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Beavers, Landowners, and Watershed Restoration: Experimenting with Beaver Dam Analogues in the Scott River Basin, California

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Cover photo: Scott River, California. Photo by Susan Charnley.

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-related restoration in western rangelands. The Scott River basin in northern California is the first place in the state where watershed restoration using beaver dam analogues (BDAs, instream post and vegetation-weave structures that mimic natural beaver dams) has been tried. The project takes place on private lands and in streams where federal Endangered Species Act-listed southern Oregon/northern California coast coho salmon *(Oncorhynchus kisutch)* spawn and rear in fresh water before migrating out to the ocean. It started in 2014 as an initiative of a local community group, the Scott River Watershed Council, with technical support from a National Oceanic and Atmospheric Administration scientist. Project goals include improving instream habitat for coho salmon to promote population recovery, improving surface water flows, raising groundwater levels, reducing stream channel incision, and demonstrating the value of BDAs as a restoration tool in California. To date, 10 BDA structures have been built at five sites on streams running through private property in the Scott River basin, and more are planned. Beavers have been active, or have taken over maintenance of BDAs, at all sites. Because this is the first project in California to use this restoration approach, and because the BDAs are being built in critical fish habitat, the project has been undertaken on an experimental basis. It has entailed a large learning curve on the part of the Scott River Watershed Council and federal and state regulatory agencies, but over time the regulatory process for permitting BDAs has gotten easier, and stakeholders are working together to collectively find solutions to ongoing BDA-related challenges. Most of the private landowners involved are ranchers who also grow hay, and who have largely positive views of beavers and beaver dams, so long as they do not interfere with irrigation infrastructure. Monitoring data and interviews with stakeholders indicate that the BDAs are starting to achieve their goals, and are benefitting both landowners and fish, although impacts are localized because the project remains small in scale owing to its experimental status. The Scott Valley case offers important lessons learned for undertaking beaver-related restoration in a private lands context.

Keywords: Scott River, beaver dam analogue, BDA, private land, ranchers, watershed restoration, salmonids.

Contents

Introduction: Beaver and Salmon in the Scott Valley, California

Scott Valley, California (fig. 1), was once known as “Beaver Valley” because North American beaver (*Castor canadensis)* were so abundant there. The Scott Valley forms part of the ancestral territory of the Shasta Tribe, the original occupants of the region (Sommarstrom et al. 1990). The “California Fur Rush,” a period lasting from the 1820s to 1841 (Lundquist and Dolman 2016), drew Euro-Americans to California to trap fur-bearing mammals. Many worked for the Hudson’s Bay Company. It was during this period, in the 1830s, that Hudson’s Bay Company trappers discovered what they called the “Beaver Valley” and “Beaver River” (Sommarstrom 1995). One trapper claimed that Beaver Valley was “the richest place for beaver I ever saw,” and described the Beaver River as being “all one swamp” owing to the high number of beaver dams found there (Sommarstrom et al. 1990: 1–5). The valley and river were later renamed Scott Valley and Scott River after John W. Scott, the first Euro-American to discover gold in the valley in 1850 (Durham 1998).


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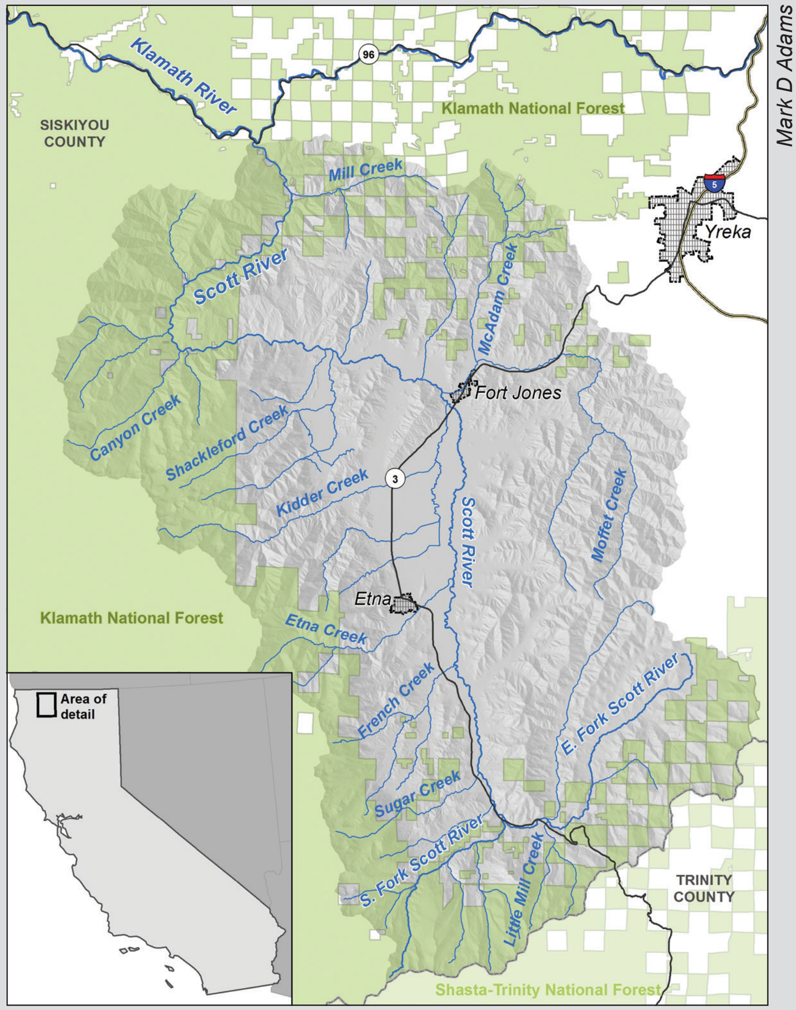
Figure 1—The Scott Valley, California.

Project Facts

Goals:

1. Improve instream habitat for threatened southern Oregon/northern California coast coho salmon
2. Improve instream flows, raise groundwater levels, and reduce stream incision by using beaver dam analogues.
3. Demonstrate the value of beaver dam analogues as a watershed restoration tool in California



The Scott River watershed, California.

Type and Scope:

- Beaver dam analogues (10 BDAs at five sites located in the Scott River main stem and three tributaries as of mid-2018)
- Seven more beaver dam analogues planned for construction in fall 2018, including one new site

Land Ownership:

Private lands

Initiation Date:

2014

Implementing Partners:

- Scott River Watershed Council
- Local landowners
- National Oceanic and Atmospheric Administration

Location:

Scott River watershed, a subbasin of the Klamath River, Siskiyou County, California.

A major shift took place in 1836, when 1,800 beaver were reportedly trapped by Joseph Meek on both forks of the Scott River in one month (Heizer 1972, Lanman et al. 2013, Sommarstrom 1995). Although this event did not cause total extirpation of the beaver population, the significant and rapid population decline and associated breakdown of existing beaver dams likely affected the hydrology of the Scott River and its tributaries (Sommarstrom et al. 1990). The Hudson's Bay Company had stopped trapping in California by the mid-1840s (Tappe 1942). Consequently, George Gibbs—an explorer who was part of the Redrick McKee expedition to northern California in 1851—wrote in his journal that beavers appeared to be multiplying again in the region (Heizer 1972). As his group crossed the Scott Valley, they were entrenched in sloughs made by beaver dams, "of which there seemed to be no end" (Heizer 1972: 164). But by the close of the 19th century, beaver had become scarce on the Scott River again (Tappe 1942). Beaver populations rose and fell in California during the first half of the 20th century as state laws protecting them from trapping were put in place, and then amended in response to outcry from farmers who considered them a nuisance (Tappe 1942). The California State Division of Fish and Game introduced four beaver into the Scott Valley in 1936, and three more in 1940, to try to reestablish colonies there; the Scott Valley's total beaver population in 1940 was estimated at 16 in three colonies (Tappe 1942). Beaver removal together with mining, logging, deforestation, road construction, urbanization, agriculture, irrigation, channel alteration, dams and diversions, grazing, and fire suppression have all had major impacts on the Scott Valley watershed over the past 150 years (described in Harter and Hines 2008, Lanman et al. 2013, NMFS 2014, Sommarstrom 1995, Sommarstrom et al. 1990).

