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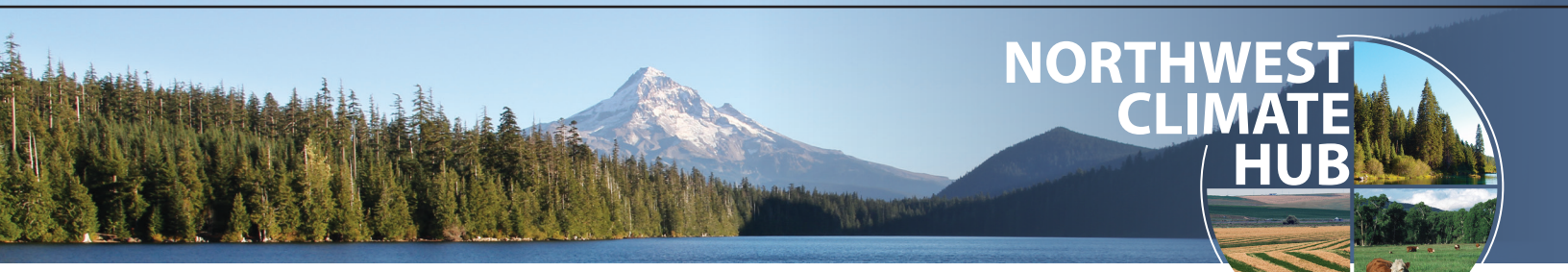

Silvies Valley Ranch, Oregon: Using Artificial Beaver Dams to Restore Incised Streams

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Fast Facts

Project Goals:

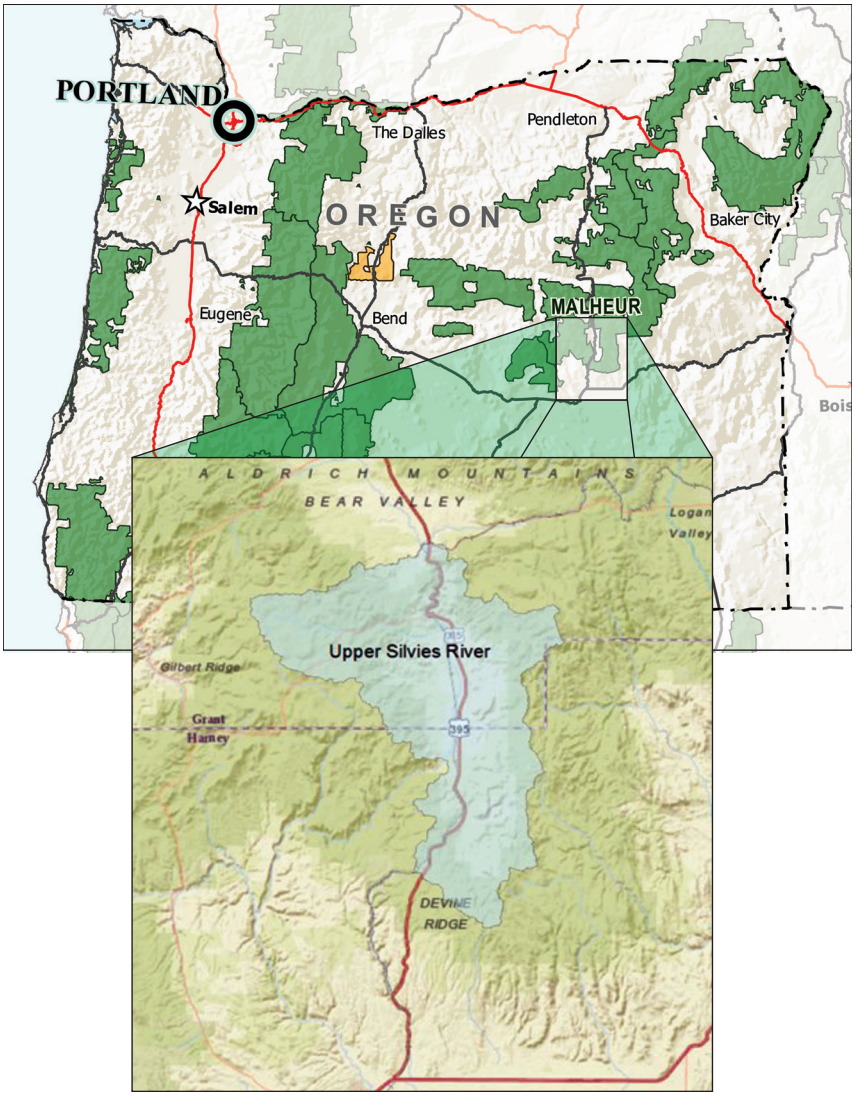
1. Develop a low-cost restoration tool that can be used on this property and others.
2. Enhance beaver habitat to meet wildlife and ranching objectives by mimicking what the beavers created over thousands of years with artificial structures.
3. Eliminate the regulatory barriers to implementation of this restoration strategy.
4. Long term: Recover fish and beaver populations after the habitat is sufficiently restored to support their life cycles.

