

BEAVERS

COEXISTENCE STRATEGIES FOR
MUNICIPALITIES AND LANDOWNERS



THE ASSOCIATION FOR THE
PROTECTION
of Fur-Bearing Animals

ABOUT THE FUR-BEARERS

The Association for the Protection of Fur-Bearing Animals (The Fur-Bearers) was formed in 1953 to advocate on behalf of fur-bearing animals in the wild and in confinement. The organization does this through conservation, advocacy, research and education (C.A.R.E.). In wildlife management, a fur-bearer is defined as wildlife whose pelt carries commercial or market value.

Community coexistence is a priority for The Fur-Bearers, who have worked with landowners, municipalities, and provincial bodies to utilize the best available science and provide in-field solutions to prevent and mitigate conflict with wildlife while simultaneously providing education to residents.

From Vancouver Island to eastern Ontario, The Fur-Bearers' team has worked with municipalities and landowners in various situations to help advance coexistence with

species such as beavers, bears, coyotes, raccoons, and other fur-bearers.

In addition to working with communities directly, The Fur-Bearers provides education through regular articles, social media outreach, attending various community events, and the popular Defender Radio podcast.

More about The Fur-Bearers, their ongoing campaigns and projects and how your community can receive assistance can be found at **TheFurBearers.com**.

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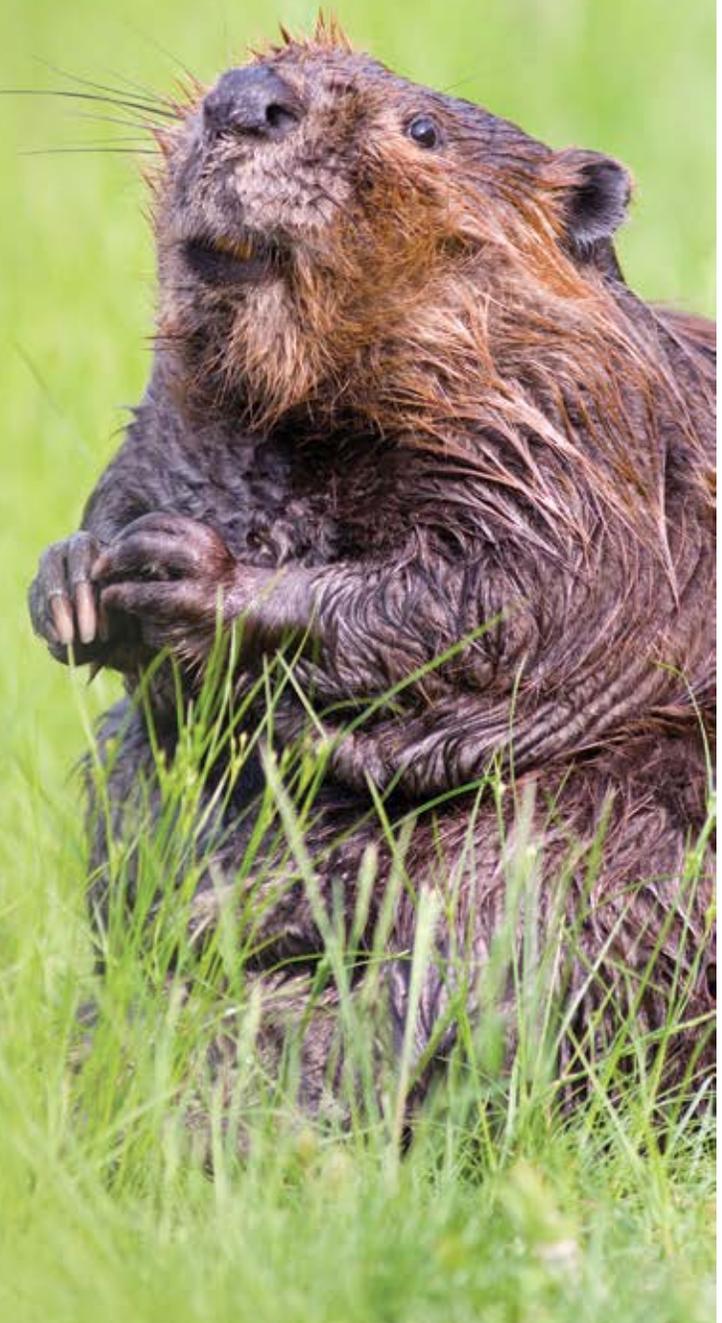


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INTRODUCTION

Our understanding and appreciation of nature has grown exponentially as a society. Science has shown us that animals of all kinds have complex emotional and social lives. History has shown us that our attempts to control ecosystems is rarely effective. And the combination of the two – through education and experience – has allowed us to understand that we need better solutions for living with wildlife.

Conflict with nature will always occur, this is true. But by acknowledging the constant growth of biological and ecological sciences, we can mitigate – and at times entirely prevent – such conflicts.

The reason The Association for the Protection of Fur-Bearing Animals (**The Fur-Bearers**) has undertaken the Living With Wildlife campaign is simple: to fill a need.

Solutions To Conflict

For hundreds of years, residents of North America have coped with wildlife conflicts in numerous manners.

The reality has often been lethal response: hunting, trapping, poisoning and habitat destruction have led the majority of conflict resolutions. These efforts have led to the extirpation (local extinction) and outright extinction of some native species.

As our societal respect for nature and the body of scientific data has grown, new and progressive alternatives have been sought in managing wildlife conflicts.

In these conversations, beavers are often among the species that come into conflict with humans. To resolve and even prevent conflict with beavers, it is important to understand the way beavers think and behave, their role in ecosystems and investigate the underlying causes of conflict. Only when these steps are taken will longterm, sustainable solutions be found.

Beavers are a keystone species and are responsible for maintaining extremely sensitive and important wetlands from coast to coast. Without them, ecosystems truly begin to fail.

It is the hope of The Fur-Bearers that this book may provide the basis for understanding of the benefits of co-existence and an introduction to the potential solutions available to landowners and municipalities. This book also compliments our hands-on training programs available to municipalities and community groups on building beaver flow devices.



UNDERSTANDING BEAVERS

A BRIEF HISTORY

The evolutionary history of North American beavers (*Castor canadensis*) is somewhat unclear. A study from Texas A&M University theorized that several million years ago the Eurasian beaver migrated to North America and began its own evolutionary path.

