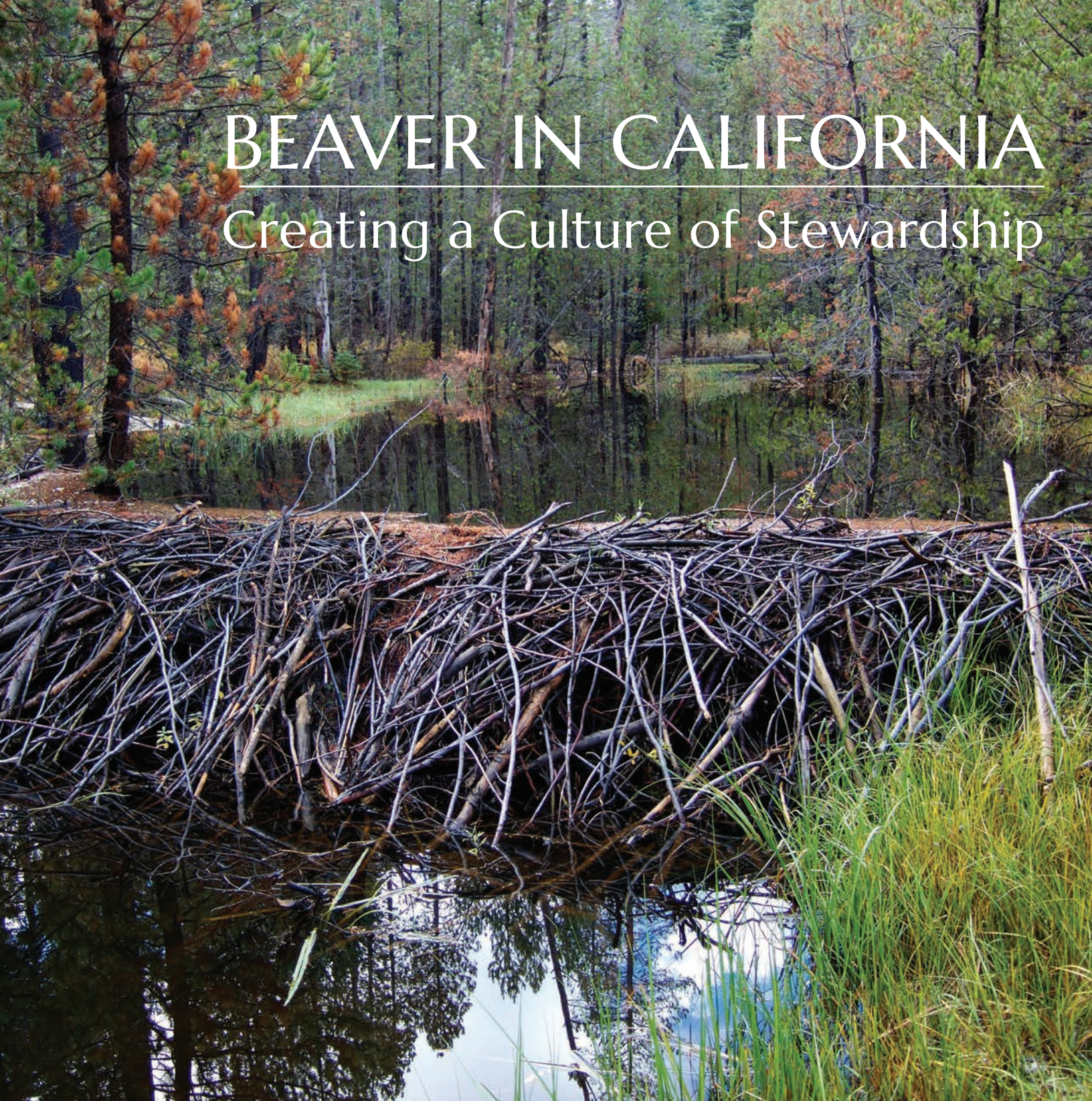


BEAVER IN CALIFORNIA

Creating a Culture of Stewardship



WATER
INSTITUTE
OCCIDENTAL ARTS &
ECOLOGY CENTER

KATE LUNDQUIST with BROCK DOLMAN

Occidental Arts and Ecology Center WATER Institute

DEDICATION

To the beaver, for their patience and perseverance; to all of the people working to promote the benefits of beaver and restore them to their former range; and to this great biosphere without which we could not engage in any of these endeavors.

ACKNOWLEDGEMENTS

Many thanks go to Kevin Swift of Swift Water Design (www.swiftwaterdesign.com) for copy-editing and to Toby Cowan of Performance Design Group (www.pdg1.com) for design and layout of this publication. We are deeply grateful for the following contributors who provided images, content and/or reviewed the document: Eli Asarian (Riverbend Sciences - www.riverbendsci.com); Dr. Jeff Baldwin (Sonoma State University); Philip K. Bairrington, Justin Garwood and Marisa Parish (CA Department of Fish and Wildlife); Anna Blackshaw (www.kitchenandtheegg.com); Mike Callahan (Beaver Solutions – www.beaversolutions.com); Rusty Cohn; Jim Coleman, Cooper Freeman and Olivia Rathbone (Occidental Arts and Ecology Center – www.oaec.org); Carol Evans (Elko Bureau of Land Management); Charnna Gilmore and Betsy Stapleton (Scott River Watershed Council - www.scottriverwatershedcouncil.com); Sherry Guzzi (Sierra Wildlife Coalition - www.sierrawildlife.org); Will Harling (Mid-Klamath Watershed Council - <http://www.mkwc.org>); Christopher Lanman and Dr. Richard Lanman (The Institute for Historic Ecology); Rachel Lundquist Diaz (copy-editor and sister extraordinaire); Zoltan Matica (CA Department of Water Resources); Mark Miyoshi and Luisa Navejas (Winnemem Wintu Tribe); Mary O'Brien (Grand Canyon Trust); Dr. Heidi Perryman and Cheryl Reynolds (Worth A Dam - www.martinezbeavers.org); and Dr. Michael Pollock (NOAA Fisheries). Finally, our work would not be possible without the generous support of the Patagonia Foundation, Jiji Foundation, Rose Foundation for Communities and the Environment and the Owl Peak Foundation.



Brock Dolman and Kate Lundquist monitoring Sonoma Creek beaver dam. (Photo: Jim Coleman/OAEC)

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WATER Institute Directors, Occidental Arts & Ecology Center

Version 3.0. Get the latest version at: <http://www.oaec.org/publications/beaver-in-california>

Cover photo of Child's Meadow beaver dam by Brock Dolman/OAEC

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INTRODUCTION

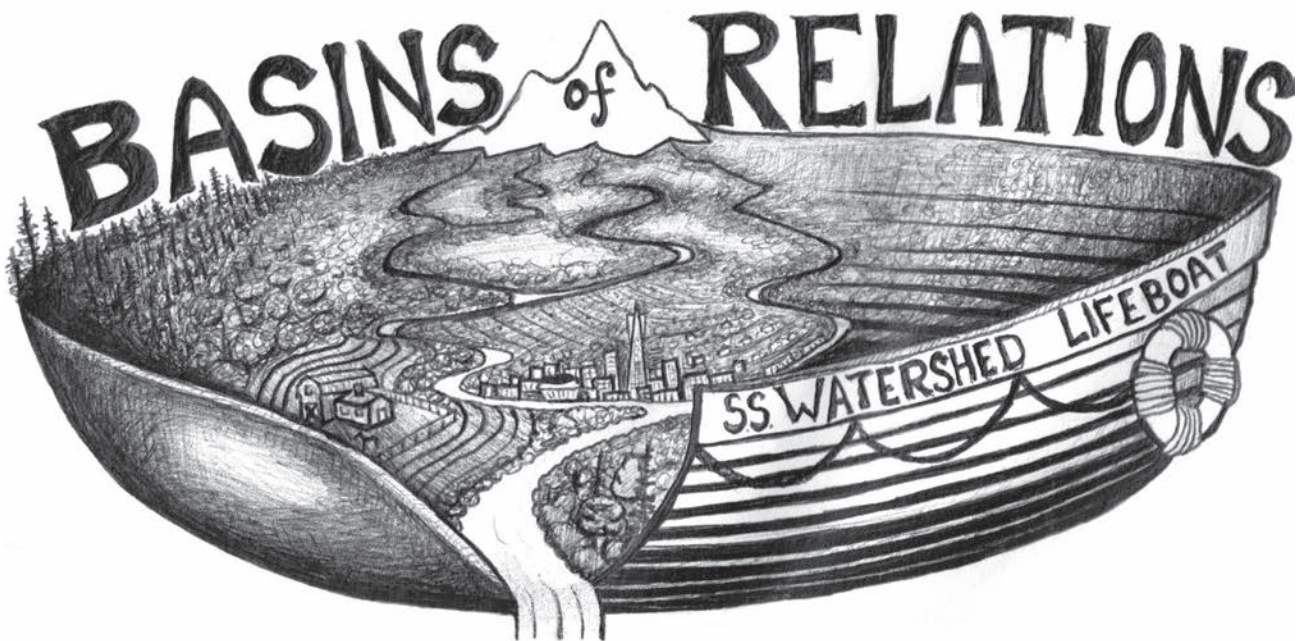
The Occidental Arts and Ecology Center WATER (Watershed, Advocacy, Training, Education, Research) Institute has been working for two decades to develop innovative, science-based solutions to the hydrologically destructive land-use practices and policies affecting California's watersheds, and address the impacts of climate change on the water cycle.

Through education, outreach, demonstration and policy change, we build the capacity of communities to restore their watersheds. A watershed encompasses all of the area that drains to a given stream, and is not limited to the stream alone. These catchment basins come in varying sizes and collect the surface water and groundwater in a given geographical area. We call them "Basins of Relations"¹ because watersheds are full of diverse organisms and life-sustaining processes. How we live in our basin can affect all of those relations and the waters we share.

