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Using Beaver Dam Analogues for Fish and Wildlife Recovery on Public and Private Rangelands in Eastern Oregon

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Cover: Beaver dam analogues in Bridge Creek, Oregon. Photo by Nick Weber.

Abstract

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This case study was developed as part of a larger, interdisciplinary research project to assess the social, hydrological, and ecological effects of beaver-related watershed restoration approaches in rangeland streams of the Western United States. It is one of five case studies being undertaken to investigate the social context of beaver- (*Castor canadensis*) related restoration in western rangelands. Research in the Bridge Creek watershed of the John Day River basin has found that beaver dam analogues (BDAs) improved habitat for fish listed under the Endangered Species Act, garnering interest from private landowners and public land managers seeking to mitigate anthropogenic habitat loss for sensitive and threatened species such as salmonids (*Oncorhynchus* spp.), greater sage grouse (*Centrocercus urophasianus*), and Columbia spotted frogs (*Rana luteiventris*). Researchers who published the studies on BDAs in Bridge Creek are providing technical advice to stakeholders through workshops and guidance documents. Regulating BDAs is a complex process because permitting rules are not well defined, and dams carry a stigma owing to a long history of water diversion for irrigation and cattle that can impede fish passage and alter water delivery. Soil and water conservation districts and watershed councils now act as intermediaries to help landowners navigate the BDA permitting and installation process. Funding agencies that support restoration work are beginning to grant financial support to BDA projects, citing results from the ongoing Bridge Creek research. Some ranchers are interested in the ability of BDAs to restore incised streams and prolong streamflow, and are starting to use BDAs to improve the health of riparian areas. Beaver population recovery may occur following the installation of BDAs on agricultural lands, and the idea of intentionally encouraging beavers to return is met with skepticism by some landowners. Understanding and addressing ranchers' concerns can help pave the way for this tool to be more widely implemented in rangeland ecosystems.

Keywords: Bridge Creek, beaver dam analogue, BDA, ranchers, watershed restoration.

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Introduction

Among watershed restoration professionals, Bridge Creek, a tributary to the John Day River in central Oregon (see Project Facts), has become synonymous with the use of stream restoration techniques that follow the form and functions of dams built by beavers (*Castor canadensis*). These include structures called beaver dam analogues (BDAs) (Bouwes et al. 2016a; Pollock et al. 2012, 2014) that use a series of channel-spanning, semiporous, wooden post structures woven with vegetation to mimic the effects of beaver dams (fig. 1). In 2003, scientists affiliated with the National Oceanic and Atmospheric Administration's Northwest Fisheries Science Center (NOAA Fisheries) and Oregon State University initiated research on Bridge Creek to assess how beaver dams and BDAs restore habitat for the local population of threatened salmonids, Columbia River steelhead (*Oncorhynchus mykiss*) (Pollock et al. 2007, USDC NOAA 2008). Their work was inspired by the long-term efforts of the U.S. Bureau of Land Management (BLM) to protect and monitor the beaver populations in Bridge Creek (summarized in Demmer and Beschta 2008). Additional collaborators from Utah State University and two consulting firms, Eco Logical Research, Inc. and South Fork Research, Inc., were soon brought in, and a long-term restoration and monitoring project was developed (Pollock 2016). Many years later, these researchers, armed with evidence of success derived from the long-term monitoring program (Bouwes et al. 2016b, Weber et al. 2017), have spearheaded the expansion of this approach to other parts of Oregon and states across the West, implementing 24 beaver-related restoration projects as of 2017 (see appendix). County- and watershed-level conservation specialists are playing an important role in bringing technical expertise about these restoration innovations to rural landowners.

Beaver-related watershed restoration is gaining popularity for its potential to promote floodplain connectivity and enhance ecological resilience in degraded waterways (Pollock et al. 2017). Most beaver-related restoration techniques are compatible with multiple-use objectives, making this type of restoration appropriate for use on active BLM and U.S. Forest Service grazing allotments and many private forests and rangelands. Bridge Creek scientists are placing a high priority on disseminating lessons learned to landowners and conservation professionals through training workshops such as those sponsored by Portland State University's Environmental Professional Program in 2015–2016. Beaver dam analogues, in combination with other beaver-related restoration approaches, demonstrate a feasible and cost-effective solution to restoration on the scale at which incised streams occur (Pollock et al. 2017), but they are not appropriate everywhere. To better estimate landscape capacity to support dam-building beavers, researchers developed a model called

Project Facts

Goals:

1. Improve stream restoration techniques to increase populations of Columbia River salmonids
2. Reduce erosion and raise the streambed to increase floodplain connectivity and off-channel fish habitat

Scope:

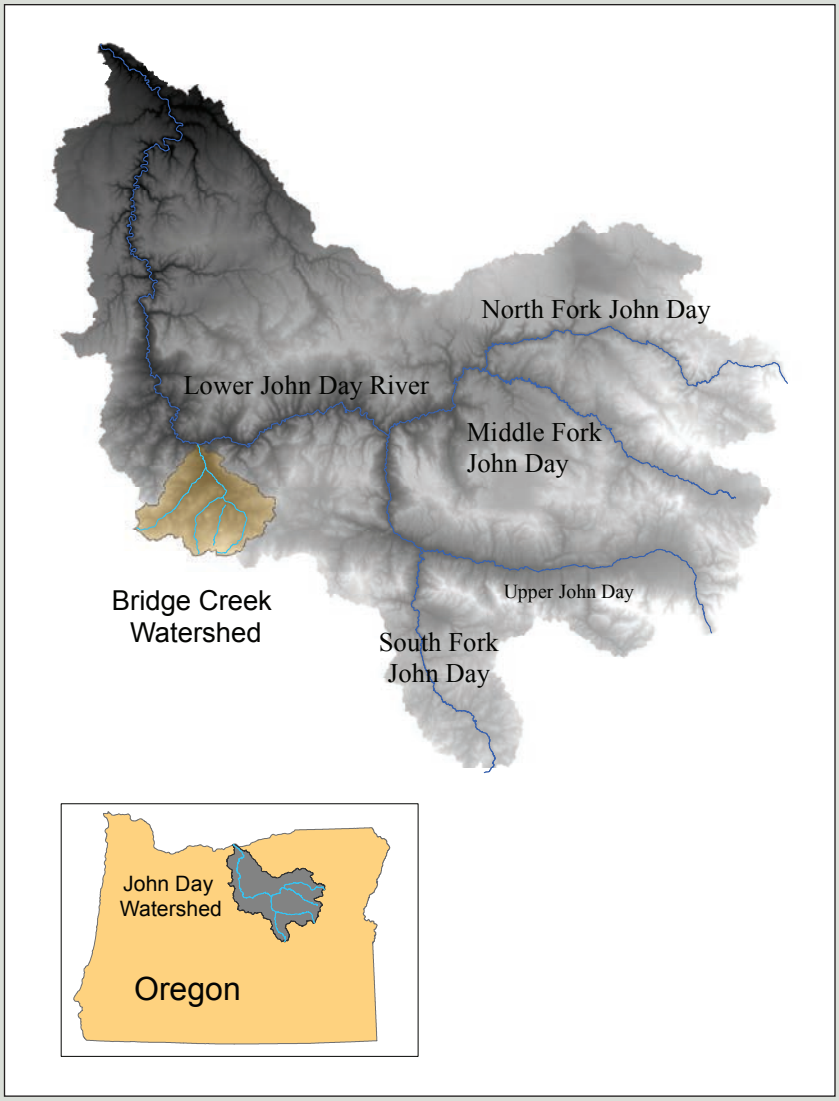
- 114 structures on U.S. Department of the Interior Bureau of Land Management land
- 35 km of stream affected by restoration

