FERIC
FOREST ENGINEERING
RESEARCH INSTITUTE
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INSTITUT CANADIEN
DE RECHERCHES
EN GÉNIE FORESTIER

ing Decadent Cedar-Hemlock Stands:

A Comparison of Tree Breakage and Wood Recovery in Summer vs. Winter Operations

L.H. Powell

May 1977

Technical Report No. TR-15

300 - 2045 WEST BROADWAY, VANCOUVER, B.C., CANADA V6J 1Z5
245 HYMUS BLVD., POINTE CLAIRE, P.Q., CANADA H9R 1G6

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FOREWORD

This report presents the results of a study of falling in decadent cedar/hemlock stands in Interior British Columbia. The work was prompted by the need for factual information comparing felling breakage and stump losses in winter operations with those for summer operations. Strict Regulations of the B.C. Forest Service with regard to stump heights and of the Worker's Compensation Board of B.C. for worker safety created conflict for winter logging operators in the wet belt region of B.C.'s Interior.

Project field work began in December 1975 and continued until October 1976. People who assisted directly in this work include: L.W. Johnson, J. McDonald and B.A. McMorland of FERIC; P.P. Tse of FERIC (programming and computer analysis); M. Simrose of Canadian Cellulose Company Ltd. (scaling of felled trees and logs); and L. Degans, D. Ritchie, R. Hamling and R. Robinson, who felled the trees in the study areas. The author also greatly appreciates the many individuals associated with the following companies and organizations who co-operated in the study:

Canadian Cellulose Co. Ltd., Interior Division, Nakusp
Downie Street Sawmills Ltd., Revelstoke
B.C. Forest Service, Nelson District Office
Nakusp Ranger Station
Revelstoke Ranger Station

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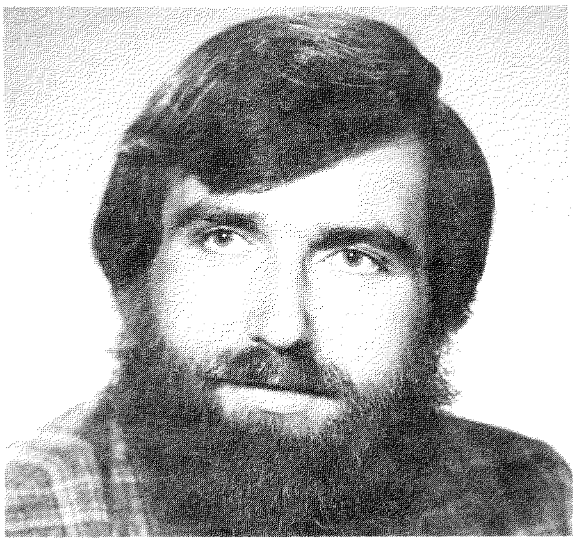

L. H. Powell received his B.Sc. Forestry from the University of Wales in 1968. He joined the Woodlands Research Division of the Pulp and Paper Research Institute of Canada in 1970 to work on logging machine evaluations and related projects. He moved over to FERIC when that organization was formed in 1975, and transferred to the Vancouver office in late 1975. He is a member of the Association of B.C. Professional Foresters, the Canadian Institute of Forestry and the Woodlands Section, Canadian Pulp and Paper Association.

SUMMARY

Winter logging, particularly in the wet belt area of B.C.'s southern Interior, means operating in snow and contending with its associated problems, including operating in freezing conditions, maintaining access and high stumps. Foresters and the general public are concerned about volume waste and unsightliness of high stumps on winter-logged areas. In 1975 the B.C. Forest Service issued a policy directive requiring a maximum stump height of 1 foot, with penalties for exceeding the stated guidelines. Together with regulations for worker safety from the Worker's Compensation Board of B.C., logging operators faced the dilemma of meeting both sets of regulations while continuing to operate under winter conditions. Recent studies have shown that logging on snow has beneficial results in reduction of soil disturbance and associated site damage. Winter falling was expected to reduce wood loss from trees breaking which would compensate for losses through high stumps, when compared to summer logging.

FERIC studied two company operations in the Columbia Valley region of B.C., monitoring falling in five sample areas under winter and summer conditions. Sample areas were chosen from decadent stands of cedar (Thuja plicata Donn) and hemlock (Tsuga heterophylla (Raf.) Sarg.), because it was surmised that the volume lost through breakage and high stumps would be less critical in these poorer stand types, as compared to spruce/fir types. Also, these cedar/ hemlock stands are often found on wet swampy terrain, which can only be logged in winter. The snow was expected to provide some cushioning for falling trees in winter and result in lower breakage losses.

