Improving the Prospects for Shallow Water Wetlands through Upland Vegetation Management in the Stuart Nechako Resource District

Society for Ecosystem Restoration in North Central British Columbia

Prepared by:

T. Kaffanke Consulting Ltd.

March, 2016

Summary

T. Kaffanke Consulting Ltd. was contracted in 2015 to undertake a reconnaissance of several stream systems tributary to the Nechako River, in the Stuart Nechako Resource District, that have a history of beaver colonization. The primary goal was to identify areas where vegetation in the adjacent upland areas no longer supports beaver colonies, and where appropriate, develop prescriptions to promote restoration of suitable vegetation (mainly aspen). A secondary consideration was current management practices in riparian areas and whether harvest and silviculture could be used to manage for beavers. In short, by explicitly reserving certain streamside stands from disturbance, and by removing aspen from plantations within a critical distance of those streams, current practices do little to promote the habitat needs of this keystone species. Fortunately, effective changes in practices need not be expensive or in complete opposition to the concept of streamside reserves.

This report briefly describes the type of stream system of interest, reviews ecosystem services provided by beavers, their habitat requirements, summarizes some observations from the reconnaissance, considers the apparent effects of current management practices, and offers thoughts on alternative practices that more closely mimic the natural cycle of vegetation development crucial to their presence in the landscape. Without resorting to a deep or extensive literature review, it is meant to foster a discussion amongst managers towards practices that will help assure the long term benefits of having beavers active in the landscape.

Streams of Interest

The Stuart Nechako Resource District, like much of the central interior of British Columbia, has numerous low gradient streams with a long history of beaver activity. These streams often occur in basins with a broad, relatively flat bottom, ranging from tens to several hundred metres wide, and a distinct margin between the bottom (whether or not flooded) and the adjacent upland which is not subject to flooding. Evidence of beaver activity is in numerous dams that span the bottom, and their associated ponds. The ponds may be drained or “brimful” with the top of the dam, or at any level between depending on the condition of the dams. These features are easily identified in the 50 cm/pixel orthophotography, and more subtle remains are also identifiable in stereo examinations of the original 30 cm/pixel aerial photos. Streams of interest were selected for field reconnaissance based on these features, with the further condition that they flow directly into the Nechako River upstream of Vanderhoof, and the reaches occur on Crown land. The following figures illustrate the ease with which these systems can be identified.

Figure 1 shows a stream reach with four long-abandoned, deeply breached dams with only remnants of the ponds remaining. Often, these remnant ponds are a linear feature on the upstream side of the dam and persist only because they were excavated by beavers to provide earth to seal the dam. In this example, the drawn-down ponds, referred to as “beaver meadows”, are about 50 m wide.

Figure 1. Four abandoned and breached dams (West arm Kluk Creek), highlighted with yellow lines, appear in this image. Three of the dams have remnants of their former ponds immediately upstream.

In Figure 2, the solid yellow lines indicate confirmed dam locations, and the dashed lines are inferred. The left half of the image shows ponds behind actively maintained dams, while the right half shows where abandoned, breached dams have lowered pond levels.

Figure 2. Both active and abandoned dams appear in this image (Nine Mile Creek). Solid lines are confirmed dam locations, dashed are inferred. Pond width is about 50 m. (Rightmost dam restored since the image was made in 2012.)

Figure 3 shows three old abandoned and breached dams on Cutoff Creek. The longest of these is approximately 200 m long.

Figure 3. Three old abandoned and breached dams (Cutoff Creek). The longest is about 200 m long. The shortest is across a tributary of the larger channel.

Ecosystem Services Provided by Beaver Dams – Why they are an important feature of the landscape

The literature regarding beavers is rich and extends back over 100 years. No attempt to review this literature is made here, as this has been recently done in a comprehensive, freely available, downloadable document by Pollock *et al*, 2015, entitled “The Beaver Restoration Guidebook”.

The guidebook was written for an audience including the "restoration practitioner, land manager, landowner, restoration funder, project developer, regulator, or other interested cooperator". Many of the publications it cites can be obtained in PDF format, and it also includes a list of website URLs as further resources. (see link under citations.)

