Beavers and Conservation in Oregon Coastal Watersheds

A background paper by
Dr. Wayne Hoffman, MidCoast Watersheds Council[1]
and
Fran Recht, Pacific States Marine Fisheries Commission

Overview

Those interested in salmon and habitat restoration are expressing renewed interest in re-establishing beaver populations as inexpensive "watershed engineers". In many places the type of work that beavers do improves conditions favorable to coho salmon, cutthroat trout and other animals. Their dams also store water that help increase nutrient levels for other organisms in the stream, build up eroded streambeds, release water during the dry seasons, and improve water quality by slowing waters to allow sediment to settle, among other things. However, in Oregon, beavers have been considered a pest as well as a game animal so their protections are limited and their numbers have fluctuated dramatically over time due to a variety of factors. In the central Coast major declines in beaver ponds and dams have been documented in the past 2 decades. This background paper provides a summary of the benefits of beavers, their conflicts with humans, and the policies and conditions that affect their survival. It also provides examples of ways to reduce conflict with humans, and suggests needed legislative actions.

Introduction

Beaver Life History

Beavers are the largest rodents in North America. They reach sizes of up to 100 lbs. (45 kg) and lengths of up to 1m. The largest beavers appear to be at least 3 years old. They are highly aquatic, depending on water for protection from their predators. In the coastal watersheds, they inhabit freshwater lakes and ponds, permanent marshes, rivers, and smaller streams. Beavers living in lakes, natural ponds, and rivers with relatively deep water typically construct burrows in banks, with the entrances under water, and tunnels angling up above the water level. Beavers living in smaller streams build dams to raise water levels and provide protection, both directly and for their burrow entrances. In situations where low-lying terrain does not provide suitable sites for burrows, beavers build "lodges"

[1] This paper was prepared in 2013 as part of a beaver outreach and education project funded by the Pacific States Marine Fisheries Commission's Habitat Program through its Sport Fish Restoration program. For more information contact Wayne Hoffman, mcwc@midcoastwatershedscouncil.org, 541-265-9195

which are large mounds of logs and sticks, generally surrounded by water, with the burrows constructed within them. Lodges are rare in the coastal watersheds, probably because most areas have suitable sites for bank burrows. The ability and propensity to build dams appears to be contingent on the habitat occupied; i.e. the non-dam-building beavers from deep water habitats may build dams if they move into smaller streams where dams are advantageous.

Beavers are herbivorous, and eat a variety of herbaceous vegetation, as well as the cambium layers of trees and woody shrubs. They do not normally eat meat or fish. On the Oregon coast, willows, Vine Maple, Western Red Cedar, and *Rubus* species (particularly Salmonberry and Himalayan Blackberry) are prominent among the woody food plants. Cottonwoods are favored, but currently are not common in most of the coastal watersheds. Other trees such as Red Alder and Sitka Spruce are less favored as food, but are often cut down for dam-building materials.

Beavers generally form monogamous pair bonds, and produce single litters of 2-4 young per year. A mature family group typically consists of an adult pair, their yearling offspring, and their sub-yearling kits. Generally by age 2, young beavers are driven from the parental colony and disperse looking for suitable habitat to establish new colonies.

Ecological roles

The ecological roles of beavers vary greatly depending on the types of habitat they occupy. The primary ecological roles of beavers in mainstem and lake habitats may be manifested through their consumption of riparian vegetation and harvest of riparian trees, and by their construction of dens, which may be used by other wildlife. In contrast, beavers that construct ponds profoundly influence their habitat. For the Oregon coastal watersheds, the ecological influences can be seen in beneficial modifications of fish habitat, habitat for a variety of other wildlife, in patterns and amounts of primary and secondary productivity, in nutrient cycling and nutrient distribution, and in stream hydrology and interactions between the stream and shallow groundwater resources.

Salmonid habitat. Among Oregon coastal salmonids, Coho Salmon and Cutthroat Trout particularly benefit from beaver pond habitats. Coho Salmon typically have a three-year life cycle, with egg laying in gravel beds in fall or winter, fry emergence in spring, freshwater rearing for 12-14 months after emergence, and then migration to the ocean for about 18 months of rapid growth and maturation before returning to spawn and die. Historically Coho showed a great diversity of habitat use and migration patterns in the period between fry emergence and smolting. Some juveniles remain near the spawning beds and live in small-stream habitats for this whole period, until they are ready to migrate down to the marine environment. Others move downstream shortly after emerging from the gravel and rear in lakes, larger mainstem streams, or marshy habitats as available. Still others remain in headwaters streams through the summer but move elsewhere during their first fall, seeking better

winter habitat. One of the consequences of recent anthropogenic landscape modification (e.g. wetland drainage, stream channelization, and pasture establishment in floodplain areas) is loss of much of these alternate rearing habitats, and restriction of Coho rearing more and more to headwater stream habitats. In smaller headwater streams, beaver ponds often provide superior rearing conditions than unimpeded streams. Beaver ponds have much greater surface area than the equivalent un-dammed stream channels, and have much greater carrying capacity for juvenile Coho. In addition, they provide more food and support faster summer growth rates. Headwater stream habitats are particularly challenging for juvenile Coho in winter. Low water temperature reduces metabolic efficiency and rate of digestion, so the fish do not feed much. At the same time, high winter flows challenge the fish to find off-current habitats so they do not have to spend the winter swimming against the currents. Beaver ponds provide high-quality wintering habitat, as the current is greatly reduced, and much cover is generally present. Ponds may also remain a bit warmer than adjacent streams in winter on the Oregon Coast. Fish wintering in beaver ponds and other slack-water habitats do not need to spend the winter swimming against the current, and may feed more than fish in stream habitats. They then emerge from the winter larger and in better physical condition than juveniles wintering in flowing stream habitats.