Trees within the sample areas were monitored during falling to provide data on standing volume, incidence of and reason for breakage and stump heights. Trees were scaled at landings after skidding for gross-log and net-log volumes. Sample areas were mapped and assessed for logging waste after operations had been completed.

Results showed that winter areas had higher stumps than summer areas. On one company's winter operation, some snow was shovelled prior to falling, and stump heights were considerably reduced compared to the other winter area. Volume lost through high winter stumps was not as large as expected, due to variable amounts of decay and the beneficial effect of some snow removal. Breakage losses were lower for winter felled areas but the cushioning effect of the snow could not be isolated from other factors as the sole cause of reduced breakage. The incidence of breakage was lower in winter, between 37% and 44% of sample trees, than in summer, 60% to 61%. In terms of volume, breakage in winter ranged from 1% to 10% of standing merchantable volume, and in summer from 14% to 15%. The more common reasons for breakage were: hitting frozen snow banks along skid roads in winter, hitting roadside banks in summer, and striking stumps or felled trees in both seasons. These reasons appear to reflect differences in fallers and terrain between the five sample areas, as well as confirming the cushioning effect of the snow.

Summer areas had slightly higher values for logging waste than winter areas. Lost volumes (sum of breakage, waste and excess stump volumes) were higher for summer falling, from 19% to 21% of standing merchantable volume than for winter, from 3% to 15%.

The study showed that there were higher volumes in stumps and less breakage loss in winter than in summer falling. In formulating guidelines for stump heights in winter logging, other criteria besides volume loss must be considered. These include economic and social benefits of continued operations in winter, desirability of replacing decadent stands with new healthy tree crops, protection of steep slopes and sites afforded by logging on top of snow, and the overriding importance of worker safety during falling.

SOMMAIRE

Les opérations d'abattage l'hiver, particulièrement dans la bande humide du sud intérieur de la Colombie Britannique, impliquent le travail dans la neige et les problèmes inhérents: froid intense, maintien des chemins d'accès et les arbres coupés hauts sur souche. En 1975, le Service Forestier de la Colombie Britannique a publié des directives fixant à un pied la hauteur maximale des souches, avec sanctions pour les réfractaires. Par conséquent, en plus des règlements déjà contenus dans la Loi des Accidents de Travail de la Colombie Britannique, les exploitants forestiers dans la poursuite de leurs opérations forestières hivernales, furent constraints d'observer non pas une, mais deux règlementations. De récentes études ont démontré que les opérations forestières en hiver permettent de réduire les perturbations du sol ainsi que la dégradation du site. On espérait que l'abattage en hiver réduirait les pertes de bois dûes aux arbres cassés lors de l'exploitation d'été afin de compenser pour la forte hauteur des souches.

FERIC a fait des études dans deux opérations forestières localisées dans la vallée de Columbia, en Colombie Britannique, pour observer l'abattage dans cinq aires d'échantillonnage sous des conditions hivernales et estivales. Les aires échantillonnées furent choisies parmi des peuplements décadents de cèdre (_Thuja_ _plicata_ Donn) et de pruche (_Tsuga_ heterophylla (Raf.) Sarg.) parce que l'on soupçonnait que les pertes de bois dûes à la forte hauteur des souches ainsi qu'aux arbres cassés seraient moins sévères dans ces types de peuplements qui sont plus pauvres que ceux d'épinette et de sapin. De plus, ces peuplements de cèdre-pruche sont souvent situés dans des terrains marécageux où l'abattage ne peut se faire qu'en hiver. On croyait

que la neige agirait comme coussin lors de l'abattage d'hiver, et que cela réduirait les dommages dûs aux arbres cassés.

Les arbres dans les aires échantillons furent observés durant l'abattage et les observateurs ont recueilli des données sur le volume des arbres debout, l'incidence et les raisons des bris des arbres ainsi que la hauteur des souches. Aux aires d'empilement, après le débusquage, les arbres furent mesurés afin d'obtenir les volumes nets et bruts des billes. Des cartes des aires échantillons furent dressées et les pertes de bois furent évaluées à la fin des opérations.

