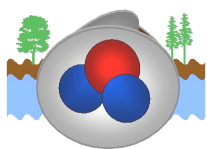


# Beavers and the San Juan Islands

## A Preliminary Review



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“Beavers are keystone species that dramatically alter nutrient cycles and food webs in aquatic and terrestrial ecosystems by modifying their hydrology and selectively removing riparian trees” (Ray et al. 2001). Beavers open the tree canopy, create riparian meadows, build ponds that are shallower and more vegetated than most natural and “dug” ponds, and provide a continual source of disturbance and rotation, producing a landscape mosaic of greater habitat diversity and species richness (Martell et al. 2006; Longcore et al. 2006; Rosell et al. 2005; Elmeros et al. 2003; Wright et al. 2003; Wright et al. 2002; Ray et al. 2001). Beneficiaries include invertebrates, amphibians, fish, birds, bats, and small mammals as well as woody and herbaceous plants (Longcore et al. 2006; Suzuki & McComb 2004; Elmeros et al. 2003; Harthun 1999).

### Ecology of beaver ponds

Beaver engineering reduces overall stream velocity, expands the area of flooded soils, and increases the residence time of freshwater; beaver ponds trap fine sediments as well as nutrients such as nitrates, phosphates, potassium, iron and silica (Gorshkov 2003; Correll et al. 2000; Maser 1998, at 182, 186). In relatively undeveloped landscapes, this process slows the transfer of terrestrial nutrients to the sea, and builds transient patches of concentrated nutrients on the land supporting lush vegetation for decades after abandoned dams disintegrate. In more developed landscapes with roads and buildings, beaver dams reduce the velocity, turbidity and nutrient loading of surface water runoff, thus offsetting the adverse hydrological impacts of hardened surfaces.

Beavers selectively harvest the trees they prefer as food, chiefly *Populus spp* (the alders, quaking aspens and cottonwoods) and *Salix spp* (willows). Beaver foraging opens the canopy temporarily, facilitating colonization by other plant species. It also appears to promote the vegetative propagation of *Populus* and *Salix* (Fustec et al. 2001; Donkor & Fryxell 2000). Indeed, quaking aspens respond to gnawing by producing compounds that make them less palatable to beavers (Basey et al. 1990), facilitating their rapid regrowth. Beaver herbivory does not make trees more nutritious, the way ungulate herbivory affects grasses (Ganzhorn & Harthun 2000), but it is sustainable in the long term.

Beavers also make use of the bark of Douglas firs and hemlocks (Maser 1998, at 187) and feed selectively on shrubs and herbaceous vegetation when available, including salmonberry, serviceberry, salal, deer fern, sword fern, bracken, sedges, skunk cabbage, and pond lilies (*Nuphar polysepalum*) here in the Pacific Northwest (Elmeros et al. 2003; Cowan & Guiguet 1978, at 171). Red maple (*Acer rubrum*) is sometimes eaten but it has chemical defenses that make these trees somewhat less palatable to beavers than *Populus* and *Salix* (Muller-Schwarze et al. 1994).

Plant diversity around beaver ponds tends to be greatest near the edge of their hydrological influence—where there is no standing water but some subsoil wetting—and

tends to increase for several years after the initial flooding (Wright et al. 2003; Ray et al. 2001; Donkor & Fryxell 2000). Selective foraging and inundation alters plant community composition while beavers are present, and alters patterns of plant community succession long after ponds have been abandoned (Longcore et al. 2006; Suzuki & McComb 2004; Wright et al. 2003; Donkor et al. 2000; Schlosser et al. 2000).

While beaver dams may block stream passage for anadromous fish (Elmeros et al. 2003), other fish species rapidly colonize new beaver ponds (Ray et al. 2004), and the overall effect of beavers on fish diversity is positive (Elmeros et al. 2003; Schlosser & Kallemyn 2000; Snodgrass & Meffe 1998), increasing habitat diversity and invertebrate prey. Beaver ponds enhance the growth of Atlantic salmon parr (Sigourney et al. 2006), and the growth and survival of Pacific salmon smolts—coho, particularly (Pollock et al. 2004). This would suggest limiting beaver re-introduction to small watersheds that either lack anadromous fish, or where the topography and hydrology favor dam-topping spring floods capable of flushing young salmonids safely downstream.

Beavers do not enhance species richness under all conditions; their impact varies with the nature of the landscape, including factors such as topography, drainage, nutrient limitations, endemic vegetation, and other sources of disturbance such as fire and logging (Rosell et al. 2005). Beavers have been an integral part of European and North American ecosystems for thousands of years (Boudreau et al. 2005), moreover, increasing the scale and frequency of disturbance in non-fire-dominated plant communities. Just as plants in fire-driven biomes (such as Rocky Mountain Ponderosa pine forests) are well adapted to fires—and some cannot recruit *without* fires—plants in wetter temperate biomes, such as the mixed forests of the Canadian Shield, Great Lakes, and Pacific Northwest, are likely to be adapted to periodic disturbance by beavers. When they were introduced recently in Chile, accordingly, beavers promoted invasive non-native species (Anderson et al. 2006).