Beaver dams perform a range of ecosystem services due to the effects they have on physical and biological processes. They are described in the above described Pollock *et al,* 2015, from which the following greatly condensed points are extracted. Note that these effects are very much inter-related, and that one positive effect is often the cause of another.

Increased Water Retention and Base Flows

- By impounding water in ponds, beavers increase its residence period in a watershed. Coupled with a change in the timing of its release, this can increase base flows. The decline or destruction of beaver dams has been observed to change some perennial streams to intermittent ones, and the restoration of dams has been observed to change some intermittent streams to perennial flow.
- Slightly losing streams (those where water entering the subsurface does not return to the channel) have been changed to gaining streams by the restoration of beaver dams.
- Slower stream velocities, lateral spreading and increased areas of saturation increase the total amount of water, including subsurface, in a watershed.
- The negative effects of increased drought frequency and reduced snow packs can be mitigated by the water stored behind beaver dams.

Decreased Peak Flows

- Peak flood levels are reduced by beaver dams by retaining water in ponds and in the subsurface and releasing it over a longer period.
- Reduction in peak flows reduces erosive energy, thereby reducing sediment deposition downstream.
- The complicated flow path through multiple small channels that typically exist below beaver dams also dissipates the erosive energy associated with peak flows.

Expansion of Habitat Area and Complexity

- Beaver dams convert moving-water environments into a combination of moving- and slow-water habitats with a greater amount of riparian and wetland habitats.
- Colonization, abandonment, and recolonization at irregular intervals leads to heterogeneity in habitats along the stream with a rich mosaic of wetland types of widely ranging ages and stages of succession.
- The resulting complex system is more resilient to disturbance, particularly from the extremes of flooding and drought.

Increased Wetland Area

- By raising the surface water level, beaver ponds force water flow laterally. Water spreads over banks, and also around the dams into new channels, creating a complex network of channels and wetlands.

Increased Groundwater Recharge

- Overbank flooding is generally thought to be the main hydrologic mechanism for recharging groundwater in riparian areas. Beaver dam impoundments flood these areas for long periods of time, resulting in sustained recharge.
- Hydraulic head due to dam height forces water into the streambed and banks, and can promote lateral flows of groundwater around the dam and eventually back into the channel further downstream, and at a later time (thereby increasing residence time and base flow).
- Both groundwater storage and aquifer recharge are increased due to beaver dams, and this is increasingly important where climate change is reducing water availability or where groundwater is used faster than it is replenished.
- Groundwater is not subject to the evapotranspiration losses of surface water.

Sediment Retention

- By increasing water depth, slowing velocity, and decreasing flow energy, beaver dams promote sediment deposition. The amount of sediment deposited in beaver ponds is strongly related to the surface area of the pond.
- Beaver dams can affect the transport rate of both suspended and bedload sediments and act as long term sinks. Even when the dams on small streams are breached after abandonment, most of the sediment can remain in the pond area (beaver meadow), with channel avulsion occurring in the immediate area of the breach.
- The amount of sediment capture can be impressive, and has been expressed in various ways in different studies: 63% of suspended sediment by 10 dams during peak flow; 78 tons in a single snowmelt period behind four dams; 5847 cubic yards stored behind 22 dams in a 620 m length of stream.

Temperature Moderation

- Maximum summer temperature is often the limiting factor for fish habitat, so riparian vegetation management practices are often aimed at protecting streamside vegetation to promote shading and thereby minimize summer stream temperature increases. Although the surface waters of beaver impoundments receive more solar radiation than flowing stream reaches, and therefore may warm considerably, deeps ponds usually remain stratified, with cool water at depth. Cooler water below dams has been reported, and the mechanism for this includes hyporheic (subsurface volume of sediment and porous space adjacent to a stream through which stream water readily exchanges) upwelling from the earlier-discussed groundwater recharge.
- Large ponds tend to dampen temperature fluctuations.

