BEAVER RE-INTRODUCTION

1 DESCRIPTION OF TECHNIQUE

Beaver can be important regulators of aquatic and terrestrial ecosystems, with effects far beyond their food and space requirements[1]. Beaver have the potential to modify stream morphology and hydrology by cutting significant amounts of wood and building dams. This in turn influences a variety of biological responses within and adjacent to stream channels. Historically, beaver have been key agents of riparian succession and ecology throughout North America. They can naturally transform pioneer woody vegetation into physical features that result in the expansion of floodplains, riparian community structure, diversity, and productivity[2].

The predominance of beaver in the Pacific Northwest drew many early trappers and explorers to this part of the country. By 1900, unregulated exploitation left beaver almost extinct. Their removal, by extensive trapping, resulted in incised channels, loss of riparian and wetland areas, and loss of channel complexity critical to fish and invertebrate production. The beaver population in the U.S. has been reduced from a pre-European estimate of 60-400 million to a current level of 6-12 million[1].

As the role of beaver in managing and maintaining stream and riparian ecosystems has gained recognition, interest in the potential for reintroducing beaver to recover stream and riparian function in degraded ecosystems has grown. Beaver have been successfully transplanted into many watersheds throughout the United States during the past 50 years. This practice was very common during the 1950s after biologists realized the loss of ecological function resulting from over-trapping of beaver by fur traders before the turn of the century. Reintroduction has restored the beaver populations in some areas, but many areas are still devoid of beavers. For example, a Wyoming survey found that beaver had been extirpated from 25% of all 1^{st-} to 3rd-order streams originally occupied by them. Furthermore, many areas that still held beaver were not ecologically functional because their numbers were so low that they did not mean much to the system. Much unoccupied habitat or potential habitat still remains, especially in the shrub-steppe ecosystem, hard hit by trapping and over-exploitation. In forested areas, where good beaver habitat already exists, reintroduction has been used to restore some areas[3]. In rangelands, where loss of riparian functional value has been most dramatic, the potential role of beaver in restoring degraded streams is most appreciated but least understood[3].

Transplanting beaver may create the conditions needed to both establish and maintain riparian shrubs or trees. In the case of newly restored habitat or areas far from existing populations, reintroduction of beaver without further habitat improvement might be warranted[3]. Transplanting success rates can be high, but this depends on the site, the condition of the predator community, the time of year they are moved, and the age class of animals transplanted[2, 4].

2 PHYSICAL AND BIOLOGICAL EFFECTS

Successful reintroduction of beaver has demonstrated: 1) an elevated water table upstream of the

dam, which in turn improves vegetation condition, reduces water velocities, reduces bank erosion, and improves fish habitat (increased water depth, better food production, higher dissolved oxygen, and various water temperatures), 2) reduced sedimentation downstream of the dam, 3) increased water storage, 4) improved water quality, and 5) more waterfowl nesting and brooding areas[5]. These effects, at the landscape level, influence the population dynamics, food supply, and predation of most riparian[1] and aquatic species. Beaver dams on coastal streams increase landscape-scale habitat diversity by creating a unique wetland type for that area[6].

Beaver ponds can alter water chemistry by changing adsorption rates for nitrogen and phosphorus, by trapping coliform bacteria[5], and by increasing the retention and availability of nitrogen, phosphorus and carbon[1]. Beaver-altered streams also cause taxonomic and functional changes in the benthic macroinvertebrate community due to the effects of impoundment and subsequent alteration of water temperature, water chemistry and plant growth[7].

Beaver can also influence the flow regime within a watershed. Beaver ponds can improve infiltration and ground water storage by increasing the area where soil and water meet. Headwaters can retain more water from spring runoff and major storm events and release it more slowly, resulting in a higher water table and extended summer flows. This increase in water availability, both surface and subsurface, usually increases the width of the riparian zone and, consequently, favors wildlife communities that depend on that vegetation. The richness, diversity, and abundance of riparian-dependent birds, fish, herptiles, and mammals can increase as a result. Beaver ponds are important waterfowl production areas and can also be used during migration. In some high-elevation areas of the Rocky Mountains, these ponds are solely responsible for the majority of local duck production[5]. In addition, species of high interest, such as trumpeter swans, sandhill cranes, moose, mink, and river otters, use beaver ponds for nesting or feeding areas[3]. Beaver ponds also provide very important salmon habitat in western Washington and Oregon. Juvenile coho and cutthroat are known to over-winter in beaver ponds and the loss of beaver pond habitat has resulted in the loss of salmon production potential[8].