Ces observations démontrèrent que les souches étaient plus hautes dans les régions où l'abattage avait été effectué en hiver. Par contre, lors d'une coupe hivernale effectuée par une compagnie, on a enlevé de la neige avant l'abattage avec le résultat que la hauteur des souches fut considérablement réduite comparativement à celle obtenue dans des opérations de coupe effectuées l'hiver dans d'autres régions. Le volume perdu par suite de la hauteur des souches fut moins élevé qu'on espérait par suite d'une quantité variable de pourriture et de l'effet bénéfique de l'enlèvement d'une certaine quantité de neige. Les pertes subies par les bris furent moindres dans les régions où la coupe fut effectuée l'hiver, mais l'effet du coussin procuré par la neige ne pouvait être isolé des autres facteurs comme seule cause de la réduction des bris d'arbres. En hiver le nombre d'arbres cassés parmi les arbres échantillonnés a été plus bas qu'en été soit entre 33% et 44%, comparativement à 60% - 61%. En terme de volume, les bris en hiver variaient de 1% à 10% du volume du bois marchand comparativement à 14% et 15% l'été. Les principales raisons des bris des arbres abattus furent les suivantes: en hiver, frapper des bancs de neige gelée le long des chemins de débusquage; l'été, des talus de remblais le long des chemins et en hiver comme en été, frapper des souches ou des arbres abattus. Ces raisons semblent refléter les différences dans les conditions d'abattage et de terrain entre les cinq régions échantillonnées et confirme en même temps l'effet du coussin que procure la neige aux arbres qui tombent au sol.

Les régions où l'abattage a été effectué l'été l'emportaient, au point de vue des pertes par le bris, sur celles où les coupes furent effectuées en hiver. Les volumes perdus (total des bris, des déchets et des surplus de souches) furent plus élevés pour les opérations d'été, de 19% à 21% du volume du bois marchand, comparativement à 3% à 15% pour les opérations d'hiver.

L'étude a aussi démontré que les volumes ont été plus élevés dans les souches et qu'il y eut moins de pertes par les bris en hiver qu'en été. En formulant des directives sur la hauteur des souches au cours des opérations d'hiver, d'autres critères que celui du volume doivent être pris en considération. Mentionnons, en outre, les bénéfices économiques et sociaux des opérations hivernales; l'avantage de remplacer des peuplements en décadence par une nouvelle et vigoureuse croissance d'arbres; la protection des pentes abruptes et des sites qu'offre l'abattage lorsque le sol est recouvert de neige et, surtout, l'importance primordiale de la sécurité qu'il faut accorder au travailleur durant les opérations d'abattage.

INTRODUCTION

During winter, logging has traditionally moved to lower altitudes where snow is not so deep, and to swampy areas where logging can take place only under frozen conditions. In the wet belt area of B.C.'s southern Interior, deep snow is often encountered in all logging areas, and operations must either contend with the snow or close.

Foresters and the general public have expressed concern over the unsightliness and apparent waste of wood in the high stumps often left after winter logging. In the fall of 1975, the B.C. Forest Service established guidelines, setting 1 ft as the maximum height for stumps.[1] Stumps between 1 ft and 3 ft in height would be subject to a penalty on the unlogged volume; further, operations could be suspended if stump heights exceeded 3 ft.

For these requirements to be met, snow must be removed either mechanically or manually with a shovel from around the base of each tree prior to falling. Digging the snow away from the tree introduces an additional problem during falling, that of worker safety. Adequate provision must be provided for easy access and egress by the faller,[2] and shoveller if an extra man is used, to ensure safety. In addition, the inhalation of power-saw exhaust fumes may become a hazard where air circulation is impeded by snow surrounding the hole. To achieve a desired level of safety may require so much digging that it becomes no longer economically feasible.

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[1] Policy directive for winter of 1975/76.

[2] Accident Prevention Regulations 60.62 and 60.66, Worker's Compensation Board of B.C.

In many cases, the winter logging areas are forested with cedar (Thuja plicata Donn) and hemlock (Tsuga heterophylla (Raf.) Sarg.), and stands are often classed as decadent. These stands have extensive butt and heart rot, which reduces the amount of merchantable timber which can be recovered. To the extent that this rot occurs in the lower part of the tree, high stumps from winter logging may not be as wasteful as was originally estimated.

Additional wood loss results from tree breakage during falling. Earlier studies reported by Dilworth (1975) show comparisons of breakage in Douglas fir (Pseudotsuga menziesii (Mirb.) Franco) felled on smooth and rough terrain, and Conway (1973) explained the most common reasons for breakage. B.C. Forest Service zonal loss factors gave average breakage loss factors of 8% for mature cedar and 3-4% for mature hemlock, as general allowances for all tree sizes, defect categories, sites and seasons.[1] No comparisons between breakage for summer and winter logging were found in the literature. During winter logging, snow may have a beneficial cushioning effect which may result in less breakage loss than in summer. This reduced breakage loss may offset the wood lost through higher stumps.

