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
# Table of Contents

Introducing “The Beaver Toolbox” ........................................................................................................... 3

Goal: Enhanced Aquatic / Riparian Habitat Condition and Resilience ....................................................... 4

Anticipatory Habitat Improvement ............................................................................................................... 4

  Grazing ...................................................................................................................................................... 4

  Minimizing Human Disturbance ............................................................................................................... 5

  Fencing and Planting New Vegetation ...................................................................................................... 5

Considerations for Beaver Restoration in Designated Wilderness ............................................................... 6

  Wilderness management resources - Wilderness.net .............................................................................. 6

  Minimum Requirements Analysis Webinars ............................................................................................. 8

  Basic Considerations for Wildlife Management in Wilderness ................................................................. 8

Considerations for Beaver Restoration in Urban Landscapes ..................................................................... 8

Evaluating Tolerance and Coping with Human-Beaver Conflict ................................................................ 9

Evaluating Current Presence / Absence of Beaver ...................................................................................... 12

Evaluating Habitat Suitability for Beaver .................................................................................................. 13

Fisheries ...................................................................................................................................................... 23

  Benefits of beaver activity to fisheries ................................................................................................... 26

  Case Study: Bridge Creek, Oregon .......................................................................................................... 26

  Costs of beaver activity to fisheries ........................................................................................................ 26

  More on Impedance of Fish Movement by Beaver Dams .................................................................... 27

Historical Distribution of Beaver ................................................................................................................. 28

Hydrology .................................................................................................................................................... 30

Live Trapping Beaver for Translocation ..................................................................................................... 33

Miscellaneous Considerations for Beaver Reintroduction Projects ........................................................... 37

National Environmental Policy Act (NEPA) and Beaver Restoration .......................................................... 39

Range / Grazing / Beaver-Livestock / Wild Ungulate Interactions ............................................................... 41

Ecosystem Resilience to Climate Change .................................................................................................... 43

Riparian Habitat Condition .......................................................................................................................... 52

  Benefits to Riparian Wildlife ................................................................................................................... 53

Sources of Beaver for Reintroduction Projects ............................................................................................ 56

Success Stories and Points of Contact ....................................................................................................... 57

Transmission of Whirling Disease / Non-Native / Invasive Species ............................................................ 67

Trapping and Potential Impacts on Stream and Riparian Ecosystems .......................................................... 68

Bibliography Sorted by Topic Area .............................................................................................................. 70
The topic map above illustrates relationships among all included content pages. Each topic area is linked through the Table of Contents to respective content within this document version of the guide. Orange boxes correspond to categories of related topics (no content) while blue boxes represent actual content pages.
Introducing “The Beaver Toolbox”

Welcome to the Beaver Toolbox – a web-based guide to assist in the development and implementation of aquatic, water storage / hydrologic function, and riparian habitat restoration projects by promoting robust populations of dam-building beaver.

This guide was developed in response to the growing body of science that increasingly underscores the extensive benefits that beavers yield to the ecosystems they occupy and alter. Technical expertise related to beaver restoration is scattered throughout the United States Forest Service, its partner organizations, universities, and members of the general public. This guide aims to provide an easy-to-use clearinghouse of relevant information that captures and disseminates the collective knowledge of those with firsthand experience in restoring beaver populations and associated wetlands. The ultimate goal of this guide is to help Forest Service staff and our partners implement successful projects that get more beavers and water on the landscapes we manage. This work is of particular value in regions where water is limited and the climate is warming and drying.

While the potential benefits of restoring beaver populations are numerous, so too are the pitfalls and logistical hurdles that must be considered and overcome. Field biologists with years of experience working with and studying beavers are quick to acknowledge that the success of any given restoration effort is not guaranteed and many important lessons remain to be learned. By reviewing the topic areas covered in this guide, resource managers can approach beaver restoration projects from a more informed perspective, and thoughtfully evaluate and augment their chances of success by setting realistic expectations in terms of time required, identifying factors that could prevent successes, and identifying potential conflicts such that adaptive management is employed from the outset.

Another service available through this site is the ability to connect directly with subject matter experts who can provide additional consultation beyond the scope of the guide. See the Expert Contacts section for details.

Note that many of the images and documents included and referenced in this guide are hyperlinked to related sites and full documents. Click on those images while holding down the ctrl button to reach linked resources.

We seek to continue improving the utility of this guide and value your input in doing so. Please contact Karl Malcolm with any feedback, recommended additions, or other suggestions.
Goal: Enhanced Aquatic / Riparian Habitat Condition and Resilience

The relationship between humans and beaver has and continues to vary greatly in time and space. Depending on the date and location of interest, the predominate attitudes of people towards beaver range from viewing them as a prized source of fur (and, in some cases, food) to seeing the species as a relentless nuisance, to understanding and appreciating the contributions to water-rich landscapes. Regardless of prevailing opinion, the capacity of beaver to modify habitat has remained inarguable; putting them on a short list of species (along with humans) recognized as “ecosystem engineers”.

In recent decades, the capacity of beaver to change their environments for the better has led many to view the species in a new light. A growing body of research indicates that the habitat modifications induced by beaver create a boon for a broad spectrum of fish and wildlife beyond the beavers themselves. Furthermore, the list of beneficiaries clearly includes people and our domestic stock in some settings. The crucial role of the beaver as an ecosystem engineer is particularly apparent in landscapes where water is a limiting factor and climates are becoming more arid and warm. Previously occupied patches of suitable beaver habitat in these settings are optimal places to consider beaver restoration projects.

Anticipatory Habitat Improvement

The habitat requirements to support beaver are fairly intuitive and basic, including adequate water flows, vegetation for food and building, a modest gradient (or lack thereof), less porous soils, and protection from various threats (trapping, overgrazing, major flooding, depredation, etc.).

There are management actions that can be taken to improve habitat quality, thereby promoting occupation by beaver. These measures can encourage incoming dispersal and can help support current or future reintroductions.

Grazing

Proper management of grazing is particularly
important in riparian areas, where the availability of vegetation, for building, cover, and food, is essential to beaver survival. Riparian rehabilitation and protection can be accomplished by resting some or all of the cattle allotment(s) that include streamside habitats or altering the season of use and the length of time spent in the pasture and/or adding riders to keep cattle moving through pastures. Cessation of grazing should be considered leading up to and during the acclimation of new beaver to an otherwise grazed area. Livestock and wild grazers can be physically excluded from riparian areas with recovering beaver populations by constructing simple exclosures.

**Minimizing Human Disturbance**
Managers should consider implementing road closures, trapping closures, and selecting release and restoration sites that are relatively inaccessible, when possible. By minimizing disturbance following the release of relocated beaver, managers can reduce the likelihood of beaver deserting release sites.

**Fencing and Planting New Vegetation**
Protecting and expanding the availability of vegetation in anticipation of new beaver colonization or release can improve chances for long-term success. Aspen and willow are excellent sources of food and building materials for beaver. The photos shown in this section were taken during a habitat improvement project implemented by WildEarth Guardians in northern New Mexico (Valles Caldera National Preserve). Note the general lack of riparian vegetation other than that being provided. More details on that particular project are available here:

[http://www.flickr.com/photos/wildearth_guardians/sets/72157628078011530/]
Considerations for Beaver Restoration in Designated Wilderness

Management activities that have the potential to compromise any aspect of the wilderness character of lands congressionally designated as part of the Wilderness Preservation System are subject to the Minimum Requirements Analysis (MRA) process. Minimum Requirements Analysis is typically addressed through the completion and approval (by various levels of line officers, depending on the proposed actions) of a Minimum Requirements Decision Guide (MRDG). By completing the steps in a MRDG, managers and decision-makers document that they have carefully considered potential impacts to specific characteristics that the federal land management agencies are mandated to maintain in these specially designated lands. Goals of wilderness designation include maintaining lands that are untrammeled, undeveloped, and natural, provide outstanding opportunities for solitude or a primitive and unconfined type of recreation, and / or contain significant cultural resources.

Wilderness management resources - Wilderness.net

A useful website was developed to serve public and government needs related to the preservation, management, understanding, and appreciation of wilderness. Some basic training can be obtained, at no cost, through the web-based resources on this site:

www.wilderness.net

In addition to training opportunities, Wilderness.net provides resources that can provide guidance for managers working on a beaver restoration project that may include reintroduction in wilderness areas. Some of the most valuable tools are completed
MRDGs that have addressed similar projects. For example, there is a completed MRDG dealing with restoration of a native fish species in wilderness. That document can be found [here](#), while other example MRDGs can be found [here](#).