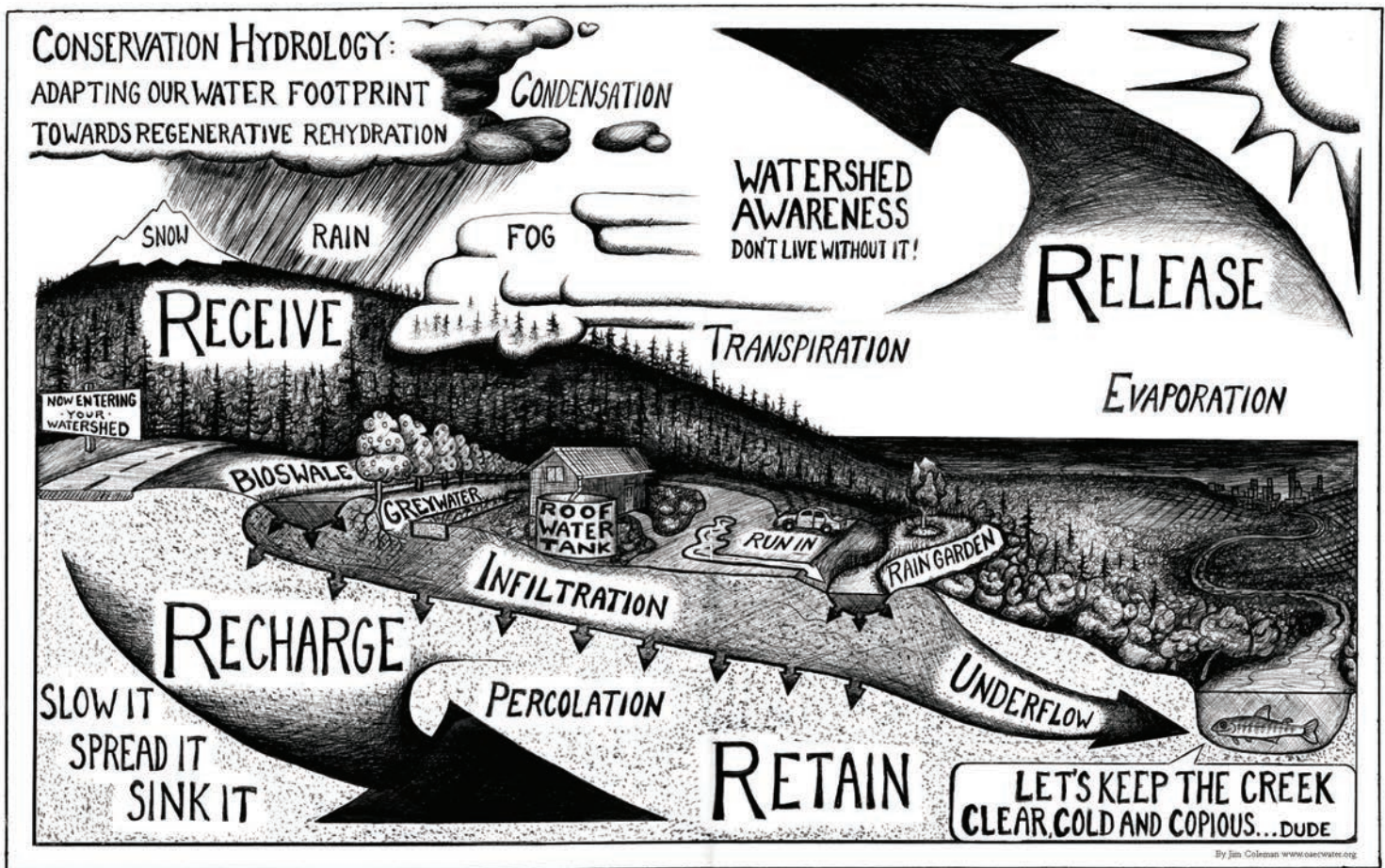
We call our philosophical and practical responses to the water challenges and opportunities before us "Conservation Hydrology."² Conservation Hydrology emphasizes community-based watershed literacy,

planning and action. It challenges the current "dehydration model" of human development and advocates for a "rehydration model" based on the mantra coined by Brock Dolman: Slow it – Spread it – Sink it – Store it – Share it!³ Rather than remove stormwater quickly, we need to design our settlements to slow the water down, spread it across the landscape and sink or infiltrate it into our soils to recharge groundwater. Humans are not the only organisms to master water management. The North American Beaver (*Castor canadensis*) is the original practitioner of Slow it, Spread it, Sink it, Store it, Share it. The dams they build spread and slow the flow of water across the landscape, reconnecting this water with the floodplain and encouraging it to rehydrate riparian corridors and their associated meadows and wetlands. By altering flow patterns in space and time, slowing high flows and creating habitat, this beaver-engineered process has profound biological and physical benefits to our waterways.

These benefits are especially important now that loss of snow pack and persistent drought are affecting all



We all live in Basins of Relations. (Illustration by Jim Coleman/OAEC)



Conservation Hydrology in Action. (Illustration by Jim Coleman/OAEC)

Californians. Stewarding beaver can be an inexpensive way for all types of land users to increase water security. Some rangeland managers in the arid west have sustained their operations in large part due to grazing regime changes and the return of beaver.

Research indicates that plummeting salmonid populations could increase their numbers and survival where beaver dams are present. Considering how much is spent on recovering native fisheries and restoring our watersheds, adding beaver stewardship to the toolbox could be a cost-effective way to accomplish these goals.

This publication is intended for land-owners, concerned citizens, conservationists, resource agency staff and decision makers interested in learning how beaver can help them achieve their management goals while reducing conflict. The topics include well-researched and science-based information about:

- The historic legacy and current benefits of beaver to California's unique ecosystems;

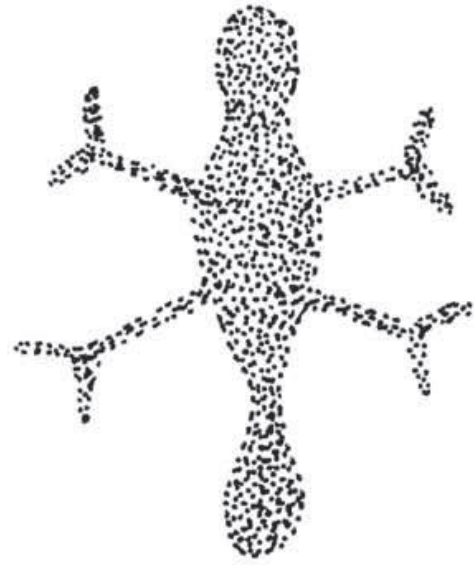
- Non-lethal management strategies that promote coexistence and decrease the need for lethal management and case studies of their application in California;
- Beaver as a cost-effective tool for restoring mountain meadows, rangelands and endangered salmonid habitat and;
- Recommendations to support the implementation of beaver co-existence and conservation policies.

Given California's current water woes and the impending shortages brought on by climate change, we can no longer afford to overlook the important ecosystem services beaver can provide. It is our hope that with this information Californians will come to recognize the importance of beaver to our State, protect the colonies we have, and support efforts to craft policies promoting the water-saving abilities of this keystone species.

THE HISTORY OF BEAVER IN CALIFORNIA

There has been confusion about where in California beaver historically lived. Many still refer to analyses conducted in the 1940s that assert beaver were only native to the Central Valley, the Klamath and the Colorado River basins.⁴

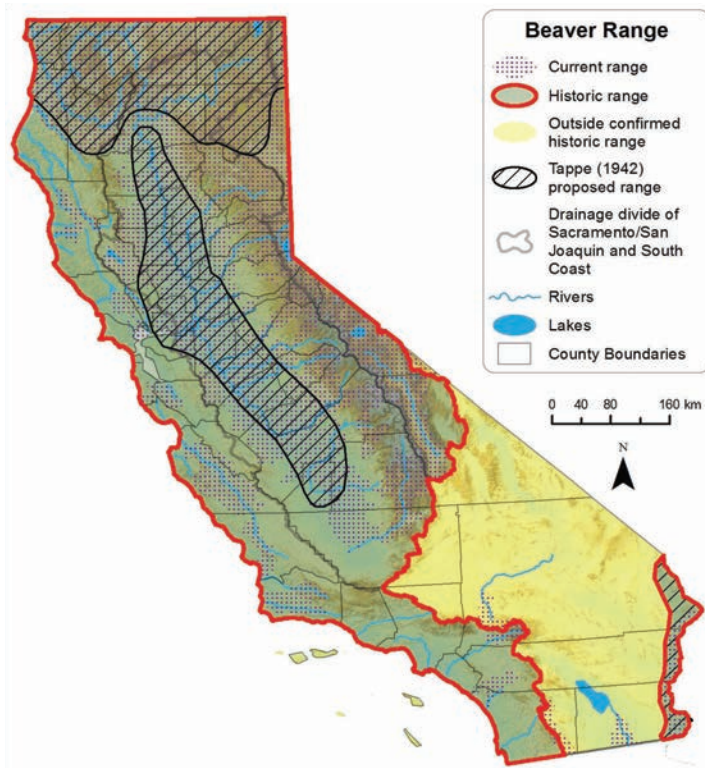
The WATER Institute joined efforts with a group of beaver advocates to re-evaluate the historic records and publish peer-reviewed papers summarizing the physical, historic and ethnographic evidence we found. This evidence suggests that beaver historically ranged across much of the state (see Revised Historic Range Map). The WATER Institute and other advocates later formed the California Beaver Working Group, an ad-hoc group of scientists, agency and non-profit staff interested in the stewardship of beaver in California (see photo on page 20). The archaeological evidence includes buried beaver dams in the Sierra Nevada (carbon dated to 530 A.D.),⁵ and buried beaver bones in the San Francisco Bay Area and the north coast of California. Numerous historic accounts from explorers,