In addition to wood loss, other criteria must be considered, such as aesthetic values, problems of post-logging treatments, worker safety, continuity of industrial operations and expeditious replacement of decadent stands by young vigorous ones. Furthermore, recent studies by Smith and Wass (1976) in the Nelson Forest District have shown that ground skidding on top of snow in winter reduces the extent and intensity of soil disturbance. Moderately increased stump heights associated with winter falling may be offset by these other factors.

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[1] From B.C. Forest Service Inventory Division, Zonal Diameter Class Decay, Waste and Breakage Factors, 1972.

Fig. 1. Summer Falling in Company 1's Area.

Fig. 2. Summer Falling in Company 2's Area. The tree shown is being felled down a 30% slope towards a skid trail and road.

THE STUDY

FERIC investigated differences of wood losses between summer and winter logging, with the following objectives:

1. In co-operation with Interior B.C. firms and the B.C. Forest Service, to determine the extent and source of breakage and waste during falling in summer and winter in decadent cedar/hemlock stands.

2. To estimate the differences in recovered volume between summer and winter logging.

APPROACH AND PROCEDURES

The hypothesis to be tested was that the volume lost because of high stumps in winter logging would be offset by a reduction in tree breakage losses through a cushioning effect of the snow cover, as compared to summer falling.

Two co-operating companies provided stands of decadent cedar/hemlock from their winter operations in the Columbia Valley. FERIC selected study areas within these stands for the winter falling and reserved areas for summer falling. To permit more effective comparisons, sample areas were chosen, where feasible, from adjacent cutting blocks, where stand and terrain conditions would be similar. There were three areas for falling under winter conditions and two areas for summer falling. A change in company plans cancelled the summer falling of a third area. In each area trees were manually felled using power saws and were tractor-skidded to landings. Slopes in the sample areas ranged between 10% and 35%.

Fig. 3. Winter Falling in Company 1's Area. The faller is shovelling snow from around the tree prior to falling. Note the snow piled up around the tree as a result of wind action.

Fig. 4. Winter Falling in Company 1's Area. The faller is cutting below the snow level, after shovelling. Note the easy and unobstructed access to the work position, which gives adequate safety for the faller.

In each area, information on tree size and species, extent of decay, stump height and snow depth was monitored for a selected sample of trees. During the falling of these trees, the incidence of and reason for breakage was recorded. The felled trees were skidded to landings where they were bucked to length and scaled by a local licensed scaler for gross volume and decay volume, in four of the five areas. The fifth area was scaled by a licensed FERIC scaler using the same scaling procedures. For one summer area, trees were bucked into log lengths in the woods before skidding and scaling. Each area was assessed for waste volume during the summer, using the line-intersect method described by Bailey (1969, 1970 a,b).

Originally FERIC planned to monitor the same fallers for winter and summer areas of each company. However, due to scheduling of company operations and movement of personnel, this was not possible. The same faller cut the two winter areas of Company 1. This faller used a hand shovel to dig around each tree, usually to a depth of 12 to 18 in, before falling. Each of the other areas were felled by different fallers. All the fallers monitored in the study were experienced and competent. They were given no special instructions for falling or avoiding breakage during the study. The purpose and details of the study were explained to each and they were asked to continue their normal working procedures. The differences between fallers monitored during the study introduces additional variation into the results, which was recognized but not segregated. The faller in the winter area for Company 2 did not remove any snow prior to falling trees. The five study areas show differences in stand composition and in the amount of decadence present. They are all however representative of decadent cedar/hemlock types (see Table 1).

TABLE 1 - SUMMARY OF STUDY AREA STANDS AND CONDITIONS

	COMPANY 1			COMPANY 2	
	Winter	Winter	Summer	Winter	Summer
Study Area Size, acres	6.6	4.2	11.4	4.0	10.2
Area covered by sample trees, acres	2.6	1.2	4.2	1.5	3.6
Species distribution by*	HC	HC	HC	CH	HC
- no. of trees, %	84/16	80/20	90/10	77/23	59/41
- volume per acre, %	67/33	73/27	89/11	86/14	48/52
Range of Slope, %	10-15	15-20	10-15	25-35	30-35
No. of merchantable trees/acre	48	25	39	75	23
Standing volume of sample trees, cunits/acre	82.3	52.5	59.5	151.3	42.8
Average snow depth, ft	5	4.5	0	5.5	0
Average stump height, in	23**	21**	14	50***	14
No. of sample trees	126	30	165	113	81
Average DBH, in	23.4	24.5	25.4	28.7	29.7

*H is Hemlock and C is Cedar, with dominant species listed first.

