

# Beaver Habitat Best Management Practices



Beaver dam at the South Prairie Creek Preserve in Pierce County, WA. Photo by Liz Bocktiegel.



Washington  
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**FISH &  
WILDLIFE**

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# Beaver Habitat Best Management Practices

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# Acknowledging the Indigenous People of the Pacific Northwest

Since time immemorial, Indigenous People have graced the Pacific Northwest with rich traditions of many diverse cultures, languages, traditional knowledge expressed artistically and practically with intricate principles passed down throughout generations. As the first stewards of this land, Indigenous People from this part of the world are ancestrally engrained in the very fabric of this region that is known today as Washington State.

Washington Department of Fish and Wildlife (WDFW) acknowledges the American Indian Tribes as the original occupants of this land enjoyed today by all Washingtonians. Their historic reliance to hunt, fish, and gather traditional foods defines their inherent responsibilities to protect and steward the precious resources on the waters and landscape shared today by all Washington residents.

The very survival of the Pacific Northwest Tribes is a testament of resiliency of what they have endured and continue to endure throughout generations on this very landscape. Through scarred valor, many historical encounters of massacre, renunciation of religious freedom, systemic racism, cultural assimilation of native children through institutional residential schools, and the fight for their inherent rights and liberties, they have prevailed. Throughout this tormented history brought by colonization, abrogated treaties, infringement of civil rights, and the salmon protests of the 1960s, the Northwest Tribes and WDFW have founded a commitment of respect, unity, and alliance taught by the realities of the past.

Today tribal governments and WDFW work collaboratively to conserve and manage aquatic and terrestrial resources across the State and practice sound science to ensure successful resource management decisions. The Tribes and WDFW work together to ensure the sustainability of fish, wildlife, ecosystems, and culture for the next seven generations and beyond.

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**List of Acronyms**

BDA	Beaver Dam Analogues
BIP	Beaver Intrinsic Potential
BMP	Best Management Practice
BRAT	Beaver Restoration Assessment Tool
BRR	Beaver-Related Restoration
HPA	Hydraulic Project Approval
PBR	Process-Based Restoration
PHS	Priority Habitats and Species
RCW	Revised Code of Washington
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife

# Introduction

## Purpose

The purpose of this document is to highlight the importance of the American beaver (*Castor canadensis*) for native ecosystems in Washington State, discuss the challenges of living (coexisting) with beavers, and identify best management practices (BMPs) that promote coexistence between humans and beavers in Washington. Coexistence is essential because while beavers can impact human infrastructure, they are crucial in supporting ecological functions and climate resilience. Our goal is to help people better understand the many benefits that beavers provide, while offering practical solutions to the challenges beaver activity poses to human infrastructure.

## Beavers in Washington: An overview of their history, benefits, management challenges, and opportunities.

In 2023, WDFW commissioned a synthesis report from Washington State University, [American Beaver \(\*Castor canadensis\*\) and Freshwater Climate Resiliency in Washington State](#) (Burgher et al. 2023) to create a foundational document for WDFW to reference and share. This report provides a detailed overview of the history of beavers in Washington and the ecological benefits they provide. It also examines the intersection between beavers and climate change, exploring how effective management of beavers can promote resiliency in a changing climate. Several additional frameworks developed in Washington recognize that beaver habitat management and restoration can increase resilience to climate change, including [Washington State Climate Resilience Strategy](#) (Department of Ecology, 2024) and WDFW's publication [Preparing Washington Department of Fish and Wildlife for a changing climate: assessing risks and opportunities for future action](#) (Shirk et al 2021). We encourage readers to explore these resources to better understand the ecology of beavers, how they influence the environment (both in natural and human-dominated environments), and how they can improve climate resiliency. Below, we summarize key points from the Burgher et al. (2023) synthesis that support the best management practices discussed later in this document.

Beavers are large, semi-aquatic rodents that have been contributing to ecosystem function in North America, including Washington, for several million years (Burchsted et al. 2010). Prior to European colonization, 60 - 400 million beavers inhabited a wide range of habitats across nearly the entire continent (Naiman et al. 1988, Seton 1929, Walcheck 2018). Over these millennia, beavers coevolved with native habitats and other animals creating a web of complex connections. Beavers are known as 'ecosystem engineers' due to their ability to transform, create, and maintain different habitats through dam building, canal digging, and altering vegetation communities. Over time, native habitats and species have adapted to and become reliant on many of the changes that beavers make to the environment, which we think of broadly as ecological benefits.

Beavers also provide benefits to humans which are referred to as ecosystem services (Costanza et al. 1997). Evidence shows that beaver activity can provide many ecosystem services, or benefits, such as

water purification, reduced impacts from extreme weather, enhanced recreation opportunities, improved habitat conditions for fish and wildlife, enabling pollination by insects and birds, increasing fire resiliency of riparian habitat, and managing floodwaters in wetlands. There have been some recent attempts, such as a review by Thompson and colleagues (2021), to propose different dollar values for beaver-provided ecosystem services to signal their value to society and aid in management decisions.



An American beaver near Bothell, WA, forages on grass. Photo by Megan Shchepetov.

Historically, beavers have been revered by Pacific Northwest and other Native American Tribes which have peacefully coexisted on the landscape with beavers for millennia before Euro-American colonization. They were sustainably harvested for their meat and fur and considered a key component of nature in balance by native people. Beavers provide many ecosystem services and benefits, but their importance is often only apparent after their removal from the landscape leads to loss or degradation of those services or benefits.

Since European colonization of North America, the relationship between beavers and humans has been a complicated one, historically marked by conflict and over-hunting (Figure 1). When Europeans arrived in North America, the abundance of beavers and the relative ease of trapping led to the rapid expansion of commercial fur trapping, driven largely by European demand for beaver pelts (Backhouse 2015). Extensive trapping continued throughout the 1800s, which led to steep declines in beaver populations

and to beavers being almost fully extirpated from most of their historic range by the early 1900s (Baker and Hill 2003). At the same time as beaver populations were declining, European settlers were rapidly moving into developing areas, that had historically supported the presence of beavers.

Over the next century, recognition of the ecological benefits that beavers provide grew along with concern about their steep population declines. To sustainably manage the beaver population, Washington State added them to the game code in 1909 (Remington and Ballinger 1910) and began implementing protections to assist in population recovery. As the population of beavers started to recover, conflicts with human development and infrastructure also became more common. Early beaver relocation efforts in Washington State began in the 1920s, involving moving beavers from areas in which their presence created undesirable impacts to less developed areas where their presence would have less impact (Washington State Department of Agriculture 1920). These relocation efforts were frequently motivated by the recognition that beavers provided major ecological benefits to streams, including water retention, erosion control, and fish habitat improvement (Couch 1942), while at the same time providing a remedy to beaver conflicts in areas more heavily populated by people (reviewed in King County 2020).

As society continues to struggle with balancing the benefits and potential impacts of beavers in human landscapes, WDFW recognizes the need to provide more guidance on how to navigate the challenge of adequately protecting human infrastructure while supporting opportunities for beavers to coexist with humans and provide ecological benefits. This document seeks to take a step in that direction. We begin by highlighting how beavers can directly benefit key habitats throughout the state (Environmental Benefits of Beavers to Priority Habitats and Species), as well as the variety of ways beaver activity can negatively impact human property and infrastructure, such as roads, bridges, human built dams, and water systems ([Human and Beaver Conflict Section](#)). We finish with a broad overview of recommendations on how to minimize and mitigate these negative impacts ([Strategies for Navigating Human-Beaver Conflict Section](#)). While only a starting point, this document intends to provide a common foundation for conversations around practices that minimize the impacts beavers have on human infrastructure and property while recognizing and upholding the ecological benefits of beavers to Washington State's natural environment.

