The Community Builder: Beaver's Role in the Ecological Community

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Introduction

> *"…But the beaver builds no walls. The beaver meticulously designs a dam. A magnificent dam built from lumber throughout the woods. Piece by piece, the beaver drags these huge trees through the woods to the creek. Hard working and dedicated, the beaver gets no praise from humankind. The wildlife, they are wiser than those humans. They watch the beaver work. They follow the beaver to this wonderful creation. Not just the wonderful creation of the dam. The creation of a deeper and wider pond. A pond that can sustain trout and other fish. The bull frogs sing their praises. The deer come to wade in the shallow edges near the shore. Drinking that clean, beautiful refreshing water. The ducks and geese come too! They are now able to swim and dive down under the water. The wolves, the foxes and even the tricksters, the coyotes come to drink and play and snack. The snapping turtles, they arrive too. Everyone at the pond now. They are a community. They thank the beaver for the hard work done. The hard work that provides each one of them with something that they need to survive and to be successful...Be a Beaver and Build a strong community where everyone and everything living is welcome at the pond…"*
> Theresa Dolata, 2015

Beavers are known to alter the physical, chemical, and biological characteristics of ecosystems, oftentimes creating benefits extending far beyond their place both in time and space. Historically, Native Americans have believed the beaver to be the "sacred center" of the land, as they create rich habitat for so many species. Today, they are considered a "keystone" species for the same reasons. This research paper explores the beaver's role in shaping the ecosystem and the effects on habitats, species, water quality, and hydrology. With the notion that the beaver functions as an ecological "community builder", what can we learn from this indispensable creature?

Keystone Engineer

Beavers, are considered "ecosystem engineers" or "niche constructors", as they create or modify habitat structure, which has a cumulative effect on ecosystem functions, habitats, resources, and species. They are among the few species that can significantly change the hydrological characteristics and biotic properties of the landscape. In so doing, beavers increase habitat and species heterogeneity, increasing biodiversity, at the landscape level. Beaver foraging also has a considerable impact on the course of ecological succession, species composition and structure of plant communities, making them a good example of an ecologically dominant, keystone species (Rosell et al., 2005).

A keystone species is one that makes habitats viable for other species, whose removal would result in changes to the habitat that would limit or exclude those other species, and whose impact far exceeds its biomass or population. These species have greater impacts on community or ecosystem function than would be predicted from their abundance, with their activities disproportionately affecting the patterns of species occurrence, distribution, and density in the community. They exert controlling influences over ecosystems and communities by altering resource allocation, creating habitats, and modifying relative competitive advantages (Rosemond and Anderson, 2003).

By creating dams and ponds, the North American Beaver (*Castor canadensis*) creates habitat, which certain other species depend on. The beaver may be more accurately considered a keystone engineer as they physically transform the ecosystem, uniquely creating habitat and resources that support a multitude of other species. It creates wetlands and modifies entire landscapes through damming, digging, and foraging activities (Rosemond and Anderson, 2003).

Ecosystem Shaping

An ecosystem, or ecological community, is a group of interdependent native plants, animals, and other organisms that naturally occur together within a habitat. Its structure, composition, and distribution are determined by environmental factors such as position within the landscape, climate, soil type, and water availability, chemistry, and movement. Beaver modification of habitat physical characteristics contributes to both ecosystem biodiversity and function (Figure 1), building and shaping ecological communities.