One important impact of these historical events and associated channel alteration, erosion, and sedimentation in the Scott River basin has been degradation of salmonid habitat. Salmonids that spawn in the Scott River watershed are steelhead (*Oncorhynchus mykiss*), Chinook salmon (*O. tshawytscha*), and the Interior Klamath Diversity Stratum of the southern Oregon/northern California Coast (SONCC) population of coho salmon (*O. kisutch*). This functionally independent population of coho salmon is at moderate risk of extinction (NMFS 2014) (fig. 2). The SONCC coho, an evolutionarily significant unit, was listed as threatened under the federal Endangered Species Act (ESA) in 1997, and in 2005 this decision was reaffirmed (NMFS 2014). In 2002, coho salmon were listed as threatened in California from the Oregon border to Punta Gorda in northern California under the California Endangered Species Act (CDFW 2017a). The most recent assessment of SONCC coho salmon population trends (NMFS 2014) concludes that it is likely to become endangered. The decline of the population throughout its range

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Figure 2—Adult southern Oregon/northern California coast coho salmon spawning in a Miners Creek reach where beaver dam analogues are present.

is attributed to a combination of fishing, fish hatcheries, hydropower development, and habitat alteration resulting from a variety of land use and management activities (NMFS 2014). The Scott River basin was historically important for native coho salmon (NMFS 2014), and today the Scott River is the most important SONCC coho salmon spawning and rearing stream in the Klamath Basin (Van Kirk and Naman 2008). Juveniles spend an entire year rearing in freshwater streams, including summer, when water quantity and quality are limiting (Van Kirk and Naman 2008).

Since the late 1980s, concerns over declining SONCC coho salmon populations have spurred efforts toward fish recovery through instream and riparian habitat improvement in the Scott River watershed. One such effort, started in 2014 by the Scott River Watershed Council (SRWC), uses beaver dam analogues (BDAs) to mimic the effects of beaver dams. BDAs are typically constructed in a series along streams and consist of wooden post structures pounded into a stream channel bottom that are then woven with vegetation and sediment (ie., rocks, gravel, silt, clay) (fig. 3) (Pollock et al. 2017). They are semiporous, and span all or part of a stream channel. By mimicking the effects of beaver dams, BDAs have the potential to trigger watershed restoration processes that support natural colonization by beavers, and new beaver dam

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Figure 3—A beaver dam analogue constructed in Miners Creek.

complexes (Pollock et al. 2017). Increasing beaver abundance is one of the highest priority recovery actions identified for the Scott River basin in the SONCC coho salmon recovery plan (NMFS 2014). This "nature-based solution" to promoting salmon recovery, which seeks to restore natural processes, seems fitting in a place once known as Beaver Valley. This case study report describes the Scott Valley BDA project, the experience and perceptions of landowners who have participated directly in it, the legal and regulatory framework in which it has taken place, and outcomes to date.

Methods

I developed this case study using two main methods: interviews with landowners, agency staff, and SRWC members involved in the Scott Valley BDA project; and a review of relevant literature and information from databases and websites. I conducted 19 semi-structured interviews between July 2016 and February 2017. Most interviews occurred in person during two one-week field trips (November 2016, January 2017); three were conducted by telephone. A total of 22 people were interviewed (some interviews had two participants): seven ranchers who were directly involved in having BDAs installed on creeks running through their private or joint property; two landowners who hoped to have BDAs installed on their property during summer 2017 (one farmer, one family forest owner); two members of the SRWC who have been active participants in the project; and 11 state and federal agency employees who have been involved with the project (affiliated with the California Department of Fish and Wildlife, North Coast Regional Water Quality Control Board, U.S. Fish and Wildlife Service, Natural Resources Conservation Service, U.S. Army Corps of Engineers, and National Oceanic and Atmospheric Administration). I recorded, transcribed, and coded the interviews using Atlas.ti, and analyzed and synthesized the coded information by topic area covered in this report (see Miles and Huberman 1994). I also reviewed relevant agency data and SRWC documents as well as relevant published and gray literature about the Scott Valley. I conducted project updates during April to June 2018. All of the information contained in this report comes from interviews unless otherwise referenced.

BDA Project History and Overview

The Scott River watershed forms a subbasin of the Klamath River watershed in northern California, and is 813 mi^2 (2106 km^2) in size (NMFS 2014). The basin is 37 percent federal land (found mainly at higher elevations) and 63 percent private land (located mostly in the valleys) (Harter and Hines 2008). The Scott River runs for 58 mi (94 km) from its headwaters to where it meets the Klamath River. Average annual precipitation in the Scott River watershed is approximately 36 in (91 cm), but varies widely by elevation (Harter and Hines 2008). It is located in Siskiyou County.

The SRWC is the organization responsible for spearheading beaver-related restoration in the Scott Valley. The SRWC began in 1992 as a Coordinated Resource Management Planning Committee under the Siskiyou Resource Conservation District, and coordinated restoration projects associated with coho salmon recovery under the Klamath River Basin Conservation Area Restoration Program (Hoben 1999, USFWS 2006). It became an independent nonprofit organization in 2011 (SRWC n.d.). The SRWC works to promote collaborative, science-based watershed restoration in the Scott Valley that addresses community and ecosystem needs (SRWC n.d.). The organization began its work with beavers after witnessing local beaver activity and becoming interested in them. Initially it conducted voluntary interventions to reduce the problems beavers sometimes create for landowners.

In 2011, the SRWC contacted Dr. Michael Pollock, a scientist at the National Oceanic and Atmospheric Administration (NOAA) in Seattle, after hearing about his work pertaining to beaver-related restoration. Since 2003, Dr. Pollock had been conducting research on how to restore freshwater habitat for salmon recovery using beaver and BDAs at Bridge Creek in central Oregon (see Davee et al., in press).

Dr. Pollock subsequently went to the Scott Valley and gave a talk about how beaver could be used to restore freshwater stream systems to benefit both fish and water resources. The talk generated much interest and enthusiasm, and was the start of what has become a strong partnership between the SRWC and Dr. Pollock to implement watershed restoration using BDAs in the Scott Valley. The Scott Valley was the first place in California to use BDAs as a watershed restoration tool and the project has been considered a research experiment. SRWC interviewees identified the project's goals as being to improve instream habitat for threatened SONCC coho salmon, improve instream water flows, raise groundwater levels, reduce stream channel incision by reconnecting streams to their floodplains, and demonstrate the value of BDAs as a watershed restoration tool in California.

Installing BDAs in the Scott River watershed required technical expertise, people to do the work on the ground, funding, willing landowners, and permits. Dr. Pollock provided technical expertise as scientific advisor to the project. Labor was performed mainly by SRWC members, Dr. Pollock, people hired by the SRWC to work on it, and volunteers. Grant funding for BDA construction came from two main sources: the U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program, and the Coho Enhancement Fund administered by the National Fish and Wildlife Foundation. The Partners for Fish and Wildlife Program provides private landowners with financial and technical assistance to help them manage their lands to benefit fish and wildlife, with a focus on anadromous fish, threatened and endangered species, and migratory birds. The Coho Enhancement Fund, established by PacifiCorp, provides grants to support restoration projects that promote salmon recovery to remediate some of the effects on salmon of its seven hydroelectric dams on the Klamath River (PacifiCorp n.d.). The topics of landowners and permits are discussed in detail below.

The SRWC originally proposed installing BDAs at six sites in the Scott River watershed, with six structures per site. However, they only received California state permits to install BDAs at three sites, with two structures per site. The three sites are located on streams running through private lands, and were chosen based on restoration need as well as landowner willingness to participate. Structures were built at these three sites in the summer and fall of 2014. Two sites are located on the main stem of the Scott River, and one on a smaller Scott River tributary called Sugar Creek (fig. 4). One Scott River site and the Sugar Creek site span two landownerships, with the upstream and downstream BDAs on different ownerships. One landownership on Sugar Creek is collectively owned by nine members of an irrigation district having irrigation infrastructure there; a majority of members had to vote to approve the project, which they did.

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Figure 4—A beaver dam analogue on Sugar Creek.

