Beaver-based Conservation and Restoration Opportunities in Mountain Ranges of California: Beaver Restoration Assessment Tool

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Introduction

Floodplains and meadows are hotspots of biodiversity and provide ecosystem services in the western United States. With development, unregulated grazing, water diversion, and extirpation of beaver (*Castor canadensis*) we have degraded many of these wetland habitats and decreased the ecosystem services they provide. New, low-cost approaches to restoration are focusing on the role of beavers and instream wood in shaping channel form and restoring incised channels disconnected from their floodplain. Promoting beaver dam building or mimicking beaver dam building with instream wood structures can increase and improve wetland habitat.

Beaver build dams, create ponds, and excavate bank burrows and canal networks for protection from predation, food storage over winter, and improved foraging pathways. At the same time, these habitat modifications also provide complex wetland habitat for other species, including threatened species like the willow flycatcher (*Empidonax traillii*). There is research underway to support the hypothesis that beaver dam analogues make wetland ecosystems more resilient to prolonged drought periods, which are becoming more frequent in California with climate change.

Beaver dam analogues are temporary, porous structures that are man-made. They may blow out during high flow events and should not be considered permanent installations. Just as a beaver dam naturally blows out and beaver rebuild their dams in the same location or nearby, the goal with beaver dam analogues is to encourage beaver dam building activity over time. This concept of jumpstarting beaver activity distinguishes beaver dam analogues from wood and rock check-dams used to address channel incision. Materials used to construct the structures includes wooden posts, vegetation, mud, and rocks. For additional information on beaver dam analogues and other instream wood structures design see the *Low-Tech Process-Based Restoration of Riverscapes* (lowtechpbr.restoration.usu.edu).

Land managers throughout the western United States have begun to partner with beaver and build beaver dam analogues to restore floodplains and meadows for various human and nature benefits. In California, beavers were present historically through a majority of the state (James and Lanman 2012, Lanman et al. 2012, and Lanman et al. 2013). However, trapping,

depredation, and land management led to widespread local extirpation limiting their current existence and their dam building influence across the State. Additionally, current California State regulations do not allow permits to be issued to the public or other agencies for beaver relocations (Fish & Game Code Sections 2118, 3005.5), which significantly limits the opportunities for enhancing the use of beavers as a restoration agent in California.

Beaver trapping and widespread beaver removal likely transformed many streams and meadows in California. In the past, beaver dams and ponds created complex wetland habitats. Many streams were characterized by multithread channels with complex wetland habitat, where today they are often degraded single thread channels that are incised. Incised streams became disconnected from their floodplains and groundwater tables drop over time. These impacts have been exacerbated by removing willows, straightening stream channels, and digging ditches to dry out meadows, further simplifying and degrading wetland habitats. The loss of beaver dams likely had a negative impact on species that co-evolved with beaver, such as Willow flycatcher.

Recent Beaver-Based Examples

Today, there is growing interest in using beaver-based approaches to restore meadows and streams in California. Between 2014 and 2019, eleven beaver dam analogue projects have been constructed in the California. These projects span six ecoregions (EPA level III):

- Audrain Meadow in the Central California Foothills ecoregion
- Boise Creek in the Northern Basin and Range ecoregion
- Childs Meadow in the Cascades ecoregion
- Doty Ravine in the Central California Valley ecoregion
- Klamath River, Scott River, and Trinity River in the Klamath Mountains ecoregion
- Martis Creek, Plumas National Forest in the Moonlight Fire restoration area, Red Clover Creek, and Squaw Creek in the Sierra Nevada ecoregion

Interest in this restoration approach was generated in some projects from the Bridge Creek, Oregon experiment using beaver dam analogues and posts to reinforce existing beaver dams to

improve steelhead habitat. This experiment showed that beaver dam analogues and beaver dams aggraded sediment, reconnected floodplains in a formerly incised stream channel, raised groundwater tables, and improved juvenile steelhead production (Bouwes et al. 2016).