Much research, primarily with hatchery Coho, has demonstrated that size at smolting, is highly correlated with ocean survival and return rates of adults. In other words, larger smolts in better physical condition coming from beaver ponds, lakes, and other slack-water habitats do better in the ocean and return in higher numbers. Thus beaver ponds not only facilitate production of more pre-smolts, but also higher-quality smolts that may survive better to return to spawn.

The role of beaver ponds in Coastal Cutthroat ecology is less clear, however ponds tend to be inhabited by larger trout than adjacent stream reaches.

Other wildlife habitat. Beaver ponds provide important habitat for several species of waterfowl. In coastal Oregon Wood Ducks and Hooded Mergansers are the species most benefitted by beaver ponds through the summer, but the ponds are also used by Mallards, Ring-necked Ducks, Buffleheads and other species in winter. Beaver ponds also provide important breeding habitat for some amphibians, including Red-legged Frogs, Pacific Tree Frogs (aka Pacific Chorus Frogs), Rough-skinned Newts, and Northwestern Salamanders. They are also used by many other birds and mammals as sites for drinking, bathing, and foraging.

Nutrient cycling and distribution. The primary sources of organic nutrients (organic nitrogen compounds and phosphates) in coastal streams are detrital, including fallen leaves, conifer needles, carcasses of spawned-out salmon, and animal fecal material deposited or washed into the streams. These nutrient sources collect in the streams, and typically are transported downstream variable distances before lodging and becoming available to the stream food webs. The leaves and particularly the conifer needles are slow-release nutrient sources that feed the biota gradually over periods of months to a few years. Salmon carcasses are used typically over periods of weeks, and fecal material

tends to be mobilized on a scale of hours to a few days. The slower-release nutrient sources are particularly important for the periphyton and planktonic algae at the base of the food web. Salmon carcasses provide critical nutrients to the riparian forest when they are pulled out of the stream by animals, and tend to be fed on in the water by a variety of invertebrates as well as by fish, birds, and mammals. Fecal material can promote algal and bacterial blooms when abundant, but these quick pulses of productivity are less useful to the food web that supports juvenile salmon than the more sustained fertilization from the slower-release sources.

Because the detrital nutrient sources tend to be transported downstream, nutrient concentration and availability increases systematically from the headwaters down into the lowlands. Headwaters tributaries can be quite nutrient-limited (oligotrophic), and lowland reaches may be enriched (eutrophic) to the point that water quality suffers. The extent of this downstream nutrient transport is affected by channel complexity in the stream network. Complex channels provide more opportunities for lodging of these nutrient sources, raising nutrient availability in the headwaters, and slowing the excess accumulation in the lowlands, thus providing a greater extent of healthy food chain productivity within the stream network. The widespread simplification of stream channels in the past 160 years has tended to facilitate downstream movement of nutrient sources, particularly leaves and salmon carcasses. Beaver ponds are the premier nutrient traps in headwaters streams, effectively sequestering leaves and other nutrient sources high in the system where they are most needed.

Primary and Secondary Productivity. As just noted, food webs in coast-range streams are primarily detritus based. Some of these nutrient sources are consumed directly by macroinvertebrates (e.g. aquatic insects that chew up and ingest the tissue of decaying leaves) while the remainder tend to be consumed by bacteria and aquatic fungi, with some leakage of organic nutrient molecules into the water to be used by primary producers, periphyton, planktonic algae, and aquatic vascular plants. Beaver ponds provide conditions for greater primary productivity both by increasing organic nutrient availability and by allowing sunlight to reach more water surface for photosynthesis. The increased primary (photosynthetic) production in turn stimulates more secondary production by the micro- and macro-invertebrates that form the food base of juvenile salmonids.

Hydrological modification. Obviously, beaver ponds modify the hydrology of the streams. That is really why beavers build ponds – to provide deeper pooled water that gives them refuge from terrestrial predators. However, the hydrological effects of the ponds extend far beyond just providing deep water. On our coastal systems (and especially on the predominant Tyee formation sandstones), streams are fed by shallow groundwater tables that are extensively depleted each summer, and recharged by winter precipitation. Beaver ponds slow and extend this groundwater flow into the streams, maintaining a higher water table into and through the summer. This tends to reduce stream flows in the spring, but maintains higher flows through the summer, to the benefit of the juvenile fish and other stream biota. The higher summer water table in the adjacent riparian areas also benefits riparian vegetation, by improving conditions for more water-dependent species. The ponded water also

raises hydraulic head, which in appropriate substrates can increase the cool underground (hyporheic) flow, benefitting stream conditions downstream.

Temperature Effects. Summer temperatures exceed levels suitable for juvenile salmonids in many coastal streams. Much of the restoration efforts directed at salmon habitat in these streams is directed at increasing shade to reduce summer peak temperatures. Because large beaver ponds provide more surface area for sunlight to reach the stream, the concern is often raised that ponds exacerbate temperature problems. Large ponds do receive increased solar radiation, and their surface waters do warm substantially in summer, often to levels above water quality limits set for salmonid health. However large ponds generally stratify, with cool water pooled under the warm surface, separated by a sharp thermocline. This cooler deep water provides refuge for fish during the warm parts of the day, and the fish can feed in the more productive upper waters during the nights and mornings, before midday heating. In addition, during summer much of the flow downstream from a beaver pond is through the dam from the bottom of the pool, reducing downstream temperature effects. And, of course any hyporheic flow promoted by the dam would be cool water from the bottom of the pool. Small beaver ponds generally do not increase surface area enough to have major temperature effects.