Project Scope:

- 640 structures
- 18 miles of stream in the Silvies River

Main Implementing Partners:

- Private landowners
- Oregon State University
- Oregon Natural Desert Association



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Executive Summary

The Silvies Valley Ranch is an example of using local innovation to combat the global problem of incised streams on rangelands. Incised channels reduce the flow between water in the channel and water in the surrounding soils, which reduces the vegetation available for wildlife habitat and cattle forage. One of the ranch owners, Scott Campbell, a doctor of veterinary medicine, believes that stream incision is related to the decline of beaver populations; thus, the ranch's approach to restoration includes efforts to mimic beavers' influence on the system. He is using an extensive network of low-rise dams made from locally available materials (dirt, gravel, rock, and logs), commonly referred to as "artificial beaver dams" (ABDs). Campbell said that the ABDs on the ranch successfully increased stream connectivity to their floodplains and increased the quantity and forage quality of wet meadows on the property, with no changes in where cattle were grazing. The experiences of this landowner exemplify a unique approach that provides a model for others facing similar challenges to doing restoration on private land.

The transformation taking place on the Silvies Valley Ranch has garnered the attention of neighboring ranch owners, some of whom are beginning to experiment with similar restoration technologies. Campbell would like to continue installing structures, but has encountered numerous roadblocks in the permitting process. He has since taken an active role in building legislative support for the ABD technology being used on the ranch, and in facilitating its adoption in other places. This case study—based on interviews with stakeholders involved in the Silvies Valley Ranch project—highlights the social benefits and challenges experienced by one rancher using ABDs as a restoration tool, and provides insights for improving their use in the future. It is part of a larger interdisciplinary study that explores the potential of different beaver-related restoration approaches for achieving watershed restoration and livestock production goals on rangelands in the Western United States.

Artificial beaver dams spreading water onto the floodplain, Silvies River watershed.

Introduction

Ranchers in Oregon's region of the Great Basin have a long history of living with environmental variability. Precipitation averages 10 to 23 inches annually, but interannual precipitation patterns (proportions of rain and snow) can vary widely. This has made water management crucially important to land stewardship and productivity because growing grass for livestock forage is highly dependent on natural flooding and flood irrigation systems. Historically, beavers helped optimize water retention by building dams that allowed water to infiltrate riparian areas and subsurface aquifers. However, the near extirpation of beavers in the 1800s caused by trappers initiated a new baseline for stream function. Following beaver removal, dramatic changes in land use practices unfolded over the next 150 years as homesteads and ranches were established and native people were displaced. These anthropogenic changes, coupled with highly erosive water runoff events, played a part in stream incision. The reduced ability of streams to access their floodplains makes flood irrigation challenging or impossible.

Climate trends are expected to cause decreasing snowpack in the Silvies River watershed. Thus, private landowners are developing a variety of instream structures to facilitate watershed restoration and promote flows that are longer in duration and more consistent to help improve hay production, forage conditions for livestock, and overall resilience to drought. These instream structures, termed "artificial beaver dams" (ABDs) by some ranch owners and "restoration check dams" by the Oregon Department of State Lands, have garnered significant attention for their potential to revolutionize approaches to watershed restoration. However, this has not been without controversy.