# Beaver History Timeline



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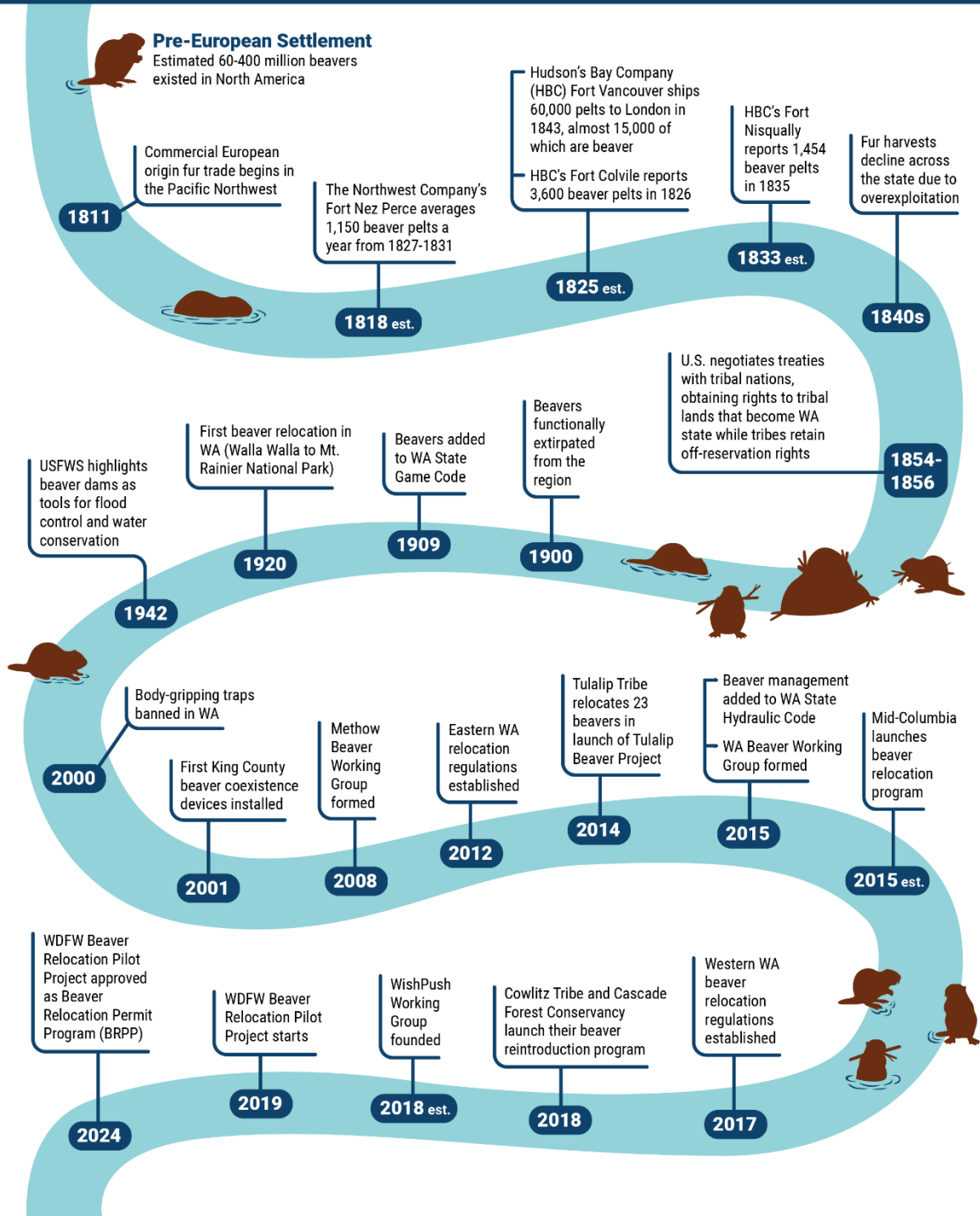


Figure 1. A detailed timeline of the history of beavers in the State of Washington adapted from King County, WA, 2019 with input from Washington Beaver Working Group.

# Environmental benefits of beavers to Priority Habitats and Species

The Priority Habitats and Species program provides WDFW's recommendations for which species and habitats local governments should designate and protect as Fish and Wildlife Habitat Conservation Areas (FWHCA) under the Growth Management Act (primarily through Critical Area Ordinances) and the Shoreline Management Act. The Priority Habitats and Species program includes species that are vulnerable to decline and habitats that are important because of their unique or significant value to many species. Beaver populations in Washington do not meet the criteria for listing as a Priority Species. Habitats supporting beaver, such as riparian areas, wetlands, in-stream habitats, and nearshore environments, are listed as Priority Habitats and often encompass areas where there are beaver dams. Beaver activities enhance the longevity, resilience, and function of many Priority Habitats and provide important co-benefits to many Priority Species. Consequently, beaver management has important implications for Priority Habitat functions in Washington. Specifically, beaver removal can have unintended and sometimes dramatic negative impacts on Priority Habitats and Species. WDFW also issues Hydraulic Project Approvals (HPA) for work that falls under the state's Hydraulic Code (Chapters 77.55 RCW and 220-660 WAC), including alterations to beaver dams to protect fish life. Below, we discuss the Priority Habitats and Species that directly benefit from beaver activity and highlight the key functions that could be lost when beavers are removed from the landscape.

## Beavers and Priority Habitats

Beavers are highly adaptable and can survive and thrive in many environments, so long as there is a perennial water source deep enough to provide cover and ample, edible vegetation. Of the 20 listed Priority Habitats in Washington ([WDFW Priority Habitat and Species List](#)), ten are known to be occupied by beaver, including: Aspen Stands, Biodiversity Areas and Corridors, Eastside Steppe, Shrubsteppe, Westside Prairie, Riparian, Freshwater Wetlands, Instream Habitat, Coastal Nearshore, and Puget Sound Nearshore. Of these ten, Instream Habitat, Riparian areas, Freshwater Wetlands, and Shrubsteppe (in its various iterations) receive the greatest benefit from beaver activities.

### Priority Habitats known to be occupied by beaver:

- Aspen Stands
- Biodiversity Areas and Corridors
- Eastside Steppe
- Shrubsteppe
- Westside Prairie
- Riparian
- Freshwater wetlands
- Instream Habitat
- Coastal Nearshore
- Puget Sound Nearshore

Most of the positive impacts of beavers are linked to how the animals modify the movement and location of water, especially where ecological functions like water retention and hydrologic complexity have been lost or impaired (Law et al. 2017). For example, dam building impounds water and forms shallow ponds and wetlands (Naiman et al. 1988), and the excavation of canals across floodplains enhances connectivity between different types of habitats along riparian corridors and improves conditions for native riparian vegetation (Cooke and Zack 2008, Cramer et al. 2012, Pollock et al. 2014). When beaver fell, girdle, and coppice trees, they also produce snags and logs (Thompson et al. 2015), a Priority Habitat feature, which are required by many Priority Species. Habitats modified by beavers tend to be more complex and dynamic, increasing the diversity of habitats and species along riparian corridors (Willby et al. 2018, Larsen et al. 2021). Combined, all these activities lead to lush, diverse habitats that are more resilient to drought and wildfire which can then provide refuges for wildlife during natural disasters (Fairfax and Small 2018, Fairfax and Whittle 2020, Grudzinski et al. 2022). Below, we provide a high-level overview of the Priority Habitats most influenced by beavers and highlight the ecological benefits beavers provide to these ecosystems.

### **Instream habitat**

Instream habitat refers to the ecological environments found within rivers and streams. Key components of instream habitat include physical features such as pools, riffles, sediment, and wood that create various niches for organisms. Healthy instream habitats are dependent on and influence key ecosystem processes such as nutrient cycling and sediment dynamics. In addition to being a Priority Habitat, instream habitat is also regulated directly by WDFW under its HPA authority to ensure that construction or performance of work by humans that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state is done in a manner that protects fish life and their habitat.

Beavers can be found in streams of all sizes across Washington, typically constructing dams in narrow, low-sloped, low-velocity streams. Beavers significantly enhance instream habitat by improving its structural complexity. Of all their activities, dam building and canal digging have the most profound benefit. The construction of dams creates ponds and digging canals creates side channels that generate slow-moving or still water areas alongside faster currents, providing critical feeding and resting habitats for fish. The impoundment of water and its redirection across the floodplain also increase water storage, including enhanced groundwater recharge, and reduce downstream sedimentation and flooding. Felling of trees to create dams also adds wood material, which creates critical habitat for fish. Over time, if dams persist, they can raise the bed of eroded streams, restore riparian vegetation, and enhance stream health and resilience.

### **Riparian areas and Shrubsteppe habitat**

Riparian areas are the zones along natural water bodies where the habitat transitions from aquatic to terrestrial (i.e., wet to dry). They can be found throughout Washington, along streams, rivers, lakes, seeps, and springs. Floodplains, which are low-lying areas that become inundated during flooding events, often co-occur with riparian areas. Riparian areas are designated as Priority Habitat because of their critical role in perpetuating fish and wildlife, connecting habitats, stabilizing shorelines, regulating

water temperatures, filtering runoff, and sustaining diverse communities of plants and animals. The ecological benefits of riparian areas are reviewed extensively in [Riparian Ecosystems, Volume 1: Science Synthesis and Management Implications \(Quinn et al. 2020\)](#), and detailed recommendations for managing Riparian areas in Washington are in [Riparian Ecosystems, Volume 2: Management Recommendations \(Rentz et al. 2020\)](#).