Implementing Partners

- National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center
- Utah State University
- Eco Logical Research
- Oregon State University
- Bureau of Land Management

Location:

- Bridge Creek watershed, Oregon



Rachael Davee

Location of the beaver dam analogue project on Bridge Creek, Oregon.

Rachael Davee

Figure 1—Bridge Creek is an intensively monitored watershed within the John Day River basin in eastern Oregon.

the Beaver Restoration Assessment Tool that incorporates human land use as a parameter (Macfarlane et al. 2015).

Research at Bridge Creek is well documented from an ecological perspective (Bouwes et al. 2016a, Weber et al. 2017). However, there is very little information available about the regulatory context for implementing BDAs as a restoration tool on public or private lands, how the research at Bridge Creek has affected the broader process and impacts of BDA use within the restoration community, or the impacts of BDAs on private landowners residing near the research site. Therefore, the purpose of this report is to provide insight into the human dimensions of the Bridge Creek story, including (1) the diffusion of BDA use from Bridge Creek to other areas; (2) the institutionalization of methods used at Bridge Creek through changes in regulations and permitting; and (3) the growing use of BDAs and the ways they are affecting restoration, monitoring, funding, and implementation strategies for landowners interested in using this approach to watershed restoration. We also document some of the concerns held by researchers, landowners, and conservation professionals about BDAs.

Methods

Methods used in this case study included a document analysis of relevant laws and policies on ecological restoration and beaver management as they pertain to

the work done in the Bridge Creek watershed. We also conducted semistructured interviews with Bridge Creek researchers from the BLM, National Oceanic and Atmospheric Administration (NOAA), and Eco Logical Research (n = 4) to understand how the permitting and installation process was navigated. In addition, we interviewed local landowners (n = 3) to understand their perceptions about beavers and BDAs. Additionally, we interviewed staff from soil and water conservation districts, NOAA Fisheries, Oregon Department of State Lands, Natural Resources Conservation Service, Oregon Department of Fish and Wildlife (ODFW), Bonneville Power Administration (BPA), Oregon Watershed Enhancement Board, and U.S. Army Corps of Engineers (USACE) (n = 15) to better understand the legal environment in which these structures are being regulated. Interviews were conducted between December 2016 and July 2017. Interview data from a related research project on public lands ranching in the Blue Mountains of northeastern Oregon are also referenced in this case study, as many of the interviewees from that project had experience with beavers and their impacts on their private land and grazing allotments (n = 20). We recorded and transcribed the interviews, or in cases where recording was not possible, indepth notes were taken during the conversation to capture relevant experiences. The interview data were analyzed along with relevant published and gray literature, and documents from state and federal agencies involved in the Bridge Creek project. All of the information contained in this report comes from interviews unless otherwise referenced.

Bridge Creek Project Background

The Bridge Creek project is located within the 710-km^2 watershed where the creek flows through low-gradient (0.5 to 3 percent) meadow systems typical of private rangelands but less common on public land. The elevation in the watershed ranges from 780 m at the top of the study site to 500 m at the lower end and is dominated by sagebrush (*Artemisia* spp.) and juniper (*Juniperus occidentalis* Hook.) steppe (Demmer and Beschta 2008, Pollock et al. 2012). The riparian areas are dominated by willows (*Salix* spp.), and additional deciduous riparian trees including thinleaf alder (*Alnus incana* (L.) Moench ssp. *tenuifolia* (Nutt.) Breitung), redosier dogwood (*Cornus sericea* L.), and quaking aspen (*Populus tremuloides* Michx.) were planted as part of the restoration project.

The BLM Prineville District acquired land in this part of the watershed between 1988 and 1992 by trading properties with a private landowner through the Sutton Mountain Land Exchange. This addition expanded the Prineville District's riparian acreage along Bridge Creek from approximately 1 km to more than 45 km. In 1989 and 1990, the Prineville BLM district manager wrote letters to the ODFW,

the agency responsible for managing beavers, seeking an emergency closure of beaver trapping on BLM land in the Bridge Creek watershed, "to begin managing beaver as a necessary ingredient in riparian recovery." A trapping moratorium was granted in 1991 and is still in place. Subsequently, the adjacent Ochoco National Forest also requested that the ODFW place a moratorium on beaver trapping within national forest boundaries, citing low populations of beaver and the ecological benefits they provide. The request was granted in 1992, resulting in a ban on beaver trapping on all public lands in the watershed. After the BLM closed the area to trapping, Demmer and Beschta (2008) observed an increase in the number of beaver dams, suggesting an increase in the beaver population. Counting dams and food cache sites serves as a proxy for beaver populations but is an imprecise method. Beaver population numbers are not well documented in Oregon because accurate estimation techniques have not yet been established (Swafford et al. 2003).

Bureau of Land Management scientists in the area echoed the belief expressed in the letters to the ODFW in the 1990s that reintroducing beavers would support watershed restoration efforts. Beavers had been almost entirely eradicated from the watershed in the 19th century as trappers entered the territory employed by large fur companies such as the Hudson's Bay Company (Langston and Cronon 2003, McKinstry and Anderson 1999, Ogden et al. 1961). Beaver populations continued to be suppressed across many agricultural lands in the 20th century owing to conflict with landowners related to flooding of roads and fields, blocked irrigation canals, and cut trees (Coe et al. 2016, Morzillo and Needham 2015).