Another useful example of documentation supporting native wildlife restoration in wilderness stems from efforts to restore **Mexican wolves in the Gila Wilderness** of New Mexico. The Mexican wolf Blue Range reintroduction project documentation (including a discussion of MRDG procedures) is linked [here](#):

**Arizona Game and Fish Department. 2005. Mexican wolf Blue Range reintroduction project adaptive management oversight committee, standard operating procedure. 44 pp.**
Minimum Requirements Analysis Webinars
The following webinar recordings are from the 2013 offering of MRA Live, an instructor-led online training course consisting of four webinars, weekly online discussions and an evaluation exercise.

These relevant trainings available on Wilderness.net:

Minimum Requirements Analysis and the Wilderness Act
The Minimum Requirements Analysis Process
Common Minimum Requirements Analysis Problems

One or more of these courses should be completed before managers attempt to complete the MRDG analysis for beaver restoration in wilderness.

Basic Considerations for Wildlife Management in Wilderness
Generally speaking, efforts to actively manage fish and wildlife are discouraged within designated wilderness. However, because beaver were historically an important part of many healthy, functioning wilderness ecosystems (prior to their extirpation), restoration of beaver can be highly desirable and justifiable in some wilderness settings.

Working in wilderness presents a unique set of challenges however, stemming from a prohibition of motorized transport, discouragement from any habitat modifications (including, for example, construction of livestock exclosures), etc. Through the MRDG process the specific management action(s) being considered are thoughtfully scrutinized. Managers are required to consider less disruptive actions (e.g., transporting beaver for reintroduction via pack stock rather than using any motorized transport) when developing their reintroduction plans. An understanding of these issues is imperative to a thorough, sound, and defensible minimum decisions analysis.

Considerations for Beaver Restoration in Urban Landscapes
When conflicts with people can be averted beavers can stand to make considerable ecological contributions in urban settings. A case study is the urban beaver population in Martinez, California, which has been highlighted for its role in improving habitat for native species of fish, birds, and mammals. The beavers have served as a valuable tool for community environmental education. More about the Martinez beaver project can be found by clicking the logo to the right:
Evaluating Tolerance and Coping with Human-Beaver Conflict

Encouraging work from researchers at Oregon State University (linked right) suggests that many members of the general public are highly supportive of expanding populations of beaver and that tools are available to managers to expand that tolerance further. Despite these encouraging findings and the benefits beaver can provide to the systems they occupy, they are still regarded as pests by many. In some cases negative attitudes towards beaver are rooted in specific, negative personal experience(s). Their potential to cause nuisance problems to people should be considered when sites are being evaluated for beaver restoration or reintroduction.

Some states require that landowners within a radius of multiple miles of a proposed relocation site be consulted prior to a sanctioned release of beaver. Consult with the state wildlife management authority to determine these requirements. Regardless of state mandate, discussing the benefits and nuisance management options while engaging landowners is strongly advised.

Many states, conservation organizations, and interested citizens have invested tremendous time developing a wide array of tools and written guidance to address nuisance beaver problems (examples from Wisconsin and Vermont are linked through the adjacent images). Some nuisance management programs depend heavily on non-lethal management techniques, which allow newly expanding or established beaver populations to remain in place. Familiarity with available and practical management tools could be crucial for obtaining buy-in from people who may be impacted by recovering beaver populations. Knowing that there are non-lethal methods that facilitate coexistence with beaver encourages landowners to view beaver restoration more favorably and discourages reactionary beaver removal.

Note: The installation of any beaver / flow management device on National Forest System lands will require NEPA analysis.
Guidance on the applicability of some non-lethal beaver damage mitigation techniques was contributed to this guide by Joe Cannon, a Plant Ecologist working on beaver restoration projects with the Lands Council. Joe’s suggestions follow:

“The Lands Council is continuing to experiment with ways to restrict beavers from causing tree damage. Fencing around each tree is very reliable, and effective in most instances. The younger trees are more of a challenge, when beavers can easily bend the tree over and remove the caging. So we’ve been experimenting with herbivory deterrents such as neem oil, cayenne, and sand paint- all advised by other sources. Each substance works to some degree, and sometimes with good success. Effectiveness of these applications seems to depend on the season and specific beaver activity. All substances need to be reapplied seasonally as trees expand and as are exposed to weathering.”

The additional resources linked below provide information about tools and management practices that can promote successful coexistence of beaver and humans.
How to Build & Install A Flexpipe

Jake Jacobson
Watershed Steward
Surface Water Management Division
of
Public Works Department

Snohomish County

New York State
State Agencies

DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Nuisance Beaver
Techniques for Controlling Nuisance Beaver

Introduction
The purpose of this manual is to provide information on the most effective techniques available for resolving beaver-human conflicts. It integrates a wide range of topics and issues pertinent to beaver damage control and serves as a valuable reference tool for members of the public who have beaver damage. Information on the history of beaver management in New York State, the natural history and habits of beavers, definitions of beaver damage, liability concerns, permit requirements, importance of good landowner/DEC relations, standard procedures for handling beaver nuisance complaints, and the methods options presently available to resolve beaver damage concerns will be addressed.

Beaver Management In New York
The North American beaver (Castor canadensis) has a long and interesting history of management in New York. Nearly extirpated by the early 1800s, beaver populations made a spectacular recovery during the 1990s. This was made possible through trap and...
Evaluating Current Presence / Absence of Beaver
Accurately determining the presence or absence of beaver in a site being considered for a management action (e.g., beaver reintroduction, habitat manipulation, etc.) is of obvious importance. Familiarity with beaver sign, behavior, and life history will also make efforts to capture beaver more productive. In some areas beaver overlap with other aquatic rodents (e.g., muskrat and nutria), and evidence of these cohabitants has the potential to be confused with that of beaver. Many resources are available that can provide guidance on identifying the signs of beaver and other aquatic rodent activity. A selection is linked here:
Evaluating Habitat Suitability for Beaver
The fact that beaver were historically found over much of the North American continent is a testament to their adaptability and capacity to alter aquatic systems to meet their needs. Despite these traits, a basic understanding of the habitat characteristics that support beaver occupancy is needed to make appropriate management decisions for a given site.

For beaver to induce many of the key habitat changes and benefits discussed in this guide they must not only survive in a given location. They must also succeed in the construction of functional dams. Therefore it is important, from the standpoint of promoting riparian restoration, to evaluate habitat in terms of supporting functional (i.e. dam-building) beaver.

Prior to initiating a riparian restoration project involving beaver translocation, candidate sites should be evaluated thoughtfully based on habitat characteristics discussed in the citations provided below. The same process can allow managers to identify restoration needs that could promote natural colonization by beaver from surrounding populations.

Through these evaluations sites can be categorized as:

- **Suitable for reintroduction of beaver (proceed with project implementation)**

- **Potentially suitable but in need of improvement prior to beaver release**
  - Anticipatory Habitat Restoration

- **Not suitable habitat for beaver (no further action taken)**

Several habitat suitability models have been developed and tested for beaver in different regions of North America. While reviewing all available literature on the subject is informative, managers should pay particular attention to the findings
reported from habitats similar to their management sites and focus specifically on the habitat characteristics that support beaver and their dams. Some of the models listed below were developed for potential application species range-wide (e.g., Allen 1983), however the variation in vegetation, climate, topography, soils, etc. across beaver range underscores the value of region-specific information (e.g., Suzuki and McComb 1998 in the Pacific Northwest). Also, most of the models focus simply on beaver survival and occupancy rather than their needs for dam building. One important exception is the Beaver Restoration Assessment Tool (BRAT), which was created specifically to evaluate habitats based on their capacity to support dam building by beaver. More information is available here:

Although there is some variation in the key parameters identified among beaver habitat and occupancy models, some general and intuitive patterns emerge consistently. The following variables are of the utmost importance in evaluating suitability of aquatic habitat for beaver and have been shown to affect beaver positively or negatively as indicated by the adjacent symbols.

