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TN #
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Trials of Two Feller-Bunchers in Coastal B.C.

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PREFACE

Mechanized logging methods already well-established in Interior B.C. are being introduced to the Coast region, as coastal timber sizes diminish. This report presents results of initial evaluations of two feller-bunchers that have been tried in second-growth coastal stands.

All measurements are reported in SI units with Imperial equivalents in parentheses. The author gratefully acknowledges the cooperation and assistance of the following individuals:

Stan Ward	Drott operator
Dwight St. Germain	Finning demonstrator operator
Don Hall	Manager, Crown Zellerbach, Campbell River
Bill Maxwell	Contract Supervisor, Crown Zellerbach, Campbell River
Tony Wong	FERIC, for assistance with field work.

ERRATA

Page 3, last paragraph:

"trees/minute" should read "minutes per tree"

Page 6, last sentence:

"Cat 255/235" should read "Cat 225/235"

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SUMMARY

This report summarizes results of two feller-buncher evaluations FERIC conducted on the operations of Crown Zellerbach Canada Limited.

Shear-equipped feller bunchers have been introduced to second-growth coastal B.C. logging operations. Evaluations of a Caterpillar 225/235 and a Drott 40, both of 51-cm (20-inch) capacity) showed that the first averaged 0.93 minutes/tree and the second 1.03 minutes/tree. This corresponds to cutting rates of 65 and 58 trees per hour, respectively. Hourly productivity, in Volume/Productive Machine Hour, averaged 71 m^3 for the Cat 225/235 and 41 m^3 for the Drott. The difference is accounted for primarily by different piece volumes: 1.10 m^3/tree for the Cat and 0.70 m^3/tree for the Drott.

Detailed information collected only for the Drott showed that tree size had little effect on head positioning and cutting time until tree size approached machine capacity. However, in smaller trees, the carrier's manoeuvring and brushing times increased.

Coastal ground conditions impeded mechanical felling. Between 25% and 30% of total time per tree was spent in path-clearing functions. Direct felling cycle times (Swing Loaded, Position and Cut, Swing Empty) are comparable to non-coastal bunchers, but path-clearing times are much greater. Efforts to reduce total time per tree should therefore be directed first towards reducing path-clearing times. Suggestions are included in the report.

The introduction of mechanical felling to the coast of British Columbia will result in logging system changes. As average piece volumes decrease new methodologies will be imported to the coastal region to handle smaller-dimension timber.

SOMMAIRE

Le présent rapport expose les résultats des évaluations de deux abatteuses-groupeuses, effectuées par FERIC sur les exploitations de Crown Zellerbach Canada Limited.

On a introduit, dans les peuplements de seconde génération de la côte de Colombie-Britannique, l'emploi d'abatteuses-groupeuses munies de cisailles. L'évaluation d'une capacité de coupe de 51 cm (20 po.), a montré une moyenne de 0.93 minute/arbre dans le premier cas et de 1.03 minute/arbre dans le second cas. Ceci correspond à un taux d'abattage de 65 et de 58 arbres par heure respectivement. La productivité horaire, en volume par heure-machine productive, atteignait 71 m^3 pour l'abatteuse Caterpillar et 41 m^3 pour la Drott. La différence s'explique principalement par la différence de volume à la pièce: 1.10 m^3/arbre dans le premier cas et 0.70 m^3/arbre dans le second cas.

Des données détaillées recueillies pour la Drott seulement ont démontré que les dimensions des arbres n'avaient que peu d'influence sur le temps de positionnement de la tête et sur le temps d'abattage, à moins que le diamètre de l'arbre ne s'approche de la capacité de coupe de la machine. Dans les arbres plus petits, toutefois, les temps affectés aux manoeuvres de l'engin porteur et au débroussaillage augmentent.

Les conditions du terrain sur la côte gênaient l'abattage mécanique. De 25% à 30% du temps total par arbre se passait à dégager la piste. Les temps du cycle directement affectés à l'abattage (rotation à vide, positionnement et abattage, rotation en charge) se comparent aux temps des abatteuses-groupeuses en zone non côtière, mais les temps de dégagement de la piste sont beaucoup plus élevés. Les efforts en vue de réduire le temps total par arbre devraient donc viser d'abord à diminuer les temps de dégagement. Le rapport comporte des suggestions à cet effet.