In summer 2015, the SRWC was permitted to install two more structures at one site on Miners Creek, another Scott River tributary, and did so. This site was added because one of the two BDAs at each of the two BDA sites on the Scott River main stem (two of four structures) blew out during a storm in the winter of 2014–2015, and the new site was needed for research purposes. No new BDAs were built in 2016. However, in late 2016, the SRWC received a new permit to install four BDAs at a side-channel site off French Creek, another Scott River tributary. Of these four, three are single BDAs and one consists of three structures—one primary and two step-down structures. In summer 2017, these four structures were installed there. The permit also allows for construction of up to 11 additional BDAs in the French Creek side channel in the future if needed for adaptive management purposes.
In fall 2017, the SRWC was permitted to undertake some additional construction work at the Sugar Creek BDA site, and did so. This work consisted of building two step-down structures below the lower BDA to help fortify it, reduce streambed scour, and enhance fish passage; and connecting the lower BDA with an ancillary structure next to it in a side channel to help maintain high winter water flows. These three improvements to the lower BDA took place in fall 2017. In spring 2018, the SRWC received a permit to build up to 15 additional BDAs in the future in Sugar Creek if needed for adaptive management as stream conditions change. The SRWC

currently has funding and permits to build five more BDAs at a sixth site, Rattlesnake Creek (another Scott River tributary), which they plan to do in fall 2018. The permit includes the ability to construct up to 10 additional BDAs at the Rattlesnake Creek site over the next 5 years, and allows for nine large wood jams to be installed upstream of individual BDAs over time to help diffuse high-velocity streamflows in places where the channel is deeply incised. The SRWC also has funding to improve the two BDA structures on Miners Creek (including constructing three step-up structures from the upper BDA), and to build two new BDAs upstream of them, in fall 2018, as soon as the permitting process is complete. The new permits for Miners Creek will also provide for construction of up to 10 additional BDAs there over the next 5 years.

Throughout this period, the SRWC has also conducted maintenance of, and made improvements to, existing BDA structures damaged by streamflows during winter storms. Of the original eight BDAs constructed in 2014 and 2015, two have blown out and been destroyed, and the others have suffered damage. Beavers themselves repaired some of the damage at two BDAs, and beavers have either occupied, or engaged in activity at, all remaining sites (Yokel et al. 2018). Because the water flows are so much greater in the main stem of the Scott River than in the tributaries, and because those flows have damaged and washed out BDAs in the main stem, the SRWC has decided to focus on installing additional BDAs in Scott River tributaries to gain more experience with the technique before proposing new structures in the Scott River's main stem. The SRWC members interviewed hope that the BDAs will continue to attract more beavers to move in and take over dam maintenance.

An important component of the BDA project has been monitoring to assess the impact of BDAs on water, fish, aquatic species passage, riparian areas, and birds. SRWC has been responsible for the bulk of the monitoring work, with some support from the California Department of Fish and Wildlife (CDFW) and the NOAA. Indicators they are monitoring include fish movement and passage using PIT (passive integrated transponder) tags, numbers of fish above and below the BDAs, habitat rearing capacity for SONCC coho, stream water temperature, surface water elevation, and groundwater levels and recharge (Yokel et al. 2016, 2018). Between 2015 and 2017, the Klamath Bird Observatory conducted prerestoration baseline monitoring of riparian vegetation and bird populations at four sites where BDAs have been constructed to date and one reference site (Rockwell and Stephens 2017). Ongoing monitoring of changes in riparian vegetation, and bird populations as an indicator of overall ecosystem health, is planned at these sites to help evaluate the ecological impacts of BDAs.

Working with Landowners

When implementing BDA projects, it is important to choose sites that are appropriate from both a biophysical and social standpoint. The reaches of the Scott River and its tributaries where it is appropriate to build BDAs according to biophysical criteria (e.g., low-gradient floodplains) run mainly through private property (fig. 5). Access to streams for installing, maintaining, and monitoring BDAs requires traversing private lands, and private property may be affected by changes in water flows resulting from the BDAs and the beavers that are attracted to them. The Scott Valley is dominated by agriculture, and land use activities may also affect project success. Thus, the SRWC had to find landowners who were willing to participate in the project and live with its impacts.

The SRWC tried to present the project to landowners in a way that helped them see its potential benefits. Although recovering and maintaining SONCC coho salmon populations was a main driver for the SRWC, the coho issue has been politically volatile in the Scott Valley for years owing to conflicts of interest between water use for agriculture versus fish recovery. Thus, the SRWC emphasized the potential benefits of increased water availability associated with BDAs, a resource that farmers and ranchers care about. For the most part, landowners have not been directly involved in project implementation, unless they are members of the SRWC. As one landowner said, "…it didn't cost us a dime. They did all the work. I get to sit back and reap the benefits… " (interview 7). Table 1 summarizes landowners' motivations for project participation (including those awaiting structures). Common themes are increased water availability, agricultural benefits, and benefits to salmon.

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Figure 5—The best sites for beaver dam analogues in the Scott Valley are in streams that run through private property.

Table 1—Landowners' reasons for participating in beaver dam analogue (BDA) projects (n = 9)

Reasons	Number of landowners participating
Raise groundwater levels (benefits cited = increased water availability for sub-irrigation of hay fields and pastures to enhance their productivity and reduce the need to irrigate, lower cost of pumping groundwater for agricultural uses, improved surface water flows)	6
Improve surface water flows (i.e., slow runoff, spread water across channels, increase late-summer streamflows, reduce summer surface water disconnections to prevent rivers from drying up)	6
Improve and increase salmon habitat to promote population recovery	6
Increase riparian vegetation and improve riparian habitat	2
Improve wildlife habitat	2
Reduce landowner liability for coho "take" through water use for farming by increasing streamflows and duration	2
Increase water storage capacity of system	2
Create more wetlands	1
Increase water availability for irrigation	1
Increase streambank stability and reduce streambank erosion and loss of farmland by slowing and redirecting streamflow	1
Promote acceptance of BDAs as a restoration tool by regulatory agencies	1
Contribute to watershed restoration and encourage other landowners to do the same	1

One key to project success has been ensuring that landowners and BDA-implementing organizations maintain good relations throughout the project, even when things go wrong. Landowners interviewed said that important considerations for maintaining good relations with them during project implementation include: notifying them when planning to be on their property to visit or conduct work related to the BDAs, keeping them informed of project activities taking place on their property, being respectful of their property, following the terms of landowner agreements, withholding judgment about how landowners manage their lands, not having ulterior motives, and mitigating any undesirable impacts to their property from the BDA structures. One interviewee also stressed the importance of approaching landowners in a way that is not threatening from a regulatory standpoint:

> A lot of people … don't like people on their land. … they're [the regulatory agencies] not gonna let you do it [the project] without them coming out and looking at it. Well, if you won't allow them, they're not gonna come out and do it. I know every rancher on the west coast is always worried about some regulatory agency finding the spotted frog, or a salamander. An endangered plant. Then it shuts your whole operation down. I don't think they're out

> looking for that…. Just as long as you … keep 'em away from that spotted frog and send 'em over there, you're okay. I think everybody nowadays is so worried about government agencies. (Interview 7.)

This latter comment points to the benefit of having a nongovernmental organization such as the SRWC implementing the project and serving as an intermediary between government agencies and landowners. Landowners are likely to feel less threatened by a nongovernmental organization than a state or federal agency. Having the SRWC implement the project instead of a landowner him or herself also alleviates landowner liability if something goes wrong, such as harm to coho salmon. One landowner said, "We want no responsibility. There's no responsibility on the landowner… the watershed council's gotta eat it if they kill stuff. Not us" (interview 7).

> The SRWC recognizes the importance of addressing landowner concerns throughout the project implementation process. As one SRWC interviewee noted: Looking back on it… I think my No. 1 recommendation would be to make sure you understand their concerns… you're addressing their (landowners) concerns… To try to eliminate or brush their concerns to the side I think is a huge mistake. I think it'll boil up later when there are issues (interview 1).

For their part, the SRWC learned that it is important to make landowners fully aware of what they are getting into when they agree to have BDAs on their property. The SRWC now has a pamphlet that it uses to guide a structured interview process with potential new landowners that explains how BDA structures work, and that asks landowners a series of questions to help them develop the level of understanding needed to make a decision about whether to participate (e.g., where is critical infrastructure located on your property, where would you want water and not want water, what if this or that happened). As one SRWC representative said:

> …a lot of what goes under the moniker of restoration is really protection of landowner infrastructure. These stream bank stabilization projects, what they're really doing is protecting landowner property … this [BDAs] is not really about that (interview 4).

Instead, BDAs promote restoration through natural processes, and natural processes are dynamic. An SRWC representative described it this way:

> … the landowner understanding has to be pretty complex about … that we're not trying to nail the river into a single location. The landowner really has to understand … that you're working with a dynamic process, and they have to buy into this. You really have to have really deep and explicit conversations about that up front, or you're gonna end up in these kind of

difficult situations. … If you're trying to build these structures in a reach where some side-channel erosion is not acceptable to the landowner, or increased frequency of water and inundation on the floodplain is not acceptable to the landowner, or an increase in meander [is unacceptable]—then that is probably not the correct location to be doing this style of restoration. Find a different site (interview 4).

The SRWC now has more landowners who are interested in having BDAs installed on streams running through their properties than they have permits and funding to build, and some landowners who were initial project participants would like to have more installed. The U.S. Fish and Wildlife Service is also now working directly with landowners in the Scott Valley to implement BDAs.

