Beaver Wetlands

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Effects Upon Wildlife and Water

A half-mile-long beaver dam in Canada made international news recently when satellite photos clearly showed the impact of *Castor canadensis* upon the earth. The beaver is one of the few species, besides humans, that builds structures, such as the huge dam in Canada's Wood Buffalo National Park, that are large enough to be visible from space. Today, only in highly remote locations of North America is it possible for nature's engineers to create similarly impressive alterations of the landscape. Ecologist Jean Thie found the immense Alberta dam while scanning satellite images for signs of climate change. This is fitting because restoring beaver wetlands is one of the most effective and economical ways to minimize some potential impacts of climate change on wildlife habitat and the land's hydrology, and thus human communities.

The path to the future requires understanding the past and how current and historic human activities have defined our present situation. Before European settlement of North America, the continent's beaver population was between 60 to 400 million, according to estimates from historic data of trapping harvests (Naiman et al. 1988). It was the quest for "brown gold" that stimulated much of the early exploration and colonization of the New World, where beaver pelts were commonly used as currency. The first waves of fur traders and trappers emanated from the Northeast coast and the mouth of the Mississippi River. By the early 1900s, beaver populations in the continental U.S. and southern Canada were nearly eradicated. Eventually beavers from isolated, surviving colonies were used to reseed vacant habitats and trapping bans were instituted as policy makers and public land mangers recognized the implications of their loss to fish and game. Yet the current beaver population of North America is probably 10 percent, or less, of the original number (Figure 1).

The estimated loss of about 90 percent of these four-footed engineers, and the vital wetlands they once maintained has profoundly affected the continent's hydrology (Figure 2). Their systematic and widespread removal represents the first large-scale Euro-American alteration of watersheds. As beavers were removed, and their dams failed from lack of repairs or were destroyed, changes took place in how water was stored and routed from upper to lower watersheds. Channels eroded into the soft sediments once trapped behind the dams. Over time, valley bottoms shifted from landscapes dominated by ponds, multiple channels, wetlands, and wide riparian zones abundant in fish and wildlife, to landscapes defined by the simple, incised, overly wide, single-thread channels with narrow strips of riparian vegetation that we know today. In addition, widespread drainage of North American wetlands via outlet ditches lined with tiles occurred; over 50 million

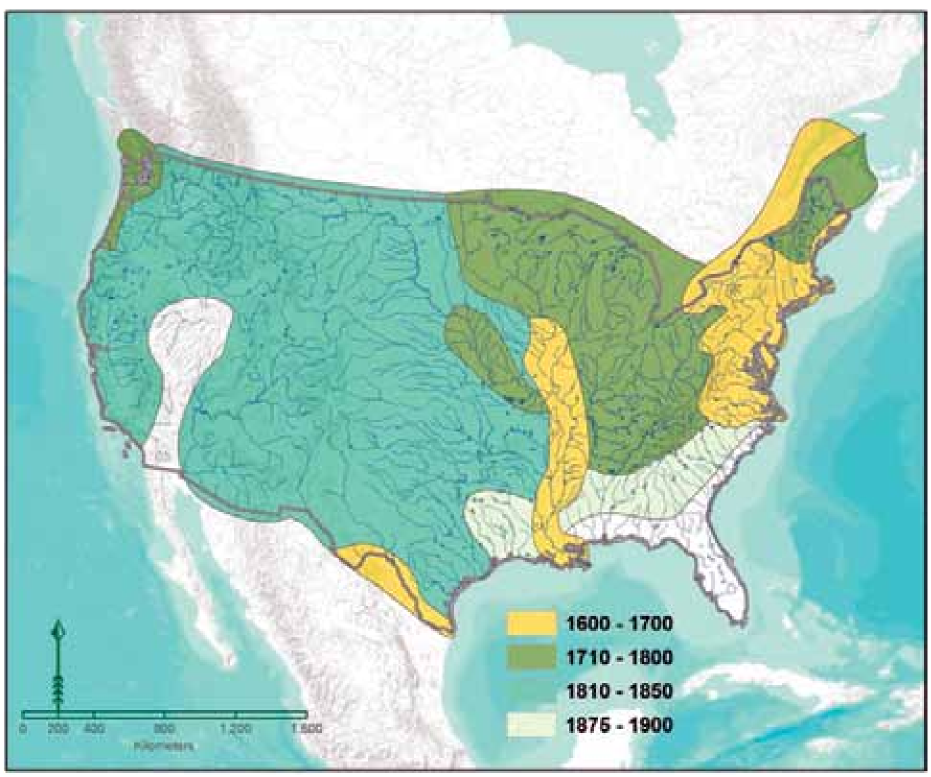

Figure 1. Historic distribution of beaver trapping in the U.S. (Jim Sedell, U.S. Forest Service).

