Results Of Operational Trials To Manage Coarse Woody Debris In The Northern Interior

interim report
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Prepared for the Morice-Lakes IFPA:

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Introduction

Coarse Woody Debris (CWD) is defined as "dead woody material, in various stages of decomposition, located above the soil, larger than 7.5cm diameter and not self-supporting" (MoF and MELP, 1998). It plays several major roles in forest ecosystems, including maintaining forest productivity, providing habitat for vertebrates and invertebrates, contributing to soil and slope stability, and providing long-term carbon storage (Stevens, 1997).

In an unmanaged forest, most trees fall and decay *in situ*, thus contributing to CWD on the ground. In a managed forest, many or most trees are removed during commercial harvesting operations. There will therefore be a decline in the amount of dead wood allowed to remain and decay within managed stands, with a corresponding decline in its ability to fulfil its ecological roles. Recent studies have shown that forest harvesting results in changes to CWD attributes, relative to those found in unharvested stands (e.g. Lloyd, 2003; Adams, 2002; Densmore et al., in prep.). In particular, while overall CWD volumes are often lower after harvest, there is a marked decrease in volume contributed by large (diameter) and long pieces. This has negative implications for CWD-dependent wildlife, invertebrate and plant species, many of which prefer or require large pieces, and also for CWD longevity in the ecosystem (small pieces decay more quickly and will not last the rotation).

In 2002, a pilot study was undertaken jointly by B.C. Ministry of Forests, Houston Forest Products Ltd. and the Forest Engineering Research Institute of Canada (FERIC) to assess the costs and benefits of using clump retention to improve CWD management at the stand level. Its primary recommendation was that to maximize operational practicality and minimize machine damage to retained logs, CWD should be managed within clumps that include large and/or long logs, together with immature and deciduous trees, stubs and other habitat elements (Lloyd, 2004). In 2003, it was decided to assess the feasibility and cost-effectiveness of these recommendations in a series of three operational trials, located in the Morice and Lakes TSAs, in the SBSdk, SBSmc2 and ESSFmc biogeoclimatic subzones. This report describes the results of these operational trials.

Acknowledgements

This project was funded through the Forest Investment Account and supported by a consortium of licencees, including Fraser Lake Sawmills, Houston Forest Products Ltd., Babine Forest Products Ltd. and Canadian Forest Products Ltd. (Houston Operations). Trials were hosted by Fraser Lake Sawmills, Canadian Forest Products and Houston Forest Products, each of which kindly provided practical and logistical support as well as field supervision. The author would also like to acknowledge the harvesting crews from Plowman Contracting, Wilson Contracting and Tahtsa Timber, whose interest and involvement contributed greatly to the success of this project.

Goals, Objectives and Rationale

This project is guided by the principle in the Forest Practices Code Biodiversity Guidebook which states that "the more that managed forests resemble the forests that were established from natural disturbances, the greater the probability that all native species and ecological processes will be maintained" (Province of B.C., 1995). Thus the primary goal of the project is to leave CWD on site after harvest that resembles CWD found in forests established from natural disturbance. To this end, extensive baseline studies have been undertaken within the Nadina District that compare CWD in postharvest and undisturbed sites (Lloyd, 2003), and a "planning/monitoring matrix" (Lloyd, in prep.) has been devised to determine ecologically appropriate levels for CWD attributes in various site types in the District. The three operational trials are therefore also intended to compare postharvest CWD attributes to the levels considered appropriate based on levels in unmanaged forests in the same site type, as described in the planning/monitoring matrix.

The specific objectives for these three trials are:

- to assess the operational feasibility and cost-effectiveness of harvesting practices that retain clumps of CWD, stubs and immature trees in the SBSdk, SBSmc2 and ESSFmc biogeoclimatic (BGC) subzones, particularly with regard to maintaining
    - overall CWD volume
    - volumes of large-diameter CWD
    - volumes of long CWD
    - elevated CWD
    - sources of CWD recruitment (residual and immature trees, and stubs)
- to determine whether increased levels of desired CWD attributes are attained when harvesting crews are given specific instruction in terms of preset target levels, compared to general instruction on clumped retention of CWD, stubs and immature trees.
- to provide guidance to the harvesting crews involved

Site Selection And Study Areas

Three study areas were set up, one in each of the three subzones where significant harvesting occurs. Study areas were required to be:

- at least 30ha in size
- logged during summer/fall 2003
- clearcut and ground-skidded using a feller-buncher and grapple skidder
- of relatively uniform timber type and site series
- capable of being subdivided into three 10ha units.

The SBSdk study area, located in Fraser Lake Sawmills' CP139 block1, consisted of the northeast portion of a 118 ha clearcut located near Hallett Lake, 25km south of Fraser Lake. The study area was divided into three approximately 10ha units by spur road layout. Timber type was predominantly lodgepole pine, with 20% spruce component. The site series was mainly SBSdk/01 (Sxw-Spiraea-Purple peavine) complexed with 05 (Sxw-Spiraea-Feathermoss) and 06 (Sxw-Twinberry Coltsfoot). These three site series fall within the SBSdk "Moderate" site series group for CWD as defined by Lloyd (in prep). The site was logged in October 2003 using two teams of feller-buncher and grapple skidder. The three study units were split such that each team harvested half of each study unit.

