Snip & Skid: Partial Cut Logging to Control Mountain Pine Beetle Infestations in British Columbia

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ABSTRACT - Small patch cutting (less than 1 ha in size) in mature lodgepole pine stands has been introduced to prevent the spread of mountain pine beetle populations in central British Columbia. This type of harvesting is locally referred to as "Snip and Skid" harvesting. Beetles are lured into trees baited with a synthetic pheromone attractant within a small patch of forest, and destroyed by removing the baited and infested trees. Scattered patches in a large area require additional time for moving equipment between patches, causing a significant increase of non-productive time and total logging cost. The total stump-to-truck costs of the Snip & Skid logging in each patch ranged from \$14.98 to \$19.71/m^3, averaging \$17.00/m^3. The overall cost would be \$22.28/m^3 if it includes other cost allowances such as overhead and profit for the logging contractor. The cost greatly increased with decrease of tree sizes: if the average stem size was 0.25 m^3, the cost would be \$32.61/m^3. Walking and low-bedding accounted for 57% of the total delay in the Snip and Skid logging. We found five trees damaged per 100 m along the skid trails created to access patches. No significant impact on soils and high stumps were found.

Keywords: logging costs, skidding productivity, lodgepole pine, forest health

INTRODUCTION

The mountain pine beetle (*Dendroctonus ponderosae* Hopk.) is the most destructive forest insect in British Columbia (Van Sickle 1995). Large outbreaks in the northern central interior of BC frequently develop in mature lodgepole pine (*Pinus contorta* Douglas *var. latifolia* Engelmann) stands that contain dense, large-diameter trees. These epidemics greatly influence harvesting scheduling and management priorities, as it is necessary to control the spread of beetle infestations and to quickly harvest infested timber over large areas.

Current mountain pine beetle control strategies being used in British Columbia include fell and burn, pesticide, single tree sanitation harvesting, partial cutting in small patches, and large clearcuts (MOF 2000). Large clearcuts are used to reduce large beetle populations in severely infested areas, and involve conventional logging practices. Harvesting numerous small patches less than 1 ha in size scattered over a large area is termed "Snip and Skid" in British Columbia. This approach has been introduced to control the spread of beetle populations to other areas by attracting adult beetles into a few trees in a patch and removing those trees. Beetles are lured into trees baited with a synthetic pheromone attractant (trans-verbenol and exo-brevicomin) within a small patch area, and then destroyed by harvesting and processing both the baited and previously infested trees during the winter.

Although Snip and Skid harvesting has been routinely used to control beetle populations in northern central BC, there is little information describing the detailed procedures and associated issues such as increased logging costs and environmental impacts when implementing the method. Past experience has shown that logging costs for implementing Snip and Skid method are typically higher than conventional harvesting because small patches are spread over a large area and long skidding distances are necessary to access the patches. Harvesting equipment spends a significant amount of time moving from one patch to the other as a result of the dispersed spatial distribution of patches, which is unnecessary in a larger clearcut block.

The removal of trees on the skid trails is necessary to access designated patches, but trails should be kept as narrow as possible. The Prince George Forest District allows skid trails to be an average of no more than 6-m in width. Skid trail width is highly co-related with residual stand damage along skid trails (Han and Kellogg 2000) and operations productivity. In order to minimize the risk of leaving beetles in a stand, stump heights should be as low as possible and the harvested stem should be utilized to 10 cm top diameter (Safranyik and et.al. 1974). Low stump heights, less than 30 cm, can be easily accomplished with feller-buncher felling (Hall and Han 2001).

The objectives of this study are to determine the actual logging costs of Snip and Skid operations with some highlights on machine utilization rates and optimal allocation of equipment, and to describe the impacts on residual trees along with skid trail information. In addition, recommendations are discussed for improving Snip and Skid logging efficiency and minimizing environmental impacts.

STUDY METHODS

Twenty nine small patches were sparsely located on the Mt. McKenzie Management Area approximately 65 km northwest of Prince George, B.C. (Fig. 1 and Table 1). Forests in this area are considered to be even-aged stands with an average age of 113 years and a range of diameter at breast height of 20 - 32 cm. The species composition is dominated by lodgepole pine trees (72%) with a minor component of Douglas-fir (15%; *Pseudotsuga menziesii* (Mirb.) Franco), white spruce (12%; *Picea glauca* (Moench.) Voss.), and subalpine fir (0.5%; *Abies lasiocarpa* (Hook.) Nutt.). The basal area in this area ranged from 30 to 45 m^2 per ha with an average stand density of 570 - 1200 trees per ha. Slopes in this area are less than 15% with a few exceptions in isolated steeper areas. Snow accumulation at time of harvesting was less than 50 cm within the stands and cannot be considered as a factor for leaving high stumps. Patch sizes were relatively small, raging from 0.01 ha to 0.8 ha. Each patch was composed of mainly lodgepole pine that has been baited with a synthetic pheromone to attract the beetles.

