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A test of three logging systems in Alberta

ABSTRACT: *This report addresses understory protection, timber utilization, and logging production for full tree, tree length and shortwood harvesting systems. Understory protection promises to provide both timber and non-timber benefits and to address public criticism of current clearcutting practices in mixed woods. There appear to be opportunities for substantial improvements in utilization, particularly with shortwood systems. These benefits must be balanced against increased costs for planning, cutblock layout, supervision, and reduced logging production.*

Introduction

The forest industry in Western Canada is being challenged to modify and adapt logging systems to harvest aspen (*P. tremuloides (Michx.)*) while protecting white spruce (*P. glauca (Moench) Voss*) understories. The industry is facing serious questions about the feasibility of protection, implications for timber use and logging production. This challenge is the result of dramatic regional increases in aspen use (Brennan 1988, Ondro 1989), much of it from boreal mixed wood stands with white spruce understories. Such stands are a primary source of softwood timber for the next 80 years.

There is growing public interest in maintaining the spruce component of mixed woods for purposes such as wildlife habitat, recreation and landscape aesthetics — an interest well documented in recent public meetings on forestry development in Northern Alberta (Concord Scientific Corp. 1989). Also, at a recent forum on the environment organized by the Canadian Pulp and Paper Association (CPPA), industry leaders strongly expressed forest management concerns much beyond timber supply (Addison et al. 1989).

A cooperative mixed wood harvesting project was initiated recently under the Canada-Alberta Forest Resource Development Agreement (FRDA). Participants include the Northern Forestry Centre of Forestry Canada, the western laboratory of the Forest Engineering Research Institute of Canada (FERIC), the Alberta Forest Service, Pelican Spruce Mills (now Weyerhaeuser Canada Ltd. (Alberta)), Weldwood of Canada Ltd., Blueridge Lumber (1981) Ltd., and Millar-Western Industries Ltd. This report addresses seven stands harvested to date in the Drayton Valley area (identified in the report as DC (control), D1 and D2), the Hinton area (HC (control) H1 and H2) and the Whitecourt area (W2).

The primary objectives of this report are to assess logging-related damage to understory white spruce trees, timber utilization and logging production for each logging system.

Harvesting methods included full tree, tree length and shortwood systems, using a variety of procedures and equipment, including feller bunchers, grapple skidders, and Swedish (Rottne) processors and forwarders (Table 1).

There were substantial differences between stands in terms of hardwood and softwood overstory composition, volume, quality, average stem size, and softwood understory density and distribution (Brace 1989). This, combined with the variety of equipment and procedures makes detailed comparisons between stands inappropriate and requires a case study approach based on data and observation.

Felling and forwarding in control stands DC and HC were carried out using conventional equipment according to prevailing operational ground rules in Alberta, resulting in a routine clearcut. No restrictions were placed on the felling sequence or on travel routes for skidders to protect understory. There was apparently a psychological effect of the protection philosophy being applied to other stands, as operators made unusual attempts to preserve some understory spruce clumps. Some spruce were also protected within clumps of non-merchantable hardwood. Control stands are therefore predominantly clearcut, with a few dense understory spruce clumps and scattered individuals, and should regenerate primarily to aspen suckers.

Understory damage

In general, felling caused less mortality but more damage than forwarding in treatments D1, D2, H1 and H2 (Table 2). Felling mortality was minor, varying from one to five per cent. Felling damage varied from 11 to 19 per cent for feller bunchers (D1, D2, H1) but was 40 to 42 per cent for the Swedish shortwood processors (H2, W2), primarily because the shortwood processors had much less directional felling control than the feller bunchers. Initial understory density in the range of 567 to 1,994 trees per hectare apparently was not a factor in felling damage with shortwood systems.

Felling damage was recorded mainly as broken tops and branches, bark scrapes on stems, and leaning trees. The Swedish shortwood processor caused a relatively large proportion of bark scrapes and leaning trees. Much of this damage was minor and would be considered acceptable on residual