In 1992, the same year that the beaver trapping moratorium on public lands in the Bridge Creek watershed took effect, the BLM began restoring the lower Bridge Creek watershed to improve riparian and aquatic habitat for a population of Columbia River steelhead listed as threatened under the Endangered Species Act (ESA) (Demmer and Beschta 2008). These efforts included closing the area to beaver trapping, riparian tree planting, boulder weir placement, culvert replacement, and removing cattle grazing in riparian areas (USDI BLM 1996). Before the BLM acquired the land, season-long grazing took place on the property, but after the land exchange, shorter grazing seasons were implemented and riparian fences were installed to exclude cattle from the creek and improve riparian habitat. Outside of the beaver monitoring efforts of Demmer and Beschta (2008), efforts to document results of the restoration were sporadic; therefore, the efficacy of these early efforts is largely unknown.

As a part of the BLM's interest in beavers, the agency also undertook a 17-year longitudinal study lasting from 1988 to 2004 on beaver populations and ecology in Bridge Creek. The findings of this research highlighted the role of beavers in

altering geomorphic conditions of the creek in ways that are generally favorable for fish habitat (improving riparian vegetation, increasing channel complexity) (Demmer and Beschta 2008). The research also indicated that natural beaver dams in the watershed were highly ephemeral. The small-diameter wood that beavers were using to construct their dams made them susceptible to failure during high flows, which occurred nearly annually in the constrained and incised channels of Bridge Creek (Demmer and Beschta 2008).

In 2006, Bridge Creek was selected to be the site of a long-term research project testing the effectiveness of BPA-funded restoration in the Columbia River basin on salmonid recovery (USDC NOAA 2008). The BPA sells power generated from four dams on the lower Columbia River, four on the lower Snake River, and two on the upper Columbia River. Because the dams are a major cause of salmonid population decline on the mainstem of the Columbia River, the BPA is required to fund mitigation measures that promote salmonid recovery in tributaries within the Columbia Basin (USDC NOAA 2008). Consistent with the court order, the BPA and NOAA Fisheries conduct research in the Columbia River basin to inform stream restoration practices that are intended to assist recovery of salmonid populations in lieu of Snake River dam removal. In 2007, after several years of studying the Bridge Creek beaver (see Pollock et al. 2007), NOAA Fisheries began designing and installing a variety of wooden post structures that would become known as BDAs and part of the restoration effort (USDC NOAA 2008). The restoration and monitoring work in Bridge Creek became part of a network of 16 intensively monitored watersheds (IMWs) in the Pacific Northwest (Bouwes et al. 2016b). The purpose of the IMWs is to test the effectiveness of specific inland restoration actions on recovering ESA-listed salmonid species. In 2009, 85 BDAs were installed in four treatment reaches of lower Bridge Creek (totaling about 3.4 km), all of them on BLM land. Following this initial installation, more dams were added for maintenance and improved function as lessons were learned, for an eventual total of 114 structures in the four reaches as of 2015.

The data collected during the study led to several publications. Pollock et al. (2014) used the Bridge Creek data to develop a general theory as to how beaver dams and BDAs could be used to accelerate the restoration of incised streams by initiating a series of linked geomorphic, hydrologic, and biological feedback loops (fig. 2). Bouwes et al. (2016a) described some of the physical changes in the reaches of Bridge Creek that were treated and how this led to measurable increases in the population of ESA-listed Columbia River steelhead. Weber et al. (2017) found that beaver dams and BDAs buffered summer stream temperature extremes and created

Nick Weber, Eco Logical Research

Figure 2—Beaver dam analogues made from wooden posts driven into the stream bed and woven with vegetation are located at four restoration sites along the mainstem of Bridge Creek, with 20 to 30 structures per site.

temperature refugia important for salmonids, increasing thermally suitable salmonid stream habitat. Although the focus of the published research is on local ecological outcomes, the potential for beaver-related restoration to raise water tables and subirrigate pasture in meadows adjacent to streams (Fountain 2014, Millman 2011, Steubner 1992) has broad implications for thousands of miles of degraded riparian and stream habitat located on rangelands across the West. The work in Bridge Creek demonstrates the reconnection of a stream channel and floodplain across a large spatial extent through the installation of BDAs in four strategic locations. The scientists who developed this technique are now working to export this technology to other places and are providing guidance for installations on public and private lands.

The Legal Landscape: Permitting Beaver Dam Analogues on Public and Private Land

Navigating the permitting process for beaver-related restoration, including instream structures, is complex and varies widely from state to state. It is further complicated by the large number of regulatory agencies that may become involved in the approval process, as it often involves considerations of land use, fish and wildlife habitat, and water law. Any restoration project usually involves permits from the

(USACE), a state fish and wildlife agency, an agency that monitors dredging and filling of aquatic habitat (in Oregon, the Department of State Lands, a state water quality agency), and, if there is an endangered species in the area, either NOAA Fisheries, the U.S. Fish and Wildlife Service (USFWS), or both. There may also be local county or city permits that need to be obtained. If the project is on federal lands, a National Environmental Policy Act (NEPA) analysis may be required. Further, state and federal agencies may require archaeological analysis, and American Indian tribes may require surveys for cultural artifacts. The permits required also differ depending on whether the project is on public or private land. This section explores some of the federal laws that apply to every state, and then focuses on laws specific to Oregon that influence beaver-related restoration.

At the state level in Oregon, regulations are being developed to streamline permitting for instream structures intended to promote ecological function (ODSL 2017). Oregon's regulatory approach to using dams for restoration is in the process of being amended through a rules advisory committee that was assembled to shepherd a rulemaking process for instream structures such as BDAs.