During winter of 2000/01, one logging contractor was selected by the licensee to remove the trees identified in 29 patches. A full tree harvesting method was used: trees were felled and bunched with Madill 3200B feller-buncher and delivered to landings using a John Deere 748G grapple skidder and a Cat 527 track skidder. The track skidder was used for forwarding trees in steep uphill or broken-slope areas. Trees were then processed into tree length logs using a Cat 320 stroke boom delimber equipped with a Limmit processing head. In loading, a Madill 3800LL butt' n top (grapple) loader was used when wood volume at a landing was greater than 5 truck loads. A self-loading truck was also used to pick up a small amount (less than 5 truck loads) of wood in isolated locations.

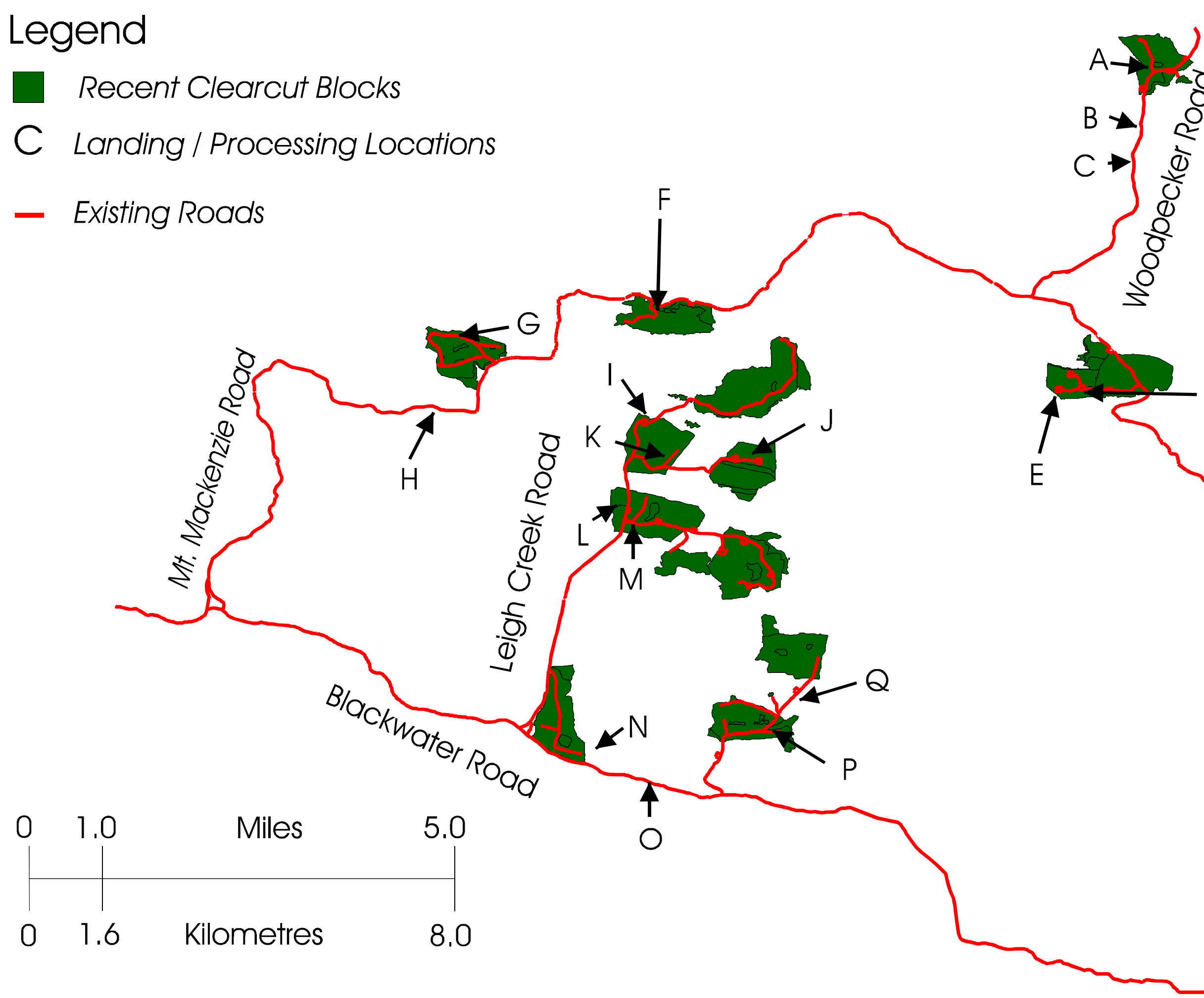

Figure 1. 17 processing/loading locations in the study site

A low-bed trailer was used to move equipment from one location to another if long distances between sites justified this. A distance of 5 - 6 km was used as an approximate threshold whether a machine would walk or be low-bedded to the next site. One foreman was designated to coordinate the equipment allocation in each site to minimize non-productive time required to move machines to another site at a distance. A low-bed was fully occupied with this task throughout the logging operations. No new roads and landings were built to access the timber, but skid trails were identified from existing roads nearby to access to each patch. A portable, small bridge was used for a temporary stream crossing when necessary.

A hand held computer (DAP Microflex PC9800) was used to collect detailed production data for feller-buncher and skidder operations, along with harvesting attributes such as slopes and skidding distance. Time spent for low-bedding and walking time between patches was recorded as non-productive time (delay) for each machine from detailed and shift-level data forms. Productivity for processing and loading was based on shift-level data forms filled in by machine operators.

Table 1. Tree volume harvested and Snip and Skid logging costs in each processing/loading location.