Legal and Regulatory Framework for BDAs in California

Because the Scott River basin was the first place in California where watershed restoration using BDAs occurred, and because it is an important spawning and rearing area for SONCC coho salmon, it has taken time for the SRWC and the regulatory agencies to navigate the BDA permitting process. One agency representative observed, "…I think we're really all learning" (interview 15), but the learning process, according to those involved, has been slow and sometimes frustrating. Nevertheless, substantial progress has been made. The legal and regulatory framework for implementing BDAs on private land in California involves both federal and state agencies, whose roles are summarized in table 2 and described in detail below. The requirements are somewhat different when BDAs are implemented on public lands, where the process is more streamlined; this topic is not addressed here.

Table 2—Federal and state agency roles in regulating beaver dam analogues

Agency	Regulatory role
National Oceanic and Atmospheric Administration	Oversees management of, and compliance with, the federal Endangered Species Act for marine species and anadromous fish.
U.S. Army Corps of Engineers	Oversees compliance with section 10 of the Rivers and Harbors Act and section 404 of the Clean Water Act by regulating the construction of structures in or over—and the discharge of refuse, dredged material, or fill into—navigable waters of the United States and three-parameter wetlands (wetlands containing hydric soils, hydrophytic plants, and having wetland hydrology).
California State Water Resources Control Board	Responsible for protecting and restoring waters in the state of California; oversees compliance with Clean Water Act section 401 in coordination with the U.S. Army Corps of Engineers by issuing section 401 water quality certifications.
California Department of Fish and Wildlife	Issues section 1602 permits, also known as lake and streambed alteration agreements, for nonfederal projects (federal projects are exempt); approves small habitat restoration projects under the Habitat Restoration and Enhancement Act; oversees compliance with the California Endangered Species Act and the California Environmental Quality Act.

National Oceanic and Atmospheric Administration

Because the NOAA is responsible for overseeing compliance with the federal ESA for, and management of, anadromous fish, its role in the Scott Valley BDA project revolves around ensuring that BDAs do not have a negative impact on the ESA-listed SONCC coho salmon, both in the short and long terms. The NOAA makes this determination through a consultation process with the Army Corps of Engineers before the Corps approves a project. Consultation occurs on an as-needed basis for individual projects. To date, the NOAA's finding has been that BDAs are not likely to have an adverse impact on SONCC coho salmon as long as they are constructed when coho are not present, or where there is hydrologic disconnection from adjacent critical habitat. It is the instream construction phase, rather than the presence, of BDAs that is their concern. Because BDAs mimic beaver dams, and salmon coevolved with beaver, the NOAA does not think that they will cause "take"[1] when their construction is properly timed. Thus, the SRWC builds BDAs during the summer when stream channels are too dry, or the water is too warm, for fish to be present. The NOAA is planning to update a programmatic biological opinion for restoration activities in northern California, including the Scott Valley, in 2022 that will include BDAs as a permissible restoration activity having no significant adverse impact on coho. The current programmatic biological opinion for this region does not have this provision. Such an updated programmatic biological opinion would streamline ESA take authorization because consultation would not be required for each individual BDA project.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers is responsible for overseeing compliance with section 10 of the Rivers and Harbors Act and section 404 of the Clean Water Act. Any entity undertaking an activity in navigable waters of the U.S. (waters that are/were/could be used for interstate or foreign commerce, or intrastate waters that could affect commerce) must first notify the Corps and apply for a permit, if required. In the case of BDAs in the Scott Valley, the permit being used is the Corps of Engineers Nationwide Permit 27, which applies to aquatic habitat restoration and enhancement projects. Nationwide permits are general permits that go through a rulemaking process every five years, and enable authorization of projects that meet their requirements and have minimal adverse environmental effects (USACE n.d.). When the SRWC applied to the Corps of Engineers to approve its

[1] Under the federal Endangered Species Act (section 3), "take" means engaging or attempting to engage in any of the following activities: harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting a listed species.

BDA project, the Corps' main concern was potential negative impacts of BDAs on ESA-listed fish. Through consultation with the NOAA, the Corps determined that BDA projects were unlikely to negatively affect SONCC coho salmon in the Scott River basin. Therefore, the Corps found that the BDAs met all of the requirements of the Nationwide Permit 27, and authorized the SRWC to move forward without being required to go through a separate, stand-alone permitting process. The SRWC must notify the Corps of Engineers every time it proposes to install any new BDA structures, but the authorization process is quick because approval is expedited under Nationwide Permit 27.

California State Water Resources Control Board

Projects in California that require a U.S. Army Corps of Engineer permit, or that could result in discharging dredge or fill materials into California state waters or U.S. surface waters, require a Clean Water Act section 401 water quality certification from the state of California (NCRWQCB n.d.). The purpose of this certification is to ensure that any activity being permitted by the federal government in state waters is not detrimental to those waters and complies with state water quality standards. The North Coast Regional Water Quality Control Board, part of the California State Water Resources Control Board, is the regional board responsible for issuing 401 certifications in the Scott River watershed. Before a certification can be issued, the applicant must comply with the California Environmental Quality Act (CEQA). In 2014, the SRWC approached the North Coast Board to obtain a 401 certification, which they received with a categorical exemption from the requirement to undergo full environmental review under the CEQA. The certification has certain stipulations that must be met, for example, the board wanted the SRWC to construct BDAs using locally sourced materials (e.g., willows, sediment) and untreated posts. Because BDAs were new to the board, and the 401 certifications were new to the SRWC, there were some initial challenges associated with aligning BDA project activities with the terms of the certification. However, the two groups have since worked together to make them align. The Water Quality Control Board also works with the CDFW to ensure that they align their respective permitting of BDAs.

California Department of Fish and Wildlife

In California, Fish and Game Code (FGC) §1602 requires anyone who is conducting an activity that could: substantially divert or obstruct a lake, river, or streamflow; change or use material from a lake, river, or streambed or bank; or deposit materials into a lake, river, or stream, to notify the CDFW (CDFW n.d. a). If the CDFW determines that the activity may substantially affect fish or wildlife in an adverse way, it requires the entity performing the activity to first obtain a lake and streambed alteration agreement, also referred to as a section 1602 permit. The agreement, issued by the CDFW, stipulates measures to be undertaken to protect fish and wildlife, and must comply with the CEQA. In order to proceed with the BDA project in the Scott Valley, the CDFW's Northern Region office required the SRWC to obtain a lake and streambed alteration agreement. Although the CDFW was familiar with other techniques for restoring instream habitat for salmon, BDAs were new to it, and it had concerns about potential detrimental impacts on SONCC coho salmon from BDAs that might result in take, specifically, by blocking fish passage. The CDFW also had to ensure compliance with the CEQA before issuing an agreement. The project underwent much scrutiny by the CDFW because it was being implemented in streams that have SONCC coho salmon protected by both the federal ESA and the California ESA, and because no scientific studies about BDA impacts were available from California.

The SRWC installed the first three pairs of BDAs in 2014 under a lake and streambed alteration agreement from the CDFW, with a categorical exemption under the CEQA because the project was considered a research experiment.[2] However, in the absence of a full environmental review, there were restrictions on what could be done. Thus, modifications to the original research design were made, reducing the number of sites and BDAs at each site (described earlier) to minimize potential adverse effects on fish. Other stipulations included ensuring that the BDAs did not block fish passage at any life stage (a regulatory requirement). The second round of BDAs constructed in 2015 in response to the blowout of two of the original main-stem structures were permitted through an amendment to the original agreement.

Instead of using a lake and streambed alteration agreement, the BDAs permitted for installation in the French Creek side channel, the additional BDAs permitted for Sugar Creek in 2017, and the new construction proposed for Miners Creek, use a regulatory tool made possible by California's Habitat Restoration and Enhancement Act, passed in 2014. This Act makes it possible for the CDFW to approve voluntary small-scale habitat restoration projects undertaken by landowners and other entities that are designed to benefit fish and wildlife without requiring them to obtain a lake and streambed alteration agreement or a California Endangered Species Act permit, as described by the CDFW (n.d. b):

[2] Section 15306, Article 19 of California's guidelines for implementing the CEQA (California Code of Regulations, Title 14) allows categorical exemptions for information collection purposes, i.e., basic data collection, research, experimental management, and resource evaluation activities that do not incur a major disturbance to an environmental resource.

> Habitat restoration or enhancement projects, as defined by the Act, are projects with the primary purpose of improving fish and wildlife habitat and meet the eligibility requirements for the State Water Resources Control Board's Order for Clean Water Act Section 401 General Water Quality Certification for Small Habitat Restoration Projects. Projects approved under the Act must be consistent with widely recognized restoration practices, must avoid or minimize any incidental impacts, and must result in measurable environmental benefits.