Structures built in the Silvies River watershed differ widely in size, materials, and scale, but all have a common goal: improving floodplain connectivity. A small-scale project on one property includes half a dozen dams made from juniper cuttings, while a mid-scale project on another uses dozens of rock dams and hardened cattle crossings. This case study focuses on the restoration approach being implemented on the Silvies Valley Ranch, a large-scale project featuring an extensive network of hundreds of rock and soil dams of varying sizes on sites chosen for their diversity to test this concept. The case highlights the perceived benefits of ABDs, and the challenges landowners experience building structures within the constraints of the current state and federal regulatory framework. The case also includes insights into factors that may improve the use of this restoration tool in the future (see "Enabling Factors" below), and characterizes gaps in our understanding of the direct and indirect impacts of ABDs.

Aerial view of a series of artificial beaver dams in the Silvies basin.

This stream channel on the Silvies Valley Ranch incised more than 6 feet, and the streamflow no longer accesses the floodplain.

Methods

This case study was developed as part of a larger, interdisciplinary research effort to assess the social, hydrological, and ecological effects of ABDs as a watershed restoration tool for incised rangeland streams, with the Silvies Valley Ranch as the focal research site. We also sought to improve understanding of what is needed to facilitate implementation of this restoration approach from a social and regulatory standpoint. The information presented here is based on interviews conducted in 2016 with Scott Campbell, who owns Silvies Valley Ranch with his wife and another family; three other private landowners in the Silvies River watershed; one staff member from the Oregon Department of State Lands; and researchers from Oregon State University and the Oregon Natural Desert Association, who are collaborating on instrumentation and monitoring of the restoration project. A 2-day field tour of the ranch that took place in August 2016 also informed this case study. Our goal is to better understand the social context surrounding beaver-related restoration strategies on Western rangelands to learn where they may be beneficial, and what is needed to implement them successfully from a social standpoint.

Background

Trapping journals from the Hudson's Bay Company indicate that, in the 1820s, thousands of beavers were removed from several valleys of the Silvies River watershed. This near-total removal of beavers initiated a change in the geomorphic trajectory of the watershed. Without beavers to maintain them, beaver dams decayed, allowing water from snowmelt and rainfall to drain off more quickly and initiate stream incision. This change in hydrology was exacerbated by rapid land use changes that occurred during the homestead era of the late 1800s and early 1900s. Families traveled up the Silvies River and developed ranches that had further impacts on riparian systems through livestock grazing and building irrigation infrastructure.

Families who established ranches along the Silvies River used the common agricultural practices of the day and cleared riparian trees and shrubs to create pastures and travel corridors. This loss of woody species in addition to heavy grazing by sheep and cattle are thought to have contributed to the erosion of streambanks. As streams began to erode and incise, they disconnected from their flood plains and channelized, gaining erosive capacity that cut down to the bedrock in many locations. This triggered a lateral erosional process that led to wide, simplified channels that drained adjacent wetlands and meadows. The declining water table led to the conversion of wet meadows and associated species to sagebrush steppe with less grass, and to an overall loss of biodiversity resulting from the loss of productive riparian habitat. Over time, ponderosa pines and other more drought-tolerant vegetation replaced riparian vegetation.

After more than 50 years of absentee ownership, the Silvies Valley Ranch, comprised of 40,000 deeded acres and 100,000 acres of grazing allotments on Bureau of Land Management and Forest Service lands, was purchased in 2007 by a local landowner, Dr. Scott Campbell. Along with the co-owners, his wife and another family, Campbell is actively designing innovative approaches to land management and restoration that serve to increase the profitability of ranching operations and provide a model for others facing similar challenges in eastern Oregon. At the time of purchase, Campbell had already restored streams on a neighboring property. He estimates that there were 54

miles of degraded stream channels in need of restoration on the Silvies Valley Ranch. With the cost of conventional approaches to watershed restoration reportedly exceeding $1 million per stream mile, restoration at the scale needed on the ranch was prohibitive. The ubiquity of stream incision motivated the landowners to develop a more "common sense," economical approach.

