Beaver Influence on Fisheries Habitat: Livestock Interactions

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Abstract: This paper will address how livestock grazing interacts with beaver colonies and the potential impacts on watershed ecology and hydrology. The introduction of livestock into the rangeland watersheds of the Inter-Mountain West, degrades stream structure, and places cattle and sheep in competition with beavers for the utilization of riparian vegetation. Where the influence of livestock results in the reduction of beaver populations in watersheds, fisheries habitat and downstream agricultural productivity can be impaired. Observations based on recent and historical reintroductions of beaver can provide guidance for improved management of public land watersheds and their fisheries.

Introduction

Both humans and beavers harvest natural resources and enhance their economies by building structures which alter stream dynamics and watershed ecology. The results of these activities often create conflict between humans and beavers as each compete to control and utilize resources. Where these conflicts occur, beaver are commonly perceived to be a nuisance and much effort is expended to remove them. Less effort has been expended to understanding how human activities, by disrupting beaver population distribution and reducing beaver habitat suitability, undermine the beneficial influence of beavers on watershed ecosystems and fisheries habitat.

Beaver habitat may be part of wetlands and side channels associated with riverine or lacustrine environments. The focus of this paper and much of the reviewed literature is about the effects of beaver dams impounding 2nd to 4th order streams. In larger streams with greater hydraulic forces, beaver dams are temporary and have less influence on the character of the stream, however, beavers commonly build dams in side channel and backwaters of riverine systems, altering the aquatic and riparian habitat diversity and area significantly.

Image showing a beaver lodge in one of the recovery areas.

Beaver habitat may be created by a single dam only a few meters long, or a complex of dams and ponds covering extensive areas. The raised water table can create impoundments of lacustrine, bog, marsh, and forested wetland types. Beaver dams are usually .5-2 meters high. Sticks, mud, and rocks are materials used to construct dams and lodges. As an alternative to lodges, beavers construct dens by tunneling into stream banks. Beavers also construct/excavate canals. Canals are usually about 1 meter wide and can be hundreds of meters long. They provide access to forage with aquatic escape from predators, and are used to transport woody materials back to the pond. Canals are frequently dammed, creating locks or supplementary ponds. Winter food caches are provisioned by anchoring fresh cut woody materials to the pond bottom.

Stream Size and Gradient

Where stream size is not the limiting factor, low gradient reaches of a stream provide the most suitable beaver habitat. Beaver habitat suitability is dependent upon a sensitive relationship between stream size and gradient. Maximums for stream size and gradient are limited by dam resistance to washout (Allen 1983; Beier and Barrett 1987; McComb et al. 1990). Minimum stream size is limited by the ability to provide beavers escape from predators, transportation for woody materials, and winter cover for food caches and den entrances. Within these limits, the greater the stream size the less the gradient must be (Beier and Barrett 1987).

Low gradient stream reaches are associated with broad valley forms and increased flood plain areas (Flint and Skinner 1974), which when flooded by dam construction, allow larger pond/riparian vegetation areas and the construction of canals (Gard 1942; Slough and Sadleir 1977).

Research conducted in the Blue Mountains of Eastern Oregon, indicate reaches of less than 7% gradient and stream cross-sectional areas 0.8-5.0 square meters (high-water depth and width) to be most suitable (McComb et al. 1990). The narrowly defined relationship between these two factors indicates the sensitivity of beaver habitat suitability to climatic variability (i.e., several years of drought), especially in arid climates primarily dependant upon winter precipitation for stream inputs, and characterized by high seasonal stream-flow instability. As a result, the upper and lower limits of beaver habitat within the stream system, may become intermittently abandoned and occupied in response to the effects of climatic variability on stream size and flow regimes (Ives 1942; Gard 1961; McComb et al. 1990). Beaver habitat suitability may be lowered by increased run-off and the exaggeration of seasonal stream flow fluctuations which can occur as the result of logging, road building, agricultural diversions, the influence of livestock, and the loss of upstream beaver habitat.

Stream Flow Stabilization

Beaver dams increase the capacity of surface and ground water storage. The effect is to slow and delay the release of water, resulting in the attenuation of stream flow rates during spring runoff and summer cloudburst freshets. This enhances stream flow rates during drought and dry summer months, and increases the availability of surface water to fisheries habitat and downstream agriculture. The influence of beavers on watersheds can mitigate the increased runoff and stream flow instability that results from livestock grazing, logging and road building. Increased stream flow stability reduces flooding and can transform an intermittent stream into a perennial one (Tappe 1942; Collier 1959; Wilen et al. 1975).