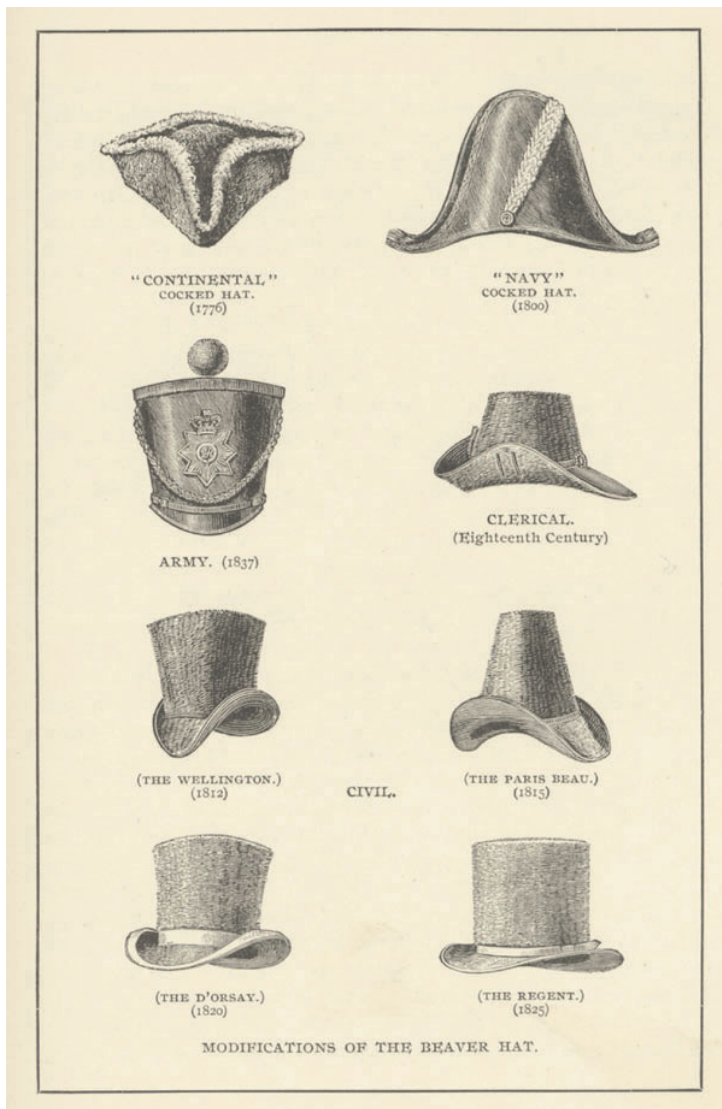
Chumash pictograph from the Cuyama Valley.
(Source: Lee and Horne 1978)⁶

sea captains and trappers arriving to the state first by boat and later on foot suggest beaver were found across the state, including the Sierra Nevada mountains and as far south as San Diego county. We gathered abundant ethnographic evidence as well. In addition to there being a word for beaver in sixty native California languages, beaver are mentioned in stories, their parts are used for ceremonial objects, their bones have been found in middens and their distinct image is portrayed in the pictographs of native California tribes.⁷

Humans have utilized beaver for food, pelts, medicine and fur for millennia. In the early Middle Ages the Eurasian Beaver (*Castor fiber*) was highly sought after in Europe and Asia as they have the perfect fur for making warm coats and felted hats. For centuries, many hat styles were made with beaver fur and top hats were often called “beavers.” Their castor glands were also very popular for making medicine and perfumes. Purportedly in the 17th century the Catholic Church, at the request of the Bishop of Quebec, declared that beaver were a fish and thus could be eaten during Lent.⁸ The demand for beaver was so great that by the 17th century the Eurasian beaver was nearly hunted to extinction.



Proposed historic range map of beaver in California.
(Source: Lanman et. al 2013)



Shapes and styles of beaver hat 1776 – 1825.
(Source: Wikimedia Commons⁹)

While Europeans were hunting *Castor fiber* nearly out of existence, *Castor canadensis* was still flourishing across the North American continent. Scientists estimate that there were between 60 and 400 million beaver on the continent prior to European colonization.¹⁰ Millions of beaver dams and ponds covered more than 300,000 square miles in pre-Columbian America. A tenth of the total land area was rich, ecologically diverse wetland, creating a mosaic of habitat for insects, amphibians, fish, birds, and mammals.

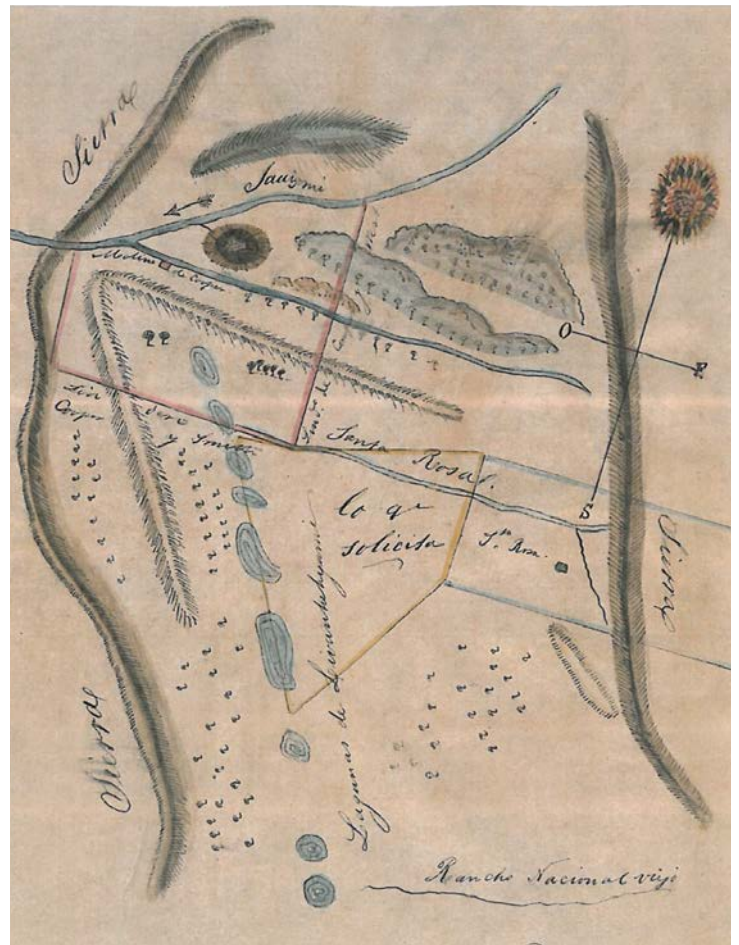
When Europeans discovered there were beaver in the New World, they immediately began trapping them for profit to finance further exploration and expansion into this “new” territory. They traded goods for pelts

with the indigenous peoples and then sold them to foreign markets at a huge profit. European colonization devastated beaver populations across North America as the beaver population on the east coast was hunted out, and trappers had to go further west to find more.

Most accounts of fur trapping in California begin with the 1826 arrival of mountain man Jedediah Smith who came in on foot from the east. We have found new evidence that suggests sea-going trappers had already begun to hunt and trade furs on the coast as early as the 1790s. Russian, American, and European fur traders sailed up and down the coast trapping and trading for whatever furs they could find. It appears from the historic records that by the time overland explorers reached California, most of the coastal populations of fur-bearing animals had already been exterminated.

“Four leagues away, more or less one finds Livantuligüeni, which forms in its basin great tularé lakes teeming with beaver.”

– Description of the Laguna de Santa Rosa by General Mariano Vallejo in 1833.¹¹



Diseño del Rancho Llano de Santa Rosa: Calif. Earliest known map of the Laguna de Santa Rosa.¹²

There is no known effort to conserve beaver while they were being trapped out of California from the 1780s to the 1850s. Quite the opposite occurred in fact. Between 1823 and 1841, the Hudson's Bay Company ordered their employees to create a "fur desert" in the west in order to edge out competing trapping companies. The high demand for fur during this period drew so many people to the west that Dr. Rick Lanman has dubbed this era the "California Fur Rush."¹³ Soon the Fur Rush gave way to the Gold Rush, and by the early 1900s there were an estimated 1,000 beaver left in the state.

Recognizing their fragile status, the California Division of Fish and Game passed a law in 1911 to protect the remaining beaver from being killed. Once beaver population numbers started to climb, the law was revised to allow the killing of nuisance beaver (also known as "depredation") by landowners suffering damage to property. Agriculturalists in the California Delta were concerned about beaver "endangering or destroying the levees or other protective works of any reclamation, levee or swamp-land districts."¹⁴ Beaver numbers again decreased and the ban on killing was reinstated. By the mid-1930s the landowner's right to depredation was restored for a final time and still stands today.

During this same period, the California Division of Fish and Game (as it was called at that time) recognized the benefit of beaver dams to soil, water and wildlife conservation and initiated an extensive translocation program to repopulate the state with this helpful watershed engineer.

California Fish and Game biologist Donald Tappe wrote in his 1942 Status of Beaver report, that "It is now understood that soil erosion and shortage of water in some places resulted from the destruction of the beavers which formerly built, and kept in repair, dams on the upper reaches of many streams."¹⁵ From 1923 until 1950, 1,221 beaver were live trapped and delivered to watersheds across the state, and were even dropped from airplanes into the El Dorado National Forest using boxes with parachutes attached. Thanks to the efforts of conservationists, scientists and agencies of that era, beaver have begun to make a comeback in our state. Some of our beaver colonies today descend from those transplanted during that period.

BEAVER BEHAVIOR AND ECOLOGY

Globally there are two species of beaver, and both are native to the northern hemisphere. The Eurasian beaver (*Castor fiber*) has a native range that includes much of Europe and Asia. The North American beaver (*Castor canadensis*) has a range that runs from the taiga in northern Canada to the deserts of northern Mexico, including California.