At the time of first contact with Indigenous peoples by colonial Europeans in the 15th century, it is estimated 60,000,000 beavers were present in North America. The extreme trapping of beavers for their pelts led to a brush with extinction for the species in the 19th century. Today, beaver populations are estimated at one-tenth their pre-colonization numbers.

Throughout North America – and sections of Europe – communities are attempting to reintroduce beavers into their ecosystems.

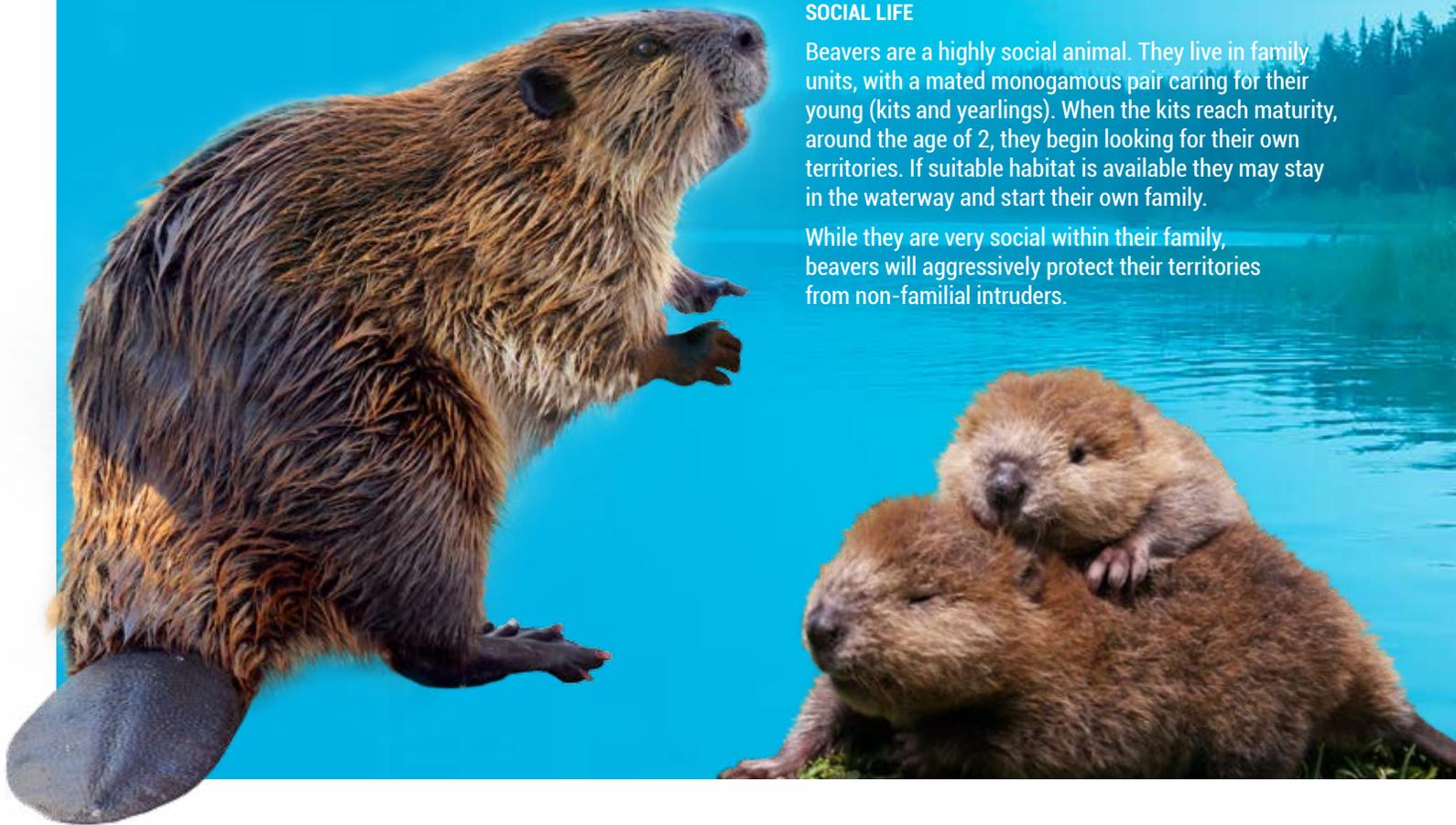
BASIC BIOLOGY

The average beaver weighs between 11 and 32 kilograms (24 to 71 lbs.) and measures 94 to 125 centimetres (36 to 48 inches) including their tail. The back feet of beavers is webbed and the front paws are clawed, used to assist in grasping logs and food. Their tails are broad and flat, assisting in their propulsion in the water and used to slap water as an auditory warning. Like other rodents, their large front incisors continuously grow – by chewing wood and foliage they are able to keep them short and manageable. One to six kits are born to each litter and only one litter is produced per year. Beavers are herbivores and eat various water-based plants and the bark of trees.

SOCIAL LIFE

Beavers are a highly social animal. They live in family units, with a mated monogamous pair caring for their young (kits and yearlings). When the kits reach maturity, around the age of 2, they begin looking for their own territories. If suitable habitat is available they may stay in the waterway and start their own family.

While they are very social within their family, beavers will aggressively protect their territories from non-familial intruders.



ROLE IN THE ECOSYSTEM



While beavers as rodents and herbivores may seem insignificant to the food web, they provide immense ecological benefits beyond that basic role.

Often referred to as nature's engineers, beavers create dams where flowing water is available. These dams are made up of logs, branches, mud and other foliage. Dams as long as 850 metres (Wood Buffalo National Park, Alberta) have been found in North America – a remarkable feat for a group of 40-pound rodents.

These dams are beneficial to ecosystems and surrounding communities because they:

Maintain water levels in drought conditions.¹

Create ideal reproductive habitat for numerous species of fish.²

Retain silt from entering streams and lakes.³

Create ideal wetlands for songbird and waterfowl populations.⁴

Remove excess phosphates and nitrates from water systems (denitrification).⁴

Slow down the movement of water in flood conditions.⁵

The benefits of these dams are significant to our ecosystems; it is difficult to fathom how differently our environment could have evolved had we not decreased beaver populations so extremely.