Project description

A variety of beaver-related stream restoration approaches make use of artificial structures to mimic the effects of beaver dams (Pollock et al. 2015). Silvies Valley Ranch initially experimented with the use of wooden post structures, commonly referred to as beaver dam analogues, but they were destroyed in high water flows, prompting Campbell to adopt the current rock, gravel, and soil ABD technique. This approach has been streamlined through several iterations of experimentation over the past 15 years, and as a result, the cost of restoration on the ranch has dropped to less than $20,000 per stream mile.

The first installation of ABDs on the ranch occurred in 2001 before Campbell bought the property, and they now extend into six tributaries of the Silvies River. ABDs are constructed from rock or gravel quarried on the property that is placed in streams and mixed with dirt. The dams vary in size, but each spans the entire width of the channel and rises approximately 6 inches above the floodplain, which can be up to 16 feet high. The structures are very visible after they are built, but after several seasons they are largely obscured by vegetation and captured silt.

Dams are built at an interval of about one per foot of elevation drop, which can easily require over 100 structures per stream mile. Although this is a large number, it is feasible because local materials are used, and construction equipment is owned by the ranch. Today, there are roughly 640 ABDs on the Silvies Valley Ranch. Using the structures to increase floodplain connectivity, promote sediment deposition, and increase streamside vegetation works synergistically to provide food and habitat that supports the return of wildlife, including beavers and beaver dam building, along the restored channels. Therefore, part of the restoration project includes beaver and other wildlife habitat enhancement. Several species of willow exist along the Silvies River and its tributaries, but only some of these species are used by beavers. The ranch owners are planting aspen, cottonwood, and willow trees, and other plants preferred by beavers. Ranchers found that aspen plantings must be caged for at least 10 years with 10 × 10-foot enclosures that allow a cluster of trees to develop without pressure from beavers or wild or domestic ungulates. In addition to enhancing habitat, the ranch has placed a moratorium on beaver trapping and shooting, which—with the habitat improvement—has led to a marked increase in the number of beavers on the ranch over the past decade. Beavers have not been relocated to the site.

Volunteers construct aspen enclosures to protect young trees from browsing by deer, elk, cattle, and beaver.

"There are places that have turned back to wetlands and we can't graze them. [So] we have given up an acre that is now swamp; but we've gained 6 acres that are good pasture that weren't before. So you give up some land because it becomes less satisfactory to graze cattle on, but you gain a whole bunch more that is outside of that."

-Scott Campbell

Project Outcomes

According to Scott Campbell, structure-based restoration using channel-spanning ABDs has provided a number of direct and indirect benefits through improved floodplain connectivity, vegetation change, and increased width of riparian areas. The overall economic benefits have exceeded the cost of the restoration through increased yields of both organic hay and livestock products, according to an unpublished study by Belton Copp, a Duke University master's degree student.

The most obvious benefit is increased forage availability for livestock in riparian areas. Campbell said that this change is most apparent in areas of the ranch where streams were previously disconnected from their floodplains, causing sagebrush to dominate. As water tables rise and riparian features expand, these areas are being converted back to a mix of perennial native grasses and sedges, which have high nutritional value to livestock. In addition to providing forage for livestock, these grasses are also bailed and sold as organic hay, generating profit for the ranch that pays for the restoration. Filling in the channels has an added benefit of eliminating steep banks that create a hazard to livestock who sometimes fall into the river and are injured or drown.

The increase in wet meadows and riparian vegetation reported by Campbell, including maturing aspen stands, also serve as a fire break that may reduce the intensity and rate of wildfire spread. In talking about a wildfire that ran through the ranch the preceding summer, the ranch manager reported that if Camp Creek—one of the tributaries to the Silvies River—was in its pre-restoration condition, the valley would not have held sufficient moisture to stop the fire, and it would have burned for many more miles.