Depending on the type of request, the CDFW approves project applications within either 30 or 60 days. The Water Quality Control Board also has authority to issue 401 certifications for small habitat restoration projects, in which case CDFW can approve a project by issuing a consistency determination with the Water Quality Control Board 401 certification, expediting the process. The old permits were retired when new Habitat Restoration and Enhancement Act permits were issued for Sugar and Miners Creek.

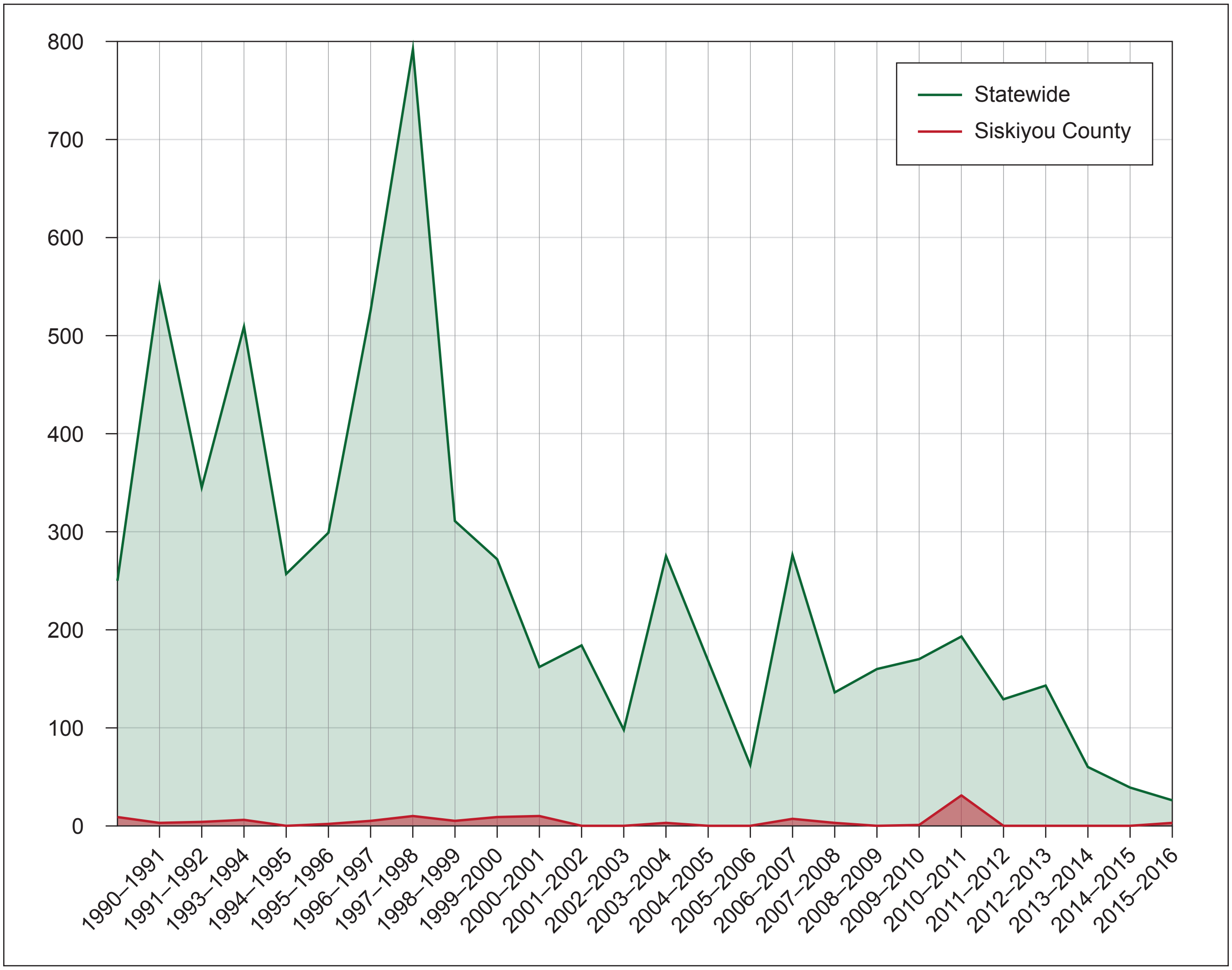
The Habitat Restoration and Enhancement Act helps streamline the BDA permitting process and provides more flexibility for adaptive management. One drawback is that projects approved using this tool must be implemented exactly as proposed owing to their categorical exemption status. Nevertheless, the SRWC was able to include provisions in their first permit (French Creek side channel) so that it (1) applies to a stream reach rather than a specific, individual site; (2) allows for construction of four BDAs rather than two (as required at the first three Scott Valley sites); (3) enables them to import sediment for building structures rather than use local materials (local sediment is sandy, making the dams too porous, and the fine-clay sediments needed do not occur locally); and (4) allows the SRWC to construct up to 11 additional structures within the project reach without obtaining a new permit as part of an annual adaptive management work plan that is reviewed and approved by the CDFW and the North Coast Board. The Sugar Creek permit has similar provisions that allow for adaptive management in the future in response to the changing stream environment. This innovative permit issued for the more recent BDAs was the result of collaborative problem solving by the SRWC and the regulatory agencies to figure out how process-based restoration approaches can be accommodated within the existing regulatory framework. The shift was possible because the SRWC and the agencies had three years of experience working together to figure out how to achieve mutual restoration goals while addressing their respective concerns.

A Word About Beavers in the Scott Valley

One potential outcome of restoration projects that use BDAs is improved habitat conditions for beaver, enabling them to move in, take over BDA maintenance, and build new beaver dam complexes. In California, it is not legal for individuals to relocate most live wild mammals, including beavers, without a permit from the CDFW (FGC §2118, 14 CCR §671). Beaver translocation is virtually nonexistent in California because the CDFW does not support the activity owing to such concerns as it could adversely affect landowners in the receiving area. Thus it is worth looking at the status of beaver in the Scott Valley to assess the potential for beaver to occupy BDA sites. As noted earlier, the Scott Valley was once called Beaver Valley owing to its abundant beaver populations. Currently, the CDFW does not survey beaver populations, making data on current populations in California, Siskiyou County, and the Scott Valley unavailable. Every landowner interviewed reported having seen beaver activity, including beaver dams, somewhere in the Scott River basin—mainly in the tributaries, and often on their own properties. Landowners had also observed beaver dam blowouts during high water flows in winter. One interviewee from the CDFW said, "…our wildlife program does not think there's a shortage of beavers in the … Scott River (interview 15)," although habitat conditions may be limiting their expansion in some places. Most beaver that occur in the watershed reportedly are bank beavers that do not build dams.

Many agency personnel and landowners interviewed perceived that beaver populations in the Scott Valley are increasing. Increases in beaver populations may in part be a product of low trapping pressure. In California, beaver are considered a furbearer species (FGC §4000) and can be trapped in most counties with a trapping license between November 1 and March 31 with no bag or possession limits. Licensed trappers are required to report their annual harvest to the CDFW at the end of the season each year. Reported beaver trapping levels in California have declined overall during the past three decades, with less than 100 beaver harvested annually by licensed trappers statewide since 2013 (fig. 8). In Siskiyou County, reported trapping levels have ranged from 0 to 10 animals annually since 1990, with one peak of 31 animals occurring during the 2010–2011 season (fig. 6). Low levels of licensed beaver trapping may be attributed to low prices for beaver pelts in California, which averaged $10 per pelt annually between 1990 and 2004 (annual averages ranged from $5 to $14) (CDFW n.d. c). More recent data were available for only the 2014–2015 season, when the average price was $16 per pelt.

Landowners whose properties are damaged or threatened by beaver can apply to the CDFW for a depredation permit (FGC §4181), which the CDFW issues if



California Department of Fish and Wildlife

Figure 6—Beaver harvest by licensed fur trappers in California State and Siskiyou County, 1990–2016.

evidence of depredation is sufficient. These permits allow the take of nuisance beavers by the landowner, someone working on his/her behalf, or USDA Animal and Plant Health Inspection Service's Wildlife Services. Table 3 indicates that Scott Valley residents do occasionally request depredation permits; the number authorized for removal on each permit is typically one or two animals. The CDFW also suggests landowners seeking depredation permits contact the SRWC to explore nonlethal control options, which the landowner may or may not do. The SRWC educates interested landowners about alternatives to removal, and helps them implement solutions such as wrapping trees with wire to prevent chewing, installing "beaver deceivers" to prevent culverts from being plugged, and installing pond levelers to prevent flooding.

Table 3—Number of beaver depredation permits issued in Siskiyou County and the Scott Valley, California, 2004–2016

Year	Number of permits issued, Siskiyou County	Number of permits issued, Scott Valley[a]
2004	1	1
2005	5	4
2006	1	0
2007	2	2
2008	5	3
2009	7	3
2010	2	1
2011	4	2
2012	3	3
2013	3	3
2014	0	0
2015	3	2
2016	2	1
Total	38	25

[a] Data are for Callahan, Etna, and Fort Jones.
Source: CDFW 2018.

Landowners, Livestock, and Beavers

Farming and livestock grazing are the dominant land uses in the Scott Valley (NMFS 2014), and both are intertwined with beaver-related watershed restoration because (1) BDA restoration activities take place in streams that run through private farms and ranches, (2) livestock grazing has the potential to affect aquatic and riparian areas where BDAs are built and where beaver live, and (3) BDAs and beavers have the potential to affect agricultural activities. This section focuses on interactions between private landowners, livestock, and beavers in the Scott Valley.

Combined, landowners interviewed owned several thousands of acres (hectares) of land in the Scott Valley. Ranching takes place on private lands; although some of the ranchers interviewed had grazing allotments on the Klamath National Forest in the past, none currently made use of them and had relinquished former permits. Instead, they irrigate pastures in summer to produce forage, and feed animals hay when needed (fig. 7). All but one landowner interviewed also grow grass hay, alfalfa, or grain on their land, and some sell these crops for income. Ranchers interviewed own from 10 to 20 cattle to several hundred, and some also keep horses and sheep. They generally manage their livestock through rotational grazing in pastures on their property. Livestock obtain water almost exclusively at stock troughs or tanks, ponds, and irrigation ditches rather than from the Scott

Figure 7—Cattle eat hay in winter when forage is scarce.

River itself or its tributaries owing to programs to exclude livestock from streams and associated riparian areas (fig. 8).

In 1986, Congress passed the Klamath River Basin Fishery Resources Restoration Act, which established a 20-year federal-state cooperative program (terminated in 2006) called the Klamath River Basin Conservation Area Restoration Program (USFWS 2006). Its purpose was to restore and maintain anadromous fish populations in the Klamath River basin. The Klamath Act authorized $21 million in appropriations to fund restoration activities over this 20-year period. One focal area was riparian restoration, with livestock exclusion fences and tree planting along streams being the main activities carried out in this arena (USFWS 2006). Consequently, in the 1990s, most ranchers in the Scott Valley had exclusionary fencing installed on their properties along riparian corridors to keep livestock out of riparian areas. The funding authorized by the act paid most of the costs associated with fencing riparian corridors and developing alternative water sources for livestock. One rancher interviewed estimated that 95 percent of the Scott River main stem and its tributaries where cattle, horses, and sheep occur on private land was fenced off by 2000. Another estimate is that about 20 percent of pastures or fields adjacent to stream channels lack exclusionary fencing, or have fencing that is not maintained, though the vast majority continues to be

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Figure 8—Most livestock in the Scott Valley drink from developed water sources, such as water troughs, owing to riparian corridor fencing that excludes them from streams.

fenced (Black 2011 in NMFS 2014). Some ranchers interviewed also participated, and continue to participate, in the Conservation Reserve Program supported by the U.S. Department of Agriculture's Farm Service Agency. They receive annual rental payments in exchange for not grazing livestock in riparian pastures. Ranchers were motivated to participate in these programs because fencing to keep livestock out of salmon-bearing streams contributes to restoration efforts and protects them from liability associated with incidental take of SONCC coho salmon by livestock (e.g., stepping on salmon nests in stream gravel, called redds).

One agency interviewee attributed the increase in beaver populations in the Scott Valley to the recovery of riparian vegetation that has occurred as a result of fencing off riparian areas on private lands from grazing:

> I've been watching the Scott River for close to 20 years now, and conditions in and along the main-stem Scott and the lower tributaries have definitely improved in most areas just by excluding livestock… We got improved vegetation conditions and improved riparian functionality, and that started to encourage beavers to come. They've been coming back… (interview 19).

However, there have been some negative unintended consequences from the fencing. Several landowners and agency representatives reported an overabundance of noxious weeds such as knapweed and starthistle (*Centaurea* spp.) inside the exclosures, which threaten pasture quality outside of them, and could be controlled by grazing there.

Because riparian areas are fenced, most interviewees did not observe any interactions between beaver and livestock, or effects of one on the other. However, one rancher who occasionally flash grazes riparian pastures (intensive grazing for a ~12-hour period) when fish are not present to control weeds believed that doing so has a beneficial effect on beaver. He had observed signs indicating that beaver use trails that livestock create to transport wood from the place of harvest to the water, and harvest food in places where grazing has occurred because it opens up the understory and makes it more accessible.

As noted, most landowners interviewed also produce grass hay or alfalfa, and do so either using center pivot or wheel line sprinkler irrigation, through flood irrigation, or both, depending on the time of year. Roughly 120 km^2 of irrigated alfalfa, grain, and pasture lie in the Scott River watershed (Van Kirk and Naman 2008). Flood irrigation takes place by diverting water out of streams into irrigation ditches; there are two irrigation districts in the Scott Valley that coordinate flood irrigation activities among members. Sprinkler systems draw water either directly from streams, or use pumped groundwater. Since 1990, there has been a transition away from flood irrigation toward the use of sprinklers, with increasing reliance on groundwater for irrigation (Van Kirk and Naman 2008). Landowners who do not use flood irrigation do not experience negative impacts from beaver associated with their irrigation systems. However, those who flood irrigate reported beaver interfering with their irrigation infrastructure.

Landowners interviewed identified both positive and negative impacts of beaver and their dams (table 4). All were generally positive about beaver, so long as they were in the “right” places where they didn’t interfere with agricultural operations. When landowners request depredation permits from the CDFW to address nuisance beavers, disruption to irrigation systems is the most common cause (table 5). Those whose alfalfa is occasionally eaten by beaver didn’t seem to mind, and reported no negative economic consequences because it occurs at a small scale. Other negative impacts were being addressed through mitigation measures. For example, one landowner interviewed had installed a V-shaped wire structure to keep beavers from plugging the head gate and culvert where stream water is diverted into an irrigation canal (fig. 9). Another had placed wire mesh screening around the base of large trees to protect them (fig. 10).

Table 4—Impacts of beavers and beaver dams on landowners (n = 9)

Impacts	Number of people reporting
Positive:	
Beaver dams slow runoff, increase water storage, raise groundwater levels	3
They make more water available for irrigation	2
Beaver dams back up water, making surface water available later into the summer, especially important in drought years	2
Beavers are fun to watch	2
Beaver dams create fish and wildlife habitat	2
Beaver dams create marshy areas where forage production is greater	1
Beavers are natural engineers that do watershed restoration for free	1
Negative:	
Beavers plug up irrigation infrastructure	4
Beavers cut down big trees	4
Beavers eat alfalfa from farm fields	2
Beaver dams can flood pastures	1

Table 5—Reasons Scott Valley landowners requested beaver depredation permits, 2006–2016[a]

Property or crops damaged	Number of depredation permits issued, 2006–2016
Water delivery/drainage system	7
Trees	5
Water delivery/drainage system, trees	1
Irrigation disrupted	3
Flooding, irrigation disrupted	1
Irrigation disrupted, plants/crops	1
Irrigation/drainage structure(s)	1
Total	19

[a] Data are for Callahan, Etna, and Fort Jones; categories were pre-defined.
Source: CDFW 2018.

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Figure 9—A V-shaped wire structure keeps beaver from plugging a water diversion into an irrigation canal.

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Figure 10—Wire mesh protects trees from beaver damage.

BDA Project Outcomes

The SRWC began installing BDAs in the Scott River watershed in 2014, and as of mid-2018, a total of 10 structures were in place at five sites (two of the original structures placed in the Scott River main stem had washed away; BDAs with step downs are counted as one). Outcomes of the project to date have been documented through ongoing monitoring of select indicators by the SRWC and collaborators, and were described in interviews based on a combination of direct observations and select interviewees' familiarity with the monitoring program. Monitoring results have been published (Yokel et al. 2016, 2018) and are summarized in the appendix. Most monitoring has occurred at the Sugar Creek site for logistical reasons, although limited monitoring has occurred at the Miners Creek and French Creek BDA sites, and a control site was established on French Creek where BDA restoration has not occurred for comparison (Yokel et al. 2018). Key hydrogeomorphic and ecological project outcomes documented by Yokel et al. (2016, 2018) include salmon using slow-water habitat created upstream of BDAs at all life stages, higher surface-water levels above the BDAs, increased groundwater levels near BDAs, restored perennial streamflow above and below BDAs, cooler water temperatures in BDA ponds, an increase in habitat rearing capacity for juvenile coho salmon, and increased beaver activity around BDAs. Interviewees observed a number of project benefits at the four BDA sites in place by early 2017 (table 6). Project monitoring data are not available for all of the variables they observed. However, where monitoring data are available, they are largely consistent with interviewees' observations.

