

**Industrial Large Woody Debris Buildup
on the Lower Fraser River:
Implications and Impacts**

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Created for:
REM 471: Forest Ecosystems Management

Introduction

Forestry practices often extend beyond the reaches of mere logging; subsequently, so can the impacts of these practices. The Fraser River in British Columbia is littered with logs and associated bark, not from direct cutting practices, but from escaped logs belonging to the various sawmills up river (FREMP 2005). This woody debris is therefore not the natural accumulation one would see in most riparian zones, but a distinction can be made under these circumstances and labeled as industrial woody debris. Log driving has long been over, since associated negative impacts became evident; instead, it is now common practice to bundle logs together creating what is known as a log boom or place them on a barge for transport. This eliminates some of the problems attributed to the old days of log driving, but not all. These log booms are still stored and transported in the water creating the risk of losing logs and bark to the flowing current. Storage in the Fraser River in this manner is desired from the sawmill perspective because logs are preserved and the freshwater reduces infestation of teredos (*Bankea setacea*), a marine clam that feeds on wood (Triton Environmental Consultants Ltd). The outcome of escaped wood from storage was significant enough that a debris trap capturing and retaining up to 100, 000 cubic meters per year was built near Hope, BC in 1998 (Fraser Basin Council 2004). Despite the efforts of this trap, an accumulation of industrial woody debris can still be seen further downstream (see fig 1 and 2). These sites, Mitchell Island and Fraser River Park respectively, are unique as compared to most riparian systems because the river is influenced by the tide. The tidal effect creates a continuously disturbed system amplified by volumes of industrial woody debris. How this debris was allowed to be input into such

a system is of central importance, since prevention could possibly alleviate negative impacts. Looking at this question and who is accountable is therefore a first focus of this paper. A multitude of studies have actually shown that in many cases large woody debris, often referred to as LWD, is beneficial to streams, so this perspective will be presented. Conversely, it will be made evident how the Fraser River system differs from these study sites. With the differences established, the implications and negative impacts on the Fraser River system resulting from this disturbance will be overviewed. These impacts are being combated in various ways, which are important to acknowledge. However, due to the fact that there is still a buildup of industrial debris despite current active measures, further steps have to be taken. In order to avoid merely critiquing an existing system, this paper will offer procedures to build on those already in existence as well as alternative actions.

Accountability, who gets the blame:

The liable party for this issue can depend on the viewpoint of the observer and is difficult to assess because the problem is a result of a combination of insufficient policy, lack of public pressure, and the presence of log booms. Accountability can be spread amongst various groups from the government not creating stringent guidelines, to local public groups not requesting alternatives, and to sawmills not exercising caution. It has been mentioned that accumulating logs along the riverbank originated from the various sawmill activities upstream. Figures 3, 4 and 5 show the distribution of some site-specific sawmills on the lower Fraser River and the areas depicted in figures 1 and 2. The Fraser River Estuary Management Program estimated that there are approximately 60 forestry industry related practices along the Fraser Estuary. There is evidence of these mills being

a probable source for the woody debris build up. Upon investigation of the logs, they are in fact cut timber without root systems, not natural logs (pers. com. Mitch Anderson). The source of industrial debris can be further discerned by the marking scheme each sawmill uses. Logs are marked by respective mills to distinguish ownership and, when recovered by beachcombers, are sold back to the mill in question (Western Sort and Salvage Co-op 2005). Logs that end up down stream are technically still the property of the sawmill that lost them and it is the responsibility of those in the log boom business to clean up the debris lost. (Government of Canada Legislative Assembly 2004). In response to this, the mills can argue that there is no incentive to improve their methods without official regulations. Besides, the wood lost is retrieved by beachcombers and bought back. In fact, according to the estuary management plan set up by FREMP, there is one hundred percent compliance by the forest industry with log storage guidelines set up in 1999 (FREMP 2005). From the forestry standpoint, their actions conform to requirements by the estuary management plan; therefore, they cannot be blamed. The accountability can then be directed towards government policy and regulations not being strict enough to ensure impacts are minimized. The estuary management plan was created to address this issue and as a result more than 20 ha of marsh and mudflat have seen habitat regrowth (FREMP 2005). The accusing cycle continues, so it is difficult to assess blame.