Location	# patches	# loads	Vol./tree	Volume harvested	Cost Felling	Skidding	Processing	Loading	Total[1]
			------ (m^3) ------		------------------------ ($/$m^3$) ----------------------				
A	3	21	0.75	997.5	2.63	5.07	3.69	2.17	16.22
B	1	3	0.63	142.5	3.13	5.07	3.69	2.33	16.88
C	1	2	0.58	95	3.42	5.07	3.69	2.52	17.37
D	1	20	0.90	950	2.20	3.46	3.69	2.96	14.98
E	1	2	0.90	95	2.20	3.46	3.69	3.42	15.43
F	3	11	0.70	550.5	2.84	5.66	2.26	3.27	16.68
G	5	29	0.69	1,377.5	2.87	4.83	3.83	2.88	17.07
H	1	1	0.52	51	3.83	4.83	3.70	4.69	19.71
I	1	5	0.34	237.5	5.73	4.68	3.70	2.84	19.61
J	1	7	0.79	332.5	2.48	4.68	3.70	2.76	16.29
K	1	10	0.80	475	2.47	4.68	3.70	2.71	16.22
L	4	5.75	0.54	273.1	3.62	4.68	3.70	2.80	17.47
M	1	0.25	0.49	11.9	3.98	4.68	3.70	2.57	17.60
N	2	3	0.39	142.5	4.99	3.82	3.70	2.57	17.75
O	1	4	0.59	190	3.32	3.82	3.70	2.57	16.08
P	1	3	0.78	142.5	2.53	3.82	3.14	4.69	16.84
Q	1	9	0.80	427.5	2.47	3.82	3.14	4.69	16.78
Average	1.7	8.0	0.66	381.9	3.22	4.48	3.55	3.09	17.00

[1]Total cost includes low-bedding ($1.12/$m^3$) and coordination ($1.54/m^3) for machine allocation.

A post-harvest survey was conducted to measure the width of skid trails and a level of residual stand damage during the spring of 2001. For each skid trail, width was systematically measured at an interval of 20 m to calculate an average width. A tree was defined as damaged if a tree sustained a scar greater than 4 cm in its width. Damage level was indicated as the number of damaged trees per 100 m of skid trail since the total population is unknown. Stumps within patches greater than 30 cm were considered high and tallied.

RESULTS AND DISCUSSION

Harvesting Productivity

In total, 6,492 m^3 of wood was harvested from 29 patches and skid trails associated with the patches, accounting for 136 truckloads. There were 17 landing/processing locations, and each landing had 1 to 5 patches (Table 1). The average volume harvested from each processing/ landing location was 381 m^3. Delay-free cycle time for felling and bunching time averaged 0.53 minutes per tree, producing 30.05 m^3 each scheduled machine hour with an average size of 0.66 m^3/tree.