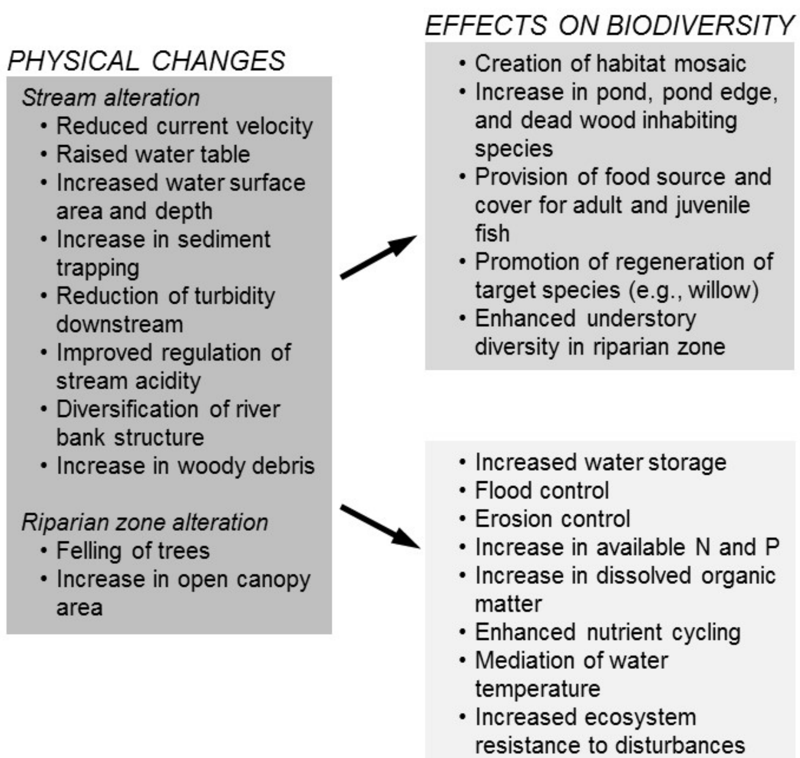

Figure 1: The most important changes to stream channel and riparian zone as a result of beaver activity, and effects these physical changes have on the biodiversity of the area and ecosystem functions.
Source: Simona, 2013

Habitat Effects

Beaver build dams across low order streams to pond water, which provides deep water refuges for protection from predators, extends foraging areas and territories, and allows for food storage during winter (Baker and Hill, 2003). They construct their dens in the form of lodges made of sticks, twigs, rocks and mud in lakes, streams, and tidal river deltas. Lodges are often constructed in the ponds formed by the dam. In riverine or lacustrine habitats, beaver may create dens in bank burrows rather than lodges. Tunnels extending from dens provide access to upland foraging areas and predatory protection. Burrowing and tunneling can also alter hydrological processes, soil composition, seed dispersal, and habitat availability for other species (Hansell, 1993). Further, channels may facilitate the movement and foraging of other organisms such as amphibians and invertebrates (Anderson, 2013; Hood and Larson, 2014).

As beaver cut down trees and dam up streams, water is impounded creating ponds and pools, effecting community structure and ecosystem function. Riparian ecosystems expand into the upland forest. This ecosystem engineering by beaver has also been found to lead to the formation of extensive wetland habitat (Wright et al., 2002). In natural systems such as the Fairview Creek headwater wetland complex in Gresham, OR, beaver improve entrenched channels, reconnect floodplains, increase water storage, and allow water to spread across floodplains, and facilitate channel aggradation (Wallace, 2016). As a result of dam building, the open water areas onsite are increasing, which is effectively decreasing certain invasive or non-native species, such reed canarygrass (*Phalaris arundinacea*), the predominant species in the area. Additionally, the increase in open water has resulted in an increase in waterfowl, other water birds, and turtles utilizing the site. The beaver are also creating dynamic change within the system. Dam building, tunnels, and burrows help create habitat that changes annually, in most cases, allowing for an increase in habitat complexity. Burrows cause bank collapses, also adding to complexity of the system.

The benefits from ecosystem alteration extend to other species as well. In their native environment, beaver's engineering activities increase plant and animal diversity at the landscape level (Wright et al., 2002). While trees are removed, other plant species such as grasses, sedges, bushes, saplings, willow, aspen, and other wetland-tolerant species emerge on the perimeter. Additionally, the abundance and productivity of these species are found to increase. As wetlands are formed, riparian habitats are enlarged, and streams are improved, plants spread into the newly the available habitat (Rosell et al., 2005). These plants provide food and cover for foraging animals in the pool and wetland habitat. Stream habitat complexity and connectivity is also improved (Figure 2). Stream channels that extend away from the pond edge creates structural connectivity by physically connecting one landscape feature, such as a beaver pond, to another adjacent wetland or upland habitat (Hood and Bayley, 2008).