**Faller shovelled snow prior to falling.

***Faller did not shovel snow prior to falling.

TABLE 1A - SUMMARY OF STUDY AREA STANDS AND CONDITIONS (S.I. UNITS)

	COMPANY 1			COMPANY 2	
	Winter	Winter	Summer	Winter	Summer
Study Area Size, hectares	2.7	1.7	4.6	1.6	4.1
Area covered by sample trees, hectares	1.1	0.5	1.7	0.6	1.5
Species distribution by*	HC	HC	HC	CH	HC
- no. of trees, %	84/16	80/20	90/10	77/23	59/41
- volume per hectare, %	67/33	73/27	89/11	86/14	48/52
Range of Slope, %	10-15	15-20	10-15	25-35	30-35
Standing volume of sample trees, m^3/ha	516	367	416	1059	299
Average snow depth, m	1.5	1.4	0	1.7	0
Average stump height, cm	58**	53**	36	127***	36
No. of sample trees	126	30	165	113	81
Average DBH, cm	59.4	62.2	64.5	72.9	75.4

*H is Hemlock and C is Cedar, with dominant species listed first.

**Faller shovelled snow prior to falling.

***Faller did not shovel snow prior to falling.

Fig. 5. Winter Area of Company 2. View of study area from the uphill side showing the post-logging condition. Stump heights averaged 50 inches for this area.

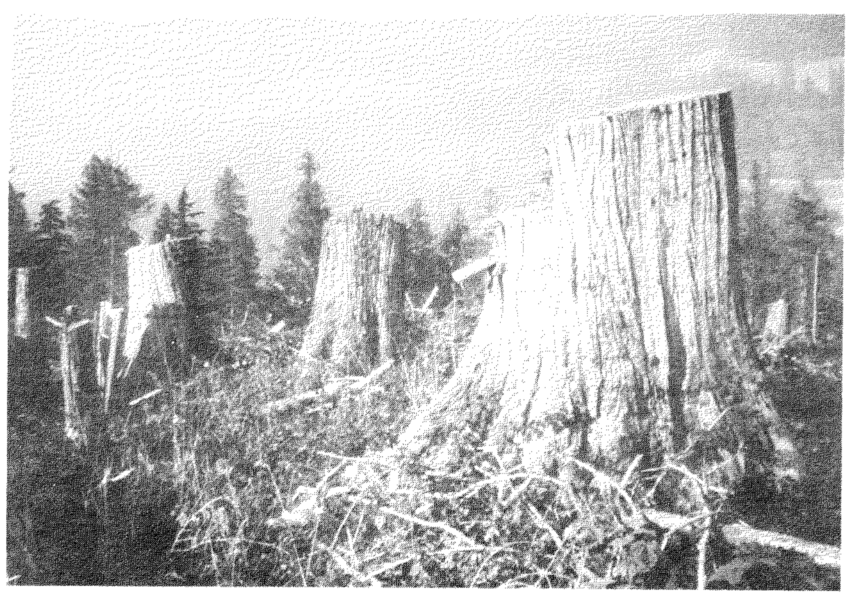

Fig. 6. Closer view of stumps in Company 2's winter area.

RESULTS AND DISCUSSION

As expected, stump heights were lower in both summer areas compared to their winter counterparts. In both, average stump height was 14 inches (see Table 1). Winter stump heights averaged 23 and 21 inches for Company 1's areas, and 50 inches for Company 2's area. The marked difference in the winter results reflected the snow removal done by Company 1's winter faller, and the lack of similar removal in Company 2's area. Differences between the two winter fallers might account for some of this variation, but the snow removal practice seemed to be the greater influence. Snow was slightly deeper in Company 2's area, which would also have influenced the stump heights.

The most noticeable result from the study was the lower incidence of trees breaking during winter falling. Under summer conditions 60 percent of the trees broke for one reason or another, and this compared with 37-44 percent during winter (see Table 2). The more common reasons for breakage were: hitting frozen snow banks along skid roads in winter, hitting roadside banks in summer; and striking stumps or felled trees in both seasons. In one summer area, the terrain was more broken than in the other areas, and this was reflected in the higher incidence of breakage because trees fell across small gullies and ridges.