L'introduction de l'abattage mécanique sur la côte de la Colombie-Britannique entraînera certains changements dans le système d'exploitation. A mesure que diminue le volume moyen à la pièce, on assistera à l'implantation dans la région côtière de nouvelles méthodologies dans la manutention des bois de plus faibles dimensions.

INTRODUCTION

In the past several years there has been a growing recognition within the coastal forest industry that the average piece volume has been decreasing and that it will continue to decrease. As forest companies face smaller timber sizes, they will also face larger piece counts. One large company, for example, has estimated a 45% increase in piece count (to obtain the same volume) between 1980 and 1990.

New procedures and equipment have been introduced to handle smaller-sized wood. Cable-thinning operations have existed for several years and more are planned. Other full-tree harvesting techniques are being examined for applicability and cost as there are some second-growth areas that have the potential to be harvested with mechanized systems.

This report summarizes results of two feller-buncher evaluations FERIC conducted on the operations of Crown Zellerbach Canada Limited. Crown Zellerbach (CZ) now have coastal operations in first-rotation (second-growth) timber and are one of the companies examining full-tree harvesting techniques. Some of their first experiments in production-level, second-growth harvesting were with feller bunchers.

In 1977 CZ conducted a short feller-buncher experiment. A shear-equipped Caterpillar 235 was tried for several days simply to determine whether or not a buncher could fell trees on the coast. Three years later, in the summer of 1980, a second unit was placed on trial for about 3 weeks. This was a shear-equipped Caterpillar 225/235 (Figure A), operated by Finning Tractor's demonstrator operator. FERIC visited this operation and conducted a brief productivity assessment.

Later in the fall of 1980, a Drott 50 with a shear head was tried at the same location. FERIC did not participate in this third trial, but did in the fourth, which occurred during the spring and summer of 1981. This latter machine, on contract for approximately three months, was a shear-equipped Drott 40 (Figure B) operated by an experienced buncher operator from Princeton, B.C.

FIGURE A. Caterpillar 225/235 with 51-cm (20-inch) shear head. CZ's 2nd trial, summer 1980.

FIGURE B.

Drott 40 with 51-cm (20-inch) shear head.

The Studies The 225/235 evaluation was conducted using a work-sampling procedure to assign machine time to the various categories. Data were collected over a three-day period and totalled 225 observations at randomly selected intervals. (A 5-hour downtime period, mainly for Wait Mechanic, was recorded separately from the work sample information.) Tree diameters were visually estimated and recorded in one of 3 diameter classes. Tree heights for each class were measured, providing tree volumes for each class.

The second evaluation was conducted on the Drott 40. Plots 12 m by 30 m (40 ft by 100 ft) were established in advance of the machine. Measurements of all merchantable trees were recorded and the trees were colour-coded by diameter classes. The buncher was timed as it moved through the plots. Local volume tables were again developed, based on the colour-coded trees, permitting analysis of cutting time by tree-volume class. Stump heights, bunch angle and the number of trees per bunch were recorded after cutting. Test-site conditions are described in the Appendix.

RESULTS

TIME AND PRODUCTIVITY

Table 1 contains time and productivity results for both machines.

New and additional time elements were defined for these studies. In Table 1 they are located under the heading "Path-clearing." The element "brushing" has long been considered part of a feller-buncher's duty cycle, but on the coast of B.C., machine mobility is affected by more than the understory or dense underbrush.

Comments

(1) Each machine cut an average of about one tree per minute. Based on Total Harvesting Time/Tree, the Cat 225/235 averaged 0.93 and the Drott 1.03 trees/minute. This corresponds to hourly cutting rates of 65 and 58 trees per hour, respectively.

TABLE 1. Time and Productivity Results.

	Cat 225/235 1980			Drott 40 1981		
	Minutes/ tree		Rate Trees/hr	Minutes/ tree		Rate Trees/hr
Move time		.15			.10	
Swing empty		.12			.11	
Position & cut		.15			.11	
Swing loaded (incl. bunching)		.17			.17	
Subtotal: Felling Cycle		.59	102		.49	122
Path-clearing						
a) brushing	.06			.11		
b) dig, trim or move old-growth stumps	.06	.28		.04	.27	
c) dig or move old windfalls	.04			.10		
d) dig, trim down or move new-growth stumps	.12			.02		
Subtotal:		.87	69		.76	79
Delays						
a) wait handfaller to cut oversize	0			.23	.27	
b) stuck	.01			.04		
c) repile misaligned trees	.02	.06		0		
d) handbuck windfalls	.02			0		
e) planning	.01					
Total: Harvesting Time/Tree		0.93	65		1.03	58
Average tree size - dbh	30 cm (12 in.)			26 cm (10 in.)		
- volume	1.10 m^3 (38.8 ft^3)			0.70 m^3 (24.7 ft^3)		
Volume/Productive Machine Hour (PMH)	71 m^3 (25.0 cunits)			41 m^3 (14.4 cunits)		
Trees/PMH	64.5			58.3		
Sample size--number of trees	564			201		