Methods and Modeling

An important first step for planning beaver-based restoration actions is to identify stream reaches with the greatest potential for success. The Nature Conservancy convened a group of stakeholders to develop and apply a quantitative mapping tool to efficiently prioritize areas for restoration in seventy-eight large watersheds (HUC8 level) that spanned eleven ecoregions (Figure 1). The main inputs to this model are a reliable water source, stream bank vegetation that can support beaver foraging and dam building, and the likelihood that dams can be built during low flow and withstand typical floods. For a complete description of the Beaver Restoration Assessment Tool (BRAT) model see http://brat.riverscapes.xyz/ (Marfarlane et al. 2017). The BRAT model has been used to predict beaver dam building potential in Utah, Idaho, the Greater Yellowstone Ecosystem, Wyoming, Washington, the United Kingdom, and Canada.

The stakeholder group included the Nature Conservancy, U.S. Forest Service, Institute for Bird Populations, Occidental Arts and Ecology Center, and Point Blue Conservation Science. They worked with the model developer team of Dr. Joseph Wheaton, Wally MacFarlane, and Sara Bangen from Utah State University who ran the model to identify places for beaver-based restoration. Funding was provided by the National Fish and Wildlife Foundation to test the BRAT model across four watersheds in the Desert Terminal Lakes geography and refine its outputs into a strategy map. The strategy map shows a range of potential restoration actions, including stream reaches where there may be conflict with land use or infrastructure. The Nature Conservancy provided additional funding to expand the model beyond these test watersheds.

We recommend the strategy map be used as a first step in prioritizing where to do beaver-based conservation and restoration. These maps should be supplemented with on-the-ground observations, including referring to the upstream and downstream mapped conditions to determine the most appropriate management.

There are limitations to the BRAT model. BRAT is created with landscape scale spatial data that may not reflect the exact stream position, current vegetation, or land uses today. The strategy of improving vegetation first before promoting beaver dam building is limited by coarse (30 m) resolution on historic and current riparian vegetation. This lack of resolution in vegetation data led to an effort to map the intrinsic beaver potential using only geomorphic variables: stream gradient, stream width, and valley width (Dittbrenner et al. 2018). There is also no information on channel incision or entrenchment in the BRAT model. In addition, the beaver dam distribution data used in BRAT are incomplete as there is no comprehensive beaver distribution data set available for California. Therefore, on the ground evaluation of existing conditions and beaver distribution is an important step for evaluating and prioritizing proposed restoration actions and locations.

Strategies

We created a map of stream reaches identified for different conservation or restoration strategies (online link). We developed the strategies by combining the outputs of the BRAT model with additional information on existing beaver dams and assumptions about which land uses would be suited for different strategies (Table 1). The approaches include *beaver conservation* where beaver dams are currently present, *restoration* where the model showed a capacity for dams exists, *vegetation restoration first-priority* where riparian vegetation likely requires improvement before dam building would be supported, and *restoration with infrastructure consideration* or *restoration with land use consideration* where infrastructure or land use may limit beaver dam building.

The strategies are specific to ~984 ft (300 m) stream reaches. The information represents a snapshot in time of current conditions. The stream reaches included in the map do not contain infrastructure within 100 ft. perpendicular buffer to the stream, except for the stream reaches classified as strategy #5: Restoration with infrastructure consideration.

Table 1. BRAT model factors used to identify beaver dam building strategies

Strategies to Promote Beaver Dam Building	**Presence of beaver dam** (Yes, No)	**Potential dams** (#/reach)	**Potential dams with vegetation modification*** (#/reach)	**Land use** (Type)
1. Beaver conservation	Y	-	-	no urban or agricultural
2. Highest restoration potential - translocation	N	≥6		public, protected private
3. High restoration potential	N	2-5	-	no urban
3a. Vegetation restoration first-priority	N	≥2	≥1	
4. Medium-low restoration potential	N	≥1, <2	-	
4a. Vegetation restoration first-priority	N	≥1, <2	≥1	
5. Restoration with infrastructure consideration	N	≥1	-	-
6. Restoration with land use consideration	N	≥1	-	urban or agricultural

*The difference between the predicted dam density/reach based on historic vegetation (pre Euro-American settlement vegetation based on biophysical environment and historic disturbance regime) compared to current vegetation.