The SBSmc2 site, located in Houston Forest Products' CP244 block WSL14, consisted of three approximately 10ha units within a 196ha clearcut near Whitesail Lake, about 100km south of Houston. Parts of this cutblock had been harvested as part of the mountain pine beetle management program; the three study units were disjunct areas bounded by roads and existing patch cut boundaries. Timber type was predominantly lodgepole pine-subalpine fir. The site series was mainly 01 (Sxw-Huckleberry) complexed with 05 (Sxw-Twinberry-Coltsfoot). The primary CWD site group is SBSmc2 "Moderate" as defined by Lloyd (in prep). The site was logged in November/December 2003 using one feller-buncher and grapple skidder. Post-harvest data are not yet available for this site due to snow conditions at the time of harvest.

The ESSFmc site, located in Canfor's CP595 block OT6, consisted of the southeast portion of a 35 ha clearcut located near Morice Lake, about 70km southwest of Houston. The northwest side of the block could not be harvested as part of this trial due to soil conditions, so the three study units were each approximately 8-9ha. Boundaries were mainly defined by spur road layout and block boundaries; a ribbon line was also laid out to define the boundary between units 1 and 2. Timber type was predominantly subalpine fir. Site series was primarily 01 (Bl-Huckleberry-Leafy liverwort) complexed with 05 (Bl-Huckleberry-Thimbleberry). The primary CWD site group is ESSFmc "Moderate" as defined by Lloyd (in prep). The site was logged in October 2003 using one feller-buncher and grapple skidder.

Methods

Adaptation of harvesting practices

For each study area, the three study units were designated Control, Treatment 1 and Treatment 2.

In the **Control unit**, no instruction was given to the harvesting crew, and harvesting operations were conducted according to normal practice. It should be noted that, for all three participating licencees, standard operating practice includes retaining deciduous trees and immature understory trees (singly or in clumps) where feasible.

In the **Treatment 1 ("Targets") unit**, the harvesting crews received a 1-2 hour tailgate training session prior to commencing operations. This training session was based on the Recommended Best Management Practices (Lloyd, 2004) and the summary document used as a handout is reproduced in Appendix I. Crews were instructed:

- to leave logs estimated to be classed as grade 5 (dead and dry lumber reject) or lower intact on the cutblock

- to maintain clumps of immature trees and patches of natural non-merchantable deadfall intact where possible
- to fell or stub dead trees estimated as grade 5 or lower and to place the felled portion in or alongside an existing clump where possible
- where no such clump existed nearby, to place the felled pieces together in a new clump, with stubs or immature trees left as clump markers. Preferred locations for new clumps include areas such as ridges and knobs where skidders would not normally travel.
- as far as possible, to place felled snags and stub tops in an approximately natural orientation ("jackstrawed", not bunched together) to simulate natural deadfall, incorporating existing downed logs where possible
- to ensure that all retention clumps were marked, usually by stubs or immature trees, for maximum visibility to the skidder operator, so that the clumps could be maintained intact during skidding

Crews were instructed to place primary emphasis on maintaining intact logs greater than 10m long, by attempting to fulfil target objectives for volume and specifically for numbers of long logs. Target objectives were set according to the planning/monitoring matrix described on page 2 and are shown for each site in Table 1.

Table 1 Target levels for CWD attributes, Treatment 1 unit

Study site	Target volume total (all logs) (m^3/ha)	Target volume for logs >10m (m^3/ha)	Target numbers for long logs (logs/ha)
SBSdk	>50	>25	40 logs/ha >15m long
SBSmc2	>150	>75	70 logs/ha >20m long
ESSFmc	>200	>80	50 logs/ha >15m long

In the **Treatment 2 ("BMP's") unit**, harvesting crews were instructed to follow the Best Management Practices as for Treatment 1, but to "do the best you can" within a reasonable time, rather than meeting predetermined targets. Crews were particularly instructed not to increase the time spent in this study unit to a degree that would be considered unreasonable during normal operations.

Study design

This study assessed attributes of CWD, immature and residual trees and stubs at the same locations before and after harvest, in an identical manner on each of the three treatment units.

CWD was assessed by means of line-intersect plots according to the method outlined in the "Field Guide to Describing Terrestrial Ecosystems" (MELP and MoF, 1998), except that transect length was increased from 48m with one 90^{o} bend ("L"-shaped) to 90m with two 60^{o} bends (equilateral triangle with 30m sides). Logs less than 20cm diameter were measured only on the first 15m of each 30m transect leg (45m in total); logs greater than 20cm diameter were measured over the entire 90m transect length. This allows for greater sampling intensity of large-diameter logs, which are typically underrepresented in many CWD surveys. Measured attributes were:

- volume
- diameter
- decay class
- length class
- height above ground

Immature trees were tallied in fixed-area plots centred on the CWD plot. Preharvest plots were $390m^2$; in postharvest plots this was increased to $2827m^2$ (30m radius) to compensate for the smaller number of trees but increased visibility.