(2) The Drott actually had the faster Felling Cycle time, probably reflecting the greater operator experience as well as the slightly smaller diameter of trees cut.

(3) Path-clearing times were virtually identical for the two machines. It is possible that path-clearing times for coastal bunchers will remain in the range of 25% to 30% of Harvesting Time per Tree.

(4) Delay time for the Drott was about 4½ times that of the Cat 225/235. The Drott's area contained more oversize trees and it is for this reason that total harvesting time per tree is higher.

(5) Volume/Productive Machine Hour (PMH) for the Cat 225/235 was substantially higher primarily because of the larger average piece volume.

(6) Table 2 shows a range of daily production values, based on these studies and assumed machine Utilization values. The shift length is assumed to be 8 scheduled hours.

A comparison between the two machines illustrates the effect of piece size on daily production. The Drott's daily piece count is only 11% less than that of the 225/235, but its daily volume is 43% less.

TABLE 2. Calculated Range of Daily Production Values.

	Cat 225/235		Drott 40	
Utilization level % of 8hr shift	Daily piece count @ 65 trees/hr	Daily volume @ 1.10 m^3/tree	Daily piece count @ 58 trees/hr	Daily volume @ 0.70 m^3/tree
60% = 4.8 PMH	312	343	278	195
70% = 5.6 PMH	364	400	325	228
80% = 6.4 PMH	416	458	371	260

EFFECT OF TREE SIZE ON HARVESTING TIME

Figure C is a graph of cutting performance by tree-size class for the Drott. The time included in "Position & Cut" (P & C) is the time between the head touching the tree for cutting and the tree moving from its stump. The time interval between the P & C curve and the "Time per Tree"(TT) curve includes all other elements in the harvesting cycle except for delays. Aside from oversize trees, delays can occur randomly and are not associated with any specific tree size.

The P & C curve is flat throughout most of its range. This means that tree size has little effect on head positioning and cutting time until the tree size approaches machine capacity. Trees in the largest class averaged 44 cm (17 inches) in diameter and 2.1 m^3 (75 ft^3) in volume. This class accounted for 10% of the trees in the study.

The TT curve increases as trees get smaller. This suggests a combination of carrier-manoeuvring problems and increased brushing time in smaller trees.

Similar information was not obtained from the work-sampling study performed on the Cat 255/235.

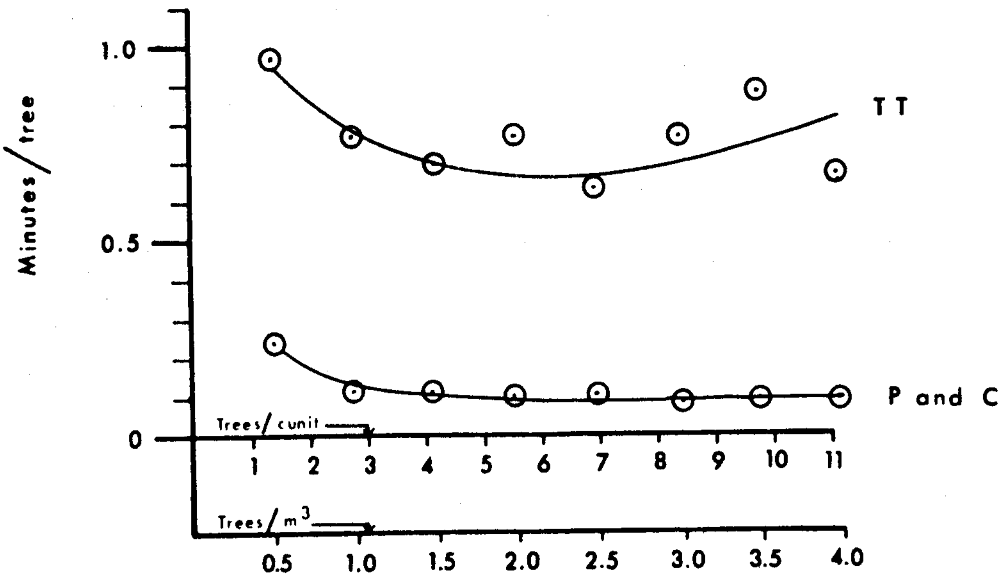

FIGURE C. Position & Cut and Total Time Curves for Drott 40.