Changes in the quantity and timing of water flows in the Silvies River and its tributaries are being observed by the landowners, but are difficult to quantify. Elaborate monitoring systems were put in place by Oregon State University hydrologists and geomorphologists to document these changes, but calculating a complete water budget has proven difficult. Although exact numbers are not yet available, the ranch owners observed that there is more water in the Silvies River now than prior to the restoration project, and that it lasts later into the summer. During a visit in August 2016, streams were still flowing in places where they had reportedly gone dry annually prior to restoration. Another benefit observed by the rancher is increased wildlife numbers. The growing presence of beavers around the ABDs may allow them to take over construction of dams in the river. An increased presence of songbirds and larger elk herds may support the development of a wildlife tourism venture on the ranch in the future.

Indirect benefits to the ranch include the return of native redband trout (*Oncorhynchus mykiss gairdneri*), which have been caught in reaches of the Silvies River, Camp Creek, and Hay Creek, where they were not previously recorded in the Oregon Department of Fish and Wildlife's period of record. The vegetative response to ABDs has reportedly been variable, but the increase in streamside willow, currants, and aspen associated with the ABDs provides shade to streams and helps maintain temperature requirements for trout. These findings suggest that, contrary to assumptions that ABDs are detrimental to fish passage, they may in fact be compatible with migratory fish.

The benefits that beavers, beaver dams, and beaver-related restoration technologies provide for ranch operations are sometimes accompanied by undesirable costs as beavers cut down trees, dam irrigation ditches, and flood pastures. Resulting frustration sometimes leads ranchers to remove beavers by trapping or shooting. Silvies Valley Ranch has experienced some of these problems—every year beavers build dams in irrigation channels that must be removed, and some pastures are flooded—but these are seen by the owners as mere inconveniences and tolerable tradeoffs for the broad benefits accrued.

Broader Impacts

The removal of beavers prior to the period when ranches in the Silvies River watershed were established helps explain why it took time for ranchers and scientists alike to appreciate the important role beavers play in stream channel formation and local hydrology. Continued suppression of beaver populations under previous ownership, along with the loss of woody vegetation that beavers need for food and to build dams, and ongoing local skepticism about their benefits, make beaver recovery a challenge. Nevertheless, they are starting to return, and ranchers are learning how to coexist with them and even promote their return by managing for beaver habitat. Many streams are degraded to the point that there is no beaver habitat remaining.

The relatively low cost of the ABD approach, and the ability to retain the use of riparian pastures—rather than fence them off—by using horseback riders to manage livestock impacts, and producing goats, which avoid walking in water, has generated interest from other landowners in the Silvies River watershed. These landowners wish to restore riparian areas and upland connectivity, but are prevented from doing so because of high implementation costs. Interviews with other landowners in the watershed indicate that there is growing use of instream structures as a restoration tool, though these structures are highly variable in size, frequency, and construction material, depending on the degree of incision, stream-channel slope, and available materials near the restoration site.

Torin Foster

Beavers have moved into the restored reaches and started building dams on top of the structures.

Developing nontraditional restoration approaches such as ABDs, based on ecosystem processes, has been referred to in the academic literature as "nature-based solutions" (Nesshöver et al. 2016). These alternatives to expensive engineering solutions offer ways for communities to navigate global challenges such as desertification from climate change-induced droughts. Expanding the number of available options by including nature-based solutions such as ABDs will allow people who depend on these incised stream systems for their economic well-being to select from a broader range of restoration options appropriate to the places in which they live, and the specific challenges they are encountering.

Concerns About ABDs

The greatest barrier to expanding the use of ABDs is the difficulty in obtaining a permit, which stems from the cost of hiring the necessary experts to do the required site analysis, and the time it takes to get approval. On the Silvies Valley Ranch, none of the existing dams were installed with a permit because the owners were unaware that a permit was required; they have since sought the necessary approvals and paid a fine that was assessed by the state. The owners would like to continue adding ABDs to another tributary of the Silvies River but are waiting for a permit to be issued by the Oregon Department of State Lands and the U.S. Army Corps of Engineers (USACE).