- Availability of hardwood vegetation +
- Availability of aspen (food and building) +
- Consistent and adequate water availability +
- Increasing stream gradient -
- Progressively well-drained soils -
- Trapping pressure -
- Grazing by ungulates -
- Proximity to human conflicts -
- Conservation / management objectives (fish, dam removal) -

A similar list of variables was considered in the Beaver Management Strategy drafted by the Malheur National Forest and the Keystone Project, dated September 2007 (shown below).
Identification of Watersheds and Subwatersheds with Potential for Beaver Recovery

Key habitat components:

- A channel gradient of less than six percent
- Channels with suitable soils/sediment for dam construction
- Water flows stable and sufficient to make a pond
- Deciduous trees, shrubs, sedges for adequate food supply
- Winter conditions which will not freeze ponds
- Sufficient valley floor area to allow for flooding
- Shelter (riparian shrubs) for safety and building materials
- Protection from trapping and recreational killing until colonies are well established

The full Strategy is available here:
The following citations provide an introduction to habitat suitability / occupancy research efforts in North America:


HABITAT FEATURES AFFECTING BEAVER OCCUPANCY ALONG ROADSIDES IN NEW YORK STATE

PAUL D. CURTIS,1 Department of Natural Resources, Fennell Hall, Cornell University, Ithaca, NY 14853, USA
PAUL G. JENSEN,2 New York Cooperative Fish and Wildlife Research Unit, Fennell Hall, Cornell University, Ithaca, NY 14853, USA

Abstract: Characterizing habitat features that influence beaver (Castor canadensis) occupancy along roadides may have important implications for managing damage to roads caused by beaver activity. We initiated this study to develop proactive and long-term approaches to deal with nuisance beaver along roadides. From June to October 1997 and 1998, we sampled 316 roadside sites in New York state. USA—216 sites where beaver occupied the roadside area and 100 unoccupied sites. We used stepwise logistic regression to identify habitat variables associated with beaver occupancy along roadsides. We evaluated regression models through measures of sensitivity and specificity. The logistic function retained the percentage of roadside area devoid of woody vegetation, stream gradient, the interaction between these 2 variables, and stream width in the final model. Precluding beaver occupancy along highways would necessarily involve large-scale removal of woody vegetation that would be impractical in all but the most intensive management scenarios. However, beaver habitat assessment adjacent to roads may be a useful tool for designing new highways, prioritizing culvert replacements, and developing proactive plans for beaver damage management.

KEY WORDS: beaver, Castor canadensis, habitat, highways, logistic regression, New York vegetation, wildlife damage.

When beaver occupy roadside areas, they can seriously damage the highway by plugging culverts or constructing dams nearby that flood the road or cause water to impede against the road base. This can result in the formation of potholes and general destabilization of the road. Beaver damage to roads is a widespread problem for highway departments throughout much of North America. Historically, many highways and smaller roads have allocate between 5 and 25 man-days of effort and $543–4,900 in total repair costs at each beaver- obstructed culvert annually (Purdy and Decker 1985; Eck et al. 1988, 1992). In a recent survey of New York highway departments, half of the respondents reporting beaver damage to their roads indicated that they spent over $1,000 at each problem site in 1999, and nearly 20% of respondents spent over $2,500 at each problem site.

Fisheries
Extensive research has focused on the effects (both positive and negative) on stream fisheries of the aquatic and riparian habitat changes induced by beaver. The purpose of this section is to provide an overview of the benefits and costs associated with beaver restoration, with supporting documentation to be referenced for more detailed reading. Kemp et al. (2012) completed a thorough review of primary literature (which predominately focuses on North America) and a subsequent meta-analysis of this topic, the results of which significantly informed this portion of the guide.

Fish species dealt with specifically (in descending order) in the literature reviewed by Kemp et al. (2012) included:

- Brook trout (*Salvelinus fontinalis*), 22 records
- Coho salmon (*Oncorhynchus kisutch*), 15 records (also see recent coho recovery language included in the recovery plan that pertains to the crucial role of beaver for this species)
- Rainbow trout (*O. mykiss*, including the anadromous steelhead trout, and the golden trout sub-species), 14 records
- Cutthroat trout (*O. clarki*, composed of several sub-species) 14 records
- Atlantic salmon (*Salmo salar*), 13 records
- Brown trout (*Salmo trutta*), 12 records

Species-specific findings and methodologies are presented in Table 4 below.

**Table 4** The impacts of beaver dams on fish and the methods used to assess the impact.

<table>
<thead>
<tr>
<th>Species</th>
<th>Effect of beaver dams</th>
<th>Method of assessment</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlantic salmon</td>
<td>Limit spawning distribution</td>
<td>Electrofishing and seine netting</td>
<td>Mitchell and Kunjik 2007</td>
</tr>
<tr>
<td>Atlantic salmon</td>
<td>Some beaver dams pose serious obstacles to migrating salmon, especially when discharge is low</td>
<td>Redd counts</td>
<td>Taylor et al. 2010</td>
</tr>
<tr>
<td>Atlantic salmon, brook trout</td>
<td>Partial to complete blockage</td>
<td>Anecdotal evidence</td>
<td>Scraton et al. 1998</td>
</tr>
<tr>
<td>Atlantic salmon, brook trout, alewife</td>
<td>Prevent both upstream migrants from reaching spawning grounds also impacts seaward movements for some species</td>
<td>Observed/speculative</td>
<td>Guignion 2009</td>
</tr>
<tr>
<td>Atlantic salmon, sea trout</td>
<td>Obstruct upstream and downstream migration</td>
<td>Quantified amount of habitat behind dams/speculative</td>
<td>Parker and Renning 2007</td>
</tr>
<tr>
<td>Bull trout</td>
<td>Blocked or delayed downstream movements</td>
<td>Radio telemetry</td>
<td>Dupont et al. 2007</td>
</tr>
<tr>
<td>Brook trout</td>
<td>Dam removal leads to range expansion but not abundance increase</td>
<td>Dam removal and electrofishing</td>
<td>Avery 1991</td>
</tr>
<tr>
<td>Brook trout</td>
<td>Fall spawners blocked from reaching spawning grounds</td>
<td>Discursive/observation</td>
<td>Grasse 1951; Doucett et al. 1996</td>
</tr>
<tr>
<td>Brook trout</td>
<td>Dam impede upstream and downstream migration, but not totally impassable</td>
<td>Fish trapping</td>
<td>Rupp 1954</td>
</tr>
<tr>
<td>Brown trout</td>
<td>Block downstream movement</td>
<td>No data</td>
<td>Tambets et al. 2005</td>
</tr>
<tr>
<td>Brown trout, minnow, bullhead, burbot, pike</td>
<td>Barriers to colonization and migration, especially for slow dispersing species</td>
<td>Discursive</td>
<td>Hjggfund and Stjberg 1999</td>
</tr>
<tr>
<td>Coho salmon</td>
<td>Dams (one = 2 m height) did not block migration. Movement facilitated by fall freshets</td>
<td>Fish trapping</td>
<td>Bryant 1984</td>
</tr>
<tr>
<td>Coho salmon, steelhead trout</td>
<td>Impact ability to colonize new areas</td>
<td>Sine netting</td>
<td>Murphy et al. 1989</td>
</tr>
<tr>
<td>Cutthroat trout, rainbow trout</td>
<td>Fish usually pass because of high spring flows</td>
<td>Discursive</td>
<td>Grasse 1951</td>
</tr>
<tr>
<td>Lahontan cutthroat trout</td>
<td>Seasonal blockage of at least upstream movement</td>
<td>Anecdotal and observational</td>
<td>Talabere 2002</td>
</tr>
<tr>
<td>Lake whitefish (Coregonus clupeaformis; Salmonidae), walleye</td>
<td>Reduce access to spawning grounds</td>
<td>Discursive</td>
<td>Bertolo and Magnan 2006</td>
</tr>
<tr>
<td>Northern pike, walleye</td>
<td>Block spawning runs</td>
<td>Speculative</td>
<td>Knudsen 1962</td>
</tr>
<tr>
<td>Oregon chub</td>
<td>Population isolation</td>
<td>Speculative</td>
<td>Scherr et al. 2004</td>
</tr>
<tr>
<td>Roach, sticklebacks, brook lamprey</td>
<td>Total barrier to movement</td>
<td>Methods not stated</td>
<td>Elmeros et al. 2003</td>
</tr>
<tr>
<td>Salish suckers (<em>Catostomus spp., Catostomidae</em>)</td>
<td>Species rarely crossed beaver dams</td>
<td>Radio telemetry</td>
<td>Pearson and Healey 2003</td>
</tr>
<tr>
<td>Sea trout</td>
<td>Partially block spawning run</td>
<td>Methods not stated</td>
<td>Elmeros et al. 2003</td>
</tr>
<tr>
<td>Sockeye salmon</td>
<td>Block access to spawning sites</td>
<td>Observational/speculative</td>
<td>McPhee et al. 2009</td>
</tr>
<tr>
<td>Steelhead trout, rainbow trout</td>
<td>Fish appeared able to cross barriers</td>
<td>Observational</td>
<td>Lowry 1993</td>
</tr>
<tr>
<td>Steelhead trout, rainbow trout</td>
<td>Upper extent of distribution fluctuates with occurrence of dams</td>
<td>Methods not stated</td>
<td>Arndorff et al. 2000</td>
</tr>
<tr>
<td>Trout ssp.</td>
<td>Adults unable to return downstream after spawning</td>
<td>Methods not stated</td>
<td>Rasmussen 1941</td>
</tr>
<tr>
<td>Trout ssp.</td>
<td>Block spawning runs or upstream migration</td>
<td>Discursive/speculative</td>
<td>Bridg 1985; Cook 1949; Knudsen 1992; Grose 1979</td>
</tr>
<tr>
<td>Trout ssp.</td>
<td>Tagged fish did not pass upstream over dams but were able to move downstream to spawning grounds</td>
<td>Tagging</td>
<td>Sayer 1995</td>
</tr>
</tbody>
</table>

Note: A full bibliography including each of these records is provided at the end of this guide.