Stump Height and Bunch Size

The following information was collected only for the Drott 40 operation.

Stump heights were measured (from ground level on the highest side) on a sample of 37 stumps. Average height was 42 cm (16.5 in.) and average diameter of the sample was 25 cm (9.8 in.). Figure D illustrates why stump heights are relatively high--debris often interfered with low head placement on the tree. Note the slight fibre pull, evident on all stumps and butts.

Twenty-one bunches were counted. These averaged 5.8 trees/bunch. Average bunch angle from machine travel direction was about 75°. Figure E illustrates a small-piece-count, high-volume bunch. Note also the slight fibre pull.

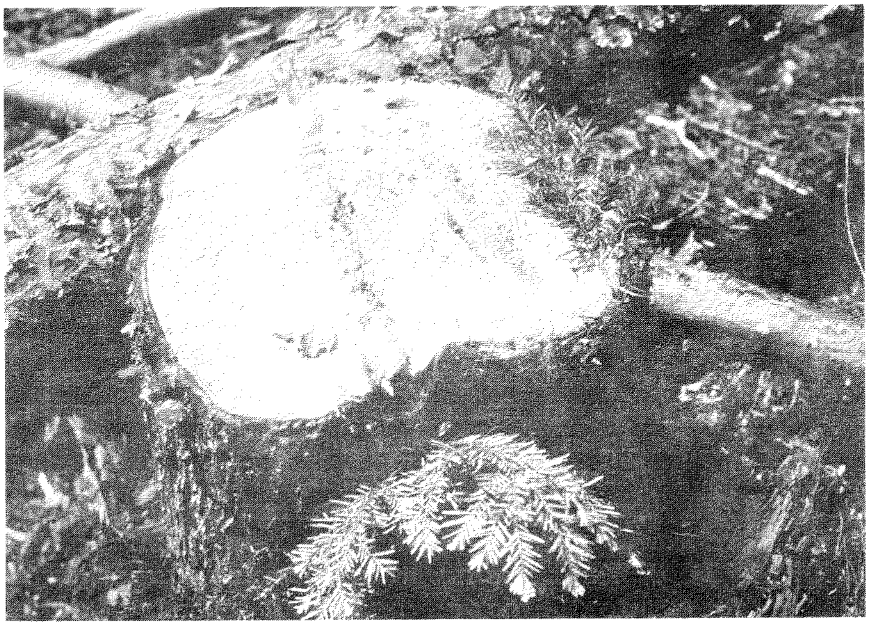

FIGURE D. High stump caused by debris interference.

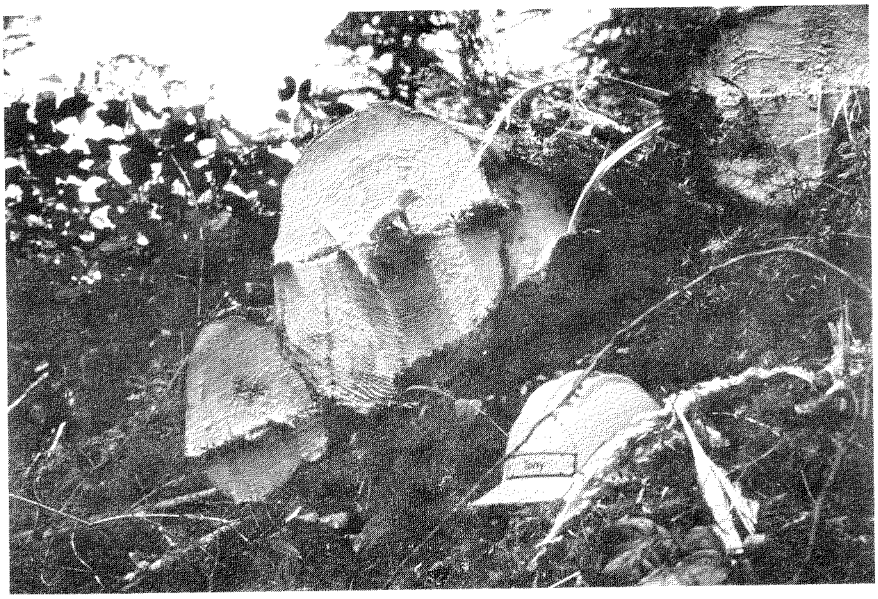

FIGURE E. Bunch prepared by Drott 40.