Nutrient Cycling

- The feeding habits of beavers and their physical alteration of the environment affect biogeochemical cycling and the accumulation of nutrients in soils, sediment and water.
- Beaver ponds trap large amounts of organic and inorganic debris that would normally be transported downstream.

- When dams are abandoned and water levels subsequently decline, exposing these sediments, the return of aerobic conditions releases nutrients in a form available to vegetation, allowing dense and rapidly growing communities.

Contaminants

- By increasing the residence time of water in a system, and through a variety of mechanisms including deposition, microbial decomposition, uptake by plants, chemical transformation augmented by filtering, and adsorption to trapped clay particles, beaver ponds and wetlands act as sinks for nutrients and toxins that would otherwise stimulate the growth of algae, other plants, and bacteria further downstream.

Geomorphology

- Channel incision is a widespread phenomenon throughout the world that causes ecosystem degradation through disconnection of the stream from its floodplain, lower groundwater tables, loss of wetlands, decreased summer low flows, higher stream temperatures, less overall habitat diversity, loss of riparian areas, and population declines in fish and other aquatic organisms. Beaver dams can reduce the rate of channel incision and even reverse it in degraded streams.
- Sediments trapped behind beaver dams cause streambed aggradation in the affected reaches; the same sediments are therefore unavailable to downstream locations where they may be less desirable.

Vegetation

- The obvious effect of beaver dams is that riparian and emergent vegetation develop to dominate where there used to be upland shrubs and trees. This vegetation further reduces flow velocities and increases rates of sedimentation beyond what the dam itself causes.
- After abandonment and dam breaching, the newly exposed sediments in the beaver meadow offer rich growing conditions, and the site progresses through successional stages from young and wet to old and moist plant communities.
- Due to varying dates of meadow creation following breaching, and their subsequent recolonization by beavers, the system of dams on a stream creates a complex of wetland communities whose composition and structure varies, contributing to landscape level heterogeneity.

Primary Productivity and Aquatic Invertebrates

- Creation of a beaver pond starts a chain of effects, beginning with an increase in organic nutrients and by allowing more sunlight to reach more surface water to power photosynthesis by various primary producers.
- Secondary producers - varied micro- and macro invertebrates - flourish with the increase in primary production. These form the base of the food web that fish rely on when rearing or overwintering in beaver ponds.

Fish

- There are commonly held views that beaver ponds somehow interfere with fish habitat, especially the notion that dams act as barriers to passage. One review of the literature

showed that positive effects of dams were more often supported by data, and that negative impacts are more often speculative, and not supported by field data.
- Beaver ponds slow the flow of water, reducing the energy expended by foraging fish. They also increase the amount of aquatic invertebrates and provide high edge to area ratios that increase cover for fish. The result is that fish found in stream reaches that have beaver dams are both larger and more numerous than fish found in streams lacking slow water habitat.
- Overwintering habitat has been identified as the production bottleneck for Coho salmon in at least one stream system, and that increasing beaver populations would effectively mitigate this loss of productivity. Other salmonid species have also been identified as benefitting from beaver dams.

Amphibians

- Beaver ponds provide important breeding habitat for some amphibians, for example, the blue-listed Western Toad. Beaver dams increase the amount of surface water and retention times within their catchments, and this may reduce egg and hatchling larvae's susceptibility to desiccation.

Reptiles

- Painted turtles use beaver ponds. As climate change continues to warm the central interior of BC, the range of these animals may move northward, and beaver ponds will continue to be a feature of their habitat.
- Snakes are commonly found near beaver ponds. Both the common garter snake and the wandering garter snake occur in central BC.
- Older ponds tend to attract more reptiles than younger ponds do, pointing to the importance of having a range of seral conditions in the landscape.

Birds

- Beaver impoundments create habitat for waterfowl and many other bird species.
- Breeding hens and their broods rely on the protein and calcium rich food supplies provided by the numerous species of aquatic insects found in beaver ponds, as well as the cover provided by riparian and emergent vegetation.
- Drowned trees attract woodpeckers and provide nesting habitat for many bird species.
- Beaver ponds offer habitat to a hugely disproportionate number of wildlife species compared to the area of landscape they occupy.