Agencies and environmental groups view ABDs as a restoration tool with cautious interest owing to concerns about potential interference with downstream water rights holders and fish passage. Downstream water users are accustomed to, and take advantage of, historically high spring runoff for flood irrigation to produce hay. Water Watch of Oregon and the Oregon Water Resources Department have voiced concern over holding the water on the ranch rather than letting it flow downstream. Conservation groups have expressed specific concerns about the water being used to benefit livestock without obtaining additional water rights. Campbell counters these concerns based on his observation that the restoration is helping to keep streams from going dry in the summer, thereby benefitting downstream users.

Additional concerns have been raised about the permanence and lack of porosity of the engineered rock and dirt structures when compared to real beaver dams. ABDs built with rock are designed to fill the entire channel and spread water to the floodplain immediately, which means they can be very large. The biggest structures on the Silvies Valley Ranch contain more than 1,000 cubic yards of material in the largest creeks, where erosion was the worst, although, on average, most structures contain closer to 200 cubic yards of material. Structures that span the entire width of the valley in which they are placed can create ponds and pools that may be incongruent with the effects that a population of beavers constructing dams would create. Limitations on structure height based on bank-full height would help ensure the structures are being used to get the water up to its historic levels and restore ecological functions rather than simply impounding water.

The Oregon Department of Fish and Wildlife has concerns that certain ABD construction styles do not have sufficient interstitial space, or are too high above the water level for trout and other native fish such as large-scale suckers to pass. There is still debate about whether fish ladders are necessary based on the life history

Cows watering upstream of a beaver dam.

patterns of the fish that occupy these streams, and their ability to adapt by migrating when the water is high and flows over the ABDs, and remain in ponds when the water is low. Having water in the creek is clearly a benefit to fish compared to the previous dry, unrestored condition. Nevertheless, fisheries biologists are also concerned that the ponds will reach temperatures too high for fish, and that they will become trapped in pools as water levels drop in the summer. On the ranch, fish ladders were installed around the ABDs; however, without sufficient monitoring it is not possible to be certain if the fish-passage issues created by these barriers have been sufficiently addressed.

Legal and Policy Framework

The Silvies River is considered "waters of the state," putting it under the jurisdiction of the Oregon Department of State Lands and the USACE, which regulate discharge of sediment and ensure compliance with Section 404 of the Clean Water Act through removal/fill permits. USACE also has regulatory authority over the Silvies River because it flows into Malheur Lake, which is classified as an historically navigable waterway; however, permits issued by the state generally satisfy the requirements of the USACE. Currently, state and federal regulations require private landowners to go through an individual permit application process administered by the Department of State Lands before they are allowed to install any instream structures, including both beaver dam analogs and ABDs. All installations require a removal/fill permit from the Department of State Lands.

Concern for fish passage also brings ABDs under scrutiny from the Oregon Department of Fish and Wildlife, which oversees compliance with Oregon Revised Statutes 509.585 and 509.610, which require artificial obstruction owners to maintain fish passage in reaches where it determines fish have occupied streams prior to European arrival. It is still unclear how well ABDs allow for fish passage in comparison to traditional beaver dams. To address this question, the Oregon Natural Desert Association and Oregon State University are working together to provide monitoring to improve understanding of the effects of ABDs on fish passage. Unfortunately, no pre-project monitoring was done to document baseline conditions.

Multiple layers of regulation make the process of installing the ABDs onerous to the point that several landowners have constructed them with the hope that forgiveness will be easier to obtain than permission. Moreover, a lack of enforcement of existing regulations when structures are installed illegally seems to be reducing the likelihood that people will go through the permitting process as currently structured. To address these problems, during Oregon's 2015 legislative session, House Bill 3217 was introduced to simplify state regulations associated with the installation of ABDs, and streamline the process for implementing this water management technology. The bill was triggered by interest in the restoration work underway at Silvies Valley Ranch. The bill failed, however, in large part because of a lack of data about the long-term effects of ABDs, which prevented the development of language in the bill that stakeholders with competing interests could agree on.

