The Grand Beaver Tour

Training with professionals in beaver-based restoration techniques

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San Luis Obispo Beaver Brigade
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Acknowledgements

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Introduction

Our names are Cooper Lienhart and Nicholas Hatalski, and this past summer and fall of 2021 we embarked on a series of four 1-week long training trips focused on learning beaver based restoration techniques. This “grand beaver tour” as we came to call it, took us to several locations across Northern California as well as Washington state. As members of the San Luis Obispo Beaver Brigade, our goal for these trips was to learn the best practices for this type of restoration from the experts who have been doing this work for years, and then summarize what we’ve learned so that we can bring these practices back to SLO County and positively impact the lands and waters around us.

Beaver-based restoration is a relatively new field of study and restoration practice. There are two main methods: beaver relocation and process-based restoration. We trained in both methods - beaver trapping and relocation with the Tulalip Tribes in Washington, and process based restoration with three groups in California: Swift Water

Design, Symbiotic Restoration, and the Scott River Watershed Council. Over the course of the report we will provide a brief history and overview of the two methods of restoration, and then we will delve into our training experience with each of the groups and the specific techniques they employ.

Beaver Trapping and Relocation

As many as 400 million beavers lived on the North American continent before they were driven to near extinction by fur trappers and the popular fashion of beaver felt hats. Now, beavers are making a comeback. Although they only make up a fraction of their original population; it is estimated that 10 to 15 million beavers currently live in North America. Instead of trapping as a method of lethal beaver removal, groups across the country are now using trapping and relocation to both expand beaver populations and restore watersheds.

Beaver relocation has an interesting, complicated history. In the 1940's, beavers were actually parachuted out of planes into the Idaho wilderness to complete an extreme, and successful restoration project. However, beaver's ability to create habitat, hold water on the landscape and restore ecosystems went largely unnoticed, because since then beavers have been labeled by law as pests and are subject to state permitted removal. Currently in California, beavers are still classified as pests, and thus are not allowed to be relocated. If a landowner or entity wants a beaver removed from their property, it must be killed. Luckily, this is not the case in every state. Now, more and more states are beginning to recognize beavers' potential as a restoration tool and have changed their laws to allow for relocation. That is why we traveled to Washington and the Tulalip Tribes - to learn from one of the most successful programs and be prepared for when beaver relocation becomes legal in CA.

We had the pleasure of spending a week in Tulalip, WA, training with wildlife biologist Molly Alves and assistant wildlife biologist Dylan Collins. The Tulalip Reservation is home to the Snohomish,

Snoqualmie, Skykomish, and other allied tribes and bands signatory to the Treaty of Point Elliott. It is located just north of Seattle on the Puget Sound. They have a large natural resources department, and thus much of their tribal community is focused on maintaining and restoring the ecosystems that support their people. Together, Molly and Dylan run the Tulalip Beaver Project, which began in 2014. The goal of the project is to relocate "nuisance" beavers from urban and suburban areas and safely move them to hydrologically impaired watersheds in order to improve fish habitat and fresh water storage.

They have found that beavers greatly improve the conditions for Chinook and Coho salmon, which are keystone species in the area and are both endangered species. They have also found that beaver wetlands retain water year-round, which has been particularly important now that they are receiving smaller and smaller snow packs. The beavers that the project is focused on are considered nuisance beavers, because there is some kind of conflict with the landowner. This conflict could be flooding of the property because of a blocked culvert, damage to trees that are valuable to the landowner, or creating potential hazards by chewing trees close to power lines. Lethal trapping is still the common practice for dealing with "nuisance beavers", so the Tulalip Beaver Project is offering an opportunity to save those beaver families, and bring them to a place where they can bring ecological benefits.

Since 2014, they have trapped 259 beavers and have successfully relocated 229, resulting in an overall survival rate of 90%. It is important to note that all of those beavers would have been lethally trapped if it were not for the Tulalip Beaver Project. Furthermore, because the project is grant funded, they are able to offer this as a free service to landowners.

Trapping

According to Molly, their window of trapping and relocating usually falls between May-October. This is because the kits are weaned off of their mother's milk by May, and the Tulalip Beaver Project felt it

would be risky and stressful to relocate beavers to a new location during the winter because they don't have an established territory and food cache. Also, there aren't as many nuisance beaver calls during the winter in Washington because the beavers are hunkering down and waiting out the snow. They start heavily building dams in the springtime to catch the snowmelt, and that is when many human-beaver conflicts occur.

We used two different types of traps: Hancock traps and Havahart traps, both of which are designed to not hurt the animal when triggered. The Hancock traps, also known as suitcase traps, were Molly and Dylan's preferred trap, and they are what we used most of the time. **Safety** was stressed above all else when handling these traps with and without beavers inside. The snapping force of the trap can easily break fingers or wrists so we were taught the proper safety procedure used to set the trap. The Havahart traps were large rectangular traps that had a trigger plate that closed a door, trapping the animal. They were preferred for trapping beavers on land or minimal water.