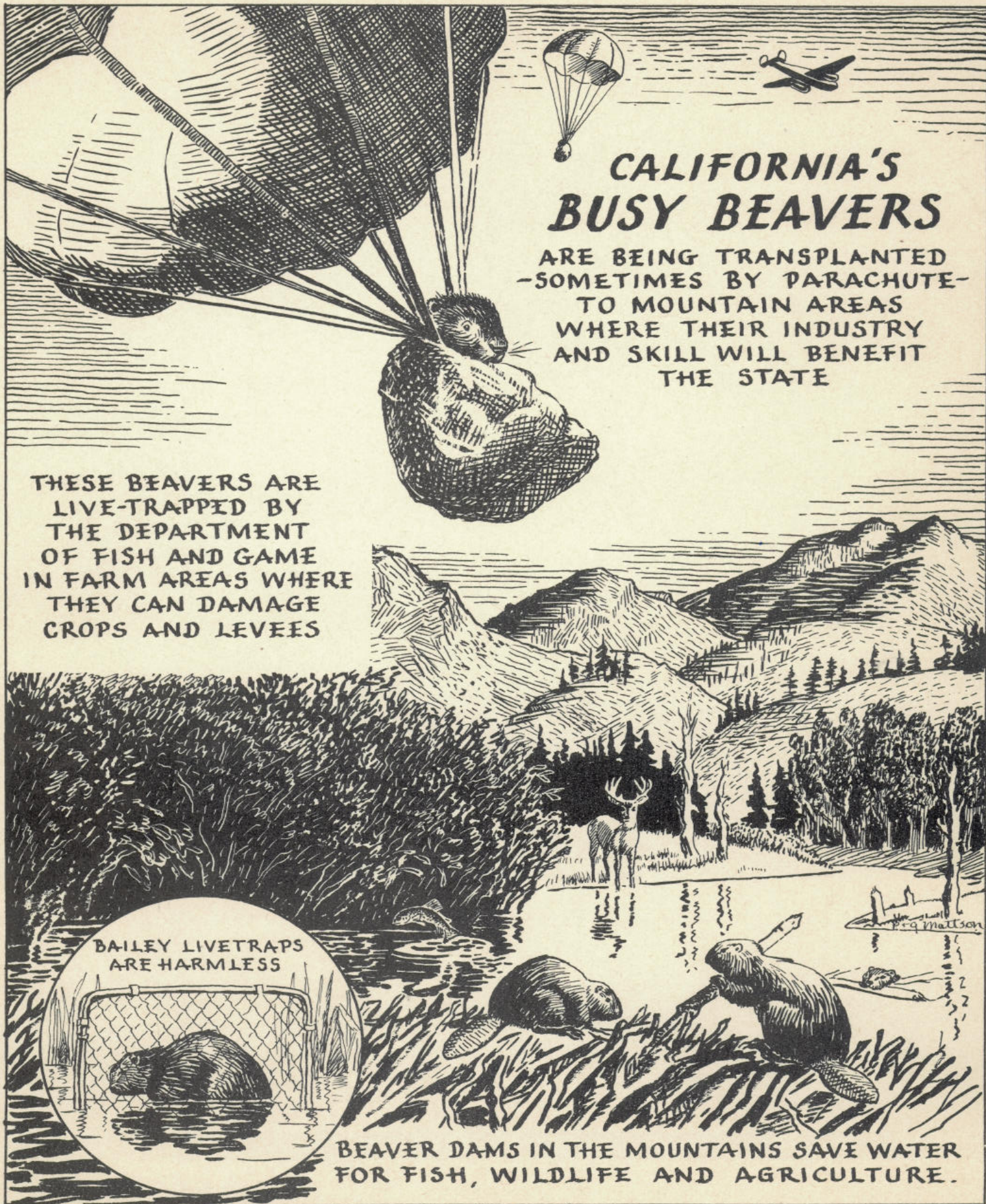
Highly adaptable, their range is limited primarily by the availability of water and food. For this publication we will only be focusing on the North American beaver.

Beaver are the second largest rodent in the world and the largest in North America. On average, adults weigh between 40-80 pounds and in some cases over 100 pounds depending on where they live. They live in tight-knit groups called colonies that are comprised of one mating pair, the young of the year (kits), yearlings and juveniles. The yearlings and juveniles help watch over and feed the kits, and the colony members groom one another. By age 2 or 3 juveniles disperse to find habitat and establish a new colony, traveling up to 30 miles by water or 12 miles overland. Unlike most rodents, beaver have only one litter of kits a year and live an average of 12 years in the wild.

Contrary to a popular misconception, beaver do not eat fish. Beaver are herbivores. Their diet varies depending on where they live. They can eat a wide range of foods from the inner bark of deciduous trees such as willow, poplar, cottonwood and aspen to herbaceous matter such as grasses, leaves, bulbs, and rhizomes.



Tulocay Creek beaver eating grass. (Photo: Rusty Cohn)



CALIFORNIA'S BUSY BEAVERS

ARE BEING TRANSPLANTED
-SOMETIMES BY PARACHUTE-
TO MOUNTAIN AREAS
WHERE THEIR INDUSTRY
AND SKILL WILL BENEFIT
THE STATE

THESE BEAVERS ARE
LIVE-TRAPPED BY
THE DEPARTMENT
OF FISH AND GAME
IN FARM AREAS WHERE
THEY CAN DAMAGE
CROPS AND LEVEES

BAILEY LIVETRAP
ARE HARMLESS

BEAVER DAMS IN THE MOUNTAINS SAVE WATER
FOR FISH, WILDLIFE AND AGRICULTURE.



Beaver-chewed aspen. (Photo: Kate Lundquist/OAEC)

Their front teeth (incisors) continue to grow throughout their lives and will outgrow their skull if they do not keep them short and sharp by chewing on wood regularly. More agile in water than on land, beaver need aquatic habitat to protect themselves from predators and trapping by humans. Mountain lion, wolf, coyote, bobcat, even bear and river otters will attempt to prey on beaver. To avoid this, beaver colonize existing ponds, lakes, streams and rivers and dig out burrows in the banks, build mud-plastered wood lodges above the water line or utilize a combination of the two depending on the site. These beaver dwellings have underwater entrances and provide them a safe space to eat, sleep and raise their young.

Beavers are amazingly adaptable and change their behavior based on the conditions they find themselves in. There is no known genetic difference between those that build bank burrows and those that build lodges or between those who build dams and those that do not. The site conditions determine what strategies they will use when colonizing a new area. While they may start with a bank burrow, they may build a lodge if conditions allow. Similarly, some habitat conditions support dam building and others do not.

Where creeks and rivers are slow moving but shallow, beavers will build dams. These dams back the water up creating deeper pools, or beaver ponds. To access food

sources without leaving the water, they dig lengthy channels off of these ponds and into the surrounding forest. These elaborate water works form a complex of beaver-engineered wetlands that provides many benefits to the landscape.



Beaver dam in Sonoma Creek, CA. (Photo: Kate Lundquist/OAEC)



North American Beaver. (Photo: Cheryl Reynolds, Worth A Dam)

BENEFITS OF BEAVER TO ECOSYSTEMS

Beaver are wetland engineers who physically modify the environment more than any other non-human organism in the northern hemisphere. The dam complexes they build have physical and biological effects on the watershed, changing how water flows across the landscape, and creating habitat for many rare, threatened and endangered species.

Despite early recognition of the benefits of beaver by our resource conservation agencies in the mid 1900s, it wasn't until recently that an interest in beaver has begun to reemerge in California and across the arid west. Landowners, conservationists and researchers are trying to assess just how much an effect beaver have historically had on the way our river, wetland and meadow systems function and how beaver could continue to have these effects if given the chance.

One or several dams on a creek or river can act as a buffer in high flows, reducing the intensity of floods. Beaver dams slow and redirect flood waters across adjacent low lands, encouraging riparian vegetation which also works to accumulate new soils and hold existing soils in place. In severely incised or down-cut creeks, beaver dams can help bring the streambed back up to its original level, reversing the effects of channel erosion.¹⁷

When beaver dams spread the water out, creating wetter habitat, they also promote subterranean recharge and the release of water later in the season to enhance base flows. This can be very helpful in California's Mediterranean climate where we do not receive rain during the hot summer and fall months and are experiencing prolonged droughts.¹⁸

In 1992 the Elko Bureau of Land Management worked with a rancher on Susie Creek (NV) to exclude cattle during the hot season allowing vegetation to recover and increase in abundance. This provided enough food for beaver to begin colonizing in 2003. Their dams have helped augment flows and trap sediment.
(Photos: Carol Evans/BLM)



1992



1999



2015



In addition to increasing the presence of water, beaver dams have the ability to enhance water quality by trapping sediment, excess nutrients and even contaminants. One study has shown that the beaver dams in Taylor Creek, which empties into the southern end of Lake Tahoe, help keep phosphorus from entering into the lake.¹⁹ When an oil pipeline broke in northern Utah in 2013, a beaver dam prevented diesel from reaching the fresh waters of Willard Bay.²⁰



Dam on Taylor Creek, South Lake Tahoe, CA.
(Photo: Kate Lundquist/OAEC)

Beaver-engineered wetlands have been shown to sequester carbon as well. Dam building keeps the sediment and soils of these wetlands hydrated, preventing the carbon from drying out and being released into the atmosphere. In this era of climate change, we need to balance the burning of fossil fuel emissions by sequestering carbon in the soil and vegetation.²¹

In addition to all of these physical effects, beaver dam building can have profound biological effects on a watershed. The different age and height of trees cut by beaver provide a rich mosaic of habitat for many mammals and birds that have different needs for foraging, avoiding predators and nesting. When beaver cut down deciduous trees like aspen and willow, this stimulates them to stump sprout and can increase their vigor.

The ponds and channels associated with beaver wetlands provide great habitat for many different species. Recent research indicates that many of



Beaver dam building in the Ruby Mountains of Nevada helps rehydrate this high-elevation arid landscape, supporting diverse phases of plant growth and creating excellent habitat for Columbia Spotted Frog.²² (Photo: Brock Dolman/OAEC)

California's native and endangered fish such as Coho salmon, Steelhead trout and Lahontan Cutthroat trout benefit greatly from the presence of beaver dams and their associated habitat. The beaver ponds provide fish with abundant food and shelter from prey and are often the most abundant source of water in the system, especially during dry summers and prolonged droughts.



Juvenile Coho salmon are abundant in this beaver pond on a sub-tributary of the Scott River in northern California.
(Photo: Will Harling/Mid-Klamath Watershed Council)

Young Coho salmon living in beaver ponds tend to get much bigger which ensures a greater chance of survival when they go out to sea. Side channels that result from beaver damming provide places for fish to retreat to during high flows. Unlike human-made dams, beaver dams are not a threat to fish passage as the fish can often go through them or can go over them during high flows.^{23,24} During peak flows dams can be breached or destroyed completely.

Amphibians and reptiles can benefit from beaver-created habitat as well.²⁵ There are several sensitive and even endangered species in California that are commonly found in or around beaver ponds. Western Pond turtle, Red-legged frog, Sierra Nevada and Mountain yellow-legged frog and Cascades frog are becoming increasingly affected by disease and climate change and can all benefit from the presence of beaver-created habitat.

The shallow wetlands or “fens” associated with beaver dams provide ideal breeding habitat for the Cascades frog, which has been identified as a species of special concern. In the fall of 2014, a group of scientists observed a cluster of over 40 Cascades frogs in a beaver-engineered fen near Mt. Lassen. These frogs are exceptionally rare in the Lassen area.²⁶



Beaver ponds provide excellent habitat for many different waterfowl and other birds including the endangered Willow Flycatcher²⁷ and Least Bell's Vireo.²⁸ Cooke and Zach (2008) found that as beaver built more dams, the abundance and diversity of songbird species increased in the associated ponds.²⁹ As beaver dams increase water on the flood plain, trees die and provide excellent nesting sites for woodpeckers, owls and other cavity nesters. Keeping beaver on the landscape can help support these and other imperiled species that depend on our ever-vanishing wetlands for their survival.