Figure 2. Beavers use their dexterous forepaws and orange incisors to build dams that impound water and restore wetlands. Photo: Sharon T. Brown.

acres were drained for cropland in the U.S. Midwest alone (Hey and Phillipi 1995). Much of the drained acreage later proved unsuitable for agriculture, yet the land's water storage, flood mitigation capacity, and complex, extensive wildlife habitat was dramatically reduced. With a few exceptions, many species of mammals, birds, amphibians, mussels, and fish have not recovered their numbers.

Human activities, past and present, have systematically stripped watersheds of those features that once helped store and slowly release water, dampen flood peaks, and sustain stream flows during droughts. Now connected, incised river systems function as sewer lines, rapidly moving water from the upper to the lower watershed with little water storage, and wetlands are a fraction of their past extent. These changes have severely compromised the ability of human and wild communities to successfully deal with climate change and increased climate variability.

The potential contribution of beavers as partners in helping to mitigate the impacts of climate change, and other environmental problems, such as the rising rate of species extinction, is considerable. Dam building by beavers (Table 1) naturally and economically restores freshwater wetlands, which have been rated as the world's most valuable terrestrial ecosystem in terms of natural services (Costanza et al. 1997). Such services include providing water storage, climate regulation, and wildlife habitat. One species that demonstrates the restorative potential of beavers is the

Table 1. Summary of Contributions Made by Beavers and Their Dams.

Element	*Narrative*
Stream complexity	Dams create ponds of varying depths, add wood to the channel, and create side channels.
Riparian vegetation structure	Rising and more stable groundwater levels result in the expansion and diversification of the riparian woody and herbaceous vegetation on valley floors and along the stream channels.
Species diversity	Expanding riparian, wetland and pond habitats, and habitat edges, plus cooler stream temperatures, result in increased diversity of aquatic and riparian dependent species.
Vegetative ground cover	Elevated groundwater tables improve the vigor of the ground cover and shift vegetation types from drought-tolerant to more water-dependent species.
Floodplain connectivity	Ponds reconnect stream to their valley floor by decreasing the available channel capacity. Valley floors become active floodplains. Temporary flood storage increases, downstream flood magnitudes decrease, groundwater recharge of the valley floor sediments increases, and water tables rise.
Species migration patterns	Elevated water tables, increased groundwater return flows, and ponds restore perennial flow back to intermittent streams and decrease summer stream temperature. Habitat connectivity and complexity in the watersheds increase and fish passage barriers (i.e., elevated temperatures or dry channels) and fish distribution sensitivity to disturbance (i.e., fire, flooding) decrease.
Sediment transport	Ponds and increased riparian woody vegetation stabilize the stream banks, increase their resistance to stream erosion and trap any sediment that enters the stream. Life of downstream reservoirs increases.
Nutrient cycling	Increase in the diversity of plant and animal species expands mineral and carbon cycles in the area.
Water quality	Sediment inputs decrease. Summer stream temperatures decrease. Other improvements are related to nutrient trapping and dissolved oxygen.
Water quantity	Yearly water quantity stays the same but its spatial distribution (groundwater, pond, stream), timing of release and passage through the watershed change. More water is stored during the spring for later release during the summer and fall, or in following years, increasing water availability though not total quantity.
Water storage	Amount of water stored in a watershed increases. Ponds hold surface water behind dams, reconnect streams to their valley floor and change valley floors from terraces back to active floodplains. Water tables rise and summer base flows increase and are cooler. Total amount of water stored may increase over time to some maximum amount as valley floor sediments fill up with water and the elevated water table slows the rate of groundwater flow from the hill slopes to the streams. Groundwater stored in hill slope sediments increases.
Climate change, drought	Water-dependent ecosystems and species become less sensitive to droughts, wet years and climate change.

wood duck. Its population has rebounded from the brink of extinction with the return of just a fraction of the former beaver population.