As far as possible, plots were laid out on a 100m x 100m grid, adapted to accommodate the shape of the treatment unit. 10 plots were located in each ~10 ha treatment unit, except for the ESSFmc treatment 1 unit, where unit size limited layout to 9 plots. Plots were not located:

- within 50m of the road edge (this is the "decking zone" where the presence of log decks and frequent machine traffic generally precludes retention of structural elements)
- within 10m of the cutblock boundary
- within 30m of a unit boundary that was not a road or cutblock edge
- within 75m of each other (where the 100m x 100m grid was adjusted)

Plot centres were marked by painting the base of the nearest tree with fluorescent orange log marking paint – the orange stump was usually clearly visible after harvesting. The base of the next nearest tree was painted blue, as a failsafe.

CWD calculations

CWD volumes for each line transect were calculated using the equation in Marshall et al. (2000):

$$y_i = \frac{\pi^2}{8 \text{ x } L} \text{ x } \sum_{j=1}^{m_i} \frac{d^2_{ij}}{\cos \lambda_{ij}}$$

where y_i is CWD volume (m^3/ha.) in the area, represented by pieces intersected by the *i*th transect, d is piece diameter at point of intersection (cm), L is the length of sample line (m) and λ is the angle of the piece with the horizontal (tilt angle).

Number of pieces per hectare for each line transect were derived from the equation in Marshall et al. (2000):

$$y_i = \frac{10{,}000 \text{ x } \pi}{2 \text{ x } L} \text{ x } \sum_{j=1}^{m_i} \frac{1}{(l_{ij} \text{ x } \cos \lambda_{ij})}$$

where y_i is the number of pieces per ha. in length class *i*, L is the total transect length (m), l_i is the midpoint of length class *i* (m) and λ is the angle of the piece with the horizontal (tilt angle).

Results

Results of the CWD assessments are shown in the following figures and tables. This report does not include postharvest results for the SBSmc2 site, as harvesting in the study area could not be completed prior to snowfall.

CWD volume

Figures 1a-1b and Table 2 show the mean volumes before and after harvest on the three units in each study area.

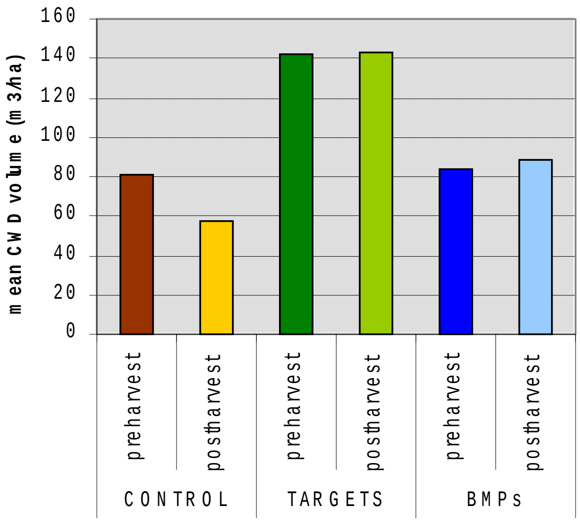

Figure 1a Mean CWD volume before and after harvest in the SBSdk

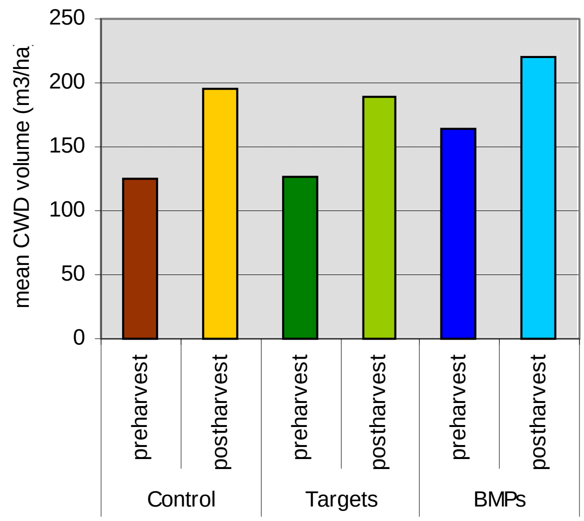

Figure 1b Mean CWD volume before and after harvest in the

In the SBSdk site, mean postharvest volumes are somewhat lower than preharvest volumes in the control unit and almost identical in both treatment units. Paired-sample t tests showed no significant difference between preharvest and postharvest volumes on any unit ($P>0.05$), although one-way ANOVA showed that treatment 1 (the Targets unit) had significantly higher CWD volumes then the other two units both before and after harvest ($P<0.05$). It is of note that the standard deviation (S.D.) in the Control unit is also considerably lower after harvest – meaning that the variation in volume is lower. The postharvest range of volumes is less than half the preharvest range; in particular there are no longer any plots with high volumes (>100m^3/ha).