Although the permitting process is seen as arduous by most people involved in this kind of restoration, it is seen by some as an important protective measure to address any potential negative ecological impacts of ABDs as we continue to learn more about them through ongoing monitoring and research. The current regulatory framework is designed to prevent negative actions, with an emphasis on safety and protection, rather than experimentation such as that which has been implemented with this restoration technique. This presents a challenge because landowner experimentation is often a critical part of developing new approaches to the widespread problem of stream incision on rangelands.

"Just because Silvies Valley with all of our resources can do it doesn't mean somebody else can. If somebody else can, then we know we've hit on a good thing... for the entire region and other ranch families.... We're gonna make money, [be]cause we're a business. We can make money when the land is in shape. When the ecology is working right."

— Silvies Valley Ranch Manager

Enabling Factors

Healthy riparian areas have long been acknowledged in ecological literature as important to stream health, but the cost of watershed restoration and apprehension over getting involved in government cost-share programs were identified as deterrents by several local ranchers. The relative affordability of the ABD approach makes it more appealing to landowners. ABDs can be constructed using local materials and equipment that landowners often already own. Also, the same quality of permanence that makes these structures controversial makes them appealing to landowners because they require little maintenance after the first few seasons. Ranches that are using flood irrigation to grow hay identified ABDs as a compatible tool because giving water more frequent access to the floodplain makes their irrigation more efficient. In addition, enhancing wildlife habitat increases the real estate value of the ranch.

Frank Israel

Water behind an artificial beaver dam 5 years after installation facilitates riparian vegetation growth.

Although there are other types of artificial structures that mimic beaver dams, low-rise rock dams are particularly appropriate for streams that have incised down to the bedrock; this is because wooden posts that form the basis of some alternate types of dams, e.g., beaver dam analogues, cannot be pounded into bedrock. Moreover, highly eroded streams may lack the sediment required to fill in behind woven post and vegetation structures. According to Campbell, ABDs immediately raise the water to the historical floodplain and dissipate the energy of the spring runoff that can wash out post structures. The ABD structures allow beaver-based restoration where no inset floodplain exists and beaver dam analogues are not an option. Finally, cattle and goats at Silvies Valley Ranch have continued to graze periodically in riparian pastures during the restoration process, allowing the ranch to maintain high livestock production levels. Whether this would be possible elsewhere depends on the grazing system in use, and on range conditions.

Bringing people together at restoration sites is an important way to create shared learning and communicate goals and challenges.

Rachael Davee

Ongoing Efforts

As stated above, in 2015 the Oregon legislature tabled a bill that would have given blanket approval to use ABDs, owing to a lack of information on the effects that these structures have on water rights and fish. The removal of a legislative solution has led interested parties such as the Silvies Valley Ranch, many state and federal agencies, and lobbying groups to work collaboratively on changing the state permitting system requirements from an individual permit to a general permit that would include approval for a series of structures within a given project.

If approved, this change in administrative rule may expedite the permitting process. The Department of State Lands reports that, in the pilot permit application program, landowners will be required to show that they have made earnest attempts to improve riparian vegetation in addition to installing instream structures to achieve restoration goals. In the meantime, permit requests for ABDs and similar instream structures must still go through the general permit process, which requires wetland delineation and evaluation by specialists, both of which can be prohibitively expensive for a landowner.

Work on developing a new administrative rule to accommodate the use of restoration structures was made possible after much debate and revision to agree on language that was suitable to the diverse members of the Rules Advisory Committee. One key to gaining a common understanding of the situation among committee members was to take several field trips to various restoration sites, including the Silvies River and the Blitzen River (also in the Malheur Lake Basin, where ABDs are in use) to see what they were making decisions about on the ground. Field trips helped reduce inaccurate preconceived notions and address valid concerns about ABDs. This type of joint fact-finding can be very effective in collaborative watershed restoration efforts where conflicts exist. No rules have yet been approved by the agency.