We set the Hancock traps either on an angled bank, along the dam, or resting partially on rocks or logs in the water. The goal is to have the trap partially in and out of the water, with the bottom submerged so that the beaver can swim all the way up to the middle of the trap and only then hit the pressure plate triggering the trap. It is very important to secure the trap against some kind of backing because the force of the trap closing can send it flipping into the air. Once the trap was in a good location with a solid backing we used rope to secure it in place and anchor it to something nearby. Dylan advised always having multiple anchor points with at least one on dry land to prevent things from shifting and the trap sliding into the water which could lead to a beaver drowning.

Fig 1.1 Nick practicing the procedure for safely setting a Hancock trap

Fig. 1.2 The Hancock trap is half-submerged, anchored to a downed tree and all set with vegetation and scent lures

Fig. 1.3 Nick camouflaging a Havahart trap with mud and leaves

We used scent lures to encourage the beavers to swim up to the traps. Beavers are more likely to be trapped with a castor based lure in the spring. Whereas in the fall, their focus turns to preparing for the winter and they are more likely drawn in with food based lures such as cambium, the inner layer of tree bark. We strategically set scent lures in the afternoon to prevent them from drying out during a full day in the sun. It's important to handle the scent lures with care, because if any of the scent lure touches the water it can disperse over the whole pond and drive the beaver crazy with an overload of stimuli.

We carefully wove vegetation that beavers like to eat onto the top middle of the traps and spread scent lure onto these leaves to make them even more appealing. Lastly, we placed guide sticks to further encourage the beavers to enter the trap straight on, as well as discourage other animals like herons from walking into the trap accidentally. As for placement of the trap, look for active beaver trails, or place them on the dam if active. You can even cut a notch in the dam and place a trap there to encourage beavers to swim over to fix it.

When retrieving the beaver it is important to check the traps as early in the morning as you can. This is to prevent any animals or

Fig. 1.4 A young kit was caught in our trap

humans from disturbing or injuring the beaver and to minimize the time the beaver needs to spend inside the trap. It is also important to communicate to the landowner to “let the beavers be” and not handle the traps or interact with the beavers as this will cause unnecessary stress. Stress has a large impact on beaver’s health, to the point where in extreme cases, beavers can stress themselves to death. This is also why we leave them in the trap while transporting them, as there is plenty of room in the chain link of the Hancock trap.

Also, if you catch a kit from a family, and still need to trap the rest of the family, a trap that was used to catch a kit could be used to catch the mother since she would be drawn back to the smell of the kit. We used this technique at our trapping site, however we were unfortunately unable to catch the rest of the beaver’s family. Molly and Dylan hypothesized that these beavers were particularly hard to catch for two reasons. First, the landowners had utilized lethal trapping several times before they knew of the Tulalip Beaver Project. This made the remaining beavers quite wise to the traps. Secondly, the water level was low because of the intense heat wave that Washington faced this summer. The beavers seemed to have adapted to the land and thus were able to maneuver around the traps which we mostly placed in the

waterways. Dylan and Molly were able to pair the trapped kit with three kits from a different family that they caught the following week.

Fig. 1.5 We carry the kit back to the truck

Beaver holding

Upon capture of the beaver, Molly and Dylan took us to their beaver holding facility. They use the raceways in the Tulalip salmon hatchery to hold the beavers; raceways are long concrete structures with walls on either side that have flowing water. Having running water is a must for holding beavers for any extended period of time. The facility was ideal since we were able to control the height of the water in the raceways as well as the flow. It is important to make sure there is enough water depth for the beavers to swim and float, and interestingly, they actually need to be suspended in water in order to “go number two”.

Fig. 1.6 Molly and Dylan prepare to release the kit into the raceway

Fig. 1.7 Nick checking on the kit inside the lodge

Beavers need water, but equally as important they need a space out of the water to dry off and get warm so they don't get pneumonia. With this in mind, we built lodges for the beavers in the raceways. This mimics their natural behavior, and it gives them a place to dry off, sleep and socialize. To construct the lodge structures we used cinder blocks and stainless steel plates (beavers can chew through aluminum); the bottom plate has small holes in it so that the water can drain through. We filled the lodge with cedar shavings to make a soft dry area for the beavers inside the lodge. One interesting observation that Molly and Dylan shared with us, is that beavers strip the bark off of branches until it is fine and fluffy, and they use that material to make perfectly circular nests! Also, beavers are actually excellent climbers, so we put a wooden board over the lodge to act as a ceiling and prevent them from escaping.

Fig. 1.8 Each raceway had two cinder block lodges, one at each end

Fig. 1.9 Lodge furnished with dry cedar shavings

In order to keep the beavers happy and healthy, they should be fed every day. Beavers are completely vegetarian, with a diet consisting of tree bark, leaves, herbaceous plants and aquatic vegetation. We harvested nearby branches and leaves from tree species that beavers prefer to eat, such as alder and big leaf maple, and threw it right into the raceway. Around the central coast of California, beavers love to eat willow and cottonwood. We also used nutritional pellets that are used to feed rodents - the kits like those especially. We placed those in food bowls inside the lodges.