Section 7 of the Endangered Species Act

If an ESA-listed species, or designated critical habitat for a listed species, is present at a proposed restoration site on federal land, or if federal funds are used on a restoration project involving an ESA-listed species, then it is necessary to comply with the requirements of section 7 of the ESA. Section 7 states that for federal projects—including restoration projects—that occur where a listed species or its critical habitat exists, the federal agency involved must consult with the USFWS (for terrestrial and freshwater species) or the National Marine Fisheries Service (NMFS) (for marine and anadromous species) to determine whether the proposed actions will cause jeopardy to the species or adverse modification of its habitat. The action agency prepares a biological assessment stating what, if any, effects the project will have on the listed species or its habitat. The biological assessment is reviewed by USFWS or NMFS, which then issues a biological opinion determining whether jeopardy or adverse modification is likely and how it can be avoided. Section 7 compliance can make new approaches to restoration challenging and time consuming to permit because, as a BDA proponent from the USFWS pointed out, "current environmental law is meant to be protective rather than permissive." In an attempt to streamline compliance with section 7 of the ESA, the USFWS and NMFS often develop programmatic biological opinions, which grant permission for specific classes of restoration activity that comply with a generalized set of expectations (USDC NOAA 2013).

When the restoration technique of using BDAs was first used in Bridge Creek, it was new and did not fit within the restoration approaches covered by existing biological opinions, so the researchers wrote their own biological opinion (USDC NOAA 2008). Now the BDA structures at Bridge Creek fit within the guidelines of an aquatic restoration biological opinion, a programmatic biological opinion jointly developed by the BLM, Forest Service, and Bureau of Indian Affairs. Another programmatic biological opinion called "HIP-III" now provides a fast-track ESA consultation process for BPA-funded projects implemented within the Columbia River basin (USDI FWS 2013). For example, in 2015, a BDA project undertaken by the Confederated Tribes of Warm Springs on the Pine Creek Conservation Area, also in the John Day basin, used HIP-III to permit the project (Portugal et al. 2015).

Currently, the Natural Resources Conservation Service is developing a programmatic biological opinion with NOAA Fisheries and USFWS that will cover future BDA projects and other riparian restoration projects on private land in Oregon and Washington funded by farm-bill conservation programs, such as the Environmental Quality Incentives Program (EQIP) and the Regional Conservation Partnership Program. These programs prioritize water quality and quantity conservation and wildlife habitat enhancement. As this effort demonstrates, the Natural Resources Conservation Service is beginning to recognize the role that BDAs can play in private land restoration, especially in the restoration of mesic habitat for greater sage grouse recovery.

The National Environmental Policy Act

The National Environmental Policy Act normally requires an environmental impact statement or an environmental assessment (EA) documenting potential effects of a project when it is on federal land or uses federal dollars (e.g., BPA mitigation funds). Although BDA installation would normally call for an EA, in the case of Bridge Creek, a categorical exclusion (allowing federal agencies to exclude certain actions from the NEPA requirement to undertake an EA) was granted by the BLM because the BDA installation was associated with a research project, and an EA was therefore not required (Jordan 2017). Two recent BDA projects on the Malheur National Forest in northeastern Oregon did not require site-specific EAs either; rather, they were written into the forestwide aquatic restoration environmental assessment as an approved aquatic restoration activity to facilitate restoration activities for ESA-listed fish and critical habitat recovery across all watersheds within the national forest (USDA FS 2012).

Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act

The U.S. Army Corps of Engineers is responsible for implementing Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into waters of the United States, which includes any nontidal water body. Section 10 of the Rivers and Harbors Act regulates the construction of any obstruction within navigable, or historically navigable, waters of the United States. BDAs are considered obstructions requiring fill material within waters of the United States, and thus require a USACE 4345 permit when constructed on private land. Beaver-related restoration projects on BLM or Forest Service land in Oregon must obtain a USACE regional general permit (RGP-04) that covers aquatic habitat restoration on these public lands.

Oregon Department of State Lands Removal-Fill Permits

Oregon's Removal-Fill Law (ORS 196.795-990) requires projects that will move more than 38 m^3 of material in a wetland or waterway to obtain a permit from the Department of State Lands in addition to the USACE permit. The law applies to both private and public lands and was required for the project on Bridge Creek. For activities in state-designated essential salmonid habitat, state scenic waterways, and compensatory mitigation sites, a permit is required for moving any amount of material. These individual permits require a minimum 120 days to process, but may take longer if obstacles are identified during the public comment period. Frustration with the permitting process for installing artificial beaver dams inspired the creation of a Rules Advisory Committee in 2015 that is charged with developing a new administrative rule to streamline the permitting process with general authorization for projects moving up to 76 m^3 of material. This change is intended to efficiently permit the movement of material for instream structures used as a restoration tool "for promoting waterway-floodplain connectivity" (ODSL 2017). If approved, the rule will create a statewide general permit for BDA projects. The proposed rule was developed by a diverse group of stakeholders representing the NOAA Fisheries, ODFW, Oregon Water Resources Department, conservation groups (Oregon Natural Desert Association and WaterWatch of Oregon), the Farm Bureau, Oregon Cattlemen's Association, and several other parties interested in or concerned with the expanded use of these restoration tools.

The draft rule also includes the creation of a pilot program in the Malheur Lake, Silver Lake, and Silvies River basins of eastern Oregon to install "restoration check dams," which are low-rise, instream dams made from rock and soil, also intended to

restore incised streams (see Davee et al. 2017). These check dams are less dynamic than wood-post structures (e.g., BDAs), and there is concern among some biologists that they do not provide the same geomorphic changes that benefit fish (Salant et al. 2012). Throughout the drafting of the rule, a leading concern from conservation groups and the Oregon Water Resources Department was that the instream structures will impound water, and that the stored water will be used to benefit livestock rather than serving solely ecological objectives. For that reason, the proposed rule requires that projects are evaluated by the Oregon Water Resources Department to ensure that they will not require additional water rights (ODSL 2017). The Oregon Water Resources Department is comfortable with the porosity of most BDAs it has evaluated and does not think impounding water will be an issue; however, restoration check dams, which are less porous, would need to be evaluated on a case by case basis (McCord 2017).

Oregon Department of Fish and Wildlife Beaver Trapping and Fish Passage Laws

In addition to federal and state regulatory frameworks for instream structures, there are state regulations for managing beavers, fish species, and fish passage in Oregon, all of which are governed by ODFW. Some counties and cities also have requirements related to flood planning, and, depending on the location and funding source, consultations regarding cultural resources may be required if ground disturbance will occur in order to protect artifacts. These requirements are not addressed here.