## **Beavers in San Juan County**

Speaking of the Cascade and Rocky Mountain foothills in our region, Larrison (1976, at 92) observed: “A characteristic feature of the western mountains are the small to large, flat valleys scattered here and there. These are largely the products of silted-in Beaver ponds. Well-watered, level, and with rich grass growth, these ‘holes’ were most valuable to the early settlers and still offer much of the hay-growing meadows of the hill country.” The extent to which Coast Salish camas gardeners or early European settlers in the San Juan Islands exploited beaver pond soils or “beaver holes” is unknown and tillage gradually destroys the evidence of beaver origins.

We do know that beavers were prized by Coast Salish peoples for their fur, teeth and meat (Suttles 1951), and that beavers were abundant throughout the Salish Sea when British fur traders arrived in the early 19<sup>th</sup> century (Mackie 1997). Beaver skins were the main business of trading posts established by British and American companies from 1820 to 1850 at Victoria, Fort Nisqually, Fort Langley, and San Juan Island.

Beavers are not mentioned in the field notebooks of C.B.R. Kennerly, who made collections of mammals and birds in the San Juan Islands in 1857-60 for the Smithsonian Institution. However, Kennerly was seeking “new” species, and generally took little note of mammals as abundant, commonplace and well described as beavers. There was hardly any need to collect beaver skins for mounting at the national museum, at the zenith of the Pacific Coast fur trade. He did not mention them in journals of his collecting trips on the mainland, either. Beavers are not mentioned in 20<sup>th</sup> century studies of the mammals and birds of San Juan County (Schoen 1972; Miller et al. 1935). Archaeological evidence is scant and would be of questionable reliability as an indication of pre-contact distribution, since Coast Salish peoples prized beaver teeth as chisel bits and “dice”. Teeth would not be left where a beaver was butchered, but carried and traded widely.

It would be surprising if beavers had never colonized the San Juan Islands. They are strong long distance swimmers, more aquatically adapted than most of the mammals regarded today as natives of San Juan County. Beavers have remained widely distributed throughout the Puget Lowlands and Georgia Depression (Eder 2002, at 226; Maser 1998, at 182; Kritzman 1977, at 50) including Vancouver Island (Cowan & Guignet 1978, 172). It seems most likely that fur trappers extirpated San Juan County beavers in the early 19<sup>th</sup> century, perhaps even before Kennerly’s collecting trips. While it is conceivable that the hydrology of San Juan County limited beaver populations historically, beavers have been successful at re-colonized small watersheds on Cypress, Orcas and Waldron Islands over the past decade. If anything, San Juan County stream flows are lower and more seasonal today than they were a century or two ago. Indeed, beavers may play a critical role today in maximizing the “residence” time of fresh water on the islands, in the absence of island snow-packs, and following the extensive draining of wetlands for fields and residences.

There has yet to be a systematic study of San Juan County soils for chemical and structural evidence of past beaver activity. As noted above, beaver ponds act as settling ponds and boost inorganic nutrient loads. The pond bottom becomes a lens of dark silty soil that is especially rich in nitrate, phosphate, potassium, calcium, and iron until plants fully utilize these nutrients over a period of decades. Unlike most “natural” ponds in our region, beaver ponds often become eutrophic, and this phenomenon leaves a record in the species of diatoms left in pond sediments (Boudreau et al. 2005). Furthermore, silt tends to accumulate behind the dam, adding to the ridge of mud and woody debris used by the beavers for construction and maintenance. A “beaver landscape” consists of many rather level silty areas, usually no more than a few acres, and many low ridges or hummocks of silty soil that lack the heavy gravels and cobbles of fluvial or glacial features—decaying and eroding dams. This kind of landscape should be easy to identify on LiDAR imagery but, unfortunately, no LiDAR has been flown yet over San Juan County.

In my 2003-2005 NSF funded study of the evolution of Waldron landscapes, we concluded that the Cowlitz Bay lowland, comprising roughly one-third of the island, was most likely constructed and maintained by beavers, based on large numbers of low, silty ridges and hummocks crisscrossing an otherwise sandy and clay-rich glaciomarine terrain. Fortunately, very little of the Cowlitz lowland was ever plowed or developed, so fine-scale surface features remain. This is not widely the case on the larger islands.

## **Impacts of loss of beavers**

In conclusion, beavers were probably a factor in the hydrology and ecology of the San Juan Islands prior to the arrival of European trappers in the 1820s. They would have made a significant difference in freshwater residence time; beaver ponds would have kept the islands moister in summer, and kept small streams flowing year-round. Moister soils would have favored more cedar, and favored forbs over grasses in clearings. More gentle and continuous streams would have been conducive to spawning salmonids such as coho and chum salmon. Abandoned, dewatered beaver ponds would have been excellent sites for gardens with rich organic soils. The high pre-contact population density of San Juan County—5,000 to 8,000 permanent residents, based on the number of Coast Salish plank houses identified in San Juan County by ethnographic and historical sources—may have been made possible by beavers.