Gross merchantable standing tree volumes were calculated using standard cubic-foot volume tables and assuming a 1-foot stump and a 4-inch top diameter (inside bark).[1] Differences between these standing-tree volumes and net log

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[1] From Forestry Handbook of B.C. 1971, published by The Forestry Club, U.B.C., Vancouver.

TABLE 2 - FREQUENCY AND CAUSE OF TREE BREAKAGE DURING FALLING

REASON FOR BREAKAGE	NUMBER AND PERCENTAGE* OF TREES									
	COMPANY 1						COMPANY 2			
	Winter		Winter		Summer		Winter		Summer	
		%		%		%		%		%
No breakage	79	63	19	63	64	39	63	56	32	40
Hit snow bank or edge of road	23	18	6	20	14	8	19	17	21	26
Broke during fall-whiplash	2	2	1	3	12	7	4	4	-	-
Broke at fork	-	-	-	-	5	3	-	-	5	6
Hit stump or felled tree	6	5	-	-	30	18	15	13	7	9
Hit by falling tree	4	3	-	-	1	1	1	1	3	4
Hit slash & deadfalls	1	1	-	-	4	2	1	1	-	-
Fell across gully/knoll	4	3	1	3	20	12	4	4	3	4
Broke on impact	6	5	3	10	10	6	6	5	7	9
Hit standing tree	1	1	-	-	5	3	-	-	3	4
Percentage of trees breaking		37		37		61		44		60
Total number of trees	126		30		165		113		81	

*Percentages are rounded to nearest integer.

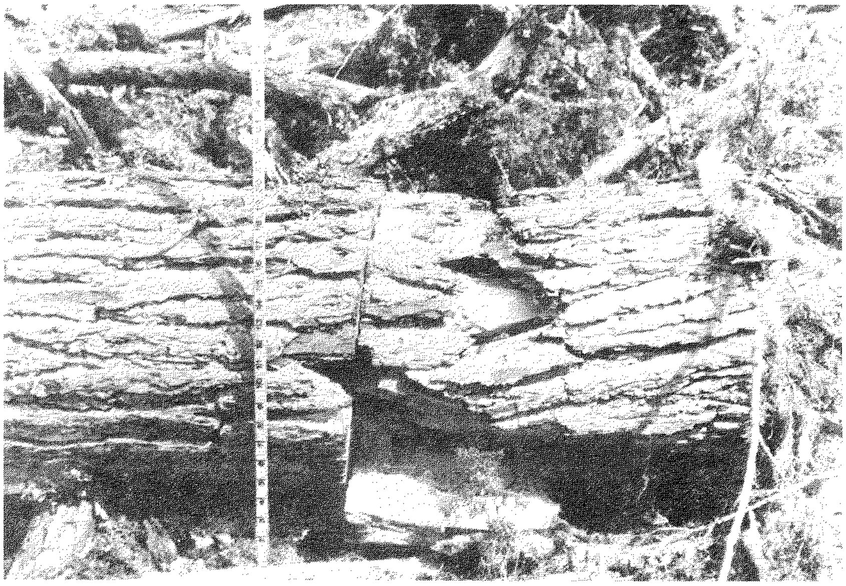

Fig. 7. Tree breakage caused by tree falling across a hollow. The break occurred in the unsupported portion of the stem over the hollow. This was a clean break and involved only a small volume loss.

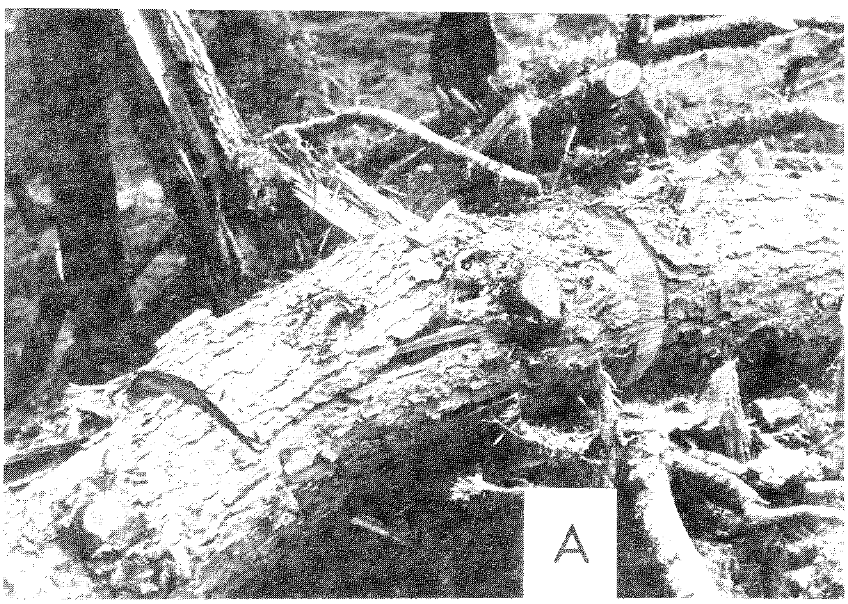

Fig. 8. Tree breakage caused by tree hitting a stump (A). This break includes some shattering up the stem from the point of impact and the volume loss is more than shown in Fig. 7.