Most riparian areas with low-gradient, perennial streams in Washington were likely historically occupied by beavers (Naiman et al. 1988). Beaver activity can establish, enhance, and maintain riparian ecosystem functions and processes (Bergstrom 1985, Cooke and Zack 2008, Hood and Larson 2014 a). The construction of dams and canal digging by beavers can promote the growth and germination of native riparian species by elevating the water table, reversing stream incision, and increasing connections between floodplains and the waterways. Beaver burrows and tunnels can also serve as habitat features for wildlife (Rosell et al. 2005, Gorman et al. 2006). Felling of trees can create light gaps in the canopy that promote the germination and growth of saplings and understory vegetation, which contributes to greater diversity in riparian vegetation communities (Cooke and Zack 2008, Gibson and Olden 2014, Fairfax and Whittle 2020).

Beavers are particularly important for riparian areas in dryland habitats, such as Shrubsteppe, where water is a scarce resource (Cooke and Zack 2008, Demmer and Beschta 2008, Gibson and Olden 2014, Pollock et al. 2014, Quinn et al. 2020). Shrubsteppe is an arid habitat that can be found across much of Eastern Washington and is dominated by an overstory of big sagebrush (*Artemisia tridentata*), woody shrubs, and perennial bunchgrasses (Dobler et al. 1996). Riparian areas in Shrubsteppe that contain beaver dams and ponds are more resilient to droughts and wildfire (McKinstry et al. 2001, Cooke and Zack 2008, Fairfax and Small 2018) than areas without beaver dams. Resilience to wildfire is especially important as wildfires in Eastern Washington have been getting more intense and damaging, fueled by invasive, fast-growing cheatgrass (*Bromus tectorum*) and other annual grass species (Azerrad et al. 2011). Overall, beaver presence and activity are strongly linked to improvement of riparian function and can help make these critical habitats more resilient in the face of increasing drought and wildfires.

## **Freshwater wetlands**

Freshwater wetlands include swamps, marshes, bogs, fens, wet meadows, vernal pools, and similar areas. The Growth Management Act classifies wetlands as a “critical area” and defines them as areas that are inundated or saturated by surface water or groundwater often enough to develop hydric soils and support a prevalence of vegetation adapted for life in saturated soil conditions (RCW 36.70A.030). Freshwater wetlands provide many critical functions, including improved water quality, providing wildlife habitat, mitigating floods and droughts, and protecting the overall health of watersheds (Mitsch et al. 2023).

Beavers will often inhabit or create wetlands in areas with suitable conditions (Brazier et al. 2020). When beaver dams and canals maintain water in low-lying areas, saturated soil can support wetland obligate plant species. Beaver complexes promote diverse and perennial wetland habitat (Gibson and Olden 2014) by constricting outlets and keeping water on the land for longer periods of the year. Beaver

wetlands can be characterized as a mosaic of plant communities and diverse flow regimes, leading to complex microhabitats that might otherwise not exist (Rosell et al. 2005, Hood and Larson 2014 b).

## Beavers and Priority Species

Many species listed under the WDFW Priority Habitats and Species program rely on or use beaver-influenced habitat for breeding, foraging, and cover. WDFW recognizes that beaver activity can greatly enhance the functions and resiliency of Priority Habitats and, in so doing, provide direct benefits to Priority Species.

### Native fish species and fish passage

Native fish and beavers in Washington have coexisted for at least six million years (Horn et al. 2011, Quinn et al. 2020), with many fish species directly benefiting from beaver activity. This includes many salmonid species such as Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), cutthroat trout (*O. clarki*), steelhead (*O. mykiss*), and sockeye salmon (*O. nerka*). and . Other non-salmonid species that benefit include Olympic mudminnow (*Novumbra hubbsi*), lake chub (*Couesius plumbeus*), river lamprey (*Lampetra ayresi*), and margined sculpin (*Cottus marginatus*).

The creation of pools behind beaver dams and the slowing down of water provide some of the greatest direct benefits to fish; it is thought that the decline of many threatened and endangered salmonid species can be linked to the decline of this key habitat. For example, Pollock et al. (2003) hypothesized that the loss of pools and slow water habitat linked to the decline of beavers across Washington contributed to the decline in Chinook and coho populations. They linked the decline of pools and slow-water habitat in the Stillaguamish Basin (attributed to the absence of beavers) in the 20th century with a 61% decline in summer habitat capacity for coho juveniles. The authors concluded that this limitation on slow-water habitat over the summer has contributed to the decline of coho salmon populations in the Pacific Northwest which led to some populations being listed as threatened under the Endangered Species Act (Pollock et al. 2003).

While beaver dams are linked to the creation of fish-habitat, there have been concerns raised about the possibility of beaver dams blocking anadromous fish movement. Overall, many studies have demonstrated that the presence of beaver dams does not block the movement of anadromous salmonids for most of the year (Lokteff et al. 2013, Bouwes et al. 2016, Pollock et al. 2022, Needham et al. 2025). This is attributed to beaver dams, unlike most human-engineered dams, being semi-permeable (e.g., water can move through the structure) and subject to change in shape (Ronnquist and Westbrook 2021). Salmonids take advantage of these characteristics to break through beaver dams, access side channels, and jump over low spots or notches in the dam. The exact method of getting around dams depends on the species, with different salmon species interacting with beaver dams in different ways. For example, Chinook, coho, steelhead, and sockeye salmon are more likely to jump over dams, while chum salmon, which are not as strong at jumping, will often ram the structure with their bodies until a hole is created. When one chum succeeds in making a hole in the dam, or deforming a section enough to swim over, other chum salmon waiting below the dam will surge through (Quinn et al. 2020).

On the other hand, some research has found that beaver dams can temporarily block the movement of fish in early fall (August-October), when stream levels can be at their lowest. This can be amplified by drought or upstream water withdrawals for irrigation in late summer (Lowry 1993, Mitchell and Cunjak 2007). Also, newer beaver dams (less than two years old) may have shallow plunge pools on the downstream side, which can limit the height that fish can jump (King County 2020, Larsen et al. 2021). When beaver dams do block fish movement, it is often only temporary, with conditions improving as dam complexes mature (which can lead to smaller, shorter dams overall; King County 2020, Larsen et al. 2021) or when they are blown out or otherwise altered by seasonally high flows (Butler and Malanson 2005). In summary, beaver dams provide critical habitat for many native species of fish in Washington, and while they can temporarily block movement, these impacts tend to be short-lived with most native fish species having evolved ways to circumvent them as they move up and down stream. Overall, beaver dams are thought to increase the complexity and diversity of instream habitat to the benefit of native fishes.

### **Amphibian species**

Several priority species of frogs, including Oregon spotted frog (*Rana pretiosa*), Northern leopard frog (*R. pipiens*), and Columbia spotted frog (*R. luteiventris*), use beaver ponds and wetlands preferentially (Hallock 2013, Lingo 2013, Arkle and Pilliod 2015, Zero and Murphy 2016). Oregon spotted frog, a federally threatened species, have demonstrated a particularly strong reliance on beaver habitat (Hallock 2013). Amphibians are often one of the first groups of vertebrates to make extensive use of beaver ponds and wetlands (Rosell and Campbell-Palmer 2022). They benefit from the improved floodplain connections and shallow, slow-moving water habitat created by beaver dams, especially along low order, headwater streams. This is especially important for the creation of amphibian breeding areas where they would otherwise not exist (Dalbeck et al. 2007). Amphibians rely on the habitat conditions that are promoted by beaver activity and are susceptible to population decline due to habitat loss when beavers or beaver structures are removed.

### **Bird species**

Many bird species, especially waterfowl, herons, and raptors, benefit directly from beaver habitat and in some cases depend on habitat provided by beavers (Brown et al. 1996, McKinstry et al. 2001, Müller-Schwarze 2011, Johnston 2017, reviewed in Rosell and Campbell-Palmer 2022). This includes several priority species of birds in Washington such as sandhill cranes (*Antigone canadensis*), trumpeter swans (*Cygnus buccinator*), common loons (*Gavia immer*), and many species of cavity-nesting ducks. When beavers impound water to create ponds and wetlands and expand riparian areas, they enhance foraging, nesting, and breeding opportunities for many bird species, which increases bird diversity, abundance, and density (McCall et al. 1996, Nummi and Hahtola 2008, Nummi and Holopainen 2020). In highly developed areas with limited wetlands, beaver activity can play an important role in creating more habitat for resident species and providing rest stops for migratory birds (Müller-Schwarze 2011). Beaver activity promotes the creation of habitat that many native species of birds in Washington require and can be a critical source of habitat in urban areas where most habitat has been altered or destroyed.