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Treatment	Function	Location Drayton Valley (D)	 Hinton (H) and Whitecourt (W)
Control	Felling	Feller buncher on tracked loader with shear head	Feller bunchers on tracks with shear head (H) and sawhead (W)
	Forwarding	Grapple skidders — full tree	Grapple skidders — full tree
	Procedures	Conventional clearcut. All species topped, delimbed and bucked on the landing by hand	Conventional clearcut. Stroke delimber and slasher at landing
Treatment 1	Felling	Same as control	Same as control
	Forwarding	Same as control — full tree	Same equipment as control, but tree length instead of full tree and rub-stumps used along trails
	Procedures	Main skid trails located before harvesting and feller buncher operator chose other trails, conifer hand-felled after aspen and skidded separately. All species topped, delimbed and bucked on landing by hand	Main skid trails prelocated and secondary trails flagged before harvesting. Conifer and aspen felled and bunched at same time and limbed and topped before skidding. Oversize spruce hand felled. Stroke delimber and slasher on landing
Treatment 2	Felling	Same as control	Rottne double-grip processor (fell, limb and buck) at (H) and double- and single-grip at (W)
	Forwarding	Same as control — full tree	Rottne forwarder — shortwood
	Procedures	Trail designation as in treatment 1 conifer and aspen machine-felled and thatched down on skid trails by feller buncher. All species topped, delimbed and bucked on landing by hand	Highly skilled operators selected trails and controlled operation

Table 1. Harvesting methods and procedures by location and treatment.

crop trees.

Large individual spruce, characteristic of many mixed wood stands containing understories, caused considerable damage when hand-felled in treatments D1 and H1. This poses a dilemma in such stands because their high timber value has to be balanced with understory protection priority and blowdown hazard when setting treatment objectives.

Equipment-related factors affecting understory damage include size and type of carrier, boom and felling head. Multiple entries for felling and forwarding also increase damage. These sources of damage can be minimized by matching equipment and harvesting pattern to stand conditions (personal comm., E.A. Sauder, FERIC). The feller buncher used in stands D1 and D2 had no boom, so it had to approach each tree before felling, increasing understory damage, but it was also relatively narrow, which compensated to some extent for the lack of a boom. The feller buncher used in H1 had a three- to four-metre boom so it could reach for trees, but it had a large counter weight which caused damage when turning and a relatively large felling head which caused damage when being positioned for a cut. Both types of feller buncher carried the trees upright after cutting and bunched them on skid trails, which reduced subsequent forwarding damage and mortality. The relatively good performance of the feller buncher in H1 was noteworthy, considering the initial understory density (Table 2). This reflects effective planning as well as operator experience and attitude.

The Swedish shortwood processor had a 10-metre boom but was unable to take full advantage of it due to the large average size of the aspen being felled. This made it necessary to move toward many trees to fell them, resulting in a zig-zag pattern in the stand rather than maintaining a relatively straight course and reaching for the trees. In addition, it had little directional felling capability and caused damage as it shifted felled trees back and forth in a horizontal plane while delimbing and bucking. It had an advantage over the feller bunchers in being able to swing the felling head above the understory when reaching for aspen, and the smaller felling head caused less damage when being positioned for a cut.

The shortwood processor would cause much less felling damage if it were operated in a stand where the trees being cut were small enough to allow it to maintain machine alignment in the stand and take full advantage of the 10-metre boom, and the smaller crowns of younger aspen would compensate to some extent for the lack of directional felling capability. The single-grip processor also

Treatment	Initial Nt/ha	Undamaged	Felling		Forwarding		Harvested	Other	Total
			Damage	Mortality	Damage	Mortality			
DC	550	33	19	1	13	28	6	—	100
HC	1744	13	16	4	14	49	3	1	100
D1	391	44	19	—	11	24	2	—	100
D2	323	65	11	1	9	13	1	—	100
H1	740	51	18	1	10	18	1	1	100
H2[1]	1994	29	40	5	(11)	(14)	1	—	100
W2[1]	567	17	42	3	(10)	(17)	11	—	100

[1]The Swedish shortwood systems are not directly comparable to others due to the combined function of felling, delimbing and bucking. Damage and mortality identified as forwarding is not distinguishable from skidder damage but is primarily caused by the delimbing and bucking functions. Forwarding effects were minor.

Table 2. Per cent damage to understory spruce trees (2.5 to 14 metres tall) during aspen harvesting.

appeared to cause less delimbing and bucking damage than the double-grip as it could perform those functions at ground level. A larger single-grip machine designed for selective harvesting could probably achieve up to 20 per cent less understory damage then demonstrated by either the single- or double-grip machines used in stands H2 and W2 (personal comm., O. Hannula, Weldwood of Canada Ltd.)

Forwarding damage

In general, forwarding caused considerably less damage but more mortality than felling in all cases (Table 2). Damage ranged from nine to 11 per cent and occurred mainly as bark scrapes and leaning trees. Forwarder damage was almost entirely skidder-caused.