Molly and Dylan also recommended having a wildlife veterinarian on hand. This is because beavers can become sick or even die while in the holding facility. They hypothesized that deaths could have come from over-stressing the beaver, or from harmful blue-green

algae that may have been in their ponds prior to trapping. If a beaver dies, they sometimes take it to a lab for necropsy testing.

Gendering/recording the beavers

Upon capture of a beaver, the team gives the beaver an identification number, writes pertinent information, and processes it to get pertinent data. If the beaver is a juvenile, they will not ear tag it, take a hair sample, or gender it. This is because the processing can be stressful for a young beaver, and they feel it would do more harm than good. Since we were only able to trap a juvenile beaver, we unfortunately did not get a chance to practice the processing or gendering. To process an adult beaver, they use essentially a canvas bag to handle the beaver. They put the beaver in head first and unroll the bag from the bottom so only the bottom half of the beaver is exposed (this helps prevent bites!). The gendering is where it gets interesting. The best way to distinguish a beaver's gender is by the scent and appearance of the secretion from their cloaca. They explained that one must express the scent gland of a beaver by massaging the area and then softly pinching (while wearing gloves) until a liquid secretion comes out, which they then wiped up with a tissue. If the secretion is dark, viscous and smells like motor oil, it is a male. If it is white colored and smells like horseradish, it is a female.

Relocation

During our time with the team, we also scouted out several possible relocation sites and learned the process and criteria for determining a suitable site. The Tulalip Tribes have ceded lands in which they have the right to hunt and fish as well as restore and maintain the land's health. Therefore, the team is able to relocate beavers back into these lands because beavers are native and bring restoration benefits. The team has relocated all of the beavers that they

have captured onto Forest Service land in the upper Snohomish Watershed.

Relocation sites might be initially identified with the help of computer generated models like the BRAT (Beaver Restoration Assessment Tool). This helps to sift through the countless possible locations and find a place to start. From there, we can take a look at the river's main channel from Google Earth and follow its path, noting any side channels as potential relocation sites. In northern Washington, most main stem rivers have powerful flows, and thus beavers are more likely to colonize and build dams upon a side channel with lower intensity flows. Potential relocation sites are judged on several criteria including the **abundance and variety of food in the area**, the **average stream flow and depth**, and the **dominant stream substrate**. An ideal relocation site is fairly flat with a stream gradient of 3% or less. It would have a fast, but not rapid, flow with an average depth of 3 feet and multiple areas where water could pool at greater depths. A silt, clay or mud system is the preferred substrate for easy dam building and channel digging. The ideal site would have a lot of beavers' favorite hardwood foods like aspen, willow, and alder located close to the stream as well as plenty of herbaceous foods like aquatic vegetation, grass, and shrubs. The availability of food, and the hydraulic conditions are without a doubt the most important factors to consider when choosing a relocation site. Once these base needs of survival are met we can start to judge relocation sites based on their potential restoration impact. Does the stream have an adjacent floodplain? Is there space for juvenile beavers to spread out and build their own dams? Have beavers historically occupied this stream in the past?

Fig. 1.10 and Fig. 1.11 Scouting out possible relocation sites

The suitable relocation sites are determined in advance, and once there is a full beaver family or bonded pair at the holding facility, it is time to relocate. One of the relocation goals of the project is to trap the whole beaver family, and then release them all together at a safe site. To facilitate a successful relocation, stage all the cages partially in the water facing the same direction and release the whole family at the same time to hopefully prevent any kits from getting lost. In some cases where there is little cover, they have built temporary lodges to release the beavers into. They are built from wood pieces found on site and resemble a Lincoln-log structure. This is to give the beavers a sense of security and some protection while they get established in the new location. However, they have found that the beavers do not use that lodge much after the first day, so they have lessened that practice over the years.

In rare cases, they have had to release a lone beaver. This happens when only one beaver from a family could be trapped, or if a dispersing juvenile is trapped by itself. Usually they try to pair lone beavers with a new family, but sometimes it doesn't work (beavers have personality preferences just like us!). If there is a lone beaver release, it is more focused on saving the life of that beaver, rather than relocating for ecological benefits. They usually relocate it into a watershed near other beavers in a location with sufficient water and cover.

After relocation, they place a couple game cameras at the site in an attempt to see if the beavers are still in the area. They check the site a couple of times over the first year, however it is often hard to know if the beaver remains on site. Also, it is hard to differentiate between individual beavers, so a beaver that shows up on the cam may not be the same one that was relocated. While looking at the cam footage at one relocation site, we saw three different bears all visiting the same wetland area at different times.

Conclusion

Over the course of the week we learned more about beavers than we thought was possible. It was incredible to see the deep knowledge of the beavers that Molly and Dylan have gained from working with them so closely for so many years. We were able to get a well-rounded training of all the practices that go into beaver trapping, holding and relocation. We utilized a variety of techniques to trap beavers, and we had the pleasure of caring for the kit in the holding facility for the week. We also learned the criteria for a suitable relocation site and scouted out a few ourselves. Being able to save the lives of these creatures, and then bring them to a location where they can positively impact so many other animal's lives, was an honor, and we thank you Tulalip Tribes for your work and the opportunity to learn from you.