From a hydrogeomorphic standpoint, BDAs can cause unpredictable responses; it is not possible to guarantee landowners that there will be no negative impacts, and some interviewees also reported drawbacks. For example, a stream might change course, and a road or fields could flood. One BDA was constructed on a landowner's property in 2014, and the following winter a major storm event led to high river flows, which caused the BDA to partially wash out. Part of the landowner's property flooded, including a sump from which water is pumped to irrigate fields and fill livestock troughs, and flooding also caused some river bank erosion on the property. The landowner believed this storm damage would not have occurred had the BDA not been in place. The SRWC took steps to mitigate the problem as best it could, and commissioned studies that found that the storm damage was unrelated to the presence of the BDA. Nevertheless, when BDAs are installed on private property, and a landowner has a bad experience with them, it can generate bad feelings about the project, and raise questions within some regulatory agencies over whether BDAs are desirable. Another project drawback was the creation of areas of shallow water

Table 6—Hydrogeomorphic, ecological, and socioeconomic benefits of the Scott Valley beaver dam analogue (BDA) project observed by people interviewed for this study (n = 17)[a]

Outcome observed	Number of people reporting
Hydrogeomorphic:	
Longer seasonal duration of streamflows; slowing down and holding back water causing increased streamflows and water ponding in reaches that previously ran dry above and below dams; increased water availability	9
Raised groundwater levels near dams	5
Reduced streambank incision and erosion	5
Increased surface water elevation behind BDAs and in nearby pools	3
Decreased stream temperatures	2
Increased instream soil deposition behind dams	2
Increased diversity in stream channel morphology, with water spreading out and going new places	2
Ecological:	
Improved aquatic habitat for salmon	9
Increased growth of riparian vegetation	5
More salmon	4
Increased beaver activity in streams or at BDA sites	4
Increased biodiversity, i.e., birds	2
Increased protection for colony of bank swallows *(Riparia riparia)*, listed as a California threatened species, owing to reduced streambank erosion	1
Socioeconomic:	
Increased dialogue and relationship building between agencies and landowners, and among agencies	5
Experience and learning to improve the regulatory process for permitting BDAs as a watershed restoration technique in California	5
Low cost, low engineering restoration approach compared to other options	4
Increased community involvement in restoration and stewardship	2
Increased groundwater level and water recharge in well	1
Climate change adaptation strategy	1

[a] Five interviewees did not report benefits; of these, one saw no benefits from BDAs, one was a nonlocal agency representative who did not have an opportunity to observe them, and three were landowners who had not yet had BDAs constructed on their property.

following initial construction of some BDAs where stream temperatures increased owing to dam levels being lower than originally designed to address fish passage concerns. Several BDAs were also damaged during winter storms, requiring more maintenance, a higher investment of time, money, and equipment to repair, and greater regulatory flexibility than originally anticipated. These problems may be related to the fact that the Scott Valley BDA project was undertaken as a research experiment, which prevented the SRWC from building the structures according to the original design that might have been better from the standpoint of functionality, but was modified to address regulatory agency concerns pertaining to potential impacts on salmon. Either way, project outcomes cannot be guaranteed to be problem-free owing to the potential for unpredictable stream behavior. As one agency interviewee said, “You give it a guess of what you think nature will do, but we’re guessing. … Restoration in general is guesswork most of the time” (interview 8). This fact makes working in the private property context particularly challenging.

One understudied topic is that of how BDAs and other restoration techniques designed to mimic beaver dams affect water rights (Pilliod et al. 2018). In the Scott Valley, water rights are fully adjudicated, but groundwater use is unregulated (although that is changing following passage of state legislation in 2014 authorizing local agencies to regulate groundwater use). None of the people interviewed for this study reported hearing any complaints about the impacts of BDAs on water rights. Nevertheless, the SRWC and North Coast Regional Water Quality Control Board are sensitive to the issue. If the board anticipates a problem—which it did not in the Scott Valley case—it can turn over the 401 permitting process to the Water Resources Control Board’s Division of Water Rights, which will explore any concerns further before deciding whether to issue a permit. For its part, at the start of the project, the SRWC made a presentation to the local watermaster (charged with ensuring that water is allocated according to established adjudicated water rights, especially important during the irrigation season) to explain BDAs, how they work, and their potential benefits. They made an agreement with the watermaster that the BDAs would be constructed at the end of the irrigation season, or once a creek had run dry. This way, water would pool behind the BDAs and fill up before the start of the next irrigation season without risking a disruption of streamflow to downstream users during irrigation season. Once the pools behind the dams are full, they spill over and streamflow continues uninterrupted. The SRWC also made sure not to build any BDAs close to an irrigation head gate to avoid blocking water diversion. Several interviewees cited positive impacts of BDAs on water rights. These included slowing water flows down so that they can be more easily diverted for irrigation; raising the water table, which helps with sub-irrigation; and creating more available downstream water in the summer as stored groundwater (enhanced by BDAs) is released.

Project Challenges and Enabling Factors

Challenges associated with the Scott Valley BDA project have been described in preceding sections. For the SRWC, they have included the regulatory permitting process and its impacts on the design, scope, and timeline of the project; working with private landowners to ensure that the project is a good fit for them, and that their concerns are met; obtaining sufficient funding to support the project, including BDA maintenance and monitoring; fully understanding what can and cannot be done under existing permits; and the sometimes unpredictable behavior of BDAs in a dynamic stream environment, requiring adaptive management. For the regulatory agencies, they have included coordinating with one another to ensure consistency in permitting, while meeting their individual mandates; finding ways to design the BDA project so that it does not harm fish; ensuring no negative impacts to other California ESA-listed species (e.g., bank swallow); ensuring that project activities comply with permits and do not damage private property; and finding ways to enable the flexibility needed for this type of restoration approach within regulatory guidelines.

Many of these challenges are attributable to the fact that the Scott Valley BDA project was the first of its kind in California, took place in a river basin containing an ESA-listed species of fish, and was implemented on private lands. Most BDA projects elsewhere in the West have been carried out on public lands (e.g., Bureau of Land Management, U.S. Forest Service). Although such projects have the potential to affect users of public lands, they are unlikely to have a direct impact on private property, especially if beaver translocation is not involved. The Scott Valley BDA project represented new territory for most of the actors involved. The process of relationship building, and the steep learning curve on the part of all parties, have taken time and effort but are now paying off. By 2016, things were working more smoothly, and new BDA structures were being permitted in a streamlined way using the Habitat Restoration and Enhancement Act authority, with more flexibility built into the permits to allow for adaptive management and improved structure design.

What, then, have been the enabling factors promoting project success? Interviewees identified the following key factors:

- Persistence on the part of the SRWC and the regulatory agencies, and not giving up when frustrated
- Presence of a local intermediary organization focused on stewardship, i.e., the SRWC, to spearhead the project, with dedicated volunteers and passionate people committed to making it work
- The fact that this was a locally generated project, initiated by the community, and that it created some local jobs in restoration
- Ongoing communication between all parties
- Willingness to address and work through stakeholders' concerns
- Strong partnerships
- Landowners willing to take the risk of being part of the initial experiment
- Scientific monitoring data to document project impacts
- Field tours to show people sites in the Scott Valley where BDAs have been installed so that they can learn about them (fig. 11)

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Figure 11—The Scott River Watershed Council sponsors field trips to restoration sites so that members of the public can learn about beaver dam analogues.