Nutrients and Sediment Trapping

"Dam-building changes the annual stream discharge regime, decreases current velocity, gives the channel gradient a stair-step profile, expands the area of flooded soils, and increases the retention of sediment and organic matter." (Naiman et al. 1988:754).

The ability of beaver ponds to trap sediments and organic material is substantial. The overall effect is to increase and stabilize the pool of biomass and nutrients within the watershed and improve ecosystem efficiency of the use and storage of organic inputs. The concentration of nutrients and the biochemical changes of water quality and quantity not only benefit the immediate beaver habitat, but also benefits the downstream ecosystem. (Naiman et al. 1986; Olson and Hubert 1994).

Small dams of 14 to 18 cubic meters of wood, are able to trap as much as 2000-6500 cubic meters of sediment. It was estimated if the sediment trapped by beaver dams of the Matamek River watershed (Quebec, Canada) were uniformly distributed throughout the stream system, the bottom of the entire stream would be covered with an additional 42cm of sediment (Naiman et al. 1986; Naiman et al. 1988). The concentration of sediments benefits fish spawning habitat by reducing the embedding of coarse gravels with fine sediments. Sediment trapping can mitigate the increased sediment loading caused by roads, logging, cattle, fire, and natural causes.

Effects on Stream Temperatures and Dissolved Oxygen

Observations of the effects of beaver activity in the Grande Ronde watershed stream rehabilitation project: *"Subinfiltration began immediately... Water from the creek began to filter underground through the dam and come out a short distance downstream...water leaving the meadow was 5 to 6 degrees(F) colder than the water entering ...temperatures in the restored reach were 8 to 10 degrees(F) colder and fluctuated less during the day than immediately upstream or downstream...".* (Hollenbach and Ory 1999)

Studies indicate that elevated stream temperatures and low levels of dissolved oxygen associated with beaver ponds, can be lethal to trout (Olson and Hubert 1994). Contrary to this, a study in the coastal streams of Oregon found that cooler peak stream temperatures occurred in streams with beaver ponds, than those without (Leidholt-Bruner et al. 1992). Streams where temperatures tended to be lower as a result of beaver ponds, were in mountain watersheds of western states (Gard 1961).

"It is not surprising that studies from unlike areas often indicate grossly different conclusions." (Gard 1961:240).

Beaver ponds expose larger water surface areas to sunlight. Although increased solar exposure tends to drive up temperatures, stream temperatures will not necessarily escalate as a result. Other beaver habitat effects upon stream characteristics must be considered. Increased volume, flow rates, temperature stratification, flow characteristics through the pond, and thermal conductivity with ground water have a temperature stabilizing effect. During warm summer months, increased stream volume resulting from flow stabilization, increases the heat capacity of the stream, thus decreasing the effect solar exposure and ambient temperature will have upon stream temperature. The net effect of these factors can result in rapid lowering of stream temperatures (Hollenbach and Ory 1999).

While studies of beaver ponds in eastern and midwestern states found elevated water temperatures and dissolved oxygen reduced to levels lethal to trout (Olson and Hubert 1994; Gard 1961), dissolved oxygen levels at the outputs of beaver ponds in the mountain streams of western states were found to be nearly the same as that of their inputs and well within ranges safe to trout (Gard 1961; Leidholt-Bruner et al. 1992).

"The overall effect of the beaver pond is to add another dimension to the stream system and to increase stream habitat heterogeneity." (Bryant 1984:192).

During winter and spring runoff when stream temperatures may be near freezing, the spreading and slowing of water as it passes through beaver ponds accelerates the warming trend of stream temperature, and thereby increases food production and the growth of trout (Gard 1961; Olson and Hubert 1994).

Vegetation and Diet

"It is commonly stated that the beaver exhausts the aspen supply in the immediate vicinity of his pond and then migrates... [this] *leaves the general impression that the beaver mines out his environment... Actually, through the interaction of a number of biotic and geologic factors, he farms it."* (Ives 1942:197).

By the construction of dams beavers actively alter their environment in ways which increase the long term productivity of the riparian and aquatic vegetation they depend upon for forage. Beaver dams raise the ground water table, and increase the contact area and infiltration of surface water into adjacent soils, thus increasing the riparian area and its vegetative productivity. (Naiman et al. 1988; Lowry 1993). Canals and locks contribute to further increasing riparian area and shoreline complexity.

