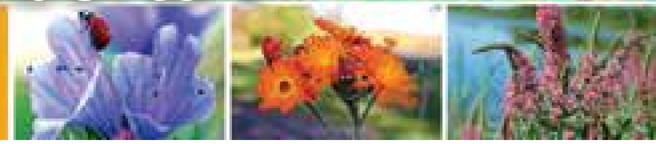



- No distinct head
- No legs
- 1/4 - 2 inches

Flatworm (Planaria)


- Soft elongated body
- Triangular shaped head with eyes on top

Invasive Plants in Alberta



February 2014

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Riparian areas

Land owners and occupiers are responsible for controlling noxious weeds and destroying prohibited noxious weeds under the Alberta *Weed Control Act*. Listed plants in the Act cause problems for the environment, health or economy. Know your responsibilities under the Act. Regardless of where plants are located, prevention is always the most effective approach in dealing with invasive plants.

What You Need to Know

What is the problem?

Riparian areas are the lands adjacent to streams, rivers, lakes and wetlands.

Managing invasive plants in riparian areas can be a challenge both because permissible herbicide use is limited and because access to these areas is usually difficult.

Invasive plants in riparian areas cause the following problems:

- can reduce forage quality and quantity for wildlife
- displace native species, reducing biodiversity
- often have shallower root systems than native plants and can cause instability of banks, increasing erosion
- spread downstream with water flows to infest new areas

Species to watch out for

Common invasive plants found in riparian areas in Alberta, listed in the Alberta *Weed Control Act*, are as follows:

- Canada thistle *(Cirsium arvense)*
- perennial sow-thistle *(Sonchus arvensis)*
- tall buttercup *(Ranunculus acris)*
- ox-eye daisy *(Leucanthemum vulgare)*
- scentless chamomile *(Tripleurospermum inodorum)*
- common tansy *(Tanacetum vulgare)*
- yellow toadflax *(Linaria vulgaris)*
- leafy spurge *(Euphorbia esula)*
- knapweeds (*Centaurea* species)
- hound's-tongue *(Cynoglossum officinale)*
- burdock (*Arctium* species)
- Himalayan balsam (*Impatiens glandulifera*)

All these species are easily spread with water and soil movement in riparian areas.

Salt cedar (*Tamarix* species) is a serious tree invader in the United States and has been found in Alberta urban settings as ornamental plantings. Salt cedars pose a serious threat to riparian areas if they are allowed to escape, either intentionally or accidentally. As a high consumer of water, salt cedar can drastically deplete water tables. The cedar then accumulates salt in its leaves, which fall in the autumn, decimating native vegetation.

Growing Forward 2
A federal-provincial-territorial initiative
Alberta Government
Canada

Canadian Aquatic biomonitoring network (CABIN) Field Manual

Pages 6 and 7

Introduction

The Canadian Aquatic Biomonitoring Network (CABIN) is the national biomonitoring program developed by Environment Canada that provides a standardized sampling protocol and a recommended assessment approach, called the Reference Condition Approach (RCA), for assessing aquatic ecosystem condition. CABIN provides the tools necessary to conduct consistent, comparable, and scientifically credible biological assessments of streams.

This manual describes the nationally standardized CABIN field protocol for the collection of benthic macroinvertebrate samples and associated stream information in wadeable streams and littoral zones of large rivers.

This manual provides information on:

- when to sample
- the importance of safety first
- how to collect required non-field data before sampling
- how to collect a CABIN benthic macroinvertebrate sample and related water quality and habitat data in the field
- what equipment is required to sample macroinvertebrates and water quality and collect habitat data

Biological monitoring – Why Sample Benthic Macroinvertebrates?

Traditionally, water quality monitoring has focused primarily on the collection of chemical and physical measures and resulting water quality assessments are made by comparing measured results to previously determined water quality guidelines. Such guidelines are established based on the use-related level of protection required and include the widely used Canadian Water Quality Guidelines for the Protection of Aquatic Life (Canadian Council of Ministers of the Environment, http://ceqg-rcqe.ccme.ca/). Monitoring using these measures provides a 'snap-shot' of the status of water quality.

Recent approaches to river health assessment recognize the importance of examining physical, chemical and biological interactions. The addition of a biological component to a suite of monitoring activities can complement the traditional approach by providing the effect measurement to the assessment (that is, the effect of a stressor on the biota). The measurement of biological effect may detect impacts on the aquatic ecosystem that cannot be measured with traditional physical-chemical monitoring such as changes in water quantity, presence of invasive species, and habitat degradation. Aquatic biomonitoring can indicate preceding river conditions for weeks or months prior to collection. For example, an episodic pollution event, such as a chemical spill, may go undetected by periodic water sampling regimes but damage to aquatic biota can be detected long after the cause of the impact has passed.

Benthic macroinvertebrates are used in aquatic biomonitoring for several reasons. They are common inhabitants of lakes and streams and are important in moving energy through food webs. The term "benthic" means "bottom-living", organisms that usually inhabit bottom substrates for at least part of their life cycle. The CABIN wadeable stream protocol only collects benthic macroinvertebrates. The term ‘macro’ refers to the size of the organism, in this instance organisms retained by mesh sizes of 200 – 500 µm, while ‘invertebrates’ are organisms with no backbone.

Aquatic insects are the most diverse group of freshwater benthic macroinvertebrates; they account for almost 70% of known species of major groups of aquatic macroinvertebrates in North America. The remaining 30% are non-insects such as worms, nematodes, and mites. More than 4,000 species of aquatic insects and water mites have been reported in Canada alone. The diversity of benthic macroinvertebrates makes them excellent candidates for studies of changes in biodiversity.

Benthic macroinvertebrates are the most commonly used biological indicators for freshwater resources because they are:

- Sedentary = stay in one place and therefore integrate site-specific impacts
- Ubiquitous and generally abundant = can be easily collected everywhere
- Long-lived (1-3 years) = reflect cumulative impacts
- Diverse = respond to a wide range of stressors
- Key part of the food web = ecologically important

Vital Signs: The Five Basic Water Quality Parameters

The five following parameters are basic to life within aquatic systems. Impairments of these can be observed as impacts to the flora and or fauna with a given waterbody.

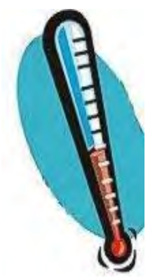
Dissolved Oxygen

It is the amount of oxygen dissolved in water. Most aquatic organisms need oxygen to survive and grow.

- Some species require high DO such as trout and stoneflies.
- Other species, like catfish, worms and dragonflies, do not require high DO.

If there is not enough oxygen in the water, the following may happen:

- Death of adults and juveniles
- Reduction in growth
- Failure of eggs/larvae to survive
- Change of species present in a given waterbody.



Temperature

Temperature is a measure of the average energy (kinetic) of water molecules. It is measured on a linear scale of degrees Celsius or degrees Fahrenheit.

It is one of the most important water quality parameters. Temperature affects water chemistry and the functions of aquatic organisms. It influences the:

- amount of oxygen that can be dissolved in water,
- rate of photosynthesis by algae and other aquatic plants,
- metabolic rates of organisms,
- sensitivity of organisms to toxic wastes, parasites and diseases, and timing of reproduction, migration, and aestivation of aquatic organisms.

Electrical Conductivity/Salinity

Solids can be found in nature in a dissolved form. Salts that dissolve in water break into positively and negatively charged ions. Conductivity is the ability of water to conduct an electrical current, and the dissolved ions are the conductors. The major positively charged ions are sodium, (Na^+) calcium (Ca^{+2}), potassium (K^+) and magnesium (Mg^{+2}). The major negatively charged ions are chloride (Cl^-), sulfate (SO_4^{-2}), carbonate (CO_3^{-2}), and bicarbonate (HCO_3^-). Nitrates (NO_3^{-2}) and phosphates (PO_4^{-3}) are minor contributors to conductivity, although they are very important biologically.

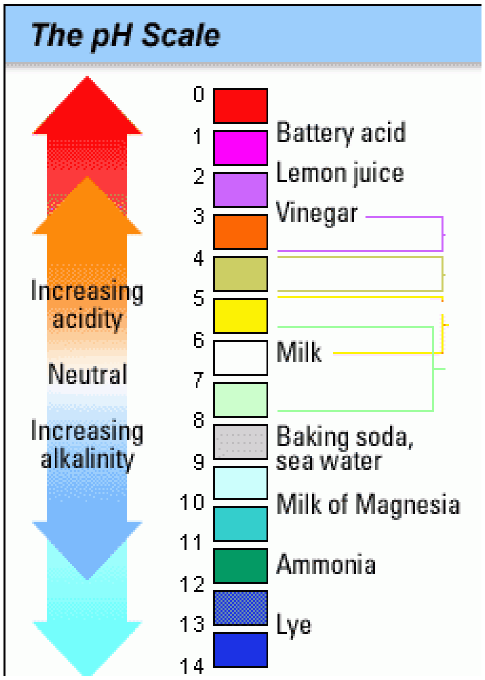
Salinity is a measure of the amount of salts in the water. Because dissolved ions increase salinity as well as conductivity, the two measures are related. The salts in sea water are primarily sodium chloride (NaCl). However, other saline waters, such as Mono Lake, owe their high salinity to a combination of dissolved ions including sodium, chloride, carbonate and sulfate.

Salts and other substances affect the quality of water used for irrigation or drinking. They also have a critical influence on aquatic biota, and every kind of organism has a typical salinity range that it can tolerate. Moreover, the ionic composition of the water can be critical. For example, cladocerans (water fleas) are far more sensitive to potassium chloride than sodium chloride at the same concentration.

Conductivity will vary with water source: ground water, water drained from agricultural fields, municipal waste water, rainfall. Therefore, conductivity can indicate groundwater seepage or a sewage leak.

pH

pH is a measure of how acidic or basic (alkaline) the water is (the term pH comes from the French: "puissance d'Hydrogène" which means strength of the hydrogen). It is defined as the negative log of the hydrogen ion concentration.



The pH scale is logarithmic and goes from 0 to 14. For each whole number increase (i.e. 1 to 2) the hydrogen ion concentration decreases ten fold and the water becomes less acidic.

As the pH decreases, water becomes more acidic. As water becomes more basic, the pH increases

- Many chemical reactions inside aquatic organisms (cellular metabolism) that are necessary for survival and growth of organisms require a narrow pH range.
- At the extreme ends of the pH scale, (2 or 13) physical damage to gills, exoskeleton, fins, occurs.
- Changes in pH may alter the concentrations of other substances in water to a more toxic form. Examples: a decrease in pH (below 6) may increase the amount of mercury soluble in water. An increase in pH (above 8.5) enhances the conversion of nontoxic ammonia (ammonium ion) to a toxic form of ammonia (un-ionized ammonia).

Turbidity

Turbidity is a measure of the amount of suspended particles in the water. Algae, suspended sediment, and organic matter particles can cloud the water making it more turbid.

Suspended particles diffuse sunlight and absorb heat. This can increase temperature and reduce light available for algal photosynthesis. If the turbidity is caused by suspended sediment, it can be an indicator of erosion, either natural or man-made. Suspended sediments can clog the gills of fish. Once the sediment settles, it can foul gravel beds and smother fish eggs and benthic insects. The sediment can also carry pathogens, pollutants and nutrients.

Other Constituents of Concern

Nitrogen (NO3-N)

Nitrogen is a nutrient that occurs naturally in both fresh and salt water. It is essential for plant growth in an aquatic ecosystem. Problems occur when large amounts nitrogen are introduced into the stream ecosystem. As a result, there can be excessive algal growth depleting the available oxygen in the stream that fish and other aquatic organisms depend upon.

Total Coliform

Total coliform bacteria, fecal coliform bacteria, and E. coli are all considered indicators of water contaminated with fecal matter. Contaminated water may contain other pathogens (micro-organisms that cause illness) that are more difficult to test for. Therefore these indicator bacteria are useful in giving us a measure of contamination levels.

E-Coli

E. coli is a bacterial species found in the fecal matter of warm blooded animals (humans, other mammals, and birds). Total coliform bacteria are an entire group of bacteria species that are generally similar to and include the species E. coli. There are certain forms of coliform bacteria that do not live in fecal matter but instead live in soils. Fecal coliform bacteria are coliform bacteria that do live in fecal matter, including, but not limited to, the species E. coli. Most of the fecal coliform cells found in fecal matter are E. coli. Therefore, all E. coli belong to the fecal coliform group, and all fecal coliform belong to the total coliform group.

Why is calibration of water quality testing equipment so important?

The calibration of water quality testing equipment is as important as the tuning of a musical instrument.

When people find out I'm a chemist, the first thing they ask me is, "Are you Walter White?" (This shows you the kind of people I typically run into). The second thing they ask me is, "Why is calibration so important?"

Simply stated, calibration is how we adjust water monitoring equipment that has started to drift a little. A drift in instrument response over time is inevitable. Small physical changes to the glass surface on a pH sensor, for example, will change the response and result in an inaccurate pH reading. A calibration will offset those changes in your water quality testing equipment.

Calibration is important; we all get that. Effective calibration is vital for getting accurate data. What I mean by effective calibration is this: an instrument should be calibrated with standards that bracket the expected results as closely as possible. For instance, suppose the water I am analyzing has a pH of 5.59. I will get better results if I calibrate a pH sensor using pH 4 and pH 7 standards than if I calibrate the same sensor using pH 2 and pH 10 standards. I would get even better results if I chose pH 5 and pH 6 standards. Of course, in order to accurately bracket expected results, I have to know something about the water beforehand. Initially selecting a broad range of calibration standards can be useful for determining the "ballpark" values of the water. I could then re-calibrate the instrument with a pair of standards that would be a tighter fit. If the water is expected to have a range of values throughout a sampling period, I would adjust the calibration standards accordingly.

When calibrating water quality testing equipment with a single calibration standard, it is imperative to use a standard close in value to that of the water. The farther from the value the standard is, the lower the quality of the data the instrument will provide. What determines how inaccurate the results are is a characteristic called linearity. When a scientist talks about linearity, he/she is referring to an instrument's response as the concentration changes. Linearity is rarely meant to be an absolute: rather, it is a degree. An instrument can have a high degree of linearity for an analyte, say, chloride, over a particular range. For example, I have an instrument that has very linear behavior between 0 and 250 milligrams of chloride per liter (mg/L) and the water I am sampling just happens to have a concentration around 150 mg/L (these are the joys of living in a hypothetical world). If I calibrate the instrument using 100 mg/L and 200 mg/L, I can feel quite confident of the results.

But not all water monitoring equipment nor analytes have linear behavior, and no instrument is linear over all ranges. Usually there are slight variations from linearity – and these are the problem areas that make effective calibrations so important. If an instrument doesn't exhibit a linear behavior over a range, the selection of two calibration standards closely bracketing the expected value will usually negate the inaccuracies created by non-linearity.

Best practices for collecting water samples

The importance of following the right steps when gathering samples.

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In order to get the most accurate results, samples need to be collected properly. While every lab may have their own set of sampling standard operating procedures (SOP), there are some common best practices for collecting samples. This article will go over some basics when collecting samples, like bottle type, preservation techniques, holding times, sampling techniques, sampling points and documentation. Before getting into sample collection and field practices, determine if samples need to meet regulatory requirement. If samples are to meet regulatory requirement, the method to be used may be dictated by the regulation. It's important to get a good idea of the scope of the project, including sampling location/conditions and what methods will be used, because this will usually dictate how many bottles will need to be filled and what time constraints you are dealing with.

Sample collection bottles and materials

Before collecting samples, make sure you have all the proper bottles, field equipment and preservatives, such as ice. There is nothing worse than being unprepared in the field, so plan ahead as much as possible. It's best to obtain sampling bottles from the lab running the analysis, as some bottle sizes and preservatives used can differ slightly.

The methods that will be followed will determine the type of bottles used. For example, samples for metals' analyses are usually collected in plastic bottles, while analyses for volatile organics and pesticides are collected in glass containers. Bottles used to collect samples for bacteria should be sterilized. The size of the container is important to ensure you have enough sample to run the analysis needed. Container size may also be affected by regulation, as larger samples may be needed to obtain lower detection levels.

Certain analysis like volatile organics and radon require vials that are to be filled leaving no head space, which keeps these analytes dissolved in the water, preventing them from escaping into the air. Additionally, some analyses require samples to be collected in amber colored bottles. These darker bottles are for analytes that break-down in sunlight, which helps keep these contaminants from breaking down while in transit to the laboratory for analysis.

Preservatives and holding times

Depending on the analysis, there may be chemical preservation. A common preservative used is sodium thiosulfate, a dechlorinating agent, used to stop any chlorine reactions. Sodium thiosulfate is used for bacteria analysis and volatile organics. Many laboratories will provide pre-preserved bottles wherever possible, but some analysis requires preservation in the field. Volatile organics should be further preserved in the field using hydrochloric acid, which is used to reduce any microbial activity that could reduce the contaminants while in transit to the lab.

The most common type of preservation is temperature; most analysis requires samples to be kept cool, arriving at the lab between four and six degrees Celsius. The cooler temperature helps contaminants from breaking down during transit. Holding time is another important consideration — this refers to the amount of time from collection to when the analysis begins. Regulatory samples need to meet these holding times and recognized holding times may vary from state-to-state. For example, most states will recognize coliform bacteria testing as a 30 hour holding time, while some states require a stricter six hours. Keep in mind holding times when planning what time samples should be collected.