Woody debris as a benefit to rivers:

Regardless of who is accountable for woody debris build up, the accused can argue that woody debris is actually beneficial to fluvial processes and river function. Many studies have shown there are numerous benefits associated with large woody debris. A lot of which made further suggestions to add amounts of wood in order to improve habitat

quality (Larson et al 2001; House 1986; Shields et al 1998). Rivers can profit from structural integrity and cover for fish associated with LWD (Larson et al 2001).

Habitat:

The presence of large woody debris provides a range of habitats for stream organisms (Flebbe 1999; Bilby and Likens 1980, as cited by Flebbe; Naiman 1992). It has been found that macro invertebrate community structure positively changes and diversity increases with structure addition (Hildebrand 1998; Gortz 1998). This could be attributed to woody debris creating habitat heterogeneity leading to increased number of niches thus allowing a greater number of species to utilize the area. In many related studies, fish populations are specifically looked at, but ambiguous results have been published. Shields et al (1998) stated uncertain responses in fish habitat usage; while Forward, (1994) established a positive correlation between juvenile coho and volume of woody debris and Flebbe (1999) found that trout nearly always occupy areas with two or more pieces of LWD. Valuable effects need not be limited to fish populations. LWD has been found to have a positive influence on avian species diversity as well as abundance of small mammals (Steel et al. 1999).

Structural alterations:

With increasing pieces of LWD structural alterations are inevitable. This debris can contribute to riverbank stability, structural cover (Flebbe 1999) and pooling (Larson et al 2001). Loss of LWD buildup can lead to a structurally uniform channel and increased sediment displacement (Hartman et al 1996). A relationship has been established between debris volume and pool area, with an increase in volume leading to a proportional increase in pool area (Byron et al 2000). A higher volume of wood can lead to debris

jams that control local channel flows and provide barrier against flood scour to allow vegetation to persist (Naiman 2000).

Shelter and cover:

As a result of structural alterations more cover for fish and other organisms is created which leads to protection against predators, reduction in competition, and shelter from strong currents (Allouche 2002). This can be especially significant for salmonids where distribution is related to cover (Allouche 2002). LWD cover can potentially provide shade for fish species and allow cooler water temperatures, thus a more ideal habitat. Opperman and Merenlender (2004) found that a study site with increased LWD resulted in lower water temperatures in late summer compared to a control area without any debris. The control was stated to be potentially detrimental to steelhead.

Significant Differences:

Not a natural cause:

Having stated the many published benefits of LWD in riparian systems, the distinction must be made between natural LWD and the industrial LWD found along the Fraser River. The benefits listed above are related to the riparian zone where nearly all LWD originates from riparian trees (Murphy and Koski 1989). In the latter case, logs have been collecting from non-natural processes. Because these industrial logs have been cut and root wads not intact, they are able to line up side to side and end to end thus paving marshes and estuaries. The presence of root wads and limbs in the natural case, results in logs not aligning symmetrically, thus leaving area between for water and fish passage.

Volume of debris:

As mentioned in the last section, the predominant source of LWD that ends up in streams is from riparian trees (Murphy and Koski 1989). This requires a tree to fall then land or slide into the river. There is therefore a limit to the volume of influx of this debris. On the other hand, the influx of industrial LWD is predominantly from upstream sawmills as outlined earlier in this paper. What limits the volume of industrial wood is the retention of logs in the log booms and caution of sawmill practices. It has been stated that there may be little incentive for mills to give extra attention insuring fewer logs lost to the Fraser River. With the high distribution of sawmills on the Lower Fraser River, there is a much greater chance of logs ending up in the water than in the case of natural riparian processes. This excess volume of industrial woody debris ultimately resides on the shore banks and marshes along the Fraser River, resulting in the smothering of vegetation marine organisms and habitat (Summary report of the steering committee 1981).