1. **Beaver conservation**: Beaver dam building or lodges observed. Data sources for beaver dam building include the Beaver Mapper, iNaturalist, and project team observations on the ground and via aerial imagery (Google Earth 2017). The dataset of existing dam building is incomplete—limited to only five watersheds and 359 actual beaver dams. It is not a comprehensive landscape assessment of beaver presence. Additional observations would improve the understanding of where beaver can be found today. Other active beaver signs on the ground could be chewed vegetation, bank burrows, and canals.

   Conservation actions could include trapping protections, promoting compatible land use practices, restoring riparian vegetation, building instream structures to reinforce existing dams or encourage new dams, and outreach efforts to share co-existence techniques to mitigate unwanted effects of beaver. For example, the California Department of Fish and Wildlife issued a trapping ban in the Sagehen Creek Experimental Forest where researchers have ongoing studies that would be impacted by beaver removal. These actions can also apply outside of 'beaver conservation' reaches where beavers are present and providing habitat but not building dams. For more information on beaver conservation please view: The Beaver Restoration Guidebook (Pollock et al. 2018).

2. **Highest restoration potential**: Likely to support the greatest number of dams, six or more dams, and located on public land, private protected for open space land, or land with conservation easements or other deed-based restrictions on development that may limit conflicts between beaver and people. Public lands include National Forests, National Parks,

National/State/Regional/Urban Parks, preserves, and wildlife areas, Land trust preserves, and other open spaces.

Translocation may be a priority on these lands; however current California Department of Fish and Wildlife regulations do not allow permits to be issued to the public or other agencies for beaver translocation because there are concerns about disease transmission, impacts on trout, effects on water conveyance, and property damage. These reaches could be some of the best future transplant sites, with the highest estimated beaver dam capacity, if the policy on moving beaver changed to allow these practices as in other western states. Lands not highlighted in this strategy, specifically tribal lands and private lands not protected as open space.

3. **High restoration potential**: Likely to support a high number of beaver dams, two to five dams per reach.

   Target these reaches for restoration and/or translocation of beaver. Consider improving riparian vegetation, changing land management practices to promote dam building, or building instream structures to encourage dam building or to mimic beaver dam building where there are no beaver.

   3a. Vegetation restoration first-priority: More suitable historic vegetation than is currently present and may need replanting or grazing management before beaver can build dams. Current dam capacity is greater than or equal to two dams per reach.

4. **Medium-low restoration potential**: Likely to support between one and two dams per reach.

   Target these reaches for restoration. Consider improving riparian vegetation, changing land management practices to promote dam building, or building instream structures to encourage dam building or to mimic beaver dam building where there are no beaver.

   4a. Vegetation restoration first-priority: More suitable historic vegetation than is currently present and may need replanting or grazing management before beaver can build dams. Current dam capacity is equal to or greater than one and less than two dams per reach.

5. **Restoration with infrastructure consideration:** Likely to support one or more dams, but where infrastructure (roads, culverts, railroads) is close to the stream and may limit beaver dam building.

   Use beaver pond levelers and other beaver management devices to limit pond size or restrain beaver activity that interferes with nearby infrastructure.

6. **Restoration with urban or agricultural consideration:** Likely to support one or more dams, but where urban or agricultural land uses may limit beaver dam building.

   Use beaver pond levelers and other beaver management devices to limit pond size or restrain beaver activity that interferes with adjacent land uses.

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Figure 1. Ecoregions in the study area.