Wetland Restoration

Fig. 2.1 Cooper stands atop a newly constructed BDA in the Scott River, Etna, CA

Process-Based Restoration

Low-tech process based restoration (PBR) is a relatively recent restoration practice. It's roots in river and stream restoration date back over 100 years to 19th century France, but the practice has only started to appear in the American West over the past decade. It differs from much of the construction-based restoration that we are used to seeing such as concrete dams which are meticulously designed and intended to remain unchanged for an indefinite amount of time. The low-tech PBR focuses instead on using natural materials, low-technology practices, and the continual adaptation and addition of structures to restore an area over time instead of all at once.

All three of the restoration groups that we trained with used the technique of **process based restoration**. We learned that the "process" is to mimic Earth's natural processes and utilize the system's own energy to help guide it back to a healthy, sustainable state over time. What many people don't know is that before European colonization, nearly every body of water in this country was colonized by beavers. So, the normal, healthy state of rivers and streams are not a free flowing trickle like many of us are used to seeing, but instead a lush wide wetland full of life, criss-crossed with beaver dams and islands of vegetation.

Therefore, one of the main practices of process-based river restoration is creating structures inside the river bed that mimic beaver dams. These structures can be known as Beaver Dam Analogues (BDA's), Post-Assisted Log Structures (PALS), Debris Jams, or various other names, and they are built out of natural materials that are preferably found on site. The structures work by slowing and spreading the water flow, as well as catching sediment. This helps the river return to its healthy state by retaining more water in the channels year-round and working to connect the river back to its floodplain. By continually adding and modifying structures over several years, the once degraded single-thread river can be built back up to a healthy wetland-like river, connected to its floodplain.

Swift Water Design

We connected with Kevin Swift after the California Beaver Summit, and he invited us to come out to one of their projects to get some hands-on experience. We met Kevin and his crew at Yellow Creek campground near Lassen national forest, known by its native Maidu people as Tásmam Koyóm. Tásmam Koyóm was returned to the Maidu Summit Consortium in 2019. This was a huge win for the consortium, started in 2003 with the purpose of re-acquiring ancestral lands. However the difficult work of restoring these neglected and overgrazed mountain meadows now began. This is where Kevin and his team came to the rescue providing a low-tech, cost effective restoration strategy that focused on helping the river system to restore itself.

Fig. 2.2 The valley and floodplain containing Yellow Creek in Tásmam Koyóm

Our Experience

We had the opportunity to tour several of the bigger existing structures that the crew had put in the previous year and had built up higher this year. Along this tour Kevin explained some fundamentals of low-tech process based restoration (LT-PBR) and what he had planned for the rest of the week.

Fig. 2.3 Kevin Swift explaining the BDA with Swift Water Design crew behind him

After the tour we headed to the active build site and got to work building our very first BDA on a sizable side channel. The group's energy was infectious and it set the precedent for the whole week. The culture was one of hard work, and having fun while getting the job done. We worked on placing structures in both the main stem of Yellow Creek, and on some side channels. There were several small side channels that had flowing water only because Kevin and the team had reactivated them by strategically placing BDA structures the year before. We then built a series of small BDA's inside the channels in order to maintain the water levels and further connect those channels to the floodplain.

Fig. 2.4 and Fig. 2.5 Smaller BDA's built in side channels

Each day we worked on several structures; we either built them from scratch, or we added onto structures that they started the previous year. Each structure was a little different depending on the conditions of the river in that area, or if it was in the large main channel versus a smaller side channel. Over the course of the week, we worked on at least 10 different BDA structures throughout the meadow. We held back water, created and improved habitat for countless animals, and improved the fire resiliency of the meadow.

In fact, we worked on this valley in June, 2021 and the Dixie Fire burned right through that area just a few months later in August. We heard word from Kevin that the BDA structures all survived the fire, and they helped create a refuge that protected much of the meadow! Instead of getting scorched like most of the surrounding hillside, Kevin described the meadow as a "nice patchy mosaic" with greenery still intact especially around the structures. He even said that some of the

tops of the structures got toasted by the fire, but they held back enough water so they wouldn't burn.

Methodology

Kevin called his technique of building BDA's the "lasagna method" because it focused on building in layers. You get a lasagna BDA by stacking multiple layers of brush, sod/sediment, and gravel until the structure reaches the desired height. Building with the lasagna methodology yields a BDA that resembles a long triangular prism. Kevin believes this method is more efficient and less labor intensive than weaving branches through a post line. Also this method was unique in not relying on a post line to start building off of. Kevin mentions that this method is also safer for our backs since we can avoid lifting a heavy post-pounder above our heads to drive in 8-foot long posts to start the build. If the base structure was already built using the lasagna method, we can stand on top of this base and drive posts in, from there only needing to lift the post pounder to chest height.

Fig. 2.6 Large BDA spanning the main channel and a bank-attached BDA behind it on river right

The first part of the BDA process is gathering the branches and trees that make up the bulk of the structure. The team was very skilled in the use of chainsaws, and they quickly thinned a large section of the dense conifer forest that was encroaching into the meadow. This thinning is doubly beneficial to **fire protection**. First, they are reducing the fuel from the overgrown forest, and secondly, they are adding it into the creek which slows and spreads the water - creating a wetter, more fire resilient meadow.