A regression model was developed from the detailed time study to predict delay-free cycle time for skidding. The number of logs per turn, slope, and tree length did not have a significant effect on total cycle time (α = 0.10). The average maximum skidding distance to all patches was 415 m, resulting in a skidding cycle time (12.43 min./cycle) approximately three times longer than the one in a normal timber production operation (Tufts et al.1988; Mitchell 1994; Keegan III et al. 1995). A skidder operator was often required to accumulate small bunches into a full load. This accumulation occurred in 61% of the total cycles observed (n=185), with an average time of 1.36 minutes when needed.

	Coefficient	P-value	Average value	Range
Skidding time (min.) =	4.1333	0.000	constant	
	+0.0204 (DIST)	0.000	415 (m)	500 - 2884
	- 0.9362 (FORD)	0.065	indicator variable	0 or 1

$r^2 = 0.716$ $\quad n = 185$

Standard error of estimate: 2.57 min./cycle

Where: DIST = skidding distance
FORD = forwarding by a crawler skidder on steep grounds

Both processing and loading productivity were based on shift-level data. Productivity in processing and loading was not greatly different from a logging operation where timber production is the primary objective, except extra walking and low-bedding time was incurred due to scattered decks of wood. Heavy traffic on logging roads raised issues of safety during processing and loading operations on roadsides.

Harvesting Costs

The stump-to-truck cost averaged \$17.00/m^3, including low-bedding and coordination costs (Table 1). The overall cost of Snip and Skid logging would be \$22.28/m^3 if overhead and profit allowances were added to the stump-to-truck cost. This cost was based on the average tree volume of 0.66 m^3, and greatly sensitive to tree size: logging costs significantly increased as tree sizes decreased (Fig. 2). For example, the overall cost was \$32.61/m^3 if the average stem size were 0.25 m^3 while it decreased to \$21.65/m^3 with the average stem size of 0.8 m^3. The overall logging cost of Snip and Skid cost was significantly higher than the one in a mechanized conventional logging where timber production is the primary objective. The overall cost of conventional logging in the study area ranges from \$12.00 to \$17.50/m^3.

The Madill 3200B feller-buncher had an hourly owning and operating cost of \$141.44. Felling costs ranged from \$2.20 to \$5.73/m^3 with an average of \$3.22/m^3. Tree size and walking time had a large effect on felling productivity and cost. Skidding cost was the most expensive cost component in the stump-to-truck cost at an average of \$4.48/m^3. The use of the Cat 527 track skidder often resulted in a higher skidding cost because it not only has a higher hourly rate (\$137.58) than the John Deere 748G rubber-tired skidder (\$100.40), but also had a lower traveling speed and required a low-bed to move it to another site. Processing and loading costs were based on the shift-level form, and calculated at \$3.55/m^3 and \$3.09/m^3 on average, respectively.

Other costs include low-bedding harvesting equipment required to transport equipment from patch to patch and move-in/-out. The total time for low-bedding was 71 hours, resulting in a cost of \$1.12/m^3. This cost may have significantly increased if they had a sub-contract for the job, resulting from higher contract rates and increased delays due to less efficient team-work.

Delays and Coordinating Machine Allocations

Walking and low-bedding delay (12.5%) represented 57% of the total delay (22% of its scheduled machine hours) in the Snip and Skid logging (Table 2). Walking and low-bedding time had a large impact on overall harvesting productivity. In the site studied, a foreman maintained good communications with machine operators, including a low-bed operator, and helped them move to the next location. During detailed timing for felling and skidding operations, small delays (<10 min.) were observed at 8.2 and 9%, respectively. These increased the total delay of felling to 36.6% and skidding to 25.8%.