The microhabitats created by active beaver ponds and wetlands increase the abundance and diversity of insects present, and this in turn provides more food for fish, mammals and waterfowl. Beaver activity creates a rich topography that supports many different life forms.



This beaver pond in arid Nevada is home to a wide array of insects including this Paddle-tailed Darner (*Aeshna palmata*). (Photo: Brock Dolman/OAEC)

Cascades frog (*Rana cascadae*) in beaver wetland near Mt. Lassen. (Photo: Brock Dolman/OAEC)



Beaver bank lodge entrance as seen from under water (Photo: Marisa Parish/CDFW)

Recent research conducted by Justin Garwood and Marisa Parish (CDFW) on the Smith River in northern California suggests that beaver bank burrows, bank lodges and food caches function like “river reefs.” By increasing habitat complexity and shade with the addition of small woody debris, beavers provide

critical habitat and cover for Coho salmon, and many other species (see images below). The results of this study reveal more opportunities for working with beaver to restore habitat and highlight the need for more research on the benefits of non-damming beaver.³⁰



Crayfish (spp.)
(Photo: Justin Garwood/CDFW)



Rough-skinned newt (*Taricha granulosa*)
(Photo: Brock Dolman/OAEC)



Foothill yellow-legged frog (*Rana boylei*) (Photo: Brock Dolman/OAEC)



Prickly sculpin (*Cottus asper*)
(Photo: Bill Stagnaro)



Klamath smallscale sucker (*Catostomus rimiculus*)
(Photo: Brian Hodge)



Coho salmon (*Oncorhynchus kisutch*)
(Photo: Brock Dolman/OAEC)



Three-spined stickleback (*Gasterosteus aculeatus*)
(Photo: Ron Offermans)



Juvenile Steelhead trout (*Oncorhynchus mykiss*)
(Photo: Brock Dolman/OAEC)



Coastal cutthroat trout (*Oncorhynchus clarkii clarkii*)
(Photo: Justin Garwood/CDFW)



Western pearlshell mussel (*Margaritifera falcata*)
(Photo: Justin Garwood/CDFW)



Western toad (*Anaxyrus boreas*)
(Photo: Justin Garwood/CDFW)

BEAVER STEWARDSHIP IN CALIFORNIA

There is growing interest in beaver stewardship in California among conservationists and agencies that recognize their potential benefits. Since beaver dam complexes can enhance watershed restoration and listed species recovery, interested stewards are focusing on what they can do to support dam building behavior.

Beaver stewardship requires varying degrees of co-existence, restoration and relocation. For those who already have beaver in their landscape, there are many ways to prevent unwanted damage while continuing to receive the many benefits they provide.

CO-EXISTENCE THROUGH NON-LETHAL MANAGEMENT

While some landowners are appreciative of beavers' presence, others are frustrated by what beaver do to the landscape. The most common complaints are beaver flooding lowlands, blocking culverts and irrigation ditches, burrowing into levees and cutting down trees. Most of these activities can be managed with economical, long-term strategies that prevent property damage, avoid the need to kill beaver and retain the many benefits beaver bring.

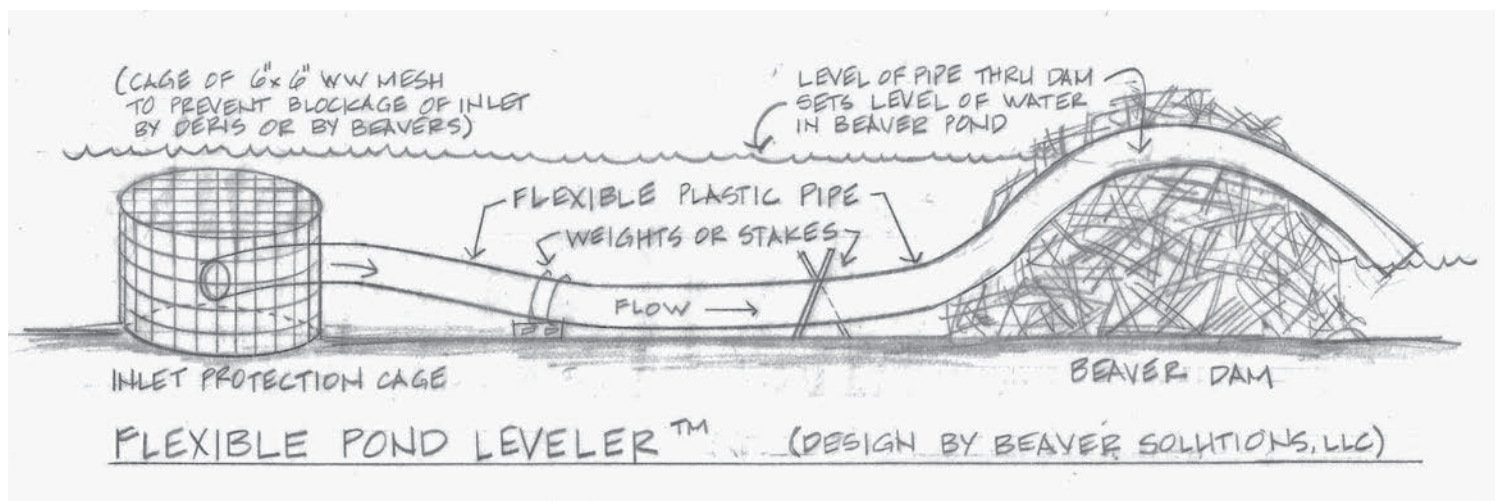
One type of flow control device designed by Mike Callahan.
(Diagram by Sherry Guzzi/Sierra Wildlife Coalition)

Lethal management should be considered the last resort as it can be costly, cause bad public relations and is ineffectual in the long run. No matter how many beaver you kill, if the habitat is favorable and there are other colonies nearby, they will continue to return.

As beaver build dams, the rising water can cause flooding. To manage water height, property owners can build or install a flow control device. This device takes advantage of beaver's dam-building behavioral cue—the sound and feel of running water. This instinct is what makes dam removal such a losing battle. Instead, putting a pipe through the dam prevents water from noisily spilling over the top, which discourages the beaver from building the dam any higher. A welded wire cage around the upstream inlet keeps beavers from blocking the pipe, and releasing water below the dam crest on the downstream side reduces dam-building cues. The installer can then lower the pond level to the desired height and maintain it there.

Flow control devices can have the additional benefit of slowing tree cutting, since some beavers do not re-use old wood. In those cases, removing the dam encourages the beaver to cut fresh trees to rebuild it.

When culverts are installed in waterways where beaver live, they will often start to block the flow of water through the culvert. An easy way to prevent beaver from blocking the culvert is to build a trapezoidal shaped fence that is narrowest at the

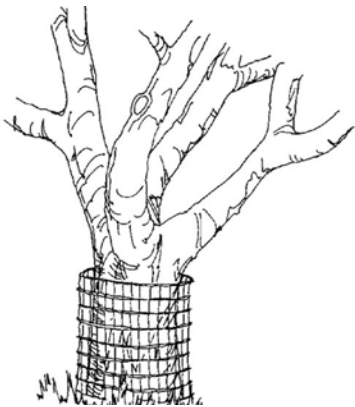


culvert and widens upstream. This forces the beaver to dam a much larger area, and as the dam grows along the fence, it gets farther and farther from the stimulus of water rushing into the culvert. Keeping the culvert open this way prevents the roadbed from becoming over-saturated or the road from washing away completely. A pond leveler pipe can also be run through the fence if needed.



Trapezoidal protection fence in Westford, MA prevents beaver from blocking the culvert.
(Photo: Mike Callahan/Beaver Solutions, LLC)

Trees can be protected either individually or in groups. In most places, wrapping trees with 3-foot-high galvanized welded wire is sufficient. Make sure the wire completely surrounds the tree, and leave a 12-inch space all the way around the tree to allow for growth. In areas where it snows, using taller fencing that will reach 3 feet above the average snow height is important to ensure year-round protection. Chicken wire is not strong enough to withstand beaver chewing. Some people use one or two strands of solar powered portable electric fencing set at beaver height to prevent them from accessing vegetation.



Wrap trees with welded wire to protect them.
Note: allow more space, 12 inches, between tree and wire than is shown in illustration.
(Illustration: Washington Department of Fish and Wildlife)

Another option for tree protection is to paint the tree trunks with a mixture of latex paint and coarse sand. Paint does require more maintenance and re-application, but can be color-matched to the tree bark to blend in well and address aesthetic concerns. To every gallon of exterior grade latex paint, add 20 ounces of mason sand (30 – 70 mesh). Mix well and make only what you can use. Remove debris from the tree bark before applying the paint and be careful not to apply too thickly or the sandy paint will roll off. Cover the entire section of the trunk that runs from the ground level to 3 feet above the anticipated snow level.



Aspen painted with sand paint to prevent beaver chewing. This two-toned paint job is so well done you can barely tell there is paint on the trunk!

(Photo: Sherry Guzzi/Sierra Wildlife Coalition)

For detailed instructions on how to install these devices yourself, look under the Beaver Restoration and Non-lethal Management Guide headings of the Resources section at the end of this publication. The materials are relatively inexpensive and readily available. Alternatively, you can call the listed contractors to have them install it for you.

BEAVER CO-EXISTENCE SUCCESS STORIES IN CALIFORNIA

There are several instances across the state where people have successfully co-existed with beaver. One of the better-known cases of citizen-led beaver advocacy began in the city of Martinez when beaver took up residence in the downtown portion of Alhambra Creek in 2006. The City was concerned about flooding and other issues and was considering removing the beaver. The public outcry was so great that the City Council agreed to form a sub-committee to investigate the issue further.

The sub-committee was made up of council members and citizens who arranged for the installation of a flow control device to prevent flooding and wrote a 167-page report addressing the city's concerns. In the end, the beaver were allowed to stay. This case is a good example of how citizens can work with their municipality to co-exist with beaver in an urban environment.



Beaver dam on Alhambra Creek next to the Martinez train station. (Photo: Brock Dolman/OAEC)

Through this process, sub-committee member Dr. Heidi Perryman founded Worth A Dam, an organization “dedicated to maintaining the Martinez beavers in Alhambra Creek through responsible stewardship, creative problem solving, community involvement, and education.” Worth A Dam maintains a robust website full of beaver information and hosts the annual Martinez Beaver Festival.³¹

As of 2015 the colony had produced twenty-four kits and was providing much-needed habitat for a diverse array of birds, mammals and fish. As the juveniles matured and left to colonize watersheds elsewhere the total Martinez beaver population never exceeded nine individuals. Martinez has now become an eco-tourism destination for a family friendly “watchable wildlife” experience.