Table 2 CWD volumes before and after harvest

		preharvest		postharvest		% change
		mean volume (m^3/ha)	S.D.	mean volume (m^3/ha)	S.D.	
SBSdk	Control	81	67	58	29	- 28%
	Treatment 1 (Targets)	142	61	143	54	+ 1%
	Treatment 2 (BMP's)	84	58	88	56	+ 5%
ESSFmc	Control	125	49	196	86	+ 57%
	Treatment 1 (Targets)	126	54	189	73	+ 50%
	Treatment 2 (BMP's)	164	79	221	105	+ 35%

In the ESSFmc site, mean postharvest volumes are considerably higher than mean preharvest volumes in all units. Paired t tests showed that postharvest volumes were significantly higher on both treatment units ($P<0.05$); on the control unit it was "not quite significant" ($P<0.1$). Control and treatment units were not significantly different from each other either before harvest or after harvest (one-way ANOVA, $P<0.05$). Standard deviation also increased after harvest, indicating that the range of volumes increased on all three units.

CWD diameter

Mean volume of large and small diameter pieces is shown in Figures 2a-2b. Mean volumes of large-diameter pieces before and after harvest are shown in Table 3. Note that >20cm was considered "large" in the SBSdk, whereas "large" in the ESSFmc was considered >40cm.

In the SBSdk, there was little difference in the relative abundance of small and large CWD before and after harvest. In the Treatment units, mean volumes of large (>20cm diameter) logs did increase by 18% and 36% (Targets and BMP's respectively), compared to a 31% decline in the Control unit, but the volumes involved are likely too small to have any biological significance.

In the ESSFmc, there was an increase in the mean volumes of small (<20cm) and moderate (20-40cm) sized CWD in all three units. The Control unit showed a 60% decline in the mean volume of large (>40cm diameter) logs; this was reduced to a 26% decline in Treatment 1 (Targets) and reversed to a 79% increase in Treatment 2 (BMP's). Volumes may be too small to have biological significance.

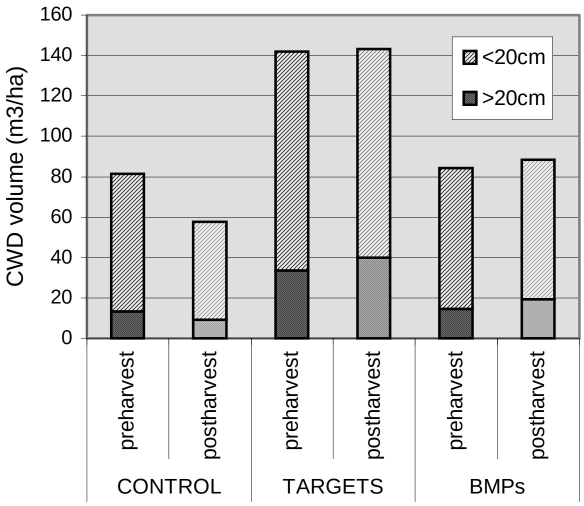

Figure 2a Mean volume of large and small diameter pieces in the SBSdk

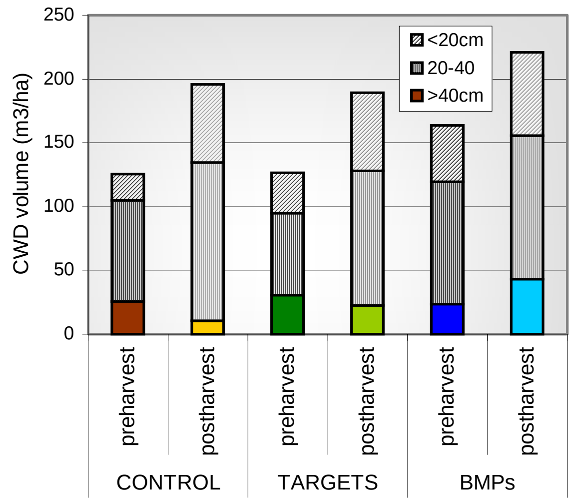

Figure 2b Mean volume of large and small diameter pieces in the ESSFmc

Table 3 Mean volume of large-diameter logs before and after harvest

		mean volume of large logs (m^3/ha)		**% change**
		preharvest	**postharvest**	
SBSdk >20cm diameter	Control	13	9	- 31%
	Treatment 1 (Targets)	34	40	+ 18%
	Treatment 2 (BMP's)	14	19	+ 36%
ESSFmc >40cm diameter	Control	25	10	- 60%
	Treatment 1 (Targets)	31	23	- 26%
	Treatment 2 (BMP's)	24	43	+ 79%

CWD length

Mean volume of long and short pieces is shown in Figures 3a-3b. Mean volumes of long (>10m) logs before and after harvest are shown in Table 4.