As for building the structures, lots of work is done under the water layering branches into the bottom of the channel to prevent scour underneath the structure. In the main channel, large trees were used to create the base, but in the smaller channels we had to dig out enough space in the bottom and sides of the channel to be able to lay down branches. We set these clumps of sod and mud to the side and layered it into the structure interspersed with gravel and branches. For the larger structures in the main stem, we even used aquatic vegetation to stuff the structure, letting the flow of the water guide it into the right spot to seal off any leaks.

The fact that this method does not NEED a post line means it can be done with very few tools and means we can put in more structures in the long run. However if BDA's are built without a post line it is even more important that a long toe is built into the dam to distribute the pressure of the water. This uses the natural forces of the system to compact the dam rather than scour under it or pull sediment away from the top. The design encourages an equal toe and scour apron on both sides of the structure, resulting in a dam that more closely resembles a beaver dam.

Planning and Design

Instead of focusing on the design of any one particular structure, Kevin emphasized the placement of structures at key locations throughout the valley. He thought of each structure as a small piece in restoring the entire meadow harmoniously. One major strategy that Kevin emphasized was the importance of identifying a switch yard.

This is an area where there is a convergence or divergence of channels in the floodplain. In many floodplains there is only one channel with flowing water, but with a thoughtful, well placed structure (at the switchyard), one or more remnant dry channels can be re-wetted.

Fig. 2.7 A series of 3 BDA's on Yellow Creek near the bottom of the valley

A key to identifying switch-yards is to find the smallest amount of lift (elevation difference) between the active channel and the remnant channel(s). This is where it is easiest to turn on a remnant channel because it requires the least amount of work (holds back the least amount of water). It is important to have auxiliary structures working in series to both turn on the remnant channel, and keep it flowing. Here are several structure location suggestions for rewetting remnant channels:

– Structure at divergence: This structure can be placed just downstream of the divergence.This way the backed up water will be able to naturally flow into the remnant channel. Note: it may be helpful to use shovels to dig out the entrance to the remnant channel so that there is less lift needed to activate that channel. The structure should be built to a height to force enough lift to activate the remnant channel but not so high that a majority of water is diverted and the main channel flow could be turned off completely.

– Structure in remnant channel: This structure can help to retain water in the newly re-wetted channel and spread that water to new areas. However, several important considerations must be taken into account before adding this type of structure. Look at the elevation difference between the two structures and make sure the downstream structure in the remnant channel is lower than the upstream structure at the divergence. This ensures that water continues to flow into the remnant channel.

Conclusion

Kevin was very practical and efficient in his approach to restoration. He wanted the most “bang for his buck”. Or, rather he wanted the most restoration he could get with the smallest carbon footprint. In his view the most efficient restoration technique would be beaver relocation, but second to that is a low-tech process based approach that maximizes the work done by the natural forces of the system.

Kevin and his team showed us how fulfilling this work can be. Restoration connects you to the land in a way that very few jobs ever could. However, this connection is not without pain. We saw first hand the sadness that comes with seeing the degradation taking place in our rivers, as well as the hope and resiliency found in those who continue to work for the good of these watersheds. Thank you to Kevin and the whole Swift Water Design team for inspiring us to do what we can.

Symbiotic Restoration

Symbiotic Restoration was founded by Garret Costello in 2018 with the mission of "Promoting innovative, holistic approaches to ecological recovery". They provide environmental consulting services and specialize in low-tech process based restoration.

Fig. 3.1 The Symbiotic Restoration team. Pictured from left to right: Nick Hatalski, Cooper Lienhart, Sky Snyder, Garret Costello, Justin Goodrich, Jill Overbaugh

Our Experience

Driving to the project site near Lassen National Forest was an unforgettable experience. We had come to Chester just months earlier to work with Kevin Swift, and since leaving, the Dixie fire had ravaged the area. It felt like a graveyard, charred trees, and ash coating everything.

The Dixie fire was by no means contained but the fire had already passed through Rock Creek, the area that we were starting our training. We met Garret and Jill at Rock Creek midday and then met the project manager Leslie (a member of Plumas Corps).

Fig. 3.2 Scorched area showing some of the hazards found in Rock Creek

We had a **safety** talk before anything else. Garret explained to us how careful we had to be when navigating this freshly burnt landscape. There were dangers above and below. The ground, coated in a thick layer of dust and ash, made it hard to know what you were stepping on. We were advised to walk where we could see some grass and knew what we would be stepping on. Areas near burnt stumps were particularly dangerous since the fire might have partially or completely burned out the root systems of these trees leaving treacherous holes beneath the surface. Other trees were burnt but stayed standing, some hanging on by a thread, these were called “widow makers” because of their inherent danger to those venturing close to them. We made sure to stay clear of these trees and made careful note of any in the area that we were working.

Rock Creek was a dry system that would be inundated with high flow in the spring. It was hard to imagine this burnt area flooded with water but that was exactly what we had to do. The plan was to install around 50 Debris Jams that would work in conjunction with several large rock riffles that a separate crew with excavators would be installing.

