Alternative Uses of Post-harvest Woody Debris Biomass

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Briefing report: Alternative uses of post-harvest woody debris biomass.
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ABSTRACT

Current forest management policy in many jurisdictions in North America manages excess woody debris by piling and burning it, mainly as a post-harvest fire hazard abatement obligation. This study highlights three key points to consider regarding utilization and disposal of waste wood piles:

1) Allocate most woody debris waste to the biofuels sector in a cost-effective manner;

2) Allocate a small portion of woody debris (e.g. 10-15%) to implement windrow habitats where necessary to maintain mammalian biodiversity on clearcuts;

3) Limit burning of waste wood to those sites near human activity (potential fire hazard) that do not have an opportunity for biofuels or windrow purposes.

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Front cover image credit: D. Gossoo

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1 Introduction

Woody debris is a major ecological component of temperate and boreal zone forests and accumulates from natural and harvesting (logging) disturbances. Current forest management policy in many jurisdictions in North America manages excess woody debris by piling and burning it, mainly as a post-harvest fire hazard abatement obligation (Figure 1 and Figure 2). Many concerns about the practice of burning the woody debris include: environmental regulations, including air quality and particulate matter pollution, are getting more stringent; burning activities are expensive; the time window when the debris piles can be burned is shortening. This report presents two alternative uses of woody debris that can be beneficial if implemented concomitantly: 1) a larger portion of woody debris could be used as renewable biomass feedstocks for wood pellets, generating economic and environmental benefits; and, 2) a smaller portion could be used create woody debris structures (e.g., piles and windrows) for wildlife habitat, which can generate vital biodiversity networks that have major roles in ecosystem function and are essential to maintenance of forest biodiversity and long-term site productivity.

Instead of being burned, wood residues from forest harvesting may have the potential to be used as renewable biomass feedstocks (Figure 3) that could help improve energy supplies and reduce greenhouse gas (GHG) and smoke emissions. Production of wood pellets from wood residues from sawmills and post-harvest debris is a major bioenergy endeavour across Canada, supplying European and other countries. In addition, retention of some post-harvest residues to create woody debris structures (e.g., piles and windrows) for wildlife habitat on clearcuts has generated some vital biodiversity networks. Such structures are built at the time of forest harvesting and log processing (Figure 4), or by an excavator after harvest is completed (Figure 5), and are composed of tops, branches, and bole ends of harvested trees, as well as trees knocked down during harvest, low-quality commercial trees, dead wood, and non-commercial trees left at the harvest site. A windrow or series of piles (Figure 6) may connect patches of mature forest (Figure 7) and riparian areas (Figure 8) to allow small mammals and some of their predators to access and traverse clearcut openings.

Figure 1. Burning of piled woody debris

Figure 2. Smoke from burning of debris piles

Figure 3. Processing of woody debris into chips for use as bioenergy

Figure 4. Construction of piles or windrows at time of harvesting and log processing

Figure 5. Construction of piles or windrows by excavator after harvest (photo by D Gossoo)

Figure 7. Windrow attached to a forest patch

Figure 6. Windrow of woody debris across a clearcut unit

Figure 8. Windrow attached to a riparian zone

The habitat attributes associated with woody debris should be part of maintaining biodiversity in commercial forest landscapes. Burning debris is exacerbating climate change and concurrently removing biomass that could be used for bioenergy production and potential habitat for wildlife, thereby compromising our attempts to conserve biodiversity in managed forests. Thus, on a project basis at two study areas (Elkhart and Golden) in south-central British Columbia, we measured (1) the monetary value of woody debris used for bioenergy purposes or simply burned, (2) the carbon emissions of burning debris with alternative scenarios of bioenergy and windrows, and (3) species diversity of small mammal prey species and activity of mustelid predators in sites with windrows and those with dispersed woody debris.

2 Bioenergy Analysis

The calculated dry mass of debris was 52.13 t/ha for Elkhart and 12.18 t/ha for Golden. These estimates provided a sensitivity range around the value of 38.2 t/ha reported in the region. Wood pellets were the bioenergy product considered in this analysis. For a sensitivity analysis, three capacities of wood pellet plants were considered: 20,000 odt pellets/year, 60,000 odt pellets/year, and 100,000 odt pellets/year. Three transportation distances were also considered for sensitivity analysis (average transportation distance between all cut blocks and pellet mill): 50 km, 100 km, and 150 km. Three scenarios were considered:

- Scenario 1) baseline; no windrow construction, no pellets production; all debris is burned;
- Scenario 2) both windrow construction and pellets production; small quantity of unrecoverable debris is burned;
- Scenario 3) only pellets production; small quantity of unrecoverable debris is burned.

3 Carbon Balance Analysis

To analyze the different carbon impacts of the three scenarios, a simple mass balance of biomass carbon was conducted. The carbon balance (or carbon dioxide balance) was calculated for the bioenergy project. For the purposes of this study, the bioenergy project was defined as the post-harvesting processing of biomass in the cut blocks and the biomass conversion to pellets in a pellet plant. The project boundary included the possible uses of biomass in the post-harvest slash. Any biomass that was not converted into pellets was assumed to be burned in the cut blocks, and it was assumed to result in instant CO_2 emissions. Assuming that one kg of dry wood contains 0.5 kg of carbon and using a coefficient of 3.67 kg CO_2/kg C, an emissions coefficient of 1,833 kg CO_2/odt of biomass was estimated. Besides the CO_2 emissions from the burning of biomass, no other emissions attributed to any activities of the project were considered.

4 Mammal Biodiversity

A total of nine species of forest-floor small mammals were captured with the red-backed vole (Figure 9), the most common species. Mean species richness and diversity of forest-floor small mammals were higher in windrow than dispersed sites at both study areas. Mean activity of mustelids (marten and weasels) (Figure 10) was higher in windrow than dispersed sites (Figure 11). The response of mustelids to our windrows was particularly clear and fits earlier observations that marten and weasels will use piles and windrows of woody debris.

Figure 9. Red-backed vole, major prey species for mustelids

Figure 10. American marten and long-tailed weasel

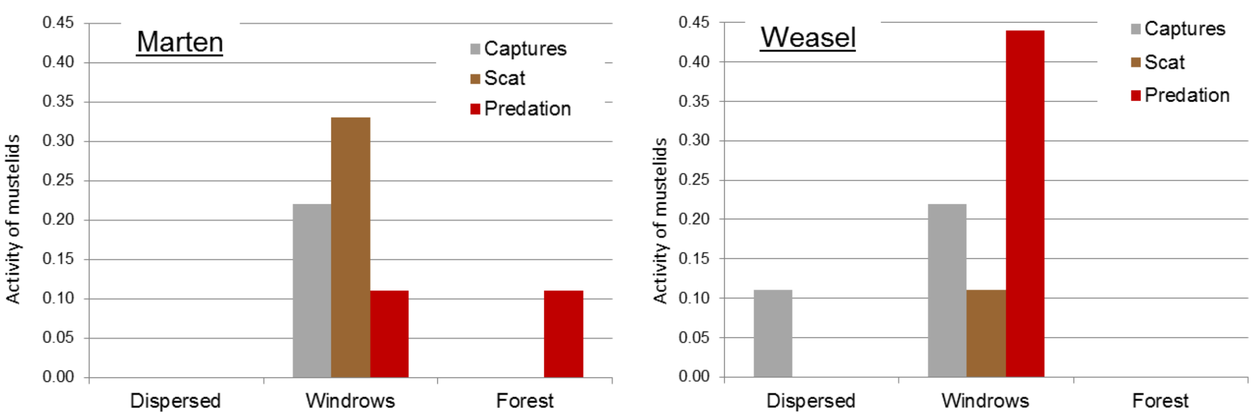

Figure 11. Mustelid activity in sites with dispersed woody debris, windrows and uncut forest

5 Bioenergy and Carbon Discussion

Construction of windrows in all cut blocks (in Scenario 2) would incur additional annual costs to the project compared with Scenario 3: there was a loss in revenue of $9,826 for the 20,000 tonnes plant, $29,569 for the 40,000 tonnes, and $49,281 for the 100,000 tonnes. However, these costs are much smaller than those of Scenario 1 (no windrows, no pellets) incurred for slash burning: $160,579 for the 20,000 tonnes plant, $481,736 for the 40,000 tonnes, and $802,894 for the 100,000 tonnes. Economic comparisons between pellet production scenarios 2 and 3, with respect to three different plant sizes and three transportation distances were calculated for Elkhart and Golden, respectively. For Elkhart-type cutblocks, there was a profit potential of $400,569 to $2,885,924 in Scenario 2, depending on the assumptions made. For Golden-type cutblocks in Scenario 2, this range was $274,873 to $2,249,649, again, dependent on assumptions. In both cases, windrows could also have been constructed on at least a portion of the cutblock units.

Windrows do not need to be constructed on all cutblocks, and hence the overall costs associated with windrow construction would be smaller. In this analysis it was assumed that all the necessary biomass feedstock required by the pellet plants would be sourced only from the harvested cutblocks. In reality, it is more likely that the pellet plants would rely also on sawmill residues for feedstock, which will reduce the amount of post-harvest slash needed.

Table 1. Elkhart scenarios for costs that do not depend on transportation distance from cut blocks to pellet mill

Removal rate of debris suitable for pellets [% CWD]	**0% (Scenario 1 Elkhart)**	**91% (Scenario 2 Elkhart)**	**100% (Scenario 3 Elkhart)**
Pellet plant size [x1000 odt pellets/year]	**20… to …100**	**20… to …100**	**20… to …100**
Cost of slash burning [$/odt]	5.00	5.00	5.00
Cost of slash burning [$x1000/year]	161… to …803	30… to …149	30… to …151
Feedstock cost [$/odt], Elkhart		4.55	5.00
Windrows cost [$/odt], Elkhart		0.45	0.00

Table 2. Golden scenarios for costs that do not depend on transportation distance from cut blocks to pellet mill

Removal rate of debris suitable for pellets [% CWD]	**0% (Scenario 1 Golden)**	**51% (Scenario 2 Golden)**	**100% (Scenario 3 Golden)**
Pellet plant size [x1000 odt pellets/year]	**20… to …100**	**20… to …100**	**20… to …100**
Cost of slash burning [$/odt]	8.33	8.33	8.33
Cost of slash burning [$x1000/year]	268… to …1,338	52… to …260	50… to …251
Feedstock cost [$/odt], Golden		4.25	8.33
Windrows cost [$/odt], Golden		4.08	0.00

CO_2 emissions were by far the highest in Scenario 1 where all the harvest slash was burned. The only CO_2 emissions considered in this study were from the burning of woody debris at the cutblock. The lowest emissions of CO_2 were observed in Scenario 2 (construction of windrows as well as manufacturing of pellets). This suggests that, from the perspective of CO_2 emissions from biomass burning, the construction of windrows resulted in less emissions, partially due to the sequestration of carbon in the windrow biomass.

The bioenergy + windrows project (Scenario 2) shows a potential to “save” between 75,682 and 378,409 t CO_2/year from being released into the atmosphere compared with the status quo (Scenario 1) for Golden-type blocks, and between 39,122 and 195,612 t CO_2/year for Elkhart-type blocks.

6 Conclusions

Our analysis of the fate of post-harvest debris with respect to bioenergy, mammal biodiversity, or smoke and carbon emissions is summarized in Figure 12. Production of wood pellets is, indeed, a worthwhile endeavour but economic feasibility is likely dependent on size of pellet production plant and distance to haul wood chips from the various harvested sites to the plant, as well as other assumptions. Bioenergy is a renewable enterprise that results in reduced use of fossil fuels. This can result in a reduction in carbon emissions, a widely supported environmental goal. In addition, biomass sources in this study were from harvest residues rather than removal of whole trees. A valuation of mammalian biodiversity has indicated at least five components that may generate some monetary revenue by constructing windrow habitats on clearcuts. Windrow construction would be site- and cutblock-specific with windrows connecting patches of uncut forest to forest reserves and riparian areas. They are not required on every cutblock, and generally use only 10-15% of excess post-harvest woody debris.