Butt Damage

Butt shatter was not measured for either machine. Although it was initially planned to examine discs cut from tree butts, initial bush observations suggested this would not be necessary. For both machines, shatter was visually estimated to extend less than 15 cm (6 in.) up the stem. The absence of significant visible shatter may be related to growing conditions found on coastal B.C. Coastal trees have a higher proportion of summerwood than interior or eastern trees, and this may have an effect on coastal shear-damage levels. However, this was not considered to be within the scope of these machine evaluations, and further work would be required to examine this possibility.

Some butt damage was observed, however, at both operations. All trees cut by the Drott showed a slight amount of pull. ("Pulling" results when the blades do not cut entirely through the tree--wood fibre is pulled from the stump or stem in the form of sharp-pointed splinters.) During the 225/235 trial pulling and barberchairing increased noticeably as the trial progressed. On the last morning of the FERIC study all trees were affected by pull and approximately 40% to 50% by barberchairing. Some of the splinters exceeded 15 cm. The operator noted that the head had been in use for about 45 working hours and that the shear blades required shimming and sharpening.

DISCUSSION

PATHCLEARING FUNCTIONS

A) EFFECT OF GROUND CONDITIONS

Coastal ground conditions interfered with machine travel. Depressions, rock outcrops, old-growth stumps and old cedar windfalls impeded machine progress along the cutting face. Some of the newly-cut tree stumps also caused travel problems.

(a) Depressions/rock Depressions often had to be filled with debris in order to form a pad, or bridge, for the tracks. Rock outcrops on the high side of depressions caused even greater amounts of "fill" to be required. Generally, debris within reach of the boom was used, without additional carrier movement.

(b) Old-growth stumps These stumps ranged up to 2.5 m (8 ft) in height and usually ranged 1 to 1.5 m (3 to 5 ft) in diameter. Figure F shows examples of old-growth stumps. Spacing between stumps (from visual observation) ranged from 6 to 12 m (20 to 40 ft). Such stumps restricted both carrier movement and head placement, and occasionally caused problems in the Swing Loaded phase, especially in high winds.

The machine operators used the boom and head to break down, trim back or uproot these stumps. They were more successful with the cedar than the Douglas fir. Where necessary, uprooted stumps were used as fill material. The addition of a handfaller for the Drott trial was helpful. He partially cut some of the old-growth stumps, making it easier for the buncher to push them over. The data presented in Table 1 shows only a small improvement for the Drott. However, the Drott was faced with more stumps, more windfalls and more oversize trees than the Cat 225/235.

FIGURE F. Old-growth stumps impede mechanical felling.

(c) Windfalls Old cedar windfalls were too large for either buncher to move unaided. On the Drott operation the handfaller made bucking cuts through the windfalls (Figure G) to assist the buncher. On the Cat 225/235 operation the machine operator performed his own bucking--only two windfalls were encountered during the FERIC study period.

(d) Newly-cut stumps Trees on coastal B.C. have butt flare (Figure H) not commonly found in the Interior. The operator of the Cat 225/235 received instructions to cut above the flare in order to produce flare-free stems. The resulting stumps were often too high to permit carrier passage. The operator had to trim back or dig out many of these second-growth stumps. Time spent performing this function amounted to 13% of Total Harvesting Time per Tree. Stump heights were not measured at this operation, but those that were left appeared to be shorter than those produced at the Drott operation.

FIGURE G.

Handfaller bucking windfalls.

FIUGRE H. Stump with flare. Operator will trim this down.

Figure I shows the Drott performing a similar function, although the instructions regarding flare-free stems were rescinded. For the Drott this function accounted for only 2% of harvesting time/tree.

FIGURE I. Carrier interference caused by new-growth stump.

B) OVERSIZE TREES

No oversize trees were observed during the FERIC study of the Cat 225/235. On the Drott operation oversize trees were handfelled. Figure J shows the buncher bracing the tree for directional falling while the faller makes the cut. In addition to the 201 plot trees cut by the buncher, 9 oversize trees (from within the plots) were cut by the hand-faller. Average machine time for each oversize tree was 3.3 minutes.

FIGURE J.

Handfalling over-size tree.

C) COMPARISON WITH NON-COASTAL MACHINES

Clearing the travel route accounted for 0.28 and 0.27 minutes per tree for the two bunchers. Although these times may not seem notable by themselves, compared to non-coastal felling machines they are extremely high. Previous studies have referred to the pathclearing function as "brushing" and a review of published FERIC felling machine studies provides comparative data.

A total of 26 sets of detailed time study information are contained in 9 FERIC publications. The machines were: shear, saw or auger-equipped; directors or bunchers; located in Interior B.C. or Eastern Canada. More than three-quarters (77%) of those machines averaged 0.09 minutes or less for the brushing category. Of the remainder, only 1 machine exceeded 0.17 min/tree (a widely-spaced stand with dense underbrush--average brushing time of 0.24 min/ tree). With the latter exception the two coastal bunchers spend between 1.6 and 28 times that required by non-coastal machines. An overall average, based on the data spread, appears to be 5 to 6 times as great.

Not only is the average pathclearing time per tree greater for the coastal machines but so is the percentage of total time that pathclearing requires. Only 3 of the 26 non-coastal felling machines had brushing times greater than 15% of the Total Time per Tree. (For those machines using a combination felling/ processing head, processing times were deducted before calculating the brushing percentage.) The coastal bunchers averaged 25% to 30% of their Total Time per Tree in pathclearing functions.

A comparison of direct felling-cycle elements (Swing Loaded, Position and Cut, Swing Empty) can also be made. (These comparisons do not include any frame-mounted directors or non-shear heads, as directors must move to each tree and non-shear heads are usually much slower.) The remaining 16 machines have average direct felling-cycle times ranging from 0.28 to 0.54 minutes/tree. The coastal bunchers averaged 0.39 and 0.44 minutes per tree which places them in the middle third of the range.

In summary, then, direct felling-cycle times for coastal shear bunchers are in the range of non-coastal machines but pathclearing times are much greater. If the objective is to increase hourly productivity in a given stand, the implication is that little improvement would be obtained through attempting to reduce direct felling-cycle times. There appears to be greater potential for improvement by examining the pathclearing functions, and ways in which they could be reduced. Some suggestions are provided below.

(a) assign a permanent handfaller: he will fall oversize trees and make bucking cuts through windfalls and old-growth stumps. The company had already instituted this procedure for the Drott trial.

(b) ensure cooperation and communication: portable radios would reduce work stoppages for communication/instructional purposes. The operator often has a clearer view of ground conditions and could instruct the handfaller with respect to preferred location of bucking cuts, for example.

(c) move as few things as possible: when a choice of cutting directions or face-openings is available, choose the route which offers the least moving of windfalls or old-growth stumps.

(d) cab upperworks which tilt can reduce pathclearing time: a cab-levelling mechanism, such as the Drott's (17° of tilt), helps maintain proper head alignment on a tree. This can result in less fill required under the tracks to make the carrier level.

(e) a military-style undercarriage would increase carrier mobility: excavator-style undercarriages are used on most feller bunchers including both the Caterpillar and Drott lines. A raised front idler (on tanks, personnel carriers, FMC's) would increase machine mobility in coastal ground conditions. A Drott 40 upperworks has been matched with an FMC undercarriage for the Northwood/FERIC Feller-Director head.

Changes to the Logging System

A feller buncher does what its name implies. It provides full-tree bunches at the felling site. No topping, delimbing or bucking is performed. How and where should the processing be done? How should the wood be brought to roadside? How should it be loaded? These are questions which have also faced Scandinavian, eastern North American and Interior B.C. logging operations. There are many answers and none are right for all operations. Some of the prime techniques are described below.

Yarding to roadside from the felling site has usually been conducted with ground skidding machines, either tracked or rubber tired. Machine types have included line, grapple or clam-bunk skidders and various styles of forwarders.

Processing has been done at the felling site, at roadside landings, or at central yards. Some form of mechanical delimbing machine, possibly with bucking ability, delimbs the stems and tops to the required diameter.

Loading usually involves some form of clam-shell grapple for shortwood or a front-end loader-style grapple arrangement for tree or log lengths. Single-stem loading machines are not usually found on highly-mechanized smallwood operations.