Fig. 3.3 and Fig. 3.4 Several Debris Jams built in Rock Creek

Debris Jams take a fraction of the time compared to BDA's. Especially in the Rock Creek system where we had no idea how the system would react to structures, they were a perfect way to slow water down. Our Debris Jams took on many different forms depending on what material was nearby. We tried to work as efficiently as possible, building with what was close by first and using sleds to haul foliage or stumps that were farther away. One of the quickest ways to build a Debris Jam was to look for a downed tree lying across the channel and essentially shave off all the branches on top of the tree and stuff them

underneath. Other nearby debris is thrown onto the upstream side of the tree and posts can be driven in behind it for additional support.

Fig. 3.5 Nick and Garrett discussing the Debris Jam structure

Conservation Easements

Conservation easements are incentives for landowners given by the National Resources Conservation Service (NRCS) to encourage restoration on their property. NRCS pays for the restoration efforts and compensates the landowners for setting aside this land. Garret worked with NRCS on multiple conservation easements, and it seemed like his most consistent source of restoration projects. By compensating landowners for the use of their land we can start to restore private land that might otherwise sit in a degraded state indefinitely. Although profitable in the long-run and without a doubt necessary, restoration is

not a financially attractive use of land. However, as long as restoration doesn't fall as a burden on the landowner, they will end up reaping its benefits.

After working on the Rock Creek project for most of the week, we traveled north with Garrett and Jill to the Fall River Mills area that is their home base. The next project was in the town of McArthur just north of Fall River Mills. This project was on a landowner's ranch, and it was made possible by a conservation easement with the NRCS. This build was different from the Rock Creek project because we would be weaving a traditional BDA into a post line. Also the stream was much wider and grassier, with almost no onsite materials. Therefore, we had to harvest conifers and other materials from off-site locations. One such location was Jill's house. She lives at the edge of a conifer forest that was overgrown close to her home, so she was in need of some forest thinning. By harvesting our materials from the right spot we satisfied our need for organic materials to build with and in doing so increased the forest's overall health and decreased fire risk.

At the site, Garrett and the team had already pounded the post lines, so it was our job to get weaving and stuffing. We started by finding Y-shaped branches to lodge into the bottom of the structure. We placed them foliage side downstream; this was to create a scour apron, which prevents the water from scouring under the structure and instead encourages pooling behind the structure. We then wove in the larger conifers as best we could: they are less flexible, but provide good mass and stability for the structure. After those big pieces, we used the more flexible willow and manzanita branches to create a tight weave between all the posts that really held the structure in place. Once that was done, we used the smaller pieces to stuff in all the cracks to help slow water and catch sediment.

Fig. 3.6 Cooper and Nick working on the longest BDA built at Mc Arthur measuring in at 90 feet

Garrett also encouraged creating a curve in the structures. This mimics beaver dams that have natural curves which helps disperse the water's energy, making the structure stronger and thus less likely to fail. At the thalweg, which is the lowest altitude, and highest energy point of the stream, Garrett sometimes put in a double post line. This was to further reinforce the structure, and it allowed us to fit larger pieces of woody material into the structure.

After working for two days on the McArthur project, we moved on to another NRCS conservation easement project in nearby Burney. This was an interesting site with both wet and dry channels, as well as complex water rights, so the river system did not have its natural flow in this area. Garrett led us on a walking tour of the BDA structures that he put in as well as the rock riffle structures that were placed by another company. There were about 40-50 structures on multiple channels along about a mile stretch of the river. The structures varied in size considerably from knee/waist height, to almost head high. He talked us through his thought process of where to put the structures and why. In

many cases, they strategically put BDA structures at convergence and divergence points on the river in an effort to reactivate the remnant or dry channels.

Key Takeaways

One easy way Garrett and the team had started to restore the areas that they worked was to plant willow alongside some of the structures. This was to encourage beaver reintroduction and to begin restoring the creek's riparian area which had been entirely destroyed by cattle grazing. Even though the creek was mostly dry when we were working, the beavers had been there earlier and trimmed the willow stems that were planted. And, while we were there we saw that new willow sprouts had come up where they chewed. So whenever possible we shoved willow stems vertically down into the structures we built, in hopes that they will root and further strengthen the structure.

Fig. 3.7 and Fig. 3.8 Successful willow plantings sprouting next to BDA's, a beaver chewed the willow on the right

Garret emphasized the practice of building in multiple stages, and to think of our build like a painting. He told us to get the rough shape, and you can always come back later and do another brush stroke. It is more important to get the whole system built rather than focus on one structure to the exclusion of others. Especially when working in a dry system, it is difficult to know what effect structures will have when flow is coming through the system. Therefore, we mitigate these unknowns by building a lot of structures.

Garret advocated for a more moderate approach to restoration. He too was focused on the same low-tech processes that Kevin utilized, but he was also willing to partner with projects using big machinery to get the job done. The take away was to stay open to all restoration techniques but be brutally honest when evaluating their strengths and weaknesses.