The recent explosion in the number of ponds dug in San Juan County reflects, at least in part, a belief that ponds conserve water and lengthen freshwater residence time—functions previously served by beavers. “Dug” ponds and beaver ponds differ chemically and hydrologically, however. Beavers raise dams up rather than excavating; beaver dams block streams while anthropogenic ponds dig down into the water table. Beavers slow or impound surface water, increasing its residence time. Dug ponds expose groundwater to the air. Both kinds of ponds increase evaporation. But dug ponds are typically dug into an existing shallow wetland underlain with clay, so that there is little infiltration, and they usually lack an outlet other than overflow. Beaver ponds, by comparison, tend to spread water rather than concentrate it in a deep reservoir, and their earthen-and-mud dams seep and leak, helping keep water cooler and preserving some downstream flow. Since beaver ponds are transitory, eutrophic conditions (if they develop) are temporary. Furthermore, since dug ponds involve earthmoving they create excellent habitats for invasion by non-native plants such as reed canary grass, tansy ragwort, thistles and Himalayan blackberry. Beavers raise water levels over living plants instead of uprooting them, and harvest them selectively without removing root masses. This promotes the spread of native plants that are either aquatic or tolerate “wet feet” without creating large mounds of bare earth, dry during the summer, exposed to windblown seeds.

Beaver ponds tend to be more completely vegetated than dug ponds because they are usually shallower, so less submerged soil lies below the photic zone. Vegetation helps keep beaver ponds cool, reducing evaporation; in addition well-established vascular plant communities in beaver ponds consume nutrients and reduce the risk of eutrophication. In turn, the lower likelihood of eutrophication makes beaver ponds better long term habitats for fish and amphibians, which cannot survive low-dissolved oxygen conditions. Beaver ponds periodically return inorganic nutrients to the surrounding environment, when dams flood, break or decay. Dug ponds tend to become nutrient sinks, impounding nutrients indefinitely in sediments unless they are periodically drained and dredged by landowners.

## Beaver re-introduction

In Europe, re-introduced native beavers (*Castor fiber*) have spread widely and increased rapidly, limited only by physical barriers such as mountains or large expanses of farmland (Halley & Rosell 2002), or limited supplies of preferred tree species (Fustec et al. 2001; also see the untested predictive model devised by South et al. 2000). While there have been no reports of adverse ecological impacts other than restricted movement of anadromous fish in some Danish streams (Elmeros et al. 2003), conflicts with human activity and property have been problematic in very densely settled areas such as Bavaria (Schwab & Schmidbauer 2003) and Flanders (Verbeylen 2003): flooding of roads, fields and homes.

The same kinds of issues have recently arisen in Snohomish and King Counties, WA, where burgeoning a beaver population often attracts complaints from landowners. Both counties have responded by providing technical assistance in mitigating the effects of beaver activities, e.g. fencing around culverts to prevent beavers from plugging them (Snohomish County 2006; King County 2006). The Washington Department of Fish and Wildlife encourages the same kinds of management measures, but Washington State law authorizes landowners to shoot a beaver if it is destroying crops, and the State still issues beaver trapping licenses (WDFW 2006). Interestingly, once a beaver dam has been built, however, a State Hydraulic Permit Approval (HPA) is required to modify or remove it.

Beavers construct and maintain wetlands more efficiently than human engineers; they do not depend on funding or paid labor. In the relatively low-relief landscape of the San Juan Archipelago, however, there is little to contain re-introduced beaver populations naturally. Landowners would need ongoing technical assistance to manage any flooding, blocked culverts or gnawed trees. Counter-measures can be simple and inexpensive such as wrapping chicken wire around the trunks of fruit trees, and planting groves of *Populus* near beaver ponds as a preferred food resource. Wire cages protect culverts, and a buried slotted hose or pipe can build a “slow leak” into a beaver dam that beavers cannot repair. Landowners should be made well aware of these tools in advance of beaver introduction.

Landowners that welcome beavers on their property should receive consideration in the county code for recreating or expanding wetlands. There are at least two possible incentives: (1) an offset or mitigation credit; or (2) tax relief. Offsets are problematic to the extent that they trade the destruction of existing wetlands for new wetlands with little or no net gain in total wetland area or processes. They are difficult to enforce, moreover. Tax relief provides an immediate reward to the landowner, and reflects the reality that a beaver-built wetland saves taxpayers the cost of undertaking funded restoration projects. The aim of this paper is not to argue the merits of different incentive schemes, but only to suggest that economic incentives and amendments to the county Critical Areas Ordinance may be prudent, in view of the mixed public response to the spread of beavers elsewhere in Puget Sound.

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