Another example of citizens successfully working with a public agency to find a solution can be found in Lake Tahoe. Sherry and Ted Guzzi of the Sierra Wildlife Coalition have worked tirelessly on behalf of beaver in the Tahoe Basin. When they heard the U.S. Forest Service was having issues with beaver damming on Taylor Creek they approached agency staff to see if there was a way to help. Forest Service employees were breaking down two different dams to prevent flooding and allow passage for the non-native, but popular Kokanee salmon during their fall run. This created a lot of work for the Forest Service and beaver alike.



Sherry and Ted Guzzi of the Sierra Wildlife Coalition install a flow control device on Taylor Creek in South Lake Tahoe. NOTE: We are sad to report that since the writing of this guidebook, Ted Guzzi has passed away. His passion and dedication to beavers will be dearly missed. (Photo: Sheri Harstein)

After meetings and forums with multiple stakeholders (including Sierra Wildlife Coalition, National Forest Foundation and the WATER Institute) the Forest Service granted Sierra Wildlife Coalition approval to install flow control devices in the two different dams. To support the Kokanee without destroying the entire beaver dam, they began notching a small portion instead. This had the added benefits of encouraging the fish to carry out their fall run despite low flows and to direct them over the dam during their run.

These strategies will ensure the beaver have a deep enough pond to store food in the winter and will prevent them from cutting more trees to repair the dam when removed. Sierra Wildlife Coalition is also

supporting the Forest Service in wrapping and painting their trees in a way that does not detract from the visitors' experience.

The Forest Service has also developed an interpretive sign to install near the beaver activity on the Rainbow Trail. This sign describes what beaver management activities they are implementing in collaboration with Sierra Wildlife Coalition and acknowledges WATER Institute and partners' research indicating beaver are native to the Sierra Nevada. This engagement is a great example of a successful public-private collaboration. The WATER Institute applauds the persistent and patient efforts of all participants, and appreciates the opportunity to continue to be involved.



New interpretive sign about beaver activity and management in Taylor Creek, South Lake Tahoe.
(Photo: Sherry Guzzi/Sierra Wildlife Coalition)

Another successful example of beaver stewardship has recently occurred in Caltrans District 5. A beaver had dammed a drainage channel, which was beginning to flood the adjacent roadbed of a new county road project in Monterey County. Caltrans' options were to do nothing, depredate the beaver or test the effectiveness of a flow control device.

After hearing a presentation on beaver ecology, history and non-lethal management options by The WATER Institute and Swift Water Design, Caltrans staff decided to submit a proposal to contract Swift Water Design to install the flow control device. Through the hard work of Caltrans Environmental, Landscape, Construction, and Maintenance staff, this proposal was approved and the Department was able to implement an innovative solution to their flooding problem.

The decision to leave this beaver pond intact is significant as it supplies one of the few perennial sources of fresh water to wildlife in this area otherwise dominated by roads, housing and agriculture. Since the beaver arrived, federally listed Threatened California red-legged frog, Western pond turtle, waterfowl and many other species have been observed utilizing this lush habitat. Caltrans' effort to conserve this critical habitat is commendable.³²



Kevin Swift (on right) of Swift Water Design installs flow control device for Caltrans in Monterey County.
(Photo: Kate Lundquist/OAEC)

The Scott River Valley, an area that used to be called "Beaver Valley" by the first European settlers has some of the best remaining Coho salmon habitat in the Klamath River Basin. In an effort to restore and enhance this habitat, in 2014 the Scott Valley Watershed Council designed and installed a series of Beaver Dam Analogues (BDAs) under the guidance of Dr. Michael Pollock from NOAA Fisheries.

BDAs are channel-spanning structures that mimic or reinforce natural beaver dams. Made with willow branches woven between posts driven into the streambed, these structures are similar to beaver dams in that they are semi-porous to water, sediment and fish and ultimately biodegrade. These structures aid in slowing the flow, catching much of the sediment and repairing incision. This method provides a low cost way of improving water clarity, rehydrating the landscape and providing much-needed habitat for fish.

This case study is critical for many reasons. While used and proven effective in other states,³³ this BDA pilot is the first to be permitted by the Department of Fish and Wildlife in California. This project demonstrates how ranchers, restoration practitioners and State and Federal agencies can work together to achieve their respective goals while leaving enough water for humans and fish.



Betsy Stapleton and Peter Thamer standing near a newly installed beaver dam analogue on the Scott River.
(Photo: Scott River Watershed Council)

BEAVER RESTORATION RESEARCH

In the fall of 2014, WATER Institute and The Nature Conservancy (TNC) co-convened a two-day workshop and field tour in Child's Meadow near Mt. Lassen. The purpose of this workshop was to bring together scientists and conservationists to discuss approaches to biological and hydrological restoration of meadows, validating the use of beaver as a restoration agent and balancing beaver with livestock grazing.



Field visit to Child's Meadow. (Photo: Brock Dolman/OAEC)

The group heard NOAA scientist Dr. Michael Pollock present about his extensive research on stream restoration and beaver, and went out in the field to get his input on the value of Child's Meadow as a site to utilize beaver for meadow restoration. This meadow was selected as a study site in part because it has a recently established active beaver colony and supports the rare Willow Flycatcher and Cascades Frog. It also has some areas that are grazed by cattle, which can have an impact on the beavers' ability to successfully colonize an area.

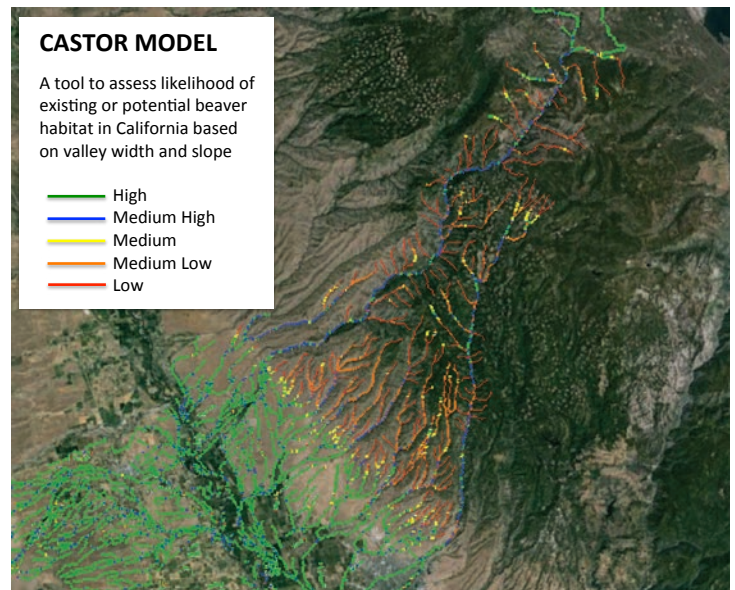
UC Davis Center for Watershed Sciences and TNC submitted a study proposal to the California Department of Fish and Wildlife and was granted an award under the Greenhouse Gas Reduction Project. This project is unique in California and will test whether beaver dams or beaver dam analogues can be used as successful meadow restoration tools to reduce greenhouse gasses and increase biodiversity. The study results could greatly inform the future use of these

tools in mountain meadow restoration across the state and the arid mountain west.³⁴

BEAVER RESTORATION MODELING

Being able to predict where suitable habitat exists can help determine where to focus beaver restoration efforts. There are several models in use across the West. The WATER Institute partnered with NOAA Fisheries and The Nature Conservancy to develop the CASTOR model: the California ASsment Tool Optimizing Restoration. To augment this effort, The WATER Institute is working with The Nature Conservancy, other partners and Utah State University to run the Beaver Restoration Assessment Tool (BRAT) in California. The BRAT predicts where in the watershed beaver could most easily build dams and be least likely to impact human infrastructure.

The purpose of the database is to provide a planning tool for land managers interested in identifying where beaver are likely to build dams. This could be useful for those wishing to work with beaver to recover endangered species, to increase water storage and mitigate climate change effects on streamflow.



In this example from the CASTOR Model, different colors indicate which parts of the waterways are easiest for beaver to colonize (green being the most suitable for beaver and red being the least).

(CASTOR Model image generated by Jacob Pollock)

BEAVER POLICY IN CALIFORNIA

The management of beaver falls under the jurisdiction of the California Department of Fish and Wildlife (CDFW). Unless otherwise noted, the following information was adapted from a presentation given by CDFW Wildlife biologist Shelly Blair. Within the Department itself, the Wildlife branch is responsible for responding to human/beaver conflicts and for providing technical assistance to try to alleviate the conflict. The Fisheries branch is concerned with the aquatic and riparian habitat changes induced by beaver. And, depending on the extent of debris removal and whether heavy equipment is used, the Habitat Conservation Program is involved in determining whether a Streambed Alteration permit is needed for the removal of beaver dams. Currently, the Department does not know how many beaver are living in the state and do not monitor current population numbers or distribution.³⁵

It is legal to trap beaver in 42 of California's 58 counties, in season, with a permit and there is no bag limit. Landowners and tenants can apply for a permit to kill beaver. The Department, upon receiving satisfactory evidence of the damage or destruction,

actual or immediately threatened, shall issue a revocable depredation permit. Permits either specify a maximum number of beavers that can be taken or they allow unlimited take during the effective period of the permit, depending on circumstances of damage as determined by the consulting CDFW biologist. Regulations do not require people to report the number of beavers taken under the permit.

Despite the numerous ecosystem services beaver provide to our watersheds, currently there are no CDFW codes that promote beaver stewardship and/or restoration. Most rodents including beaver have been designated as "detrimental species" because the Fish and Game Commission (FGC) and the CA Department of Food and Agriculture have determined that their importation, transportation or possession could pose a threat to native wildlife, the agriculture interests of the state or to public health and safety. For this reason under FGC section 2150, special permits cannot be issued for the possession, import or transport of beavers. These policies currently limit the relocation of live beaver by those other than the Department.



CA Beaver Working Group members meet at the Occidental Arts & Ecology Center in 2012.