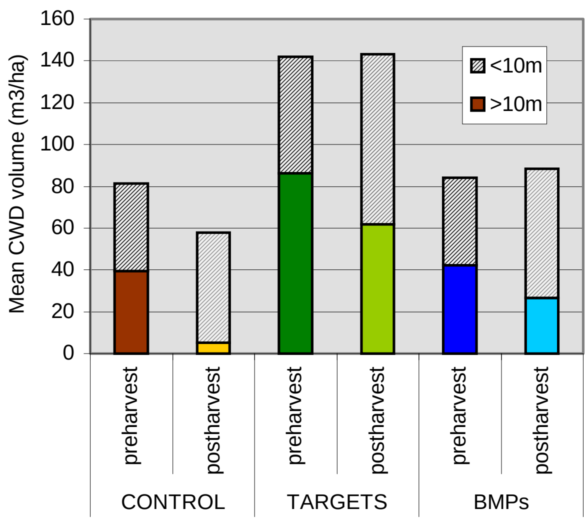

Figure 3a Mean volume of long and short logs in the SBSdk

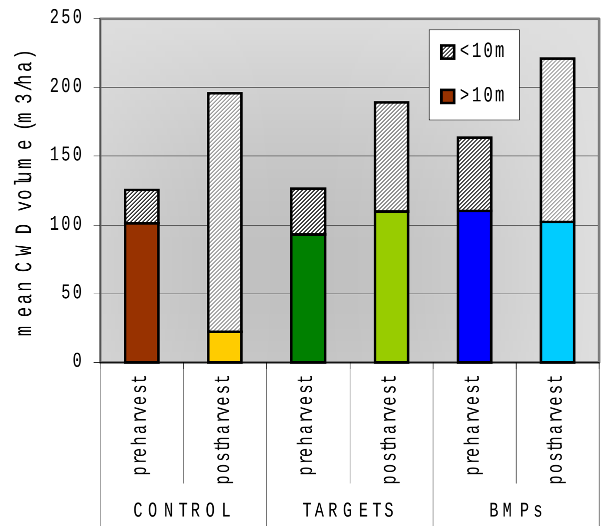

Figure 3b Mean volume of long and short logs in the ESSFmc

Table 4 Mean volume of long (>10m) logs before and after harvest

		mean volume of long logs (m^3/ha)		**% change**
		preharvest	**postharvest**	
SBSdk	Control	39	5	- 87%
	Treatment 1 (Targets)	86	62	- 28%
	Treatment 2 (BMP's)	42	27	- 36%
ESSFmc	Control	101	22	- 78%
	Treatment 1 (Targets)	93	110	+ 18%
	Treatment 2 (BMP's)	110	102	- 7%

In the SBSdk, volumes of long logs were significantly lower after harvest in control and treatment 2 (BMP's), not in treatment 1 (Targets) (paired t-tests, $P<0.05$). All three units showed a shift towards shorter logs after harvest. In the Control unit, the preharvest volume of long logs was reduced by 87%, and none of the remaining volume exceeded 15m long. In the Treatment units, this shift was still present but much less drastic – preharvest volumes of long logs were reduced by 28% and 36%, and the actual volumes remaining were 5-12 times higher than in the Control. Most of the volume reduction was in the longest log categories. In Treatment 1 (Targets), the longest remaining logs were 20-25m long; in Treatment 2 (BMP's), longest remaining logs were 15-20m long.

In the ESSFmc, volumes of long logs were significantly lower after harvest in the control unit but not in either of the treatment units; and volumes in the treatment units were not significantly different from each other (paired t-tests, $P<0.05$). The Control unit showed a significant shift towards mainly short logs after harvest, with the preharvest volume of long logs reduced by 78%. In both treatment units, there was little difference between long log volumes before and after harvest, and the actual volumes remaining after harvest were about 5 times higher than in the Control. There was also little difference in the volume distribution between length classes before and after harvest in the Treatment units – that is, the longest logs present prior to harvest were mostly either retained or replaced by similar logs.

CWD elevation

The percentages of pieces on each transect that were supported off the ground is shown in Figures 4a-4b.