DID YOU KNOW?

A BEAVER'S HOME IS CALLED A LODGE. IT'S A DOME-SHAPED HOUSE THAT IS MADE FROM BRANCHES, STICKS, GRASS AND MUD. THE ENTRANCE IS UNDERWATER.

¹ University of Alberta, 2006

² Langcore, T., Rich, C. & Miller-Schwarze, D., 2006

³ Cooke, H., Zack, S., 2008

⁴ U.S. EPA, 2016

⁵ Hood, G.A., & Larson, D.G., 2014

TREES AND INFRASTRUCTURE PROTECTION

THE CONCERN

Long before residents know a beaver is in an area, the damage to trees can be seen.

Beavers use their large teeth to chew down trees. The bark is eaten for sustenance and the trees are floated down a current and used in the construction of a dam or lodge. The removal of certain tree species can actually speed up the development of other plant and animal life in an area. But some municipalities and landowners do not want trees removed, which is where the conflict occurs.

Many municipalities invest heavily in tree planting to produce preferred canopy rates; others invest for simple aesthetic. In established areas, the felling of trees can impact power lines, homes or other sensitive infrastructure.

THE SOLUTIONS

Beavers will continue to chew down available trees when they are present. It's important to note, however, that the most significant activity in regards to tree removal occurs when a new - often the first - dam is being built.

Removing the dam will prompt the beavers to take down more trees to replace their dam.

Tree wrapping by surrounding a tree - or group of trees - with a thick wire mesh, beavers are prevented from chewing and downing trees. The mesh should not rest flush against the targeted tree; a spacing of several inches gives the tree room to grow. The Fur-Bearers does not recommend chicken wire but something of a heavier gauge galvanized steel

This strategy can also be employed when wooden poles are used for hydro or cable lines.

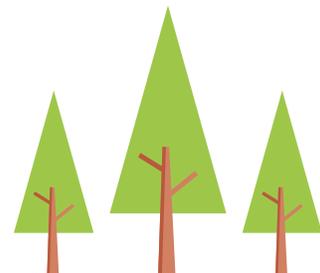
HOW TO INSTALL TREE FENCING:

Materials

- Wire fencing, 2" x 4" mesh (metal tree wrap/fencing cylinders)
- Gloves
- Safety glasses
- Wire snips
- Wire fasteners (e.g. small zip ties, hog rings)

Procedure

1. Ensure you have permission to wrap trees.
2. Visit your local hardwood store to purchase your supplies.
3. Put on your gloves and safety glasses before rolling out material.
4. Roll out fencing cylinder and using the wire snips, cut the fencing so it's at a minimum 4 feet high and long enough to wrap around the base of the tree.
5. Wrap the fencing around the tree and secure with fasteners. You do not need to anchor the fencing to the ground. To avoid restricting the growth of the tree, leave a 4-6 inch gap between the wire cylinder and the tree trunk.



STRATEGIC PLANTING

Beavers do have a preference amongst the many tree species native and imported to Canada. Studies have indicated that trees belonging to the family Salicaceae, specifically the genus of Populus (poplar, aspen and cottonwood) and Salix (willow) are the most preferred. It has also been noted that the closer to the beaver pond the tree is, the higher the probability that it will be used by beavers. Avoiding the planting of these species of trees near known beaver activity will assist in conflict reduction.

RECYCLING

Trees fall regularly from a variety of causes; it often falls to municipalities or landowners to remove them.

Some of those logs and trees can be left for beavers. It may not stop them from cutting down fresh trees, but they will likely recycle logs left for them.



TIPS

WRAP TREES THAT POSE A DIRECT THREAT TO PUBLIC SAFETY OR PROPERTY FIRST (E.G. TREES THAT IF CHEWED COULD POTENTIALLY FALL ON YOUR HOME, BLOCK ROADWAYS OR DESTROY POWERLINES). REPLACE THE FENCING IF IT STARTS TO CORRODE OR RESTRICTS THE TREE FROM GROWING.

CULVERTS AND EXCLUSION FENCES

THE CONCERN

Man-made culverts are a natural attractant for beavers: a small area with the sound of running water triggers their desire to build a dam. These culverts – and other similar drainage systems – are critical for managing floodwaters, storms and waste. As a result, municipal workers often spend hundreds of person-hours and thousands of dollars trying to remove dams or prevent beavers from damming culverts in the first place. But a single device – built with materials that are readily available at local hardware stores – can be a cure.

THE SOLUTIONS

Knowing that beavers will naturally be attracted to culverts gives landowners and municipalities a leg up on prevention: installing an exclusion fence will prevent a beaver from damming, period.

An exclusion fence is a trapezoidal-shaped fence that is placed in front of, or surrounding, a culvert-like area that beavers want to dam.

Using a wire fencing (we recommend six-gauge galvanized steel with six inch gaps), a simple fence is created. It's important to build a bottom to the fence, as beavers will attempt to dig underneath it. This fencing is lowered onto the upstream side of the desired area with the wide-end of the trapezoid facing away from the culvert.

Steel fence poles are pounded into the ground and attached to hold the fence in place and in shape. The Fur-Bearers prefers to add a 'header' to the top outside of the fence with two-by-fours, as it provides extra security for environments that deal with harsh winters and has great aesthetic qualities.

The exclusion fence, which takes one person with the appropriate training only a few hours to build and install, will last ten or more years, depending on the quality of materials. It defeats beaver activity in three main ways:

1. They are unable to dam straight across the culvert. Beavers want to place debris across the flow of water. The exclusion fence forces them to dam parallel to the flow of water.
2. They are forced away from the culvert. By using the odd-shaped trapezoid, beavers may begin to try and dam, but are pushed further away from the culvert opening. As they are moved further from the opening, their drive to build diminishes.
3. We've made the task of damming a lot harder, increasing what was a small hole to a much larger surface.

By using a six-gauge fencing with a six inch gap, fish, plant life, debris and other small aquatic animals will still be able to pass through the exclusion fence, but the openings will be too small for beavers to access it or drag materials through.

This can also make debris clean up after a storm easier as it keeps large objects from clogging the culvert.