This study highlights three key points to consider regarding utilization and disposal of waste wood piles:

1) Allocate most woody debris waste to the biofuels sector in a cost-effective manner;
2) Allocate a small portion of woody debris to implement windrow habitats where necessary to maintain mammalian biodiversity on clearcuts;
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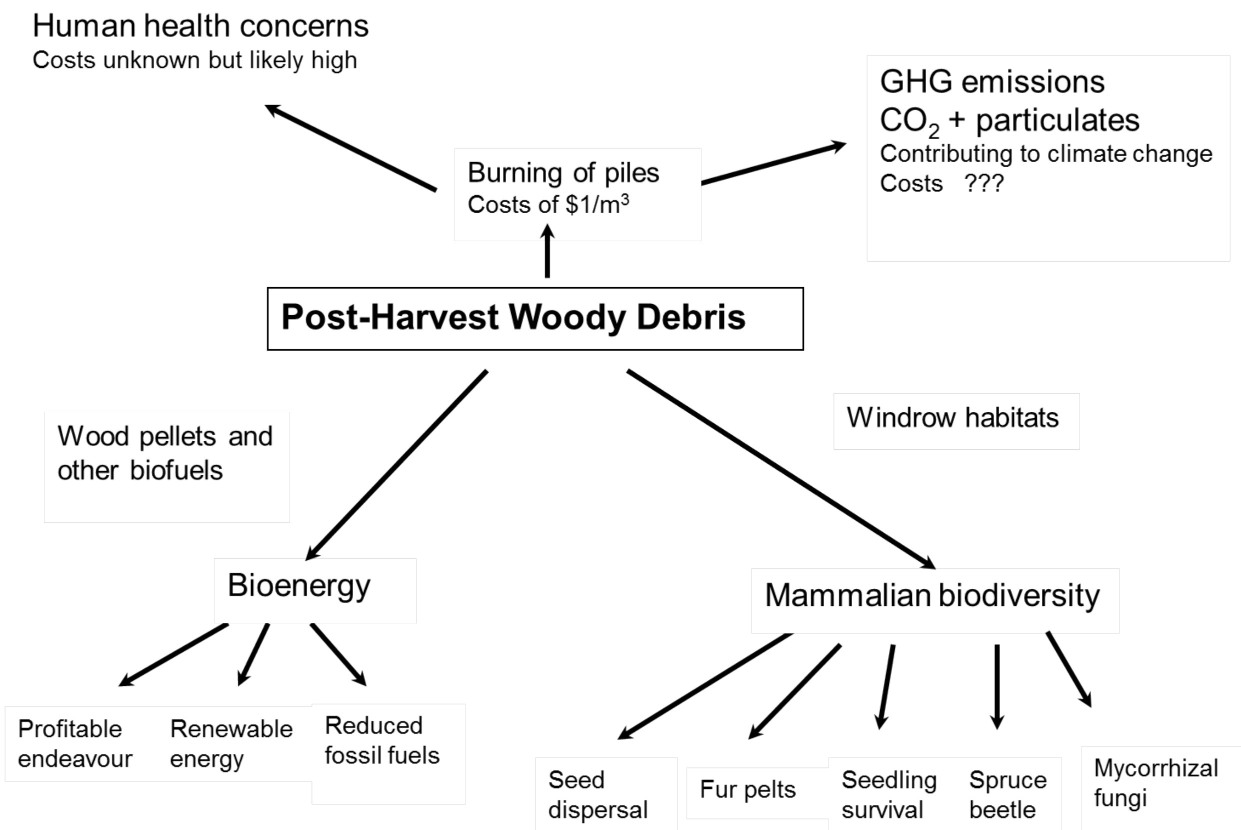

Figure 12. Utilization and disposal of Post-harvest woody debris piles

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