GREEN ZONE

GAMING FOR THE

Beaver

Our Watershed Partner

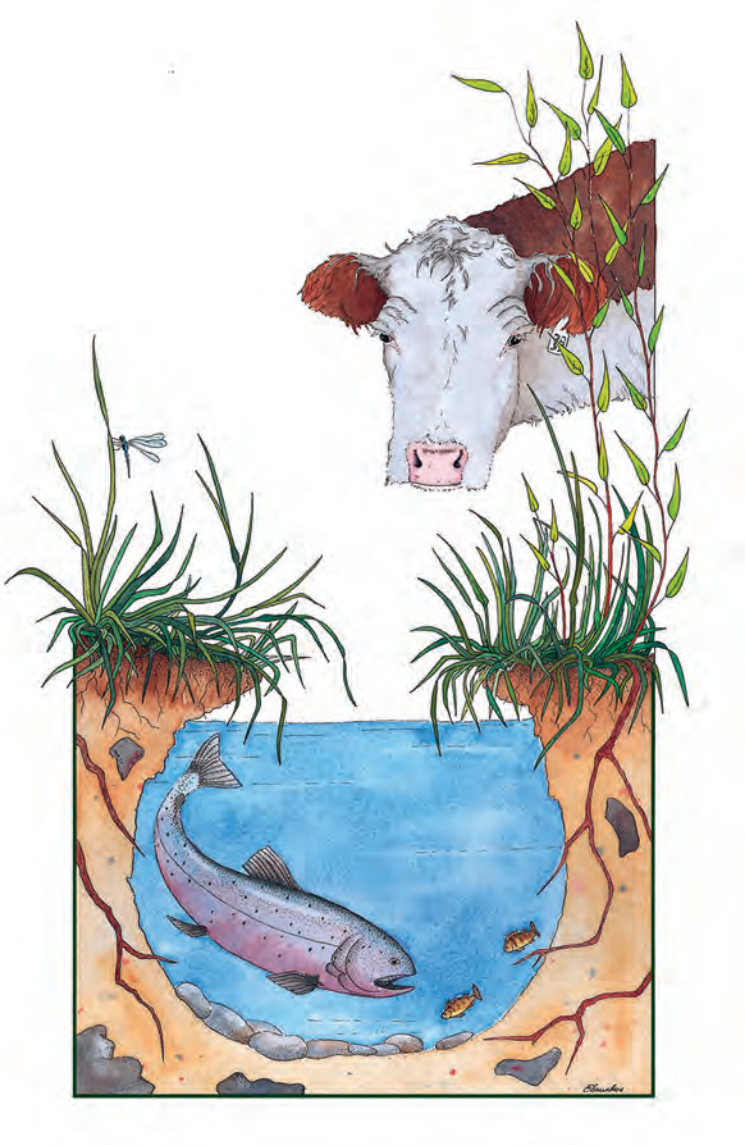
Beaver – Our Watershed Partner

Lorne Fitch, P. Biol., Provincial Riparian Specialist

What's in this Book?

In "*Beaver - Our Watershed Partner*" you will find:

- A short history of beaver in our landscape.
- Beaver biology and ecology.
- Beaver and their interaction with the watershed.
- The benefits of beaver.
- Beaver as a restoration tool.
- The challenges of living with beaver and some solutions.
- Beaver as a part of riparian and watershed management.



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Foreword

This booklet has been written for the people who can most effectively influence watersheds and riparian areas - ranchers, farmers, landowners, municipalities, conservation groups and industry. Riparian management initiatives in Alberta have dealt primarily with livestock grazing, agricultural cropping, recreational use and industrial concerns.

In this document are key insights on the role of beaver in riparian areas that all interests might find useful. Beaver have been building and modifying watersheds for thousands of years. These natural engineers and dam builders can be aggravating and helpful, costly and beneficial depending on one's perspective, interest and understanding.

The following includes information on: beaver biology and ecology; their role in watershed function and health; the interaction of beaver with vegetation, fish and wildlife and livestock; how beaver can help us adapt to climate change, especially flood and drought; beaver as a watershed restoration tool; and, thoughts on beaver management.

This information on beaver and riparian area management has been compiled by Cows and Fish - Alberta Riparian Habitat Management Society - a cooperative effort between many organizations and agencies concerned about the health and management of riparian areas and the watersheds within which riparian areas exist. Cows and Fish works to foster awareness about riparian areas, and how improvements in management can enhance landscape health, resilience and productivity, for the benefit of landowners and others who use and value these green zones.

Introduction

Beaver are a Canadian icon - every time we touch a nickel, there is a beaver. But, we hardly give them a thought, unless they cause us problems. Love them or hate them, we should at least pay homage to beaver.

It was the lure of beaver pelts, the “gold” skins, which led Europeans to consider North America, especially Canada, as being something more than rock, snow and black flies. The trade for beaver in the period 1534 to 1869 stimulated the exploration, mapping and settlement of most of northern North America, irreversibly changed the life of native peoples, contributed to the economic base of early governments, led to the formation of the continent’s first multi-national corporations and in a real sense laid the foundations for the development of Canada. Not bad for a 20 kg rodent.

Some call beaver “ecosystem engineers” while others use a variety of unflattering and sometimes unrepeatable names to describe them. No one seems to be neutral on the subject of this creature. What about beaver? Are they good, bad, or are they just being beaver, making a living on the land and changing the land in the pursuit of that living? As it turns out, beaver have neither horns nor halos.

If we want to understand them, recognize their role in our watersheds and figure out how to live with them, a good starting point would be to educate ourselves on their ecology, life history and the connections to watersheds. Then we might be better able to grasp the issues, challenges, the options and alternatives, and the future possibilities of living with beaver.

The beaver wears the Latin name Castor canadensis which links it to Canada, despite being found throughout most of North America. Throughout Canada there are at least 709 communities, lakes, rivers, harbors, gullies, bluffs and streams named “Beaver”. Close to 50 Alberta localities, lakes, streams, rivers and administrative entities are named for this Canadian symbol. If Canada is our home, beaver are our native rodent.

The beaver is quite a package: it swims like a fish, cuts like a chain saw, moves materials like a front-end loader, is the first water engineer and the first logger, and transforms landscapes like we humans do.

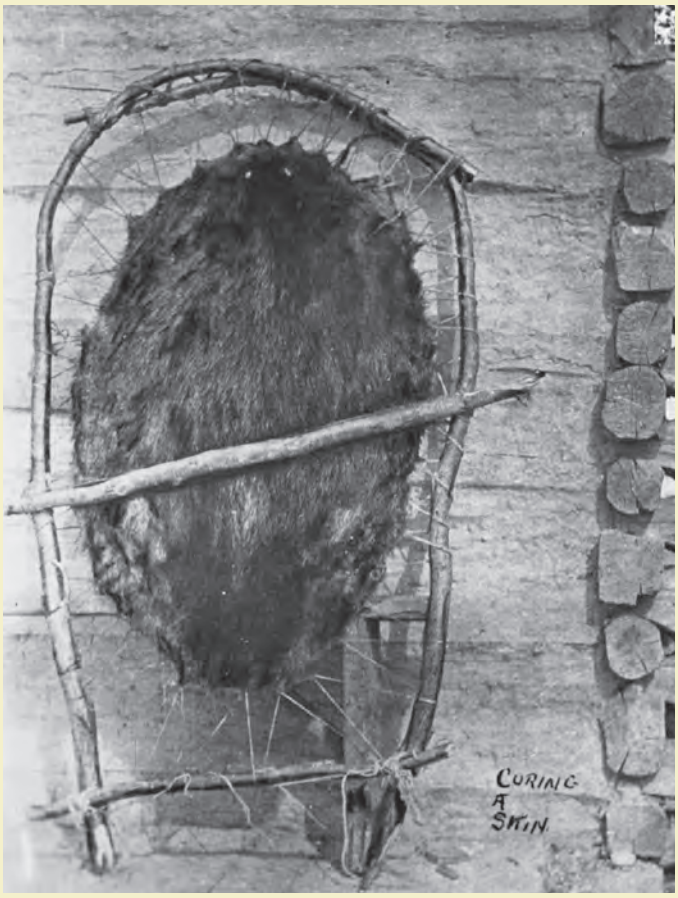
Beaver Through the Years

"Modern" beaver have been around for over a million years (mid-Pleistocene) and were active in damming melt water from the Laurentide and Cordilleran ice sheets over 15,000 years ago. They overlapped with prehistoric "Giant" beaver up to 10,000 years ago. These were about the size of black bears, up to 100 kg and with incisors up to 15 cm long. There is no evidence they were dam builders but based on their size they must have made trees tremble. Giant beaver, along with mammoths, mastodons and ice-age horses all disappeared from the landscape, leaving modern beaver as the largest North American rodent.

Fashion in the 1500s through the 1800s created a rage in Europe for beaver hats. Beaver fur was the prime ingredient in the manufacture of felt, the basis for a variety of apparel, but mostly the beaver hat, in various shapes and styles. With the virtual elimination of the European species of beaver, the search for pelts shifted to North America. It is notable that someone's fashion statement on the other side of the Atlantic would drive the exploration, transition and commerce of a continent for several centuries.

Eventually silk took over as the fashionable material for hat making and beaver could start breathing a sigh of relief.

In the first years of the continental fur trade the number of beaver trapped annually increased, to over 200,000 by the late 1790s. Beaver numbers then began to drop and beaver became scarce in many former trapping areas. Rivalry between the Hudson's Bay Company and



The evolution of the beaver hat.

the North West companies compounded the problem. Competition caused many areas to be trapped out.

Conservation measures were initiated by the Hudson's Bay Company in 1822, after the rival entities merged. Shortly after, steel traps, invented in 1825, increased trapping efficiency and harvest levels. But, some level of commercial harvest persisted until the end of the Bay's monopoly in 1869.

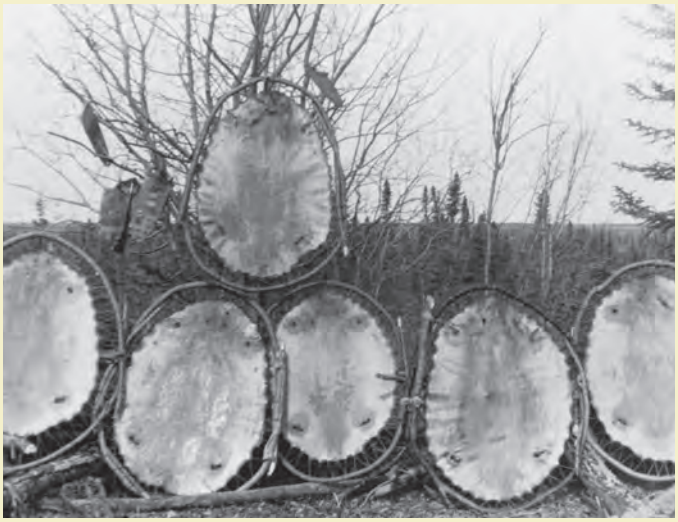
Harvests in the late 1800s were high and led to population declines. At local scales, beaver were extirpated in the rush for pelts. In some areas, especially the grasslands, beaver populations have never fully recovered. Beaver trapping in Alberta was closed in 1902 to help populations recover and the closure extended for many years afterwards.