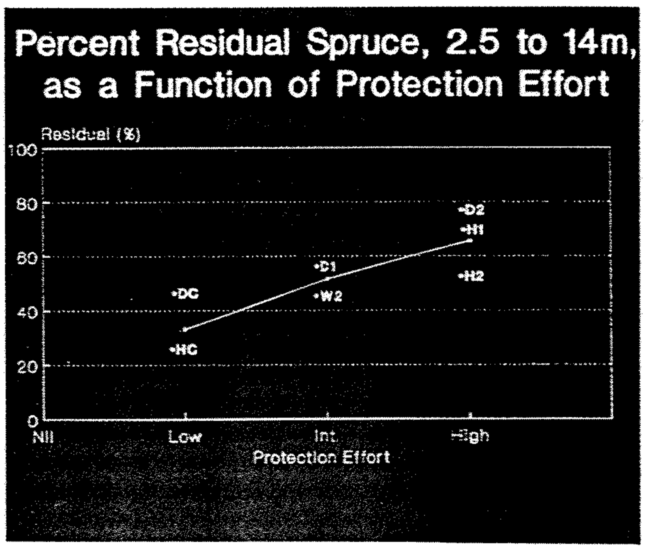
Damage statistics for the Swedish shortwood forwarder are misleading because they really reflect the delimbing and bucking functions of the processor as described earlier, but could not be separately identified. The shortwood forwarder itself did minor damage when loading logs — mainly upper stem scrapes — and virtually no damage during forwarding as it was the same width as the processor.

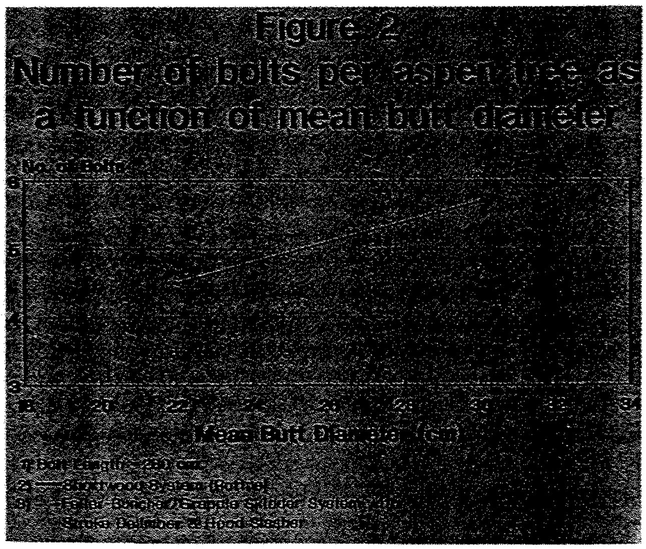
Forwarder-caused mortality varied from 13 to 24 per cent and again was almost entirely skidder-related, since the 14 to 17 per cent mortality shown for the Swedish forwarder is really related to processor delimbing and bucking functions. Differences in undamaged understory between H2 and W2 are explained by the amount of understory harvested in W2 (Table 2).

The good performance of the skidder operation in relatively dense understory in H1 is noteworthy, reflecting effective coordination of the skidder and feller buncher functions, and operator experience and attitude. The 24 per cent skidder-related mortality in D1, compared to 13 per cent in D2 in a stand of comparable initial understory density, and 18 per cent for H1 in a stand of relatively high initial understory density is largely a reflection of protection effort, not of equipment.

Protection effort

Stands were rated according to the degree of protection effort, which was assigned to reflect the planning, layout, supervision, crew experience and crew attitude which characterized each case. Figure 1 shows that low





protection effort resulted in protecting a 33 per cent crop tree residual and high protection effort resulted in protecting a 66 per cent crop tree residual. Protection effort was much more significant than type of equipment, an observation which is consistent with the results of previous mixed wood harvesting studies (Brace and Stewart 1974, Froning 1980). Once experience is gained, the extra costs of protection effort should be minimal because good planning and training will increase productivity and safety, and the supervisory role can be most effectively filled by trained equipment operators.

Timber use and production

A preliminary aspen utilization study based on the recovery of 260 centimetre oriented strand board (OSB) bolts was conducted in the Hinton project area by Weldwood of Canada Ltd. in 1989. They compared the Swedish double-grip shortwood system (H2), which fells, delimbs and bucks in the bush, to combined full tree and tree length systems (HC and H1) using feller bunchers, grapple skidders, and a stroke delimber and hood slasher at roadside.

The shortwood system averages 0.9 bolts per tree more than the full tree and tree length systems (Figure 2), which caused more breakage and losses during skidding, delimbing and bucking. If losses are assumed to occur in an average bolt, they represent a 20 per cent volume loss; and if they occur between the top bolt and the average bolt they represent a 10 to 20 per cent loss.