Rapid restoration of watershed systems is critical for our survival, and the return of abundant, actively maintained and widespread beaver dams is critical to that restoration. The following examples from five different areas demonstrate the role that beavers, and beaver trapping, plays in enhancing or degrading stream and riparian stability, complexity and water storage capability. These five examples show that the influence of beavers is not limited by geography.

Example 1: Upper Mississippi and Missouri River Basins (Hey and Phillipi 1995).

The researchers estimate that beaver ponds covered 51.1 million acres in 1600 compared to 511,000 acres in 1990. This reduction in surface water and groundwater storage has resulted in a huge loss of flood control, and system stability during droughts and years with high precipitation.

Example 2: Kabetogama Peninsula, Minnesota (Naiman et al. 1988).

This study evaluated changes in stream and riparian systems between 1940 and 1986 as a result of beavers returning to the area. Table 2 shows the increase in ponds, wetlands, wet meadows, and moist meadows – indications of increased amounts of surface and ground water stored in the system – during the expansion of beavers and beaver dams in the drainages. While the article does not talk about climatic variability, it is certain that in the 46-year-period there were dry periods and wet periods, yet during that time the amount of water stored increased.

Table 2: Change in Ecosystem Type, Abundance, and Water Stored in the Drainages of the Kabetogama Peninsula, Minnesota Between 1940 and 1986 (Naiman et al. 1988).

Cover type	*Area (acres)*	*Area (acres)*
	1940	*1986*
Forest	8668	0
Moist	531	3378
Wet	69	2542
Pond	40	3388
Total	9308	9308

Example 3: Elk Island National Park in east-central Alberta, Canada (Hood and Bayley 2008).

This study examined changes in the amount of open water during dry and wet years between 1948 and 2002 as a result of the presence or absence of beavers. Both 1950 and 2002 were very dry years. Beavers were absent in 1950 but present in 2002. In 1950 wetlands held 61 percent less open water (565 acres) than in 2002 when beavers were well established (1467.5 acres). The average pond size in 1950 was 9.6 acres compared to 87.7 acres in 2001 (ponds were measured in 1948, 1950, 1996, and 2001). The 2001 values represent a huge increase in the amount of water stored in the system. The beaver dam building and maintenance has made the area much less sensitive to drought as well as helped to decrease downstream flood peaks by increasing the river's rapid access to its floodplain during high flows.

Example 4: Crane Creek, Oregon (Schaffer 1941).

Prior to 1924 beavers were present in Crane Creek and the meadows had stirrup-high native grasses that were sub-irrigated by beaver ponds. In 1924 the beavers were trapped out. In 1925 the channel began to incise and by 1935 the channel had deepened 25 feet. Instead of stirrup-high native grasses, there were clumps of new sagebrush and only sparse remnants of the original grasses, showing how fast channelization and transformation of an ecosystem could occur. In 1936 the beavers were reintroduced, and by 1938 the water table had risen and the hay meadow production had improved. 1939 was a drought year, yet water was abundant on the ranch with beaver ponds, while absent downstream on the ranch without beaver ponds.

Example 5: Price Creek, Montana (Fouty 2003).

This study showed the impact of the trapping of beavers, and their presence, upon water depths (i.e., water stored). Beavers were trapped out between 1994 and 1995, but the beaver dams inside the cattle exclosure were still largely intact and functional in 1995. In contrast, dams were absent downstream of the exclosure (Reach 1), though remnant dams had been noted during the 1994 survey of Reach 1.

Table 3 shows the average water depths and the variability in water depths (standard deviation) in the three reaches in 1995 and 1998. In 1995, the average water depths in Reaches 2 and 3 (beaver-dam controlled reaches) were twice the average depths in Reach 1 (no beaver dams). In addition, the variability in water depths in Reaches 2 and 3 was greater than in Reach 1, indicating more variable channel bed habitat with possible fisheries and macroinvertebrate benefits. By 1998, the dams in the cattle exclosure had either completely disappeared or were actively breaching. Water levels were now similar in all three reaches. Figures 3 and 4 show the visual difference between reaches with and without beaver dams.