Modest population recovery was replaced by scarcity in the 1930s, a function of severe drought and over-harvest in depressed economic times. This was the era of Grey Owl who promoted beaver and the idea of their reintroduction to landscapes where they had disappeared. From the 1930s to the 1950s extensive beaver reintroductions were undertaken across Canada; in Alberta the idea developed to move problem beaver to areas of low density. Several landowners brought in beaver to improve stream flow for livestock water supply.

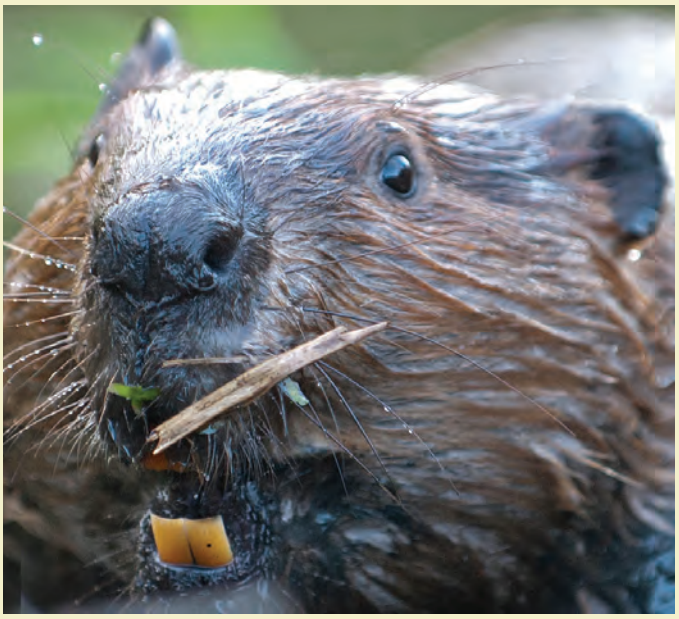
In the 1950s declining markets and prices for fur allowed populations to rebound again. In much of occupied Alberta, agricultural expansion shifted society's perspective on beaver to a "nuisance" status. Better regulations for trapping, low demand for fur and depressed predator populations have allowed beaver populations to increase, perhaps to 10-20% of historic levels.

We don't value beaver today so much for their fur; we appreciate them for their ability to store water, a commodity more precious and valuable.

Grey Owl (Archie Belaney) was one of the first to promote the reintroduction of beaver to landscapes from which they had disappeared.



Basic Beaver Biology



Beaver are semi-aquatic mammals, with one foot in water and the other on land. They are well adapted to this dual existence. Water is prevented from entering their noses underwater by specialized valves. Their fur is made water repellent with repeated applications of oil produced from glandular secretions. Beaver are expert at holding their breath, staying underwater for extended periods. The broad, flat tail is both rudder and propeller as well as a repository of body fat. The webbed hind feet are specialized for swimming.

A beaver colony is a family operation. At its hub is the adult female who is dominant and leads efforts to maintain the lodge, cache winter food and keep dams functional. The adults form a monogamous relationship that persists until one of the pair dies. Beaver breed in mid-winter and a litter, on average of four kits, is born in spring. The number of young born is related to food availability and the age of the female.

A typical colony contains an average of five individuals; the adult pair, kits of the year and kits of the previous year.

Prominent incisors (hence the handle "buck-toothed") are used to cut down trees and peel bark for eating. These teeth are harder on the front surface than on the back, ensuring wear creates a constant sharp edge to enable beaver to easily cut through wood, of which they do a lot. The teeth grow constantly throughout a beaver's life.

Two year-old beaver disperse to form new colonies, in the spring coincident with runoff and high water. Beaver may move 8 to 16 km to find suitable conditions to reestablish, although they have been known to move up to an epic 236 km.

Beaver can live up to 16 years in the wild but that is exceptional given high mortality rates. One out of every three beaver will not survive during dispersal. Predation, disease and trapping account for most mortality, although starvation, water level fluctuations and falling trees are ever present dangers. Young beaver, dispersing to find or make a new home, are subject to high risk.

Beaver cut wood, move wood, build with wood, store wood and eat the bark of wood. This distinguishes them from virtually every other species of wildlife.

Beaver mark their territory with scent derived from the castor glands. Up to 100 scent markers on mounds warn foreign, dispersing beaver the site is “taken”. Every colony is highly territorial, making colonies distinct and non-overlapping. The density of colonies is regulated by territories and those are limited by food.

The beaver is a herbivore that consumes cellulose and digests it with microbial action. Aspen and willow are the mainstays of the daily meal, but beaver will use a wide variety of tree and shrub species depending on availability. Beaver maximize the nutrient content of woody plants by eating the bark, twigs and leaves of woody species.

While woody species make up about half their diet annually, there is a substantial amount of non-woody plants used in the spring and summer. The shift to woody species begins in the fall and over the winter beaver are reliant on food caches of tree and shrub branches. The caches are submerged allowing beaver to access them under ice cover, reducing the risk of predation.

A Beaver's World

Beaver are best known for their dam-building talents, but they also inhabit lakes, wetlands and large rivers where dams are not part of their signature. What beaver look for in a desirable home is adequate water, especially water depth, and accessible foods such as aspen and willow.

The sight, but especially the sound of running water clicks a beaver's switch into dam-building mode. In streams the motive for dam building is to impound water to create a safe depth for the lodge, food caches and to access supplies of trees and shrubs. Water depths have to be sufficient to allow movement under ice cover to safely access food caches.

The sight and sound of running water clicks a beaver's switch into dam-building mode.

Beaver dams and the ponds upstream are variable in shape and size. Most dams are between 0.7 and 2.0 m in height, with an average length of 32 m. These pale in size beside the world's longest beaver dam, in Wood Buffalo National Park, that spans 850 m.

Beaver create dams with whatever material is handy - tree branches, logs, cattails, grass, rocks and mud. Anything that can be rolled, floated or dragged is used. Tree branches and logs anchor the structure while sediment from the stream bottom, upstream of the dam is used to glue the materials together. Excavating substrate materials also helps deepen the pond adjacent to the dam. Although the dams wouldn't win a beauty contest or meet standard engineering protocols, they effectively capture and store water, while also allowing leakage to maintain flows downstream.

Beaver create dams with a variety of materials - branches, logs, cattails, grass, rocks and mud.

There are city beaver and country beaver.

It isn't easy to categorize the structures beaver build but they might best be considered "wet" dams. Beaver dams act more like sieves than impermeable barriers. Water spills over the top, leaks through the main bulk of the dam and seeps underneath. There is an inescapable logic to this. A leaky dam doesn't have as much pressure built up against it from the weight of water held back. Beaver build in safety valves that relieve and reduce hydraulic pressure.

The welter of sticks and logs on the downstream face effectively dissipates the erosive energy of water spilling over and through the dam. Because of this design, the base of the structure does not become undercut by erosion and stability is maintained. Rather than falling vertically, water runs down and over a matrix of logs along the length of the dam, slowing to a trickle. There is a myriad of pathways for water to take, and rarely does it flow directly into the downstream channel.

Beaver houses – both lodges and bank dens – provide escape from predators, places to rest and eat, thermal cover for the winter and security for young beaver. The lodge is the beaver's castle, the pond is the moat.

There is often a succession of dams built, downstream, upstream and flanking the primary one that impounds water around the lodge. Secondary dams improve transport of woody materials, extend the safe swimming range of beaver and ensure better year-round water supply. On average, every beaver colony consists of three dams. Above the impounded water level, beaver excavate canals to transport food and dam-building materials with more ease and safety.

A system of complex and multiple dams represents several generations of beaver occupancy. There may not be continuous beaver use through time, but the site may be re-used many times. Radio-carbon dating of some beaver-chewed wood in California suggested a dam built in 580 was still in use, with repairs made, in 1730. The dam was finally abandoned in 1850 after 1200 years of periodic use.

Multiple dams, often in sequence, increase water supply, buffer floods and create complexity in the watershed.

Where do Beaver Like to Live?

SOLD

CASTOR ESTATES

Featuring:

- Adequate water supply
- Optimal stream gradient less than 3% (range from 0-15%)
- Large rivers, wetlands and lakes
- Valley width greater than 45 m
- Adequate woody vegetation (aspen, willow)

This stream valley meets all of the requirements for beaver occupancy.

Beaver are found in a variety of settings - along smaller streams, in larger rivers, and in wetlands and lakes. Not all beaver build dams, but all require an adequate water supply (and water depth) and woody vegetation, especially deciduous trees and shrubs such as aspen, cottonwoods and willow. On streams that they dam, a gradient of less than 3% is optimal. Beaver will dam streams with gradients up to 15%, but less successfully than ones with gentler slopes. Beaver prefer to build dams on streams with valley widths greater than 45 m. Those wider valleys have greater amounts of preferred woody vegetation and the wider floodplains allow dams to last longer in the face of flood events.

Beaver create their own habitat, but are still subject to fluctuations in water level. For beaver to prosper, annual water levels shouldn't fluctuate more than 1.5 m. Winter water levels are the most critical. Beaver need at least 0.7 m of water depth under ice cover to access food caches and avoid predation.

Beaver consume between 0.5 and 2.0 kg of bark/day/animal. To do so they cut down 0.6 to 1.0 aspen/day/animal both for food and dam construction/repair. A colony of 5 to 6 animals could support itself with 1.0 acre of aspen for up to 2.5 years.

Although woody species are prominent in a beaver's menu, their diet varies seasonally. Non-woody species include cattails, bulrushes, water lilies, pond weeds, duck weed, grass, forbs and sedges.

Woody plants constitute 32% of a beaver's diet in spring, 16% in summer, 60% in fall and 86% in winter.

Beaver prefer to use trees and shrubs within 30 m of water. They will forage up to 200 m from water but the risk of predation becomes greater than the benefit of food.

Beaver prefer to use trees within 30 m of water and smaller trees and shrubs (5-10 cm in diameter) are selected first. They utilize the branches and bark, but there is only about a 36% utilization of the wood cut - unsafe distance to water, tree trunks hanging up and trunks too large to drag limit the use of cut wood.

Woody species do regenerate after cutting. Regenerated aspen shoots develop bitter compounds causing beaver to shift to bigger trees with larger stem diameters. In aspen-dominated stands tree regrowth is sometimes not fast enough to sustain a beaver colony and, after the aspen are eliminated, the beaver move.

Cutting by beaver stimulates vigorous sprouting of willow and the amount of woody biomass increases. Beaver and willow are called "mutualists" because of this shared benefit. Willow can also tolerate higher water tables created from beaver dams. Where willow dominate the riparian area, beaver colonies are sustained for long periods of time.

Most woody plants regenerate after cutting by beaver.

Beaver Cycles

Where the habitat is suitable, beaver occupy the watershed; where there is habitat potential, beaver could expand their range.

The cycle of colony establishment, maturity and abandonment can be as short as 10 years or up to 30 years and even longer. The longer cycles are usually on low-gradient streams and in wetlands. Longevity of beaver colonies is highly variable based on beaver recruitment, dispersal and mortality rates, predation, availability of woody species other than aspen, seasonal changes in diet, weather conditions (floods, droughts), size of trees, distance to vegetation, and variable woody species regeneration rates.

Beaver continually test a variety of sites to see where dams and colonies might persist. Young beaver, trying to make a new home, occupy marginal habitat and their efforts are often unsuccessful.

Although beaver are generally believed to go through boom and bust cycles, some watersheds offer greater stability and colonies have persisted in the same location for over 30 years, and sometimes up to 200 years. The cyclic nature of beaver and their food was probably less pronounced before the development-caused habitat loss of the last century.

Many old beaver ponds go through a succession to meadows and eventually back to willow or aspen communities. The dams may be rebuilt or reused by future generations of beaver after woody species regenerate.

Factors that Determine the Ability of Beaver to Set up and Maintain a Colony:

Long-lasting ← Vulnerable → Short-term

Stream Slope	<1%	1-3%			>3%
Valley Form	Wide floodplain	Narrow floodplain			Confined channel
Channel Incision	Out-of-bank flood yearly	Occasional out-of-bank flood			Floods never go out-of-bank
Riparian/Floodplain Corridor	Continuous/wide	Partly continuous/wide			Discontinuous/narrow
Beaver in Watershed	Found throughout watershed with capability to move freely	Very few in watershed/evidence of past occupation			No evidence of past occupation
Vegetation	Landscape heavily forested with aspen/cottonwood/willow	Valley sparsely forested		Forest of mainly spruce/fir/pine	Predominantly grassland/cropland without significant woody vegetation
Hydrologic Regime	Spring-fed	Snowmelt	Rain	Rain on snow	Convective thunderstorms

A downstream dam may be abandoned, while a new dam is constructed upstream where food is closer to the lodge.

Woody species regenerate after beaver use and the cycle can continue.

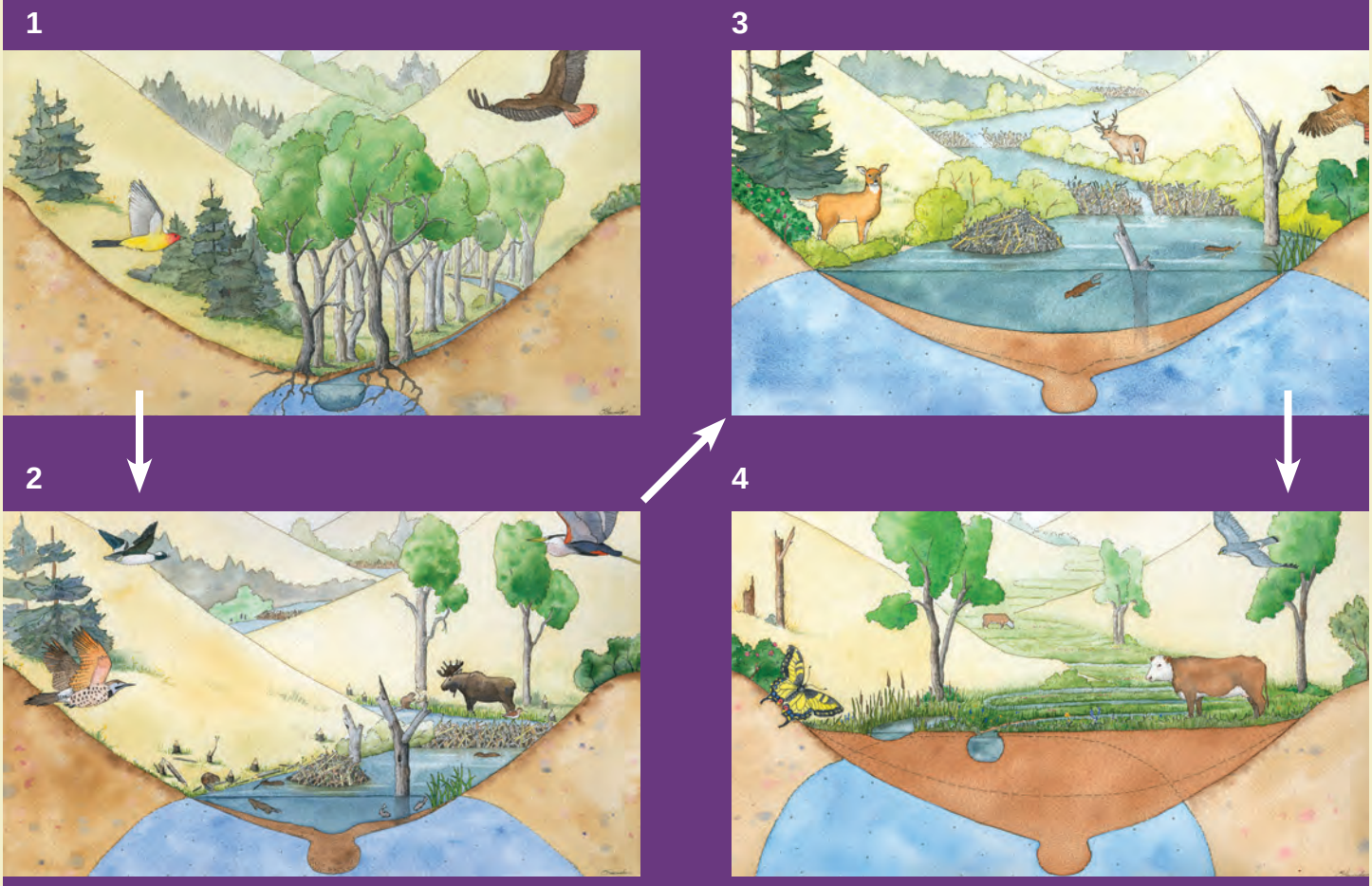
After abandonment, beaver ponds dry out and are colonized by vegetation.

Beaver and the Watershed

Building Riparian Foundations

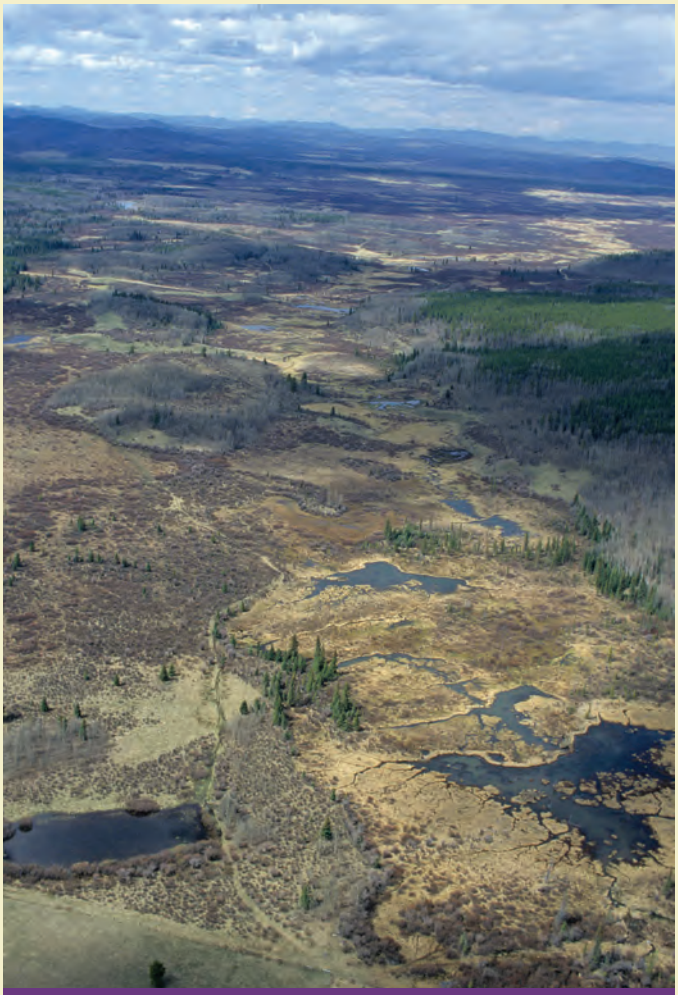
Beaver have been industriously building dams successively upstream from lower reaches for thousands of years. Over long periods of time, the sediment trapped by dams causes the elevation of the streambed to rise, widening the valley. A series of stair-stepped dams flattens out the gradient of the valley floor. Stream valleys that were once deep, "V" shaped and steep sloped have been transformed by beaver activity into wider, "U" shaped valleys with gentler gradients. The process and evolution of changing stream gradients, elevating stream channels, changing cross-sectional valley profiles and aiding riparian vegetation continues today. Beaver have transformed the landscape, even though it may not be evident. Conversely, losing beaver from a watershed may cause erosion to increase and streams to down-cut, reversing the process begun decades or centuries earlier.

The March of Time in a Beaver-occupied Stream Valley



Beaver modified valleys - over time, beaver activity changes a steep gradient (1) into a flatter, stair-stepped one (2) and widens the valley (3). Deep, rich soils from centuries of sediment capture, sub-irrigated with high water tables, create fertile valley bottoms (4).

Beaver create a mosaic of open meadow areas in the boreal forest.



Stream valleys and watersheds are transformed by beaver into a wider, flatter profile.

The effect of beaver on stream valleys and vegetation lingers long past abandonment. Old dams may become enduring landscape features.

Natural Filters

Erosion is a natural phenomenon, but as the footprint of land-use in a watershed increases, the sediment load in a stream may exceed natural levels by several orders of magnitude. The sources of sediment are numerous - roads, trails, forestry cutblocks, cultivated fields and urban runoff.

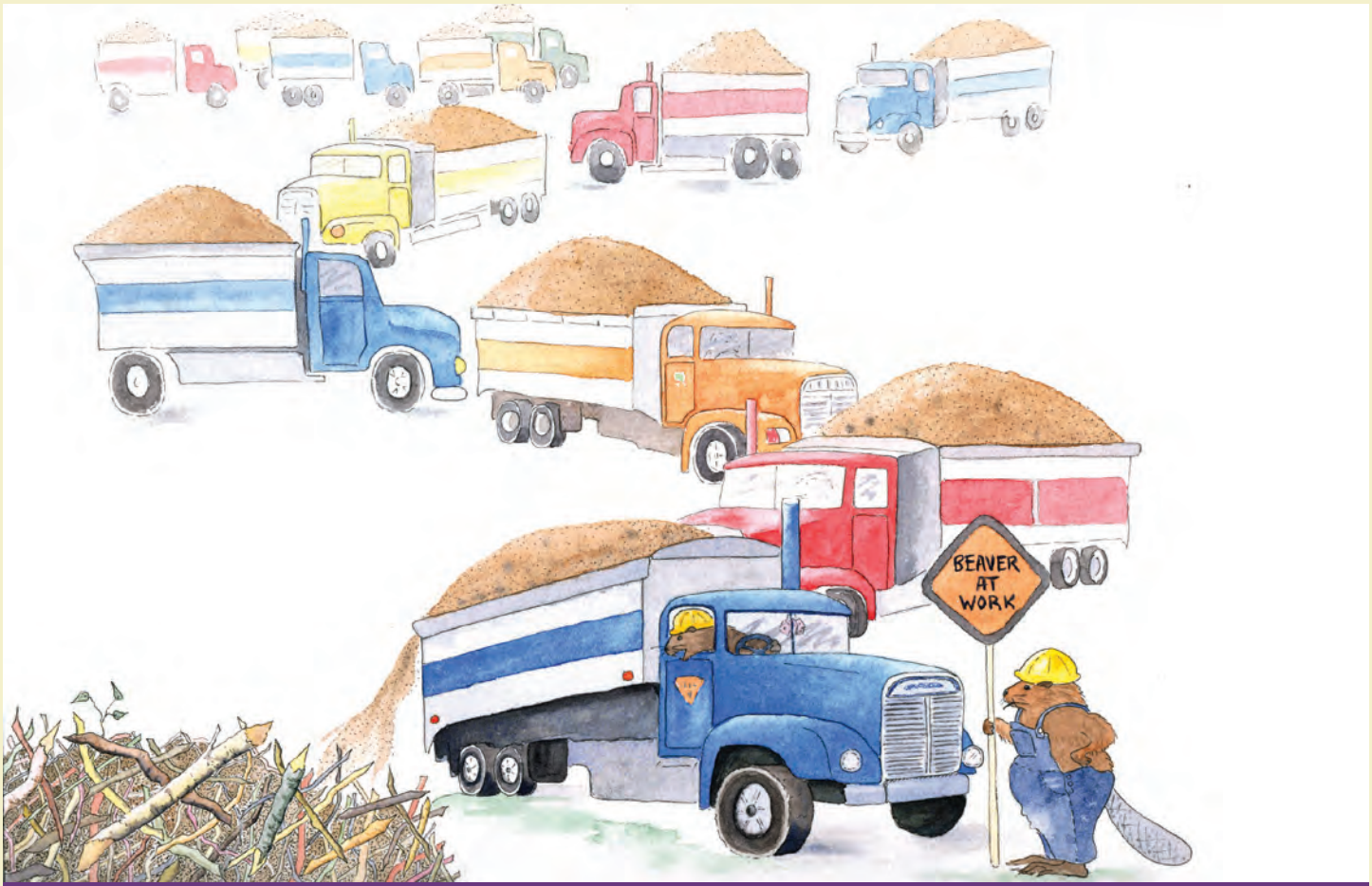
Beaver dams capture and store much of this sediment; the range is from 35 to 6500 m^3 per pond. At the upper end, 6500 m^3 represents 382 tandem dump truck loads of sediment stored behind each dam. Up to 90% of the finer sediment load in a stream can be captured in beaver ponds.

Old beaver ponds retain most of the sediment collected over time.

Many water quality contaminants (e.g. herbicides), nutrients (e.g. nitrogen, phosphorus), and pathogens (e.g. *E. coli*) attach and bond to sediment particles. Carbon is sequestered in beaver ponds. The capture of sediment in beaver ponds aids in the natural purification of water.

The longer water lingers in ponds, the greater the removal rate of nutrients and contaminants. Beaver dams increase water residence times often by a week or more. Streams with beaver ponds have 10 times greater purification capability than streams without beaver.

Even when beaver colonies are abandoned and dams are breached, most of the sediment stays in the riparian area. Fresh sediment is rapidly colonized by vegetation, which, over time, captures even more sediment. Some sediment is lost when the stream down-cuts into the old pond, but old beaver dams still slow water velocity and allow sediment to settle out, before it can move downstream. Slowing water down also reduces stream bank erosion, another source of sediment.



A large beaver pond can store up to 382 tandem dump truck loads of sediment.

Downstream of a beaver pond, we **find:**

- 50-75% fewer suspended solids
- 20-60% less phosphorus
- 5-45% less nitrogen
- Up to 23% less carbon
- Reduced fecal coliforms

Downstream of a pond the filtering effect is profound – each pond acts as a natural water treatment plant, capturing, treating and sequestering potential contaminants.

Beaver are not the sole vectors of the beaver fever parasite (Giardia) in the wild, nor are they as significant a reservoir as other mammals, including humans. One study indicated 13% of beaver carried the Giardia cyst compared to 95% of muskrats.

Water in the Bank

While it is true that beaver store water, it is the extent to which they store water that is the story.

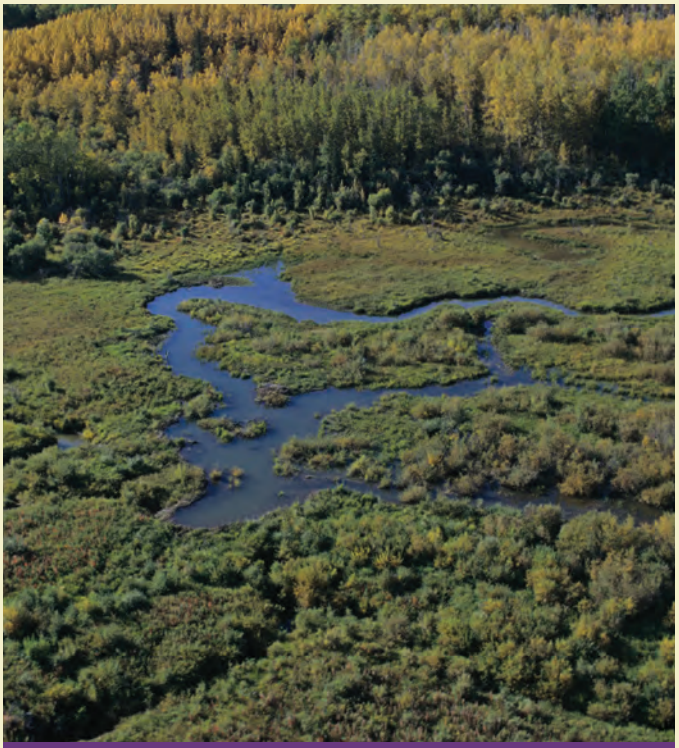
Beaver can increase the amount of open water in a landscape by 9%. Beaver dams increase the wetted width of streams up to 30%. The wetted perimeter of wetlands increases by an average of 575%.

Where there is beaver activity, a substantial amount of the water in a watershed is temporarily stored in dams. Beaver can excavate canals that are hundreds of meters long and sometimes over a meter deep. This substantially increases the volume of water stored in a pond. Beaver ponds retain water 50% longer than stream sections with no beaver activity.

Beaver activity substantially increases the size of wetlands.

Canals excavated by beaver substantially increase the water storage of a pond.

A beaver pond increases the water we can see on the surface; what is stored beneath the pond and surrounding area is another story. Shallow ground water storage is defined by the capacity of subsurface materials to hold water. The quantity stored lies roughly between a volume equivalent to surface storage to orders of magnitude higher. Some speculate it is 3-10 times the amount of surface storage. The conditions that determine shallow storage are complex, variable and not well understood throughout Alberta watersheds.



Beaver workings lift the water table, giving many plants a productive boost. A single beaver pond with an area of 40 x 50 m could potentially influence ground water storage over an area 1.0 km², or larger.

Beaver activity raises the ground water table and maintains it at higher levels, even in dry periods. This allows streams and wetlands to connect hydrologically with more of their valleys and basins. Perennially dry sites are transformed to moist riparian areas with greater productivity.

Beaver ponds both store and deliver water. By slowing water down and allowing shallow ground water capture, downstream flows can be enhanced by 2-10 times. Beaver activity has been shown to change intermittent streams to ones that flow year round. Most importantly, through ground water release, water is delivered in low flow periods when fish and downstream users need it most.

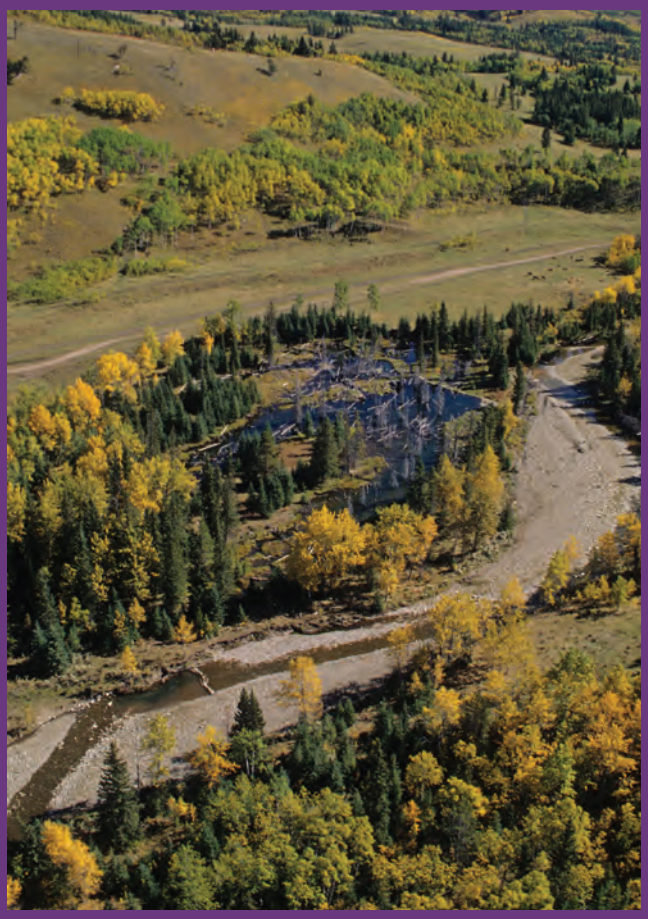
Calculating the Effects of Beaver in the Bow River Watershed

Upstream of the urban centres of Calgary and High River, in the Bow River watershed are found 1639 beaver ponds. Each beaver pond holds a little more than the volume of two Olympic-sized swimming pools. Collectively, these ponds currently store about 10 million m^3 of water, about half the volume stored in Glenmore Reservoir. Unlike a single large reservoir though, beaver dams are dispersed and are capable of capturing runoff from intense rainfalls, rain-on-snow events and snow melt, throughout the watershed.

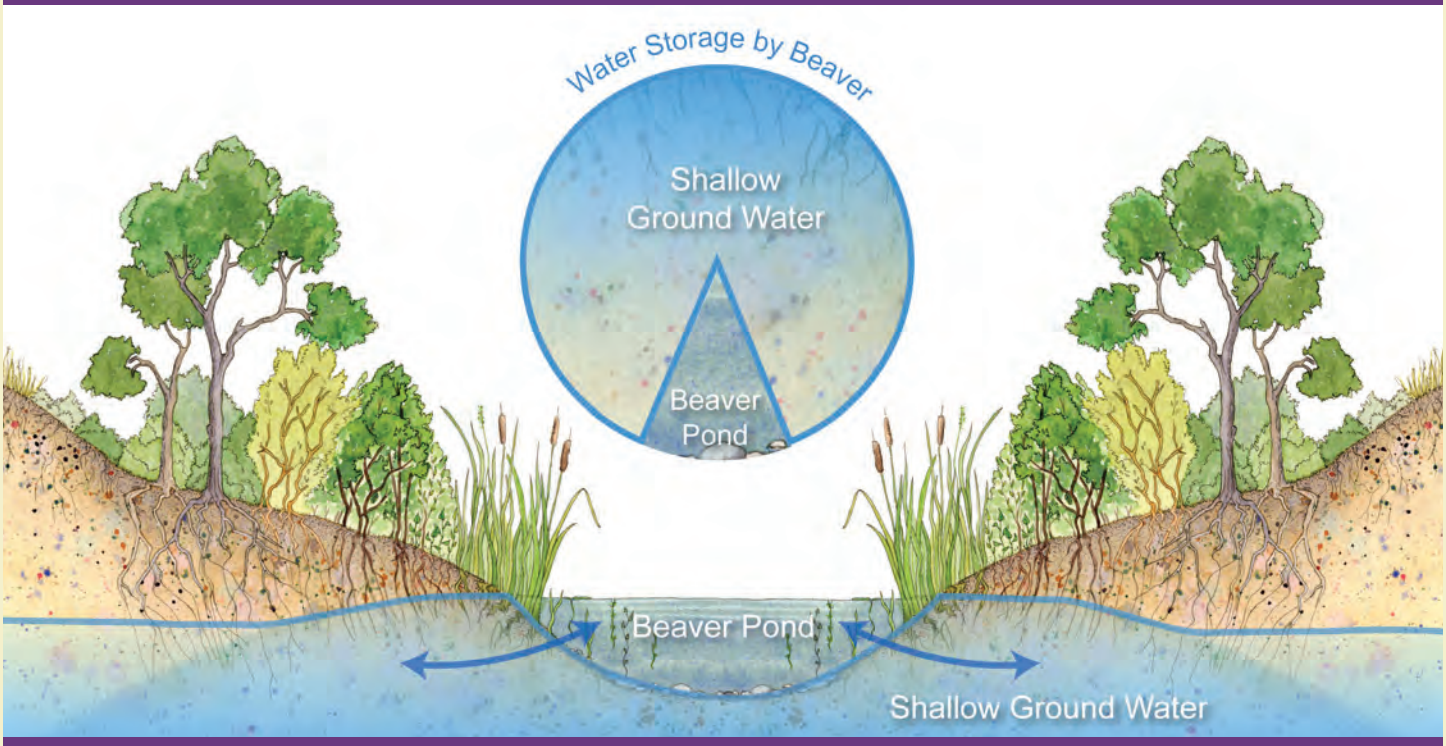
Through ground water storage beavers can play an important role in moderating the effects of droughts. Beaver dams store substantial amounts of invisible ground water and allow it to slowly return to bolster stream flows during low flow periods.

Not all smaller watersheds are at capacity for beaver; not all watersheds have equal potential for beaver; or, are hydrologically similar. But the potential of beaver for flood storage and drought mitigation is evident.

Beaver help keep streams flowing and wetlands wet. Beaver can help mitigate the effects of drought, especially the loss of wetland and riparian habitats. This is accomplished through a process of surface water retention behind dams, shallow ground water storage and slow release that contributes to enhancing downstream flows.



On larger streams and rivers where dams are not feasible, adjacent beaver ponds collect and store flood water for later release.



The water we can't see moves and is stored beneath the channel and pond as well as laterally, adjacent to the pond and, upstream and downstream of the beaver pond.

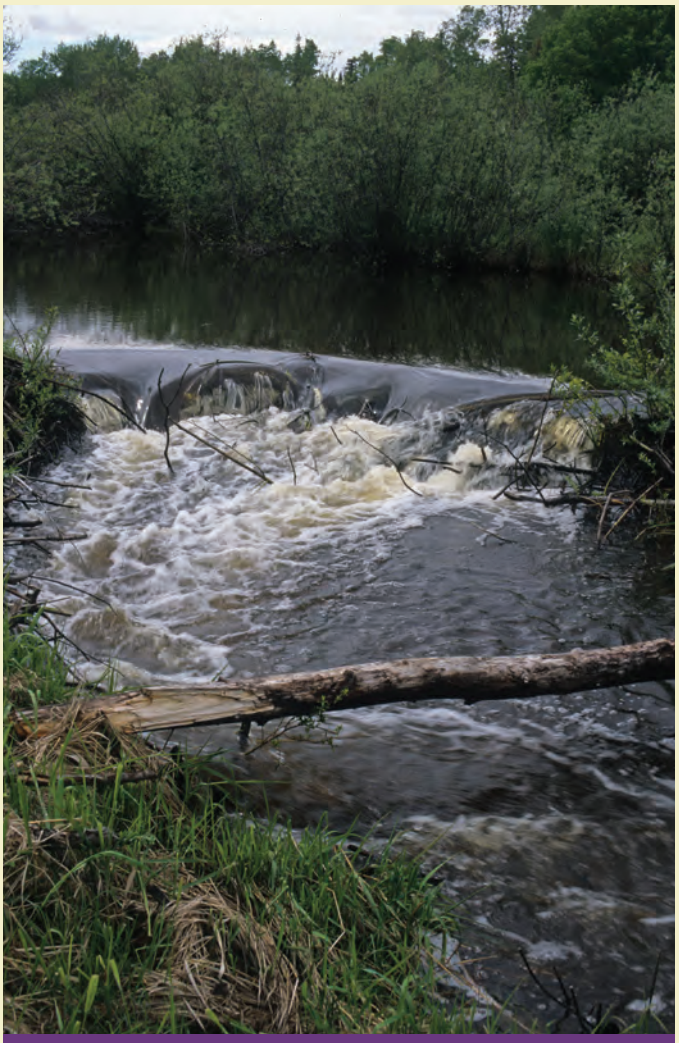
Speed Bumps

Beaver ponds discourage a stream from speeding.

Dams reduce stream velocity and power. When velocity is doubled, the streams' ability to erode increases by four times and the ability to carry eroded material by 64 times. Slowing down a stream reduces erosion rates and the amount of sediment carried downstream.

Beaver dams and ponds capture and slow flood flows. A beaver pond increases the size of the effective floodplain up to 12 times. Wider floodplains are better able to slow down speeding water, spread it out and allow temporary storage. A single beaver dam can extend the width of a floodplain to accommodate a much larger flood.

Studies indicate that beaver ponds can store 7-22% of spring runoff. As the number of ponds increases, so does the ability to capture more of the flood flow.



Beaver ponds can decrease stream velocity by 82% and reduce stream power by 92%.

Beaver dams are Nature's speed bumps, discouraging streams from racing wildly and promoting a sedate pace.

The overall ability of beaver dams to slow flood waters is variable. It depends on how big the flood is, the size of the watershed above the ponds, the number and size of ponds along the way, and how full the ponds are before the flood occurs. In theory, a single pond can reduce peak flood flows by 5.3%. One study on a stream with a series of dams showed an attenuation of a flood peak by 94%. In another study, five ponds in series reduced peak flow by 14% for a small flood event and 4% for a moderate to large one.

The real virtue of beaver dams and ponds isn't just storage, but in slowing down the flood peak and the energy associated with it. Beaver "speed bumps" dampen velocity and discharge rates. This effect across the upper watershed could assist in emergency preparedness downstream, providing more time for flood planning, protection and evacuation of high risk residential areas.

Rivers are a sum of their tributaries and the watersheds within which those feeder streams flow. Floods are natural, recurring events, which may be influenced by climate change and our land-use footprint. At a watershed scale, in the tributaries to major rivers, beaver play a major role in slowing and storing some of the flood waters. This builds natural resilience into our watersheds, to deal with both floods and drought.

Beaver ponds are surcharged with flood water, adding to storage, decreasing water velocity and detaining flood peaks.

The complexity of beaver modified valleys assists in moderating flood peak and energy.

Controlling the Thermostat

Beaver ponds stabilize water temperatures as the deeper water is less influenced by air temperatures than is the stream.

There is a lag between the time water enters the pond, is absorbed as ground water and its eventual release. The lag can be up to three months.

Water that eventually flows back into the stream from the ground is typically cooler than surface water - that benefits fish, especially trout and other sport fish species.

Beaver ponds help to cool down streams, creating better conditions for fish.

Beaver Ponds - Pulsing with Life

Beaver ponds create diverse and productive habitats for plants and animals, both big and small. Beaver are called a “keystone” species because they have a disproportionately large effect on landscapes, relative to their abundance. A few beaver can transform a watershed with their workings.

Beaver are also a “foundation” species, upon which other creatures depend. The presence of beaver and their workings allow a large suite of other plants and animals to exist. Without beaver and the role they play in modifying and maintaining the structure in watersheds, most of the biodiversity we associate with wetland habitats would disappear.

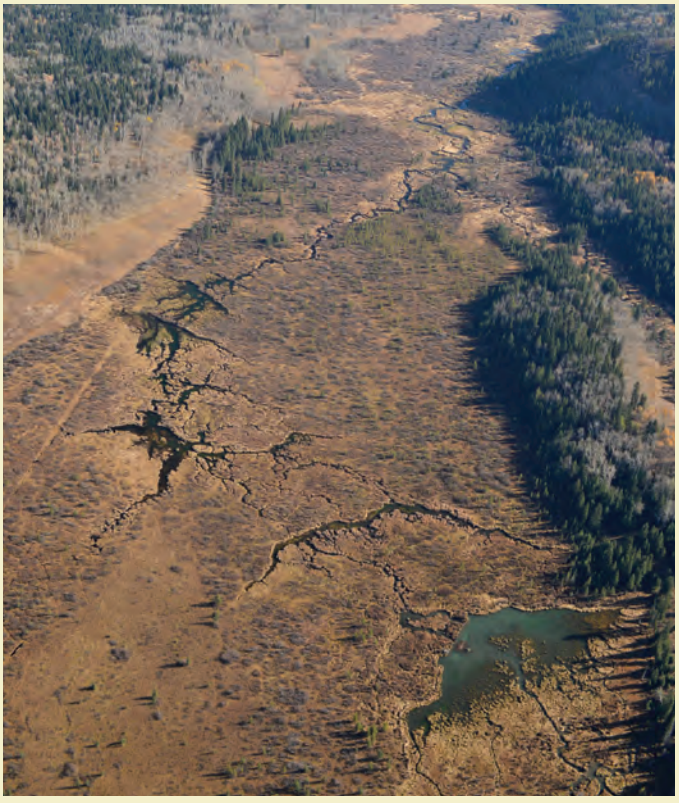
A variety of wetland wildlife species, such as red-winged blackbirds, benefit from beaver created habitats.