Minimal maintenance will be required to remove large debris and ensure the fence has not been damaged after severe weather systems. The estimated cost for the materials required to build an exclusion fence is approximately \$600 (retail).





DAMS AND POND LEVELLERS

THE CONCERN

Beaver dams are an excellent example of nature's ability to engineer itself. But they also represent an ever-present concern for landowners and municipalities. By creating a dam, beavers can hold back water from areas where water is needed, divert water from one location to another, and, if ruptured, result in a flood.

Destroying a beaver dam is extremely time-consuming and does not address the root problem: beavers building a home. Removing beavers will not solve the problem, because if one beaver family found the area desirable, surely another will, too.

There is, however, a solution that is not only cost-effective and sustainable over a period of time, but keeps beavers in the habitat – and the plethora of environmentally benefits they bring.

THE SOLUTIONS

A pond leveller is both simple and complex. It requires only two components, but plays off of beaver's own design capabilities and management of wetlands.

Simply put, a pond leveller is a long pipe, one end of which is sunk into a pond with a cage around it, the other pushed through a beaver dam. This allows the continuous movement of water through a dam without obstruction from the beavers, and mitigates the need to remove the beavers (see Tree and infrastructure protection, page 8).

The construction begins on land, where a dome of wire mesh (The Fur-Bearers recommends six-gauge, galvanized steel with six inch gaps) is built. A long tube (The Fur-Bearers recommends

high-density polyethylene pipe, double-walled) is inserted into this dome and the other remains free.

Using a simple flotation device (The Fur-Bearers has used things such as Rubbermaid containers, wooden pallets, inner tubes and even pool noodles), the mesh end is floated into the centre of the pond, about 30 to 40 feet away from the dam. This distance is varying based on the depth of the pond, the width, etc. The open end of the tubing is placed into an open area of the dam. This can be accomplished by opening up the dam by hand using a potato rake and/or shovel.

The height of the pipe will determine the high point of the water level in the pond. It's important to keep some depth, as beavers store their winter food under the frozen section of water. Using nearby sticks, logs and mud, the tube is covered up again.

The beavers will attempt to repair this passage through the dam, further securing the tube in place – but they will be unable to block it.

The pond leveller is a terrific solution as it protects the pond and habitat managed by the beavers, the beaver family living in the area and any nearby infrastructure.

These devices last for up to 10 years or longer, depending on the quality of materials, and take two trained individuals only a few hours to build and install.

There should be no required maintenance and in deep-enough ponds, there will be no evidence of the device beyond a small amount of tubing at the dam. The estimated cost for the materials required to build a pond leveller is approximately \$800 (retail).



**DID YOU
KNOW?**

ONE REASON BEAVERS
BUILD DAMS TO CREATE
PONDS IS DAMS ARE A
MEANS OF PROTECTION
FROM PREDATORS LIKE
BEARS, COUGARS AND
WOLVES.

COMBO DEVICES

There are occasions when a pond leveller or exclusion fence isn't ideal for a situation. For example, in a small culvert, a full-sized exclusion fence may not fit, or may not be as effective.

In these circumstances, a combo device is the best solution.

By using elements of both designs, a beaver dam can actually be built in a culvert or drainage ditch without fear of blockage. On many occasions, The Fur-Bearers has simply created a pond leveller that runs through a scaled-down version of an exclusion fence.

This hybrid solution is most commonly used in narrow landscapes or when a large exclusion fence is unwanted.

The beavers will dam against this smaller exclusion fence but the pond leveller will continue to allow water to flow through it.



DID YOU KNOW?

AS A KEYSTONE SPECIES, BEAVERS PLAY AN ESSENTIAL ROLE IN MAINTAINING A BALANCED ECO-SYSTEM.



CASE STUDY

CONFLICT WITH BEAVERS LED TO CONFLICT WITH RESIDENTS IN BELLEVILLE, ONTARIO.

A wetland – one that doesn't have a formal name according to most maps – is home to a diverse group of species, including at least two beavers, who had established a lodge and multiple small dams. However, one of their dams was at the mouth of a large culvert, which passes under a significant, but secondary road in a community.

Due to concerns about rising water, city staff first attempted to remove the dams created at the mouth of the culvert, then, following the traditional trajectory of beaver management when the beavers kept returning, contracted a trapper to remove the beavers.

One evening in early summer 2018, a resident saw splashing at the culvert – only about 10 feet from a sidewalk. Upon investigation, he saw a beaver struggling to stay afloat and presumed that they were caught on some kind of debris; with the help of a neighbour, the resident was able to assist the beaver, ultimately discovering the trap holding the beaver and releasing them. The residents expressed their outrage on social media – and city council responded with similar concerns: a trap set next to a busy sidewalk where many children and dogs walked was ill-advised, and other solutions should be available.

The Fur-Bearers worked with city staff and were able to contract the services of Skip Lisle (Beaver Deceivers LLC). Over two days, Skip built and installed a large pond leveller at the site utilizing two pipes running through a fence installed at the mouth of the concrete culvert; the other ends protected by a cage and sunk into a deeper part of the pond; and, even a small passage that would allow wildlife to pass through the fence but not allow beavers to drag debris through for damming activity.

This solution served multiple purposes: the legitimate concerns of infrastructure damage from the beavers was directly addressed and prevented with the flow devices, residents who wanted to protect their natural spaces were able to do so without great expense from the city, it prevented the potential calamities of having lethal traps in places where people and their families frequent, and staff were able to learn the basics of building and maintaining flow devices from one of the original innovators of the technology. It also created good will between city staff, city council, residents, and external stakeholders. The solution also provided a satisfactory conclusion to the documentary being made locally about the residents' journey to protect beavers that is expected to hit film festivals in 2020.



DID YOU KNOW?

BEAVERS RESPOND QUICKLY TO THE SOUNDS OF RUNNING WATER, DAMMING IT WITH BRANCHES, STICKS AND MUD, THEREBY MAINTAINING THEIR PONDS.

PHOTO BY DOUG KNUTSON • WINDSWEPT PRODUCTIONS

COEXISTENCE SUPPORTS YOUR COMMUNITY

Beavers are a natural part of our communities. Whether we're in a big city, a mid-sized town, or a gathering of properties in a district, entire ecosystems are kept alive and healthy by the activities of our national animal.