Habitat Requirements of Dam-building Beaver

Again, the reader is referred to Pollock *et al*, 2015 for a thorough review of beaver habitat requirements.

Although there are beavers that do not build dams, this document is concerned with those that occupy small and medium sized streams, building dams to alter the local environment for their benefit. Their preferred habitat is low gradient streams (typically less than 6%, but more commonly only 1-2%) in unconfined valleys, but they will build dams almost anywhere that additional water can be retained. For example, the outlet of a lake may be chosen for a dam site, thereby deepening the water in any associated wetlands and improving the access to adjacent uplands.

The streams must also have riparian areas that contain vegetation for food and construction material for dams and lodges. Their preferred material for building and food, especially for winter stores, are trees and shrubs of the genus *Populus* and *Salix*. Specifically, aspen, cottonwood, and various willow species are preferred.

Beaver are herbivores that consume a wide variety of plants. They eat leaves, twigs and bark of most types of woody plants (generally avoiding conifers), as well as a wide range of herbaceous plants, including sedges, grasses and aquatic plants such as water lilies and cattails. In preparation for winter, when their ponds freeze and herbaceous species become unavailable, they store aspen, cottonwood, and willows in caches adjacent to their lodges. These caches are often visible as a raft of woody stems frozen into the ice, with most of the material accessible from below. They swim underwater from their lodge to cut and retrieve pieces from which they consume the bark.

Beaver prefer to cut smaller aspen, generally less than 10 cm in diameter, but as the supply of the preferred size is depleted, they will cut fully grown trees and use the limbs and smaller diameter parts of the stem.

Some observations of tree use by beaver in the Stuart Nechako Resource District

- A seeming necessity for aspen within 100 m of the pond margin, but less if terrain makes exploitation of it too difficult. Abandoned dams were almost always associated with a complete lack of aspen in this zone, but old stumps could be found within the remaining conifer forest or open area. Even when willow are plentiful and large, if no aspen is present the site is less likely to support an active colony than if aspen is present.
- When aspen were absent and willow very sparse, but a beaver colony persisted in the basin, there was generally also plentiful cattail in the pond.
- Beaver will go to great lengths to cut the last remaining aspen within 100 m of the pond. For example, in one generally aspen-depleted basin, a small group of aspen was found 70 m into the upland, within a dense spruce stand. The stem was felled and hauled to the water, whereupon it was conveyed at least another 700 m and across five dams to the presumed lodge location (inaccessible due to the extent of flooding).
- Beaver recolonized an abandoned stream system where aspen had not recovered from the previous depletion. Instead, they were cutting aspen from the same cohort that the earlier colony used, but deeper into the upland than the earlier colony was willing to use.
- Almost all caches observed were capped with willow, yet the onshore evidence indicated that aspen had been felled and moved into the pond. It is concluded that the beaver preferentially place the aspen deeper in the cache where more of it can be recovered during the winter, with the willow available later, or not consumed.
- There is often a distinct line in the upland next to an abandoned site beyond which large aspen are plentiful, but only old stumps are present closer to the pond margin. Suckers

generally do not occur if the stand is dense conifers. Where the stand is open, aspen suckers have often been browsed concurrently with shrub species.