Fig. 9. Tree breakage caused by tree hitting a boulder (A). Damage is similar to when tree hits a stump.

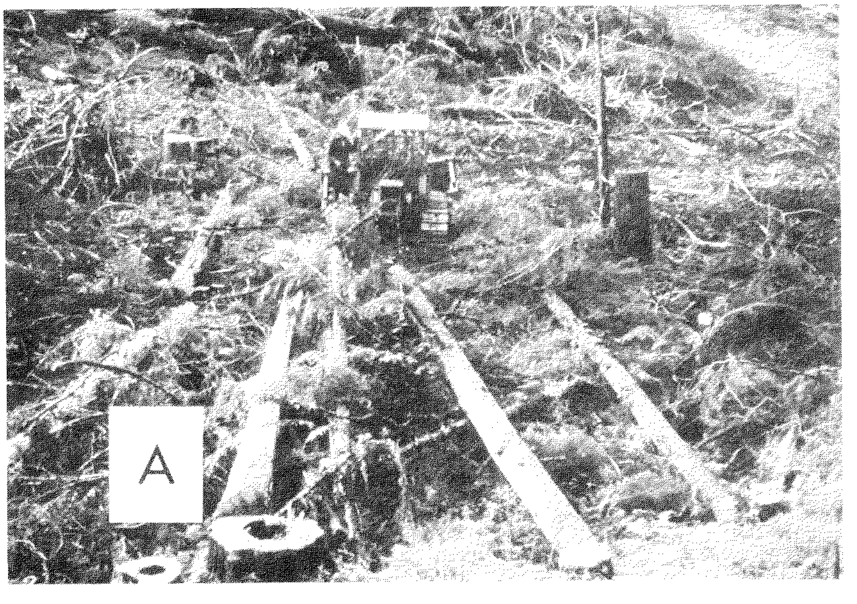

Fig. 10. Tree breakage caused by tree falling across a hollow. Damage was very extensive in this decadent cedar (A). The stem snapped at a point by the tractor, and also split open from the butt to that point.

volumes at the landing gave the unrecovered volumes. These included decay volumes, waste volumes, excess stump volumes and breakage volumes. Recovered and unrecovered volumes are shown for the different areas in Table 3. The decay volumes show the amount of decay present in the sample trees. Expressed as percentages of standing volumes, decay volumes showed a wide variation, ranging from 10 to 41 percent, between study areas. Differences in terrain condition and decay volumes between the sample areas undoubtedly influenced the breakage which occurred, and accounted for some of the variation between sample areas. Waste volumes were calculated for the study areas using the line-intersect method of sampling (Bailey 1969, 1970 a,b) to give a per-acre value. This was then converted to volume per-tree and percent of standing volume bases. Summer areas showed slightly higher values for logging waste than winter areas. Normally waste is higher in winter because logs are lost in the snow. But during the study, trees were skidded shortly after falling and snow conditions remained unchanged, so no logs were lost.

Excess stump volume was calculated as the difference between the stump volume recorded for each area and the volume calculated using the required B.C. Forest Service 1-ft maximum stump height, excluding all rot and decay. The summer areas had stump heights of 14 inches, just exceeding the required maximum, and therefore had very small excess stump volumes. The higher stumps in winter areas meant larger excess volumes. In Company 1's areas these were considerably less than for Company 2's area, reflecting the snow removal prior to falling.

Breakage volumes were calculated as the total unrecovered volumes less decay, waste and excess stump volumes.