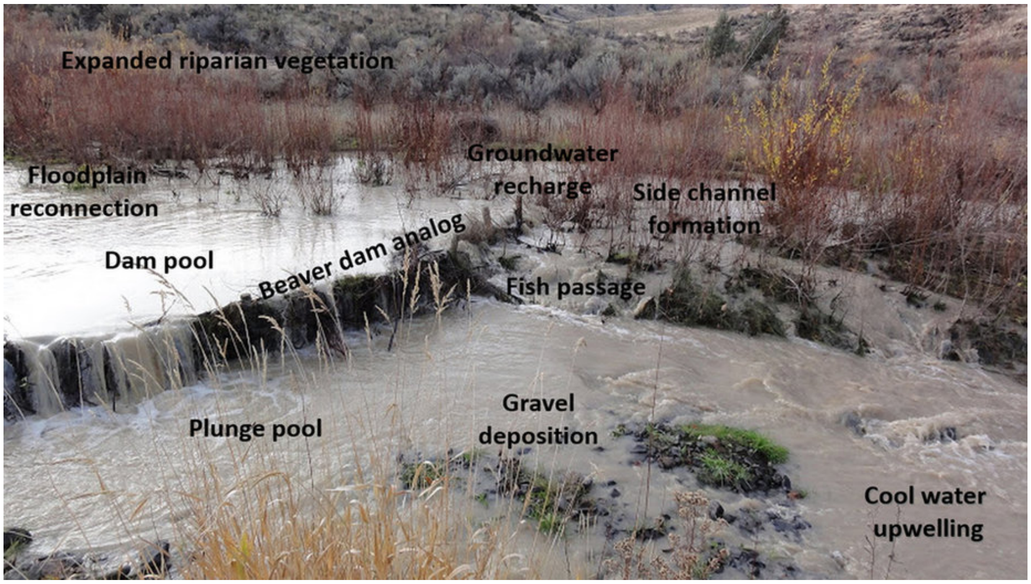

Figure 2: Beaver Dam or Analog Effects to Stream Habitat
Source: Bouwes et al., 2016

Animal Species Effects
The modified system provides habitat for a variety of animal species including insects, invertebrates, herptiles, fish, mammals, waterfowl, songbirds, and other aquatic and wetland-associated species.

The population composition of insects and other invertebrates changes, with some species disappearing and others appearing. The diversity and density, however, is found to be higher in ponds and dams than in free-flowing systems. In association with the increase in input of organic material and sediment into the impounded areas, total invertebrate density and biomass in impounded sites can be up to two to five times greater than in free-flowing streams in spring and summer (McDowell and Naiman, 1986). The abundance of invertebrates increase the food source for higher level organisms.

Herptiles that prefer slow-flowing, pond and wetland habitats, such as frogs, toads, salamanders, and turtles, increase in beaver bonds. The richness and abundance of these species increase in the ponds as compared to un-impounded streams. With the return of beavers following the eruption of Mt. St. Helens, the input of organic material into the beaver dams increased water levels and provided oviposition sites so that species of salamanders, frogs, and toads could breed (Muller-Schwarze, 2011).

The habitat changes may dramatically increase bird species richness, diversity, and abundance (Baker and Hill, 2003). A study in Idaho by the USDA Forest Service (1990) found that total bird density in the beaver pond habitat was three times that of the adjacent riparian habitat. Total breeding bird biomass was also substantially higher in the willow-dominated beaver pond complex. Further, bird species richness and diversity values were higher in the beaver pond habitat. Open water and adjacent vegetated areas provide waterfowl nesting, brood-rearing, and roosting habitat and raptor nesting sites. The snags in the flooded impoundments provide nesting and feeding sites for woodpeckers. Once abandoned, those snags provide nesting cavities for many other birds.

Snags also provide perching sites for raptors. Piscivores and raptors hunt for fish in beaver ponds and raptor hunting success for rodents may increase around beaver ponds (Rosell, 2005).