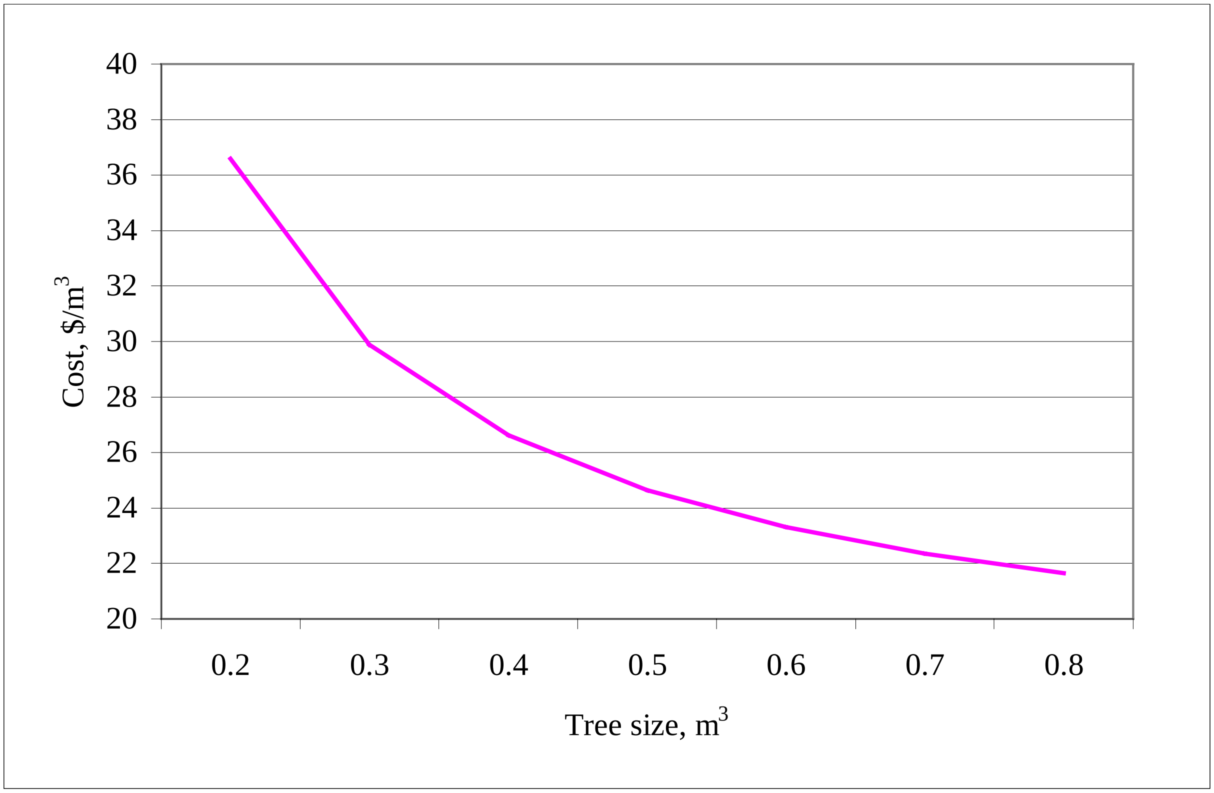

Figure 2. Changes of Snip and Skid logging costs over different size of tree. Costs are the mean values calculated from all patches and include stump-to-truck and overhead and profit allowances.

For tracked machines, prolonged walking on the hard surface of roads may result in the shortening of track, undercarriage, and machine body life as well as other attachments. This may increase maintenance and repair costs. The authors observed that machine operators attempted to walk on the snow pile next to the road when possible to minimize impacts on tracks and machine body. Walking time for the rubber-tired skidder had less impact on its productivity compared to other crawler-type machines as it was able to travel at higher speeds

Good communications between a licensee and the logging contractor are essential to increase operations efficiency. For example, the feller-buncher was required to move back into an area adjacent to where it had felled timber previously in the winter, this required low-bedding. This unnecessary low-bedding could have been avoided if the contractor knew which patches were to be harvested in advance. Highly visible flagging and clear mapping are necessary for the machine operator to avoid wasting time looking for an entrance to skid trail and patch location. This should be emphasized to crews conducting field layout and marking of patches to be harvested since the planning and layout for the operation is prepared often 6 months before logging occurs.

Table2. Large delay summarized from shift-level data for each phase of logging operations. Values in ( ) represent % of delay in each phase of logging.

Activities	SMH[1]	Personal delay	Service	Walking[2]	Low-bed[3]	Mechnical delay	Others[4]	Total
	------------------------------------- hour							-------------------------------------
Felling	76.5	2.5 (3.3)	3.25 (4.2)	11.5 (15.0)	2 (2.6)	1.5 (2.0)	1 (1.3)	21.75 (28.4)
Skidding	223.5	10.25 (4.6)	10 (4.5)	10.75 (1.3)	3 (1.3)	1 (0.4)	2.7 (1.2)	37.7 (16.9)
Processing	83.5	3.5 (4.2)	0.5 (0.6)	8 (9.6)	6 (7.2)	0 (0.0)	0.8 (1.0)	18.8 (22.5)
Loading	84	3 (3.6)	3.5 (4.2)	13 (15.5)	4 (4.8)	0 (0.0)	0 (0.0)	23.5 (28.0)
Total	467.5	19.25 (4.1)	17.25 (3.7)	43.25 (9.3)	15 (3.2)	2.5 (0.5)	4.5 (1.0)	101.75 (22.0)