## **Conclusions: Managing beavers for ecosystem benefits**

WDFW encourages local governments and other landowners and managers to consider the benefit of beavers for Priority Habitats and Priority Species when making land use decisions. When feasible, we encourage local governments to retain beavers on the landscape to promote natural processes that enhance habitat functions, including increasing water retention, promoting fish habitat, improving connections between a stream and its floodplain, and enhancing habitat complexity. Allowing beavers to persist can be a natural way to buffer many Priority Habitats from negative impacts that come from development in and around these critical areas. Improving these habitat functions supports conditions for many Priority Species and promotes ecosystem services that directly benefit people, such as mitigating the risks of flooding and drought (Brazier et al. 2020, Jordan and Fairfax 2022).

We do recognize that, despite the many ecological benefits beavers provide, when they live near humans, the same beaver activities that provide ecological benefits can cause damage to infrastructure and property. As a result, it can be challenging to maintain beavers in certain landscapes. In the next section, we provide an overview of the most common sources of beaver-human conflict and where they are most likely to occur.

## Human-beaver conflict

Human-beaver conflicts are most likely to occur in areas where there are sufficient freshwater and woody vegetation, and significant human development such as roads, private properties, natural resource restoration sites, stormwater facilities, or agricultural lands. Below, we describe the three most common sources of human-beaver conflict: damage to trees, crops, or other vegetation; impairment of culverts and other water infrastructure; and flooding of property or infrastructure built in historic floodplains and other low-lying areas (Müller-Schwarze 2011, Krueger et al 2021).

### Beyond Removal

In the past, human-beaver conflicts were often managed by removing beavers from the landscape. However, removal is rarely a long-term solution due to high rates of recolonization in areas with suitable beaver habitat.

Advancements in coexistence strategies aim to mitigate the negative impacts on humans without removing beavers from the landscape.



An urban beaver chewing on branches at a feeding station set up under a bridge. Photo by Jen Vanderhoof.

## Damage to trees, crops, and other vegetation

One source of beaver conflict can occur when beavers damage trees, plants, and crops. Beavers often feed on deciduous trees and shrubs within a short distance of water and can fell several small trees in a single night. Beavers do not ingest wood for nutrition but instead feed on the sugary inner layer of bark on trees and shrubs known as cambium. They will also eat the leaves, twigs, fruits, and younger stems of a plant. Beavers typically prefer to feed on willows (*Salix* spp.), poplars (e.g., *Populus trichocarpa* and *tremuloides*), and alders (*Alnus* spp.), but they can ingest hundreds of different plant species (Rosell and Campbell-Palmer 2022). Beavers typically harvest trees and shrubs with a stem diameter of less than 4 inches (Haarberg and Rosell 2006, King County 2018). However, they are fully capable of felling very large trees. This behavior and activity can cause conflicts when beavers impact agricultural or ornamental trees and plants. This type of conflict is one of the most reported types (Kruger et al. 2021) and one of the most noticeable, given the stumps and de-barked trees and branches that beavers leave behind.

Beavers are known to forage on a wide variety of crops, including wheat, oats, sugar beets, carrots, cabbages, potatoes, broccoli, peas, corn, sunflowers, and many types of nut and fruit trees (Müller-Schwarze 2011, Rosell and Campbell-Palmer 2022). Valuable plants, crops, and orchard trees can be difficult to protect from beavers, but several protective techniques, like fencing, do exist. While trees can be replanted, this comes at a cost, and it can take many years for them to achieve a size sufficient to provide the desired benefits and functions.

## Blocked culverts and compromised water infrastructure

Another common source of human-beaver conflicts can occur when beavers plug culverts (Krueger et al. 2021). Culverts are concrete, metal, or plastic pipes used to convey surface water under and around infrastructure like roads and buildings. Wherever roads, trails, or railways cross waterways, culverts are a common way to maintain flow and prevent flooding harmful to infrastructure. Culverts can overlap with beaver habitat because of their varied uses in streams, irrigation ditches, and stormwater conveyance. Beavers are often drawn to culverts as a constriction point in the stream that is easily blocked. When beavers dam up and block culverts, they impair the intended function of the infrastructure. This can cause flooding upstream and on adjacent roadways or property and can clog irrigation infrastructure affecting flows expected for crops. Often, these blockages require immediate maintenance to restore flow.

Beavers are known to build dens within stormwater ponds, catch basins, on top of pipes, or within other stormwater infrastructure. While beavers living in and around stormwater infrastructure may not cause direct impacts all times of year, beaver activity can present a challenge during flood events. Stormwater systems are designed to convey water and their ability to do so may be compromised by wood or denning material collected by beavers.



Beaver lodge built in a channel adjacent to an active railroad line. Photo by Jen Vanderhoof.

## **Flooding of adjacent floodplain property**

Flooding is a primary source of human-beaver conflict. Flooding can result from plugged culverts, especially near roads, and free-standing beaver dams can lead to flooding of businesses, parking lots, homes, and other infrastructure in the floodplain, especially during high-water events. Flooding upstream of beaver dams is more common than downstream, although downstream flooding can occur when large beaver dams fail (Butler and Malanson 2005). Flooding can limit access to property, damage and destroy infrastructure, and lead to the loss of vegetation when the roots of shrubs and trees that are unadapted to long-term, wet conditions are inundated. Beavers can also damage and jeopardize berms, dikes, levees, or other infrastructure intended to prevent flooding in specific areas by excavating through these structures. When these structures are compromised, they are more likely to breach during high-water events, leading to significant impacts.



Beaver lodge and pond flooding a fenced area. Photo by Jen Vanderhoof.

### **Conclusions: Managing beaver impacts on human infrastructure**

Despite the many benefits of beavers, they can have significant and widespread impacts on human infrastructure and property. Damage to trees, crops, and other valuable vegetation can cause financial stress, blockages to culverts and other water infrastructure can lead to costly maintenance and damage repair, and flooding from beaver activity can cause widespread, negative impacts to property and infrastructure. Coexistence between beavers and humans can be promoted through the adoption of best management practices that can minimize the impacts of beaver activities on human property and infrastructure, while retaining many of the ecological benefits provided by beavers. In the following section, we explore the possibilities of coexistence and provide recommendations for best management practices for avoiding or reducing these conflicts.

# Strategies for navigating human-beaver conflict

Beavers can often co-exist with people and infrastructure. Working with local governments and landowners we can proactively identify areas where beavers can live without causing conflict with humans, where human infrastructure and development will not be impacted, or where potential impacts can be mitigated. Where beavers are present, anticipating potential future impacts to infrastructure can be the most cost-effective solution for land managers and property owners.

Once suitable beaver habitat or the presence of beavers are identified, beaver coexistence BMPs (Table 1) can be used to minimize damage associated with beaver activity by using affordable and effective solutions that seek to retain as much of the beaver-related ecological benefits as possible (Callahan 2003, Hood et al. 2017, King County 2017). These actions allow beavers to stay on the landscape while reducing or eliminating the risk to property, agriculture, or infrastructure from their activity. Choosing to coexist with beavers, as opposed to repeatedly removing them, can also be the more economical option, with many of the BMPs costing less money and time than repeated removal (WDFW 2004, King County 2017, Shockey 2024a, b).

The BMPs described in Table 1 can help address the major conflicts discussed in the [Human and Beaver Conflict Section](#). Preventing and resolving human-beaver conflicts should be approached on a site-by-site basis, preferably with advice and consultation with trained professionals. Because every site and situation is unique, a combination of strategies and tools may offer the best solution for different conflicts. Many Washington-based coexistence practitioners, non-governmental organizations, or Conservation Districts have programs or access to funding or, in the absence of funding, can provide technical assistance for this type of work. At the time of this writing, the Washington Beaver Working Group hosts an [online map of Washington beaver coexistence practitioners and relocators](#).

**Table 1. Summary of beaver coexistence best management practices**

Beaver Impact	Best Management Practice (BMP)	Overview of how BMP reduces beaver impacts
Damage to trees, crops, and other vegetation	#1 Restore native species in riparian buffers	Planting dense native vegetation can help provide a stable source of food and denning material for beavers which can reduce the likelihood they will damage valuable vegetation.
Damage to trees, crops, and other vegetation	#2 Tree protection	A barrier is installed around trunks of individual trees or surrounding groups of valuable trees to deter beavers from chewing or damaging trees.
Blocked culverts and compromised water infrastructure	#3 Culvert exclusion fencing*	Fencing is installed around the ends of a culvert to prevent beavers from building a dam within the culvert. This can help encourage dam building in areas that are not going to negatively impact human infrastructure.
Flooding of adjacent floodplain property	#4 Notching beaver dams*	Creation of a strategically placed hole in a beaver dam that controls the water level in the pool behind the beaver dam. This can help reduce the chance of flooding by keeping the pools behind beaver dams at a specific level. May require exclusion fencing to prevent beavers from plugging up the notch.
Flooding of adjacent floodplain property	#5 Installation of water level control devices*	A pipe is inserted into the beaver dam that limits the height of the water and regulates the water level behind the dam. This is often paired with an exclusion fence to prevent beavers from plugging the pipe up. It tends to be more permanent than a notch and can also help reduce the flooding risk around the dam.
Flooding of adjacent floodplain property	#6 Beaver dam removal*	Can be used when other BMPs are not feasible and can help reduce the chance of flooding around a beaver dam. If beavers are still in the area, it is highly likely they will rebuild so this tends to be a short term solution.