Overall, the references cited indicate that beaver have a net positive effect on stream fish in most settings (see Table 5 below and refer to bibliography for more information).

The impacts (positive and negative) most commonly cited were:

**Benefits of beaver activity to fisheries**
- Increased fish productivity / abundance
- Increased habitat and habitat heterogeneity (which promotes biodiversity [Smith and Mather, 2013])
- Increased rearing and overwintering habitat
- Enhanced growth rates
- Providing flow refuge
- Improved production of invertebrate

**Case Study: Bridge Creek, Oregon**
Some of the most compelling data regarding the relationship between beaver restoration and improved fish production are beginning to emerge from an ongoing project on Bridge Creek, a tributary to the John Day River in eastern Oregon. Preliminary data from monitoring efforts indicate that human-facilitated beaver restoration is increasing production of a population of Endangered Species Act-listed steelhead (*Oncorhynchus mykiss*). The project and findings were presented in a recorded webinar presented by Dr. Joe Wheaton which, along with related PowerPoint slides can be found here:


(See slides 85-91 for information from Bridge Creek.)

A detailed description of the Bridge Creek Project can also be obtained from the following documents:


**Pollock M, Wheaton JM, Bouwes N and Jordan CE. 2012. Working with Beaver to Restore Salmon Habitat in the Bridge Creek Intensively Monitored Watershed: Design Rationale and Hypotheses. NOAA Technical Memorandum, NOAA Northwest Fisheries Science Center, Seattle, WA, 63 pp.**

**Costs of beaver activity to fisheries**
- Barriers to fish movement
- Siltation of spawning habitat
- Low oxygen levels in beaver ponds
- Altered temperature regime
Note: Over half (51.5%) of the positive impacts cited were based on data, whereas for negative impacts (71.4%) were speculative. The commonly cited negative impact of beaver dams impeding fish movement was supported by data on 21.6% of occasions (Kemp et al., 2012).

More on Impedance of Fish Movement by Beaver Dams
Recent research focused on the passage of beaver dams by stream fishes further illustrates that these concerns may be largely unfounded and that beaver dams might even provide a competitive advantage to native fish species relative to non-natives.

In a 2013 paper accepted by the Transactions of the American Fisheries Society, titled “Do beaver dams impede the movement of trout?” scientists Ryan L. Lokteff ¹, ², Brett B. Roper¹, ², and Joseph M. Wheaton² report that Bonneville cutthroat trout (a native trout species in their study area) pass dams more frequently than both non-native brown trout and brook trout. They determined that timing of spawning affected seasonal changes in dam passage for each species. Physical characteristics of dams such as height and upstream location affected the passage of each species. Movement behaviors of each trout species were also evaluated to help explain dam passage. These data suggest beaver dams are not acting as barriers to movement for cutthroat and brook trout but may be impeding the movements of invasive brown trout.

Author Affiliations:

1. Fish and Aquatic Ecology Unit, US Forest Service, 860 North 1200 East, Logan, Utah, 84321, USA
2. Department of Watershed Sciences, Utah State University, 5210 Old Main Hill, Logan, Utah, 84322, USA

In their paper Lokteff et al. (2013) provide an illustration (below) that depicts the various channels that commonly exist in beaver dams, which facilitate travel of stream fishes around or through these natural obstacles. Side channels (shown in red) often act as particularly effective fish ladders.
Side channels often act as fish ladders that allow movement of stream fishes around otherwise impassable obstacles created by beavers. Recent research has shown that some native species are better able to navigate past beaver dams than their invasive competitors. **Illustration provided by:**


**Historical Distribution of Beaver**

One of the most logical criteria for evaluating potential beaver restoration sites is whether or not a given location was historically occupied by beaver.

Prior to the fur rush of the mid-19th century, beaver could be found throughout the North American continent, from Alaska to Mexico. Even in areas from where beaver have long been extirpated, evidence of their historic activity may still exist.

A combination of field reconnaissance and scouring historical trapping records can help identify the locations where beaver could be found centuries ago. In many cases streams have become incised

Note: The range map shown above has recently been shown to be inaccurate. Nearly the entire contiguous 48 United States were historically occupied by this species.
in the absence of beaver during the subsequent decades or centuries.

An especially compelling case can be made for riparian restoration, including beaver reintroduction, in settings where managers can provide clear evidence of historic occupation by beaver, and demonstrate degradation of stream health following their removal.

In a recent case study, researchers studying a site in California showed, through carbon dating of recently exhumed dam remnants, that beaver were active in the Sierra Nevada, disproving long-held claims that beaver were not extant to that region. The results of their analysis suggest that beaver activity in the area lasted for over a millennium, and ceased in the mid-1800’s coinciding with a concerted trapping effort in the region (James and Lanman, 2012). In the decades since beaver extirpation, stream channels have become incised, possibly as a direct result. Information like this can be a strong foundation upon which managers can build a case for beaver and riparian restoration.
Hydrology

Early accounts from trappers and mountain men traveling the land that today is the western United States often referred to the seemingly endless supplies of beaver in many of the watersheds they encountered. Undoubtedly, the landscapes rich with beaver looked and functioned differently before beaver populations plummeted in the face of unsustainable trapping. One of the
most basic and important changes induced by beavers is that vast quantities of water are stored by beaver dams, which remain available to vegetation, fish, and wildlife.

**Beavers directly impact the hydrology of the watersheds they occupy by:**

- Storing water for more consistent and later season delivery *(Gurnell 1998)*
- Raising ground water levels *(Westbrook et al., 2006)*
- Altering water temperature regimes *(Collen and Gibson, 2001)*
- Introducing complexity and dynamism to streams *(Naiman et al., 1988)*
- Increasing nutrient availability in streams *(Naiman et al., 1986)*
- Improving stream function by reconnecting floodplains *(Rosell et al., 2005)*
- Decreasing sediment delivery to the stream system *(McDowell and Naiman, 1986)*

*Each bullet point above is accompanied by a peer-reviewed source that can be referenced for more detailed information. Single references are far from representing an exhaustive literature review, but are included to serve as a starting point for those seeking further reading.*

**Selected References**

*Collen, P., and Gibson, R.J. (2001) The general ecology and beavers (*Castor spp.*), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish – a review. Reviews in Fish Biology and Fisheries 10, 439-461.*


For further reading, links to a selection of relevant webpages are provided below:

Live Trapping Beaver for Translocation

When an appropriate source of beaver has been identified for removal and translocation, the task of capturing live beaver becomes a potentially challenging reality. Because there are many “tricks of the trade” when it comes to trapping beaver, the assistance of an experienced trapper can accelerate the learning process (see expert advice provided by Sherri Tippie, left). Selecting trap types, deciding on trap location, selecting bait / lure, and understanding safe handling practices (for trapper and beaver alike) are examples of some steps in the process that can benefit from the guidance of an experienced mentor.