- Alder is commonly used to build dams, and most stumps are found close to dams, but it does not appear to be a preferred food species. Most abandoned sites have much alder present in easily accessible locations.
- Occasionally, small spruce and pine stumps (beaver felled) were found in abandoned systems.
- Birch was being felled on the upland of a recently recolonized site where aspen was absent and willow was plentiful in the pond, but few stems were being cut.
- Beaver will explore long distances from their lodge. Active beaver slides, trails, and evidence of feeding on both herbaceous and fine willow stems on the crests of old dams was observed. Often, a few small willows will be cut and placed in a breach, raising water levels enough to improve their safety or efficiency when later passing through the same area.
- When recolonizing a reach where there were no large deciduous stems available to repair dams, beaver used small willows and salvaged old large stems from elsewhere (possibly waterlogged, sunken aspen left by the previous colony), as well as root wads, rocks, and logging debris from nearby cut blocks, to fill the breaches.
- Exploring beavers cut small diameter willows and simply deposited them into the channel. The next freshet is likely to transport them downstream to where a breach repair has been started and they are likely to hang up in the manner of a small log jam.
- Beavers used aspen growing on any site from hygric to subxeric, as long as stems and branches could be dragged to the water.
- The extent of expected flooding after recolonization is generally very predictable based on the height of abandoned dams and the location of the margin of the beaver meadow. Wherever “nuisance” flooding or felling of plantations was observed, it coincided with planting in historically used beaver meadows, or with inadequately protected culverts at crossings of streams that beaver would colonize.

Quantifying the Systematic Depletion of Aspen near Beaver Ponds

The depletion and lack of recruitment of aspen in the upland areas within approximately 100 m of beaver ponds and meadows was a recurring observation during the reconnaissance of streams in the Vanderhoof District. It is clear that in most cases, long ago, there had been a stand-replacing fire that had burned to the edge of the wetland and that aspen had been a component of the initial stand. Beaver exploited the aspen resource for dam building and winter food stores. Suckering has not replaced these trees. This is either because the conditions under the remaining coniferous stand were not conducive, or because repeated cutting by beaver or browsing so depleted their reserves that they died. By contrast, there is often a significant component of live, mature aspen just outside this zone.

Stereo pairs of the 2012 digital aerial photography were examined for two stream reaches with a history of beaver dam building. All interpreted aspen crowns, whether single or in clones, that occurred within 125 m of the wetland margin were outlined. Buffer strips paralleling the margin were set at distances of 20, 50, 75, 100 and 125 m from the margin and the intersection of these buffers with the aspen outlines was determined. Figure 4 illustrates the concept as applied to a portion of one of the reaches. The extent of depletion is readily apparent along the north margin, as is the low water level in the abandoned ponds.

The percentage of the area of each buffer occupied by aspen crown was then charted (Figures 5 and 6). The aspen component rises continuously from less than 1% crown cover in the first 20 m to approximately 9% and 19%, respectively, at 100-125 m distance.