Most foraging by beavers occurs within 100 meters of the water. Their diet is comprised of a wide variety of herbaceous, woody, and aquatic plants. Herbaceous vegetation is the preferred food of beavers, however, in temperate climates availability is limited by short growing seasons, dry summer months which can desiccate plants, and winter snow cover. As a result, from fall through early spring, beaver diet becomes more dependant upon woody vegetation and aquatic plants. The leaves, twigs, and inner bark of woody vegetation is considered the most important food source to insure winter survival (Allen 1983).

Aspen, willow, cottonwood, and alder are the most common woody forage and dam building materials, however, preferred species vary in different geographic areas. Inundation caused by the raised water table of new (or expanding) beaver ponds, and beaver efficiency at tree falling, can have a dramatic effect on other tree species as well. One beaver can cut 200-300 trees per year (DeByle 1981). Although deciduous trees are preferred, beavers will fall conifers.

Where aspen occur along streams and waterways it is the first tree beaver select for food and dam building materials. Although aspen stands can be rapidly depleted by foraging and inundation, they often provide construction materials for new dams.

In some environments willows are the single most important tree species suppling the food requirements of beavers (Grasse and Putnam 1955; Neff 1957; Aleksiuk 1970). Willows are especially tolerant of repeated cutting and partial inundation (Scheffer 1941; Neff 1957). Beavers create an environment that favors the asexual reproduction of willows and cottonwoods. Grazing by domestic livestock in these areas can eliminate that reproduction, beaver food supply, and lead to the desertion and failure of dams with resultant erosion.

It is important to note that the beavers preference for herbaceous vegetation, relieves the browsing pressure from woody vegetation during its active growing season, late spring and summer. Beaver's tendency is to avoid eating young willow sprouts and to harvest more mature woody materials while they are dormant and the nutrients for regrowth are stored in the root system. Beaver's sharp, chisel like teeth cleanly cut woody stems, minimizing damage to the remaining plant. In contrast, domestic livestock impacts willow productivity during the active growing season. Browsing by sheep and cattle leaves stems shattered, susceptible to dehydration, and the invasion of disease (Kindschy 1985; Kindschy 1989; Harwood 1995).

Image of willow shoots showing cut stems and regrowth.

Willow cuttings are often left with some of the bark intact. As these materials are used for dam and lodge construction they tend to sprout in place and become a living part of the structure. The beaver's planting and harvesting strategy, along with willow's vigorous regrowth response to beaver cutting, results in the expansion of willows (Harwood 1995).

If beaver foraging outpaces vegetation regeneration, they abandon the site and relocate. Although available forage and building material may be temporarily depleted, browsing stimulates new growth and shoot production, allowing rapid vegetation recovery and the possibility of reoccupation. The duration of occupancy of an individual site may be limited by the quantity and quality of the vegetation available. Where other marginally suitable habitat sites are nearby, alternating residence between 2 or more sites may provide the requisites to sustain a reproductive colony. The cyclic or intermittent occupation of marginally suitable sites can be important to maintaining beaver colonies in the tributary systems of a watershed where climate and topographical features limit the size and numbers of suitable sites.

Multi-Successional Pathways

"...we see a complex pattern that may involve the formation of emergent marshes, bogs and forested wetlands, which appear to persist in a somewhat stable condition for centuries." (Naiman et al. 1988:761).

The concept of *succession* is often defined as a successional sequence which leads to a relatively stable climax plant community (Cronquist 1971). The concept of *multi-successional pathways* (Naiman et al. 1988) is defined by a plant community and habitat type (seral stage), responding to environmental factors which cause succession back to a plant community/habitat type of a previous seral stage. A sedge meadow which follows the deterioration of an abandoned beaver pond, may become a bog/shrub or wetland forest environment, which in turn succeeds to a conifer forest, commonly considered a climax seral stage. At any seral stage, environmental events, such as fire, or if stream flows return to conditions more favorable to beaver occupation (i.e., in response to climatic variability), the plant community/habitat type may again become a wetland forest or beaver pond. The possible sequences of replacement of one plant community and habitat type with another are numerous (Cronquist 1971; Naiman et al. 1988).

Beaver population density and distribution in a stream system, depend on a dynamic equilibrium (Vannote et al. 1980) of many factors including disease, predation, and other factors which influence a stream system's biological community and physical structure. These factors create a "shifting mosaic" (Naiman et al. 1988) of habitat modification which both determines, and is influenced by dam site abandonment, emerging opportunities for colonization, or the reoccupation of former sites. Dam sites may be occupied cyclicly, intermittently, persist for centuries or be abandoned indefinitely.