Increased aspen utilization of up to 20 per cent, coupled with reduced roadside cleanup costs suggest substantial advantages for the double-grip shortwood system in this application and indicate the need for more in-depth utilization studies.

Comparisons of production rates at the felling and forwarding stages for the full tree, tree length and shortwood harvesting systems used in this project are constrained by the relatively small sample size and by differences in overstory composition, volume, quality and mean tree size, and by differences in the amount and distribution of understory spruce. However, some generalizations can be made.

Felling

Felling production should decrease with increasing effort to protect understory spruce, and should be sensitive to size of tree felled, decreasing as mean tree size decreases.

Felling production data for the full tree system, comparing control DC (low protection effort) to D1 and D2 (increasing protection effort), indicate production losses of 24 per cent for D1 and 29 per cent for D2 as protection effort increased (Table 3). The relative efficiency of the feller buncher used in DC, D1 and D2 compared to that used in HC and H1 is noteworthy.

In the tree length system H1, production was 11 per cent lower than control HC, even though there was a high level of protection effort. The relatively large mean tree size in H1 reduced production loss and the intensive planning, layout and supervision, and highly motivated equipment operators which characterized H1 suggest that such actions may reduce production losses at the felling stage.

Productivity at the felling stage for the shortwood system (H2 and W2) averaged 60 per cent less than control HC. This low productivity is due, in part, to the time taken during felling for the delimbing and bucking functions. Other systems would incur production losses to perform these functions at another stage. Felling productivity for the shortwood system might be increased by as much as 20 per cent by using a large single-grip processor designed for selective harvesting (personal comm. O. Hannula, Weldwood of Canada Ltd.).

Forwarding

In general, forwarding production should decrease as skid trail length increases with increasing effort to protect spruce understory.

Forwarding production for the full tree system, comparing DC (low protection effort) to D1 and D2 (increasing protection effort) indicates a mean trail-length increase from 80 metres to 130 metres as a result of protection effort. However, there was

Location and treatment	Equipment	System	Protection effort[2]	No. trees /PMH[3]	Felling production m³/PMH	Production change %
DC	FB/GS[4]	full tree	low	113	73	100
D1	FB/GS	full tree	intermediate	87	56	-24
D2	FB/GS	full tree	high	119	52	-29
HC	FB/GS	full tree	low	120	28	100
H1	FB/GS	tree length	high	97	25	-11
H2	Rottne[5]	shortwood	high	25	12	-57
W2	Rottne	shortwood	intermediate	—	10	-64

[1]Data from Sauder (1990)
[2]Protection effort reflects the combined effects of planning, layout, supervision, crew experience and attitude in each case.
[3]PMH = productive machine hour.
[4]FB/GS = feller buncher/grapple skidder.
[5]Rottne = Swedish shortwood processor/forwarder combination.

Table 3. Production summary for felling[1].

Location and treatment	Equipment	System	Protection effort[2]	No. logs per turn	Mean skidding distance (metres)	Forwarding production m³/PMH[3]	Production change %
DC	FB/GS[4]	full tree	low	3.1	80	12	100
D1	FB/GS	full tree	intermediate	4.0	130	17	42
D2	FB/GS	full tree	high	4.9	130	11	-8
HC	FB/GS	full tree	low	9.9	90	21	100
H1	FB/GS	tree length	high	9.4	190	26	24
H2	Rottne[5]	shortwood	high	—	—	11	-48
W2	Rottne	shortwood	intermediate	—	—	11	-48

[1]Data from Sauder (1990).
[2]Protection effort reflects the combined effects of planning, layout, supervision, crew experience and attitude in each case.
[3]PMH = productive machine hour.
[4]FB/GS = feller buncher/grapple skidder.
[5]Rottne = Swedish shortwood processor/forwarder combination.

Table 4. Production summary for forwarding[1].

only a minor decrease in productivity of 8 per cent for D2, and a significant increase of 42 per cent for D1 (Table 4). Apparently, skidder production losses were mitigated because designated trails become faster with use and operators did not waste time looking for new trails or incur equipment damage by travelling through slash and residual trees (Sauder, 1989).

In the tree length system (H1), skidding production was increased by 24 per cent compared to HC, even though skid trail length was relatively long (190 metres compared to an average of 90 metres for the control), again indicating the advantage of designated skid trails. The relative efficiency of skidding operations in HC and H1 compared to DC, D1 and D2 is noteworthy.