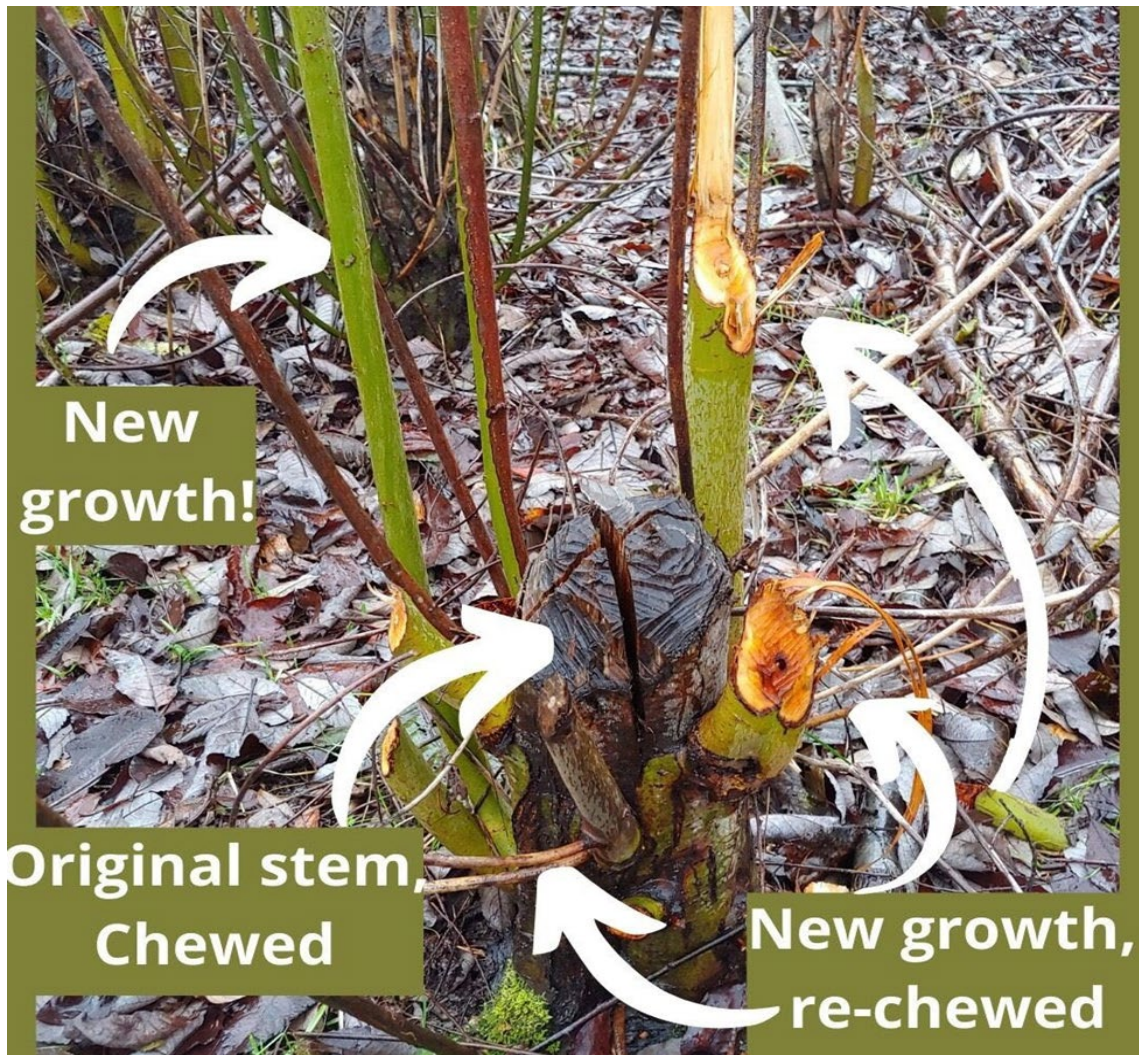
*\*These actions likely require [Hydraulic Project Approval](#) permit from WDFW. Please reach out to your [local area habitat biologist](#) for further assistance.*

## Beaver Impact: Damage to trees, crops, and other vegetation

Beavers feed primarily on the cambium (inner bark) of deciduous trees and shrubs. This feeding behavior frequently creates conflicts with humans when beavers damage agricultural crops, ornamental plants, and fruit trees. Damage to trees is one of the most reported and visible types of human-beaver conflict. The following coexistence strategies seek to prevent beavers from damaging valuable trees, crops, and other vegetation.

## **Beaver Coexistence BMP #1: Restore native species in riparian buffers**

One proactive strategy that can help protect valuable plants is to install and maintain a buffer zone of riparian plants. A dense planting of beaver-preferred species such as willows, cottonwoods, or aspen along shorelines can help satisfy the foraging and feeding needs of beavers and reduce consumption of other trees, crops, or other valuable plants all year round (Rosell and Campbell-Palmer 2022). Riparian buffers can have the added benefit of protecting water quality and improving habitat conditions for fish, other aquatic species, and wildlife species that use riparian areas (Rentz et al. 2020). The implementation and maintenance costs of this BMP are concentrated in the first few years, with costs varying depending on the type of tree and shrub species being introduced (preferably native to that area), the number of individuals being planted, and the size of the riparian buffer. Some maintenance may be required in the beginning, such as installing covers to protect new plants from herbivory. However, once established, most riparian areas will require little maintenance since most native species like willows are well-adapted to beaver herbivory and will resprout after being eaten (Figure 2). For more specific recommendations and guidance on considerations and approaches for restoring native riparian buffers in areas where beavers are active, we point readers to [Planning for Beavers Manual: Anticipating Beavers when Designing Restoration Projects](#) (King County 2022).



Example of a woody plant species resprouting many new stems after beaver herbivory, leading to a shrubbier form that is more resilient against future beaver foraging. Graphic by Beavers Northwest.

### **Beaver Coexistence BMP #2: Tree protection**

A simple, direct method for protecting commercially valuable or otherwise desirable trees is to strategically install fencing to prevent beavers from chewing or felling trees. There is a range of techniques that can be used, from protecting individual plants to fencing off a large area with valued vegetation. Regardless of technique, proper installation is key to success as it is easy for beavers to bypass barriers (Figure 3; King County 2018, King County 2022).

Broad recommendations to consider when designing and installing protective fencing:

- Beavers can stand up on their hind legs; therefore, fencing around any tree or shrub should cover the first four feet of the plant. In places with significant amounts of snow accumulation or uneven topography, fencing taller than four feet may be necessary.

- Beavers are excellent diggers, so fencing should be buried or tucked under and secured and held in place with T-posts, U-posts, or wooden stakes.
- At least a one-foot gap between the fencing and the tree should be maintained. This gives the tree room to grow and prevents beavers from pushing the fencing up against the tree to chew off the bark.
- Chicken wire or plastic mesh should be avoided as they are easily bypassed by beavers.
- Fencing should be inspected annually to ensure plants are not being impacted and that beavers are not digging under or moving the fence.



(A) is an example of how plastic mesh can be ineffective at protecting trees from determined beavers (Photo credit Dash Paulson). (B) is an example of an effective fencing strategy. Note the height of the welded wire fence and the wide perimeter of the fence around the trees. Wooden posts prevent the fencing from being pushed against the tree bark. Photos by Beavers Northwest.

There are many resources available to help choose the most effective fencing approach for protecting priority trees and vegetation. Project Beaver in Oregon provides a free guide to [“Best Management Practices for Tree and Crop Protection”](#) (Shockey 2024a) with overviews on installing fencing, protecting vegetation, modifications to standard designs, and the use of electric protection fences for crops and orchards. The Beaver Institute developed [How To Protect Trees from Beaver Chewing](#), which provides additional information and techniques.