A typical scenario following livestock presence and beaver absence is: destruction of the dam, dewatering of the pond, down-cutting of the stream channel, a rapid lowering of the water table and subsequent decline of the riparian vegetation. (Neff 1957; Parker et al. 1985; Harwood 1995).

"If the willows are destroyed, as they occasionally are by livestock, the beavers emigrate; if the beavers are trapped out, stream erosion proceeds to lower the water table and the willow die for lack of water." (Scheffer 1941:322).

"*The difficulty in sorting out causes* [of erosional down-cutting and degradation of streams] *is exacerbated in many places because the introduction of grazing tended to coincide with removal of beaver."* (Parker et al. 1985:37).

The reduced water velocity in beaver ponds increases the rate and area of sediment deposition. Accumulated sediments decrease the gradient and broaden the area of the floodplain, thereby increasing the floodplain's potential riparian vegetation resources. As a result, a stream system's carrying capacity for beaver population tends to increase with time. The scale of topographic alteration is easily underestimated. Over time periods spanning thousands of years (between the last ice and present day), the activities of beavers in mountain watersheds can perpetuate wetlands and create areas of low gradient terrain that are extensive on a regional scale. These topographic features of watersheds are often mistaken to be the results of glaciation or underlying geologic structure (Ives 1942). Low gradient meadows with a stair-step profile, and deep peat soils vertically honeycombed with woody debris, are a signature of previous beaver habitat that may persist for thousands of years (Ives 1942).

Fisheries

"The physical attributes of ponds appear to offer trout habitat superior to that in the streams except for the obvious deficiency of spawning gravels." (Gard 1961:225).

In the western United States salmonid/beaver habitat studies consistently relate greater salmonid productivity to streams with beaver habitat than those without. Although the invertebrate community of a beaver ponds tend to be comprised of the same species present in the remaining stream, the beaver pond produces a dramatic increase of invertebrate density, and a 2-5 times increase of invertebrate biomass. This provides an important food source for juvenile migratory fish and trout (Naiman et al. 1988). The average weight of fish residing in the beaver ponds may be as much as five times greater than those in the remaining stream (Neff 1957; Gard 1961). A few stretches of creek influenced by beaver activity can produce a large proportion of a river system's young fish (Johnson 1984).

"Key summer habitats for coho, age 0+ and age 1+ steelhead are beaver ponds, side channels, and pools respectively." (Everest et al. 1984:iv).

In headwater streams, the deep pools and greatly increased water volume of beaver ponds provide habitat important to fish survival during periods of low or intermittent stream flow (Gard 1961; Leidholt-Bruner et al. 1992). In climates where severe winter weather can freeze streams solid (i.e., high desert habitats) beaver ponds provide critical winter fish habitat with escape from ice (Olson and Hubert 1994).

Beaver ponds are particularly important to fish populations in watersheds that would otherwise be lacking pools formed by coarse woody debris (McComb et al. 1990). The tree cutting activities of beavers along streams, contribute to the availability of woody materials that form debris dams. Upwelling water tends to occur downstream of beaver dams and pools formed by woody debris. These areas of upwelling, in 2nd to 4th order streams, are the preferred spawning habitat of salmonid species (Baxter 2000). This influence on ground/surface water exchange, combined with sediment trapping, benefits fisheries by improving the quality and quantity of spawning gravels, and by increasing habitat diversity (Naiman et al. 1986; Swanston 1994).

The existence of beaver ponds is sometimes perceived to be detrimental to salmonids because they occupy stream channel that may otherwise be riffles/spawning habitat (Marcus et al. 1990). The net effects of beaver habitat on salmonid reproduction is relative to a larger spatial scale than the effect of ponds displacing spawning gravels; and relative to a larger temporal scale than the potential detrimental effects caused by an event of dam failure/washout and the release of a fraction of the accumulated sediments.

"Many trout spawn in the short riffles between ponds...37 redds were observed between dams 1 and 13, a section of almost continuous beaver dams...It is not the number of eggs (within limits) that determines the number of adults resulting, but rather the survival rate of the eggs present." (Gard 1961:289).

Fish Passage Barriers

"*Grasse and Putnam, in their studies of beaver in Wyoming in 1955, photographed a [beaver] dam that was only 30 feet wide but was 18 feet high."* (Rue 1964:589). This single dam impounded more than 10 million cubic feet of water (Grasse Putnam 1955).