Conclusions

The structure building taking place on the Silvies Valley Ranch is unique and indicates a sea change happening in the larger watershed as private landowners are seeking affordable ways to keep their ranches in an ecological condition that helps them meet their economic and environmental goals. To date, the perceived ecological and economic benefits of ABDs on the ranch have far outweighed any drawbacks to the landowners, including drawbacks associated with the behavior of beavers themselves. Concerns include uncertainty about potential adverse effects on fish and on downstream water users with water rights; more information is needed on these possible impacts.

The ranchers at the Silvies Valley Ranch view the current permitting process as onerous and believe it warrants reconsideration. People who are overwhelmed by the application process won't take advantage of ABDs as a restoration tool, leaving streambeds in a degraded state and continuing to incise. Nevertheless, some say the permit process must be sufficiently rigorous to protect stream systems from alterations that lead to negative impacts in the future. Including monitoring protocols in the pilot permit process would improve the ability to track the effects of ABDs on watersheds. At a minimum, semiannual photo points are effective for tracking temporal change and could be taken by the landowner. Additional monitoring to document changes in water timing over the year would also be useful, but may require outside expertise. Monitoring data would also provide guidance to future projects. Including federal and state agencies as stakeholders in participatory monitoring processes is an important step in addressing their concerns so that ABDs can also be considered as an option for watershed restoration on public lands.

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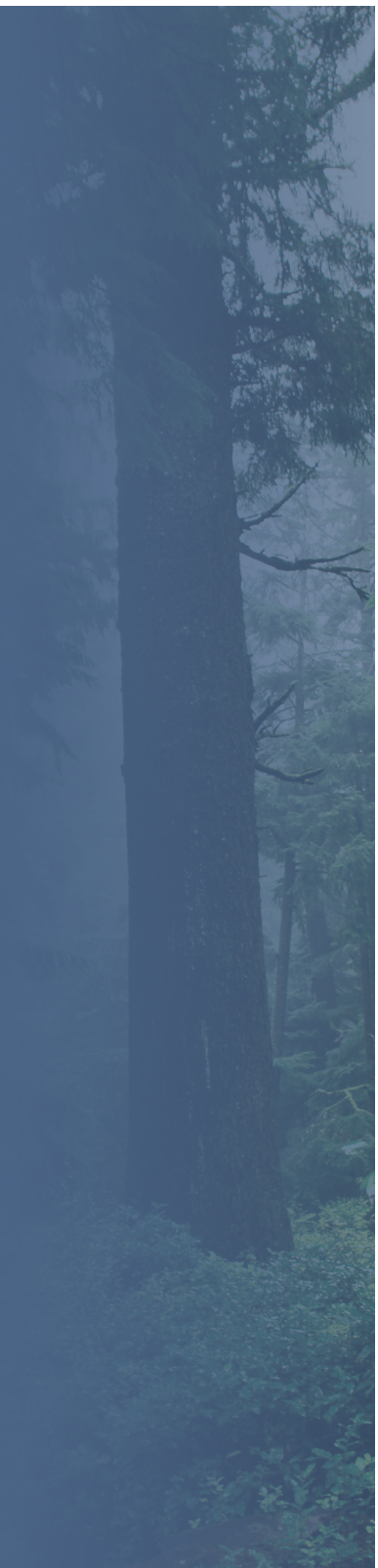

Summary of Findings

1. ABDs represent a bottom-up, place-based approach to restoration that creates a working riverscape that can meet the dual objectives of ecological restoration and economic gain.
2. ABDs can be a relatively cost-effective approach to watershed restoration, especially when using materials sourced locally to make them more affordable.
3. The potential benefits of ABDs for ranching include improved forage quality and quantity in riparian pastures, increased yields of hay, and longer duration of water in streams in the summer, leading to economic benefits for livestock production that may outweigh restoration costs.
4. It is important for structures to be sized appropriately and allow for fish passage where habitat exists.
5. If current regulations associated with installing ABDs and other instream structures are simplified, landowners may be more likely to follow the legal permitting process, report their use, and mitigate any potential negative impacts.
6. Further investigation into water rights issues is needed; there is a lack of information on whether and how ABDs affect downstream users.
7. Field trips have been useful in addressing concerns of regulatory agency personnel.

Acknowledgments

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