Fig. 3.9 A beaver trail running through the water right up to a BDA

Conclusion

Overall, our training with Symbiotic Restoration provided an invaluable look into building a variety of in-stream structures. We got to see how Garret managed his business and restoration projects. In order to have consistent work, Garret always had multiple projects on the docket. We visited several of these projects and got to see the different constraints that came along with each site and how they shaped the design process.

Garret's mentorship gave us confidence at the prospect of starting our own restoration business. It was inspiring to see how he has stepped up to serve his community and bridge the gap between restoration and landowners. He further continues to help the larger community of California by helping to organize the creation of a California Process-Based Restoration Network to connect and support restoration practitioners. Thank you Garret and the whole Symbiotic Restoration team for your guidance, support, and friendship.

Fig. 3.10 Dirty and happy after a hard day's work at Rock Creek

Scott River Watershed Council

The Scott River Watershed Council (SRWC) is a community nonprofit dedicated to facilitating collaborative solutions for natural resources in the Scott River. The Scott River Watershed Council implemented the first Beaver Dam Analogues in California in 2014 under the guidance of Michael Pollack. The original structures are still maintained and have been augmented with several small auxiliary structures to help prevent scour. They were also instrumental in establishing the Habitat Restoration and Enhancement Act. This was the first permit of its kind allowing adaptive management practices that are essential to process based restoration. This allowed them to go back year after year to adjust and maintain their structures as well as add additional structures without getting a new permit each time. Through the HREA permit, a gradual, natural restoration approach is possible.

Fig. 4.1 Nick and Cooper with Charnna Gilmore (left) and several members of the SRWC

The SRWC hosted a hands-on BDA workshop that connected a variety of groups from CA and Oregon, so it was a perfect opportunity for our training visit. Over the half-week long program, we learned the history of SRWC's BDA efforts as well as their challenges and successes. And, we all got the opportunity to get in the water and get first hand experience constructing several BDA structures. The SRWC also hosted a similar workshop in 2017, and both were a successful win-win for the council, allowing them to build several new BDA's and giving participants hands-on experience with process based restoration practices.

Our Experience

We arrived several days before the start of their 2021 BDA workshop and got to help with the preparations for the workshop. The SRWC wanted to have the posts pre-pounded and materials staged so we could jump right into building in the workshop. They had worked with a construction company in the past to utilize an excavator in their build, and they did the same this time around. The excavator easily cleared away large swaths of vegetation in a single scoop. It cleared an entire section for a BDA in 20 minutes or less - something that would've taken the whole day with a 6-8 person crew with shovels!

Fig. 4.2 The excavator pounding posts with a vibratory plate attachment

Once the area was cleared for a post line, the excavator was fitted with a vibratory plate attachment and a custom collar that the SRWC had developed to fit around posts. The excavator was able to pound huge wooden posts (6-8 in diameter) into the rocky riverbed in seconds. The posts were about double the size of the posts we had used in our previous experiences and they were secured in a fraction of the time. It certainly would not have been possible to drive those posts without heavy machinery. They used large, heavy posts because the river system was strong, and they wanted to ensure that the structures would survive heavy flows.

There were not any onsite materials so the SRWC used this as an opportunity to help their community. We traveled to several nearby properties with willow thickets in need of thinning and collected from there. Later in the week they also thinned an overgrown conifer forest for material, reducing fire risk and improving that forest's overall health.

The workshop started with a tour of the site and a history of the BDA's. They showed us the first BDA ever installed in California, which they placed in 2014. And, they showed us how they have added to that structure over the years and continued to add supporting structures. During the workshop we constructed four BDA's that worked in series with the SRWC's existing two BDA structures. Each BDA was between 30 and 60 feet long and contained anywhere from 30 to 50 posts. They were constructed out of willow, hay, gravel, surrounding cattails, and sometimes conifers. Luckily, we had about 15 people all working together to construct the BDA's so we were able to finish each structure in two to three hours. The use of heavy machinery to clear the area and pound the posts saved us a lot of time. With the site all prepped, all we had to do was fill in the post line with our materials - weaving the willow branches and stuffing with hay, gravel and cattails.

Fig. 4.3 Nick and Cooper on the first finished BDA built during the workshop

The SRWC's funding was for restoration of salmon habitat. This meant they had to monitor fish passage over the BDA. The structures technically had to be passable year round by any age of fish. This proved to be impossible since the Sugar Creek section of the Scott River regularly dried out every year during summer. The SRWC said that this is inevitable at some locations, and they undertook efforts to catch any stranded fish during the fall when the creek was drying up and transferred them to a perennial river. If this situation were to occur, the best course of action is to notify local CDFW personnel.

However, it is important to note that there would not have been any salmon in Sugar Creek without their BDA's. With the structures, the creek is able to hold and maintain flowing water for months after it

would have normally run dry. In fact, before our arrival Charnna said that the creek was dry, but on the Saturday before we got there it actually rained. So, when we first saw the BDA's there was a little water pooled behind them. The incredible thing was, each day the water level rose higher and higher even though the rain had come and gone! The structures were able to catch rainwater that had fallen farther up in the watershed, and thus were able to continually fill up the riverbed for a week after the rains.