Although the effects of beaver habitat are a part of the natural perturbation of stream systems in which native fishes have evolved, beaver dams are sometimes assumed to limit fish reproduction if/when they block fish passage. It is not always readily apparent how fish manage to negotiate dams. Often they can jump dams, bypass them through side channels, or pass through the interwoven sticks and mud. In a study of trout in Sagehen Creek (a small creek of the eastern slopes of the northern Sierra Nevada), brown, brook, and rainbow trout were marked and released to test their ability to cross a series of 14 beaver dams. With the exception of the lowermost dam, all dams were crossed in both directions during spring, summer and fall. The lower dam was crossed only in the downstream direction (Gard 1961).

In southeast Alaska, coho salmon densities were highest in streams with beaver ponds. Coho were able to jump dams as high as 2 meters and were found above all beaver dam complexes (Bryant 1984).

Where dams are barriers to fish movement, the question remains whether they limit the reproductive success of fish species; or does the existence of beaver habitat, by improving spawning/rearing habitat, increase the successful reproduction of adult fish (Gard 1961; Bryant 1984; Lowry 1993).

"a high percentage of steelhead redds were found just below beaver dams...Dam blockage was probably not a factor in redd location, since fish were observed above several dams in the area." (Lowry 1993:96).

<u>History</u>

Since the 1800's, streams in the western United States have been influenced by many forms of resource extraction that compound understanding beaver population distribution prior to trapping, and how the effects of human activities have limited the current distribution of beavers in watersheds. The effects of climatic variability on stream flow regimes, also alters beaver habitat suitability, and is a factor influencing current beaver distribution.

Systematic trapping of beaver began in North America in the 17th century. The Hudson's Bay Company and American brigades of trappers reached the upper Columbia River by 1826 (Johnson 1974). Trapping went unabated until about the turn of the century, 1900, when concern over low beaver populations resulted in moratoriums on beaver trapping in the United States and Canada. In most of North America beavers were completely extirpated. Regulated trapping resumed in the following decades (Scheffer 1941; Olson and Hubert 1994).

As an "agent of soil and water conservation" (Scheffer 1941) and to manage nuisance beaver, in 1920, the Biological Survey and the State of Washington Department of Game began a series of experiments involving the transplanting of beavers. In 1932, Oregon State and federal agencies began a similar live trapping and relocation program. It was the perception of biologist at the time that beaver populations had rebounded, but had not successfully reoccupied their former range in the uplands of mountain watersheds. Some records of these projects and their results were found:

1) *Management Studies of Transplanted Beaver in the Pacific Northwest* (Scheffer 1941). Three-fourths of the released beavers disappeared from planting sites within a few days or weeks. This report lists the reasons for the low success rate of establishing colonies at release locations:

   a) Stream flow regimes unsuitable for beaver habitat.
   b) Unsuitable topography or excessive elevation (> 1800 meters in Oregon).
   c) Predation and poaching.
   d) Improper handling of beavers preliminary to planting.
   e) Insufficient or inappropriate browse and dam construction materials.
   f) Riparian vegetation impacted by livestock and elk.

   The conclusions were that successful transplanting of beavers is dependant upon careful site selection and the exclusion of livestock. The duration of established colonies varies from sites that beavers will exhaust the food supply within a few years and then emigrate, to sites that may be occupied indefinitely. Willow and beavers can exist in a virtual state of symbiosis, willow supplying the food, and beavers raising the water table to increase willow abundance (Scheffer 1941).

2) *Beaver Distribution and Planting Map, Okanogan Forest* (U.S.F.S. 1937). This map indicates the location of known suitable beaver habitat sites; the location of occupied sites; and the location, year and the number of beaver released in the Okanogan Forest.