A variety of mammals also use the beaver pond habitat for shelter, breeding, and food sources. Otters, muskrat, and mink may use active or abandoned beaver lodges, bank dens, or holes for shelter and breading. In a study in Idaho, beaver bank dens and lodges were used by otter more often than any other type of den or resting site, with beaver dens and lodges making up to 38 percent (Melquist and Hornocker, 1983). Otter activity at beaver ponds has been found to be positively associated with beaver presence, pond size, and vegetation cover (LeBlanc et al., 2007). Bear, deer, other herbivores, and predatory mammal species are also found visiting the ponds.

Beavers may result in benefits and detriments to fish. In some cases, or for particular fish species, dams may impede fish passage; however, studies have found that the pond habitats formed by beaver are highly beneficial to may fishes and species regularly cross dams (Pollock at al., 2003). Beaver ponds have been found to provide habitat for more than 80 fish species, including juvenile salmonids, with 48 species commonly using them (Pollock et al., 2003). Within the Pacific coastal ecoregion, fishes identified as making substantial use of beaver ponds include cutthroat trout (*Oncorhynchus clarki*), steelhead (*O. mykiss*), Dolly Varden (*Salvelinus malma*), coho salmon (*O. kisutch*), sockeye salmon (*O. nerka*), and chinook salmon (*O. tshawytscha*) (Pollock et al., 2004).

A network of off channel and wetland complexity is created, providing connectivity, creating slow, deep water pools, shade, and protection for juvenile salmonids (Figure 3). The deep pools allow juvenile salmon and trout to hide from predators. The accumulated woody debris provide habitat complexity and shade for juvenile salmonids. The ponds trap nutrients and increase invertebrates, which juvenile salmon and steelhead rely on when rearing and overwintering.

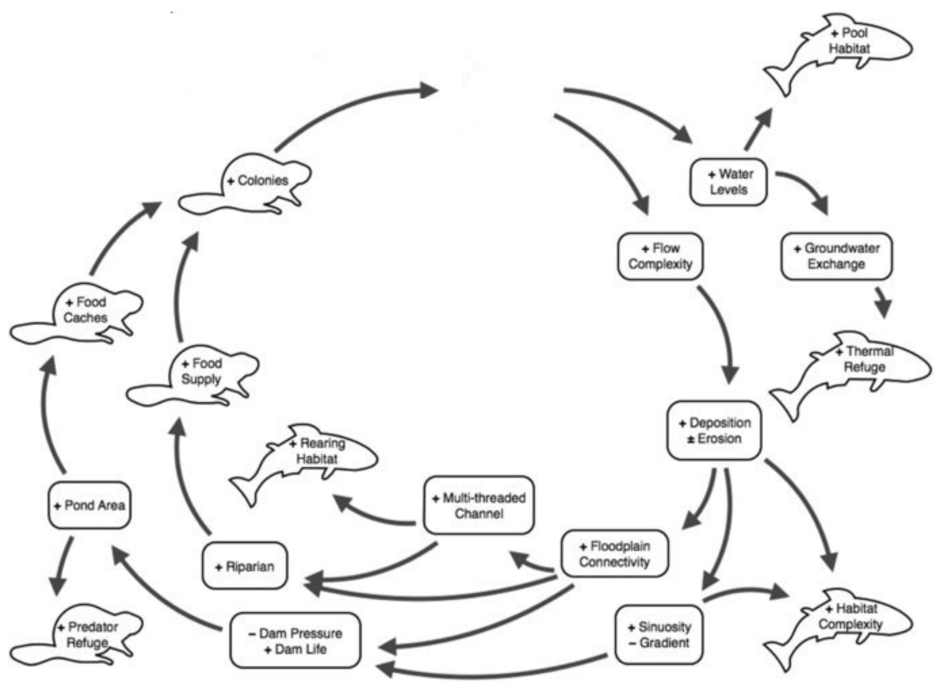

Figure 3: Expected Beaver Dam or Analog Effects to Steelhead Habitat Conditions
Source: Bouwes et al., 2016

The slower water allows juveniles to save energy for growth rather than fighting currents. Pond attributes that promote fish production include high vegetative cover, high invertebrate prey production, and slow current velocities, allowing a reduction in energy expenditure by overwintering and foraging fish (Pollock et al., 2003). Additionally, the dams and pools reduce erosion, retain sediment, and absorb/filter pollutants, improving water quality.