Beaver ponds create diverse and productive habitats for plants and animals, both big and small, not only in and adjacent to the ponds, but also downstream.

Vegetation

Beaver transform drier landscapes into wetter ones with the flooding created by their dams. Wetland habitats, with riparian and emergent vegetation become dominant where there used to be upland grasses, forbs and trees. This happens with a water table that rises with flooding and creates succession towards a wetland community. The size of the aquatic, or open, surface water area increases. Vegetation diversity increases, as does productivity in the area of higher ground water on the margins of the beaver pond.

The effects of beaver persist, even after they are gone from the area. When dams wash out, or are abandoned, the exposed sediment accumulation in the pond is colonized forming a grassy “beaver meadow”. These meadows may persist in the watershed for long periods of time and provide variety and diversity in the landscape.



Bugs and Beaver

When beaver modify streams, rivers, lakes and wetlands the result is more organic material (e.g. cut wood, flooded plants), sediment with nutrients attached and more water surface area for photosynthesis to occur. This boosts primary productivity and that results in more aquatic insect biodiversity and biomass.

Damselfly

Fish

In stream systems the pools and ponds built by beaver create a variety of important and key habitats for fish. Beaver ponds add depth to shallow streams, important for refuges during low flows and successful overwintering of fish populations. Slower flows, greater edge effect and more overhead cover enhance and diversify fish habitat. Food (aquatic invertebrates) is more plentiful in beaver ponds.

Beaver are often blamed for fish population declines based on concerns over sediment accumulation, increased water temperatures and barriers to fish movement. While fish population declines are serious, they are more often associated with the cumulative impacts of land-use at a watershed scale than with local beaver activity.

Beaver dams trap sediment that would otherwise impact free-flowing stream sections. Beaver ponds moderate water temperatures, especially through the release of cool ground water downstream of dams. This cool water release has an underground lag time and provides critical flow during natural times of low flow when warm water temperatures can impact fish.

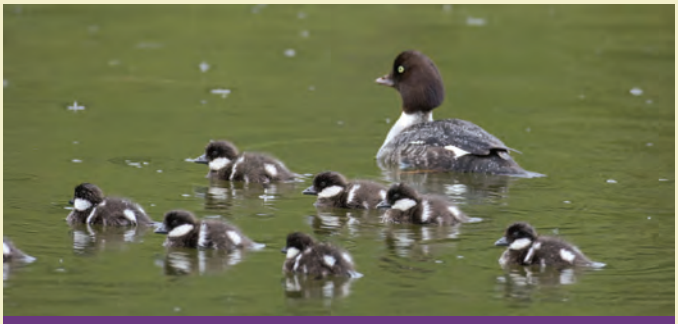
Beaver dams can be temporary barriers, but native fish species evolved with beaver and their dams. No study has ever demonstrated a detrimental, population-level effect of beaver dams on most fish species, including trout.

Beaver dams add habitat diversity to stream systems, increase the biomass of fish sustained, are critical for overwintering and low flow refuges and store water for later release that cools receiving waters. The influence on water temperatures and flows will become more pronounced with warmer, drier summers.

Native cutthroat trout, like most sport species, require cool water to survive.

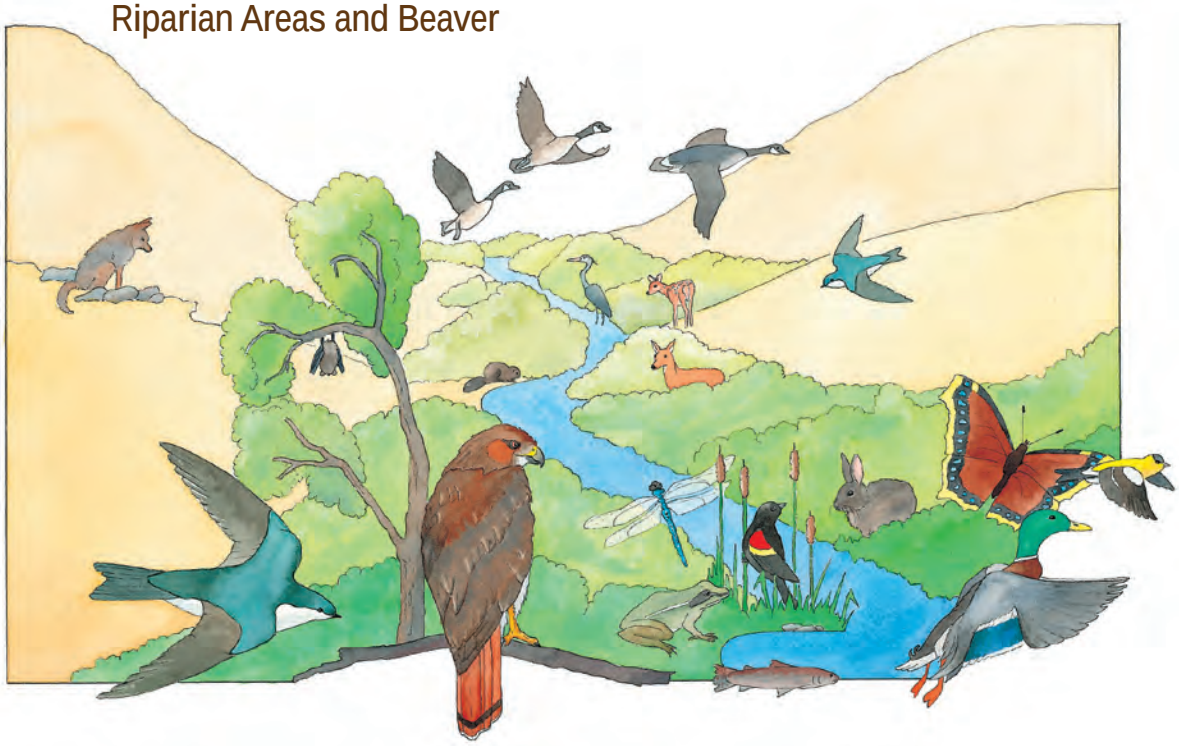
Other Wildlife

Beaver workings contribute substantially to the complexity, connectivity and vegetation diversity of landscapes, which translates into many more opportunities for wildlife species on, near and beneath the surface of beaver ponds. Amphibian populations are enhanced with the creation of more surface water and ponds in stream systems. Small mammal populations (e.g. mice, voles, muskrats) benefit from more diverse, and productive habitats created by beaver. Predator populations (e.g. hawks, owls, coyotes) respond to more prey. Waterfowl and other wetland bird species find appropriate habitats for nesting, rearing and migration. Large mammals (e.g. moose, deer, bears) use beaver-created habitats for foraging, cover and escape terrain.



Barrow's goldeneye favour beaver ponds as flooded trees make excellent nesting sites.

Riparian Areas and Beaver



Approximately 80% of Alberta's fish and wildlife use riparian areas for all, or part, of their life cycle requirements. Beaver enhance riparian landscapes.

Beaver and Cows

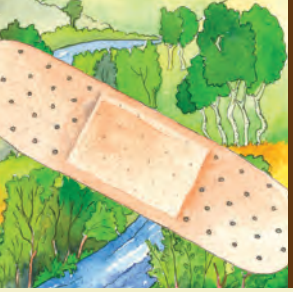
For a livestock producer beaver provide some tangible benefits. Beaver ponds provide alternate sources of water for livestock, allow better distribution throughout a pasture unit and drought-proof a pasture. Higher water tables increase forage production from pounds/acre in the drier uplands to tons/acre in beaver-modified valleys.

Maintaining these benefits also means maintaining beaver. Some adjustments in grazing plans might be considered to allow both livestock and beaver to coexist.

Late season livestock grazing, grazing during drought and exceeding carrying capacity of the pasture means cattle and beaver will compete for woody plants. Cattle will browse trees and shrubs if frost or drought have reduced the nutritive content of grass. If carrying capacity for the pasture is exceeded, cattle will turn to woody plants to maintain condition. If the use of woody plants by livestock persists over long periods, these plants will decline and die out. That leaves nothing for beaver to sustain themselves over the winter or to repair dams. A loss of woody species also reduces the resilience of stream banks to erosion.

The Cows and Fish document "*Riparian Areas and Grazing Management*" provides insights on grazing plans that allow cows and beaver to coexist, for the benefit of both.

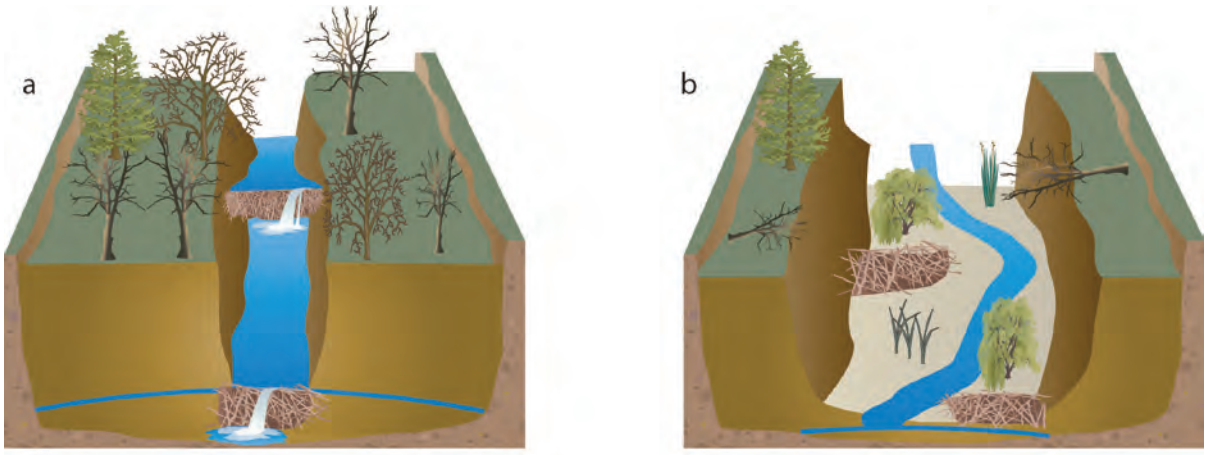
Beaver ponds can be reliable water sources for livestock, especially when coupled with off-stream watering.