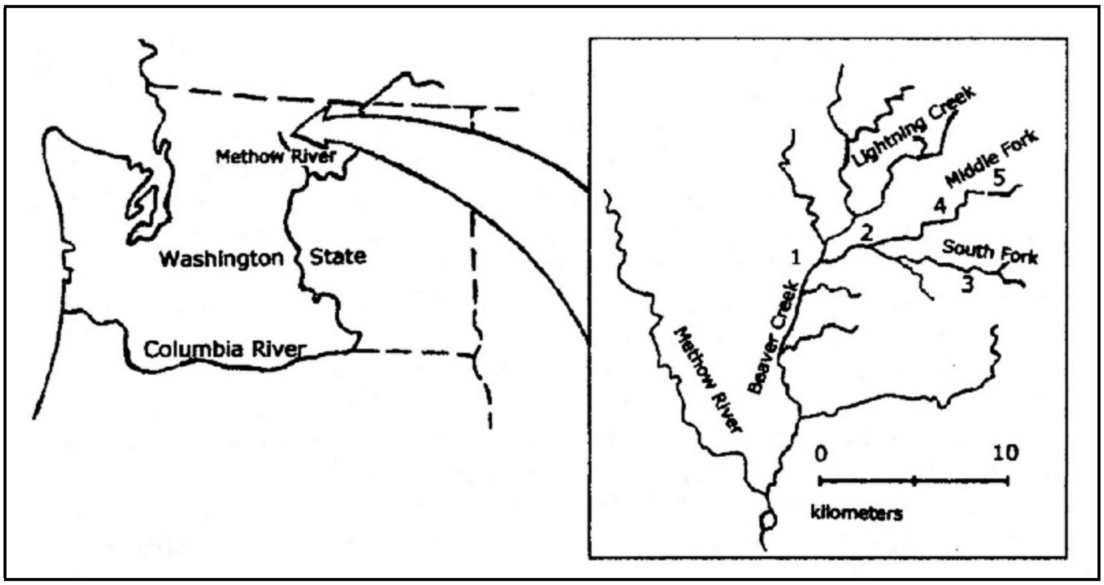
<u>Methow Valley Study</u>

<u>Field Reconnaissance</u>

To pursue understanding the current status of beaver in the sub-basin watersheds of the Methow Valley a limited field reconnaissance is of value. The proximity of Beaver Creek and the availability of the *Beaver Creek Stream Survey Report*, (Hamon 1993) and the *Beaver*

Distribution and Planting Map (U.S.F.S. 1937) qualify it as the most convenient (and aptly named) sub-basin to investigate with the limited resources available to this study. Beaver Creek is also of interest due to the U.S.F.S. beaver transplant and habitat rehabilitation project which began in 1990 on an abandoned beaver habitat site of the South Fork (South Fork Meadows).

Image showing approximate location of the reconnaissance site.



Beaver Creek

The Beaver Creek watershed is a sub-basin of the Methow River Watershed, a tributary of the upper Columbia River. Beaver Creek drains approximately 310 square kilometers in Okanogan County, Washington. Elevations range from 500 to 2245m. The climate is arid with most precipitation occurring in the winter as snow. Temperatures can vary from -33C to +41C.

From the confluence of Beaver Creek with the Methow River, to a point up stream approximately 13 kilometers, Beaver Creek is predominately low gradient, and broad valley form, typical of suitable beaver habitat. This part of Beaver Creek is privately owned and supports a valuable agricultural resource which is dependant upon stream diversion for irrigation water. Agricultural demand for irrigation water exceeds available stream surface water supply during summer.

Upstream from the privately owned land, Beaver Creek enters D.N.R.(Wa. State) and U.S.F.S. land (Okanogan Forest) which is mountainous terrain characterized by a more steep gradient and narrower valley forms which offer fewer and more isolated suitable areas for beavers.

The 1993 stream report cites the presence of bulltrout, cutthroat, redband, coastal rainbow, and brooktrout. During summer 2000 a new culvert installation remedied a fish barrier at State Highway 153 (<1 kilometer from mouth of creek) and preceded the return of spawning steelhead (spring 2002 and 2003) to parts of lower Beaver Creek. Removal of the remaining fish barriers are in planning and construction. Extensive logging and high road density have impacted the watershed ecosystem to a great extent. A paucity of quality pool habitat and spawning gravels is cited by the *Stream Survey Report* as the limiting factors to the resident fish populations.

Field Reconnaissance (May-June, 2003), Notes, and Observations.
Site 1: Beaver Crk. Reach 1

This location is currently ponderosa forest and a state campground. The *Beaver Distribution and Planting Map* indicates this site is favorable for transplant and that no beaver were relocated here. Except for its low gradient and the presence of the stream, this site does not reflect that it was previously favorable beaver habitat.

Site 2 South Fork, Reach 3

The *Beaver Distribution and Planting Map* indicates beaver were occupying this site in 1937. The *Stream Survey Report* notes historic evidence of former beaver occupation and subsequent long term absence. Large aspen are present. Reach 3 is 1.4 kilometers long, has an average 7% gradient, with a steep narrow valley form. There is not an existing pond or meadow complex.

Site 3: South Fork, Reach 5 and the beaver rehabilitation project.

South Fork Meadows: The *Beaver Distribution and Planting Map* indicates that 5 beavers were planted in 1935. The *Beaver Creek Stream Report* records some of the recent history of this beaver pond/meadow complex and the U.S.F.S. beaver habitat rehabilitation project. In 1990 the site had been vacant of beaver since the early to mid 1980's. The stream channel of the South Fork was deeply incised in the flood plain and through breaches in the dam structures. The Stream Report describes the effects of cattle browsing, trampling of beaver dams and degradation of the stream banks occurring at the time of the survey.