River dynamics:

Studies supporting the benefits of natural LWD have predominantly been performed on relatively small systems, whereas the Fraser River is a significantly larger river with a strong current. This allows logs to be carried much farther while being unobstructed. Combined with the aerodynamic shape of a timber log compared to one with natural branches and root wads, there is increased probability of movement. The Fraser River is also the largest single river producer of sockeye salmon, with adult returns exceeding 15 million in some years (Hume et al 1995). The magnitude of productivity in this case may magnify impacts of woody debris.

Negative impacts:

Logs and loose bark in the volumes being discussed in this scenario end up floating in the Fraser River, residing on riverbanks and adjacent marshes, ultimately altering natural habitat and processes. Left untouched, there is potential for long-term damage as LWD may persist in the natural environment for more than one hundred years (Powell et al 2004). The resulting effects can envelop aquatic and shoreline vegetation, soil and water quality, alter habitat, as well as cause direct effects on fish and species diversity.

Vegetation:

The primary effect on vegetation is the smothering of native species and direct collisions with logs. This area is unique in the fact that it is a continually disturbed system coinciding with tidal trends. Local plants have to be adapted for the continual rising and falling of the tides. With an alteration such as the mass amounts of bark smothering the floor, these plants may lose their competitive advantage, leaving room for other vegetation to take over. Plants best adapted for such a take over are those labeled as invasive species. Riparian zones tend to be the habitats most susceptible to invasions (Alpert 2000; Planty-Tabacchi 1996; Kotanen et al 1998; Stohlgren et al 1998). A possible explanation is that riparian regions have a naturally high degree of hydro disturbances causing water levels to vary (Lake and Leishman 2004). Lake and Leishman further investigated to find that sites without disturbance did not support exotic/invasive species. It can be said that the Fraser River is a disturbed site due to tidal flux, further enhanced by the wood and bark buildup. Surrounding areas such as marshes are less impacted with bark, which is mostly deposited on the immediate shoreline, but logs remain a concern. The result is a less disturbed scenario, but invasive species may have a

larger effect. Dukes and Mooney (1999) suggest that low stress may favor invasive species because they are able to take advantage of high resource availability.

Soil and water quality:

Soil acidification and water quality have a secondary effect on vegetation as well as hindering benthic invertebrates, shoreline mammals and aquatic organisms. Lechate resulting from decaying wood can cause acidification as well as remove oxygen from soil and release high levels of dissolved metals (Samis et al 1999, Brownlee et al 1981). Leaching in this manner is similar to that of a landfill with resulting pH ranging from 3 to 6.5 pH, where bark tends to result in higher acidity than logs (Samis et al 1999). These combined effects point to a decrease in optimal conditions for plant growth, with the potential result of long-term alterations of local vegetation composition. Decomposing wood can also produce methane and hydrogen sulphide gasses, which are soluble in water and can be lethal to aquatic organisms (Samis et al 1999). Water quality can become degraded from the decomposing process to the point that small organisms living in the bottom sediments cannot survive leading to diminished prey abundance for higher trophic levels such as crabs and fish (Sedell 1991; Williamson 2000).

Habitat alteration:

Wood accumulation into or adjacent to fish habitat can cause alteration, disruption or destruction of the habitat (Samis et al 1999). Adjacent tributaries can become blocked by wood debris limiting the range of available habitat for an aquatic species. In extreme cases barriers may be unsurpassable to fish migration leading to reduced living space (Samis et al 1999). These physical barriers prevent access to alternative habitat and decrease the overall range of dispersal. This holds true for benthic organisms as well as

larger ones such as fish. Bivalves, crustaceans and polychaetes require unobstructed access to the water column, whereas obstruction can lead to decline and subsequent effects on higher trophic levels (Pease 1974; Conlan and Ellis 1979).

Marshes have been targeted by the Estuary Management Plan as a site of concern as log booms can damage habitat if not stored carefully (FREMP 2005). Marshes are home and stop over sites for many migratory bird species (FREMP 2005). The lower Fraser River marshes have been classified as one of the most significant “Important Bird Areas” in the country (FREMP 2005).