The general public's interest in environmental policy is growing alongside what will inevitably be conflict with nature as our communities continue to expand; even when one area isn't growing, another is, causing changes that ripple out over property lines and boundaries. New solutions – ones that consider long-term consequence to ecosystems and the ethical quandaries of the past – must be found.

Municipalities and individual landowners are also facing increasing pressure from provincial (or state) and federal governments who download responsibility for managing issues related to the environment, wildlife and social programs. While this difficult change is a challenge, it is also an opportunity: necessity is the mother of invention.

Not every community will welcome change to traditional practices of wildlife and infrastructure management; not every community will accept staying with the status quo. Ultimately, this booklet was created to illustrate that innovation of non-lethal solutions is not only possible, but ecologically and economically responsible.

Basic fencing can protect individual trees, bushes, or crops from beaver activity; exclusion fences can prevent damming from starting on sensitive culverts or properties; and, with a little education and beaver-like hard work, entire ecosystems can be rebalanced to protect wildlife and infrastructure.

The Fur-Bearers are proud of the goals accomplished by working with municipalities and landowners in the past, and look forward to supporting your community through coexistence strategies.

The Association for the Protection of Fur-Bearing Animals (The Fur-Bearers) is a non-profit based in British Columbia. We have worked with municipalities and landowners across the country learn to co-exist with beavers. If you would like The Fur-Bearers' assistance in learning how to use flow devices, developing co-existence strategies or writing wildlife-specific by-laws, please contact us:

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BEAVERS IN CAPTIVITY

Campbell-Palmer, R., Rosell, F., 2015. Captive Care and Welfare Considerations for Beavers. *Zoo Biol.* 34, 101–109.

DISTRIBUTION OF BEAVERS AND/OR REINTRODUCTION

Bailey, D.R., Dittbrenner, B.J., Yocom, K.P., 2018. Reintegrating the North American beaver (*Castor canadensis*) in the urban landscape. *Wiley Interdiscip. Rev. Water* 6, e1323. <https://doi.org/10.1002/wat2.1323>

Bloomquist, C.K., Nielsen, C.K., 2010. Demography of Unexploited Beavers in Southern Illinois. *J. Wildl. Manage.* 74, 228–235. <https://doi.org/10.2193/2008-456>

Bloomquist, C.K., Nielsen, C.K., Shew, J.J., 2012. Spatial Organization of Unexploited Beavers (*Castor canadensis*) in Southern Illinois. *Am. Midl. Nat.* 167, 188–197.

Destefano, S., Koenen, K.K.G., Henner, C.M., Strules, J., 2006. Transition to independence by subadult beavers (*Castor canadensis*) in an unexploited, exponentially growing population. *J. Zool.* 269, 434–441. <https://doi.org/10.1111/j.1469-7998.2006.00160.x>

Pietrek, A., Escobar, J.M., Fasola, L., Roesler, I., Schiavini, A., 2017. Why invasive Patagonian beavers thrive in unlikely habitats: a demographic perspective. *J. Mammal.* 98, 283–292. <https://doi.org/10.1093/jmammal/gyw169>

Small, B.A., Frey, J.K., Gard, C.C., 2016. Livestock grazing limits beaver restoration in northern New Mexico. *J. Soc. Ecol. Restor.* 24, 646–655. <https://doi.org/10.1111/rec.12364>

ECOSYSTEM ENGINEERING OF BEAVERS: BENEFITS AND HARMS

Bartel, R.A., Haddad, N.M., Wright, J.P., Bartel, R.A., Haddad, N.M., Wright, J.P., 2010. Ecosystem engineers maintain a rare species of butterfly and increase plant diversity. *Nord. Soc. Oikos* 119, 883–890. <https://doi.org/10.1111/j>

Collen, P., Gibson, R.J., 2001. The general ecology of beavers (*Castor* spp.), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish – a review. *Rev. Fish Biol. Fish.* 10, 439–461.

Hood, G.A., Larson, D.G., 2015. Ecological engineering and aquatic connectivity: a new perspective from beaver-modified wetlands. *Freshw. Biol.* 60, 198–208. <https://doi.org/10.1111/fwb.12487>

Law, A., Gaywood, M.J., Jones, K.C., Ramsay, P., Willby, N.J., 2017. Using ecosystem engineers as tools in habitat restoration and rewilding: beaver and wetlands. *Sci. Total Environ.* 605–606, 1021–1030. <https://doi.org/10.1016/j.scitotenv.2017.06.173>

Law, A., Mclean, F., Willby, N.J., 2016. Habitat engineering by beaver benefits aquatic biodiversity and ecosystem processes in agricultural streams. *Freshw. Biol.* 61, 486–499. <https://doi.org/10.1111/fwb.12721>

Malison, R.L., Kuzishchin, K. V, Stanford, J.A., 2016. Do beaver dams reduce habitat connectivity and salmon productivity in expansive river floodplains? *PeerJ* 4, e2403. <https://doi.org/10.7717/peerj.2403>

Malison, R.L., Lorang, M.S., Whited, D.C., Stanford, J.A., 2014. Beavers (*Castor canadensis*) influence habitat for juvenile salmon in a large Alaskan river floodplain. *Freshw. Biol.* 59, 1229–1246. <https://doi.org/10.1111/fwb.12343>

Martin, S.L., Jasinski, B.L., Kendall, A.D., Dahl, T.A., Hyndman, D.W., 2015. Quantifying beaver dam dynamics and sediment retention using aerial imagery, habitat characteristics, and economic drivers. *Landsc. Ecol.* 30, 1129–1144. <https://doi.org/10.1007/s10980-015-0165-9>

Nummi, P., Holopainen, S., 2014. Whole-community facilitation by beaver: ecosystem engineer increases waterbird diversity. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 24, 623–633. <https://doi.org/10.1002/aqc.2437>

Rosell, F., Bozsér, O., Collen, P., Parker, H., 2005. Ecological impact of beavers *Castor fiber* and *Castor canadensis* and their ability to modify ecosystems. *Mamm. Rev.* 35, 248–276.

Rozhkova-Timina, I.O., Popkov, V.K., Mitchell, P.J., Kirpotin, S.N., 2018. Beavers as ecosystem engineers – a review of their positive and negative effects. *IOP Conf. Ser. Earth Environ. Sci.* 201.