Beaver legal protections

Though some federal laws acknowledge the importance of the habitat created by beaver dams for salmon and other fish and seek to protect the habitat, implementation of these laws to protect habitat is still weak. This is aggravated by other laws that not only do not protect this habitat, but actively promote the killing of beavers as pests. For example, one law in Oregon (ORS 496) designates beavers as furbearers, which allow beavers to be hunted with no bag limits, and records kept only at the county level. Another law in Oregon (ORS 610) considers beavers a “predatory animal”, similar to the U.S. Department of Agriculture law which considers beaver a “varmint”. Both the “predator” and “varmint” designations allow and even encourage anywhere, anytime control (with no record keeping required). More discussion of the state laws is found on page 14.

Under the federal Endangered Species Act (ESA) the “take” of a species (i.e. killing or harming of a listed species, including harming the habitat on which the species depends) is prohibited. The habitat on which the species depends for survival and population recovery and where take is prohibited is called “critical habitat”.

Critical habitat maps and descriptions have been prepared for Oregon’s threatened coastal coho salmon. Beaver dams, depending on location and type of service they may provide for coho, may be protected under ESA. If a beaver dam/pond is in critical habitat area, and has the characteristics noted as a Primary Constituent Element (see below), destroying the dam or the beavers necessary to maintain that dam would be unlawful.

Primary Constituent Elements of coho habitat include:

Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks. These features are essential to conservation because without them juveniles cannot access and use the areas needed to forage, grow, and develop behaviors (e.g., predator avoidance, competition) that help ensure their survival.

(see Endangered Species Act (ESA) Primary Constituent Elements http://www.nwr.noaa.gov/Publications/FR-Notices/2008/upload/73FR7816.pdf page 7832 middle)

Under the Endangered Species Act (ESA) federal agencies (or other entities that have funding from federal agencies) are required to consult on their activities to avoid harm to listed species (these are called “Section 7’ consultations). State and private take prohibitions also apply and activities would be permitted (or not) under what is called a “Section 10” permit.

However, to date, there have been no consultation s between U.S. Dept of Agriculture, Oregon Department of Agriculture, Oregon Department of Forestry, Oregon Department of Fish and Wildlife (or any other agency) and the National Marine Fisheries Service (NMFS) regarding their beaver removal actions and policies. Failure to consult may result in loss of federal dollars or delays in project activities.

Essential Fish Habitat and Habitat Areas of Particular Concern

Essential Fish Habitat (EFH) is habitat described by the NMFS and the Pacific Fishery Management Council under the provisions of The Magnuson-Stevens Fishery Conservation and Management Act (MSA). EFH is described by species and includes all types of aquatic habitat where federally managed fish (such as coho) spawn, breed, feed or grow to maturity. The EFH description for coho identifies “Beaver removal and habitat alteration" as a threat to salmon.

If a federal agency is undertaking an action in an area designated as EFH they must consult with NMFS on those actions. The agencies receive management guidance back from NMFS to avoid harming the habitat. Tribal, state and private entities are not required to consult with NMFS, except when receiving federal funding for their work.

Certain habitats, called HAPCs (habitat areas of particular concern), may also be described under EFH. These HAPCs don’t have any special regulatory authority under the MSA, but help to focus attention during the consultation process. A proposed HAPC for salmon, (which may be adopted if accepted by the Pacific Fishery Management Council in June or November 2013) is called "Complex

channels and floodplain habitats". Beaver ponds are specifically identified within the description of this HAPC, noting a link to higher densities, growth rates and overwinter survival rates for Coho Salmon. The loss and/or isolation of these habitats is a threat noted in this HAPC description.

Trends in coastal beaver populations

Incidental observations by several of the MidCoast Watersheds Council's cooperators over the past 15 years noted disappearance of beaver ponds, particularly the large winter-persistent ponds, from a number of streams in the region, and led to suspicions of a substantial region-wide decline. Beginning in 2006 the MCWC and cooperators, particularly Bio Surveys LLC, undertook more comprehensive surveys to determine the extent of any changes in numbers and sizes of ponds. In the three areas of the MidCoast region surveyed, results were compared directly to numbers of dams and ponds counted on the same streams during Aquatic Habitat Inventories (AHIs) during the 1990s. The AHIs were conducted in different years on different streams, during a period of about 8 years, mostly 8-14 years before the recent pond surveys.

It needs to be stressed that the recent surveys counted dams and ponds, not beavers, and were only conducted in wadeable streams. No attempts were made to actually census beavers or estimate beaver populations. Further, no attempt was made to assess beaver populations or occupancy of larger mainstem streams or lake environments. The trends described below apply only to beavers occupying wadeable streams where dam construction by beavers is feasible.

One survey area was the upper portion of Five Rivers basin, tributary to the Alsea River. The survey included Five Rivers and all perennial tributaries above the confluence of Buck Creek, except for Crab Creek and Green River. The survey was done by Bio Surveys LLC as part of a Limiting Factors Analysis of upper Five Rivers to assess restoration needs. Crab Creek and Green River were excluded because they had already received extensive restoration treatment in earlier projects. The AHIs in upper Five Rivers recorded 71 beaver ponds (recorded in the data as "step over dam" followed by "beaver pond"). Complete foot surveys in 2007 recorded only 3 dams and ponds.