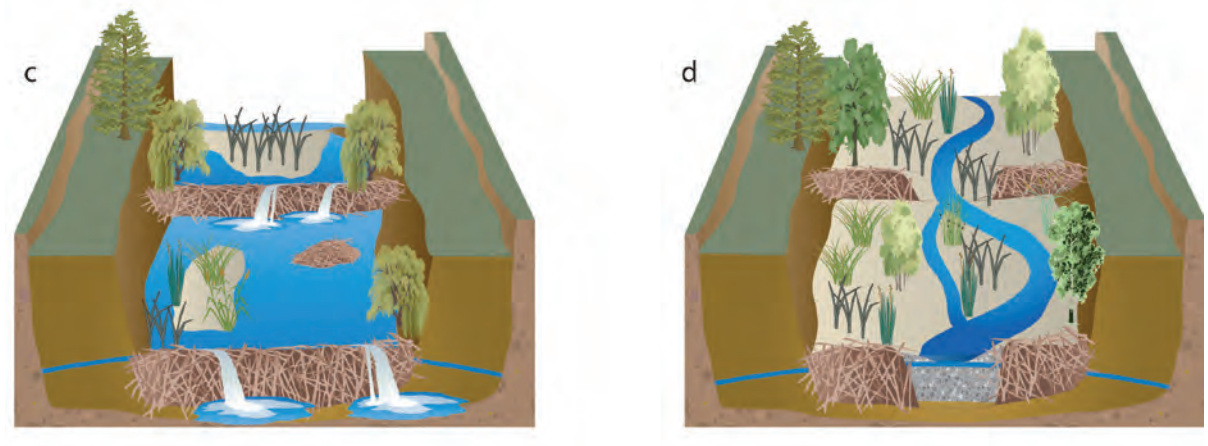
Beaver – A Restoration Tool

Many jurisdictions are seriously and thoughtfully considering the role of beaver for water security, flood protection and fish and wildlife conservation. Several have created guidelines for living with beaver. Some jurisdictions have started down the road of using beaver to help restore damaged watersheds and streams.

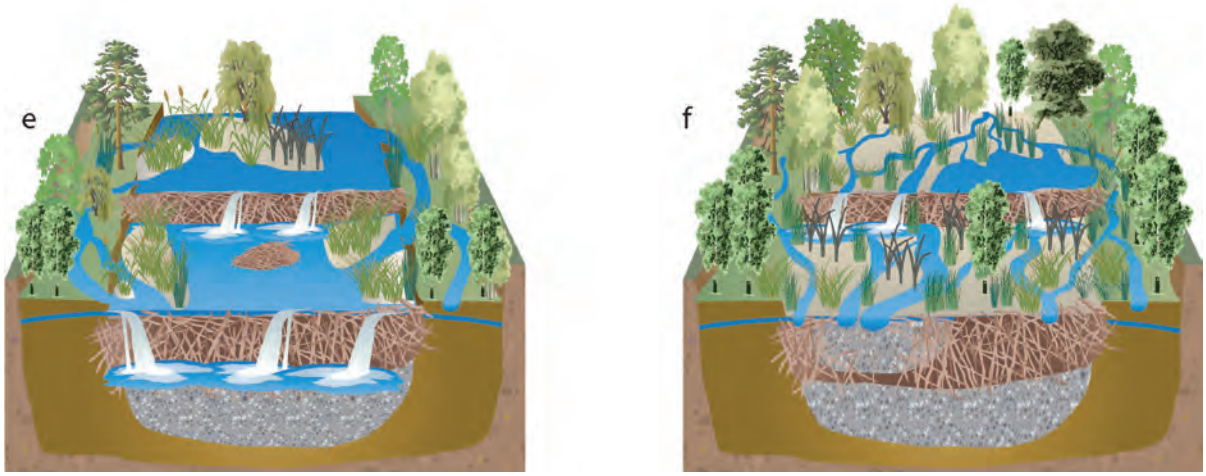
Beaver trap sediment, elevate stream channels (aggradation), reduce incisement (degradation), increase water tables and allow greater riparian vegetation establishment and maintenance. Through their activity, beaver lift stream channels and bring water tables up to restore lost productivity. This turns streams with intermittent flow into permanently flowing ones, which is especially important during drought periods.



Beaver attempt to build dams in streams that have become incised from excessive erosion (a). Lack of a floodplain means the dams may not stay long, but the action of beaver starts the rebuilding of a place for flood waters (b).



A wider floodplain, with less stream energy allows beaver to build wider, more stable dams (c). With high sediment loads beaver ponds rapidly fill and are abandoned, but the sediment is the foundation for riparian vegetation recovery (d).



This process is repeated until beaver dams raise the water table to the point the stream is reconnected to its former floodplain (e). A complex interaction of dams, riparian vegetation, dead wood and multiple channels form and recreate a resilient valley ecosystem (f).

This is a typical degraded stream, down-cut with water table lowered. A riparian zone that used to produce tons/acre of forage now produces mere pounds/acre. Banks are subject to erosion and the stream may not flow year round.

Beaver can help restore these systems to health.

Beaver provide a pathway to restoring lost biodiversity.

Beaver Challenges - A Gnawing Problem

Living with wildlife sometimes isn't easy. Living with beaver has the potential to be frustrating, expensive, time consuming and challenging. Perceptions about beaver seem to depend on whether or not they have caused problems and damage or constrained economic activity. If you've had problems with beaver, your attitudes about them are much more likely to be negative compared to a neighbour that has had positive interactions. Understanding beaver is the first step in dealing with the challenges they bring.

The range of issues beaver create is extensive:

Flooding of crops and difficulty of harvest.

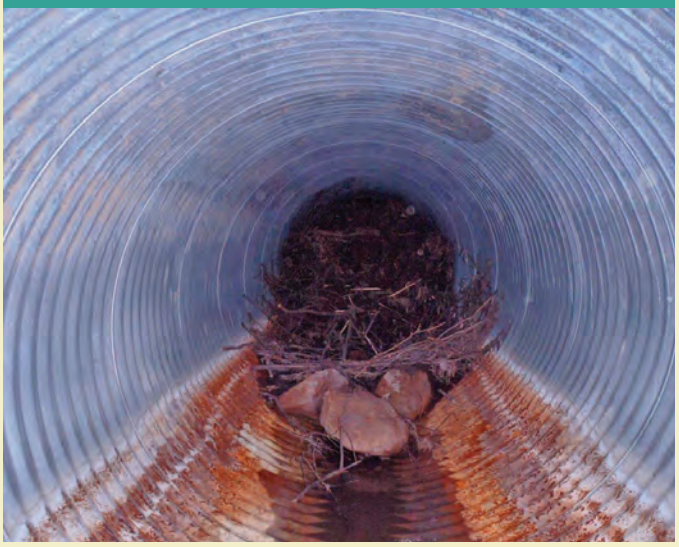
Flooded fences and damage to fences from dropped trees.

Impacts on infrastructure, flooding of property resulting in diminished land values, and difficult construction situations are also prevalent.

The risk of dam blow-outs with downstream flooding concerns some. This is relatively rare because of a flat dam profile and the dissipation of energy over a large area. Dam failures usually happen after abandonment and rarely does the entire dam disappear.

The tunnels that beaver create can create hazards for livestock, machinery and people.

When beaver plug culverts there is a risk to roads and human safety.



Beaver like to chew things – this is a telephone cable. They also like PVC pipe, perhaps the one that is feeding an off-stream livestock watering system.

An animal that gnaws wood, makes dams of wood and has teeth that grow endlessly will cut a lot of wood, some of which are cherished trees.

Beaver Solutions - Living with Beaver

On the positive side, beaver provide many benefits. Unfortunately, sometimes we aren't prepared to accept or accommodate the workings of beaver. But, there are ways to accommodate beaver, reduce some of the negative aspects and learn to live with these sometimes frustrating creatures. In addition to the information here, Cows and Fish has produced: "*An Overview of Beaver Management for Agricultural Producers*". This is a decision matrix tool with a list of potential management actions and the relative costs, benefits, effectiveness, consequences and considerations.

The following are some basics on living with beaver.

Barriers - Separating beaver from places where issues will arise.

Barriers, to keep beaver away from places where problems will happen, are low to moderate in cost, with reasonable effectiveness, but do require periodic maintenance.

For smaller areas, excluding beaver with a mesh fence is an option to protect valuable trees and shrubs in yards.

Fences can protect young trees, often the most targeted age classes of woody vegetation by many animals, including beaver.

Wire mesh keeps beaver from cutting down bigger trees. Allowing beaver to cut down unprotected hazard and decadent trees opens up the canopy for new growth.

Effective protection requires thick wire mesh (mesh size 2.5 cm) and wrapping the tree trunk a minimum of 1.2 m high. Leave room for the tree to grow.

Circular, wire mesh extending upstream of a culvert may prevent beaver from damming the flow. Maintenance is required to remove debris from high flows.

Greater success can be had by increasing the area blocked from beaver upstream of a culvert. Beaver may create a dam upstream but the culvert will remain unplugged.

The most effective deterrent is fencing coupled with moving the intake of water far upstream of the culvert with a pipe system.

There are a number of designs to keep water flowing and beavers at bay.

Habitat Management - Changing the **beaver's playing field.**

These are a combination of short and longer term solutions, with moderate effectiveness, but varying degrees of effort.

A short-term solution, especially to protect valued trees, is to provide an alternate source of food and dam-making materials. Beaver can be temporarily bribed with cut material and it diverts attention away from areas where problems might occur. Providing a wood supply from off-site minimizes cutting of trees by beaver, but has high costs in time.

Better riparian grazing management creates suitable habitat to attract beaver, away from other areas. This is a long-term solution that may require cooperation with the neighbors to create an area where beaver can be tolerated.

Deterrents - Chasing beaver from their homes in the hopes they'll stay away.

People have tried a variety of noise and frightening devices and methods (e.g. dogs, propane cannons, flashing lights) without much success. Removal of dams and lodges with hand tools, heavy equipment or explosives are all common, but expensive, techniques.

While dam and lodge removal provide short-term fixes, if the area contains good beaver habitat the dam will be quickly rebuilt and the colony re-established. In one notable example in Quebec, despite 82 attempts to keep a culvert open and the stream undammed, the beaver prevailed.

They may just keep coming back.

Repellents - Territorial behavior and bad taste.

Beavers use scent markers (castoreum) to send a message the area is “taken”. This may have some seasonal effectiveness, when young beaver are migrating, looking for new territories to establish. Natural repellents such as predator urine, cayenne pepper, hot sauce, and other animal hair have limited effectiveness. All of these wash off and have to be reapplied routinely.

Some have suggested use of chemical repellents - examples include a combination of creosote and diesel fuel, trinitrobenzene-aniline (rodent repellent), or mothballs. All of these would be dangerous to use so close to water plus none have been shown to be effective as deterrents.

There are no toxicants or fumigants that are licensed or specifically designed for beavers. Existing ones designed for other species may also be dangerous to use close to water.

Repellents used in the forest industry to deter use by deer and rabbits may have some value.

Regulate Water Levels - Keep the beaver, reduce the pain.

There are a number of devices, all of which perform a similar function - reduce water levels and hence flooding and thwart the beaver’s ability to stem the flow of water.

The most effective repellent seems to be a simple recipe of six cups of coarse sand mixed in a gallon of indoor latex paint and brushed onto tree trunks. You can select paint to be color coded to your trees. The mixture has to be reapplied periodically.

Moving the intake of a culvert upstream and under water relocates the sound of running water, the trigger that alerts beaver to plug the leak. Silent leaks are not detected or repaired; beaver only react to the noisy ones.