A number of changes could further enable watershed restoration using BDAs in the Scott Valley and elsewhere in California in the future, where appropriate. On the regulatory side, taking advantage of, and improving upon, existing regulatory tools that streamline permitting would ease the permitting process. Regarding federal permitting, examples are the Army Corps of Engineers Nationwide permitting, and the NOAA programmatic biological opinions for restoration projects that include using BDAs as a permissible restoration activity that will not significantly adversely affect SONCC coho salmon or aquatic habitat. Regarding state permitting, one example is streamlined permitting under the Habitat Restoration and Enhancement Act. Another would be for the CDFW to add a chapter to its California Salmonid Stream Habitat Restoration Manual on BDAs once it becomes sufficiently knowledgeable about, and confident with, them. Doing so would make BDAs an officially sanctioned restoration technique, with guidelines for using them, in California, allowing CDFW staff statewide to permit BDAs more easily in the future. Another key to easing the regulatory process for BDAs is having proponents within the regulatory agencies. One agency interviewee observed: "… a critical message is that I think each area needs to have their own proponent, and if an area doesn't have that… it may be a while before that practice is adopted…" (interview 16). Monitoring data that document the effects of BDAs on water, fish, wildlife, vegetation, and hydrology will also help with permitting. As evidence that demonstrates positive impacts mounts, and that allays concerns over detrimental fish impacts, regulators will become more comfortable permitting them.

Collaboration and communication between stakeholders involved in BDA projects are also critical for success and can ease the regulatory process. In 2016, state and federal agency representatives involved in funding and permitting BDAs in the Scott Valley—including the U.S. Fish and Wildlife Service, NOAA, CDFW, Army Corps of Engineers, and the Water Quality Control Board—formed a BDA technical team. They meet periodically to discuss BDA projects, coordinate the permitting process and compliance with permits to promote consistency, ensure that each agency can meet its mission in the process of implementation, identify monitoring needs, discuss design features, and find ways of making the permitting process easier. For its part, the SRWC hopes to eventually undertake a full environmental impact assessment under the CEQA of BDAs in the Scott Valley, or at least some of its major tributary watersheds, which could make it possible to obtain a programmatic permit for beaver-related restoration there. A programmatic permit would enable BDA implementation where appropriate without having to go through an individual site-by-site permitting process.

Conclusions and Take-Home Messages

The Scott Valley BDA research experiment is pioneering a new approach to watershed restoration in California that has potential to help threatened fish species recover, reduce stream channel incision, promote drought adaptation, and streamline the regulatory process for implementing beaver-related restoration. The project is still limited in scope, but initial monitoring results and observations of stakeholders indicate that, although BDAs are not without challenges, positive hydrogeomorphic, ecological, and socioeconomic outcomes are being experienced (Yokel et al. 2018). In the Scott Valley, water is a critical resource for ranching, farming, and fish. More than two decades of debate about water allocation for agriculture versus coho salmon, combined with a prolonged drought during water years 2012 to 2016 (October 1 to September 30), make beaver-related watershed restoration appealing. If BDAs can increase water availability for agriculture and improve the capacity of streams to produce salmon through instream habitat restoration, they will help both landowners and fish. As one landowner remarked, "We've observed … that the better and happier the fish are, the better our cattle are; the better the deer are, the better our cattle because that means things are working" (interview 5).

The key messages emerging from this case study are the following:

- Social considerations are as important as biophysical considerations when identifying sites for beaver-related restoration. When taking place in a private-lands setting, it is important to select sites where landowners fully understand the project and what they are getting into, and they are willing to accept the uncertainties associated with restoring natural processes in dynamic riverine environments.
- To work successfully with landowners, it is important to maintain good relations with them throughout the project by seriously addressing any issues and concerns they raise about it.
- BDAs aim to restore natural processes, and therefore represent a dynamic approach to restoration that calls for adaptive management. Flexibility on the part of regulatory agencies, implementing partners, and landowners is important for success.
- For BDA and beaver-related restoration to occur, proponents are needed who are committed to the project, and who persist without giving up when encountering road blocks.
- Local community-based organizations having the initiative and capacity to serve as project implementers are especially valuable when projects take place on private lands because they can serve as intermediaries between government agencies and landowners.
- Clear and ongoing communication among regulatory agencies, funding agencies and organizations, and implementing organizations to coordinate the regulatory process and collaboratively problem solve facilitates success.
- A central goal of BDAs is to promote recovery of threatened and endangered fish species by improving instream habitat. However, building these structures in streams within critical habitat for ESA-listed fish is difficult from a regulatory standpoint owing to concerns that they could put these species at further risk, at least in the short term. More research, monitoring, and experimentation are needed in California to address these concerns and potentially ease the regulatory permitting process.
- Lessons learned in the Scott Valley about the regulatory process for implementing beaver-related watershed restoration, and about working with landowners when such projects occur in a private lands context, can be applied elsewhere in California as this approach becomes more widespread.

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U.S. Equivalents

When you know:	Multiply by:	To find:
Centimeters (cm)	.394	Inches
Meters (m)	3.28	Feet
Kilometers (km)	.621	Miles
Degrees Celsius (°C)	1.8 °C + 32	Degrees Fahrenheit

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Appendix: Outcomes of Beaver Dam Analogues in the Scott River Basin, California (based on monitoring results from Yokel et al. 2016, 2018)

Hydrogeomorphic Outcomes

Surface Water

Sugar Creek: Late summer water surface elevation was 1 to 6 ft (0.3 to 1.8 m) higher above the lower beaver dam analogue (BDA) than below it. Late summer water surface elevation increased by 107 cm (3.5 ft) in BDA Pond 1 of Sugar Creek between 2014 and 2017. Overall, approximately 1,600 linear ft of stream above and below the BDAs (in lower Sugar Creek and a Scott River side channel) retained flow throughout the summer in reaches that had previously run dry.

Groundwater

Sugar Creek: Groundwater levels increased and are estimated to rise at least 15 cm for every 30 cm of height that BDAs are raised up; this effect occurs at least as far as 0.9 km up valley. Groundwater levels also increased as far as 350 m down valley, but not by as much. BDAs also increased groundwater recharge and storage capacity during high winter and spring flows.

French Creek: Elevations in groundwater levels increased near the BDAs after BDA construction.

Stream Temperature

Sugar Creek: BDAs created cool, deep water pools in areas where they had not previously been. Stream temperatures in 2017 improved (cooled) during 2016 and were generally within the optimal summer range for coho salmon. Some summer temperature spikes occurred in BDA ponds in association with very low flow conditions correlated with rapid drops in upstream surface water flows. These summer temperature spikes decreased by 2017 relative to those in upstream environments, attributed to the ability of large volumes of water stored behind BDAs to buffer temperature changes.

French Creek: The side-channel site with BDAs remained within, or close, to the ideal temperature for coho salmon throughout the 2017 monitoring period.

Miners Creek: Temperatures rose to levels that can cause stress in coho salmon (>20 °C) upstream of the BDA treatment area for a short period in August (possibly due to upstream water withdrawals); temperatures downstream of the BDA ponds were much cooler, remaining near or within the optimum temperature for coho salmon throughout summer 2017.

Ecological outcomes

Fish Movement and Passage

Sugar Creek: Thousands of mostly juvenile salmonids (especially coho salmon and steelhead/rainbow trout) used slow water habitat and ponds upstream of the Sugar Creek BDAs over the summer and winter while rearing. A 2017 experiment conducted to test whether PIT (passive integrated transponder)-tagged juvenile salmonids were able to pass over the BDAs found that 97 percent of coho juveniles moved upstream of one, and 89 percent moved upstream of both. Juvenile salmonids were more likely to cross BDAs by swimming around them using side-channel passages than by jumping over them, but many fish also jumped over at least one BDA (49 percent of coho salmon and 43 percent of steelhead).

Miners Creek, Sugar Creek, and Scott River: Adult salmon spawned above all of the BDAs in every year after construction.

Fish Population Numbers

Sugar Creek: Juvenile coho salmon population estimates in 2017 decreased by roughly 25 percent compared with 2016 levels. This decrease is attributed to heavy flooding that occurred during the preceding winter, which may have destroyed redds, typically constructed in sandy stream bottoms with limited areas of suitable gravel.

Sugar Creek and French Creek: Juvenile coho salmon populations were way below capacity, indicating that their population numbers were being limited by low numbers of adult coho returning to spawn or low egg-to-fry survival rates.

Habitat

Sugar Creek: The volume of aquatic habitat in BDA ponds in 2017 increased roughly 40 percent over 2016. The total area of wet habitat (e.g., streams, ponds, permanently flooded wetlands) increased by 11 percent compared with 2016.

BDAs created habitat that is suitable year round for all life stages of coho salmon and steelhead.

Habitat Rearing Capacity for Fish

Sugar Creek: Habitat rearing capacity for juvenile coho salmon was about 7,500 fish, an 18-percent increase over 2016 numbers and a 2, 000-percent increase over pre-project conditions.

Beaver Activity

Beaver activity has been observed at all BDA sites since their installation. Sugar Creek is the most active site, with beaver maintaining and modifying both structures there, and with beaver activity increasing over time.

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