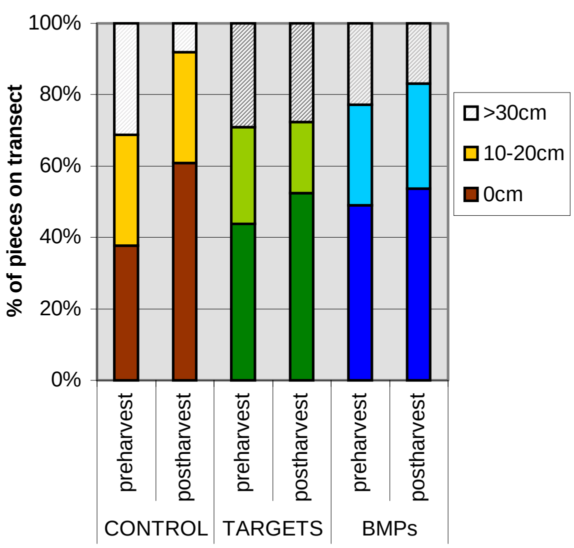

Figure 4a Proportion of elevated CWD in the SBSdk

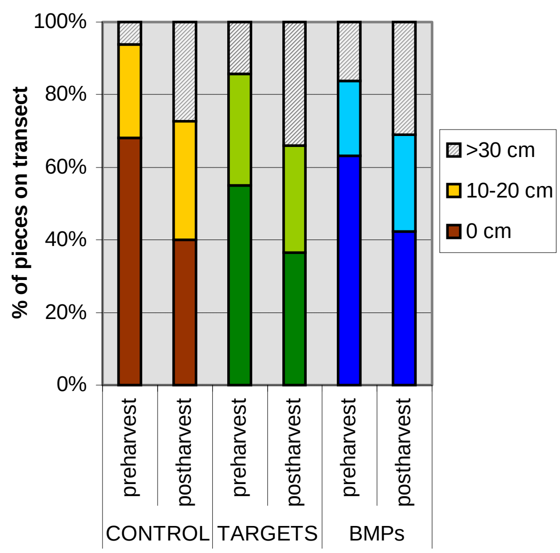

Figure 4b Proportion of elevated CWD in the ESSFmc

In the SBSdk, there were significantly more pieces lying directly on the ground and fewer elevated pieces in the control unit, whereas there was no significant difference in either of the treatment units (chi-squared test for independence, $P<0.05$). The control unit showed a 50% increase in the number of pieces that lay directly on or in the ground after harvest, and a corresponding decrease in the number that were elevated 30cm or more above ground. In both treatment units, the proportions were similar before and after harvest, indicating that elevated logs had been either retained or replaced.

In the ESSFmc, there was a significant increase in the number of elevated pieces after harvest in all three units, and there was no significant difference in CWD elevation between the control and treatment units after harvest (chi-squared test for independence, $P<0.05$). There was a high proportion of CWD directly on the ground before harvest in all units – this is typical of an older forest where there is a relatively high proportion of old, well-decayed pieces. After harvest, the proportion of CWD that was supported off the ground increased in the control and both treatment units. This is similar to the situation after a natural disturbance, where trees fall and are often supported either on their own branches or across other logs, although it is unlike the usual post-harvest situation (Lloyd, 2003).

CWD recruitment – immature and residual trees and stubs

The density of residual immature trees and stubs found after harvest is shown in Figures 5 and 6. Preharvest numbers of understory trees were highly variable between plots, but were not significantly different in control and treatment units (Kruskal-Wallis test, $P<0.05$; this test was used where unequal standard deviations in the samples invalidate a basic assumption of ANOVA). Since stubs are created during harvesting, they are not present prior to harvest.

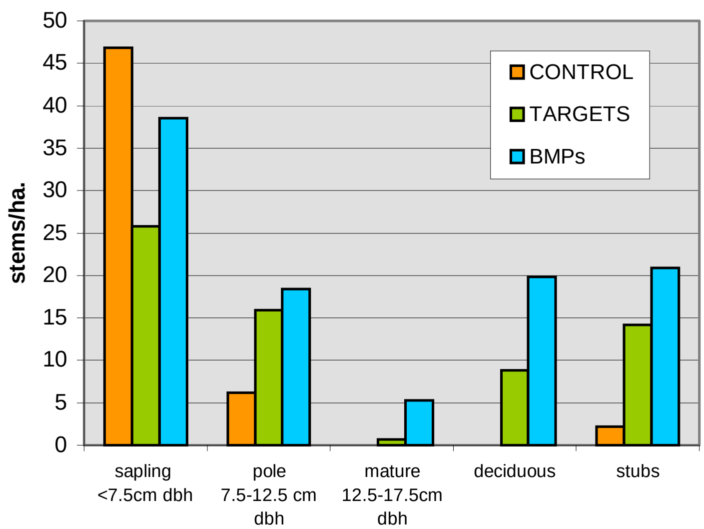

Figure 5 Density of residual immature and deciduous trees and stubs in the SBSdk

In the SBSdk, large immature trees (>7.5cm dbh) were significantly more abundant on treatment units than on control (Kruskal-Wallis test with Dunn's Multiple Comparison post-test, P<0.05). Of the two treatment units, mean densities were somewhat higher on the BMP's unit than on the Targets unit, however, preharvest densities were also somewhat higher. These differences were not significant (Kruskal-Wallis test, P<0.05). Small immature trees (<7.5cm dbh) were somewhat more abundant on the control unit than on either of the treatments; this difference was not significant (Kruskal-Wallis test, P<0.05).