Coping with Climate Change

We are entering a period of increased climatic variability. At the same time our demands for surface and groundwater are increasing, the quality and quantity of this resource is decreasing. Groundwater levels continue to drop, perennial streams go seasonally dry, wet meadows transform into sagebrush-dominated systems in the West, and large floods appear to be increasing. Too often the response has been to build more reservoirs, or build more and higher levees along rivers, further confining them. These activities may give us greater control over the short-term but little else. Reservoirs provide little habitat or groundwater storage compared to natural wetlands. Reservoirs often serve only a very few people at the expense of many species and communities. Confined rivers do not recharge water tables or develop complex habitats. Instead, they increase downstream flooding by severing the connection between the river and its floodplain – so there is nowhere to temporarily store water.

Coexisting with Beavers

Common reasons given for keeping beaver populations at a fraction of an area's possible number are that their dams flood roads and properties, and they cut

Table 3. Comparison of the Maximum Water Depths in Price Creek, MT in 1995 and 1998.*

Stream Reach	*Average water depth (ft)*		*Standard Deviation (ft)*	
	1995	*1998*	*1995*	*1998*
Reach 1 (no beaver dam influence)	0.9	0.75	0.36	0.32
Reach 2 (beaver dam influence)	2.15	0.9	0.7	0.42
Reach 3 (beaver dam influence)	1.73	0.8	0.75	0.4

*By 1998 all the dams in the reaches that had been controlled by beaver dams had either totally failed or were failing.

Figure 3. Price Creek, MT (1995). This beaver dam controlled reach is just upstream of Reach 3 in Table 2.

Figure 4. Price Creek, MT (1998). This is Reach 1, downstream of Figure 3. In both 1995 and 1998, this section lacked beaver dams.

down desirable trees. But challenges can be met with a creativity that benefits the beaver, the environment, and human communities. For instance, modern water level control devices are highly effective, and can be installed for an economical and environmentally sound, lasting solution (Brown et al. 2001; www.BeaversWW.org). In addition, a variety of methods are available to protect special trees since beavers rarely engage in clear-cutting. Individual trees, or stands, can be guarded with sturdy fencing for long-term solutions.

At lakeside sites, beavers may use a dock as a roof, and/or dig into Styrofoam flotation material for a cozy den. Using galvanized wire fencing to exclude beavers from beneath docks, and/or wrap flotation blocks, provides lasting solutions. Such fencing can also be staked along the water line at earthen dikes to discourage burrowing.

Education about these good-sized, but amicable animals, and their natural methods of population control, including territorial behavior, is essential. Exaggerations about population sizes are common. Most people are unaware that one colony (family) often builds several lodges, and routinely guards a large territory from strange beavers. Like humans, their footprint can be large even when their numbers are small. Several environmental groups, including the Grand Canyon Trust, Wildlife 2000, and The Lands Council, are involved in restoring beavers to suitable habitats in the West and improving how people perceive beavers through education.

Conclusion

Competition is increasing between communities and groups for water, a limited resource. It is time to systematically and rapidly restore the stability, complexity, and water retention capability of stream and riparian ecosystems. Beavers are key to this restoration.

For beavers to successfully aid us in restoring watershed vibrancy, stability, and complexity, we must first begin to restore riparian woody vegetation (beaver food and building materials) to stream banks, where this is in short supply. In addition, we must change beaver trapping regulations to provide them, and their wetlands, with greater protection.

The return of beavers, and recognition of their contribution, will lead to rapid increases in surface and groundwater storage, improved wildlife habitat, decreased regional flood damage, improved water quality and increased water quantity within a few years. Beavers will not make sense everywhere because of the extent and location of human development. There are, however, large areas of public land with less development where beavers could be allowed greater freedom to expand. Certain private lands exist, too, where beavers would be a welcome addition. These areas would become water storage zones – complex ecosystem reservoirs that would provide huge benefits to many human and wild communities. Proactively identifying suitable sites for beavers, and the acceptable limits of beaver-driven changes, would allow communities to plan how to minimize beaver conflicts while maximizing their benefits (Figure 5).

Time is short. There are many things human and wild communities can live without. Water is not one of them.

Figure 5. This beaver dam, pond, and lodge are located along the Snake River in Grand Teton National Park, Wyoming. Such public lands could be ideal places for more beaver wetlands. Photo: © 2004 Bruce Thompson / Pangraphics

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