The second survey, in the upper part of the Yaquina Basin was also done by Bio Surveys LLC as part of a Limiting Factors Analysis. The 100k GIS streams layer includes 47.2 miles of streams in this area. The AHIs from the 1990s recorded 128 beaver dams and ponds, and surveys in 2007 found 20 in the same stream reaches.

The third survey was conducted in 2006 and 2007 in the rest of the Yaquina Basin by MCWC, using funding from a program to hire commercial salmon fishermen (trollers) whose livelihood was impacted by the fishing closures put in place to protect endangered California salmon runs. The trollers located 227 dams in 56.7 miles of stream surveyed. Some of these streams did not have prior AHIs, but of the streams that had both 2006-07 beaver pond surveys and earlier AQIs, the number of dams was 150, compared to 180 in the AHIs, a less dramatic decline than in the other areas, but still statistically

significant. The 2006-07 surveys also measured the dams and ponds, and found that the average dam heights and pond sizes were significantly smaller in 2006-07 than in the AHIs. Dam heights averaged 0.44m on the 2006-2007 surveys as compared to dam heights measured in the AHIs of 0.68m, and average pool length also declined from 49.4m in the AHIs to 29.4m in the surveys. So, not only were there fewer ponds, but there were also fewer of the large sturdy dams that create the deeper, winter-persistent ponds that provide the most ecological benefit to the system.

Bio Surveys LLC also conducted beaver pond surveys while doing summer snorkel counts of juvenile Coho Salmon in the 320 stream miles in the five rivers of the Tillamook Basin in 2006 and 2007. They found a total of 136 dams and ponds in 2006, and only 113 in the same streams in 2007. Much of the decline resulted from breaching of dams and loss of ponds in the Tillamook River basin. These were large dams that had persisted for multiple years but that lacked signs of beaver presence in 2006. Many of the remaining dams in that basin also appeared untended, and on a trajectory to breaching.

Possible causes of decline in numbers of beaver ponds.

The cause(s) of the decline documented above are not known with certainty, but seven hypotheses are available. Likely several of these have contributed to the decline, and likely different ones are more important in different basins.

Hypothesis 1: Natural Population Fluctuations. Beavers are rodents, and many rodent species (also rabbits and hares) inhabiting temperate to arctic habitats have spectacular cyclic fluctuations in population numbers. These tend to have very regular periodicity (e.g., 4-year cycles for many voles and lemmings; 9-11 year cycles for some hares) and possibly have internal drivers such as hormonal changes caused by crowding or reduced food quality. These kinds of cycles have not been well-documented in beavers, and if they do occur, the period of the cycle may be as long as a few decades.

Hypothesis 2: Forest Succession. Over the period since the early 1990s, clearcutting has largely ceased on National Forest lands in Oregon coastal watersheds, and residents commonly attribute declines in beaver occupancy in smaller streams in these areas to the succession of the forest toward mature conifer forest, which provides much less food for beavers than the more open early successional communities that followed tree harvests. One problem with this hypothesis is that similar declines have been documented on industrial timberlands that are being managed on progressively shorter rotations, so this is unlikely to be the whole cause.

Hypothesis 3: Disease. The infectious disease Tularemia, caused by the bacteria *Francisella tularensis*, is known to infect beavers and sometimes to cause mortality. Other infectious diseases are likely to affect beavers as well, and on occasion dead beavers have been found along coastal streams that showed no signs of trauma, suggesting disease as a likely cause of death. Epidemic-level outbreaks of tularemia have not been documented in the Oregon Coast Range, but are certainly possible. The

simultaneous depopulation of whole stream reaches with multiple dams and ponds is consistent with infectious disease outbreaks.

Hypothesis 4: Trapping and Shooting. Under authority of ORS 496, Oregon has a legal winter trapping season for "furbearers" including beavers. Participants are required to purchase a license and to report the animals trapped, but these results are only reported and summarized by county, making it difficult to correlate trapping activity to changes in populations in particular streams. Sport harvest results reported by ODFW for 2010-2011 for coastal counties are summarized in Table 1. The numbers reported for the five entirely coastal counties are summarized separately from the numbers from Lane and Douglas counties, because the latter undoubtedly include take from interior as well as coastal areas. So for that year overall reported coastal take was somewhere between 800 and 1500 animals.

In addition, another Oregon statute (ORS 610) classifies beavers as "predatory animals" and allows private property owners to kill them on their own property (and also to allow others access for that purpose) at any time of year, and by the means of their choice, with no reporting obligations. The lack of reporting requirements greatly complicates rational management . The magnitude of this take is completely unknown, but in some areas is likely to be significant. Further, some parts of the Midcoast area have had a history of (illegal) shooting of beavers, generally at night, using spotlights. So overall it is not possible to accurately assess the amount of deliberate human take, nor its geographic distribution within coastal watersheds.

Table 1. Beaver sport trapping results for 2010-2011 season (from ODFW)

County	Clatsop	Tillamook	Lincoln	Coos	Curry	total	Lane	Douglas	total	grand total
numbers	257	219	115	197	1	789	265	282	747	1536

Hypothesis 5: Increased Cougar depredations. Since use of dogs for Cougar hunting was banned by Oregon voters in 1994, Cougar populations have expanded greatly in the Coast Range and elsewhere in the state. Cougars are known to include beavers in their largely mammalian diet, so they may have contributed to the declines in smaller stream systems. Like other top-level predators, individual Cougars may tend to specialize on particular prey animals within the array of species taken by the population as a whole, and an individual that has learned to specialize on beavers might well be able to catch most of the individuals in a local area. This hypothesis is popular among residents of rural areas on the coast.