Stevens, C.E., Paszkowski, C.A., Foote, A.L., 2007. Beaver (*Castor canadensis*) as a surrogate species for conserving anuran amphibians on boreal streams in Alberta, Canada. *Biol. Conserv.* 134, 1–13. <https://doi.org/10.1016/j.biocon.2006.07.017>

FACTORS INFLUENCING DAM ESTABLISHMENTS

Barnes, D.M., Mallik, A.U., 1996. Use of woody plants in construction of beaver dams in northern Ontario. *Can. J. Fish. Aquat. Sci.* 74.

Barnes, D.M., Mallik, A.U., 1997. Habitat Factors Influencing Beaver Dam Establishment in a Northern Ontario Watershed. *J. Wildl. Manage.* 61, 1371–1377.

Mumma, M.A., Gillingham, M.P., Johnson, C.J., Parker, K.L., 2018. Where beavers (*Castor canadensis*) build: testing the influence of habitat quality, predation risk, and anthropogenic disturbance on colony occurrence. *Can. J. Zool.* 96, 897–904.

Swinnen, K., Rutten, A., Nyssen, J., Leirs, H., 2010. Environmental Factors Influencing Beaver Dam Locations. *J. Wildl.* 83, 1–9. <https://doi.org/10.1002/jwmg.21601>

HUMAN-BEAVER CONFLICTS

Barnes, J., Dibble, A.N.D.E., 1988. The effects of beaver in riverbank forest succession. *Can. J. Bot.* 66, 40–44.

Curtis, P.D., Jensen, P.G., 2004. Habitat Features Affecting Beaver Occupancy along Roadsides in New York State. *J. Wildl. Manage.* 68, 278–287.

- Donkor, N.T., Fryxell, J.M., 1999. Impact of beaver foraging on structure of lowland boreal forests of Algonquin Provincial Park, Ontario. *For. Ecol. Manage.* 118, 83–92.
- Erlandsen, S.L., Sherlock, L., Bemrick, W.J., Ghobrial, H., 1990. Prevalence of *Giardia* spp. in Beaver and Muskrat Populations in Northeastern States and Minnesota: Detection of Intestinal Trophozoites at Necropsy Provides Greater Sensitivity than Detection of Cysts in Fecal Samples. *Appl. Environ. Microbiol.* 56, 31–36.
- Fortin, C., Lizotte, M., 2007. Castors, routes et chemins de fer: une problématique méconnue. *In Vivo (Brooklyn)*. 27, 8–10.
- Jonker, S.A., Muth, R.M., Organ, J.F., Zwick, R.R., Siemer, W.F., 2006. Experiences with Beaver Damage and Attitudes of Massachusetts Residents Toward Beaver. *Wildl. Soc. Bull.* 34, 1009–1021.
- Malison, R.L., Kuzishchin, K. V, Stanford, J.A., 2016. Do beaver dams reduce habitat connectivity and salmon productivity in expansive river floodplains? *PeerJ* 4, e2403. <https://doi.org/10.7717/peerj.2403>
- Martell, K.A., Foote, A.L., Cumming, S.G., Martell, K.A., Foote, A.L., Riparian, S.G.C., 2006. Implications for forest management Riparian disturbance due to beavers (*Castor canadensis*) in Alberta's boreal mixedwood. *Écoscience* 13, 164–171. <https://doi.org/10.2980/i1195-6860-13-2-164.1>
- Papier, C.M., Poulos, H.M., Kusch, A., 2019. Invasive species and carbon flux: the case of invasive beavers (*Castor canadensis*) in riparian Nothofagus forests of Tierra. *Clim. Chang.* 153, 219–234.
- Touihri, M., Labbé, J., Imbeau, L., Darveau, M., 2018. North American Beaver (*Castor canadensis* Kuhl) key habitat characteristics: review of the relative effects of geomorphology, food availability and anthropogenic infrastructure. *Écoscience* 25, 9–23. <https://doi.org/10.1080/11956860.2017.1395314>
- Tremblay, G., Valeria, O., Imbeau, L., 2017. Characterisation of Beaver Habitat Parameters That Promote the Use of Culverts as Dam Construction Sites: Can We Limit the Damage to Forest Roads? *Forests* 8, 494–507. <https://doi.org/10.3390/f8120494>
- Westbrook, C.J., Cooper, D.J., Anderson, C.B., 2017. Alteration of hydrogeomorphic processes by invasive beavers in southern South America. *Sci. Total Environ.* 574, 183–190. <https://doi.org/10.1016/j.scitotenv.2016.09.045>
- Proulx, G., Barrett, M., 1989. Animal Welfare Concerns and Wildlife Trapping: Ethics, Standards and Commitments. 1989 *Trans. West. Sect. Wildl. Soc.* 25, 1–6.
- Rosell, F., Hovde, B., 2001. Methods of aquatic and terrestrial netting to capture Eurasian beavers. *Wildl. Soc. Bull.* 29, 269–274. <https://doi.org/10.2307/3784008>
- Rosell, F., Kvinlaug, J.K., 1998. Methods for live-trapping beaver (*Castor* spp.). *Aspen Bibliogr.* 19, 1–28.
- Southwick, R., 2007. Eliminating trapping escalates beaver complaints and costs to the public. *Human-Wildlife Conflicts* 1, 141–143.
- Vantassel, S., 2006. The Bailey Beaver Trap: Modifications and Sets to Improve Capture Rate a b. *Proc. 22nd Vertebrate Pest Conf.* 22, 171–173.
- Weaver, K., Arner, D., Mason, C., Hartley, J., 1985. A Guide to Using Snares for Beaver Capture. *South. J. Appl. For.* 9, 141–146.