The processing location affects overall system performance. Some machines, such as the OSA 705 Processor, are capable of in-field processing in the wake of a feller buncher. However, trials reported by Powell and St. Jean in Interior B.C. showed an average piece volume of 0.54 m^3 (19.1 ft^3) and they indicated this was not sufficient to make the processor viable. Moreover, the processor was located on landings and required few moves. It does not appear that such equipment would function well off-landing. On the coast, then, processing will most likely occur at roadside or landing, or a remote yard facility.

The choice of processing equipment and location cannot easily be divorced from yarding and loading/hauling considerations. Some delimbing/bucking machines, (for example, the Hahn and OSA 705) when stationed at roadside, do not obtain their best performance if yarded trees are perpendicular to the road. Trees must be angled or, preferably, placed parallel to the road to permit easy feeding of the processing unit. Others, like the Volvo SM-880 Processor, have a turntable chassis, permitting processing at right angles to the road. The problem is that processed log lengths are ejected from the rear of the machine, resulting in jumbled log piles stretched across the road. Truck loading would be more difficult in this instance, but with either system trucks are transporting log-length wood.

If the processing machine is stationed at a central yard, the truck fleet must haul full trees, including the tops. In theory the processor would be continuously supplied with wood. However, the longer loads may require that changes be made to existing road networks, particularly in areas with steep switchbacks.

There are other machines on the market which delimb and top, but have no bucking ability. Single-stem delimbers such as the Harricana, Roger, Denis and Logma are currently working or are on trial in northern Alberta and Interior B.C. These units have not yet been tried on coastal B.C. Without bucking capability, these units may see limited usage in a sawlog-oriented market.

With the introduction of feller bunchers to coastal B.C. the possibility exists that ground skidding could follow in selected areas. Feller-buncher/grapple-skidder combinations form successful, productive teams on many interior operations. A tracked machine, like the FMC Bunk Grapple, could conceivably perform well in well-selected and designed areas.

Crown Zellerbach is experimenting with operational techniques new to coastal B.C. As more second-growth and other small-dimension stands are harvested new methods and systems will be instituted. Cable yarders have been, and will continue to be, examined for their ability to yard bunched wood. Processing machines will undergo trials at roadside and at central yards. In the future other companies will be facing potential system changes as a result of the decreasing average piece size.

CONCLUSIONS

(1) Shear-equipped feller bunchers have been introduced to second-growth coastal B.C. logging operations.

(2) Evaluations of a Caterpillar 225/235 and a Drott 40 showed that the first averaged 0.93 trees/minute and the second 1.03 trees/minute. This corresponds to hourly cutting rates of 65 and 58 trees per hour, respectively.

(3) Hourly productivity, in Volume/Productive Machine Hour, averaged 71 m^3 for the Cat 225/235 and 41 m^3 for the Drott. The difference is accounted for primarily by different piece volumes: 1.10 m^3/tree for the Cat and 0.70 m^3/tree for the Drott.

(4) Detailed information (collected only for the Drott) showed that tree size had little effect on head positioning and cutting time until tree size approached

machine capacity. However, in smaller trees, the carrier's manoeuvring and brushing times increased.

(5) Coastal ground conditions impeded mechanical felling. Between 25% and 30% of total time per tree was spent in pathclearing functions. Direct felling-cycle times (Swing Empty, Position and Cut, Swing Loaded) are comparable to non-coastal feller-bunchers, but pathclearing times are much greater. Efforts to reduce total time per tree should therefore be directed towards reducing pathclearing times. Possibilities include: a permanently assigned handfaller; close cooperation and communication between operator and handfaller; greater attention to planning the buncher travel path; a cab with tilt capability; a military-style undercarriage with raised front idler.

(6) The introduction of mechanical felling to the coast of British Columbia will result in logging system changes. As average piece volumes decrease, new methodologies will be imported to the coastal region to handle smaller-dimension timber.

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APPENDIX I

TEST SITE CONDITIONS - DROTT 40

Species composition	85% hemlock 15% cedar occasional Douglas fir
Average dbh of study trees	26.5 cm (10.4 in.)
Average tree volume	0.70 m^3 (24.7 ft^3)
Average slope in travel direction	10%
Average slope across path	13%
Merchantable stems per hectare	1,105 (447 stems per acre)

Stand measurements were not made for the Caterpillar 225/235 study.