Hypothesis 6: Reduced food supply. It is widely believed that beaver populations are capable of eating most of the palatable food in the area surrounding a colony, and that colonies then "move on." Then, when food supplies regenerate, the beavers will recolonize. In some parts of the Midcoast area, streamside flats that formerly were beaver ponds have become colonized and dominated by Reed Canary-Grass (Phalaris arundinacea) an aggressive invasive. Reed Canary Grass often grows so thickly

that it prevents establishment of the native plants that provide beaver forage. So whatever the cause of beaver disappearance from a pond site, this grass does appear to be preventing re-establishment of food suitable for beavers.

Hypothesis 7: Reduced supply of building materials. In some places that formerly had large persistent dams and ponds, the only dams found are low dams constructed of small-diameter and relatively soft materials such as salmonberry stalks, along with mud. These dams normally blow out during the first fall rainstorm. In addition, sites dominated by Reed Canary Grass usually do not grow any woody vegetation suitable for dam building.

As noted above, several of these hypothetical causes may have contributed to the decline in beaver dam-building activity in coastal watersheds. Cougar depredations are very likely to contribute. History tells us that human trapping and other take is capable of extirpating beaver populations, although we lack data to tell how intense human pressure is in this area. The forest succession and reduced food supply hypotheses are strongly supported in some local areas, but are unlikely to be important in some others. Disease remains a plausible hypothesis, but without a lot of local evidence. Shortage of building materials is known to be an issue where reed canary grass dominates, but declines due to other food and building material shortages are still speculative. Fluctuations due to natural population cycles also remain speculative.

Possible Age Structure Changes

The lower frequency of large, winter-persistent dams and ponds is suggestive of changes in the beaver population age structure. In particular, it is likely that older adult beavers are responsible for the development and maintenance of these larger structures, and if there were higher mortality of adult beavers, the population might become skewed toward smaller, younger beavers, incapable of building and maintaining the higher and longer dams necessary for large ponds. Of the various hypothetical causes of decline, number 4, trapping and shooting, and number 5, increased cougar depredation, plausibly could target larger animals. Some trapping sets are designed to challenge beavers' territoriality, and tend to catch the largest males first, and trappers possibly favor large pelts. Cougars are adapted to capture relatively large prey, and likely are very capable of killing even the largest beavers without difficulty, but data on their prey-size preferences are apparently not available.

Potential Conservation Actions to benefit dam-building beavers in coastal Oregon.

A variety of actions are possible that might lead to increases in the number of beaver dams and ponds, and particularly numbers of large winter-persistent dams. These can be grouped into three categories: Actions to improve habitat for beavers; actions to increase human tolerance of beavers,

hence reducing take as nuisance animals; and changes in Beavers' legal status to afford greater protection. The first two categories can be addressed at local and regional levels, while the third would likely require state-wide organization.

Beaver conservation and watershed restoration.

The three most pervasive restoration actions currently undertaken in Oregon coastal stream habitats are restoration of native riparian vegetation, restoration of passage at road crossings, and placement of large wood (trees, logs) into streams to improve channel complexity. It is possible to affect habitat for beaver in all three restoration categories, positively or negatively.

When restoring native riparian vegetation choices are made about which species to plant. Where beaver ponds are appropriate and desired, planting favored beaver foods is helpful. Where beavers are not wanted (e.g. banks of larger streams that would not be dammed) planting more of species that beavers do not eat can reduce beaver damage to the plantings. Planting approaches to benefit beavers are described in the next section.

When restoring passage, a variety of approaches are available to reduce conflicts with beavers, described below under "Actions to increase tolerance."

When placing large wood, some of the project goals (increasing channel complexity, increasing number and surface area of pools, aggrading the stream bed, sediment capture) are very similar to the ecosystem functions provided by beavers. In the absence of large wood beavers can improve habitat in small, low-gradient streams by dam-building, but they are limited by gradient, velocity, and stream size. The presence of adequate large wood extends the range of stream habitats beavers can use and effectively create better habitat through dam-building. Of course, large wood improves salmon habitat even in the absence of beavers, but the combination is particularly effective. Designing large wood structures to benefit beavers is addressed further in the next section.

Actions to improve beaver habitat.

Suitable habitat for beavers needs to supply the plant food beavers eat, including a variety of herbaceous plants, as well as bark and cambium of trees and wood shrubs. It also needs to provide aquatic refuge from terrestrial predators and suitable den sites. In small, low-gradient streams beavers also need adequate supplies of dam-building materials, particularly woody vegetation of sizes the beavers can transport.

Colonizing beavers are typically young animals, 1-2 years old. When they arrive in uninhabited small streams, they need to find refuge sites to allow them to survive until they have built dams and

raised water levels enough to provide protection. Steve Trask (Bio Surveys LLC) has experimented with creating pockets within constructed log jams that beavers might be able to use. He has also designed log structures in ways that might serve as foundations for dams.

The other approach to improving beaver habitat is to manage streamside (riparian) areas to improve the food supply. In particular, when riparian plantings are designed, it makes sense to determine whether beaver ponds are appropriate to that stream reach, and if so, to plant tree and shrub species that provide preferred beaver forage and building materials. Conversely, in places where beaver dams and ponds are not feasible, nor desired, plant species can be selected that are less palatable to beavers. Preferred beaver foods include, among other Oregon coastal plants, willows, cottonwoods, vine maple, and *Rubus* species (blackberries, salmonberries, thimbleberries). Alders are favored building materials, but less desired as food. Western Red Cedar is favored as a food, but grows too slowly to provide long-term benefit as a food supply (if available it is eaten quickly, and does not re-sprout). Nine-bark is generally not eaten by beavers and is a good choice in places where beavers are not desired or will not improve fish habitat (e.g. mainstem bank plantings).

One particular issue on the coast is the colonization of floodplain areas with Reed Canary Grass (RCG), which is an aggressive invasive plant, and which outcompetes seedlings of the plants beavers prefer to eat (and are needed for healthy, shaded riparian areas). Areas dominated by RCG are essentially stuck in an early successional stage, unable to progress to the woody communities that otherwise would grow there. RCG is also not favored beaver food, and is not good dam-building material. It is possible to establish woody vegetation in these areas by clearing the grass down to mineral soil , planting large nursery stock with mats and caging or fencing, and providing grass control for 3 years, until the trees and shrubs are taller than the grass can get. RCG needs full sun for most aggressive growth, so once a canopy is established above it, other plants have an opportunity to colonize under it. The MCWC has used excavators for initial grass removal and mechanical cutting for the three years of control. Herbicides treatments may also work, if an appropriate treatment schedule is developed and if the chemical is approved for streamside application.

Actions to increase tolerance

If coastal ecosystems are to fully benefit from the actions of dam-building beavers, means are needed to increase the tolerance of people for beavers and beaver ponds and dams. Beavers can truly be nuisances, and too often the response has been to eliminate the beavers. Two approaches, used together, can be successful in promoting tolerance of beavers and their constructions. The first is education and outreach, to teach people that the beavers are not *just* pests, but do provide the ecosystem services described above. The second approach is to use technology that prevents the beavers from causing as much damage as they otherwise would.

The main ways beavers damage human property and possessions are 1) by eating trees and other plants that people value, 2) by using culverts as dam sites, thus threatening to wash out roads, and 3) by flooding areas that people do not wish to have flooded. All three can be alleviated with simple technological fixes.

Valued trees can be protected with wire mesh caging or wrapping of trunks. We prefer wire mesh fencing that is sturdier than chicken-wire. For trunk protection, wire wraps need to be placed so that they can expand over time, and not strangle the trunk. For gardens and groups of trees, perimeter fencing will work better. Perimeter fencing needs to be dug unto the ground to prevent beavers pushing under it, but does not generally need to be very tall.

Several methods have been devised to prevent culvert plugging. First, if the upstream end of the culvert is sloped back (beveled), rather than cut vertically, beavers may be able to build a low dam but generally cannot fully plug the culvert, threatening the road fill. The resulting dams, however, might significantly impede fish passage. Second, in places where beavers want to block undersized culverts, replacement with bridges can be considered. Third, a welded wire cage can be built around the culvert mouth. Several designs are available. One such one is called a "Beaver Deceiver", a trapezoidal cage, based on the theory that beavers are less capable of damming flow when that flow is at an acute angle through the structure than when it is perpendicular. See the short video: How does a Beaver Deceiver Work? http://www.youtube.com/watch?v=WTo4GchSHBs . These cage structures may need periodic maintenance, particularly trash removal. One issue with the Beaver Deceiver approach is that the device itself can be a barrier to upstream migrant fish. A lower-tech approach that generally does not block fish passage involves placing wooden fence posts in a u-shaped arrangement above the culvert mouth, to provide a foundation for the beavers to use. The result will be a beaver dam just upstream of the culvert that does not block it. This can remove the threat to the road, and also allow the pond to remain. This solution is only appropriate for sites where the road fill is not threatened by a low dam, i.e. where the road bed is of adequate elevation above the stream and the road fill is well-built and stable.

In some places small to moderate-sized beaver ponds can be tolerated, but larger ponds cause conflicts with human land uses. Technologies have been developed to control maximum water levels in beaver ponds. The simplest of these involve a horizontal pipe placed into the dam and extending well out into the pond, at a tolerable water level. Generally, the upstream end of the pipe should be enclosed in a wire mesh cage to prevent plugging, either by the beavers or by floating debris. This cage may need occasional cleaning. A good DVD is available that shows construction techniques for these water leveling devices and other measures: *The Best Beaver Management Practices* http://www.beaversolutions.com/ .

The Issues with Beaver Translocation

When an area lacks or has lost beaver pond habitat, relocation of beavers is often proposed as a solution. This potential has made relocation attractive to people experiencing beaver problems (plugged culverts, flooding, tree loss) who see translocation as a win-win; i.e. they get relief from their beaver problems without having to kill them, and get to assume that the beavers are benefiting the ecosystem somewhere else. ODFW developed its relocation policies to address potential problems caused by relocations, such as disease transmission, and research has generally shown short-term mortality rates greater than 50% for translocated beavers. On the Oregon coast, it appears that beavers are still common enough that recolonization should occur naturally, provided the habitat is to beavers' liking. One important point to consider is that ODFW's policy discourages inter-basin relocations. The Willamette Valley has more human-beaver conflicts than the local basins, any organization planning relocations in this area is likely to get pressure to take Willamette Valley beavers, against the policy. On the Oregon coast, a focus on habitat improvements to facilitate natural recolonization seems more likely to succeed.

In the South Umpqua, Oregon and other areas, beaver groups released into human-built lodges that provide predation protection until the beaver family is established in a new area, may increase survival rates.

Possible Changes to State Statutes/Rules to provide protection for beavers, dams, and ponds.

As noted above, Oregon statutes are somewhat contradictory in their treatment of beavers. In ORS 496 (wildlife laws) beavers are included in the definition of "Fur-bearing mammal," and ODFW is given authority to set seasons and license requirements, and regulate gear for trapping (License fees are set by the legislature). However, ORS 610 includes "rodents" in its definition of "predatory animals" and as rodents, beavers are included in this definition. ORS 610 gives landowners authority to shoot, trap, poison, or otherwise dispose of "predatory animals", and ORS 496.162(3) explicitly bars ODFW from regulating such activity. In practice, Oregon holds that beavers are furbearers and subject to ORS 496 when on public land, and are "predatory animals" and subject to ORS 610 when on private land. Legislative resolution of this inconsistency might be advisable.

Several possible changes to statute are described below, and the relevant sections of statute follow in Attachment 1.

1. The simplest alteration would be to change ORS 610.002 (definition of "predatory animals") to exclude beavers, thus making their status consistent as fur-bearers across the state.

2. It might also make sense to rewrite ORS 610 to change "Predatory animals" to "nuisance animals" (as beavers and other herbivores are not predators by definition) and making a list of the species to be considered nuisances, leaving off species such as beavers (where non-lethal methods are effective deterrents) and such species as the Washington Ground Squirrel which is listed as federally endangered and the Red Tree Voles which are candidates for federal listing, so as to avoid conflicts with species recovery efforts. Federal listing trumps ORS 610, but it might make sense to give ODFW rule-making authority to support recovery efforts even though these are "predatory" rodents.

4. ORS 496.012 (Wildlife Policy) sets policy to prevent "depletion of any indigenous species and to provide the optimum recreational and aesthetic benefits for present and future generations of the citizens of this state," and provides 7 directives to implement this policy. This policy is single-species based and utilitarian in focus, and it might be useful to propose modifications to recognize ecological roles (e.g., keystone species) and values to other game species (e.g., salmon).

5. ORS 496.270, under the heading "FISH AND WILDLIFE HABITAT IMPROVEMENT" establishes immunity from liability for actions designed to improve habitat, including large wood placements, among other activities. It may be worth analyzing how this liability limitation applies to actions to encourage dam building by beavers, and if appropriate to expand coverage.

In addition to these changes in State rules and policies, it is critical that state and federal agencies need to acknowledge their obligation to consult with NMFS under the Federal Endangered Species act to avoid take of coho salmon by impacting necessary beaver ponds in critical habitat areas. A

Summary

Beavers can play a significant role in restoring Oregon's coastal watersheds for coho salmon and cutthroat trout. Public education, streamside planting, simple technological fixes, and policy changes are necessary to re-establish and maintain beaver populations.

Other publications for useful background and information:

American Fisheries Society Symposium: The Hydrologic and Geomorphic Effects of Beaver Dams and their Influence on Fishes.
http://www.albergstein.com/cao/Best%20Available%20Science/Fish/Beaver%20dam%20effects%20paper%20final.pdf

Boyles, S.L. and B. A. Savitsky. 2008. An Analysis of the Efficacy and Comparative Costs of Using Flow Devices to Resolve Conflicts with North American Beavers Along Roadways in the Coastal Plain of

Virginia. Proc. 23rd Vertebr. Pest Conf. (R. M. Timm and M. B. Madon, Eds.) Published at Univ. of Calif., Davis. 2008. Pp. 47-52

Buckley, M. et al. 2011. The Economic Value of Beaver Ecosystem Services: Escalante River Basin, Utah EcoNorthwest. www.econw.com.

Dyrdahl, S. 2013. Restoration of aquatic habitats dominated by Reed Canarygrass in the Mid-Willamette Valley. (PowerPoint presentation) Calapooia, South Santiam, and North Santiam watershed councils.

Hood, W.G. 2012. Beaver in Tidal Marshes: Dam Effects on Low-Tide Channel Pools and Fish Use of Estuarine Habitat. Wetlands (online) DOI 10.1007/s13157-012-0294-8.

NOAA Technical Memorandum NMFS-NWFSC-118. June 2012. Scientific Conclusions of the Status Review for Oregon Coast Coho Salmon (Oncorhynchus kisutch)

ODFW. Living with Beaver : Beaver Bibliography; Landowner Incentives and Tolerances for Managing Beaver Impacts in Oregon http://www.dfw.state.or.us/wildlife/living_with/docs/beaver.pdf
http://www.dfw.state.or.us/wildlife/living_with/beaver.asp

Beaver Solution video (eastern WA)
http://www.youtube.com/watch?v=wI5AjJd00cM

ANON. (undated). The landowners guide to non-lethal Beaver Solutions -how to help beavers and benefit from them at the same time.
http://www.wildearthguardians.org/site/DocServer/Publication_APNM_Beaver_LandOwners_Guide.pdf?docID=862&AddInterest=1059

News article: Beaver nation: the struggle to co-exist (Oregon)
http://www.corvallisadvocate.com/2012/beaver-nation-the-struggle-to-co-exist/

Attachment 1

Relevant sections of ORS 496 (Wildlife Law) and ORS 610 (Predatory Animals)

ORS 496.002 Definitions

(8) "Fur-bearing mammal" means beaver, bobcat, fisher, marten, mink, muskrat, otter, raccoon, red fox and gray fox.

496.012 Wildlife policy. It is the policy of the State of Oregon that wildlife shall be managed to prevent serious depletion of any indigenous species and to provide the optimum recreational and aesthetic benefits for present and future generations of the citizens of this state. In furtherance of this policy, the State Fish and Wildlife Commission shall represent the public interest of the State of Oregon and implement the following coequal goals of wildlife management:

(1) To maintain all species of wildlife at optimum levels.