A number of live traps are available for the job as are various sources of written technical advice. The Association of Fish and Wildlife Agencies issued a set of Best Management Practices (BMPs) for capturing beaver using both fatal and live trapping techniques. The full
guide is available here:

**Association of Fish and Wildlife Agencies. Best management practices for trapping beaver in the United States, 24 pp.**

Another outstanding resource for related information is the Beaver Best Management Practices Guide produced by the Grand Canyon Trust, provided below:

![Beaver Best Management Practices Guide](image)

One of the most commonly used live traps for capturing beaver is the suitcase style trap (also called the “Hancock” or “Bailey” trap”. Many how-to videos are available online that explain the use of this type of trap. A selection is provided here:

![Beaver Trapping Videos](images)
Another commonly used live trap for capturing beaver is a wire cage type trap. A selection of videos is linked here for more information on their use:

Multiple companies manufacture the various models of live traps appropriate for beaver. Several options for online orders are linked here:

Tomahawk Live Trap

Advanced Trap

http://advancedtrap.com/

Comstock Custom Cage LLC

http://www.comstockcustomcage.com/
Miscellaneous Considerations for Beaver Reintroduction Projects

Seek to Relocate Matched Pairs or Family Groups When Possible

To establish a reproducing population of beaver in an unoccupied site requires, of course, a minimum of one male and one female. Ideally, a live trapping program will lead to the capture of an entire family group. Paired adult beaver that have successfully reared offspring may be more prone to breed successfully again following translocation than two beaver from disparate sources. When family groups cannot be captured and moved together managers should consider acclimating unfamiliar beaver to each other prior to release, and matching them based on opposite sex.

Sex identification of live beaver can be challenging because males and females lack external sex organs. During the Methow Beaver Project, advancements were made in non-invasive and rapid beaver sex identification. The same project report describes outcomes of captive pairing and wild release attempts.

Sex Determination (Reported by Methow Beaver Project)

One of the significant innovations of this project, beyond developing a strong GIS analysis of the beaver habitat, was the ability to rapidly and reliably tell male and female beavers apart. The need to determine gender is obvious, but is confounded by the confusing physical structure of beavers, with two sets of glands, internal reproductive organs, and genital openings that are difficult to discern – especially on live beavers that could inflict serious injury with their teeth.

Our initial effort was to work with the University of Idaho Genetics Laboratory lead by Lisette Waits. We helped the team there develop DNA markers for beaver males and females. We then collected hair from all beavers we captured and sent it to the lab for gender ID. This proved 100% reliable for sexing beavers and resulted in a 2011 publication (Goldberg et al. 2011). Issues were the 10 – 15 day turnaround time and the expense for the lab analysis.

In May 2011, with the generous help of beaver expert Dr. Lixing Sun at Central Washington University, we learned how to determine gender with secretions from the oil glands of beavers captured. His approach involved expressing oil from oil glands while beavers were anesthetized and examining color, odor, and viscosity. We learned that oil from male and female beavers is distinctly different. Issues were the 1-2 hour processing time for each beaver and the expense for anesthesia.
The next improvement involved connecting with the local North Cascades Smokejumper base where we asked for help designing a restraint bag that could eliminate the need for anesthesia. After a few trials, our jumper friend, J.T. Sawyer created a sturdy nylon funnel that fit over the Hancock traps and very effectively allowed us to hold a beaver immobile for our entire intake process, including sex determination, with no injury or trauma to crew members or beavers. Now, three to five minutes was the time required to remove beavers from the trap, sex, tag, and release the beavers into the holding facility. For the rest of the season we compared the crew’s ability for oil gland sex determination with DNA hair analysis. At the end of the season we learned the process was 100% accurate and reliable.

The ability to quickly and reliably determine the sex of captured beavers greatly improved our competence in making grouping choices in the holding facility. This innovation, along with providing a period of group acclimation at the facility, was perhaps the most substantial benefit to increasing the establishment rate for groups released, because we had strong assurance that compatible males and females were included in release groups.

**Be Cognizant of Overheating Captive Beaver**

Beaver are prized for their lush, insulating fur which effectively protects them in nearly frozen water. As a result of their fur they are prone to overheating in warm temperatures, particularly when they lack access to water. These conditions may be encountered during relocation and every effort should be made to ensure that captive beaver do not overheat. One creative technique employed by Dan Tyers during his work in the Greater Yellowstone Area was to pack captive beaver with block ice while traveling via pack stock into backcountry release sites. By keeping beaver on ice during hot weather he avoided any losses to hyperthermia.

**Late Summer and Early Fall are Preferable Release Times**

Movement rates and behavior of beaver change dramatically with season. Beaver released in the early spring are prone to travel great distances from release sites, possibly seeking out their original territories. Conversely, those that are released during the late summer or early fall are more likely to begin making preparations for winter in their new location. By releasing beaver too late in the autumn months (or early winter) they may have inadequate time to prepare for cold weather (lodge building, caching food, etc.) and may suffer or perish as a result.

**Road Closures**

Temporary road closures might be considered if release sites are at risk of being compromised by traffic or disturbance from people with easy access.
For a case study example of proposed actions related to beaver reintroduction see the Beaver Management Strategy drafted by the Malheur National Forest and the Keystone Project, dated September 2007:

The full Malheur / Keystone Strategy is linked here:

![Beaver Management Strategy]

**National Environmental Policy Act (NEPA) and Beaver Restoration**

The United States Forest Service has developed extensive guidance to facilitate appropriate and defensible NEPA analysis and support the decisions made by line officers. Like any other management actions agency personnel might consider, the following example beaver management activities are subject to various levels of NEPA analysis in most circumstances, depending on the location and other considerations (e.g., presence of species of conservation concern):

- Habitat modification
- Construction of exclosures in riparian habitats
- Removal / Translocation / Reintroduction of beaver
When NEPA analysis has already been completed for directly related activities in a given jurisdiction, management actions like live trapping, moving, and managing beaver populations may be exempted from further NEPA review. The U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS) in particular has completed statewide analyses for aquatic mammal management programs in some select states. In those cases, the previous work may be adequate to cover (some or all) current beaver restoration actions. USDA-APHIS posts all NEPA decision documents to the internet, where they are searchable by state. Managers are advised to familiarize themselves with any past NEPA work related to beaver management done by the Forest Service and other federal agencies. A collection of pertinent USDA-APHIS NEPA decisions is provided here:

Maine
Minnesota
Nebraska
South Carolina
Washington

Up-to-date information on state-specific NEPA analyses and decisions completed by USDA-APHIS can be searched here.

**Structures built by beaver not subject to NEPA**

One of the great advantages of riparian restoration through ecosystem engineering by beaver is that the structures created by beaver are not subject to NEPA analysis. When contrasted to the lengthy and demanding process to which any manmade flow-control devices must undergo, natural riparian restoration via beaver construction becomes even more appealing.

Forest Service staff are encouraged to collaborate with their unit-level NEPA specialists on crafting the appropriate level of NEPA documentation to support beaver restoration projects. A good starting point for other Forest Service NEPA guidance is provided here:

http://www.fs.fed.us/emc/nepa/nepa_procedures/
Inadequate water is one of the primary factors limiting the quality of forage for domestic and wild grazers in western rangelands. As droughts become more frequent and intense throughout much of western North America, the ability to increase and retain soil moisture will be a key determinant of the condition of range vegetation. Many farmers and ranchers have historically viewed beavers negatively for their role in flooding agricultural lands. An improved understanding of and appreciation for the capacity of the beaver to increase range health through water retention has prompted some to take an active role in fostering beaver activity on the lands they manage.

This turnabout in opinion has garnered attention in the popular press. For example, the Wall Street Journal ran a story on August 30th, 2011 titled "With Trouble on the Range, Ranchers Wish They Could Leave It to Beavers". The article describes efforts in several western states to promote better range conditions through the reintroduction of live-trapped beaver. In some cases beaver are in such high demand that ranchers are put on a waiting list for their ranches to be considered as release sites.

In grazed rangelands, lacking riparian vegetation and competition with livestock can be key limiting factors for beaver (Ott and Johnson, 2005). Minimizing competition by excluding cattle from sensitive riparian habitats can help promote beaver activity, thereby improving range health on adjacent lands (Baker, 1995; Hosten and Whitridge, 2007).

Managers considering beaver restoration should be familiar with the potential benefits beaver can yield for domestic and wild grazers as well as the sensitivity of beaver to riparian habitat degradation stemming from foraging and trampling by domestic and wild ungulates. Highlighting increased water availability for water-limited grasses can be an effective approach for engaging ranchers who might otherwise oppose beaver restoration programs. Gaining support for excluding livestock from riparian areas might
be facilitated by clarifying the subsequent benefits anticipated for grazing elsewhere in the watershed.

Citations:


For further reading, links to a selection of relevant webpages and popular press articles are provided below:

http://www.americanrivers.org/newsroom/blog/dnylen-2012124-can-beavers-help-us.html
Ecosystem Resilience to Climate Change

Beaver promote dynamic and resilient systems that can better tolerate variation induced by climate change. The current absence of beaver from significant portions of their historical range significantly compromises the resilience of riparian and aquatic ecosystems.


http://globalrangelands.org/dlio/55374
The western and southwestern United States are already experiencing climate change impacts that underscore the increasing value of water retention on arid lands. In the Northwest, the regionally averaged temperature has risen about 1.5 degrees F over the past century (with some areas experiencing increases up to 4 degrees F) and is projected to increase another 3 to 10 degrees F during this century.

**The U.S. Global Change Research Program has identified the effects of these increasing temperatures in the Northwest (USFS Region 6) to include:**

- Declining springtime snowpack leading to reduced summer stream flows, straining agricultural and municipal water supplies;
- Increased insect outbreaks and wildfires, and species composition changes in forests, posing challenges for ecosystems and the forest products industry;
- Salmon and other coldwater species experiencing additional stresses as a result of rising water temperatures and declining summer stream flows; and
- Sea-level rise along vulnerable coastlines, resulting in increased erosion and the loss of land.

Warming trends in the Southwest are considered to be swifter than other regions of the country and may be significantly greater than the global average. The rapid increase in temperatures in this region, particularly during summer, will have drastic effects on hydrology which in turn may result in severe water supply challenges in the near future.

**The U.S. Global Change Research Program has identified the effects of increasing temperatures in the Southwest (USFS Regions 3, 4, 5) to include:**

- Water supplies becoming increasingly scarce, calling for trade-offs among competing uses, and potentially leading to conflict;
- Increasing temperature, drought wildfire, and invasive species, accelerating transformation of the landscape;
- Increased frequency and altered timing of flooding, increasing risks to people, ecosystems, and infrastructure;
- Unique tourism and recreation opportunities likely suffering; and
- Cities and agriculture facing associated risks.

Changes in snowpack and timing of runoff are certain in much of the western U.S. but are especially grave for the southwestern and interior western U.S. river basins. The National Research Council has concluded that runoff in the Rio Grande Basin will decrease by 12% for every one degree of temperature rise, the greatest reduction projected for any stream basin in the U.S. Both the upper and lower Colorado River basin will experience decreases in runoff of more than 6% for every degree in
temperature rise. The Great Basin will experience a decrease in runoff of 5%, California a decrease of 3%, and the Pacific Northwest could see an increase of 1%.

Adapting to these changes will require a herculean effort on the part of modern society, especially in the western U.S., and coordination across large landscapes will be critical. An advantage in the West is the presence of vast, relatively well-connected holdings of federal lands that can buffer and mitigate the impacts of climate change. The Secretaries of Interior and Agriculture have acknowledged these unique opportunities and directed their respective departments to address climate change.

Adaptation to the effects of climate change is an objective that fits with the missions of the U.S. Forest Service. The federal forest lands were originally reserved at the end of the 19th century to protect watersheds and secure favorable flows of water. Approximately one out of five Americans depends on a national forest for drinking water. In an area of climate change, forests and grasslands will play an increasingly vital role in protecting the Nation’s watersheds. Successful response to climate change will entail sound stewardship of America’s watersheds.

Through the hydrological and ecological effects of ecosystem engineering (i.e., dam-building), functional beaver populations rapidly and significantly contribute to climate change adaptation.

**Beavers significantly contribute to climate change adaptation by:**

- Storing Carbon ([Wohl, 2013](#))
- Slowing snowmelt runoff, which
  - Extends summertime stream flow
  - Restores perennial flow to some streams
- Creating beaver ponds, which
  - Create and maintain wetlands
  - Provide critically needed habitat for amphibians
  - Increase habitat for small mammals and birds
  - Foster the establishment of deep-rooted sedges, rushes, hydric grasses, and woody riparian vegetation
  - Create mesic meadows
- Increasing groundwater upstream and downstream of dams, which
  - Sub-irrigates adjacent habitats
  - Allows water to re-enter flows as cooler seeps
  - Expands riparian vegetation which
    - Buffers banks against erosion during high flows
    - Shades creeks / streams, which
      - Reduces water temperature
      - Provides hiding cover for fish and wildlife
Our gratitude to WildEarth Guardians, Grand Canyon Trust, and The Lands Council for contributions to this section.

Peer-Reviewed Citations:


For further reading, links to a selection of relevant webpages are provided below:

http://www.beaversww.org/assets/PDFs/ClimateChangeBeaverActivity.pdf
http://www.seventh-generation.org/Climate_riparian_beaver.html

http://www.wildearthguardians.org/site/PageServer?pagename=priorities_wild_places_jemez_mountains_beavers

Leave It to Beavers
Can they help us adapt to climate change?

David Ferry | May 24, 2012 12:11 PM ET

IN THE 1820S, one of the largest corporations on Earth tried to kill every beaver in the Pacific Northwest. Britain's Hudson's Bay Company, threatened by the United States' westward expansion, sent trappers sweeping down the Columbia River watershed to exterminate all the beavers they found and harvest their valuable pelts. Without beavers to hunt, the company's governor reasoned, the United States would have "no inducement to proceed thither." Within 20 years, the beaver was nearly eradicated from an area the size of France.

Now, nearly two centuries later, beavers are valued not just for their pelts, but for the environmental benefits of their gnawing and nesting. A growing community of "beaver believers" is reintroducing the animal to regional waterways throughout the Pacific West in the hope of reducing the evidence of

http://www.theatlantic.com/magazine/archive/2012/06/leave-it-to-beavers/308980/

Beavers Sign up to Fight Effects of Climate Change

Beavers Offer Solution to Climate Change
by DAVID MALAKOFF
May 03, 2008 4:00 PM

In the Southwest U.S., biologists are talking about returning beavers to rivers they once inhabited in order to fight droughts — which are expected to get worse as the globe warms. Beaver dams create great sponges that store lots of water.


Climate Change Adaptation Strategies for Resource Management and Conservation Planning

Joshua J. Lawler

College of Forest Resources, University of Washington, Seattle, Washington

Recent rapid changes in the Earth's climate have altered ecological systems around the globe. Global warming has been linked to changes in physiology, phenology, species distributions, interspecific interactions, and disturbance regimes. Projected future climate change will undoubtedly result in even more dramatic shifts in the states of many ecosystems. These shifts will provide one of the largest challenges to natural resource managers and conservation planners. Managing natural resources and ecosystems in the face of uncertain climate requires new approaches. Here, the many adaptation strategies that have been proposed for managing natural systems in a changing climate

http://training.fws.gov/csp/resources/climate_change/lcc/june_09/cc-adaptreview.pdf
Engineering role models: do non-human species have the answers?

A.D. Rosemond*, C.B. Anderson

*Department of Ecology, University of Georgia, 18 Ecology Building, Athens, GA 30602-1861, USA

Received as revised form 5 December 2002; accepted 4 August 2003.

Abstract

A shift from traditional engineering approaches to ecologically-based techniques will require changing societal values regarding 'how and what' is defined as engineering and design. Non-human species offer many ecological engineering examples that are often beneficial to ecosystem function and other biota. For example, organisms known as 'ecosystem engineers' build, modify,...
Riparian Habitat Condition

Riparian habitat condition depends on the consistent availability of water to support hydrophytic vegetation. Water retention associated with dam construction by functional (i.e., dam-building) beaver populations provides increased supplies of groundwater thereby spurring vigorous vegetative growth in riparian corridors.

http://www.seventh-generation.org/files/Beaver_As_a_Climate Change_Adaptation_Tool_Concepts_and_Priority_Sites_in_New_Mexico2.pdf
Benefits to Riparian Wildlife

The changes in riparian health induced by beaver can also be a boon for diverse species that rely on the unique vegetation communities supported by readily available water (particularly in arid landscapes). By increasing water availability, raising groundwater tables, and promoting consistent flows, beaver dams can play a critical role in increasing the availability of these habitats. In some settings (e.g., Greater Yellowstone Ecosystem, Olechnowski and Debinski 2008) the relative abundance and condition of willow (Salix spp.) was a key determinant in songbird richness. Differences in willow availability in the Greater Yellowstone Ecosystem have been attributed to decreased browsing by ungulates following wolf reintroduction (which altered ungulate behavior, Ripple and Beschta 2006), and the fires of 1988 (which, at least in part, prompted a decline in Moose, Dan Tyers, personal communication). Similar relationships among herbivores, beaver, and aspen were reported from that region as well (Runyon 2013). The notion that beaver could play a role in generating habitat for species of conservation interest is a commonly cited motivator for managers considering project initiation.

The benefits to riparian habitats are directly related to many of the hydrologic changes described in the Hydrology section of this guide, however a rich body of literature also exists related specifically to the impacts beaver have on riparian habitat condition. Wright et al. (2002) provide a good introduction to understanding the capacity of the beaver to increase species richness at the landscape scale. These changes are, in large part, attributable to the dramatic improvement and expansion of riparian and wetland habitat caused by damming. For example, a recent Master’s thesis (Runyon, 2013, embedded below) documented the impacts of beaver activity in promoting aspen recovery in the Northern Yellowstone Winter Range.

Citation:


For further reading, links to a selection of relevant webpages are provided below:

The bibliography shown above is available at this link:

http://www.landscouncil.org/beaversolution/beavers_in_wetland_restoration.asp
The Role of Beaver in Riparian Habitat Management

Habitat Extension Bulletin
No. 38

In recent years, resource managers have placed increased emphasis on protecting and managing riparian habitats (those areas next to or influenced by water). Land managers recognize that healthy riparian habitats provide numerous benefits. Proper management of these habitats can improve water quantity and quality, increase livestock forage production and quality, allow wildlife


Forest Features

Beaver Dams Restore Riparian Areas

Many streams and rivers in eastern Oregon have been heavily impacted by activities such as mining, grazing, logging, road building, farming, and urbanization. However, in the southern portion of the Wallowa-Whitman National Forest near Whitney Valley the Whitman Ranger District, in partnership with the Powder Basin Watershed Council, Oregon Department of Fish and Wildlife, Oregon Watershed Enhancement Board (OWEB), and Whitman College in Walla Walla, Washington are working to reverse

Sources of Beaver for Reintroduction Projects
Throughout much of their range beaver are targeted for removal in response to conflicts with humans. Many states allow affected landowners to shoot or trap nuisance beaver to alleviate problems including flooding, damage to trees, and plugged culverts. If nuisance beaver are identified they can be ideal candidates for relocation and reintroduction projects, with live trapping and removal providing an alternative to lethal control. Coordination with the state agency responsible for game and fish management is a must, and state furbearer specialists are key points of contact who stand to be valuable collaborators in the process.

Utah Division of Wildlife Resources. 2000. Final protocol for the transplant and reestablishment of beavers into selected locations in Utah Division of Wildlife Resources’ Southern Region. 27 pp.
When nuisance beaver are not available for relocation, managers should consider trapping from other proximate wetlands with robust beaver populations. Again, coordination and support from the state is critical for live trapping and relocation.

Many states have developed strategic guidance for managing beaver. Many of these plans address nuisance beaver management. Some plans even deal directly with translocation (e.g., Utah, upper right). The Colorado State Parks Beaver Management Plan is also provided as another example (lower right).

**Success Stories and Points of Contact**
The list of successful watershed restoration projects based in part or whole on reintroducing and / or reinvigorating beaver populations is growing steadily. During the course of these efforts, many valuable lessons have been learned and a tremendous amount of experience gained. This section was created to provide motivating and informative examples as well as contact information for experts on the projects. For more information, readers are encouraged to direct follow-up questions to those responsible for these outstanding examples of watershed and beaver restoration.
Dr. Joe Wheaton is an Assistant Professor at Utah State University and a fluvial geomorphologist with over a decade of experience in river restoration. Joe runs the Ecogeomorphology & Topographic Analysis Lab in Utah State University’s Department of Watershed Science and is a leader in the monitoring and modeling of riverine habitats and watersheds. Joe and his students are among the leading scientists and practitioners in the realm of river restoration through beaver. Together they have assembled excellent resources, including a website with many examples of success. Information about his group’s Beaver Restoration Assessment Tool (BRAT) is also available online.

Dr. Joe Wheaton
Joe.Wheaton@usu.edu
Watershed Sciences Department
Utah State University
5210 Old Main Hill, NR 360
Logan, Utah 84322-5210
USA
Direct: (435)-554-1247
Main Office: (435)-797-2459
Fax: (435)-797-1871
As an Ecosystems Analyst, Dr. Michael Pollock has been studying forest, stream and wetland ecosystems for the past 12 years. During this time he has engaged in a diverse suite of scientific studies including: the influence of disturbance and productivity on biodiversity patterns in riparian corridors, the influence of beaver habitat on coho smolt production and ecosystem function, the historical patterns of riparian forest conditions in the Pacific Northwest, and the importance of riparian forests to maintaining stream habitat. Dr. Pollock also provides policy analyses to parties interested in understanding the potential effects of proposed or existing laws, policies, and regulations on our environment. Past analyses include the environmental impact of habitat conservation plans (HCPs), the likely effect of proposed state legislation concerning the protection of salmonid habitat, and the probable environmental impacts of various specific land use proposals. Dr. Pollock holds a B.S. in Biochemistry (California State University, Humboldt, Cum Laude) and a Ph.D. in Ecosystems Analysis (University of Washington, College of Forest Resources). Prior to joining the Watershed Program in 1999, Dr. Pollock was a partner in a local consulting firm and director of a small, non-profit scientific research institute.

Dr. Michael Pollock
Email
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, WA 98112
Phone: 206-860-3451

Dr. Nick Bouwes received his BS at University of Wisconsin, Madison, and his MS and PhD at Utah State University. After that he was employed as a fish population analyst and a biometrician/modeler for Oregon Department of Fish and Wildlife. Nick started Eco Logical Research in 2000, and has since been working collaboratively with state, federal, tribal fisheries agencies and NGOs to review and develop status and effectiveness monitoring programs addressing NOAA and USFWS Biological Opinions and Recovery Plans and the Northwest Power Planning Councils Fish and Wildlife Program throughout the Columbia River Basin. Nick is a fisheries expert who has been critically involved with experimental design and monitoring for the Bridge Creek Beaver Project.

Dr. Nick Bouwes
Ecologist / Owner
Eco Logical Research, Inc.
nbouwes@gmail.com

Justin Dolling is an outstanding point contact at the Utah Division of Wildlife Resources. He is largely responsible for drafting the current Utah Beaver Management Plan.

Justin Dolling
Utah Division of Wildlife Resources
justindolling@utah.gov
801-476-2740
The Methow Beaver Project: History and Establishment

In 2000, John Rohrer had an idea. As a Forest Service District Wildlife Biologist working in the Methow Valley, he thought that ‘nuisance’ beaver removed by Washington Department of Fish and Wildlife enforcement agents might be valuable to restore an old wetland on Forest Service land where he had seen water tables lowered and riparian vegetation lost. After a series of releases there, the beaver set up shop and began restoring the site, returning the wetland to a 23 acre complex of dams and wet meadows. For the next few years, more attempts followed, some successful, some less than successful. All of this was a backyard, spare-time effort to try to improve places that had once held beavers. An inspiration for John was a 1932 map from the Forest Service archive that showed the original beaver relocation work at 61 sites in the Methow Valley. If it was possible to re-establish beaver then, maybe now would be even more feasible.

Points of Contact:

John Rohrer
jrohrer@fs.fed.us
509-996-4001

Kent Woodruff
kwoodruff@fs.fed.us
509-996-4043
More information about the Methow Beaver Project can be found here:

[Image of the NOAA HABITAT CONSERVATION website with a section titled "Highlights"]

Beavers: Mother Nature’s First River Restoration Engineers

Until recently, the role of beavers in maintaining healthy river ecosystems was not well understood or appreciated. Not everyone wants beaver dams in their backyard! But the same things beavers do naturally—cut down trees, dam up water, flood meadows—are exactly what we are trying to do to improve habitat for Pacific salmon.

That’s why beaver reintroduction is identified as a priority action in the Upper Columbia/Spring Chinook Salmon and Steelhead Recovery Plan. The Methow Valley Beaver Reintroduction Project is relocating them from places where they are unwanted and moving them to places where beavers can be part of the solution to salmon recovery.

The project is restoring wetland and riparian habitat by relocating “nuisance” beavers to four areas within the Methow watershed in the Upper Columbia/River Basin in Eastern Washington. As part of their natural behavior, beavers add wood to streams, create natural dams, and reconnect streams with their floodplains. These are the very same objectives of many river restoration projects.
Climate Change and Beaver Activity
How Restoring Nature’s Engineers can Alleviate Problems

By Suzanne Fouty

Variability is a defining principle of our global climate. Both species and stream/riparian ecosystems evolved with that reality. There have always been years when the rains did not come or years when the rains came too soon or too much. Species responded by developing survival mechanisms, such as wide distributions and variable timing of flight or spawning. These

Figure 1. Price Creek, MT (1995). beaver-dam

Point of Contact:

U.S. Forest Service Hydrologist Dr. Suzanne Fouty has been an outspoken proponent for beaver-based restoration projects since focusing on the topic for her PhD dissertation at the University of Oregon over a decade ago. Her writing and aquatic restoration projects in the Pacific Northwest have drawn considerable public attention to the value of beaver in their native habitats and the potential for expanding beaver / riparian restoration practices more broadly. Find related blog here.


Dr. Suzanne Fouty
sfouty@fs.fed.us
541-523-1344
Dr. Dan Tyers has spent much of his career studying and managing wildlife in the Greater Yellowstone Area in various positions with the Forest Service. His personal experiences with beaver restoration work include establishing partnerships with key stakeholders, developing programs for live trapping and relocation, completing projects within designated wilderness areas (including pack transport of live beaver), and long-term monitoring and follow up after project completion. See the story linked above for more information.

Dr. Dan Tyers
dtyers@fs.fed.us
406-994-2281
WildEarth Guardians, Grand Canyon Trust, and The Lands Council are among the most active and involved conservation organizations working to enhance beaver populations throughout their historic range. The groups collaborated to create the report linked above, and the three report authors (listed below) have considerable expertise in the science and policy related to beaver restoration.

Bryan Bird, Wild Places Program Director, WildEarth Guardians

Bryan received his Masters in conservation biology from New Mexico State University in 1995 and holds an undergraduate degree in biology from the University of Colorado, Boulder in 1990. He has undertaken conservation research, planning, and protection projects in Central America, Mexico, and the Southwestern United States. Since first working for the Guardians in 1996, Bryan has focused on restoration of national forestlands and their critical ecological processes, as well as monitoring, reviewing, and
challenging destructive Forest Service logging proposals and land management plans. He has served as President of the Board of Directors of the National Forest Protection Alliance and is currently the New Mexico state delegate. He also currently serves as a volunteer on the Sierra Club’s National Forest Protection and Restoration Committee. Bryan lives with his family in the Galisteo River watershed and in his spare time enjoys backpacking, snowboarding, and traveling. Bryan also leads our Clean Waters, Wild Forests priority campaign.

bbird@wildearthguardians.org
505-501-4488

Dr. Mary O’Brien, Utah Forests Program Director, Grand Canyon Trust

Mary joined Grand Canyon Trust in Fall 2003 to help organize and co-coordinate the Three Forests Coalition’s efforts to obtain greater care for native wildlife, vegetation, and ecosystems on southern Utah’s Dixie, Fishlake, and Manti – La Sal National Forests. Since earning a B.S. in Sociology, a Masters in Elementary Education, and a Ph.D. in Botany, Mary has worked as a staff scientist for toxics reform, environmental law, and public lands conservation organizations for 28 years. She thinks backpacking and hiking are particularly amazing ways to spend days on Earth.

info@grandcanyontrust.org
928-774-7488

Mike Peterson, Executive Director, The Lands Council

Mike has been Executive Director of The Lands Council for eight years. Mike is a board member of a number of groups, including the Northwest Washington Forestry Coalition, the Coeur d' Alene Forest Coalition, and Farm Power. He is helping the City of Spokane write their Climate Action Plan and sits on the Spokane Sustainability Task Force. Mike has an MS in Mechanical Engineering from Colorado State and over 30 years in environmental advocacy. Mike has a weekly environmental talk show, Tuesdays at noon on KYRS 92.3 FM.

mpetersen@landscouncil.org
509-209-2406
Other Forest Service Contacts by FS Region

Washington Office
Brett Roper (WO Remote), broper@fs.fed.us, (435) 755-3566

Region 1
Eric Tomasik, etomasik@fs.fed.us, (406) 329-3086
Scott Spaulding, scottspaulding@fs.fed.us, (406) 329-3287
Mary Manning, mmanning@fs.fed.us, (406) 329-3304
Jay Frederick, jfrederick@fs.fed.us, (406) 682-4253
Lynn Burton, lburton@fs.fed.us, (208) 983-4094

Region 2
Melanie Woolever, mwoolever@fs.fed.us, (303) 275-5007
Dave Winters, dwinters@fs.fed.us, (303) 275-5023

Region 3
Brian Dykstra, Dykstra, bdykstra@fs.fed.us, (505) 842-3268

Region 4
TBD

Region 5
Chrissy Howell, cahowell@fs.fed.us, (707) 562-8929

Region 6
Robert Alvarado, ralvarado@fs.fed.us, (503) 808-2901

Region 8
TBD

Region 9
Mary Maj, mmaj@fs.fed.us, (414) 297-1254
Chris Riley, criley01@fs.fed.us, (231) 723-2211, ext. 3122

Region 10
Cheryl Carrothers, ccarrothers@fs.fed.us, (907) 586-7905
Transmission of Whirling Disease / Non-Native / Invasive Species

Whirling disease is a parasite that can have severe negative impacts on coldwater fishes (particularly trout) by causing skeletal and neurological damage. Several life history traits of the parasite (durable spores, extended period of infectivity, etc.) render the disease exceedingly easy to spread. It is a reasonable precaution to avoid spreading whirling disease during beaver relocation. Beaver from infected waters should only be relocated to other infected waters and these actions should be done only with the direct collaboration of fisheries specialists from the relevant state-level fish and wildlife resource management agency. If you are unsure of the whirling disease status of a given watershed err on the side of caution until you can obtain more information.

Other non-native / invasive species

Similar precautions should be followed in any setting where other non-native invasive aquatic species are present. The potential for transporting vegetation, vertebrate, and invertebrate species during beaver translocation necessitates that relevant partner agencies be consulted. Aside from these organisms being transported on relocated
beaver, they could also be moved on gear, including live traps, waders, wading boots, trapping tools, etc.

**Trapping and Potential Impacts on Stream and Riparian Ecosystems**

The majority of states with occupied beaver habitat allow recreational and commercial beaver trapping. In wetlands that are readily accessible trapping remains one of the leading causes of mortality for beaver in North America. Because newly established beaver populations can be quickly eliminated by minimal trapping pressure, trapping can be a key limiting factor that must be considered and addressed.

One of the most effective approaches to protecting recently restored and recovering beaver populations is to work with the state agency responsible for managing fish and wildlife resources to institute a closure encompassing a specific recovery area.

Such closures should be widely advertised (e.g., included in the annual state trapping regulations / proclamation). Installation of signage might also be a worthwhile endeavor.

In order for states to agree to any limitation on trapping it may be prudent to engage active trapping organizations in the local, state, and (possibly) national levels. Trappers should be recognized and included as important stakeholders in states where they trap beaver legally. Where possible, trappers should be engaged as partners and allies in working to expand beaver populations – a goal that is mutually beneficial.

In one example case study Dr. Dan Tyers (USFS) was able to work with the State of Montana and local beaver trappers to institute a permanent beaver trapping closure in a watershed where he led a beaver restoration project. In addition to supporting and
obeying a closure to protect newly introduced beaver, the local Montanan trappers contributed their expertise and services to capturing beaver live for reintroduction. In the years since the project beaver have dramatically altered the watershed where they were reintroduced, and trappers have had expanded trapping opportunity in the surrounding wetlands outside the closure zone.

The National Trappers Association website is a good starting point to learn more about active trapping groups in your area:
Bibliography Sorted by Topic Area

Considerations for Beaver Restoration in Designated Wilderness

Arizona Game and Fish Department. 2005. Mexican wolf Blue Range reintroduction project adaptive management oversight committee, standard operating procedure. 44 pp.

Evaluating and Coping with Human-Beaver Conflict


Evaluating Current Presence / Absence of Beaver


Evaluating habitat suitability for beaver


**Fisheries**


implications for current angling practices in Scotland. Scottish Natural Heritage Review No. 86.


Johnson, J. and Weiss, E. (2006) Catalog of waters important for spawning, rearing or migration of anadromous fishes, southwestern region, Anchorage, Alaska. Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services.


**Historical Distribution of Beaver**

James, C.D. and R.B. Lanman. 2012. Novel physical evidence that beaver historically were native to the Sierra Nevada. California Fish and Game 98(2) 129-132


**Hydrology**


**Live Trapping Beaver for Translocation**

Range / Grazing / Beaver-livestock interactions


Resilience to Climate Change


Riparian Habitat Condition


Sources of Beaver for Reintroduction Projects

Utah Division of Wildlife Resources. 2000. Final protocol for the transplant and reestablishment of beavers into selected locations in Utah Division of Wildlife Resources’ Southern Region. 27 pp.