WHAT YOU CAN DO TO CREATE A CULTURE OF BEAVER STEWARDSHIP

There are many ways to support beaver stewardship in California. The WATER Institute has found that the most effective strategies are 1) Education and Outreach 2) Beaver Restoration Demonstration and 3) Policy Change. Through the Bring Back the Beaver Campaign, in collaboration with the efforts of many other partners, the WATER Institute has seen the beaver tide in California begin to turn. People are becoming more aware of beaver in the state and are interested in their stewardship.

OPPORTUNITIES FOR EDUCATION AND OUTREACH

There seems to be what Brock Dolman calls a “beaver blind spot” in California. People are not aware of beavers’ presence let alone the benefits they can provide. This lack of awareness often leads to mismanagement, to the detriment of sensitive species recovery and water supply security for humans and wildlife. There is a great need to share this information, especially with those communities living with beaver, the agencies that work in these areas and the decision makers who dictate how these beaver are managed.



Since they are a keystone species, educators can use the subject of beaver to talk about the interrelatedness of ecology, biology, physical processes and how human land uses affect these systems.

The work of restoration practitioners, resource managers and researchers could all potentially benefit from the presence of beaver dams. Their installations, monitoring and research could be informed by existing peer reviewed beaver studies and beaver restoration installations. Considering the potential benefits to water and wildlife resources and climate change resiliency, California cannot afford to overlook the role beaver stewardship could play in helping us manage these resources.

WHAT YOU CAN DO:

- Educate yourself further about beaver
- Host a talk about beavers in your community
- Share this publication and other resources listed in the Resources section
- Let people know that beaver advocates are available to offer advice, site visits and provide resources to implement non-lethal strategies
- Convene meetings for stakeholders to express their concerns and explore options for beaver co-existence
- Talk to decision makers and resource agencies about how to co-exist with beaver
- Start a beaver festival to celebrate the importance of this keystone species

WATER Institute tabling at the Martinez Beaver Festival.
(Photo: Brock Dolman/OAEC)

OPPORTUNITIES FOR BEAVER RESTORATION DEMONSTRATION

Lacking confidence in existing California-specific evidence, policy makers and scientists have been slow to adopt beaver restoration practices (preservation of existing beaver or reintroduction of beaver from elsewhere). Therefore, additional beaver studies need to be conducted in California to further determine to what degree impacts and benefits differ between our ecosystems and those outside of the state.

The WATER Institute is working with the scientific community to support the study and monitoring of beavers' impact on California's ecosystems and is partnering with landowners and agencies to implement pilot beaver restoration projects in carefully selected eco-regions across the state.

Beyond the stewardship of existing beaver populations, California tribes may have an opportunity to initiate their own beaver relocation programs on their sovereign lands. The WATER Institute has been learning from tribal relocation programs in other states and is interested in supporting similar efforts in California.

WHAT YOU CAN DO:

- Help us understand where beaver occur in the state by learning to identify signs and contributing beaver sighting data to the Beaver Mapper and iNaturalist ³⁶
- Create your own citizen-science effort to monitor beaver in your watershed
- Contact your local watershed councils, conservation organizations, universities, tribes and agencies to determine if they are conducting beaver monitoring or research and if not, why?
- Support research, implementation and monitoring of beaver restoration
- Identify information gaps and dedicate resources to fill those gaps

Salmonid-bearing watersheds, Cascade/Sierra mountain meadows and riparian grazed lands are all regions whose land use and conservation priorities could greatly benefit from beaver presence. The WATER

Institute has strategically selected these areas as a focus of their beaver restoration efforts. Each of these eco-regions has been identified by state and federal agencies as being critical to the state's biodiversity and listed species recovery and is receiving priority funding for restoration. Harnessing this momentum, The WATER Institute is initiating pilot beaver studies and restoration projects in these areas.

These innovative pilots are essential to legitimizing the process, to vetting the potential obstacles and opportunities and to identifying what is needed to support our regulators in adopting beaver restoration as a best management practice. You too can work on the following:

WHAT YOU CAN DO:

- Identify what eco-regions in your area could benefit from beaver restoration
- Reach out to those whose land management and/or conservation goals could benefit from the presence of beaver (ranchers, fishing enthusiasts, land trusts, watershed councils, etc.)
- Conduct a beaver restoration feasibility assessment to determine if beaver restoration would be appropriate in your watershed
- Use the Beaver Restoration Guidebook to implement restoration practices in your watershed ³⁷



Coho salmon (*Oncorhynchus kisutch*) in Lagunitas Creek are one of the many endangered species who benefit from beaver dams. (Photo: Brock Dolman/OAEC)

OPPORTUNITIES FOR BEAVER POLICY CHANGE

It is far too common to focus on the potential risks beaver present rather than taking into account the potential benefits. Good stewardship looks at the entire picture and weighs both sides before making management decisions. By investing time to identify potential benefits, it may become clear that non-lethal management is well worth the investment.

In California, hundreds of beaver are killed every year due to lack of awareness of these benefits, absence of technical and financial support to implement non-lethal solutions and lack of policy to ensure comprehensive stewardship.

We need to create a more integrated management decision-making hierarchy that looks at the cultural, biological and physical impacts/benefits beaver have on a system. Where beaver damage can easily be mitigated, the benefits of beaver can far outweigh the perceived damage. Listing beaver as a “detrimental species” does not adequately acknowledge the benefits this keystone species can provide and can color the way people perceive and manage them.

While there are cases where depredation is an expedient, albeit temporary response, we recommend a much more rigorous assessment of what beaver are contributing to water supply and habitat in that particular location. By mandating this kind of assessment before depredating beaver or removing their dams, we could help avoid jeopardizing water supply and damaging critical habitat for listed species and other wildlife.

To implement beaver restoration we need policy, code and permitting pathways that support efficient and affordable enhancement of existing beaver populations and where appropriate, the ability to reintroduce them from other watersheds. This is going to require either special permitting or policy change within CDFW. To support the Department in adopting new management policies one must work with the CA Fish and Game Commission or through the state legislature to change codes.

WHAT YOU CAN DO:

- If you are working to preserve wetland habitat, water supply and listed species that currently are benefitting from beaver dam presence, call your regional CDFW biologist to:
 - Discuss whether or not recreational trapping is allowed and whether or not a ban can be placed on that watershed to protect the water supply and/or listed species
 - Learn more about their depredation protocols (how well do they resource landowners with information on non-lethal solutions and ensure they implement them)
 - Offer information on non-lethal solutions
- Contact CDFW to discuss how citizens, conservation organizations and other agencies can support the Department in stewarding beaver for their benefits
- To help keep track of beaver populations in the state, contact CDFW to insist that the Department track and report to the public the total number and watershed of beaver depredated as they do number of beaver hunted recreationally
- To ensure the protection of listed species, contact CDFW to insist that beaver dam removal, beaver hunting and depredation be carefully regulated in areas where listed species are present to prevent the incidental take of those species
- Work with staff from other agencies to develop their own internal beaver stewardship plans (Flood Control, US Forest Service, Caltrans, etc.)
- Look to other states’ beaver management/ stewardship approaches to inform change in California³⁸

There are many ways to steward beaver while meeting our land management goals. The WATER Institute hopes this publication give readers the resources needed to inspire landowners and policy makers to implement these innovative techniques. While beaver will not solve all of our water and habitat woes, with proper stewardship, their presence can go a long way towards improving conditions in a cost-effective way.

RESOURCES

BEAVER ADVOCATES AND ORGANIZATIONS

- **The Beaver Institute**, Mike Callahan (MA, USA) - www.beaverinstitute.org
- **The Beaver Mapper**, Eli Asarian (CA, OR) – www.riverbendsci.com/projects/beavers
- **Beavers Northwest**, Ben Dittbrenner (WA) – <http://www.beaversnw.org/home.html>
- **Beavers, Wetlands and Wildlife**, Sharon Brown (NY) – www.beaversww.org
- **The Grand Canyon Trust**, Mary O’Brien (UT) – <http://www.grandcanyontrust.org/utah-forests>
- **The Lands Council Beaver Solution**, Joe Cannon (WA) – www.landscouncil.org/what-we-do/beaver-solution/
- **Mid Klamath Watershed Council**, Will Harling (CA) – <http://www.mkwc.org/programs/wildlife/beavers/>
- **Occidental Arts and Ecology Center WATER Institute**, Kate Lundquist & Brock Dolman (CA) www.oaec.org/beaver
- **Scott River Watershed Council**, Charnna Gilmore (CA) <http://www.scottriverwatershedcouncil.com/#!/projects/c1vvv>
- **The Seventh Generation Institute**, Cathryn Wild (NM) – www.seventh-generation.org
- **Sierra Wildlife Coalition**, Sherry Guzzi (CA, NV) – www.sierrawildlife.org
- **Southland Beaver Blog**, Duane Nash (CA) – <http://southlandbeaver.blogspot.com/>
- **Wild Earth Guardians**, Bryan Bird (NM) – www.wildearthguardians.org
- **Worth A Dam**, Heidi Perryman (CA) – www.martinezbeavers.org

BEAVER RESTORATION AND NON-LETHAL MANAGEMENT GUIDES

- **The Beaver Restoration Assessment Tool (BRAT)** - <http://brat.joewheaton.org/>
- **Beaver - Our Watershed Partner** by Lorne Fitch, Cows and Fish, 2016. <http://cowsandfish.org/publications/documents/BeaverOurWatershedPartnerWEB.pdf>
- **The Beaver Restoration Guidebook: A Practitioner’s Guide to Working with Beaver to Restore Streams, Wetlands and Floodplains** by Gregory Lewallen, Chris Jordan, Kent Woodruff, Michael Pollock and Janine Castro, 2015. <http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp>
- **Beaver Restoration Toolbox: A Collection of Insights, Resources and Expert Contacts to Guide Riparian Restoration Projects that Capitalize on the Engineering Capacity of the North American Beaver** by Karl Malcolm, 2013. <http://oaec.org/wp-content/uploads/2014/10/USFS-Beaver-Restoration-Guide.pdf>
- **Landowners’ Guide to Nonlethal Beaver Solutions: How to Help Beavers and Benefit From Them At The Same Time** by Animal Protection of New Mexico, 2012. www.apnm.org/campaigns/beavers/BeaverLandOwnersGuide.pdf
- **Report on the Efficacy and Comparative Costs of Using Flow Devices to Resolve Conflicts with North American Beavers along Roadways in the Coastal Plain of Virginia**, submitted by Stephanie L. Boyles, Christopher Newport University, 2006. www.beaversww.org/assets/PDFs/BoylesReport2006-1.pdf
- **Working with Beaver for Better Habitat Naturally** by Sherri Tippie, Wildlife 2000, 2010. <http://digitalcommons.unl.edu/icwdmother/63/>