By introducing beaver into the lower watersheds of first-, second-, and sometimes third-order drainages, or below areas of erosion, beaver activity and stream sediment transport can re-elevate the bed level of incised channels; reactivate floodplains; increase stream bank water storage and aquifer recharge; and increase sediment deposition and storage, creating favorable micro-site conditions for maximizing natural vegetative stabilization of the drainage[2]. Once viable beaver complexes become established and are self-sustaining (3 to 4 years), the complexes themselves will begin to form natural gully plugs of a quarter- to a half-mile in length, accelerating sediment deposition and riparian recovery further upstream. By facilitating the establishment of beaver dam complexes at intervals throughout a watershed, this process can create a leapfrog effect, helping to accumulate or stabilize sediment throughout the system[2].

Beaver can be used to initiate or accelerate the natural restoration of degraded or lost riparian systems. Identifying limiting factors and providing supplemental management techniques to compensate for these factors are important. When physical site conditions can be improved for initiating natural riparian establishment, the system can develop to a self-sustaining level in as little as 3 to 4 years. By transplanting beaver to degraded sites, providing supplemental dam material during initial construction (to reduce dam washout prospects), and maximizing

vegetative re-growth and establishment, riparian recovery and succession can be accelerated[2].

3 APPLICATION OF TECHNIQUE

Beaver can be reintroduced to any watershed where they have been extirpated within the following parameters:

- The channel is less than 3% slope to minimize dam blow-outs
- The water supply is perennial or beaver are released on ephemeral streams during a period with sufficient water to create a dam and lodge.
- The stream geomorphology is such that beaver activities will be supported. For example beaver do not seem to colonize as well in volcanic stream systems due to the instability of the channel.
- Beaver will not cause unacceptable damage to public or private property or facilities (See McKinstry and Anderson[9], for problem areas to avoid as well as benefits that landowners feel they receive from beaver.)
- There is an adequate food source (at least 18 acres of willow or 6 acres of *Populus* species within 100 feet of the stream)[10] and dam building materials.
- Their activities will not conflict with other management prescriptions, such as endangered species management or instream flow issues.
- The valley is at least 60' wide (150' or more is best)[10].
- The site is below 6,000' elevation. The short growing season and heavy snowfall above this elevation may be limiting factors for beaver[10].

4 RISK AND UNCERTAINTY

4.1 Uncertainty of Technique

Perhaps the most difficult aspect of this technique is trapping beaver. The process can be time-consuming and requires dedication. However once they are captured, they are easy to handle and transport[11]. Transplanting beaver is not an exact science. On average only 15-20% of relocated beaver stay in their new stream systems[4]. Translocated beavers in Wyoming lived an average of 86 days post-release and predation and emigration accounted for 30% and 51% of the losses, respectively[4]. Beavers in the 2.5 year-old age class were the most likely to survive and modify habitat, although older beavers had similar survival rates. All beavers < 1-year old died within 60 days of release. Other researchers have found that the average distance from the release site to the area of establishment is eight miles, and many move further[12].

Reintroduction into degraded riparian areas within the shrub-steppe zone is controversial. Conventional wisdom holds that a yearlong food supply must be present before reintroducing beaver. In colder climates, this means plants with edible bark, such as willow, aspen, or cottonwood must be present to provide a winter food supply. But often these species are the goal of restoration. In some cases, willow or other species can be successfully planted as described in the *Riparian Restoration and Management Technique*. In other areas, conditions needed to sustain planted cuttings, such as high water table and minimal competition with other vegetation, might preclude successful establishment. Transplanting beaver before willows are established might create the conditions needed to both establish and maintain riparian trees and shrubs. In these cases, supplemental food should be provided at or near the reintroduction site[13].

With the dramatic drop in beaver trapping that has occurred since Initiative 713 in Washington, the population is expected to increase, making available vacant beaver habitat increasingly scarce. Being territorial, their numbers are self-limiting, but they will continue to increase stream occupancy in the streams of Washington if left untrapped.

4.2 Risk to Infrastructure and Property

Moving beavers during spring and summer can result in them emigrating and becoming a nuisance downstream. However, transplants in spring have been used in Wyoming to effectively colonize ephemeral streams that might otherwise be dry by late summer[4]. Potential conflicts with other stream restoration or management activities should always be considered in transplant operations[2]. Common problems include cutting or eating desirable vegetation, flooding roads or irrigation ditches by plugging culverts, and increasing erosion by burrowing into the banks of streams, reservoirs, or dikes[9]. In addition, beaver carry Giardia pathogens, which can infect drinking water supplies and cause human health problems. In these areas, it is important to work in cooperation with adjacent landowners[3].

4.3 Risk to Habitat

Beavers can disrupt the habitat of other wildlife species. Negative impacts include loss of spawning habitat, increase in water temperatures beyond optimal levels for some fish species, alteration of riparian vegetation and habitat, barriers to migration for some fish species, and habitat conversion from lentic to lotic systems. Therefore, caution should be used in introducing beaver into areas where they were not endemic[3].

5 METHODS AND DESIGN

5.1 Data Collection and Assessment

In any stream where beaver restoration is being considered, first evaluate whether the habitat is suitable and if beavers once used the area. Eight variables are helpful in this evaluation: (the following information is adapted from Vore 1993[10])

1. Previous beaver activity – indications of previous beaver occupancy include old dams and lodges, beaver cuttings, collapsed bank dens, and old beaver runways. If there has been no beaver activity for many decades evidence may be overgrown and appear as humps or small ridges. Interviews with people who have long lived in the area and/or trappers can also be useful in this assessment.
2. Water – a relatively stable, perennial water source is important. After damming, the water depth should be sufficient to accommodate lodges or bank dens and winter food caches.
3. Stream gradient – this is one of the most important factors. Beaver favor streams with low gradient. Less than 3% is ideal, although they will use higher gradient streams.
4. Valley width – beaver prefer valleys that are a minimum of 60’ and preferably greater than 150’ wide to provide sufficient quantities of their preferred food sources.
5. Food – winter food is often a limiting factor. There should be at least 18 acres of willow or 6 acres of *Populus* species within 100’ of the stream per beaver colony.
6. Dam building material – The same species used for winter food are used to build dams. Heavy conifer cover is not thought to be good beaver habitat.

7. Stream substrate - beaver do not seem to colonize as well in volcanic stream systems due to the instability of the channel
8. Elevation – the short growing season and heavy snowfall above 6,000' elevation may be limiting factors.

Additional considerations for managing beaver include watershed erosion rates and volumes, dam and pond cycling frequencies, carrying capacity, population dynamics and their management, and site-specific factors, such as bank stability, soil type, stream order and size[1]. Note the presence of culverts, irrigation structures, or other structures the beaver may plug and infrastructure that may be flooded. A contingency plan should be developed if that occurs (see section 10 *Maintenance*). Determine the level of cooperation or concern from the neighboring landowners.

5.2 General Design Information

- Transplant beaver during their principal dam building period, August-October. This will allow for time to gather a food cache, but limit their time to emigrate prior to constructing a dam, lodge, and food cache for the coming winter.
- Transplant at least 4 beavers (2 of each sex) to a site, preferably from the same colony[10]. See section 5.5 *Aging and Sexing*, on sexing beaver.
- Target trapping to dam- and lodge-building beaver (as opposed to river-dwelling beaver) since that is the habitat type you are trying to restore.
- Target trapping to 2.5 year old beaver as much as possible since they are the most likely to survive and modify habitat[4]. See section 5.5 *Aging and Sexing*, on aging beaver.
- Expect beaver to cut and use a large number of trees for dam construction during the first year or two after transplant.
- It may be helpful to provide beaver with additional building materials to use near the reintroduction site. This can encourage beaver to stay near the site and strengthen dams built of sagebrush or other shrubs[13]. The primary criteria for placing wood to encourage beaver use are:
    - the height of the structure above the water (< 0.2 m)
    - the proximity of a structure to a bank den (< 70 m)
    - the proximity to a deep pool (< 70 m)
    - and an unconfined stream channel[14].
- Do not allow harvest of beaver in newly established colonies for at least three years. If the project is on private property, "No Trapping" signs should be posted to identify the area off limits to trapping. If the project is on public property, the Washington Department of Fish and Wildlife will need to develop trapping closures for that area.
- Grazing may need to be delayed or deferred for several seasons, depending on riparian condition. When resumed, use a grazing system beneficial to riparian systems, especially one that benefits willow and *Populus* communities.
- To be successful, there must be cooperation between adjacent landowners and local wildlife officials. A cooperative evaluation of existing habitat quality and potential adverse beaver activity is very important[2, 3].
- When evaluating sites for potential beaver releases, gradient should be less than 3%, and the site should have adequate food supply.

5.3 Trapping

Snares and suitcase-style traps are the best methods for trapping beaver[15], however, snares are illegal for use in Washington State. For Bailey live traps, select small channels and make sure the beaver frequent the shore for feeding. The water should be at least 10 to 12 inches deep. Hancock live-traps can be used in any area that beaver frequent including dry land. Most commonly they are set on lodges and dams.

Both Bailey and Hancock live traps are shaped and operate like a large suitcase. The Bailey's trap must be set in an open position, entirely under water with the trip pan 8 inches below the water surface. Some shoveling may be required to properly position the trap for optimal trapping conditions. The trigger should also be adjusted to about 4 inches under the water. This will ensure that muskrats swimming over it will not spring the trap. Remember, it is very important that you do not disturb the surroundings more than absolutely necessary when setting the beaver trap. Freshly cut willow branches, or poplar (aspen or cottonwood) less than 1¼-inch diameter can be used as bait, and placed on the shoreline where the beaver visit. If there is a chance that the beaver will not pass over the center of the trap while moving towards the bait, long sticks or small logs should be placed in the mud out from the shore, leading to the trap at an angle to form an open "V" on the lake side. The opening generated by the logs should be about 14 to 16 inches wide over the center of the trap. The open "V" forces the beaver to swim over the trip pan of the trap and through the opening to reach the willow bait on the shore at the rear of the trap. As the beaver swims over the trap, its body hits the trip pan and springs the trap. Before leaving the set trap, splash water over everything that was handled, including the area that was walked over. Wait until the water clears and look the trap over very carefully. Make sure that none of the mesh strands are over the end of the trigger arms at the hinges, and that the safety hooks are released. Once sprung, the trap is positioned about one-half of the way out of the water, capturing the beaver unharmed and able to breathe.

Hancock traps are similar to Baileys, however, water depth is not an issue and they can be set on dry ground as well. For Hancock traps, select an area where beaver are frequenting and anchor the trap so that when it is closed it is not under water. Since the back portion of the trap is out of the water you can use fresh cut willow or aspen as bait and even artificial scent mounds with commercial beaver lure can be used to attract them to the trap.

All traps need to be checked on a daily basis, preferably in the early morning since prolonged exposure may cause death to the trapped beaver. Both Bailey and Hancock traps may be used to transport captured beavers, although it may be preferable to store them in a caged area prior to transplanting to wait while other beavers are captured.

5.4 Handling

It is often necessary to keep beavers in captivity while other adult beavers of the appropriate sex are caught. Rasmussen and West, as quoted in Vore[10], discuss holding captive beaver for as long as 10 days as follows:

> "Holding live beavers to obtain pairs and numbers for transplanting should be done in specially designed holding pens and crates to insure success. Beavers held for transplanting should have access to water to enable them to partly

submerge at all times as a necessity in performing certain bodily functions.

Care must be taken in preventing the beavers from becoming chilled or overheated while being transported to new sites. Kits are particularly susceptible to extremes in temperature and all ages are sensitive to excessive exposure to heat and sunlight.

A temporary collapsible holding pen was constructed which measured 6' by 4' by 4'. The top was left open, or shaded with shrubbery when in use. All four sides were made of 20-gage sheet metal, and were held together at the corners by means of iron rods pushed through a series of hasps and eyes. The bottom consisted of an angle iron frame covered with netting, and was made to fit in flanges formed by turning in the bottom of the four sides. The bottom screen must be very heavy, comparable to material used in screening gravel. This pen was placed in a stream or pond in such a way that several inches of water was present along one side or in the corner while the remainder of the pen remained dry."

If it is necessary to sedate beavers for any reason (to determine sex, for example) during handling, transport, or confinement, ketamine HCL combined with acepromazine has been used successfully[16]. Ketamine is a fast-acting non-barbiturate, general anesthetic that is an uncontrolled substance and therefore obtainable from a veterinarian. Animal sedation should only be performed by a qualified and experienced biologist.