Deciduous trees were somewhat more abundant on the BMPs unit than on either the Targets unit or the control unit; the difference was not significant and deciduous trees were not encountered on the control unit prior to harvest. Stubs were significantly more abundant on the BMP's unit than on Targets or control unit.

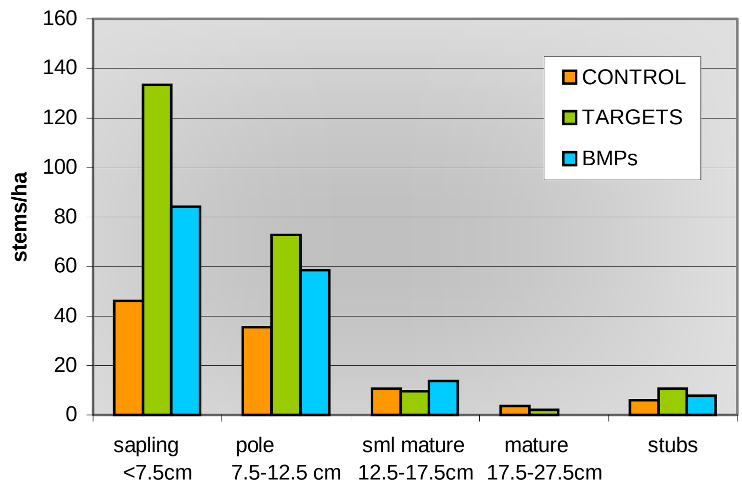

Figure 6 Density of residual immature trees and stubs in the ESSFmc

In the ESSFmc, large and small immature trees were significantly more abundant in treatment units than in control (one-way ANOVA, P<0.05). Densities in the Target treatment were somewhat higher than in the BMP treatment; this difference was not significant. Deciduous trees were not encountered on this site (they occur rarely in the ESSFmc), and there was no significant difference between densities of stubs.

Summary and Discussion

Table 5 provides a brief summary of changes to CWD attributes after harvest in control and treatment units of the SBSdk and ESSFmc study areas. Attributes shown in this table are those listed in the “Objectives” on page 2. Table 6 shows a summary of how CWD attributes on each of the study units compared with the target values set in Table 1.

Table 5 Summary of changes to CWD attributes after harvest

CWD attribute	SBSdk	ESSFmc
Volume (total)	***Control:*** reduced (n.s.)[1] ***Targets:*** no change ***BMP's:*** no change	***Control:*** increased ***Targets:*** increased ***BMP's:*** increased
Diameter	***Control:*** slight decrease in volume of large-diameter logs (n.s.) ***Targets:*** slight increase (n.s.) ***BMP's:*** slight increase (n.s.)	***Control:*** slight decrease in volume of large-diameter logs (n.s.) ***Targets:*** slight decrease (n.s.) ***BMP's:*** slight increase (n.s.)
Length	***Control:*** large reduction in volume of long logs ***Targets:*** slight reduction (n.s.) ***BMP's:*** small reduction	***Control:*** large reduction in volume of long logs ***Targets:*** no change ***BMP's:*** no change
Elevation	***Control:*** fewer elevated pieces ***Targets:*** no change ***BMP's:*** no change	***Control:*** more elevated pieces ***Targets:*** more elevated pieces ***BMP's:*** more elevated pieces
Immature/ residual trees	more large (>7.5cm dbh) immature trees in both treatments than in control unit	more large (>7.5cm dbh) and small (<7.5cm dbh) immature trees in both treatments than in control unit
Stubs	more in treatment units than in control unit	same in control and treatment units

These summary tables indicate that the primary change in postharvest CWD attributes attributable to the adapted harvesting practices is a large increase in the volume and number of long logs retained on the cutblock compared to the volume and number remaining on the control units. All treatment units had long log volumes similar to or only slightly less than preharvest volumes. Since reduction in piece size following harvest is widely reported as the major change to CWD after harvest (Lajzerowicz, 2000; Adams, 2002; Lloyd, 2003; Densmore et al., in prep), this project appears to have been successful. The other major change reported in the literature is a reduction in large-diameter logs and in overall volume compared to preharvest levels – this appears not to be an issue in this study. Overall volume may become an issue (e.g. Densmore et al., in prep) but this is outside the scope of this report.