[1]Scheduled machine hours
[2]Machine traveling between patches
[3]Transporting equipment between patches using a low-bed
[4]Poor layout, waiting for a low-bed, pre-work meting, plowing snow, and building bridge

Post-harvesting survey: skid trail width, stand damage and high stumps

In total, 17 skid trails were used to access the small patches. When there was more than one patch nearby, one skid trail often accessed multiple patches. The total length of skid trails surveyed in this study was 5,974 m, and new skid trails created from clearing trees represented 59% (3,520 m) of the total length. The remaining skid trail length used open areas in recent clearcut blocks. The average width for each new skid trail ranged from 4.4 to 6.5 m, and three skid trails had an average width beyond the maximum allowed (6 m). Stand density (trees/ha) varied between locations, and influenced on the final width of skid trail.

We found 177 trees scarred along 3,520 m of skid trails, resulting in 5 trees damaged per 100 m. The average values for scar width and length measured from each skid trail were 13 – 20.4 and 34.6 – 68.6 cm, respectively. Damaged trees were located right to the skid trails and most scars were faced in the direction of skid trails. These indicate that skidding was a primary cause of scarring damage to the trees. There was no damage observed on boundary trees of harvested patches. Increased scarring damage was observed in narrow and curved skid trails.

All stumps in all patches were lower than 30 cm in height, and most stumps were cut close to ground level. The stumps on skid trails were also low. This confirms that mechanized felling is effective in leaving a low stump, reducing the risk of leaving beetles in the stumps. The winter logging helped to protect soils from repeated skidding, as a combined effect of snow and frozen soils.

CONCLUSION

Production rates for each machine in the Snip and Skid logging were significantly lower than those in a normal timber harvesting operation that timber production is the primary objective. This was mainly due to increased non-productive time for moving between small patches scattered in a large area. Walking and low-bedding accounted for 57% of the total delay in Snip and Skid logging. These types of delay would not occur in other normal harvesting operations.

Long skidding distances to the patches contributed to a low harvesting productivity and the high cost of Snip and Skid logging.

The total stump-to-truck costs of the Snip & Skid logging in each location ranged from $14.98 to $19.71/m^3, averaging at $17.00/m^3. The overall cost would be $22.28/m^3 if it includes other cost allowances such as overhead and profit. This cost represents an increase of logging costs by 30.3 to 85.7% over a conventional logging in the study area. Tree size had a large effect on the cost: the cost would be $32.61/m^3 if the average stem size were 0.25 m^3. The average tree size in this study was 0.66 m^3.

Large scarring damage was often found on sharp curves and increased scarring damage was noted on the lower side of sloping skid trails. It was found that 5 damaged trees occurred per 100 m of skid trail. Careful layout of skid trails would minimize damage to trees along skid trails. Mechanical felling and winter logging eliminated concerns on leaving high stumps and soil disturbance.

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LITERATURE CITED

Hall, R and H.-S. Han. 2001. A comparison of mechanized and manual felled stump heights in north-central British Columbia. For. Prod. J. Submitted for review.

Han, H.-S. and L.D. Kellogg. 2000. Damage characteristics in young Douglas-fir stands from commercial thinning with four timber harvesting systems. West. J. of Appl. For. Vol. 15 (1):27-33.

Keegan III, C.E., C.E Fielder, and D.P. Wichman. 1995. Costs associated with harvest activities for major harvest systems in Montana. For. Prod. J. 45(7/8):78-82.

Mitchell, J.L. 1994. Commercial thinning of mature lodgepole pine to reduce susceptability to mountain pine beetle. FERIC Special Rep. No. SR-94. 20p.

MOF (Ministry of Forests). 2000. A socio-economic analysis of mountain pine beetle management in British Columbia. For. Practices. Branch. Victoria, B.C., 6p.

Safranyik, L., D.M. Shrimpton, and H.S. Whitney. 1974. Management of lodgepole pine to reduce losses from the mountain beetle. Can. For. Serv. Pacific For. Res. Cen. For. Tech. Rep. 1. 24p.

Tufts, R.A., B.J Stokes, and B.L. Lanford. 1988. Productivity of grapple skidders in southern pine. For. Prod. J. 38(10):24-30.

Van Sickle,G.A. 1995. Forest insect pests in the Pacific and Yukon region. P. 73-79 *in* Forest insect pests in Canada, Armstrong, J.A. and W.G.H. Ives (eds). Nat. Res. Canada, Canadian Forest Service, Ottawa.