In an attempt to raise the water table and restore the riparian vegetation willows were transplanted along the stream channel, and the construction of small check dams and livestock exclusion fencing was accomplished.

The total area of the existing dam/pond complex is approximately 20-30 acres. There is a series of old beaver dams, which are approximately 300 meters long and span the entire width of the flood plain. The presence of a >1 meter diameter spruce on top of one of these dams is evidence of the longevity of these structures. Three of these dams are well defined and each has one major breach, while others are more fragmented.

One beaver was released in 1995 but did not stay. In the spring of 2001 seven beavers were released. (J. Rohrer, U.S.F.S., pers. comm. 2003)

By the fall of 2001 beavers had constructed small dams at several places along the stream channel and within the breaches of the 2 uppermost dams, successfully raising the water table several feet in some areas. (personal observation). The shoot productivity and growth of willow and sedges across the floodplain was noticeably improved by the raised water table and has increased the availability of materials for consumption and dam building. The abundant new growth suggests that a dormant root structure was present.

In the spring 2003 it appeared that there was probably only one resident beaver (personal observation). Beaver activities had altered the pond/meadow complex to a large degree. The breaches and down-cut stream channels of the 2 uppermost dams were partially repaired with dams constructed of small willow sticks and mud excavated from the submerged stream channel. Willow abundance has increased dramatically and the old dam structures support vigorous willow and grasses. Many of the transplanted willows graphically illustrate repeated, seasonal beaver browsing and regrowth. In May, 2003 another beaver was released (J. Rorher, U.S.F.S., pers. comm. 2003).

Although the single pond above the uppermost of these old dams is approximately equal in elevation to the bottom of the old dam, the pond impounded runs along the base of the old dam for most of its length and is perhaps 1.5 meters deep in places.

The repair of the incised breach in the lower dam is approximately 2 meters high from the surface water below it, to the surface of the pond it impounds. Although this repair appears to present a barrier to fish passage, beaver slides and leaks in low spots of the old dam structures deliver water through the old dams and distribute it intermittently to different areas across the width of the floodplain as the water level is altered by the beaver's construction and repair activities. It is this rapidly changing control of water direction, by the activities of beavers, which account for fish passage routes which bypass the dam. Partially dammed side channels which lead from the ponds and return to the stream, combined with canals, slides, tunnels, and flood irrigated sedge/willow areas, offer a maze of possible fish routes.

Image of a narrow three-foot deep canal being filmed for workshops.

Reach five of the South Fork is recorded *(Stream Survey Report*) as 1.8 km in length, with an average 2% gradient, and a broad valley form. The existing fenced and currently occupied beaver habitat is a small portion of this stream reach. The remaining portions of this stream reach were previously extensive beaver habitat that has <u>become dense conifer forest</u> with few areas of willow/sedge meadow and open canopy. Remnant dams are common throughout the area. Spruce and fir trees up to .5 meters in diameter grow above, below, and on top of many of these dams. The few remaining, open sedge and willow areas are isolated from direct stream source water, by breaches in dams which spanned the flood plain and provided the lateral distribution of water delivered to these areas (below the dam). The relatively recent impact of livestock, upon willow and other deciduous woody plants is apparent and there is notable stream bank degradation associated with cattle.

The rehabilitation project demonstrates the value of livestock exclusion and the restoration of beaver occupancy. The existing open pond complex, inside the exclusion fencing, is a small part of the historical extent of beaver habitat in reach 5 of the South Fork.

Site 4: Middle Fork, reach 3

Although nine beaver were released at two sites in this reach in 1934, the size and dominance of spruce/fir/lodgepole pine among the remnant dam structures are evidence of the long term absence of a beaver colony. The remaining willows and woody shrubs have been heavily impacted by livestock grazing. The restoration of beaver to this site would mitigate the increased sediment loading and the degradation of downstream fish spawning habitat resulting from nearby upslope clear-cut logging and high road density.

Image of an old, overgrown beaver dam.