[1] n.s. – not statistically significant (P<0.05)

Table 6 Target and actual levels of postharvest CWD attributes

CWD attribute	SBSdk		ESSFmc	
	target	actual (mean)	target	actual (mean)
Volume (total) m3/ha	>50	Control: 58 Targets: 143 BMPs: 88	>200	Control: 196 Targets: 189 BMPs: 221
Volume (>10m long) m3/ha	>25	Control: 5 Targets: 62 BMPs: 27	>80	Control: 22 Targets: 110 BMPs: 102
no. of long logs/ha.	>40 logs/ha >15m long	Control: 0 Targets: 58 BMPs: 13	>50 logs/ha >15m long	Control: 0 Targets: 51 BMPs: 37

In the SBSdk, both treatment units retained a higher percentage of preharvest CWD volume than did the control unit, and retained a higher proportion of logs that were supported off the ground. This has implications for wildlife use (e.g. small mammals are frequently associated with CWD volume (Hayes and Cross, 1987); elevated pieces provide cover and snow-free spaces) (Keisker, 1999) and also for rate of decay – decay would be slower in pieces that are not in contact with damp ground. Large (>7.5cm dbh) immature trees were also more abundant on treatment units than on control. It should be noted that all units on this site had a much higher density of residual immature trees than is usual in recent postharvest sites in the SBSdk (Lloyd, 2003) despite a windstorm that uprooted a large number of them prior to the postharvest assessment. The site may have had an unusually high number of understory trees prior to harvest, or the harvesting crew may be more conscientious than most in maintaining immature trees during normal harvesting.

In the ESSFmc, total CWD volume increased after harvest on all three units – this is not unusual in the ESSFmc (Lloyd, 2003) and is likely due to the relatively high proportion of unmerchantable wood in a subalpine fir stand. The increase in elevated pieces in the control unit is unusual.

Overall, there was little difference between the treatment units on either the SBSdk or the ESSFmc site. In the SBSdk, differences are somewhat confounded because the Targets site had more and bigger CWD before harvest, and also because the crews reported that it was more difficult to log. In the ESSFmc, there was no discernable difference between the treatment units.

Cost-effectiveness

None of the three licencees reported increased logging costs attributable to the clump retention (other than operator training time) although changes in operator and machine time could have been masked by terrain differences in the area harvested or other unrelated factors that affect ease of harvesting. Potential costs due to merchantable wood being inadvertently left on the cutblock will be assessed in 2004.

No discernable differences were reported between the two treatment units – i.e. whether or not operators were given targets for volume and numbers of long logs. Differences may exist but were masked by harvesting conditions, which had a greater impact on overall machine time spent.

Practical recommendations for adapted harvesting methods

1. Day and Night harvesting

Crews in the SBSdk trial, who began harvesting operations before dawn, reported that CWD retention was considerably easier during daylight hours. During pre-dawn operations, the lights on the feller-buncher illuminated the area directly in front of the machine but provided limited visibility on either side, making identification and placement of retained logs to the side of the machine's path more difficult. This suggests that where aggressive retention of CWD is planned across an entire block, it could be more easily achieved during the summer. Where CWD retention is concentrated in a part of a block (e.g. a riparian or lakeshore management zone), this area should be harvested during daylight hours.

2. Field guides to desired CWD levels

Crews in the SBSmc2 trial commented that targets in terms of either volume or numbers of logs per hectare were not easily understandable to field crews, because they had no clear idea of what the target value should look like. They suggested that, given sufficient experience, desired levels would be easier to visualize relative to a previous block (i.e. a little more or a little less than on a specific block harvested earlier). Pictorial guides may also be useful, especially with novice crews.

3. Alternatives to retention of clumps

Crews in the SBSmc2 trial felt that CWD and other structural elements could be retained more easily and efficiently in strips rather than in clumps – that is, the feller buncher would cut a series of paths into the block, separated by "retention strips" where CWD and immature trees would be relatively undisturbed. The skidder would then use the same paths as the feller-buncher, to minimize disturbance in the retention strips. Results of this approach will be assessed in 2004.

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APPENDIX I - OPERATIONAL STRATEGIES FOR CWD MANAGEMENT

Maintain clumps of CWD and other structural elements

Clumps could be built around:

- existing deadfall
- a group of snags (stubbed, with tops left in clump
- existing clump of immature trees
- alder patch (or other tall shrubs)
- existing deciduous or cull trees
- a ridge crest or area where the skidder doesn't go

Remember they must be **visible**!

Keep the larger, longer logs intact and on the block

- don't skid unwanted logs
- identify unmerchantable stems at the stump and leave on site
- place unwanted snags
    - in direction of skid
    - to one side of skid route
    - in or adjacent to clump
- applies particularly to snags with branches and bark

Think Jackstraw!!
Imitate natural distribution

- try not to disturb natural accumulations of downed logs
- if a tree or snag is felled and left, put it down across other logs (off the ground if possible).
- avoid bunching groups of logs if they are not going to be skidded to the landing

Maintain immature, deciduous and large cull trees for habitat and for future CWD

For immature trees, look for

- pole size or larger preferred
- large, healthy crowns
- in clumps where possible

Large green trees could be

- aspen or cottonwood
- declining or cull trees of little commercial value

Stub snags around the outside of a clump

- the stubs act as "rub trees" to prevent damage to the clump

Place unwanted snags (or stub tops) in or around the clump

- in direction of skid
- at the side to avoid damage to live trees

Even a single stub could be a marker for two or three logs at its base!