By the end of the week we had completed 4 BDA structures, and we actually gave design suggestions that were incorporated into the final two BDA's. We had run out of willow for the last structure or two, so we suggested using conifers like we had done on our previous trips. The SRWC had never used them in their BDA's before, but they knew of some properties that could use forest thinning. So, they quickly harvested a lot of conifer from an overgrown property nearby, which was easy free material, and it improved the forest health as well as fire resiliency. The SRWC ended up loving using conifers because their needles provided good surface area for stuffing the structures. Now they have a new readily available material source, as well as a way to help their community by thinning forests on surrounding properties.

Fig. 4.4 3 of the 4 BDA's working in series on Sugar Creek. Each BDA took about 2-3 hours with 15 people

Methodology

A key difference in the SRWC's BDA's was their use of an excavator to clear vegetation and drive in a post line of 6-8 inch diameter posts. These massive posts would provide an undeniably strong base to build off of and would have been impossible to drive in without the excavator. The SRWC's methodology was based on their large post line. They focused on weaving long willows through these posts and then stuffing the resulting spaces with hay. The use of hay was a new technique and could provide a low cost, readily available material for stuffing BDA's. Gravel and rocks were then piled at the base to help seal the bottom of the BDA and prevent water from eroding underneath the structure. The potential problem with building in this way is that it results in a structure that is more of a wall with a small, steep toe that is more likely to spring a leak. Although aesthetically pleasing, a structure built around a strong weave is vulnerable to scour which the SRWC had already experienced. However, when we used conifers in the later structures, we were able to shove them perpendicular into the bottom of the weave on either side to add depth to the structure and give it a larger toe and apron. This made the structure wider and flatter in relation to itself which helped to distribute the hydraulic forces and encourage flow **over the top** of the BDA.

Fig. 4.5 The first ever BDA built in California at Sugar Creek and behind it a couple smaller supporting BDA's

Because the SRWC has dealt with scouring in the past, they invented a technique of creating multiple BDA's in direct succession like a staircase. This supports the main BDA by decreasing the distance the water would fall after flowing over the top. Instead of one large drop in elevation, the water cascades down over multiple pools created by the auxiliary BDA's and the forces are distributed across multiple structures. That way, the structures are more likely to survive and it helps prevent scouring underneath the structures. It also allows for easier fish passage which was crucial for the SRWC. Another practice they employed was using a laser measure to determine the height of the weave in all of their structures. This was to create an accurate system that showed the differing water levels behind each structure, so that they could ensure proper fish passage. Finally, the SRWC created fairly straight post lines unlike the curved structures we had built with the other groups. Their reasoning for this was to have equal hydrologic pressure across the whole structure and evenly spread the water flow onto the floodplain.

Fig. 4.6 Nick learning how to use the laser level to ensure the BDA is the same height all the way across

Conclusion

Thank you to the Scott River Watershed Council for being such gracious hosts and for pioneering the use of BDA's in California. It was fascinating to learn about the various unexpected challenges that have arisen with their BDA's over the years, and those stories will prepare us for our future endeavors. We got an up close look at working with heavy machinery, and we saw what it takes to work on a project focused on fish restoration. The SRWC provided us an invaluable example of how to maintain the health of our environment while benefiting the community.

Conclusion

Over the course of the four trips and nearly a month total of hands-on training, we learned invaluable information that will surely help us support not only the beavers in our county, but the health and resiliency of our county as a whole.

Thanks to our beaver relocation training with the Tulalip Tribes, we now have the knowledge to perform successful relocations from start to finish. We know the proper trapping procedures that will keep us, the beavers, and the surrounding wildlife safe. In addition, we have seen what it takes to have a functioning holding facility and what to look for in terms of healthy beaver behavior. Finally, we learned how to identify suitable relocation sites and how to properly release and monitor the beavers. Armed with this knowledge, we are ready to make beaver relocation a reality in California! Even though it is currently against the law to relocate beavers in California, we as the SLO Beaver Brigade are working with a network of beaver-related organizations across the state to make relocation legal, and we are now prepared to be a pilot testing group for beaver relocation.

Thanks to the kindness and generosity of the three restoration groups we trained with, Swift water design, Symbiotic Restoration, and the Scott River Watershed Council, we now have a diverse training in the process based restoration field that we can apply to the rivers and

streams in our county. One of the most beneficial aspects of training with these groups is that they each had a slightly different, unique way of creating their structures. Kevin Swift employed a very low-tech approach, using little equipment and mostly manpower, mimicking beaver dams with his lasagna method. Garrett Costello and the Symbiotic Restoration team used a more moderate approach. They weren't afraid to work with companies using heavy machinery, and they employed a wide variety of BDA building techniques depending on the environmental conditions, whether it was a long post line or smaller Debris Jams. Finally, the SRWC leaned more towards a long-lasting structure approach. They readily used heavy machinery to save time and money, especially because they worked in larger river systems, and they had great insight on fish passage and community outreach.

Last but not least, this training would not have been possible without the generosity of Biodiversity First!, and we cannot wait to show our thanks by putting this knowledge to use restoring our wetlands.