Pond levelers have a similar design. The intent is to manage water levels in the pond at a point that minimizes problems of flooding. Some of these devices use available, flexible and durable drainage pipe. The materials are initially assembled on shore and then the structure is positioned in the pond.

Population Management - Regulating and reducing numbers.

Sometimes population reduction, by traps or shooting is a way to manage beaver numbers and the issues they create. Professional trappers and wildlife damage specialists can assess population numbers and determine a harvest level that reduces the population. Periodic removal of some of the population (especially younger beaver) may stabilize numbers at a sustainable level.

Beaver removal can be a “damned if you do, damned if you don’t” situation. As beaver are trapped, their removal leaves a vacuum into which other beaver move. As long as habitat is suitable, migration will fill the void. What seemed simple might not be a long-lasting solution. The cost and time incurred with beaver removal can be higher than mitigative solutions that protect culvert intakes, reduce water levels or create barriers.

Mitigation devices can substantially reduce the cost of problem beaver management. Cost savings, in terms of reduced preventative maintenance, road repairs and beaver population control, range from 35 to 85% in a number of situations.

Find Beaver a Place - Where can beaver be tolerated?

Sometimes beaver can be directed to sites where problems are minimized, or better managed by providing temporary sources of food and dam-building materials. Creating constrictions where water drops or speeds up provides an audio cue to beaver to build a dam there. There may be locations in a watershed where beaver are more readily tolerated, such as in an isolated stream section, on a pond or in a lake setting.

Beaver might be encouraged to build if a surrogate dam is first constructed, constricting water flow and providing a positive signal.

Many places would benefit from better retention of water by beaver.

Community/Watershed Approach -
It's a question of scale.

Beaver cheerfully ignore our property lines. Often issues that arise are ones involving several landowners. We might be able to solve collectively what we can't individually. This speaks to a community response and a watershed approach.

At a community and watershed scale, there might be increased ability to balance some of the issues beaver bring, with the benefits we enjoy. Things like a better water supply especially in low flow months or in drought periods, is a benefit beaver bring. That we can only achieve at a watershed scale.

Getting together, learning about beaver with the neighbours and involving people with expertise provides more long-lasting solutions.

From community effort comes a landscape/watershed approach to successfully living with beaver.

Many conflicts can be prevented by better understanding beaver behavior and considering their needs in our development plans. This could help us by considering: where we build to avoid flooding from dams; what we use for landscaping to reduce beaver use of planted shrubbery and trees; fencing locations to avoid beaver felling trees on them; how beaver might react to new road construction and stream crossings; and, retrofitting old culvert crossings with clear span structures to prevent plugging.

Working together with your neighbours, at a larger scale, provides opportunities to benefit from beaver and manage the issues.

How Many Beaver are Enough?

This is a difficult question to answer given the variation in landscape across the province. Beaver numbers are based on ecological carrying capacity, especially the amount of woody vegetation available. Before we can answer the question about population goals we also need to consider watershed objectives for water quality, flood/drought prevention and relief, biodiversity protection and agricultural benefits. That answer requires an assessment of current land-use (and conflicts) that constrain beaver occupancy. Ultimately it is about the tolerance level for beaver, part of which is the cost of beaver management and the effectiveness of available tools to reduce conflicts.

We might start by thinking about how many beaver were present historically. Beaver regulate and modify landscapes rather than being just passive inhabitants. Much of our landscape is a beaver-created one, with significant benefits to us, even though the paw of the beaver may not be evident. Understanding historic beaver levels gives us a bookend from which a goal for present and future beaver numbers can be assessed.

Anthony Henday found beaver to be “common” in the parkland region of Alberta when he traveled through in 1754-55. Peter Fidler, a Hudson’s Bay Company trader described streams in the grasslands near the confluence of the Red Deer and South Saskatchewan rivers as “entirely full of beaver” in 1800. Fidler’s journals note that beaver dams were located every 20 to 40 m along these streams. In 1815, James Bird, also a Hudson’s Bay trader, reported the Edmonton district (which encompassed most of Alberta, south of the Athabasca watershed) as being one of the richest fur producers within all of the Bay’s territories.

It seems reasonable to conclude beaver were a common feature of the Alberta landscape, from the grasslands to the boreal forest, and unexploited populations were at or near their carrying capacity. A variety of land uses since settlement have reduced the overall habitat availability for beaver. In a recent study of 384 Alberta watersheds, beaver activity was observed in 250; but beaver were missing from 134. It is unlikely beaver are near to carrying capacity anywhere in Alberta, except for remote portions of the boreal forest.

The average density of beaver colonies in stream systems across North America is 0.95 colonies/km, with a range of 0.32 to 1.9/km. The probable maximum density of beaver colonies in wetland environments has been noted at 1.0 to 1.2 colonies/km^2 from data across Canada. However, notable exceptions do occur. In 1968, in the Minburn Grazing Reserve, west of Vermilion, a density of 3.51 colonies/km^2 was found. In 2008 a density of 4.0 colonies/km^2 was reported in Miquelon Lake Provincial Park, south east of Edmonton.

The answer to “how many beaver are enough?” will vary based on land ownership, conflicts with beaver (real or perceived) and the goals for watershed management that may be provincially driven or part of a watershed group decision. Areas with cropland, urban settings, rural subdivisions, areas with a high density of roads (and culverts) and predominantly private lands will have a lower social tolerance for beaver. These are the areas where restoration of streams and riparian habitats are most needed however, because of the land-use footprint. Setting a population goal for beaver in urban settings may be particularly contentious, with limited habitat, overlapping interests and few, or no, predators to help regulate numbers. In headwater areas of largely undeveloped lands, where beaver will aid in flood and drought mitigation, larger populations of beaver may be seen as a benefit.

Beaver have been a natural and essential part of landscape processes for thousands of years. If we think we can do without them, we may find the alternatives expensive, unsatisfactory and difficult to duplicate compared to what beaver do naturally.

Beaver – A Final Slap of the Tail

Water … we can't live without it. No substitute exists for this precious and essential resource. We currently see the flow of water declining as our climate becomes warmer and drier. The amount of snowpack in the mountains will be less, melting and runoff will occur earlier in the spring, and stream flow will diminish earlier in summer. By late summer when we need water the most, it may be in short supply.

Ironically, our weather patterns are becoming more unstable with localized, heavy rainfall giving us extreme flood events that seem to have a regular occurrence.

As the reality of climate change becomes ever more apparent, we will need to manage, catch and store water more effectively. Humans have given water lots of advice, in the form of man-made dams and reservoirs but is it enough? Likely not!

Have we overlooked a natural ally in our efforts to conserve and manage water? Yes, consider the beaver, a species that has survived through huge climatic variation. Nature has given beaver a triple "A" rating for water storage, biodiversity maintenance and climate change adaptation.

Advances in research continue to demonstrate that beaver can provide an effective, non-structural, low cost means for restoration and climate change mitigation, compared to traditional methods and approaches.

Current population levels of beaver are a small fraction of historical numbers. Excessive trapping eliminated beaver from large portions of the landscape by the 1900s. This was followed by intensive use of the land. Without beaver, smaller streams eroded downward, water tables dropped, some streams and wetlands dried up, riparian vegetation disappeared, fish and wildlife populations declined and the landscape lost both diversity and resilience.

What is keeping us from using beaver for climate change mitigation and landscape restoration?

The impediments to re-establishing functional beaver populations on a landscape basis are numerous and require the efforts of many to overcome.

Population Resistance. There may not be a sufficient critical mass of beaver at a landscape scale to balance mortality and allow natural migration and colonization.

Landscape Resistance. The physical environment (and how it has changed with land-use) provides many impediments to beaver: stream incisement; lack of woody vegetation in riparian area or uplands; ephemeral stream flow; drought conditions; recurring flooding; blockages to movement on stream/river corridors (dams/diversions); stream gradient excessive; and fencing (e.g. page wire).

Mortality Resistance. Issues like predation, trapping, mortality at road crossings and predation/harassment from pets may keep beaver populations below a sustainable size.

Social Resistance. The way that people respond to beaver and the challenges they bring may be an impediment to re-establishing populations: indiscriminate shooting/trapping; removal of dams/lodges; lack of tolerance/understanding; and concerns over effects on sport fish (blocking movement).

Policy Resistance. There needs to be clear, consistent policy on beaver management to enable population re-establishment and system restoration. Population inventories are necessary to set beaver harvest numbers at sustainable levels.

We need to move from an individual landowner problem (perceived or otherwise) to a community/watershed approach to find the places where beaver can be tolerated and where the community senses an advantage.

Part of the solution is giving beaver the opportunity to move and re-establish naturally; another is to define how and where beaver can successfully be relocated. Guidelines for reintroductions, with community involvement are part of the package. An integral feature is an analysis of habitat suitability for reintroduction efforts, to target those areas with the greatest chance of success. Beaver have the potential to influence 20-40% of the length of small streams.

We need to reduce vulnerability and increase resilience in our watersheds to deal with flooding and drought. Beaver re-establishment isn't the complete answer, nor is it our get-out-of-climate-change-free card, but it is part of a viable long-term strategy.

Life is all about water - a substance more precious than gold and likely more scarce as we move to a warmer, drier and uncertain future. With their ponds serving as natural water reservoirs and flood prevention, beaver can help us. But, only if we accommodate their activity in more places. Will we stick to outdated intolerance or will we partner with Nature's engineer to help manage water for free?

The health of our watersheds - from headwaters to drinking tap - depends on our answer.

Life is all about water and how we choose to manage the risks of too much and too little. Beaver can be our watershed partner to navigate an uncertain future.

Further Resources to Chew On

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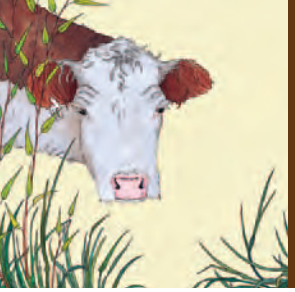

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Alberta Beef Producers
165, 6815 - 8th Street NE
Calgary, Alberta
T2E 7H7
403-275-4400

Trout Unlimited Canada
6712 Fisher Street SE
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Calgary, Alberta
T2E 7H7
403-275-8558

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2nd Floor Great West Life Building
9920 - 108th Street
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T5K 2M4

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206 JG O'Donoghue Building
7000 - 113th Street
Edmonton, Alberta
T6H 5T6

Producer and Community Groups

Beaver are our watershed partner in sustaining healthy riparian areas. We invite you to work with Cows and Fish to conserve, restore and maintain these vital green zones.

Cows and Fish

Alberta Riparian Habitat Management Society

Executive Director: Lethbridge 403-381-5538

FAX: 403-381-5723

Email: riparian@cowsandfish.org

Mail: c/o Alberta Environment and Parks

2nd Floor YPM Place

530 - 8th Street South

Lethbridge, Alberta, Canada T1J 2J8

www.cowsandfish.org

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