Production at the forwarding stage for shortwood (H2 and W2) was 48 per cent less than HC. Lower production reflects time required to load the forwarder in the bush and unload it at roadside.

Conclusions

Major improvements in the protection of understory white spruce during aspen harvesting are possible using conventional logging equipment like feller bunchers, grapple skidders and shortwood systems, with mean protection success ranging from 33 to 66 per cent depending on the degree of protection effort. Understory protection promises to enhance short-term softwood timber supply and to reduce public criticism of the effects of current clearcutting practices on non-timber values.

The key to success is protection effort, regardless of equipment used. It includes:

- selecting equipment and harvesting patterns to match stand and site conditions, thereby minimizing multiple stand entries for felling and forwarding, which are a significant cause of understory damage;
- pre-planning and pre-locating skid

trails, landings and protective features like rub stumps in relation to understory density and distribution;

- adequate crew training and supervision. The attitude and motivation of operators are critical elements in protection, as well as production.

Once experience is gained, the extra costs of protection effort should be minimal because good planning and training will improve productivity and safety, and the supervisory role can be effectively filled by trained equipment operators.

Utilization based on aspen bolts was up to 20 per cent higher for the shortwood system than for the full tree and tree length systems, which would tend to compensate for logging production shortfalls in the shortwood system.

Felling production losses characterized all logging systems. They were as high as 29 per cent for full tree, 11 per cent for tree length, and 60 per cent for shortwood (inflated by the inclusion of delimbing and bucking). It is also apparent from the tree length example that felling production losses may be reduced by effective planning, layout, supervision, crew experience and motivation. Felling production losses for full tree systems may be partly recovered at the forwarding stage because of the tendency of the feller buncher to make larger average bunches due to the limited available space for bunching in the understory protection scenario. Felling production for the shortwood system might be increased by as much as 20 per cent by using a large single-grip processor designed for selective harvesting.

There was a 48 per cent forwarding production loss for the shortwood system, whereas production increases of 42 per cent and 24 per cent were achieved for full tree and tree length systems in two out of three cases, indicating that skid trails designated for understory protection can increase logging production within the trial length limits of this study — up to 190 metres.

A significant amount of understory can be retained using any of the logging systems tested if there is adequate protection effort. Potential benefits include increased short-term softwood timber supply, improved wildlife habitat, better cutblock aesthetics and reduced public criticism of current logging practices. Additional benefits include the potential for significantly increased forwarding production for full tree and tree length systems using designated skid trails. Costs associated with understory protection include reduced felling production for all logging systems as well as increased costs of planning, cutblock layout and supervision, which should decline with increasing crew experience. Characteristics of the shortwood system which are not protection-related include improved utilization of aspen bolts, and reduced forwarding production compared to other systems.

References

Brace, L.G., Stewart, D.J. 1974. Careful thinning can preserve amenities and increase yield. Reprint from *Pulp and Paper Magazine of Canada*, August 1974.

Brennan, J.A. 1988. The changing profile of the Alberta forest industry. *Management and Utilization of Northern Mixedwoods*. J.K. Samoil ed. Northern For. Cen., Can. For. Ser., Inf. Rep. NOR-X-296. p. 32-34.

Concord Scientific Corp. 1989. Report on public information meetings on forest development in Northern Alberta. Submitted to the Minister of Forestry, Lands and Wildlife, Edmonton, Alberta, Oct. 16, 1989.

Froning, K. 1980. *Logging hardwoods to reduce damage to white spruce understory*. Environ. Can., Can. For. Serv., North. For. Res. Cen., Edmonton, Alberta. Inf. Rep. NOR-X-229.

Ondro, W.J. 1989. *Utilization and market potential of poplar in Alberta*. Forestry Can., Can. For. Serv., North. For. Res. Cen., Edmonton, Alberta. Inf. Rep. NOR-X-305.

Unpublished reports:

Addison, P. et al. 1989. Report on the forum on environment, organized by the Canadian Pulp and Paper Association. Oct. 31 to Nov. 1, 1989. Montreal, Que.

Brace, L.G. 1989. *Protecting understory white spruce when harvesting aspen*. Paper presented at Northern Mixedwood '89. Fort St. John, B.C. Sept. 12-14, 1989.

Sauder, E.A. 1989. *Harvesting in the mixed wood*. Paper presented at Northern Mixedwood '89. Fort St. John, B.C. Sept 12-14, 1989.

Sauder, E.A. 1990. *Harvesting in the mixedwood*. Paper prepared for the XIX IUFRO World Congress, Montreal, Que., August 5-11, 1990.

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