TABLE 3 - RESULTS OF TREE BREAKAGE STUDY BY AVERAGE TREE VOLUMES IN CUNITS AND PERCENT OF STANDING TREE VOLUME (MERCHANTABLE)

AVERAGE TREE VOLUMES	COMPANY 1						COMPANY 2			
	Winter		Winter		Summer		Winter		Summer	
	Ccf	%	Ccf	%	Ccf	%	Ccf	%	Ccf	%
Gross Merchantable Standing	1.70	100	2.10	100	1.51	100	2.01	100	1.90	100
Decay	0.60	35	0.86	41	0.27	18	0.20	10	0.35	18
Waste (Logging Residue)	0.03	2	0.03	1	0.05	3	0.03	2	0.13	7
Excess Stump	0.02	1	0.02	1	0.01	1	0.08	4	0.01	1
Breakage Loss	0.10	6	0.01	1	0.23	15	0.19	10	0.26	14
Total Decay, Waste, Excess Stump & Breakage (= unrecovered volume)	0.75	44	0.92	44	0.56	37	0.50	25	0.75	39
Net recovered	0.95	56	1.18	56	0.95	63	1.51	75	1.15	61
Lost (Waste, Excess Stump & Breakage Volume)	0.15	9	0.06	3	0.29	19	0.30	15	0.40	21

TABLE 3A - RESULTS OF TREE BREAKAGE STUDY BY AVERAGE TREE VOLUMES IN CUBIC METRES AND PERCENT OF STANDING TREE VOLUME (MERCHANTABLE) (S.I. UNITS)

AVERAGE TREE VOLUMES	COMPANY 1						COMPANY 2			
	Winter		Winter		Summer		Winter		Summer	
	m^3	%	m^3	%	m^3	%	m^3	%	m^3	%
Gross Merchantable Standing	4.81	100	5.95	100	5.69	100	5.38	100	5.38	100
Decay	1.70	35	2.44	41	0.76	18	0.57	10	0.99	18
Waste (Logging Residue)	0.08	2	0.08	1	0.14	3	0.08	2	0.37	7
Excess Stump	0.06	1	0.06	1	0.03	1	0.23	4	0.03	1
Breakage Loss	0.28	6	0.03	1	0.65	15	0.54	10	0.74	14
Total Decay, Waste, Excess Stump & Breakage (= unrecovered volume)	2.12	44	2.61	44	1.59	37	1.42	25	2.12	39
Net recovered	2.69	56	3.34	56	2.69	63	4.28	75	3.26	61
Lost (Waste, Excess Stump & Breakage Volume)	0.42	9	0.17	3	0.82	19	0.85	15	1.13	21

No breakage of the sample trees was observed during skidding, and thus all breakage losses were attributable to falling. Both summer areas showed higher breakage loss volumes, from 14 to 15% of gross standing merchantable volume, than their winter counterparts, from 1 to 10%. This can largely be attributed to the marked reduction in the proportion of trees which broke during falling in winter, as compared to summer. The sums of breakage, waste and excess stump volumes (Lost Volumes, Table 3) were higher for summer falling than for winter. Considering these volumes as percentages of the standing volume, the higher values for summer are again shown.

CONCLUSION

The hypothesis to be tested was that volume lost in higher stumps in winter logging would be offset by a reduction in breakage losses, compared to summer logging, through the cushioning effect of the snow cover. The study data supported this hypothesis. However the lower breakage loss in winter could not be attributed entirely to a cushioning effect of the snow, because of differences between fallers observed, and differences in stands and terrain between the sample areas.

Losses due to excess stump heights were in the order of 1% of standing volume for summer and winter cutting of Company 1. Excess stump losses for Company 2 were 1% for summer cutting and 4% for winter. The differences between excess stump volumes in the winter areas reflect the beneficial effect if some snow removal is carried out prior to falling.

The avoidance of high stumps is basic to good utilization, ease of post-logging treatments and good aesthetics on the cutover. In decadent Interior cedar/hemlock stands, however, the volume losses due to excessive stump heights appear to be minor when reasonable snow removal is practised. These losses are offset by the cushioning effect of the snow for falling trees. In drawing up guidelines for stump heights in winter logging additional criteria must be seriously considered, and these include:

- the economic and social benefits of continued operations during winter;
- the desirability of replacing decadent stands with new healthy tree crops;
- the protection of steep slopes and soils afforded by logging on top of the snow;
- the overriding importance of worker safety during falling operations.

POSTSCRIPT

The B.C. Forest Service guidelines for stump heights from 1975/76 winter logging were in force during the study. These were superseded in August 1976 by a new policy directive for the 1976/77 winter season, which reads in part as follows:

> "Where proper planning has been done, or where alternative low snow areas are unavailable and continued employment of logging or mill crews is a factor, or site protection and environmental considerations dictate winter logging, stump heights at one foot or more below the snow line will be considered non-flagrant."

"Where conditions outlined in (2) above have not been met, suspension procedure will apply, and volumes in high stumps will be classed as flagrant waste."

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