## **Beaver Impact: Blocked culverts and compromised water infrastructure**

When beavers block culverts and other water infrastructure, the result is often flooded or damaged roads that require immediate intervention to restore service. When beavers are found within or near infrastructure, assessing their impacts is important before making management decisions. Coexistence techniques should be tried first, since beavers are likely to be attracted to the habitat within the infrastructure over the long term. Additionally, being proactive and implementing coexistence strategies that seek to prevent beavers from plugging culverts can be a cost-effective way to minimize damage. A study by Boyles and Savitzky (2008) found that when the Virginia Department of Transportation switched from a reactive strategy of beaver removal and road repair to a proactive strategy of installing water level control devices at chronic conflict sites, they saved \$8.37 for every \$1.00 spent to install, monitor, and maintain those devices. Most importantly for the public, the roads stayed open consistently and no longer suffered seasonal damage and closures.

Most issues can be relieved by preventing beavers from blocking culverts or by replacing under-sized culverts with larger structures like box culverts, [climate-resilient culverts](#), or bridges.

### **Permit Considerations**

Techniques or activities that require conducting hydraulic work, including installing culvert exclusion fencing; notching, modifying, or removing a beaver dam; and installing water level control devices are regulated by WDFW under Chapter [77.55](#) RCW and require an HPA before work can begin. Visit [WDFW's HPA website](#) for more details.

In emergency situations, when there is an immediate threat to property or life, verbal permission from WDFW can be obtained for work necessary to abate the emergency. A 24-hour hotline is available for emergency calls during non-working hours.

We also strongly recommend consultation with local authorities to determine if other local permits are required.

### Beaver Coexistence BMP #3: Culvert exclusion fencing

Culvert exclusion fences are a versatile technique that can be used to prevent beavers from plugging culverts and other narrow waterways (Figure 4), while ensuring fish can still pass through the structure. This technique involves installing heavy gauge, steel fencing (six inch by six inch, 6 gauge concrete mesh fence considered optimal by [Beaver Solutions](#)) with a wide perimeter around the ends of culverts or drainage paths, that block the culvert from beaver access without inhibiting upstream or downstream passage of smaller aquatic species. Exclusion fences should be built on the upstream side of culverts where beavers are most likely to build dams, although installation on the downstream side can be done to keep beavers completely out of culverts.

In situations where a large perimeter fence is impractical, where there is a deep pond along the waterway, or a specific level of water control is necessary, the addition of a pipe for the water to flow through may be needed. When this occurs, the structures are designed to encourage beavers to build along the fence, which does come with an increased risk of blocking the movement of other aquatic species and should be implemented with care and consideration and periodically monitored.

The guidance document, [Best Management Practices for Pond Levelers and Culvert Protection Systems](#) developed by Project Beaver provides additional guidance that can be used to determine the most effective way to build a culvert exclusion fence.



Examples of exclusion fence. Photos by Beavers Northwest.

## **Beaver Impact: Flooding of adjacent floodplain property**

Beavers build dams to create, expand, or deepen ponds and wetlands that increase their access to food and building materials and provide better cover from predators. There are several factors that aid in predicting dam-building behavior and placement, including watercourse width, depth, gradient, and the size of the watershed and valley floor width (Dittbrenner 2018, Petro et al. 2018). When beavers build dams, they often locate them at natural constriction points in the stream or where an existing logjam or other obstruction allows them to anchor the dam (Petro et al. 2018). Once a dam is built, a pond will form behind the dam, making it more likely that a stream will flood adjacent property. Beavers appear to prefer water depths of at least 2-3 feet throughout their territory, which keeps shelter entrances submerged and allows for diving and quick escapes (Rosell and Campbell-Palmer 2022).

If a beaver dam is causing concerns about flooding, several water control techniques can be used to modify the dam and reduce the risk of flooding (Callahan 2003, Lisle 2003, Taylor and Singleton 2014). These techniques offer long-term solutions that are relatively simple, use inexpensive materials, and can usually be completed by professionals in a day. Design recommendations for water level control devices are constantly being updated and improved by coexistence practitioners, and the lifespan of each device may vary depending on site conditions and frequency of maintenance. In certain cases, complete removal of the beaver dam may be necessary to temporarily alleviate flooding, though it is likely beavers will rebuild the dam unless conditions change or the beavers are prevented from rebuilding.

### **Beaver Coexistence BMP #4: Notching beaver dams**

One of the simplest ways to lower the water level of a beaver dam is by creating a notch in the dam. This technique can help reduce flooding while also retaining enough water so that beavers will remain on-site and maintain the habitat. While each situation is site-specific, the notch should drop the water level as little as possible to resolve the flooding conditions. Using hand tools, material from the top of the beaver dam can be removed until a notch is created which lowers the water to the desired level. All removed dam materials should be retained on site. To minimize downstream impacts from water release, notching should be done incrementally and gradually. Water is drained to an elevation that meets landowner needs and is conducive to beavers remaining on site. Beaver dams should be notched as little as possible while still reducing the risk of flooding or infrastructure damage. Notching is often sufficient to temporarily reduce localized flooding, while keeping beaver lodge and burrow entrances underwater. The lower the water level is in the pond after notching, the more likely beavers are to immediately repair the damage and begin reinforcing the dam.

While notching beaver dams can be a useful, low-cost technique for temporarily lowering pond levels, in many cases, beavers will swiftly repair dam notches. To counter this behavior and increase the longevity of a notch, an exclusion fence can be added (Figure 5). The fence is extended upstream of the dam with a wide perimeter to prevent beavers from blocking flow through the fence by building around it. A notch exclusion fence allows for water to flow through a dam and can provide fish upstream access, if properly installed and maintained. Notch exclusion fences require regular maintenance, the frequency of which is dependent on several variables. It is worth noting that notch exclusion fences are occasionally defeated

by beavers getting inside or placing material through the fence. Design recommendations are still being updated frequently. The lifespan of these devices varies depending on site conditions. More frequent monitoring is recommended to ensure the continued efficacy of these devices.



(A) Aerial view of a notch exclusion fence through a beaver dam. Photo by Kenny Katz and (B) ground view of a notch exclusion fence through a beaver dam. Photo by Beavers Northwest.

### **Beaver Coexistence BMP #5: Installation of water level control devices (i.e. pond levelers and flow control devices)**

Another way to regulate the water level upstream of a beaver dam is to install a water level control device, which is a flexible, large-diameter pipe that is inserted into the dam to lower and control the water level above the dam (Figure 6). The ends of water level control device pipes are extended well upstream of the dam to reduce the likelihood of beavers detecting flow into the pipes. One of the key design elements of a water level control device is the placement of a wire cage around the pipe inlet to prevent beavers from plugging it with mud and sticks. When used correctly, water level control devices reduce flooding risk by controlling water levels while retaining the dam and pond so that the habitat remains suitable for beavers. They are designed to retain hydraulic flow so fish can pass over, around, or through beaver dams. In addition, during high rain events, overtopping of dams provides additional pathways for fish passage.

Water level control devices have been shown to be a highly effective solution. A study by Hood et al. (2017) in Alberta, Canada, found that when staff at the Cooking Lake-Blackfoot Provincial Area installed and maintained pond levelers at conflict sites, they reduced their annual beaver-related costs by 90%. An added benefit was that the trails in the park stayed open throughout the year instead of being seasonally flooded and requiring regular closures.

To ensure that water level control devices work properly and allow continued fish passage, beaver coexistence practitioners should be consulted in their construction, placement, and maintenance. Depending on the situation, a biologist or fish passage professional should also be consulted. A water level control device requires regular and ongoing maintenance (four or more maintenance checks per year) and can last up to 10 years. An incorrectly installed or infrequently maintained water level control device may be less effective, more vulnerable to damage, and can impact fish passage. Water level control devices can enable long-term coexistence with beaver ponds, but keys to success include proper placement of the pipe and avoiding lowering water levels so much that beavers become focused on plugging the pipe. For more guidance on considerations when installing water level control devices refer to [“Best Management Practices for Pond Levelers and Culvert Protection Systems”](#) provided by Project Beaver. For more detailed information, Taylor and Singleton’s (2014) review paper provides an overview of the history and evolution of the technology used to manage beaver dams.



Two examples of water level control devices that have been installed through beaver dams. The photo on the right showcases how wire cages can be used to protect the pipe inlet from being plugged up by beavers. Photos by Beavers Northwest.