Breaching of Dams

- Billman, E.J., Kreitzer, J.D., Creighton, J.C., Habit, E., Mcmillan, B., Belk, M.C., 2013. Habitat enhancement and native fish conservation: can enhancement of channel complexity promote the coexistence of native and introduced fishes? *Environ. Biol. Fishes* 96, 555–566.
- Butler, D.R., Malanson, G.P., 2005. The geomorphic influences of beaver dams and failures of beaver dams. *Geomorphology* 71, 48–60.
- Collen, P., Gibson, R.J., 2001. The general ecology of beavers (*Castor* spp.), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish – a review. *Rev. Fish Biol. Fish.* 10, 439–461.
- Gibson, P.P., Olden, J.D., 2014. Ecology, management, and conservation implications of North American beaver (*Castor canadensis*) in dryland streams. *Aquat. Conserv. Mar. Freshw. Ecosyst.* 24, 391–409. <https://doi.org/10.1002/aqc.2432>
- Knudsen, G.J., 1962. Relationship of beaver to forests, trout and wildlife in Wisconsin. *Wisconsin Conserv. Dep. Tech. Bull.* 25, 50.
- Niles, J.M., Hartman, K.J., Keyser, P., 2013. Short-term Effects of Beaver Dam Removal on Brook Trout in an Appalachian Headwater Stream. *Northeast. Nat.* 20, 540–551.

Flow Devices

- Boyles, S., Savitzky, B., 2009. An Analysis of the Efficacy and Comparative Costs of Using Flow Devices to Resolve Conflicts with North American Beavers Along Roadways in the Coastal Plain of Virginia. *ICOET Proc.* 411, 641–646.
- Callahan, M., 2003. Beaver Management Study. *AMWS Newsl.* 44, 12–15. (USA) Region. *North Am. J. Fish. Manag.* 38, 1203–1225. <https://doi.org/10.1002/nafm.10223>
- Callahan, M., 2005. Best Management Practices for Beaver Problems. *AMWS Newsl.* 53, 12–15.
- Hood, G.A., Manaloor, V., Dzioba, B., 2018. Mitigating infrastructure loss from beaver flooding: A cost – benefit analysis. *Hum. Dimens. Wildl.* 23, 146–159. <https://doi.org/10.1080/10871209.2017.1402223>
- Lisle, S., 2001. Beaver management at the Penobscot nation, USA: using flow devices to protect property and create wetlands. *Proc. Eur. Beaver Symp.* 2, 147–156.
- Simon, L.J., 2006. Solving Beaver Flooding Problems through the Use of Water Flow Control Devices. *Proc. Twelfth Vertebr. Pest Conf.* 22, 174–180.
- Taylor, J.D., Singleton, R.D., 2014. The Evolution of Flow Devices Used to Reduce Flooding by Beavers: A Review. *Wildl. Soc. Bull.* 38, 127–133. <https://doi.org/10.1002/wsb.363>

MANAGING HUMAN-BEAVER CONFLICTS

Trapping

- Buech, R., 1983. Modification of the Bailey Live Trap for Beaver. *Wildl. Soc. Bull.* 11, 66–68.
- Gilbert, F., N., G., 1982. Terminal Dives in Mink, Muskrat and Beaver. *Physiol. Behav.* 28, 835–840.
- Huffaker, R.G., Bhat, M.G., Lenhard, S.M., 1992. Optimal trapping strategies for diffusing nuisance-beaver populations. *Nat. Resour. Model.* 6, 71–97.
- Koenen, K., Destefano, S., Henner, C., Beroldi, T. 2005. Capturing Beavers in Box Traps. *Wildl. Soc. Bull.* 33, 1153–1159.
- Ludders, J.W., Schmidt, R.H., Dein, F.J., Klein, P.N., Ludders, J.W., Schmidt, R.H., Dein, F.J., Klein, P.N., 1999. Drowning is not euthanasia. *Wildl. Soc. Bull.* 27, 666–670.
- McKinstry, M., Anderson, S., 2002. Survival, Fates, and Success of Transplanted Beavers, *Castor canadensis*, in Wyoming. *Can. Nat.* 116, 60–68.
- McKinstry, M.C., Anderson, S.H., 1998. Using snares to live-capture beaver, *Castor canadensis*. *Can. Field-Naturalist* 112, 469–473.
- Powell, R.A., Proulx, G., 2003. Trapping and Marking Terrestrial Mammals for Research: Integrating Ethics, Performance Criteria, Techniques, and Common Sense. *ILAR J.* 44, 259–379.

General Management Papers:

- Beck, J.L., Dauwalter, D.C., Gerow, K.G., Hayward, G.D., 2010. Design to monitor trend in abundance and presence of American beaver (*Castor canadensis*) at the national forest scale. *Environ. Monit. Assess.* 164, 463–479. <https://doi.org/10.1007/s10661-009-0907-8>
- Bhat, M., Huffaker, R.A.Y.G., Lenhart, S.M., 1993. Controlling Forest Damage by Dispersive Beaver Populations: Centralized Optimal Management Strategy. *Ecol. Appl.* 3, 518–530.
- DeStefano, S., Deblinger, R., 2005. Wildlife as valuable natural resources vs. intolerable pests: a suburban wildlife management model. *Urban Ecosyst.* 8, 179–190.
- Jensen, P.G., Curtis, P.D., Lehnert, M.E., Hamelin, D.L. 2001. Habitat and structural factors influencing beaver interference with highway culverts. *Wildl. Soc. Bull.* 29, 654–664.
- Johnson-Bice, S.M., Renik, K.M., Windels, S.K., Hafs, A.W., 2018. A Review of Beaver – Salmonid Relationships and History of Management Actions in the Western Great Lakes (USA) Region. *North Am. J. Fish. Manag.* 38, 1203–1225. <https://doi.org/10.1002/nafm.10223>
- Longcore, T., Rich, C., Muller-Schwarze, D., 2007. Management by Assertion: Beavers and Songbirds at Lake Skinner Riverside County, California. *Environ. Manage.* 39, 460–471. <https://doi.org/10.1007/s00267-005-0204-4>
- Payne, N., Peterson, R., 1986. Trends in Complaints of Beaver Damage in Wisconsin. *Wildl. Soc. Bull.* 14, 303–307.
- Riley, S.J., Decker, D.J., Carpenter, L.H., Organ, J.F., William, F., Mattfeld, G.F., Parsons, G., 2002. The Essence of Wildlife Management. *Wildl. Soc. Bull.* 30, 585–593.