- **Working with Beaver to Restore Salmon Habitat in the Bridge Creek Intensively Monitored watershed: Design Rationale and Hypotheses** by Pollock, M. M., J. M. Wheaton, N. Bouwes, C. Volk, N. Weber, and C. E. Jordan, 2012. NOAA Technical Memorandum, NMFS–NWFSC–120.
<http://www.nwfsc.noaa.gov/research/divisions/fe/documents/NMFS-NWFSC-120.pdf>

NON-LETHAL BEAVER MANAGEMENT DEVICE INSTALLERS

- Kevin Swift, Swift Water Design (CA) - www.swiftwaterdesign.com
- Jacob Shokey, Beaver State Wildlife Solutions (OR) – <http://www.beaverstatewildlifesolutions.com/>
- Mike Callahan, Beaver Solutions (MA) - www.beaversolutions.com/
- Skip Lisle, Beaver Deceivers, International (VT) - www.beaverdeceivers.com/

BEAVER RELOCATION PRACTITIONERS AND PROGRAMS IN THE WEST

- The Beaver Advocacy Committee of the South Umpqua Rural Community Partnership, Leonard and Lois Houston (OR) – <http://surcp.org/committee-bac/>
- The Lands Council Beaver Solution, Joe Cannon (WA) - www.landscouncil.org/what-we-do/beaver-solution/
- The Methow Beaver Project, Kent Woodruff (WA) – www.methowsalmon.org/beaverproject.html
- The Sky Beaver Project (WA) - <http://www.beaversnw.org/conservation.html>
- Wildlife 2000, Sherri Tippie (CO) – (303) 935-4995
- Yakima Beaver Project, Melissa Babik (WA)
<http://midcolumbiafisheries.org/restoration/beaver-restoration/>

BEAVER ECOLOGY, BENEFITS TO COMMUNITIES, SALMON, BIRDS AND CLIMATE CHANGE

- **The Beaver, Its Life and Impact (second edition)**, by Dietland Müller-Schwarze, 2011.
<http://www.cornellpress.cornell.edu/book/?GCOI=80140100591290>
- **The Beaver Manifesto** by Glynnis Hood, 2011.
http://www.rmbooks.com/book_details.php?isbn_upc=9781926855585
- **The Economic Value of Beaver Ecosystem Services, Escalante River Basin, Utah** by ECONorthwest, 2011.
<http://www.econw.com/our-work/publications/the-economic-value-of-beaver-ecosystem-services-escalante-river-basin-utah>
- **Hydrologic and Geomorphic Effect of Beaver Dams and Their Influence on Fishes** by Michael M. Pollock, Morgan Heim and Danielle Werner (American Fisheries Society Symposium 37, 2003).
https://www.researchgate.net/publication/231218389_Hydrologic_and_Geomorphic_Effects_of_Beaver_Dams_and_Their_Influence_on_Influence_on_Fishes
- **The Importance of Beaver Ponds to Coho Salmon Production in the Stillaguamish River Basin, Washington, USA** by Michael Pollock, George R. Pess, Timothy J. Beechie and David R. Montgomery (North American Journal of Fisheries Management, 2004). <http://www.tandfonline.com/doi/abs/10.1577/M03-156.1>

BEAVER ECOLOGY, BENEFITS TO COMMUNITIES, SALMON, BIRDS AND CLIMATE CHANGE (continued)

- **Beaver and Birds Website** - www.ecology.info/beaver-birds.htm
- **Beaver and Climate Change Adaptation in North America: A Simple, Cost-Effective Strategy for the National Forest System** by WildEarth Guardians, Grand Canyon Trust and Beaver Solutions, 2011. http://www.wildearthguardians.org/site/DocServer/Beaver_and_Climate_Change_Final.pdf?docID=3482
- **Beaver as a Climate Change Adaptation Tool: Concepts and Priority Sites in New Mexico** by Cathryn Wild, Seventh Generation Institute, 2011. www.oaec.org/wp-content/uploads/2015/03/Beaver-As-a-Climate-Change-Adaptation-Tool---Concepts-and-Priority-Sites-in-New-Mexico.pdf

HISTORIC RANGE OF BEAVER IN CALIFORNIA

- **Novel Physical Evidence that Beaver Historically were Native to the Sierra Nevada** by James, C. D. and R. B. Lanman (California Fish and Game 98:129-132, 2012) <http://oaec.org/publications/evidence-beaver-native-to-sierra/>
- **The Historical Range of Beaver in the Sierra Nevada: a Review of the Evidence** by Lanman, R. B., H. Perryman, B. Dolman and C. D. James (California Fish and Game 98:65-80, 2012) <http://oaec.org/publications/the-historic-range-of-beaver-in-the-sierra-nevada-a-review-of-the-evidence/>
- **The Historical Range of Beaver (*Castor canadensis*) in Coastal California: an Updated Review of the Evidence** by Lanman, C. W., K. Lundquist, H. Perryman, J. E. Asarian, B. Dolman, R. B. Lanman, and M. M. Pollock (California Fish and Game 99:193-221, 2013) <http://oaec.org/publications/historical-range-of-beaver-update/>
- **The Historic Range of Beaver in the North Coast of California: a Review of the Evidence** by K. Lundquist, B. Dolman, R. B. Lanman, M. M. Pollock, J. R. Baldwin, 2013. <http://oaec.org/publications/historic-range-of-beaver/>



Beaver Dam in Child's Meadow near Mt. Lassen keeps water on the landscape longer. (Photo: Brock Dolman/OAEC)

ENDNOTES

- ¹ <http://oaec.org/our-work/projects-and-partnerships/water-institute/about-the-water-institute/>
- ² <http://oaec.org/our-work/projects-and-partnerships/water-institute/conservation-hydrology/>
- ³ <http://oaec.org/our-work/projects-and-partnerships/water-institute/conservation-hydrology/>
- ⁴ Tappe, Donald A., 1942. The Status of Beavers in California, Game Bulletin 3:1-59, State of California Department of Natural Resources Division of Fish and Game.
<http://oaec.org/wp-content/uploads/2016/06/The-Status-Of-Beavers-in-CA.pdf>
- ⁵ James, Charles and Lanman, Richard, 2012. Novel Physical Evidence that Beaver Historically were Native to the Sierra Nevada, California Fish and Game 98(2):129-132.
<http://oaec.org/publications/evidence-beaver-native-to-sierra/>
- ⁶ Lee, Georgia; & Horne, Stephen, 1978. The Painted Rock Site (SBa-502 and SBa-526): Sapaksi, The House of the Sun. Journal of California Anthropology, The, 5(2). Retrieved from: <http://escholarship.org/uc/item/1qd28483>
- ⁷ Lanman et al. 2012 (<https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=67444>) and Lanman et al. 2013 (<https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=78258&inline=1>)
- ⁸ <http://blogs.scientificamerican.com/thoughtful-animal/once-upon-a-time-the-catholic-church-decided-that-beavers-were-fish/>
- ⁹ Licensed under Public Domain via Wikimedia Commons
https://commons.wikimedia.org/wiki/File:Chapeaux_en_peau_de_castor.jpg
- ¹⁰ Naiman, R. J., C. A. Johnston, and J. C. Kelley, 1988. Alteration of North American Streams by Beaver BioScience 38(11):753-762 <http://bioscience.oxfordjournals.org/content/38/11/753>
- ¹¹ Vallejo, Mariano, Glenn Farris and Rose Marie Beebe, 2000. Report of a Visit to Ft. Ross and Bodega Bay in April 1833, California Mission Studies Association Occasional Paper #4. <http://www.fortross.org/lib/46/report-of-a-visit-to-fort-ross-and-bodega-bay-in-april-1833-by-mariano-g-vallejo.pdf>
- ¹² United States District Court, C.N.D. circa 1840
- ¹³ https://en.wikipedia.org/wiki/California_Fur_Rush
- ¹⁴ Tappe, 1942 (see note 4)
- ¹⁵ Tappe, 1942 (see note 4)
- ¹⁶ Lundquist et al. 2013. The Historic Range of Beaver in the North Coast of California: a Review of the Evidence <http://oaec.org/publications/historic-range-of-beaver/>
- ¹⁷ Pollock, M. M., T. J. Beechie, and C. E. Jordan. 2007. Geomorphic Changes Upstream of Beaver dams in Bridge Creek, an Incised Stream Channel in the interior Columbia River Basin, Eastern Oregon.
http://www.nptwaterresources.org/wp-content/uploads/2014/01/Pollock_et_al_2007_ESPL.pdf. Earth Surface Processes and Landforms 32:1174–1185.
- ¹⁸ Hood, G.A., Bayley, S.E., 2008. Beaver (*Castor canadensis*) Mitigate the Effects of on the Area of Open Water Climate in Boreal Wetlands in Western Canada, Biological Conservation 141:556-567
<http://www.sciencedirect.com/science/article/pii/S0006320707004557>
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BECOME BEAVER AWARE

Beaver are often nocturnal and can be difficult to observe in the daytime. Learn to recognize and age the following signs to determine if beaver are currently present on the landscape:



Beaver dams – see pp. 1, 9, 10, 11, 16, 18, 26 for more examples. (Brock Dolman/OAEC)



Bank lodge on a river. (Michael van Hatten/CDFW)



Bank lodge on a lake. (Kate Lundquist/OAEC)



Bank burrow with channel leading to entrance. (Kate Lundquist/OAEC)



Bank burrow entrance. (Brock Dolman/OAEC)



Beaver-dug channel provides safe access to forage and a means to drag food back to lodge. (Kate Lundquist/OAEC)



Beaver slides in and out of water. (Kate Lundquist/OAEC)

MORE BEAVER SIGN



Beaver trail. (Brock Dolman/OAEC)



Beaver track front foot.
(Mary O'Brien/Grand Canyon Trust)



Beaver track rear foot.
(Mary O'Brien/Grand Canyon Trust)



Felled trees (Aspen) with tooth marks and wood shavings. (Photo: Brock Dolman / OAEC)



Chewed sapling. (Brock Dolman/OAEC)



Chewed sapling. (Kate Lundquist/OAEC)



Beaver building scent mound.
(Sherry Guzzi/Sierra Wildlife Coalition)



Beaver scat.
(Jim Coleman/OAEC)



Scat on pond bottom. (Kate Lundquist/OAEC)



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