### **Beaver Coexistence BMP #6: Beaver dam removal**

In some cases, beaver dams cannot be modified with water level control devices to relieve impacts or are insufficient to address human-beaver conflicts. In these cases, beaver dams may have to be removed entirely. Using hand tools, remove the dam gradually to allow the water to release slowly and prevent the downstream release of sediment at the bottom of the pond, avoid damage to the stream bed and banks, and avoid fish stranding. All removed materials should remain on site. We encourage the use of this practice only when all other options have been considered, as beaver dam removal is likely to negatively impact habitat. Impacts may include changes in hydrology, loss of habitat for fish and other stream-associated species, sediment displacement downstream, a decrease in aquatic vegetation, fragmentation of the local food web, and the loss of wetland habitat in general.

Removing a beaver dam for flood relief is rarely a long-term solution (King County 2018). If beavers remain in the area and the habitat is still suitable, they will rebuild dams immediately, often in a single night (WDFW 2004). Furthermore, beavers rarely reuse building materials removed from their dam, which could lead to an increase in impacts to vegetation, including the felling of more local trees and vegetation to rebuild (King County 2018). This can lead to a negative feedback loop where dams are removed and then rebuilt, and less woody vegetation remains standing on the site.

Water level control devices are typically a better alternative to completely removing beaver dams. These devices allow for water level control while also retaining some of the ponding and associated benefits of continued beaver activity.

## **When coexistence isn't possible: Beaver relocation or removal BMPs**

When conflicts between humans and beavers cannot be avoided or resolved with coexistence methods, property owners can either seek to relocate beavers away from the site or lethally remove animals. We always encourage people to pursue relocation over lethal removal when possible. However, removing beavers from a site through relocation or lethal control may only provide a temporary reprieve from flooding and property damage. New beavers usually discover and reoccupy good habitat, often in spring as young beavers move away from their home areas (King County 2020). These new beavers can restart the same issues that led to removal in the first place and can ensnare land managers and property owners in a cycle of expensive, reactive management.



Safely moving a captured beaver into a temporary husbandry facility at the Winthrop National Fish Hatchery. Photo by the Methow Okanogan Beaver Project.

## Relocation of conflict beavers

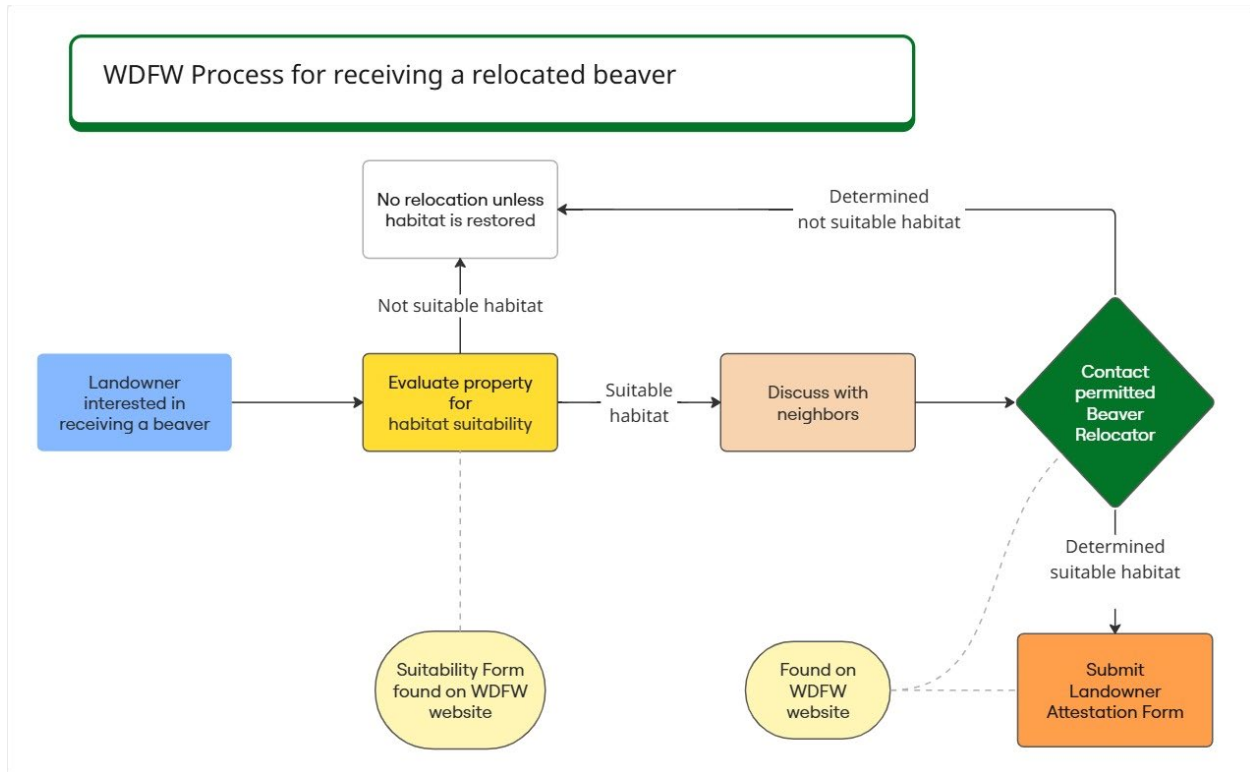
In 2012, the Washington State Legislature passed a law regulating the capture and release of wild beavers in Washington ([RCW 77.32.585](#)). The legislation was based on the fact that "...beavers have historically played a significant role in maintaining the health of watersheds in the Pacific Northwest and function as key agents in riparian ecology...Relocating beavers into their historic habitat provides a natural mechanism for improving the environmental conditions in Washington's riparian ecosystems without having to resort to governmental regulation or expensive publicly funded engineering projects" (RCW 77.32.585). In 2019, in collaboration with the Tulalip Tribes' Beaver Project and the Methow Okanogan Beaver Project, WDFW launched the Beaver Relocation Permit Pilot Program. This program became permanent with the adoption of [WAC 220-450-230](#) in December 2024.

The Beaver Relocation Permit Program oversees the capture, housing, transport, site identification, and other aspects of relocating beavers in Washington by trained and permitted relocators. A permit can only be issued in situations when beavers have caused damage to property or infrastructure and where previous attempts to mitigate beaver damage have failed or are infeasible. The determination of whether coexistence is infeasible and relocation is possible is made by the permitted relocater in consultation with the landowner. Relocation can only be considered when lethal removal is the only other available option. A beaver relocation permit allows participants to legally capture, transport, house, and release beavers within Washington, in line with the conditions of the permit and the regulations concerning the proper release of wild beavers on public or private land. Working with beaver management practitioners is often the fastest and most effective means for resolving conflicts. For more information, visit the [WDFW web page on beaver relocation in Washington](#), which includes a list of [current permitted relocators](#). Another resource is an [online map of Washington beaver coexistence practitioners and relocators](#), developed by the Washington Beaver Working Group. For a more general overview of beaver relocation practices, including information on established relocation programs in Washington, refer to Chapter 5: Beaver Relocation in the most recent edition of the [Beaver Restoration Guidebook](#) (Pollock et al. 2023), prepared by the US Fish and Wildlife Service.



Beavers are released by permitted relocators into their new home. Photo by the Methow Okanogan Beaver Project.

There is a process by which land managers or property owners can elect to have relocated beavers introduced onto their property. Those who are interested are encouraged to contact WDFW or a [local beaver relocation project](#) to determine the feasibility of relocating beavers onto their property. If the landowner is interested in receiving a beaver, they can evaluate their land for beaver habitat suitability using the Suitability Form on WDFW’s website (Figure 7).



**Figure 7. WDFW Process for receiving a relocated beaver.**

If the habitat appears suitable after the evaluation, neighbors are supportive, and a permitted relocator approves of the plan, the last step is to fill out a [Landowner Attestation Form](#) (available through the WDFW website), which documents that beavers can be relocated onto the property.

The Methow Okanogan Beaver Project provides a succinct overview of their methodology for beaver reintroductions in Okanogan County in the guidance document [Methow Okanogan Beaver Project – Some Steps of Beaver Restoration](#).

### Lethal control

Lethal control may become necessary if all efforts to coexist with beavers fail and relocating beavers is infeasible and damage is threatening safety or critical property. If landowners have explored coexistence options, relocation is infeasible in their area, and they believe they need to have beavers lethally removed, they can invite a licensed trapper to harvest the beavers from their property. Beavers may be trapped for harvest only during the open furbearer trapping season and with a valid trapping license.

Alternatively, property owners can hire a private Wildlife Control Operator (WCO) who works directly on a fee basis to remove beavers. [Contact information for WCOs can be found via a directory on the WDFW website.](#) Please note that state wildlife officers do not provide animal removal services.