BEAVER MANUALS BY GOVERNMENT OR OTHER AGENCIES

- Animal Protection Party of Canada & Animal Alliance of Canada. 2016. Techniques for Mitigating Human/Beaver Conflicts in Urban and Suburban Environments. Available at: https://www.animalalliance.ca/wp-content/uploads/2018/04/Beaver-Manual_May-2016.pdf
- D'Eon, R., LaPinte, R., Bosnick, N., Davies, C., MacLean, B., Watt, W., Wilson, G., 1995. The beaver handbook: a guide to understanding and coping with beaver activity. Ontario Ministry of Natural Resources, Northeast Science and Technology, FG-006, Queen's Printer for Ontario, Canada.
- Jennifer Rae Pierce. 2016. Understanding and Managing Beavers in Vancouver. Available at: https://sustain.ubc.ca/sites/sustain.ubc.ca/files/GCS/2016%20Project%20Reports/Understanding%20and%20Managing%20Beavers%20in%20Vancouver_Pierce_2016_0.pdf
- La Fondation de la Faune du Québec. 2001. Guide D'Aménagement et de Gestion Du Territoire Utilisé par le Castor au Québec. Available at: <http://www.fondationdelafaune.qc.ca/documents/File/GuideAmenagGestionTerritoireCastor.pdf>
- Ministry of Environment, Lands and Parks. 2001. Beaver Management Guidelines. Available at: <https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/best-management-practices/beaver-guide.pdf>
- Province of British Columbia. Management Guidelines in British Columbia, Beaver.
- The British Columbia Society for the Prevention of Cruelty to Animals [BCSPCA]. 2018. Wildlife and Rodent Control Standards. Available at: <https://spca.bc.ca/wp-content/uploads/AnimalKind-Wildlife-Control-Standards.pdf>
- United States Department of Agriculture. 2005. How to Keep Beavers from Plugging Culverts. Available at: <https://www.fs.fed.us/t-d/pubs/pdfpubs/pdf05772830/pdf05772830dpi300.pdf>
- Vermont Fish & Wildlife Department. 2002. Best Management Practices for Resolving Human-Beaver Conflicts in Vermont. Available at: https://dec.vermont.gov/sites/dec/files/wsm/wetlands/docs/Best_Management_Practices_for_Human-Beaver_Conflicts.pdf

PHYSIOLOGICAL KNOWLEDGE OF BEAVERS (INCLUDES BOTH *CASTOR CANADENSIS* AND *CASTOR FIBER*)

- Gruninger, R.J., Mcallister, T.A., Forster, R.J., 2016. Bacterial and Archaeal Diversity in the Gastrointestinal Tract of the North American Beaver (*Castor canadensis*). *PLoS One* 11, e0156457. <https://doi.org/10.1371/journal.pone.0156457>
- Stefen, C., Habersetzer, J., Witzel, U., 2016. Biomechanical aspects of incisor action of beavers (*Castor fiber* L.). *J. Mammal.* 97, 619–630. <https://doi.org/10.1093/jmammal/gyv209>

PREDATOR-PREY INTERACTIONS

- Baker, B., Peinetti, H., Coughenour, M., Johnson, T., 2012. Competition favors elk over beaver in a riparian willow ecosystem. *Ecosphere* 3(11), 1–15.
- Gable, T., Windels, S., 2018. Kill Rates and Predation Rates of Wolves on Beavers. *J. Wildl. Manage.* 82, 466–472. <https://doi.org/10.1002/jwmg.21387>
- Gable, T.D., Windels, S.K., Bruggink, J.G., Homkes, A.T., 2016. Where and How Wolves (*Canis lupus*) Kill Beavers (*Castor canadensis*). *PLoS One* 11, e0165537. <https://doi.org/10.1371/journal.pone.0165537>
- Latham, A.D.M., Latham, M.C., Knopff, K.H., Hebblewhite, M., Boutin, S., 2013. Wolves, white-tailed deer, and beaver: implications of seasonal prey switching for woodland caribou declines. *Ecography (Cop.)* 36, 1276–1290. <https://doi.org/10.1111/j.1600-0587.2013.00035.x>
- Tadich, T.A., Novaro, A.J., Kunzle, P., Chacón, M., Barrientos, M., Briceño, C., 2018. Agonistic behavior between introduced beaver (*Castor canadensis*) and endemic culpeo fox (*Pseudalopex culpaeus lycoides*) in Tierra del Fuego Island and implications. *Acta Ethol.* 21, 29–34.

PUBLIC OR STAKEHOLDER PERCEPTIONS OF BEAVERS

- Jonker, S.A., Muth, R.M., Organ, J.F., Zwick, R.R., Siemer, W.F., 2006. Experiences with Beaver Damage and Attitudes of Massachusetts Residents Toward Beaver. *Wildl. Soc. Bull.* 34, 1009–1021.
- Jonker, S.A., Organ, J.F., Muth, R.M., Zwick, R.R., Siemer, W.F., 2009. Stakeholder Norms Toward Beaver Management in Massachusetts. *J. Wildl. Manage.* 73, 1158–1165. <https://doi.org/10.2193/2004-160>
- McKinstry, M., Anderson, S., 1999. Attitudes of Private- and Public-Land Managers in Wyoming, USA, Toward Beaver. *Environ. Manage.* 23, 95–101.
- Morzillo, A.T., Needham, M.D., 2015. Landowner Incentives and Normative Tolerances for Managing Beaver Impacts. *Hum. Dimens. Wildl.* 20, 514–530. <https://doi.org/10.1080/10871209.2015.1083062>
- Organ, J.F., Ellingwood, M.R., 2008. Wildlife Stakeholder Acceptance Capacity for Black Bears, Beavers, and Other Beasts in the East. *Hum. Dimens. Wildl.* 5, 63–75. <https://doi.org/10.1080/10871200009359188>
- Payne, N., Peterson, R., 1986. Trends in Complaints of Beaver Damage in Wisconsin. *Wildl. Soc. Bull.* 14, 303–307.
- Santo, A.R., Guillozet, K., Sorice, M.G., Baird, T.D., Gray, S., Donlan, C.J., Anderson, C.B., 2017. Examining Private Landowners' Knowledge Systems for an Invasive Species. *Hum. Ecol.* 45, 449–462. <https://doi.org/10.1007/s10745-017-9920-7>
- Siemer, W., Jonker, S., Decker, D., Organ, J., 2013. Toward an understanding of beaver management as human and beaver densities increase. *Human-Wildlife Interact.* 7, 114–131.

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