The combination of factors provides juvenile salmonids with a greater chance of survival and reaching the ocean. In anadromous-fish streams in British Columbia and Washington, juvenile coho use the ponds for overwintering habitat and important refuge and rearing areas throughout the year (Figures 4 and 5; Pollock et al., 2003 and 2004). Coho upstream of the beaver dam were consistently larger, more abundant, and grew faster than those downstream. Additionally, Chinook and steelhead use off-channel and floodplain habitats for overwintering.

In an Alaskan river, the highest densities of juvenile coho in reaches upstream of beaver dams and virtually all the larger coho were in beaver ponds (Pollock et al., 2003). Juvenile sockeye were also found use reaches upstream of beaver dams. In the Skagit Delta, high fish densities and occurrence in low-tide beaver pools suggest tidal beaver dams provide valuable fish habitat, particularly for juvenile Chinook salmon, sticklebacks, prickly sculpins, and juvenile lamprey (Hood, 2012). Salmon recovery plans along the west coast of North America have recently identified beaver habitat as important for salmon and steelhead that must be protected to ensure future stocks of this important resource (Pollock et al., 2015).

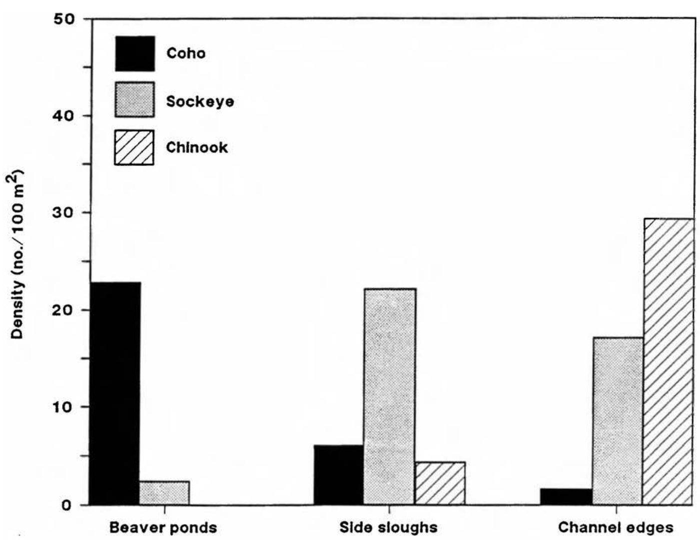

Figure 4: Mean Density (no./100 m2 of age-0, -1, and -2 fish in beaver ponds, side sloughs, and channel edges in Taku River, Alaska, May-November, 1987 and May 1988.
Source: Thedinga et al., 1988

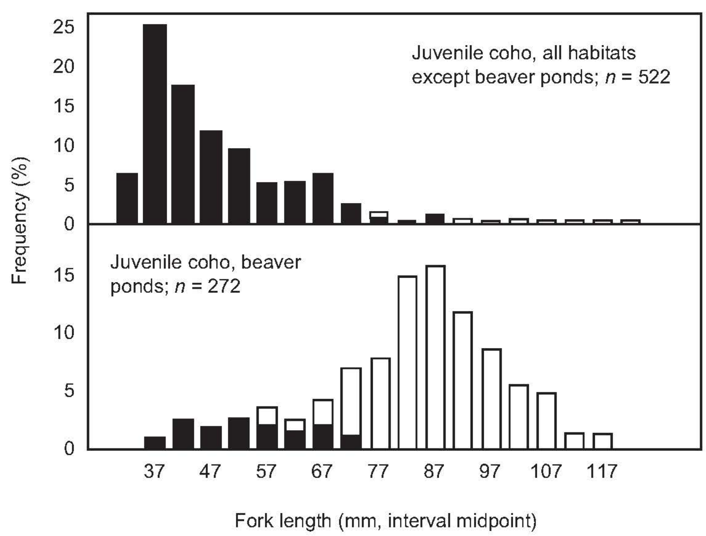

Figure 5: Size-frequency distribution of juvenile coho in main channel and off channel habitat in the Taku River, southeast Alaska, showing that larger coho (age-1 light columns, age-0 dark columns) overwhelmingly prefer beaver ponds over any other habitat. Beaver ponds account for just 0.7% of the total instream habitat area in the Taku River floodplain.
Source: Pollock et al., 2003