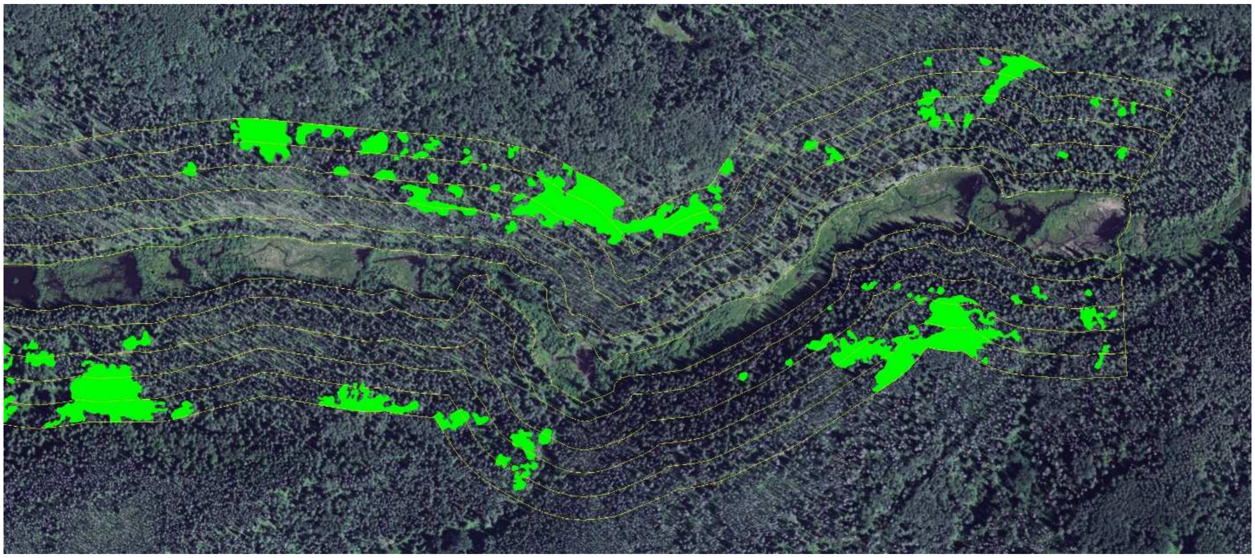

Figure 4. Aspen clones outlined and colored in the upland areas adjacent to an unnamed tributary of Hogsback Creek. Buffers on the wetland margins are at 20, 50, 75, 100, and 125 m.

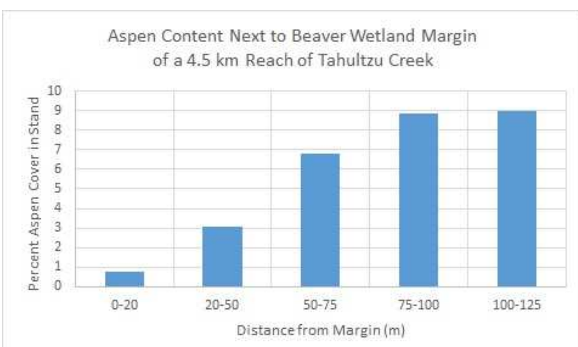

Figure 5. This reach of Tahultzu Creek is located downstream of the 1100 Road Bridge and upstream of where this stream enters private land.

Figure 6. This reach of the unnamed tributary is upstream of where it crosses the Blackwater Road, near the Mapes Road junction, and along the north foot of Sinkut Mountain.

Recovery from Aspen Depletion

In an unmanaged state, a wildfire would eventually burn through all or parts of these upland areas. Depending on a number of factors, including the length of time since the previous disturbance and the severity and extent of the fire, the root systems of the presently live aspen, which extend towards the wetland margin, would sucker and the cycle of growth and exploitation by beaver would repeat. This effect was observed along the wetland margins of Cutoff Creek, where the 2004 Kenney Dam Fire burned the upland to the wetland edge.

Figure 7 illustrates an example from the Kenney Dam Fire where aspen suckers originating from large dead stems upslope are present about 12-15 m from the wetland margin. They are heavily browsed near the water, but 15 m upslope many have escaped browsing. All but one of the large old stems are near the first slope break. This reveals much about the regenerative potential for many other areas where live large aspen are only found a long distance upslope. Figure 8 shows the downslope density of non-browsed aspen suckers in the vicinity of two large, fire-killed stems. Elsewhere, dense clones were present without nearby aspen snags, which may have fallen since the fire, or may indicate suckering from small residual understory stems sometimes found amongst conifers.

Figure 7. Aspen suckers occur to within 12-15 m of wetland margin, well downslope of the mature stems that were killed by the Kenney Dam Fire.

Figure 8. Two large aspen killed in the Kenney Dam Fire are the source of a large area of suckers, not browsed, and within easy distance of water if the adjacent pond level is raised.

By 2015, beavers had begun to recolonize this area and were exploiting the largest of the suckers originating from the fire. It should also be noted that this fire was a landscape level event that abruptly altered the vegetation over a large area. A consequence of this scale of event is that while browsing by moose does occur on aspen suckers, many stems escape browsing to grow beyond shrub size, eventually suitable for exploitation by beaver.

It is clear that the species composition and condition of the uplands adjacent to streams that support beavers strongly affects how they in turn influence the wetland ecosystems. Large landscape level disturbances in the form of fires rejuvenate the vegetation that is necessary for their survival. This is consistent with the concept of ecosystems with frequent stand initiating events, which are the dominant Natural Disturbance Type in the Stuart Nechako Resource District (BC MOF and BC MELP 1995).

Current Timber Harvesting Practices

A common harvesting practice includes the retention of large, mature aspen wherever it is safe or operationally expedient to leave them standing. These provide the benefit of tall vertical structure (e.g. roosting or nesting sites) in the cut block, and also tend to reduce the amount and vigour of suckering, a concern of silviculturists.