(2) To develop and manage the lands and waters of this state in a manner that will enhance the production and public enjoyment of wildlife.

(3) To permit an orderly and equitable utilization of available wildlife.

(4) To develop and maintain public access to the lands and waters of the state and the wildlife resources thereon.

(5) To regulate wildlife populations and the public enjoyment of wildlife in a manner that is compatible with primary uses of the lands and waters of the state.

(6) To provide optimum recreational benefits.

(7) To make decisions that affect wildlife resources of the state for the benefit of the wildlife resources and to make decisions that allow for the best social, economic and recreational utilization of wildlife resources by all user groups. [1973 c.723 §6; 1993 c.659 §2; 2001 c.762 §6]

496.162 Establishing seasons, amounts and manner of taking wildlife; rules. (1) After investigation of the supply and condition of wildlife, the State Fish and Wildlife Commission, at appropriate times each year, shall by rule:

(a) Prescribe the times, places and manner in which wildlife may be taken by angling, hunting, trapping or other method and the amounts of each of those wildlife species that may be taken and possessed.

(b) Prescribe such other restrictions or procedures regarding the angling, taking, hunting, trapping or possessing of wildlife as the commission determines will carry out the provisions of wildlife laws.

(2) In carrying out the provisions of subsection (1) of this section, the power of the commission includes, but is not limited to:

(a) Prescribing the amount of each wildlife species that may be taken and possessed in terms of sex, size and other physical characteristics.

(b) Prescribing such regular and special time periods and areas closed to the angling, taking, hunting and trapping of any wildlife species when the commission determines such action is necessary to protect the supply of such wildlife.

(c) Prescribing regular and special time periods and areas open to the angling, taking, hunting and trapping of any wildlife species, and establishing procedures for regulating the number of persons eligible to participate in such angling, taking, hunting or trapping, when the commission determines such action is necessary to maintain properly the supply of wildlife, alleviate damage to other resources, or to provide a safe and orderly recreational opportunity.

(3) Notwithstanding subsections (1) and (2) of this section, except as provided in ORS 498.146 or during those times and at those places prescribed by the commission for the hunting of elk, the commission shall not prescribe limitations on the times, places or amounts for the taking of predatory animals. As used in this subsection, "predatory animal" has the meaning for that term provided in ORS 610.002.

FISH AND WILDLIFE HABITAT IMPROVEMENT

496.270 Immunity from liability for damages resulting from habitat or water quality improvement project; exceptions. (1) The Legislative Assembly declares that it is the policy of the State of Oregon to encourage operators, timber owners and landowners to voluntarily improve fish and wildlife habitat. In order to carry out this policy, the Legislative Assembly encourages cooperation among operators, timber owners and landowners and other volunteers.

(2) Consistent with the limitations of ORS 105.672 to 105.696, a landowner is not liable in contract or tort for any personal injury, death or property damage that arises out of the use of the land by:

(a) A volunteer conducting a fish and wildlife habitat improvement project; or

(b) A participant of a state-funded or federally funded watershed or stream restoration or enhancement program.

(3) An operator, timber owner or landowner shall not be held liable for any damages resulting from:

(a) A fish and wildlife habitat improvement project done in cooperation and consultation with the State Department of Fish and Wildlife or the Oregon Watershed Enhancement Board, or conducted as part of a forest management practice in accordance with ORS 527.610 to 527.770, 527.990 and 527.992; or

(b) Leaving large woody debris within the waters of this state to protect, retain and recruit large woody debris for the purposes of fish habitat and water quality improvement.

(4) The limitations to liability provided by subsections (2) and (3) of this section do not apply if the damages, injury or death was caused by willful, wanton or intentional conduct on the part of the operator, timber owner or landowner or by the gross negligence of the operator, timber owner or landowner. As used in this subsection "gross negligence" means negligence which is materially greater than the mere absence of reasonable care under the circumstances, and which is characterized by indifference to or reckless disregard of the rights of others.

(5) The limitation on liability provided by subsection (3) of this section does not apply to claims for death or personal injuries. [1993 c.701 §2; 1997 c.207 §1; 1999 c.863 §3]

Note: 496.270 was enacted into law by the Legislative Assembly but was not added to or made a part of ORS chapter 496 or any series therein by legislative action. See Preface to Oregon Revised Statutes for further explanation.

610.002 Predatory animals defined

As used in this chapter, predatory animal or predatory animals includes feral swine as defined by State Department of Agriculture rule, coyotes, rabbits, rodents and birds that are or may be destructive to agricultural crops, products and activities, but excluding game birds and other birds determined by the State Fish and Wildlife Commission to be in need of protection. [1959 c.240 §2; 1971 c.658 §29; 1977 c.136 §4; subsection (2) of **610.002 (Predatory animals defined)** renumbered **610.003 (Bobcat and red fox control permitted)**; 1979 c.399 §2; 2001 c.125 §2]

610.060 Effect of certain wildlife law provisions on predatory animal control. Nothing in the wildlife laws is intended to deny the right of any person to control predatory animals as provided in ORS 610.105. [1971 c.658 §28; 1973 c.723 §126; 1975 c.214 §2; 1975 c.791 §3]

610.105 Authority to control noxious rodents or predatory animals. Any person owning, leasing, occupying, possessing or having charge of or dominion over any land, place, building, structure, wharf, pier or dock which is infested with ground squirrels and other noxious rodents or predatory animals, as soon as their presence comes to the knowledge of the person, may, or the agent of the person may, proceed immediately and continue in good faith to control them by poisoning, trapping or other appropriate and effective means. [Amended by 1971 c.658 §30]