Water Quality and Hydrological Effects

Beaver impoundments are found to improve the water quality within streams systems. A large amount of organic material enters and is trapped within the complex, instead of being washed out with high flows. As the material decomposes, microbial activity increases, processing the organic matter. The enhanced retention and processing of organic matter increases nutrient availability (Rosell et al., 2005). The enhanced nutrient levels can facilitate growth of aquatic vegetation. This increase in aquatic system production is a major component of the total production required to support terrestrial food webs, making up over 60 percent of the diets of higher level organisms (Moravek, 2015). Further, algae and plants absorb dissolved nutrients and pollutants and process organic wastes. As woody debris and vegetation retain sediment from moving downstream. The settled sediments then store and filter pollutants (e.g., heavy metals, pesticides, and fertilizers) and sediment deposition facilitates aquatic vegetation growth.

While water released downstream of dams can be warmer, it is only slightly warmer as it is cooled by the inflow of groundwater and increase in low hanging vegetation. Tunnels also allow groundwater to enter the system, providing a cool water source. Additionally, ponds moderate diel temperature fluctuation (Rosell et al., 2005).

Beaver ponds are found to improve system hydrology as well. Surface and subsurface water storage is increased through impoundment and groundwater infiltration, which can increase stream flow during drought periods or in seasonally dry streams. Streams with beaver impoundments are found to provide ecosystems with a high resistance to disturbance (Naiman et al., 1988). During dry periods, up to 30 percent of the water in an Oregon catchment could be held in beaver ponds (Duncan, 1984). By increasing storage capacity, beaver dams lead to greater flows during late summer, which may result in continual flows in previously intermittent streams (Rosell et al., 2005).

Further, the increase in quantity and diversity of wetland habitat, increases water storage and connectivity, which can buffer and even mitigate the effect of drought (Hood et al., 2008) over beyond the stream system. Hood et al. (2008), found that the presence of active beaver lodges accounted for over 80 percent of the variability in the area of open water in wetlands of Elk Island National Park, Canada over a 54-year period. The results of this study confirmed that beaver have a significant influence on wetland creation and maintenance and can mitigate the effects of drought and possibly some of the adverse effects of climate change. Even after abandonment of lodges habitat development continues, with open-water wetlands draining and transforming into wet meadow habitats called “beaver meadows”. These abandoned beaver dams and the successive meadow habitat have residual effects of on water retention (Naiman et al., 1988).

Community Builder

The beaver is an “indispensable creator of conditions that support entire ecological communities” (Backhouse, 2015), creating a web of habitats and food systems extending far beyond their immediate locale. The beaver can be looked at as a role model in the natural world, a “faunal philanthropist”. They improve habitat using alternative, efficient, and natural engineering and design practices. They integrate the context-specific and dynamic natural, living system, improving not only their well-being, but that of others as well. They are building communities. The community builder. We can learn from the beaver – learn to understand and work with the place; be flexible and adapt to the organic and ever-changing environment; work hard, efficiently, instinctively; create symbiotic, mutually beneficial relationships and outcomes; facilitate the presence and success of others; build place-based communities.

Limitations

This paper provides a broad overview for a number of subtopics, rather than a deep dive into any one component of the beaver's effect on habitats and species. Further, this paper is focused on the benefit of beaver, mainly at the landscape scale. At the local level, beaver may impact individuals, such as the trees they take down. In some areas and situations, they may even cause far-reaching, undesired effects, such as when they are introduced as a non-native species and when they move into urban systems. Increasingly, however, regions, cities, and landowners are learning about how to coexist with beaver and even utilize them to improve impacted ecosystems.

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