A landowner, the landowner's immediate family, an employee, or a tenant of the property may trap or kill a beaver on that property if the beaver is threatening human safety or causing property damage ([RCW 77.36.030](#), [WAC 220-440-060](#)). In such cases, no special trapping permit is necessary for the use of non-body-gripping traps. However, a special trapping permit is required for the use of all body-gripping ([RCW 77.15.192](#), [RCW 77.15.194](#), [WAC 220-417-040](#)). There are no exceptions for emergencies and no provisions for verbal approval. All special trapping permit applications must be in writing on a [form available from WDFW](#). Shooting beavers that are causing property damage requires skilled marksmanship and is not recommended. Most populated areas have shooting restrictions within city limits; thus, for safety considerations, shooting is generally limited to rural areas and is considered too hazardous in more populated areas.

## **Conclusions: Navigating human-beaver conflict through coexistence strategies**

Beavers create and enhance critical habitats that bolster the resilience of Washington's ecosystems. In many situations, beaver impacts on human infrastructure can be mitigated through cost-effective preventative measures that have greater long-term success than beaver removal. The implementation of beaver coexistence BMPs can balance human interests with ecological benefits by preserving beavers in areas where they generate important ecosystem services and benefits. By co-existing with beavers and their habitats, we can promote services that benefit people, fish, and wildlife.

# Using beaver to restore ecosystems

Beaver-generated ecosystem services are so valued that restoration practitioners are now implementing projects that mimic and promote beaver habitats to further enhance ecosystem health and biodiversity. Encouraging beaver activity to restore native riparian habitat is known as **Beaver-Related Restoration (BRR)**, which is part of a broader practice of what is referred to as Process-Based Restoration. Beaver-related restoration encompasses a range of tools and practices aimed at promoting beaver activity in suitable environments, or mimicking beaver activity through activities such as the construction of Beaver Dam Analogues (BDAs). While there have been some studies that have demonstrated the effectiveness of BRR, overall, it is relatively understudied (Pilliod et al. 2017, Nash et al. 2021). However, with more emerging research supporting its efficacy, BRR presents a promising, low-cost intervention for restoring aquatic habitats across Washington's diverse landscapes. BRR can also benefit from integrating indigenous knowledge and practices into the body of knowledge and fostering Tribal collaboration on projects. Indigenous communities have long and rich relationships with beavers and possess valuable insights into sustainable ecosystem management (Druschke et al. 2024).

There are significant opportunities for BRR projects to contribute to restoring aquatic habitat functions and natural processes in all regions across Washington. Watersheds with mid-elevation forested landscapes and sparse human populations may present some of the best opportunities, including the Cascades, the Blue Mountains, and the Okanogan ecoregions in Washington. BRR projects in lowland areas like the Puget Trough could result in high-value habitat restoration, but dense human populations increase the chances of human-beaver conflicts (Siemer et al. 2013). There are also low-elevation, eastside watersheds that have been degraded by agricultural activities. Public outreach, education, and financial assistance with beaver coexistence techniques can reduce and defuse these conflicts.

BRR projects can be particularly beneficial in wildfire-prone landscapes and recently burned areas. Beaver activities enhance the resilience of riparian zones and streams by improving water retention and keeping soil moist and vegetation lush, making these ecosystems less susceptible to future fires and potentially reducing burn severity. Additionally, beaver ponds may be able to capture post-fire sediment and debris flows, aiding recovery after wildfires, and preventing water quality degradation. This is especially true in the Columbia Plateau, where, while dominated by agricultural and livestock grazing land uses, it has an arid climate and limited water supplies. Well-planned and executed BRR could result in enormous benefits to native Shrubsteppe as well as habitat on agricultural land by recharging groundwater, reducing erosion, boosting riparian vegetation growth, and increasing landscape resistance to drought and wildfire (McKinstry et al. 2001, Westbrook 2006, Cooke and Zack 2008, Quinn et al. 2020, Fairfax and Westbrook 2024). By restoring hydrological processes, BRR may be able to help mitigate the impacts of wildfires and contribute to long-term ecological stability in affected landscapes.

Identifying where BRR should be targeted is one of the key steps to restoration. Several habitat modelling tools can help restoration practitioners locate potential project locations that have a high potential of serving as beaver habitat. The primary tools in Washington are the Beaver Intrinsic Potential (BIP) model (Dittbrenner et al. 2018) and the Beaver Restoration Assessment Tool (BRAT; Macfarlane et

al 2014). The BIP model is currently the primary tool for predicting beaver habitat in Washington. It is used by WDFW's beaver relocation process, and it has been used for siting BDAs. Modelling tools, like the BIP, along with remote sensing products like land use and digital elevation models, can be used as a first step to narrow down candidate BRR sites. This should be followed by field-based assessments of the candidate sites, including close coordination with landowners. Site assessments should include a careful on-site evaluation of available riparian vegetation for beaver forage and dam-building materials. The presence of relic beaver habitat features should also be assessed along with the presence of beaver predators like gray wolves (*Canis lupus*), American black bear (*Ursus americanus*), and cougars (*Puma concolor*). Like all restoration projects, BRR projects should have specific goals and performance standards. These could include goals such as increasing rearing habitat for salmonids, rehabilitating or enhancing wetlands, stream aggradation (reducing stream incision), increasing water storage, and improving water quality.

There are two main approaches within BRR: a passive approach such as creating suitable habitat or an active approach that mimics beaver activity to replicate some of the ecosystem benefits, thereby encouraging beavers to occupy an area. Passive BRR includes actions that promote suitable habitat for beaver, such as increasing the abundance of woody riparian vegetation and improving beaver survival rates on-site. This can be used to promote and coexist with beavers that are currently occupying a site, prepare an area to be a potential beaver relocation site, or encourage beavers to naturally occupy a site. Planting woody vegetation that beavers prefer, which include trees and shrubs such as willows, poplars, and alders, may help to foster future beaver use of stream reaches. This tactic can help ensure that beavers who are currently occupying a site (or ones that will do so in the future) will have adequate food and dam-building resources available. Even if the site is not used by beavers, the increased riparian vegetation may have other benefits like increased stream shading. It can be difficult to quantify how much riparian vegetation is needed by a beaver family, but experts recommend somewhere between three to ten acres of established riparian vegetation to sustain a beaver family in semi-arid to arid environments (King County 2022, RRNW 2025). Other quasi-passive BRR strategies include protecting trees and preparing a site to accept relocated beavers.

Active BRR is primarily focused on creating BDAs. These are channel-spanning instream structures comprised of untreated wooden posts and a wicker weave of native materials (such as vine maple) built by humans to mimic the effects of a beaver-built dam (Pollock et al. 2012, Pollock et al. 2014). BDAs are designed to be semi-porous, allowing water and aquatic organisms, including fish, to pass through and around, which can stabilize stream channels, reconnect floodplains, and improve water quality, just like a beaver dam (Pilliod et al. 2017). However, research suggests BDAs without beavers underperform compared to actual beaver activity (Pollock et al. 2023, Orr et al. 2024). The construction of BDAs can also encourage beavers to move into an area by creating more suitable deeper water habitat and providing 'starter dams' for relocated beaver families.



A recently installed Beaver Dam Analog in a creek in Thurston County, WA slowing down water and capturing sediment. Photo by Daniel Trovillion, WDFW.

When employed correctly, BRR strategies can be an effective way to restore native habitat and increase the climate resiliency of Washington’s streams and riparian ecosystems. The BRR strategies, along with the BMPs described earlier in the document, can all be used to help reduce summer water temperatures, increase summer base-flows, and enhance floodplain habitat (Burgher et al. 2023), all of which are essential to ensuring the continuation of many iconic Washington species. While BRR has many benefits, it is not a universal solution for ecological degradation and requires careful planning and consideration of site-specific factors and potential human-beaver conflicts. It should be considered one tool in the broader toolbox of ecological restoration that can be used to help restore, conserve, and promote native ecosystems in Washington.

## **Additional resources for beaver-related restoration**

There are multiple publicly available tools, guidelines, and resources available to support BRR projects. Several of these resources are listed below and include hyperlinks to their relevant webpages.

- [The Beaver Restoration Guidebook](#), U.S. Fish and Wildlife Service
- [Low-tech Process-Based Restoration of Riverscapes](#), Utah State University
- [Beaver Restoration Assessment Tool \(BRAT\)](#), Riverscape Consortium
- [The Beaver Intrinsic Potential Model \(BIP\)](#) and [User Guidelines for BIP](#), Dittbrenner et al. 2018
- [MRRMaid: Mesic Resource Restoration Monitoring Aid](#), Boise State University
- [Overview of process-based and beaver-related restoration techniques and resources](#), National Association of Wetland Managers

- [Planning for Beavers Manual: Anticipating Beavers when Designing Restoration Projects](#), King County
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