Deep below the surface, effects of habitat alteration can't be seen, but are nonetheless significant. Wood and bark are known for buoyancy, however, can and do sink after extended periods in water. Bark accumulations have been documented beneath log booms in Alaska to reach depths of 40 to 70 meters (Kirkpatrick et al 1998). Reduced species richness was documented in all bark-dominated habitats. Another method using deep-water video survey has shown logs in the magnitude of 10 000 on the bottom of Clio Bay, British Columbia (Bornhold and Harper 2000). No report was given on species abundance, however it is evident that the scenario constitutes an altered habitat.

Direct effects on species:

There is a cumulative consequence on aquatic and terrestrial organisms associated with effects of limited native vegetation growth, poor soil and water quality and habitat destruction. These factors will all have some negative impact on fish species, invertebrates, plants and mammals that require the natural conditions of the Fraser River area. A consistent pattern seems to be emerging: vegetation stress due to industrial LWD results in a decrease in abundance of species; poor soil and water quality due to industrial

LWD results in a decrease in abundance in species; and a loss or alteration of habitat due to industrial LWD results in a decrease in abundance of species. One further, direct impact can be added to the list of negative effects set forth. With the Fraser River being the largest sockeye salmon run there is an immense quantity swimming upstream in the spring. Loose logs flowing down stream can easily collide with a number of these fish as well as pose as obstacles for this event, which is already taxing on individual survival.

What's being done:

The problem of industrial LWD has been recognized enough for some action to have commenced. Log booms were initially the main source of reducing the impacts of log driving in the days of old. These booms are currently the measures sawmills use to retain logs from ending up down stream. As a second approach, barriers have been set up at what are thought to be crucial areas along the Fraser River. Barriers can be somewhat effective in keeping logs out of an area, but in the process bark gets knocked loose and accumulates in the river and on the shoreline. These efforts are largely due to existing policy forcing the forestry industry to minimize their impacts. Sometimes the industry will go a step further and initiate voluntary mechanisms exceeding the baseline policy. Individual organizations such as non-governmental organizations (NGO) also play an active role in reducing negative environmental impacts. A third mechanism is the removal of logs by log salvors or beachcombers. None of these methods tend to prevent the problem, but rather are a response to the existing issue.

Policy and regulation:

The estuary management plan (EMP) set up guidelines in 1994, which were most recently updated in 1999 (FREMP 2005). The current report states that there is 100% compliance by forestry companies with log storage guidelines. This has resulted in more than 20 ha of marshland and mudflat witnessing habitat growth (FREMP 2005). The plan is designed to "...integrate habitat management and recreation activities with strategies for water and sediment quality, log management, navigation and dredging, and urban and water related industrial development" (FREMP 2005). Part of this plan aims at promoting best management practices to reduce LWD influx to the river as well as oversee the operation of a debris trap at Agassiz (near Hope, BC). Some relevant accomplishments include establishment of mini log barriers in estuaries, debris disposal alternatives and most significantly, up to 100 000 cubic meters of wood caught in the debris trap annually. One major drawback to FREMP's efforts is that they are not legally enforceable. There are, however, certain regulations that are legally binding. This involves the license to operate for the sawmills. Companies are required to provide information regarding the site(s) that may be impacted, as well as dive surveys (Triton Environmental Consultants 2005) Furthermore, there is an extensive referral process to relevant organizations including the Department of Fisheries and Oceans, Ministry of Forests, Ministry of Water, Land and Air Protection, Coast Guard, First Nations and Canadian Wildlife Service, all of which can stipulate operational conditions within their jurisdiction.

Voluntary Mechanisms:

In conjunction with government regulations, companies may choose to go above and beyond the required criteria. Motives may include a good public image, pressure and

awareness raised by the public or NGO, and/or maintaining profits through retaining all logs cut. FREMP's attempt to influence companies to institute best management practices falls under voluntary mechanisms. In some cases, this is successful and industry does implement such strategies. Triumph Timber located on Paril River, British Columbia has acknowledged that LWD can damage and smother aquatic habitat. In response, a debris management plan has been established that has succeeded in building a log slide system reducing woody debris, as well as sea rake to collect and remove floating woody debris from aquatic habitat (Fisheries and Oceans Canada 2003). Helicopter logging is also used in some areas where logs are lowered directly onto log booms, reducing loose debris generated by sliding logs into the water (Fisheries and Oceans Canada 2003).

Voluntary mechanisms also occur from groups outside of the forestry industry who have a genuine interest in preserving pristine habitat and maintaining ecological integrity.

River Works, is a "Vancouver Aquarium Marine Science Centre initiative that inspires the stewardship of aquatic habitats through community connections, habitat restoration, monitoring activities and educational experiences" (Riverworks 2005)) Volunteers associated with this organization remove LWD by hand from estuaries; LWD is then loaded into dumpsters and taken to a fiber recycling plant. As a separate, but related initiative, volunteers also perform invasive species removal. A second organization directly involved with wood debris removal is the Northwest Wildlife Preservation Society. This not for profit organization initiated in 1987 is dedicated to preserving healthy wildlife and wildlife systems in northwest North America (Northwest Wildlife Preservation Society 2005). The removal of industrial LWD is also done by hand, but often smaller hands as the project is geared towards school children as part of public

education programs. The Preservation Society is also involved indirectly via this and other public education programs as well as land stewardship projects.

Beachcombers (log salvors):

Despite preventative measures established by policy and voluntary mechanisms, industrial LWD does end up in the Fraser River and adjacent estuaries. One further removal method comes from a group of individuals known as log salvors. The logs targeted and removed are floating or semi submerged in the river; however they are also those that have monetary value, which will exceed the cost of removal. These salvors anchor their logs then move the bundle together to Gulf Log Salvage Co-operative or, if the sawmill marks logs, they are returned to the mill for a fee (Western Sort and Salvage Co-op 2005). These efforts remove some wood from the river itself, however logs deemed of low value are left behind as well as inaccessible wood in estuaries.

What could be done better:

Firmer Regulation, more effective policy:

FREMP has stated 100% compliance with recommended log storage guidelines and government regulations are being met because licenses are required to operate; yet the problem of industrial LWD persists. It can therefore be said that regulations are not being properly designed to address the issue. LWD accumulation has been recognized and discussed in a number of BC Legislative assemblies from 1972 to the present, (Official Report of Debates of the Legislative Assembly 1972, 1976, 1977, 1981, 1996, 2004). Despite addressing the issue, there is a current build up of LWD along the Fraser River. Stricter regulations are needed, holding sawmills responsible for lost logs and liable for the resulting damage. Harsh penalties for non compliance to new regulations is a further

step to ensuring logs are not lost in the first place and, if they are lost, immediate remedial actions can be initiated.

Ownership of the problem:

The tragedy of the commons is the phenomenon whereby each individual (sawmill in this case) is pursuing their own best interest while the cumulative impacts are spread amongst the commons (Hardin 1968). Ownership of this problem would reduce the consequence spreading and mills would be responsible for their actions. This inevitably ties in with regulations and compliance.

Log salvor mill creation:

At the present moment there exists only one milling site for log salvors to bring their wood. The resulting monopoly can therefore set purchasing prices for each log. Often these prices barely exceed the cost of effort and transportation to the mill. Salvors often leave less valuable wood as they may actually cost to be brought to the mill (Western Sort and Salvage Co-op 2005). There has recently been a proposal submitted to the government for the creation of a new mill for LWD which intends to offer competitive prices for wood, making it worthwhile for previously undesirable wood to be collected. While the existing mill resells logs for pulp, the Western Sort and salvage Co-op has established alternative markets, paying premium rates (Western Sort and Salvage Co-op 2005) .

Prevention:

While many current remedies for reducing industrial LWD are aiming at reducing impacts, preventing these impacts in the first place seems like a more efficient and

sensible approach. Once a habitat is destroyed, an invasive species moves in or vegetation and invertebrates are smothered, it is often difficult to reverse the damages. Bark deposits, in particular, have a negative impact on benthic invertebrates causing reductions in species diversity, abundance and biomass, which may persist for decades (Samis et al 1999, Jackson 1986). If such impacts are limited or, ideally, removed, the problem is avoided. Prevention includes creating regulations and measures to be sure logs and associated bark are not lost to the current. It is not expected that all milling practices grind to a halt or even that logs be required to be stored out of the water. One solution to reduce and even eliminate bark is to have the trees debarked prior to boom storage. The further revamping of storage mechanisms could allow for a higher proportion of logs retained and therefore a reduction of buildup down stream.

Conclusion:

It has been well established that the accumulation of industrial LWD is a problem and had been deemed so by government, the public and forestry companies alike. The resulting impacts are numerous, affecting vegetation, soil and water quality, habitat and species abundance. These negative impacts have the potential to persist for long periods of time and alter natural ecosystem functioning. Certain mechanisms are in place to deal with this problem; however, as a buildup of industrial LWD is currently ongoing, these strategies are inadequate. New management techniques are needed to address the problem, with a strong focus on prevention.

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Figure 1: Industrial Woody Debris site, Mitchell island. Notice logs have no intact branches or root systems. Also note shoreline suffocation from bark (see map figure 4)



Figure 2: Industrial Woody Debris site, Fraser River Park. (see map figure 3)

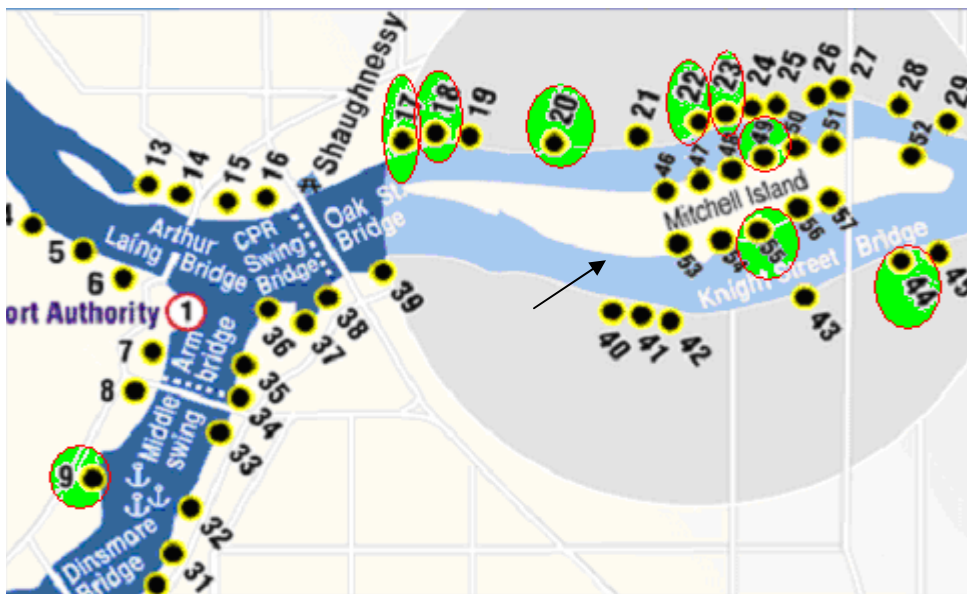


<http://www.nfpa.ca/02business/02busbylocation.html> North Fraser Port Authority, 2005
 Figure 3: Milling sites circled in red and green. South West Vancouver area
 The black arrow indicates the place of figure 2

9) Gulf Log Sort and Salvage

17) Doman Forest Products

18) Terminal Forest Products



<http://www.nfpa.ca/02business/02busbylocation.html> North Fraser Port Authority, 2005
 Figure 4: Milling sites in red and green. South East Vancouver area.
 Black arrow indicates the area of figure 1.

9) Gulf Log Sort and Salvage

22) Elk falls forest industry

17) Doman Forest Products

23) Western Forest Products

18) Terminal Forest Products

44) Richmond Plywood Co-op Association

19) Mainland Sawmills

49) Terminal Forest Products

20) West Coast Cellulibre

55) Terminal Forest Products



<http://www.nfpa.ca/02business/02busbylocation.html> North Fraser Port Authority, 2005
Figure 5: Milling sites. Burnaby, New Westminster.

59) Weyerhaeuser