5.5 Aging and Sexing

Sexing beaver is difficult since they do not have external sex organs and they have a cloaca, which makes identification extra difficult. Palpating for the baculum is the most common methods of sexing beaver. Teats are evident in females only while they are nursing. Beaver can be easily handled with a commercial catchpole and these allow you to handle the beaver for sexing, ear-tagging, or attaching radio transmitters.

There is no way to positively age live beaver. However, beaver can be placed into one of four age classes (kit: 0-1 year, juvenile: 1-2 years, subadult: 2-3 years, adult: 3 years or more) based on weight, total length, and tail width. Use at least two criteria to determine age[10].

Age of Beaver	Weight	Total Length	Tail Length	Tail Width
Adult	≥43lbs	≥42"	≥11.5"	≥6.5"
Subadult	30-43lbs	38-42"	10.2-11.3"	5.0-6.2"
Juvenile	10-29lbs	27.5-37.7"	7.1-10"	3.1-5.0"

6 PERMITTING

A Permit is required from the Washington Department of Fish and Wildlife to live trap and move beaver. Washington Administrative Code 232-12-271 (http://www.wa.gov/wdfw/wlm/game/trapping/index.htm) covers the Criteria for Planting

Aquatic Plants and Releasing Wildlife. Check with a representative of the Washington Department of Fish and Wildlife.

7 Construction Considerations

If you are not an experienced beaver trapper, it is recommended that you hire someone who is. Contact the Washington Trappers Association for information at: Washington State Trappers Association, Box 2245, Olympia, WA 98507.

8 Cost Estimation

Live traps are approximately $350 each.

9 Monitoring

Transplanted beaver can be radio tracked by using tail-mounted transmitters. See Rothmeyer et al.[17] for details on this technique. Radio tracking may be desirable to determine how many of the transplanted beaver stay in the area and where they go if they emigrate. Based on the objectives of the transplant, you may also want to monitor water quality, temperature, fish presence/absence, and riparian vegetation. Infrastructure and land use constraints may require additional monitoring, including water level recording and visual inspection of culverts, irrigation structures, or other structures that may become plugged, flooded, or otherwise compromised by beaver activity. See the *Monitoring Considerations Appendix*.

10 Maintenance

In cases where beaver live in close proximity to humans or features important to humans, they may need to be removed or their damage controlled. Control of nuisance beaver usually involves removing the problem animals directly or modifying their habitat. Beaver can be live-trapped (Bailey or Hancock traps) and relocated to a more acceptable location or killed by trapping (e.g., Conibear #330) or shooting[18]. In cases where the water level in a dam must be controlled to prevent flooding, a pipe can be placed through the dam with the upstream side perforated to allow water flow. This will allow the dam to be retained while controlling the water level of the pond. See Finnigan and Marshall[19] for more information on ways to manage beaver impacts.

Grazing may need to be withdrawn for several seasons, depending upon riparian condition. When resumed, use a grazing system beneficial to riparian areas.

11 Examples

North Fork Nooksack River:
http://www.n-sea.org/fishtale/fall2001/BeaverRelocationProject.shtml

Fox Creek, Oregon:
http://www.freedom-here-and-now.com/foxcreek/beaver.html

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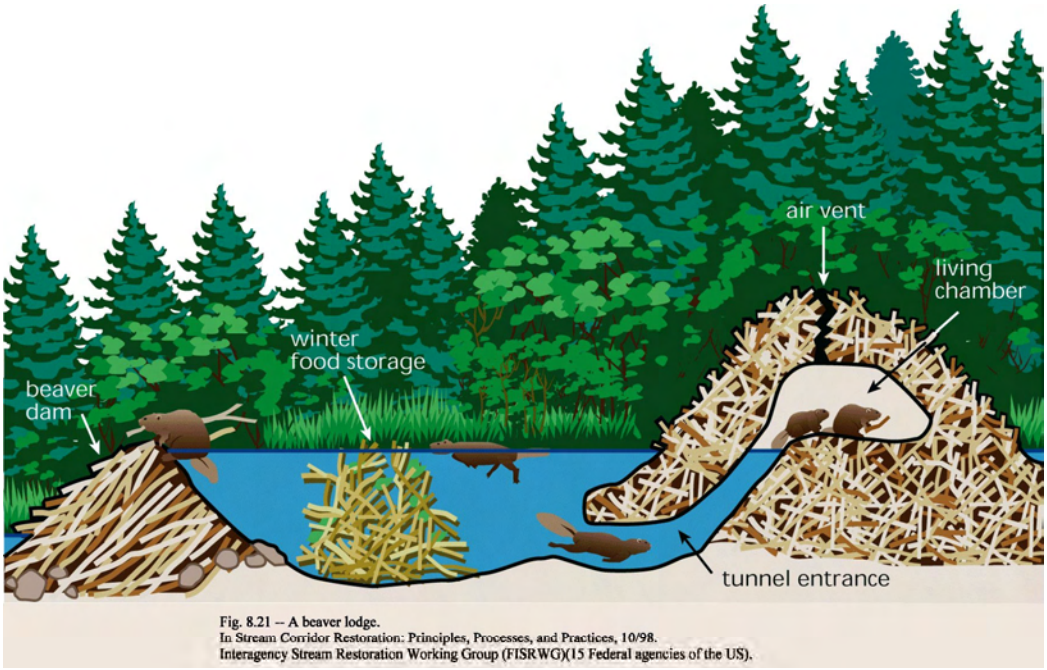
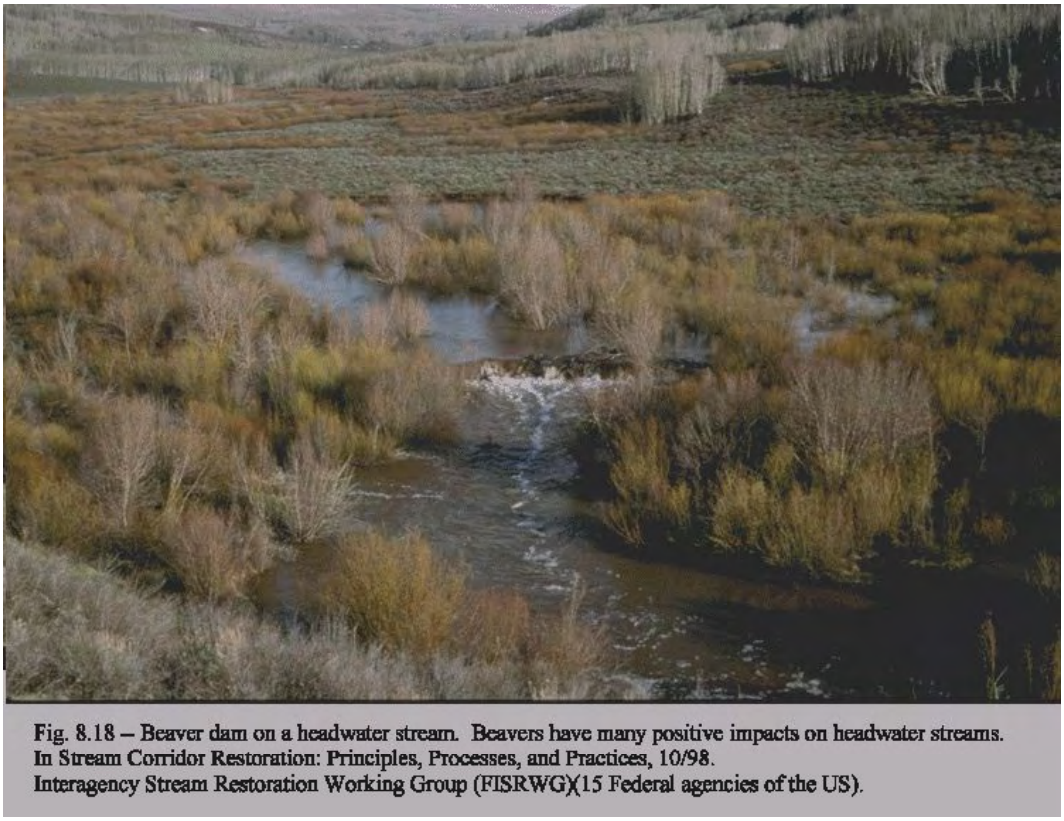


Beaver Reintroduction Figure 1: Beaver Lodge. *Source*: Federal Interagency Stream Restoration Working Group (1998)[3]



Beaver Reintroduction Figure 2: Beaver dam on a headwater stream. *Source*: Federal Interagency Stream Restoration Working Group (1998)[3]

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