Site 5: Middle Fork, reach 5

This reach was occupied in 1993 (Hamon 1993). The complex is estimated to be 30 acres. The most recent beaver cuttings suggest this site has been vacant of beavers for one year. The recent presence of cattle within the pond/meadow complex is apparent by the tracks, droppings, and stream channel degradation. The upper and lower most dams are nearly intact but are deteriorating due to lack of maintenance by beavers and the impact of cattle. Remnants of numerous dams span the floodplain and have been breached. One of these has been incised to eight feet (from the top of the old dam, to the water surface in the breach) and exposes 2 meters of peat soil. Sandbars in this pond complex indicate the influent stream is heavily loaded with sand, largely derived from upslope clear-cut logging (Hamon 1993). This entrapment of sand in the pond complex precludes degradation of fish habitat immediately downstream. The Stream Report approximates the volume (surface water) of this complex to be 40% of the total surface water of the Middle Fork tributary, which is 11.2 kilometers in length.

Image of a breached dam on Middle Fork.

<u>Undocumented sites</u>

Personal communication with U.S.F.S. (J. Molesworth, U.S.F.S., pers. comm. 2003) indicates the existence of an unoccupied site with evidence of historical beaver occupation in a South fork tributary. This site is not shown on the *Beaver Distribution and Planting Map* and indicates incomplete knowledge or documentation of beaver habitat locations.

Implications and Summary

Previously, beaver habitat in the Beaver Creek watershed was more extensive than it is currently, and this may have been more apparent when the *Beaver Distribution and Planting Map* was made. Beaver habitat sites which were not successfully recolonized by the transplant program of the 1930's have converted to conifer forest. Beaver populations in the upland tributaries have not recovered from the trapping and near extermination of the 19th century.

The trampling of beaver dams by livestock initiates erosional processes that can down-cut and deeply entrench streams through longstanding dams that were well vegetated and otherwise erosion resistant. The influence of livestock transforms beaver habitat to a conifer dominate habitat type that is resistant to recolonization by beavers. This is an ongoing process that continues to suppress the distribution of beavers in low order tributaries of Beaver Creek. Although beavers will fall conifers, the lowered water table, conifer canopy shading, and livestock grazing, reduce the abundance and vigor of deciduous woody species necessary for dam/lodge repair and construction, and to provide food. Without sufficient resources to create aquatic habitat, ensure predator escape, and provide food cache reserves, winter survival is impaired and the presence of a resident colony is not possible.

The influence of beaver dispersion, that can occur if beaver populations are not suppressed, may return these areas of conifer forest to beaver habitat if livestock exclusion is implemented. The construction of check dams, planting willows, and transplanting beavers can expedite the restoration of beaver habitat.

Meadows which have recently (i.e., the last few decades) been beaver habitat and now have insufficient stream-flow (climatic variability/drought) to support wetlands, are common in the upper reaches of streams in the Okanogan National Forest. Livestock grazing of these areas reduces the probability of future recolonization by beaver, even if stream flow regimes return to more favorable conditions for beaver occupation.

The process of beaver habitat reduction observed in the Beaver Creek watershed is not unique. Similar processes have been documented in many watersheds of western North America. Trapping, poaching, and shooting of beavers is common in North America and contributes to the reduction of beaver habitat in stream systems (Tappe 1942; Collier 1959; Harwood 1995).

The historical model of pristine watershed ecology, prior to the trapping of the early 19th century, indicates concurrent abundant beaver and native fish populations (Johnson 1974; Lichatowich 1999). Beavers have been an integral component of maintaining watershed structure and ecological function since the end of the most recent glaciation. Almost two centuries of human activities have disrupted the interdependent relationship between beavers and watershed ecosystems. The potential for restoration of watershed ecosystems which produced native fisheries cannot be understood without consideration of wetland losses and fisheries habitat degradation which have occurred due to beaver absence/elimination.

The evidence is well documented that wetland areas are shrinking on a global scale (Noss et al. 1995). This is especially true in the western United States. Although the causes of wetland losses are numerous, the disruption and elimination of beavers is a factor. Beavers create and perpetuate wetlands.

The decline of threatened and endangered native fishes causes concern for the detrimental effects of reduced/interrupted in-stream flows resulting from agricultural stream diversions. Beaver habitat reduction exacerbates this conflict by decreasing stream flow stability, which negatively impacts the availability of water for agricultural use and the maintenance of stream flow/continuity during summer months.

Although beaver activities often conflict with human land use, the beneficial effects of beaver habitat have been undervalued. Insufficient effort to minimize human impact on beaver habitat has resulted in counter-productive effects to native fisheries and human land use purposes.

"In addition to their importance at the ecosystem level, these effects [of beavers] have a significant impact on the landscape and must be interpreted over broad spacial and temporal scales..." (Naiman et al. 1988:753).

"In practice... most modern conservation continues to focus on local habitats of individual species and not directly on communities, ecosystems, or landscapes." (Noss et al. 1986).

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