Although large wildfires continue to occur despite suppression attempts, forest harvesting is the main agent of stand replacing disturbance on the landscape in the Stuart Nechako Resource District. Harvested sites are generally replanted with native coniferous species, and where there is significant competition from other species such as aspen, brushing is often undertaken.

The stream and wetland combination that occur where beavers are active are typically classified as S3 or S2, and W1 or W5 (Forest Planning and Practices Regulation [FPPR], BC Reg 14/2004), though other classes also apply. These, however, require retention of a reserve zone, as well as consideration of windfall potential and other values, so it is common that 25% or more of the adjacent riparian management zone is also retained. These reserved areas are considered part of stand level retention, with the effect of concentrating retention in areas that wildfires would not necessarily have skipped over. No consideration is given to the fire history of the reserved areas. Even without considering the FPPR, operational constraints imposed by steep slopes would often result in strips of timber being retained next to these streams. Viewed over short time spans, these practices are consistent with FPPR Section 8, *Objectives set by government for water, fish, wildlife and biodiversity within riparian areas,* which states:

> *The objective set by government for water, fish, wildlife and biodiversity within riparian areas is, without unduly reducing the supply of timber from British Columbia's forests, to conserve, at the landscape level, the water quality, fish habitat, wildlife habitat and biodiversity associated with those riparian areas.*

A longer term view of simply excluding disturbance from these sites (and including practices that suppress aspen regeneration) is that it is a disruption of a natural process that is vital to the health and functioning of the riparian/aquatic system. Current management practices have the effect of retaining the species composition of late seral stages in a significant part of the landscape where such a “locking in” is detrimental to the long term functioning of the adjacent aquatic system.

Alternate Practices to Consider

In many cases, terrain considerations will prevent harvesting as the disturbance agent in areas immediately adjacent to beaver pond systems, regardless of what regulation or other policy prescribes. Therefore, the retention of riparian zone vertical structure immediately following harvest is assured for at least some portion of these areas.

Elsewhere, managers have an opportunity to reconsider whether a blanket retention policy is appropriate. This is not to suggest that retention should not be a part of riparian areas practices, but rather that activities be guided by a combination of factors to be considered together. Managers might ask:

- Is the harvest area adjacent to a stream with historic beaver activity?
- If the above is true, what does field reconnaissance of the zone where beavers typically harvest aspen indicate about the potential for aspen suckering?
- Are there old beaver-felled aspen stumps in the proposed harvest area, or closer than 20 m to the pond margin?
- Is there a clear line beyond which mature aspen are present, but where no difference in site series or previous stand initiation events explains the absence of aspen closer to the stream?
- Are there stands adjacent to the pond margin that may be fire remnants, with a low aspen potential, which are wider than the standard retention width, and which could be reserved in lieu of higher aspen potential sites?
- Could a reserved area be control burned shortly after harvest, with the intent of also blackening soils in the harvest area within 100 m of the margin, prior to reforestation?
- What is the likelihood that suckers will be heavily browsed by moose and unable to attain a size that beaver will use? Can scale of disturbance be set to reduce this possibility?

The answers to these questions should lead to harvesting layout and a site plan that considers burning of reserved stands and portions of cut block, discusses brushing restrictions, and thereby explicitly favors the development of aspen for the benefit of the adjacent aquatic system.

Literature Cited

British Columbia Ministry of Forests (BC MOF) and British Columbia Ministry of Environment, Lands and Parks (BC MELP). 1995. Forest Practices Code of British Columbia: Biodiversity Guidebook. Queens Printer, Victoria, B.C. http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/biotoc.htm

Forest Planning and Practices Regulation, BC Reg 14/2004

Pollock, M.M., G. Lewallen, K. Woodruff, C.E. Jordan and J.M. Castro (Editors) 2015. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 1.02. United States Fish and Wildlife Service, Portland, Oregon. 189 pp. Online at: http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp