Wood Debris Removal from British Columbia’s Lower Fraser River Marshes: An Analysis of a Complex Restoration Issue

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ABSTRACT

Although large quantities of wood debris were historically found in the Fraser River and its estuary, present day policy and public opinion support its removal in the name of “restoration.” Removal does address concerns many have about the impacts of excess wood debris on boating safety, aesthetics, and the growth of estuarine marsh plants, especially Carex lyngbyei. However, there are no scientific studies that have evaluated either the positive or negative effects of removing wood from marshes. Related research suggests that wood may contribute to the detritus cycle, promote marsh development, and act as an agent of disturbance. In a highly urbanized estuary such as the Fraser, these structural and ecological roles for wood may have been replaced or diminished by human structures and influences such as training walls, rip-rap, and carbon inputs from urban runoff and sewage. Thus, the science and human issues surrounding wood debris removal from these marshes creates a complex restoration issue.

Preliminary results from the case study showed that removing the wood debris off the Fraser River Park marsh did allow for some plant growth, but not to the extent expected. Dune grass (Elymus mollis) grew or bare soil persisted when wood debris was removed off some high elevation quadrats. The following are recommendations based on the literature review, professional opinion, and results of the case study: 1) Leave well-embedded pieces of wood located in the high marsh area in place, but remove it from mid and low marsh areas where soils support the growth of Carex lyngbyei; 2) Support the work of the Debris Management Committee; 3) Build “mini” debris traps along the Lower Fraser; 4) Focus efforts on creating structures and conditions that would allow the river to build its own marshes; and 5) Choose habitat compensation sites carefully and ensure the dredge spoils used in construction have the characteristics of natural marsh soils.
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1. INTRODUCTION AND BACKGROUND

Several years ago, I participated in a "Marsh clean-up" at Fraser River Park in Vancouver, British Columbia, as a part of a wider, ongoing "River Works!" program sponsored by the Vancouver Aquarium, the Department of Fisheries and Oceans (DFO), and others (FREMP 1997; DFO 1999; Anonymous 2000). Volunteers were told that our efforts in removing wood debris off this estuarine marsh site would "help the fish" and "let the fish food grow." This remark had substance: The Fraser River, which drains nearly a quarter of a million square miles (one quarter of the total area of BC), supports the largest salmon run in the world (FREMP 1994). The marsh clean-up was also an enjoyable community activity, and it certainly made the marsh look better. However, I had many questions about our "good deeds."

I found a more scientific explanation for our "clean-up" activities in a popular DFO publication (Adams & Whyte 1990):

Wood debris is constantly released into estuarine and coastal marine habitats. Through some of this debris is natural, the majority of it originates from log transport/storage and milling activities.

Small debris, such as wood chips and bark fragments, smothered mudflats and marshes. Large debris, such as logs, scour or compacts mudflats and marshes. Both types of debris eliminate marsh vegetation and maintain intertidal sediments in a constant state of flux. Both conditions prevent the establishment of persistent, productive benthic communities. Woody debris decreases the productive capacity of intertidal habitat.

Debris removal temporarily restores intertidal habitats… (p. 196)

Despite this explanation, I still wondered whether the "marsh clean-ups" paralleled historical "stream clean-ups." Whereas we used to clean wood out of streams, we now go to great efforts to "restore" wood to these same aquatic ecosystems (see Zaldokas 1999). Research by Ford and Smith (2000), that outlined the "cultural history" behind stream clean-ups in Oregon between 1940-1970, shed much light on this issue. These researchers documented that from 1940-60, timber companies were required to remove in-stream wood following severe clearcutting or salvage logging, but the companies opposed this directive because of the cost and work involved. Their inaction was supported by the public, who viewed the fisheries as a minor resource. However, in the 1950s-1960s, many salmon runs declined and public opinion began to shift in favor of wood removal, perceiving that this activity would "help the salmon." Thus, enforcement around wood removal became more stringent and "vigorouus" stream clean-ups occurred. Perceptions about wood began to change again following a seminal 1975 workshop on "Logging Debris in Streams" that concluded 1)There were likely both positive and negative impacts of logging debris on fish communities and 2)There was an urgent need for systematic study and evaluation of the impact of debris removal operations, which had been going on for more than 20 years with little if any
assessment of the results (Ford & Smith 2000). Thus, at first glance, it did seem that we were repeating history in our efforts to “clean-up” marshes.

At the same time, I did recognize that the excess wood debris on marshes was an issue for several reasons. First of all, the forestry industry’s activities (i.e., logging, bundling, booming, storage) constantly released wood into the river and often created a serious hazard for boat traffic. Secondly, I did find the piles of wood debris on marshes unattractive. Thirdly, I was aware that development, dyking and filling had destroyed most of the wetland “habitat” for wood debris in the Fraser Estuary (see Kistritz 1993; FREMP 1994) and did note that even small quantities of wood easily smothered the few remaining marshes. Compounding this loss of habitat was the nature of its replacement: Wood debris does not "stick" well to steeply sloped, hard rip rap banks that line the Fraser in many places. Finally, I was aware that much effort went into removing wood debris off the river, including a Debris Trap at Agassiz, log salvaging, and marsh clean-ups. Clearly, the issue of wood debris clean-ups on the Lower Fraser marshes deserved further attention and research.

Hence, the purpose of this paper is to address the following questions:
1. What is the role of wood on marshes?
2. Is the removal of wood from marshes “restoration”?
3. What are the effects of removing wood from a marsh?
4. What could be done to address the issues of wood debris and marsh restoration on the Fraser River?
   (Recommendations)
Each of these questions is addressed sequentially below through literature reviews and a case study analysis.

2. WHAT IS THE ROLE OF WOOD ON MARSHES?

Although there is some literature that describes the role of wood of marshes, no detailed research has been done that documents either the positive or detrimental effects of removing it from marshes. Thus, insights on marsh clean-up activities must be inferred from other related research on wood in aquatic ecosystems. In general, the research describing the ecological and structural roles of wood in marshes can be organized under the headings of detritus cycle, disturbance role, marsh development, and “other.” All these roles are inter-related, but for the sake of clarity, I discuss the research behind these four areas separately.

2.1 Detritus Cycle

Estuaries are recognized as one of the most highly productive ecosystems in the world (Smith 1995). The Fraser River’s marshes, mudflats, and eelgrass beds provide input into food webs (see Figure
1 below) that support the largest salmon run in the world. Thus, many users of the estuary are very concerned about any real or potential impact to the detritus cycle by wood debris. Their concerns are discussed below.

Figure 1: Typical Detritus Food Web of slough/channel tidal marsh habitat in the Fraser Estuary (from Kistritz 1993)

In 1975, Yamanaka studied the productivity of 1901 hectares of marshes in the Fraser River Delta Foreshore area. He noted that:

The soil associated with driftwood had a very high organic matter content; the contribution of this wood as a source of organic detritus or energy for marine animals is not known. The clear fact, however, is the drift wood occupies a large area (56 ha or 3% of total vegetation area) where otherwise marsh plants would grow (p. 110).

In addition, Yamanaka (1975) found that the Musqueam marsh had the highest net productivity of all the marshes studied, and that this site was formerly a log storage area (see Levy et al. 1982 discussed below).

In 1982, Levy and others studied the "Effects of Estuarine Log Storage on Juvenile Salmon." The authors compared various fish utilization indices from a log storage site at Point Grey devoid of vegetation, to that of its neighboring, well vegetated, Musqueam marsh. The authors found that:
...while the availability of insects in the log storage area appears to be reduced due to the absence of marsh plants, the availability of some of the epibenthic food sources appears to be higher in the log storage area than the adjacent Musqueam marsh (p. 64).

They concluded that:

In spite of the drastic physical impact of intertidal log storage at Point Grey there was no strong negative effect on fish utilization of the area. There were no decreases in fish abundance, or fish growth that could be attributed to the presence of stored log booms (p. 66).

In addition, Levy et al. (1982) noted that log booming caused increased sedimentation, elevating a former mudflat by 0.5 metres. This increased elevation facilitated plant growth, resulting in the conversion of a mudflat into a marsh.

However, for a variety of reasons, it is difficult and inappropriate to draw generalized conclusions from this one study. The study sites were well flushed and log storage occupied a small area relative to the large size of the Fraser estuary. Such conditions are not always present in other estuaries (e.g., Nanaimo estuary) where numerous concerns about the effects of log storage, including the buildup of wood debris, has led to a recent court case (Pynn 2001; see also Hagen 1987). In addition, Levy et al. (1982) looked at logs stored on an area devoid of vegetation, not on a vegetated marsh where wood debris accumulates. Thus, their findings are insightful, but not conclusive, as they pertain to the issue of wood debris on marshes.

Healey, Richardson, and Lissimore (1995) noted that wood debris was a source of “low quality” organic carbon for the Fraser River estuarine food webs. Maltby (1992) suggests that:

Although woody material has a lower food value than non-woody material, it may sustain organisms during periods when few leaves or needles are available. It is also important in that it increases the stability of the channel and retards the loss of other more palatable detritus (p. 332).

Maser and Sedell (1994) believe that driftwood provides much needed terrestrial carbon for ocean foodwebs, where it is quickly broken down by marine wood-boring organisms. In this regard, the marsh acts as a “holding area” for the ocean.

In summary, the above limited research suggests that wood on marshes contributes to the estuarine detritus food web in the following ways:

1. Its decomposition contributes to soil fertility in marshes, which then leads to enhanced plant growth and hence greater primary productivity.
2. It traps other forms of detritus (e.g., plant material) that both contribute to the food web and soil fertility.
3. It functions as a "slow-release" form of carbon.
4. In areas that have good tidal flushing and a wide variety of intact habitat, wood debris/logs support a different, but equally beneficial compliment of "fish food" as compared to vegetated areas.

2.2 Disturbance Role

Disturbances are a normal part of any ecosystem, including marshes. Researchers believe that an intermediate level of disturbance results in high biodiversity in ecosystems (Smith 1995). Common sources of disturbance for marshes include ice, vegetation rafts ("wrack mats"), fire, herbivory, pulse floods, and wood debris (Middleton 1999). Wood debris is also recognized as a source of disturbance in other aquatic ecosystems (Harmon et al. 1986). In streams, large woody debris or snags cause a natural disturbance by altering channel morphology and long-term geomorphology in streams and rivers (Harmon et al. 1986; Middleton 1999). Along seashores, wood smashes the organisms living on rocks, creating a mosaic of communities in various stages of development (Harmon et al. 1986; Simenstad et al. 1997). On marshes, wood scours sediments and squashes and buries plants (Seliskar & Gallagher 1983; Harmon et al. 1986; Adams & Whyte 1990).

In 1980, the Council of Forest Industries (COFI) commissioned "A Review of the Impacts of Log Handling on Coastal Marine Environments and Resources." The study acknowledged that most of the logs ending up on marshes were from forest industry activities and could be identified as such by their cut ends. The study noted that impacts of wood debris on plant communities may result from scouring of both hard and soft substrates, shading and other alterations in the light environment, deposition of bark and wood debris, and toxic and sublethal effects associated with increased oxygen demand and release of log leachate. However, these authors noted, "...there are no quantitative data describing these impacts and only a limited amount of observational information" (COFI 1980:78).

Although disturbance by log debris is thought to lead to the establishment of Purple Loosestrife (Lythrum salicaria), an invasive, exotic species, in marsh ecosystems at the expense of native vegetation such as Carex lynchyi, Adams (1993) concedes that, "To date, there have not been any studies that have quantified the impacts of log debris on foreshore plant assemblages." (p. 19). In addition, Purple Loosestrife is found in wetlands all across North America, including areas where wood debris is not a source of disturbance (e.g., prairie potholes)(White 1993). Thus, any presumed "cause and effect" relationship between disturbance caused by wood debris and establishment of this invasive species is tenuous at this point.
Although researchers recognize that wood debris is an agent of disturbance on marshes, they lack information on what the appropriate intensity, frequency, and scale of this event should be for this ecosystem. Without this information, it is difficult to draw any conclusions about either the positive or detrimental effects of this type of disturbance.

2.3 Development of Marshes

Some research suggests that wood plays an important role in marsh development, by trapping sediments and by providing structural support and protection.

Maser and Sedell (1994) noted that:

Driftwood is abundant in an upper salt marsh, and the boundary of the marsh is clearly delineated by extensive and continuous piles of large driftwood, including whole trees. Large driftwood is also scattered throughout the marsh and remains in place for long periods, which allow the general level of the marsh around them to increase through the deposition of silt and the accumulation of organic matter (p. 83).

COFI (1980) noted that that log booms reduce shoreline erosion by dampening wave and current action. DFO “uses” log booms to protect certain marshes (Levings & Nishimura 1996; see Figure 3). Park staff in the Saanich Peninsula also welcome the presence of logs on their beaches for the same reasons. However, some local residents object to the logs’ presence because storms sometimes drive these same logs into their seashore homes (Personal communication, Bert Brink, October 2001).

Middleton (1999) also documented that root wads, dead or alive, greatly reduced bank erosion. This researcher and others also noted that jams created by large woody debris trap sediment and create sandbars, providing opportunities for tree colonization in smaller streams and rivers (Harmon et al. 1986; Sedell & Maser 1994; Edwards et al. 1999; Middleton 1999; Stuller 1999; Zaldokas 1999). Maser and Sedell (1994) also document how large floating wood rafts, covered with trees and plants, floated down some rivers (e.g., the Mississippi) and out to the oceans, where they provided habitat for fish and bird species.

Hale (2000) studied the impact of human activity on marsh development in the South Arm of the Fraser River. She noted that:

Another human-induced change in the river which has not been considered in great detail is the removal of large woody debris. Prior to snag removal, which began in 1880, large numbers of uprooted trees and logs were carried down the river during the annual freshet. Many of these were deposited on the tidal flats, where they may have created the protected environment required to initiate marsh growth...Logs strewn across the marsh surface may have acted as a breakwater during periods of high wave activity. Contrarily, movement of such large debris during storms of periods of unusually high water must have created havoc as they dragged across the marsh surface.
Today large woody debris is captured and contained by the Agassiz Debris Trap. Jetties and training walls\(^1\) also deflect floating debris away from marshes, with the result that woody debris is no longer the factor in marsh sedimentation that it once was (p. 119).

However, she also found that marshes experienced rapid aggradation during the period (1910-1954) when major river training structures were constructed in the study area. In addition, the marshes also grew laterally between 1930-1954, experiencing a 16% increase in area. She noted that much of the marsh growth has taken place in the lee of river training structures, which provide sheltered, stable environments. Training structures and dredging have also prevented natural migration of the river, allowing marshes to develop undisturbed for longer periods of time than might otherwise have been possible (p. 130).

2.4 Other roles

In addition to the roles discussed above, wood may also perform the following functions on marshes:

1. Sediment compaction: Wave action causes wood to have a "rolling pin" action on marshes, compacting sediments. This process may increase the stability of marsh soils and decrease erosion rates.

2. Provision of microhabitat: Certain plants may grow better in the depressions logs create on marshes. These depressions also hold water at low tide in the summer and harbor juvenile fish (Maser & Sedell 1994).

3. Debris piles provide important perching opportunities for birds and other animals (Maser and Sedell 1994).

I hypothesize that the above roles are affected when all wood is removed from marshes.

2.5 Summary

Harmon et al. 1986 noted that the functional importance of wood in marshes (and other ecosystems) depends on the amount present, as well as its distribution in terms of size, spatial arrangement, degree of decay, and position. Unfortunately, we lack information on what the "wood budget" for the Fraser River and its marshes was or should be (Bratty 2001). We need further research to determine what the appropriate levels of wood are for marshes, including information about its size, quantity, volume, and location.

It is also important to keep in mind that human structures and influences in the Fraser Estuary may have replaced or diminished some of the roles of wood discussed above. For example, dykes and rip-rapped banks provide structural support in marshes along the Lower Fraser. Artificial structures such as

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\(^1\) River training is done to establish and maintain a navigable channel. Training walls and jetties constrain the main channel throughout the delta, eliminating lateral migration and inducing scouring of the channel bed. Jetties have also effectively extended the river channel.
training walls and jetties influence sediment deposition (Hale 2000). The estuary receives carbon from a variety of sources, including sewage and urban runoff (Kistritz 1978; Healey et al. 1995). We also require additional research on all of the above points before we can draw conclusions about the present role of wood in marshes (Harmon et al. 1986).

3. IS THE REMOVAL OF WOOD FROM MARSHES “RESTORATION”?

The question of whether “marsh clean-ups” are restoration is not easily answered. In the absence of conclusive scientific evidence for the activities, the answer to the question depends on what time period is used as a restoration reference point and what the legal, policy and public support is for the undertaking. Subjective and site-specific criteria are also considered when determining whether these efforts yield “restoration.”

3.1 Historical perspective

Wood has always been a ubiquitous part of the Fraser River and its estuary. In 1792 at Point Grey, Captain George Vancouver noted that the:

... shoal continues along the coast to the distance of seven or eight miles from the shore, on which were lodged, and especially before these [river] openings, logs of wood, and stumps of trees innumerable (Roberts et al. 1998:300).

In 1874, Boddam-Whetham noted that, “The course of the Fraser is full of dangers and difficulties... the river is as full of 'snags' and 'sawyers' as the Mississippi" (p. 301). In 1921, Johnston noted that, Large quantities of driftwood are carried seaward by the river during the freshet. For a few days during the height of the freshet, there is almost a continuous procession past Steveston... It collects especially in the channels of the river, and along the shore face of the delta where it becomes buried by the advance of the delta. It is most abundant in the top-set beds of the delta.

Wood was also a prominent feature of other great rivers in the United States. Harmon et al. (1986) notes that huge accumulations of Coarse Woody Debris (CWD) up to 8 kilometres long were common and blocked navigation on most of the large rivers in the United States. Thus, in 1776, the US Congress made appropriations to clean rivers and streams of driftwood to maintain navigation. In the West Coast Region, the Sacramento, Chehalis, and Willamette Rivers had significant amount of snags removed between 1870-1920. Records show that snags have been removed from the Fraser River since the 1880s (Hale 2000).

Thus, if we use historical observations as restoration reference points, removal of large wood debris removal from the river or off marshes does not constitute “restoration.” The authors’ lack of commentary on “small woody debris,” however, needs to be treated with caution. No doubt, “small woody

km across the tidal flats, increasing the ability of the river to retain material in suspension and to transport sediment offshore (Hales 2000).
debris” was present alongside the “large woody debris,” but it is easier to see large pieces of wood from a boat. The above comments reflect concerns related to navigation, rather than ecology. However, restoring wood to these historical conditions is neither practical nor acceptable in the highly urbanized Fraser estuary. Therefore, historical benchmarks provide insight, but not answers, to restoration questions for these marshes.

3.2 Legal, policy, and program perspective

There are legal, policy, and program initiatives in place, supported by public opinion, for marsh clean-ups in the Fraser Estuary. The *Fisheries Act*, administered by federal and provincial agencies, contains provisions that prevent the harmful alteration, disruption, or destruction of any fish habitat. In addition, DFO’s “*Policy for the Management of Fish Habitat*” (1986) has an overall objective of “net gain” of productive capacity for fisheries resources. This objective is achieved through: 1) The conservation or “no net loss” of fish habitat; 2) Fish Habitat Restoration; and, 3) Fish Habitat Development. In this policy document, fish habitat restoration is defined as: “Rehabilitate the productive capacity of fish habitats in selected areas where economic or social benefits can be achieved through the fisheries resource” (p. 12).

With above directives in mind, the Fraser River Estuary Management Program (FREMP)² coded the shoreline along the Fraser River estuary into red, yellow, and green areas. The table below explains this coding scheme (from FREMP 1994:18):

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<th>Coding</th>
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<td>RED</td>
<td>No development permitted unless mitigation can be applied to ensure that no alteration or alienation to existing habitats will occur.</td>
</tr>
<tr>
<td>YELLOW</td>
<td>Development permitted subject to satisfactory mitigation and/or compensation.</td>
</tr>
<tr>
<td>GREEN</td>
<td>Development permitted subject to environmentally sound design and timing restrictions.</td>
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Marsh habitat is considered to be the most highly biologically productive habitat type and is coded “red.” Any marsh lost must be replaced on a 2:1 ratio basis (for every unit of marsh lost, 2 units of new marsh must be created). This ratio is designed to account for the time required for created marshes to reach the productive capacity of mature or natural marshes (FREMP 1997). FREMP (1994:30) classifies restoration as it pertains to fish and wildlife habitat in the Fraser Estuary as: “removing debris and unauthorized fill to increase productivity.” Thus, red-coded marshes are targets for restoration efforts.

² The Fraser River Estuary Management Program (FREMP) is a cooperative program linking federal and provincial government agencies, port authorities, regional districts, municipalities and First Nations. The program provides a vehicle for coordinating decision-making on environmental conservation, and development in the estuary. The six funding partners to FREMP are: Environment Canada, Fisheries and Oceans Canada, the Greater Vancouver Regional District, the BC Ministry of Environment, Lands and Parks, the Fraser River Harbour Commission, and the North Fraser Harbour Commission (FREMP 1995)
Kistritz (1993) documented the following about the wood debris problem in the Fraser Estuary:

1. Most of the wood debris accumulates along the high tide line in the high marsh zone.
2. The percentage of affected area is much greater in the narrow fringe marshes of the North, Middle, South and Main Arms of the river compared to the broad expanses of marsh along Boundary Bay, Sturgeon Banks, and Roberts Bank.
3. The minimum proportion of affected red-coded marshes is assumed to be 5% since virtually no area of marsh is entirely unaffected.
4. Wood debris covered 0-60% of marshes.

The North Arm has the highest percentage of its marshes affected by wood debris, and it is also the area that has suffered the greatest loss of wetlands (i.e., a 96% loss) (Levings & Nishimura 1996).

Public opinion and effort supports the removal of wood debris off these marshes. Some members of the public made the following comments at a Habitat Workshop sponsored by FREMP:

I have been involved in cleaning up debris on the river. There should be fines involved. Every other industry has to be accountable for their polluting. Timeliness for cleanup of log spills is critical, so there should be fines imposed, by the hour, for companies who pollute the river with logs and debris...

There is so much debris clogging up the existing marshlands, that something has to be done about it. There is a lot of potential in the old marshlands, but they are so clogged up they aren’t doing anything. The problem should be addressed before you [DFO] start creating new marshlands (FREMP 1995:83).

Thus, the stage is set for “marsh clean-ups.” From 1994-1997, FREMP coordinated volunteer clean-up efforts in the Estuary (see FREMP 1997). Achievements include:

- more than 500 volunteers from environmental groups, businesses, industries and community service organizations have donated more than 9,000 hours to the clean-up;
- more than 4,100 cubic metres of wood debris and garbage were removed from the Estuary

In addition, other organizations have begun to lead clean-up activities:

- MacMillan Bloedel (now Weyerhaeuser) holds annual clean-up days during which employees and their families clean up marshes adjacent to their properties;
- the T “Buck” Suzuki Foundation-associated with the United Fisheries and Allied Workers Union (UFAWU)-is coordinating marsh clean-ups throughout the Estuary which are being completed by UFAWU members;
- the Lower Fraser River Stewardship Program is developing an Estuary wide volunteer based clean-up program; and,
the Vancouver Aquarium is coordinating clean-up and monitoring events and encouraging community groups to take an ongoing stewardship role (see their brochure in Appendix 1).

DFO includes some marsh clean-up efforts in their calculations of "No-Net-Loss" and "Net Gain" of Fish Habitat in the Fraser Estuary (Kistritz 1996). For example, DFO "gained" 17,000 square metres of marsh habitat when driftwood and log debris was cleaned off 34 hectares of "red-coded" marsh at Boundary Bay. They also accepted a clean-up, along with 1:1 marsh habitat creation, as compensation (i.e., "No-Net-Loss") for development in "yellow-coded" habitat (Kistritz 1996: Site 11-002). However, DFO does not "count" all marsh clean-ups as restoration, especially if they are small-scale or done by volunteers (Kistritz 1996: Site 09-006).

3.3 Other jurisdictions

Our American neighbors in Washington and Oregon have a different view of the wood "problem." Komar (1997) relates the following story:

The Taft Beach in Oregon accumulates large masses of driftwood—so much, in fact, that it hinders recreational use of the beach. To remedy the situation the state of Oregon permitted log removal during the summer of 1976. Before the driftwood was removed, the cliffs backing the beach had not eroded for many years. Soon afterward, however, during the winter of 1977-78, there was major erosion of the cliff. Since that time, logs have returned to the beach and there has been no subsequent cliff erosion... Although we cannot be certain that log removal was an important factor in the cliff erosion at Taft, this episode should cause us to pause before undertaking whole-scale log removal from beaches (pp. 139-140).

Maser and Sedell (1994) are deeply concerned about a "wood shortage" in their Pacific Northwest estuaries because numerous dams have interfered with wood transportation dynamics on their rivers. They estimate that, since 1939, there has been a 50% decline in the number of pieces and a 60% decline in volume of driftwood in the lower Nehalem estuary in Tillamook county. They note that most beach logging is now prohibited in Oregon, and that no credit is given for removal or retention of wood in the wetland mitigation process (Maser & Sedell 1994). However, in Washington, the Department of Natural Resources licenses individuals who retrieve driftwood from Puget Sound or from the Columbia River (Maser & Sedell 1994).

On a final note, it is somewhat ironic to learn that restoration activities planned for the Green/Duwamish River Basin in Washington include the collection and removal of Large Woody Debris from above the reservoir over the Howard Hanson Dam, trucking it below the dam, and replacing it in the

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3 It is important to note that the Fraser River's mainstem is not dammed, unlike other rivers in the Pacific Northwest.
lower river (Goetz, Gilbrough, & Cagney 2000). Presumably, some of this “restored” wood will end up the marshes.

3.4 Summary

In summary, from an historical perspective, large amounts of wood were a part of this riverine and marsh ecosystem and thus the removal of it does not constitute “restoration.” However, from a policy and public opinion point of view, “marsh clean-ups” in the Fraser Estuary are “restoration.” In Washington, wood “replacement” in dammed rivers constitutes “restoration.” It is clear that there is no one “right” answer to the question whether “marsh clean-ups” are restoration.

It is interesting to note the words we use to speak of “wood” and how this influences our restoration activities. George Vancouver, Johnson, Maser, and Sedell speak of “logs and stumps” and “driftwood.” When wood needed to be removed from the river to allow for navigation, it was called “snags and sawyers.” We now refer to wood as “debris” and “pollution.”

I believe that human considerations directly influence how we “restore” these marshes—we are directly and intimately involved in defining what “nature” should look like and we can provide the right words and rationale to support our “views of nature.” Many considerations influence “what to restore to,” on these marshes, including public safety. Aesthetics are also important, probably much more than anyone would admit. Put simply, fields of green sedges look nicer than piles of wood debris. There is also great value in getting volunteers involved in “taking care of their estuary.” Thus, we need to consider “human” issues alongside “scientific” ones when determining whether an activity is “restoration.”

4. WHAT ARE THE EFFECTS OF REMOVING WOOD FROM A MARSH?

I studied the effects of wood debris removal on a marsh by monitoring vegetation changes over a period of a year. Although I hoped to continue the vegetation monitoring for a longer period, the sheer boom around AN1 was not consistently effective in keeping wood off the marsh from September 1998-September 2001. Thus, this case study is of a preliminary nature, and should be interpreted as such. I describe the approach and findings of this case study below.

4.1 Methods

My study sites consisted of a created/restored sedge marsh in Fraser River Park known as “AN 1” and a natural, reference site known as “AN 2” located in the Sea Island Conservation Area (see Figure 2). The sites were chosen because they were easily accessible, closely located, and located in a section of the river known to have excess woody debris on its marshes. Furthermore, a previous study (Levings and Nishimura 1996) had shown that AN1 did not differ from the natural marsh (AN 2) on the basis of measured attributes including mean vegetative cover, plant species and invertebrate community, and fish
species presence and residency. However, the authors noted that AN 1’s substrate was gouged by floating wood debris, whereas AN 2 was protected from the same problem by storage structures parked off shore to it (see Figures 3 and 4). Table 2 compares the geographical features of the two sites.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Study Site (AN 1)</th>
<th>Reference Site (AN 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surrounding Land Use</td>
<td>Highly urbanized, extensive dyking &amp; draining</td>
<td>Conservation area, extensive dyking &amp; draining</td>
</tr>
<tr>
<td>Latitude</td>
<td>49 degrees, 12’27.939”</td>
<td>49 degrees, 12’26.207”</td>
</tr>
<tr>
<td>Longitude</td>
<td>123 degrees, 09’09.195”</td>
<td>123 degrees, 09’19.624”</td>
</tr>
<tr>
<td>Easting</td>
<td>488888</td>
<td>488677</td>
</tr>
<tr>
<td>Northing</td>
<td>5450563</td>
<td>5450510</td>
</tr>
<tr>
<td>Aspect (degrees)</td>
<td>240</td>
<td>60</td>
</tr>
<tr>
<td>Slope (%)</td>
<td>0.5 (estimate)</td>
<td>0.25 (estimate)</td>
</tr>
<tr>
<td>Mean elevation (m) (from Levings &amp; Nishimura 1996)</td>
<td>0.79</td>
<td>0.70</td>
</tr>
<tr>
<td>Soil classification</td>
<td>Loamy sand-&gt; rubble at west end of site</td>
<td>Loamy sand-&gt;silty clay at river’s edge</td>
</tr>
<tr>
<td>Mean % submergence between May and Sept. 1999 (from Levings &amp; Nishimura 1996)</td>
<td>33.2</td>
<td>37.3</td>
</tr>
</tbody>
</table>

(from FREMP 1994:4)  
Figure 2: Study area
Figure 3: Marsh boundaries (from City of Vancouver 1994)
I relied on Levings and Nishimura's study (1996), airphotos, and presence of riparian vegetation (e.g., willow shrubs) to define the boundaries of both marshes. For AN 1, I used the edge of the boardwalk as a permanent measuring point. I measured out 20 metre intervals along the boardwalk and established perpendicular transects to these points. I use the edge of the rip-rap to establish the edge of the AN 1 study marsh (see Figure 5). For AN 2, I took similar measurements starting from pilings located at the edge of the marsh to the water edge (See Figure 6).
Figure 5: Sketch Map of AN 1
4.2 Results and Discussion

At both sites, I established 1-metre quadrats at 5 metre intervals along the perpendicular transects. This approach was similar to that taken by Levings and Nishimura (1996), and allowed for intensive and representative site analysis. The locations of the 21 quadrats at AN 1 and 27 at AN 2, are shown in Figures 5 and 6, respectively. For each quadrat, I estimated percentages of plant species, plant detritus, unvegetated soil, and woody debris in the manner adapted from Luttmgarding et al. (1990). I first surveyed both sites on August 10-11, 1997. I then participated in a marsh clean-up on AN 1 in September 1997 and re-surveyed both sites on August 15-16, 1998. During this time period, the sheer boom on AN 1 had been repaired and appeared to be reasonably effective in keeping wood off the marsh.
Table 3: Variation in site characteristics between years.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Study Site (AN 1)</th>
<th>Reference Site (AN 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of site covered by woody debris (%)</td>
<td>25</td>
<td>11</td>
</tr>
<tr>
<td>Quadrats with most woody debris (&gt;20%)</td>
<td>A0,A1,B0,C0,C1,</td>
<td>A1,C0,E1,F0</td>
</tr>
<tr>
<td>D0,E0,E1</td>
<td></td>
<td>A0,A2,B0,C0,D0,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A0,B0,B1,C0,D0,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E0,F1</td>
</tr>
<tr>
<td>Proportion of site covered by detritus (%)</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Proportion of site covered unvegetated soil (%)</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Proportion of site covered by vegetation (%)</td>
<td>47</td>
<td>52</td>
</tr>
<tr>
<td>Proportion of site covered by each dominant species (%)</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Carex lyngbyei</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>Juncus balticus</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>Proportion of site covered by Lythrum salicaria (%)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td># of plant species on site</td>
<td>19</td>
<td>20</td>
</tr>
</tbody>
</table>

While there was a significant decrease of wood debris on AN 1 following the marsh clean-up, there is not a corresponding dramatic increase in overall vegetation on the site (see Figures 7,8,9). The reference site had a higher percentage of total vegetation during both surveys, as compared with the study site. Despite using different methodologies, Levings and Nishimura (1996) also noted that AN 1 had lower standing crop biomass than AN 2 in August 1991. As could be expected, the quadrats farthest away from the water had the highest amounts of woody debris. The amount of unvegetated soil was higher on AN1, and increased slightly following wood debris removal. Both AN 1 and AN 2 were dominated by Carex lyngbyei and Juncus balticus. It is interesting to note that percentage coverage of these species decreased slightly on AN 1 following marsh clean-up, suggesting that, for this site, wood removal did not immediately increase the “fish food.”

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4 I arbitrarily chose “20%” to delineate the quadrats with the most woody debris
Figure 7: AN 1 on July 11, 1997 before marsh clean-up

Figure 8: AN 1 immediately after marsh clean-up
Lythrum salicaria levels were higher on the reference site as compared to the study site, though both sites had very low overall infestation rates. Although there were some Purple Loosestrife plants in the AN 1 quadrats, its lower infestation rate may be reflection of successful removal activities by the volunteers from the Vancouver Natural History Society and the Vancouver Aquarium.

Additional plant species were found on AN 1, however, they were mostly “weedy” species (e.g., Plantago spp.). The table below summarizes what happened on the quadrats with the most woody debris.
Table 4: Changes noted on the Quadrats with the most woody debris

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Study Site (AN 1)</th>
<th>Reference Site (AN 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of quadrats covered by woody debris (%)</td>
<td>48</td>
<td>24</td>
</tr>
<tr>
<td>Proportion of quadrats covered by detritus (%)</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Proportion of quadrats covered by unvegetated soil (%)</td>
<td>28</td>
<td>29</td>
</tr>
<tr>
<td>Proportion of quadrats covered by vegetation (%)</td>
<td>18</td>
<td>28</td>
</tr>
</tbody>
</table>

The above analysis of the quadrats with the most woody debris does not show that vegetation increased after wood debris was removed on AN 1. While both the study site and reference site had 48% coverage by woody debris at the time of the first survey, AN 1 had only 24% after the marsh clean-up. However, AN 1 had a higher amount of unvegetated soil as compared to AN 2 and this difference persisted after the marsh clean-up, suggesting that wood presence or absence had little effect on vegetation growth in some quadrats. Although there was an increase in Carex tyngbyei on AN 1 after the marsh clean-up, the dominant species on the quadrats with the most wood was Elymus mollis or Dunegrass. This particular species grows on coastal dunes, sand and gravel beaches, and edges of shoreline forests. It plays an important role in erosion control. AN 1 also has Carex macrocephala, another dune species, which is absent on AN 2. Because Carex tyngbyei is the dominant species on the AN 2 sites summarized in Table 4, marsh clean-ups here may yield more “fish food” than any work done on AN 1.

It is important to note that the percentages in the columns in both tables do not add up to 100%. This is due two factors. In some cases, detritus was trapped on top of the wood or amongst plants, and thus the quadrat had a “double coverage” of either plants or wood, and detritus. In the case of AN 1, its
edges were rip-rapped to decrease erosion. Rocks are not a feature of natural marshes, so I omitted their percent coverages from the data analysis. Please see Appendix 2 for a detailed presentation of quadrat results.

4.3 Conclusion

The marsh clean-up on AN 1 had “mixed” results. It was beneficial for some quadrats that had conditions necessary for the growth of Carex lyngbyei, a plant species recognized for its contributions to the detritus web. However, on other quadrats, Elymus mollis grew where wood was removed. The role of this particular plant is providing “fish food” is unclear. I question the value of removing the wood off these “sandy” sites since both Dunegrass and wood decrease erosion in high marsh/sand dune areas. On other quadrats, wood debris removal had little effect, and its removal may contribute to already documented erosion problems on the site (Adams & Whyte 1990; Kistritz 1996). The limited findings from this one simple study suggests that we need to take a more careful and considered “site-specific” approach when we “clean-up” marshes.

The relatively insignificant improvements in vegetation cover on AN 1 following wood debris removal suggests that there are other factors limiting the productivity of this site as compared to AN 2. Some of these factors may be:

1. Site location: AN 1 is located in a high wave energy area that is prone to erosion and has high rates of disturbance. The wave action here has created berms of sandy substrate, which does not support sedge growth (Kistritz 1996). In contrast, natural marshes develop in protected areas with low wave energy from predominantly clay and silt depositions.

2. Site design: The boardwalk on the site functions as a “wall” and causes sediment and wood deposition. It appears that the originally planted “low” sedge marsh is being slowly converted to a “high” Dunegrass marsh because of the boardwalk location.

3. Substrate quality: AN 1 was created from dredge spoils and it is unclear whether this substrate performs as well as naturally accreted sediments. This point is discussed in more detail below.

The use of more sophisticated measuring tools, including the use of a GPS unit and a detailed analysis of soil organic value, soil particle size, standing crop biomass, and other variables would be useful in future studies (see Levings & Nishimura 1996; Zedler 2001). The use of a more statistically robust design would also allow better interpretation of the significance of the above findings. In addition, longer term monitoring of more “marsh clean-up” projects would help us better understand this restoration activity. Specifically, more attention and study is needed regarding the clean-up of areas that have “very fine wood debris” accumulations accompanied by anoxic conditions (Personal communication, Bert Brink, October 2001).
The above findings do not indicate that wood debris removal should stop on AN 1, but rather that they should be carried out more carefully and with consideration of multiple restoration values and interests. There is much value in getting the community involved in restoration work, but their efforts need to be supported by scientific research and public education on the roles of wood on marshes. Aesthetics are also very important: In a survey to determine the values and perceptions of 67 residents who lived near a proposed salt marsh restoration in a park, Casagrande (1996) found that residents placed the highest value on aesthetics, wanting the park to have good views and be free of pollution and garbage. The restoration challenge, therefore, is to come up with solutions that combine science and human interests. As Hull and Robertson (2000) note: “There exists no single ecologically optimum or naturally best environmental condition that can serve as an objective, unequivocal goal for ecological restoration projects” (p. 98).

5. RECOMMENDATIONS

The following general principles need to be kept in mind when agencies (e.g., DFO, FREMP) design overall restoration strategies for the highly urbanized Fraser estuary:

1. A framework of “adaptive restoration” should be used to guide activities in the Fraser estuary.
   Restoration projects need to be designed as experiments, with ongoing monitoring and evaluation of outcomes (Zedler 2001).

2. Restoration goals need to be set at a microspatial, patch, and landscape level (Zedler 2001).

3. Restoration activities should aim to be self-sustaining so as to not require intensive long-term management.

4. Restoration strategies and goals must be acceptable to the users of the estuary, and trade-offs between ecological, hydrological, aesthetics, and safety will be necessary (Bratty 2001).

5. Restoration strategies need to take an ecosystem approach, rather than being “species-specific.”

6. Marsh restoration activities and wood debris management need to undertaken in conjunction with a broader plan for the conservation, protection, and restoration of existing wetlands in the Fraser estuary.

5.1 Marsh clean-ups

We need research to determine the “wood budget” for the Fraser River and its marshes. Specifically, we need to know what the appropriate amount, location, size, and volume of wood is for marshes. Possible research approaches include ecological modeling and/or direct empirical assessments (Bratty 2001), and paleoecological studies. In addition, we need to conduct more pre- and post-surveys of marsh clean-ups to assess the positive and negative effects of wood debris removal. Both short and long-term studies are required. The above research needs to be disseminated widely in the form of “guidelines” for marsh clean-ups.
In the interim, I recommend the following approach to marsh clean-ups:

1. Leave large pieces of wood debris in high marsh areas where sandy soils are present, as these pieces have an important erosion control function;
2. Remove wood debris from low to mid marsh and backwater areas where Carex hyemalis is growing. Wood debris in these areas are most likely to be interfering with the productivity of the marsh;
3. Leave well embedded, decaying logs in place as they provide habitat for insects and other fauna;
4. Aim for habitat complexity and diversity on marshes, rather than mono-typical stands of vegetation; and,
5. Educate volunteers and others doing “marsh clean-ups” about the many roles of wood in aquatic ecosystems.

5.2 Management strategies for wood on the river

Agencies and industries need to support the efforts of the Debris Management Group that has been recently set up to address the wood debris issue in the Fraser estuary. The vision of this Group is “effective regional management of debris to meet desired levels.” The “desired levels” of debris will be determined through focused research, consensus-building, management practices and monitoring programs (Debris Management Group 2000:3). Membership in this group includes the Canadian Coast Guard, DFO, industry, FREMP, provincial ministries, and conservation groups. This group’s efforts to keep the existing debris traps functioning requires ongoing financial support from its membership.

   The above group should also consider the following strategies.

1. Build “mini-debris” traps along the lower Fraser or modify existing shear booms to also function as “mini” debris traps. These traps will require regular cleaning and maintenance.
2. Experiment with the use of engineered log jams (ELJs) in parts of the river (Stuller 1999; Abbe et al. 2000; Drury 2000). These structures have been found to be very stable, and trap debris, modulate flows, and provide habitat for fish when used in the North Fork Stillaguamish, the Cowlitz and the Cispus rivers in Washington. ELJs require a comprehensive geomorphic, engineering and ecological analysis prior to installation. It is also important to carefully tag and monitor the position of the logs.
3. Explore beneficial uses for the “wood debris” removed off marshes. For example, volunteers could stack the wood to dry somewhere off-site, and local residents could use this wood in their fireplaces. Alternatively, small pieces of wood could be bundled together to form larger pieces for use in instream and other restoration projects.
4. Continue to advocate for better control over woody debris deposition at the source (Personal communication, Bert Brink, October 2001).
5.3 Marsh Restoration and Creation strategies for the Lower Fraser

There are two approaches to marsh restoration and creation, either “self design” or the “designer” approach (Adams & Whyte 1990; Mitsch & Wilson 1996; Middleton 1999). In the “self design” approach, humans create the conditions necessary for marsh establishment, but nature ultimately chooses the plant species that can be maintained on the restoration site. In the “designer” approach, humans actively plant vegetation at a created marsh, based on the site characteristics. The approach adopted depends on such factors such as nearness of seedbank, specific site characteristics, and the timelines for the project.

5.3.1 Self-Designed marshes

Hale’s (2000) research showed that man-made structures often created the conditions for marsh development. Earlier research has revealed that stored logs can augment sediment buildup—the first step in marsh creation (Levy et al. 1982; COFI 1980). In a highly urbanized estuary like the lower Fraser, and especially in the North Arm, numerous man-made structures exist that either are contributing to marsh development or could be modified to “let the river do the work” (see Figures 10 and 11 below).

Figure 10: Marsh development below the Oak Street bridge
These "self-designed" marshes could be "built" at a lower cost and need less maintenance than "designer" marshes. The challenge for restorationists is to understand and create the conditions that would accelerate the natural regeneration of marshes. I recommend the following strategies:

1. Undertake further research to better identify the conditions needed for marsh development in the Fraser estuary.
2. Undertake a detailed analysis of the estuary to identify sites that would support natural marsh development (i.e., sites near existing marshes, protected areas with low wave energy).
3. Create or place structures on the identified sites that would promote marsh creation (i.e., store logs on intertidal flats and allow marsh to develop on top of logs).
4. Use “wood debris” removed off marshes to build “marsh creation” structures.
5. Incorporate “marsh creation” structures in any new development planned for the estuary.

5.3.2 Created “Designer” marshes

The need to compensate or mitigate lost fish habitat necessitates the construction of “designer” marshes in the Fraser estuary. I recommend the following strategies as ways to improve existing practices and address some of the shortcomings of these built marshes.

1. Use natural marshes as templates for created marshes. Incorporate small creeks and irregular edges into the design (Zedler 2001).
2. Save marsh soil from marshes to be destroyed and use on created marshes. This preserves the seedbank and micro-organisms of the original marsh (Zedler 2001).

3. Salvage the plants off marshes to be destroyed and replant them on created marshes.

4. Incorporate pieces of “wood debris” into the marsh soil to increase stability of the site.

5. Pile wood debris at the highest point of the site to decrease erosion and provide habitat for other species.

6. Carefully analyze and compare the dredge spoils used in marsh creation with naturally occurring marsh soils for the following characteristics: texture, organic content, nutrients, compaction, soil salinity, and soil pH. Add amendments as necessary to the dredge spoils to ensure appropriate site conditions for plant growth (Zedler 2001).
REFERENCES


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