Currently in Oregon, beavers are categorized as a furbearer, which allows seasonal trapping and hunting with a furtaker's license. Between 2010 and 2014, beaver harvesters in Oregon reported an annual average of 2,746 beavers harvested recreationally (Broman 2017). The U.S. Department of Agriculture's Animal Plant Health Inspection Service also traps beavers when they are causing damage to property. During the same time period, they trapped an average of 506 beavers per year (USDA APHIS 2014). On public land in Oregon, beavers can be trapped with a furbearer permit in most locations with a few exceptions, most notably the entire Ochoco National Forest and the Bridge Creek watershed. Beavers are also classified by the Oregon Department of Agriculture as a predatory species and can be exterminated on private land without any permits or reporting; therefore, there are no data on beavers that may have been exterminated on private land during this timeframe. These missing data prevent precise tracking of total annual beaver take. ODFW published requirements for trapping and relocating problem beavers that allow these activities following the established guidelines (ODFW 2017). The survival rate for relocated beavers is less than 50 percent (Petro et al. 2015), but can

vary based on conditions at the release location. A statewide beaver working group meets annually to discuss ways to improve management and relocation programs. In the Oregon Conservation Strategy published by ODFW, beavers are acknowledged for their role in creating stream complexity and off-channel habitat (ODFW 2016), but they are not included as a species that is in need of conservation in the state conservation strategy.

Regarding fish passage, written approval must be obtained from ODFW for any work done in streams where fish are present (ORS 509.580-585). In 2017, the department created new forms for writing fish passage plans specifically with BDAs, which include post-implementation monitoring requirements twice a year for three years.

Funding Sources for Beaver-Related Restoration on Public and Private Lands

BDAs can potentially fulfill the restoration objectives of many natural resource agencies by taking an ecosystem-based approach to restoration designed to take advantage of the interactions of living and nonliving systems, such as altering the flow of water through the system and increasing riparian and wetland habitats. However, acquiring agency funding for this new restoration tool can be challenging. Athough BDAs are lauded for their low implementation cost in comparison to other active restoration techniques (Pollock et al. 2017), evidence of their ecological and economic outcomes is limited, and there are few models to provide guidance on budgeting building material costs, permitting, project engineering, and developing a timeline for project execution. Despite these challenges, all BDA projects identified through this research (see appendix) were funded through a combination of federal and state funds. BPA mitigation funds, and federal dollars generated from energy ratepayers and designated for use to restore streams on public and private lands, have been the primary sources of funding for the BDAs and associated research conducted at Bridge Creek. State funds that support BDA projects in Oregon are often administered via Oregon Watershed Enhancement Board (OWEB) grants associated with the agency's open solicitation program. The program provides funding for landowners, agencies, and nonprofit organizations to implement restoration projects on lands designed to improve habitat for salmonid species. OWEB is a state agency funded by the Oregon Lottery and federal funds, including the Pacific Coastal Salmon Recovery Fund. OWEB funding is given preferentially to private landowners, but can be obtained for projects on public land, especially if it is a joint application with a private land owner.

The Natural Resources Conservation Service, recognizing that outcomes associated with BDAs align with the agency's priority to restore function to ecosystems on working lands where they overlap with greater sage grouse habitat, is amending practice code 643 to include "scenario 40," which provides funding that can cover the costs of building a post line-wicker weave or a BDA structure. When this change is finalized, the structures can be funded on private land through EQIP (Meastas 2017). Funding for EQIP projects on private land typically requires an in-kind match, e.g. a landowner's contribution of materials or labor, which serves as a cost share. The Natural Resources Conservation Service has been working on standardizing the costs of BDA installations and providing a design template that can be applied in a wide variety of circumstances, and this is leading to expanded use of BDAs by OWEB and EQIP grantees. For example, OWEB recently funded the Wheeler County Soil and Water Conservation District and NOAA to collaborate on a multiday workshop to train landowners, conservation staff from agencies and watershed councils, and local contractors to install the structures on an unrestored tributary to Bridge Creek, thereby increasing the number of people trained to use this tool (OWEB project #217-6044). OWEB staff interviewed indicated that funding is granted preferentially to projects that target contiguous land ownerships, and projects with a recovery trajectory that does not require long-term maintenance.[1] The rationale for funding self-sustaining projects is that once a recovery trajectory is set, continued investment of restoration dollars will not be required owing to the positive feedback loops that are set in motion.

The Malheur National Forest is part of a congressionally established ecosystem restoration initiative called the Collaborative Forest Landscape Restoration Program (https://www.fs.usda.gov/detailfull/malheur/workingtogether/partnerships/?cid=STELPRDB5244635&width=full). Funds from that program were used to install BDAs in the John Day watershed portion of the national forest because of the presence of ESA-listed Columbia River steelhead, and in the Malheur River watershed because of the presence of an ESA-listed bull trout (*Salvelinus confluentus*).

Bridge Creek Research Facilitating Beaver Dam Analogue Expansion

Information about BDAs to help people understand how to get started on their own projects is spreading through classes and workshops taught by scientists, professionals, and practitioners from NOAA Fisheries, USFWS, Forest Service, Portland State University, and Utah State University; private consultants, such as Eco Logical

[1] OWEB staff, interviewed March 2017.

Research and Fiori GeoSciences; and nongovernmental organizations, such as the Scott River Watershed Council in California, the Oregon Natural Desert Association, and the Nature Conservancy. In June 2017, researchers published the second version of the Beaver Restoration Guidebook (Pollock et al. 2017) to provide an accessible manual for people interested in beaver-related watershed restoration. According to Nick Weber, of Eco Logical Research, these structures are a way to extend the spatial extent of restoration for the same amount of money as traditional restoration because, "you cut out the middle man because you don't need engineer's design specs" (Weber 2016). This low-cost and low-tech approach is attracting a lot of interest, but it is important to the researchers that the tool is not seen as low risk. Lessons about BDA design and placement were learned over a decade, and adaptive management techniques were incorporated to achieve targeted restoration goals. With that in mind, the researchers are sharing their technical expertise in order to prevent haphazard use of the tool, which could undermine the benefits of targeted use.

> Each structure that you build needs to have a purpose and have assigned its purpose before you start… You [can't] just walk along the stream and say let's put one here and here and here. You think about what you want for that whole [system].
>
> —Chris Jordan, NOAA Fisheries, Bridge Creek researcher

Researchers lead workshops that often entail multiday gatherings combining field trips and classroom training to allow people to see a project site and learn about the way beavers and beaver dams function in a healthy ecosystem (fig. 3). Workshops have been attended by conservation workers affiliated with state and federal agencies, American Indian tribes, soil and water conservation districts, watershed councils, nongovernmental organizations, conservation groups such as Ducks Unlimited, OWEB, and interested landowners who have heard about the benefits beavers may bring to their operations. For example, workshops conducted by the Oregon Natural Desert Association, a nonprofit environmental group, take groups to restoration sites where they volunteer, making these projects even more cost-effective for landowners. Such workshops are effective because participants get to see the benefits of BDAs firsthand, they learn the complexities of permitting BDA projects, and they exchange tips on what needs to be done to meet state and federal regulatory requirements. Hearing about the change in watershed conditions that the restoration can achieve from experienced practitioners can be helpful for guiding expectations for timelines and outcomes. Herb Winters, a soil and water conservation district employee, reflected on the importance of landowners seeing the BDAs in action in order to understand what a difference the structures and

Eco Logical Research, Inc.

Figure 3—Groups learn about installing beaver dam analogues on workshops and field trips, such as this one on Bridge Creek in Oregon.

beavers can make in a short time: "When [people] drive down the road and see the transformation that [has] occurred in [a] brief time, it makes others curious to try."

In Wheeler County (where Bridge Creek is located), the local soil and water conservation district expanded this type of peer-to-peer learning through an OWEB funded workshop to train interested implementers on the resources required to install a BDA project. The workshop covered an introduction to beaver-related watershed restoration and familiarized participants with technical tools like the Beaver Restoration Assessment Tool for assessing a site's capacity for beaver habitat, and a monitoring and design iPhone[2] application. Workshop participants went out to the field and helped install BDAs and tested the application. An August 2017 workshop in Condon, Oregon, also provided an opportunity for local implementers and state regulators from the Oregon Department of State Lands, ODFW and OWEB to discuss coordinating monitoring requirements across agencies to keep projects affordable for private landowners.

The Natural Resources Conservation Service is also consulting with beaver restoration experts at Utah State University involved in the Bridge Creek research,

[2] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

sending 30 staff there to learn about how BDAs can be used to improve greater sage grouse habitat on private land. A Natural Resources Conservation Service staff biologist suggested that incorporating guidelines for BDAs into language and documents that staff are accustomed to seeing would make them more likely to utilize the tool in their rangeland restoration projects (Santana 2017). The Natural Resources Conservation Service is also using its Regional Conservation Partnership Program to collaborate with Trout Unlimited to use BDAs as a strategy for improving habitat where greater sage grouse, red band trout (*Oncorhynchus mykiss gairdnerii*), and Columbia spotted frog populations overlap, in hopes of creating drought resiliency on ranches (USDA NRCS 2016a). This type of program creates opportunities for producers to engage in restoration that will benefit both livestock and threatened species while keeping water in streams longer. The Natural Resources Conservation Service and soil and water conservation districts provide tools and options for altering grazing management in ways that will aid in the recovery of woody riparian vegetation and help cattle ranchers use BDAs to contribute to agency conservation objectives.

Benefits and Challenges Associated With Beaver-Related Restoration

Benefits

Beaver dam analogues are not just being used as a tool for restoring fish habitat; agencies are also hoping they will be useful in restoring riparian and mesic habitat that is important for other species of concern, such as the Columbia spotted frog (Munger and Lingo 2003) and greater sage grouse (USDA NRCS 2016b). In Bridge Creek, the placement of structures was designed to encourage beavers to return to the area and continue the work that the restoration project started by maintaining the installed dams as stable platforms and encouraging persistent colonization (Pollock et al. 2012, USDC 2008). The transition from degraded riparian pastures to thriving riparian communities at the Bridge Creek site is proving to be of interest to landowners and managers dealing with degraded rangelands that are being used for cattle production. Because the BLM does not permit grazing along Bridge Creek where the research took place, we do not know how the presence of cattle would have changed the recovery trajectory in that area. However, on an adjacent private ranch, ranch managers perceived the elevated water table on Bridge Creek as a benefit of BDAs, and installed them on their ranch in 2016 with funds from OWEB.

> It's been proven that if you can get your water table up, it spreads that water out, so you will have more wet spots show up and more green grass... everything benefits.
>
> —Private ranch manager, Bridge Creek

Post-style restoration structures have been in use on rangelands for close to a century to control erosional processes and prevent stream incision (Kraebel and Pillsbury 1934), but researchers at Bridge Creek are the first to link the design and function of these structures to beaver dams. The design of the BDA project by the NOAA Fisheries team is beneficial because it is accessible to others in the restoration community with smaller budgets. Restoration costs using traditional methods and heavy equipment can exceed $1 million per mile, while BDAs are being installed for about $1,000 to $5,000 per structure, including the cost of design and permitting (Winters 2017).

> Before the Bear Creek project, I never had to do the permitting and I was dreading it. I thought it was going to be a daunting process, but it turned out to be pretty painless.
>
> —Herb Winters, Wheeler County Soil and Water Conservation District specialist

Challenges

Not all ranchers are as tolerant of beavers as those carrying out beaver-related restoration projects on their property. In interviews with 20 grazing permittees on the nearby Umatilla National Forest conducted in 2016, several concerns were voiced: three permittees stated that beavers cause problems when they build dams in irrigation systems; four said they disliked the fact that beavers cut down large trees; and two reported that beavers create unwanted flooding in pastures. These drawbacks challenge efforts to promote beaver-related restoration on rangelands shared by ranchers (who typically grow hay). Project implementers caution that BDAs alone are not as effective as having beavers present to use them (Weber 2016), and BDA projects are often designed with the hope that beavers will move in and take over maintenance of the structures. Thus, it is important to communicate the need for beaver tolerance where people are interested in BDAs, and to seek ways of mitigating unwanted beaver behavior.

Several ranchers we interviewed at the Umatilla National Forest and Bridge Creek emphasized the importance of being able to control beavers when they are in the stream system in order to protect their property from flooding or losing large

trees (fig. 4). Control often takes the form of lethal measures to reduce populations and remove beavers from areas where they are not wanted. A rancher interviewed in the Bridge Creek area for this case study said he worries about losing the ability to work in his flooded fields if they are declared wetlands because of the beaver-dams; he therefore uses heavy equipment to pull dams out of the creek. Even with this work to deter beavers, he can point out areas on his property that are being converted from grass pasture to willows.

In 2016, the Malheur National Forest fisheries and watershed program and the Collaborative Forest Landscape Restoration Program provided match funding for the Confederated Tribes of Warm Springs to do restoration on the Malheur National Forest that included 70 BDA structures on Camp Creek (USDA FS 2016). The area has multiple grazing permittees, and over the next several years, this project will provide valuable insight regarding the ways in which the installations affect grazing.

A survey of 1,512 private landowners from all regions of Oregon, including 432 from eastern Oregon, indicated that the public is interested in coexisting with beavers and that incentive programs that supply materials to reduce beaver damage would likely increase tolerance of beavers even when beavers have caused damage (Morzillo and Needham 2015). No such incentive programs have been implemented to date.

Rachael Davee

Figure 4— Beavers cut down large trees that provide shade, which can lower ranchers' tolerance for beavers.

Other concerns with BDAs surfaced during the Oregon Department of State Lands' rulemaking process to create a general permit for BDAs between 2015 and 2017. The creation of a general permit is intended to benefit small groups like soil and water conservation districts and landowners by expediting the permitting for restoration projects. During the public comment period, numerous letters were submitted to the Oregon Department of State Lands expressing a range of concerns from excessive permissiveness to excessive regulatory burdens (ODSL 2017). Gilliam County Soil and Water Conservation District expressed concerns that the Oregon Department of State Lands' proposed requirement to develop a grazing plan in order to receive approval for installing BDAs on private land is an overreach of the department's authority. Concerns about the potential for increased stream temperatures with these projects were also expressed; like natural beaver dams, they create ponded water with more surface area that may result in stream-temperature increases (Majerova et al. 2015). Elevated temperatures are an issue in already impaired streams and require more research; however, research from Bridge Creek indicates that beaver ponds lower temperatures, presumably by increasing rates of exchange or mixing between shallow groundwater and surface water (Weber et al. 2017). Others writing letters opined that even if elevated temperatures result from beaver dams, this elevation may be preferable to the stream going dry seasonally in the absence of BDAs or natural beaver dams. Water rights were also on the list of concerns from water managers and conservation groups in the public comments. According to Oregon Water Resources Department staff involved in drafting the Department of State Lands permit, however, there have been no complaints by individuals about BDAs affecting their water rights.

The rapid expansion of BDAs is premised largely on data from the Bridge Creek project, a single research site that has been in existence for less than 10 years. The same technique is now being applied in different landscapes in hopes of producing comparable results. This rapid scaling up in the use of BDAs suggests a potential risk of misuse owing to their simple design and low implementation cost. It is a challenge to regulate them sufficiently to ensure high-quality installations while not creating onerous regulations that deter landowners.

Though the results of the Bridge Creek study demonstrated that both juvenile and adult salmonids could pass multiple BDA structures, some fisheries biologists still express concerns about the ability of fish to safely pass BDAs. One biologist referred to the post structures as "glorified wood check dams" because he believes that real beaver dams have a more ephemeral quality than the BDAs and are thus more fish friendly. In Oregon, ODFW reviews all BDA installations and must grant approval before a structure may be installed. In one case, the design of a BDA

project was amended to address the ODFW concern that willow branches woven too tightly would create a barrier to fish (Porter 2017). Cumulatively, these concerns clarify the need to learn more about the effects of BDAs at sites beyond Bridge Creek. Data gathered through monitoring would be beneficial for understanding how the structures respond in alternative environments.

Conclusions

Research findings from the BDA experiment at Bridge Creek are being used to design beaver-related restoration projects on public and private rangelands in eastern Oregon and elsewhere in the Western United States. Researchers from the Bridge Creek project are involved in expanding the use of BDAs to ensure that the functional integrity of this tool is not diminished through inappropriate applications. Ranchers and other land managers in eastern Oregon report a mix of benefits and challenges associated with BDAs and beaver-related restoration more broadly. Oregon Department of State Lands is developing a statewide general authorization permit for instream structures that promote floodplain connectivity that will fast track future applications for BDA permits. Beaver population recovery is an important component in achieving restoration on streams where BDAs are used, which means understanding and addressing ranchers' concerns about beavers will be necessary for the tool to be widely implemented. Soil and water conservation districts and watershed councils are important partners in securing funding as well as providing technical expertise to landowners for permitting and installing BDAs. The research on Bridge Creek is informing the development of programmatic biological opinions that allow BDAs to be used in accordance with the ESA, and federal agencies have or are in the process of developing similar enabling programmatic direction.

Future Beaver Dam Analogue Applications

Recognizing the scale at which beavers historically engineered the landscape is the basis for the argument to mimic their impacts by using BDAs as a model for future restoration projects on private and public land (Naiman et al. 1988, Pollock et al. 2014). In Oregon, many BDA restoration projects on rangelands involve soil and water conservation districts and watershed councils, both of which have institutional knowledge about permitting requirements and funding opportunities. These intermediary groups could facilitate the adoption of more BDA projects among private landowners by helping expedite the permitting process, and by helping landowners increase the size of a project by acquiring matching funds through federal and state grantors. To scale up this technology, it may be necessary to

secure additional funds for BDA monitoring because OWEB large grants currently limit monitoring to $2,500 per project. Securing funds through technical assistance grants or effectiveness monitoring grants would ensure projects are able to comply with monitoring requirements and contribute to understanding the effects of BDAs in different environments. With additional funding, grant writers could also consider expanding the scope of a project's monitoring plan to include economic metrics in order to engage more landowners in restoration projects. BDA installations on public lands will likely become more common as federal agencies continue developing more programmatic biological opinions to streamline the paperwork and create precedent about this nascent restoration technique.

> We're going to ramp up and do whole stream systems with hundreds of these BDAs. At $1,000 each, you can't beat it.
>
> —Herb Winters, Wheeler County Soil and Water Conservation District specialist

If Oregon's administrative rule to create a general authorization covering BDA installations statewide is approved as drafted, it will require each project to be reported to OWEB upon completion, and OWEB will maintain a database of all projects implemented under the rule. This inventory will be important because, currently, monitoring of OWEB-funded projects is often limited to photo points and a written description of observed responses to the installation, but the records are not compiled into a database cataloging all BDAs. The Bridge Creek project demonstrates the value of collecting rigorous data on BDA implementation, including long-term changes such as vegetation cover and type, water holding capacity of the soil, total area of riparian habitat, and fish impacts so that future expansion of this restoration tool can occur with confidence that it is promoting environmental benefits. Integrating a socioeconomic monitoring component into BDA projects to examine their impacts on landowners, grazing permittees on federal lands, and their agricultural operations would provide valuable information to ensure that BDAs are implemented in a manner that also provides social benefits, and mitigates their costs.

The use of BDAs is increasing across the West and the effects these projects will have on grazing lands and the ranchers who use them will be more apparent after the structures have been in place for several years. Ideally, if beavers take over BDA maintenance, the cost-benefit ratio will improve by maintaining a recovery trajectory after the financial investment ceases. For the BDAs to achieve desirable long-term ecosystem objectives, explicitly incorporating the role of beavers into restoration planning may help increase success.

U.S. Equivalents

When you know:	Multiply by:	To find:
Meters	1.094	Yards
Kilometers (km)	.621	Miles
Square kilometers (km^2)	.386	Square miles
Cubic meters (m^3)	35.3	Cubic feet

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Appendix

The following projects were designed in full or in part by the research scientists involved with the Bridge Creek intensively monitored watershed (IMW), and initiated based on lessons learned from the Bridge Creek and Asotin Creek IMWs. The projects are directly related to either methods that promote beavers and the construction of beaver dam analogues, or methods to increase large woody debris loading to improve hydraulic and geomorphic diversity and reconnect floodplains using post-assisted log structures.

Stream	State	Objective
Bear Creek	OR	Designed to test the effectiveness of beaver dam analogues (BDAs) in restoring perennial flow to 1 km of an intermittent stream channel tributary to Bridge Creek. During August of 2017, 20 BDAs installed.
Beech Creek	OR	The Oregon Department of Fish and Wildlife (ODFW) installed BDAs to increase habitat complexity for steelhead. The ODFW designed the project based on the BDA work at Bridge Creek.
Nehalem River	OR	A BDA project was implemented by Upper Nehalam Watershed Council and ODFW to demonstrate the utility of BDAs for restoring coho habitat on state forest land. Test structures were installed in 2017, full implementation is planned for 2018.
Pine Creek	OR	Project aims to improve steelhead and riparian habitat in an incised channel with a much less competent flow regime than Bridge Creek. Main partners are the Confederated Tribes of Warm Springs and the Oregon Natural Desert Association.
South Fork Crooked River	OR	The goal is to restore 8 km of stream using BDAs to reconnect the floodplain, recruit riparian vegetation, increase water storage, and create suitable beaver habitat. Pilot structures installed in summer 2015, full implementation in 2016–2018.
Alpowa Creek	WA	87 post-assisted log structures (PALS) installed in 2014 to improve steelhead habitat; also used posts and small trees to improve bank protection on 1.2 km of streambank. Work carried out in cooperation with the Public Utility Department, Clarkston, Washington.
Asotin Creek	WA	The goal of this project is to promote a more dynamic and complex creek to improve rearing habitat for juvenile steelhead. Created high-density large woody debris using PALS with 4 years of treatment in three streams totaling 12 km and over 540 structures.
Little Tucannon River	WA	Proposal with the Salmon Recovery Funding Board to install PALS in the lower 2 km of the watershed in 2016 to improve steelhead habitat.
Methow River	WA	Focused on translocating beaver into the upper portions of the watershed in the Okanogan-Wenatchee National Forest. Project staff have collaborated in workshops and on developing guidance for linking translocation with BDA installation.
North Fork Palouse River	WA	PALS are being used for bank protection in an effort to stabilize bank erosion. This is a prerequisite for getting funds to plant riparian vegetation.
Pataha Creek	WA	The project aims to restore steelhead habitat in a heavily incised channel. Main partner is the Pomeroy Conservation District, and some local Natural Resources Conservation Service and Watershed Councils. Funding secured to install 100 BDAs in 2016–2017 based on results of the Beaver Restoration Assessment Tool model.

Stream	State	Objective
Penawawa Creek	WA	Proposal with the Salmon Recovery Funding Board to install BDAs and PALS to improve steelhead habitat.
South Fork Palouse River	WA	PALS are being used to help stabilize bank erosion; BDAs are being used to improve water retention near intensive riparian planting sites.
Squaw and Rock Creeks	WA	A BDA and PALS project was planned for implementation in 2018 by the Central Klickitat and North Yakima Conservation Districts. Bridge Creek project staff are involved in the planning and design of the project.
Triple Creek	WA	A BDA project was implemented in 2016–2017 by the Okanogan Highlands Alliance, U.S. Fish and Wildlife Service (USFWS), and Trout Unlimited. Project staff have been involved in the planning and design of the project.
Wenas Creek	WA	Ten BDAs were installed by the North Yakima Conservation District to reconnect the floodplain and improve aquatic and riparian habitat.
Basin Creek	UT	Thirty pilot structures were installed on 2 km of one stream in 2014; another 40 to 50 were planned in 2015 on another tributary in the same system. Monitoring is on-going. This is primarily targeted at improving forage for cattle, instream habitat for Yellowstone cutthroat trout, and brood rearing habitat for sage grouse. Partners are two ranchers (it is private property) and the Utah Division of Wildlife Resources.
Curtis Creek	UT	An adaptive beaver management plan for Harware Ranch Wildlife Management Area to mitigate impacts to ranch infrastructure and demonstrate "living with beaver" strategies. Built in spring 2016.
Grouse Creek	UT	A large-scale demonstration project planned on 20+ km of streams in Grouse Creek drainage with Tanner Family Ranches.
Park City	UT	An adaptive beaver management plan for the city adopted in 2012; structures have been in place since then.
San Rafael River	UT	A large-scale pilot implementation project planned for 50 BDA structures to restore degraded habitat to benefit three listed suckers in a moderately incised stream. Partners are the U.S. Bureau of Land Management and Utah Division of Wildlife Resources.
Spring Creek	UT	The project purpose is to mitigate potential flooding and harvest impacts of beavers in an urban area, specifically Walmart. Partners are Bear River Watershed Council, Walmart, and the City of Logan. Constructed in 2016.
Scott River	CA	The project goal is to restore critical habitat for Endangered Species Act-listed coho salmon. The Scott River Watershed Council installed BDAs with funding from the National Fish and Wildlife Foundation and the USFWS.
Birch Creek	ID	The project is targeted at restoring hydrologic perennial flows and restoring Bonneville cutthroat trout. Beavers were translocated, several BDAs were built, and a workshop for Natural Resources Conservation Service staff working on the Sage Grouse Initiative was hosted in 2016.

OR = Oregon, WA = Washington, UT = Utah, CA = California, ID= Idaho.
Source: Chris Jordan.
National Oceanic and Atmospheric Administration's Northwest Fisheries Science Center.
Bridge Creek researcher..

Pacific Northwest Research Station

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