When shipping samples, you will want to collect your samples later in the afternoon and ship them the same day via overnight delivery to allow for samples to arrive at the laboratory in time and within temperature requirements. Temperature control can be tricky, especially when sampling in the heat of summer. In the summer, it becomes critical to sample as late as possible and have samples delivered as early as practical to minimize transit time. You will need to pack the samples in ice, and you may want to consider using a combination of wet ice and gel packs. Sometimes this may not be enough, especially if sampling in heat that is over 90° F. If sampling in extreme heat, you can cool samples in an ice bath before shipping, while figuring in an hour or two to adequately chill them before shipping.

Sampling techniques

When collecting samples, you will need a representative sample and, while sampling well water, you should run the water for several minutes so that you are getting water directly from the well and not from a source that has been sitting in a storage tank or pipes. Before running water, remove any aerator from the spigot. A good way to determine if you have run the water enough is to use onsite measurements like pH, temperature and conductivity. Take measurements every two to three minutes, and once you get three consistent measurements in a row, you are ready to collect samples.

Once you have allowed sufficient water to flow, you are ready to collect samples. You should conduct this process in order, starting with samples for any field parameters and then moving on to any light gases, such as volatile organics or methane, ethane and propane. Next you collect any samples that do not require filtration or preservatives like metals, some inorganics and semi-volatile organics. When testing for dissolved metals, you will need to field filter samples, and these varieties should be collected next. Finally, you should gather bacteria samples. Before sampling bacteria, turn the water off and disinfect spigot.

Bacteria

There are a variety of ways to disinfect a sampling point; the easiest and most effective way is to use an alcohol swab. If the spigot is metal, you can use a flame; however, you should not use a flame, if you suspect methane. You should not collect a bacteria sample from a gooseneck faucet as these are difficult to fully disinfect and you may not get a representative sample.

When collecting the bacteria sample, consider wearing gloves to minimize potential contamination. You should also use a sterilized, sealed pre-preserved bottle — do not use if the seal has been broken.

The best practice when gathering the sample is to hold the cap while filling the bottle. You do not want to set the cap down or touch the inside of the cap or bottle as you could potentially contaminate the sample.

Sampling toolkit

If you sample on a regular basis, put together a sampling kit. A good sample kit would include supplies and equipment to run any onsite analysis, such as meters to measure pH, temperature and conductivity as well as standard solutions to properly calibrate equipment. Carrying tools, including a wrench for removing difficult aerators, screwdrivers and a flashlight, can be helpful in some situations. Supplies, such as gloves and alcohol swabs, can also be stored with your other sampling equipment.

Sampling points

Where you collect the samples will depend on the objective of the analysis. For instance, if you are collecting a sample to establish a baseline of water quality for a private well, you should gather the sample prior to any treatment devices. It’s important to inspect for treatment equipment because many homeowners will not recognize a sediment filter as water treatment. In most cases, collecting a sample from the kitchen sink is recommended, unless there is a specific water quality issue being experienced at a different tap, like a bathroom sink. To determine if treatment equipment is functioning, you may need to collect "before" and "after" examples to get the best idea of how the equipment is operating. To meet a particular regulation, where you obtained the sample is usually specified.

Documentation

Documenting when you are collecting samples is critical to record information such as the date and time collected so the laboratory can determine if samples are being run within proper holding times. It’s a good idea to include identification, whether noting an address or a more specific location like the kitchen sink. Having the sample identification on your reports will be helpful when comparing results from year to year. When submitting samples to a lab, a chain of custody form will need to accompany the sample to indicate what analysis needs to be run, the date and time collected, sample identification and who assembled the sample. In addition to filling out a chain of custody, it’s a good idea for samplers to keep a field notebook. In the field notebook, you can record any onsite analysis you run, observations concerning water quality such as odor or discoloration, weather conditions, the sampling site and anything else that may be important to note.

Every sampling project is different. You should secure as many details upfront to prepare as much as possible in advance. Working with a good laboratory is crucial because it will provide you with the bottles and preservatives as well as with guidance on proper sampling techniques. A reputable lab can also advise you on the best sampling points depending on the objective of the testing. For the most part, collecting samples is easy. You just need to take the time to think the details through.

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