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

Comparison of Two Logging Systems in Interior British Columbia: Central Processing Yard vs Conventional

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COMPARISON OF TWO LOGGING SYSTEMS IN INTERIOR BRITISH COLUMBIA: CENTRAL PROCESSING YARD vs CONVENTIONAL

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ABSTRACT

FERIC's member companies in the Interior of British Columbia requested an examination and evaluation of the Central Processing Yard (C.P.Y.) System. A study comparing the Conventional and the C.P.Y. Systems was considered necessary. The objectives of the comparison were to quantify some of the expected advantages and disadvantages of the C.P.Y. System; to determine if phase productivity improved with the C.P.Y. System offsetting the increased handling of the wood; and to determine whether log quality improved.

Alternate strips of a timber block were harvested by each system and all the logging phases were monitored by FERIC in both winter and summer. Utilization of equipment and manpower was better in the C.P.Y. System but total hours and cost/m^3 increased. The total cost of the C.P.Y. System was 7% higher in the winter and 14% higher in the summer. Debris was 12.3% of full-tree weight in the winter and 17.6% in the summer. Skidding production increased 3.8% in the winter and 10% in the summer with the C.P.Y. System. Off-highway trucks were less expensive per volume-distance than highway trucks on gravel roads. Using the winter data, with an off-highway haul of over 100 km, the cheaper off-highway hauling can offset the increased loading and unloading costs of two fleets.

The study did not show any distinct advantage in either system, indicating that the choice of central processing must be made after considering the specific timber conditions, logging chance, haul route and mill requirements. The yard in this operation processed small pine and spruce trees with low potential for quality improvement. If higher value trees had been processed there may have been a quality advantage in the yard.

The data collected in this study can be used as a base by operators considering the installation of a Central Processing Yard. The data is presented in such a way that the reader can calculate the per-m^3 costs for his specific operation. Although the cost attractiveness of the system is marginal at this time, it may increase in the future. Central Processing Yards permit greater use of forest debris for byproducts and fuel, provide an opportunity for fully mechanized processing, and divide the truck haul into "bush" and "highway" where specialized equipment could be used to advantage. FERIC is continuing to explore methods to improve overall wood supply systems in the Interior of British Columbia.

RÉSUMÉ

Les compagnies membres de FERIC, qui exploitent dans la zone intérieure de Colombie-Britannique, nous ont demandé d'étudier le système d'exploitation comportant un parc central de façonnage (C.P.Y.) et d'en faire l'évaluation. Nous avons jugé nécessaire d'effectuer une étude comparative de ce système et du système traditionnel. La comparaison avait pour but de quantifier quelques-uns des avantages et des inconvénients prévus du système C.P.Y., de déterminer s'il contribuait à augmenter la productivité de cette phase de l'exploitation, contrebalançant ainsi la manutention accrue des bois, et d'établir s'il y avait amélioration de la qualité des billes.

On a coupé selon chaque système des bandes alternées d'un bloc forestier, et FERIC a observé toutes les phases de la récolte, en hiver comme en été. On a constaté dans le système C.P.Y. une meilleure utilisation de l'équipement et de la main-d'oeuvre d'une part, et une augmentation du nombre total d'heures et du coût au mètre cube d'autre part. Le coût total du système C.P.Y. était plus élevé de 7% en hiver et de 14% en été. Au cours de l'hiver, les déchets ligneux représentaient 12.3% du poids de l'arbre entier, alors qu'ils s'élevaient à 17.3% en été. La production au débardage augmentait de 3.8% en hiver et de 17.6% en été. Les camions de route privée coûtaient moins cher par unité de volume et de distance sur les routes de gravier, alors que les camions de route publique étaient plus économiques sur les routes pavées. Selon les données obtenues en hiver, en camionnant le bois en-dehors des routes publiques sur plus de 100 km, on peut économiser suffisamment si on se sert d'un camion de route privée, pour contrebalancer l'augmentation des coûts due au chargement et au déchargement de deux camions au lieu d'un.

L'étude n'a laissé entrevoir aucun avantage frappant, ni dans un système ni dans l'autre, laissant à l'exploitant la décision d'établir ou non un parc central de façonnage, compte tenu des conditions particulières de la forêt, du site de la coupe, de la route de camionnage et des exigences de l'usine. Le parc de façonnage étudié ne traitait que des pins et des épinettes de faible diamètre, ayant peu de potentiel d'amélioration de la qualité. Si l'on y avait traité des arbres de plus grande valeur, le parc de façonnage aurait pu représenter un avantage au point de vue qualité.

Les données recueillies au cours de cette étude peuvent servir de base aux exploitants que songent à l'installation d'un parc central de façonnage. Elles sont présentées de façon à ce que le lecteur puisse calculer les coûts par mètre cube applicables à sa propre exploitation. Bien qu'à l'heure actuelle, l'attrait économique du système soit marginal, il peut augmenter dans l'avenir. Un parc central de façonnage permet une meilleure utilisation des déchets ligneux en sous-produits et à des fins énergétiques, fournit l'occasion idéale de mécaniser complètement le façonnage et divise le camionnage en une section "route publique" et une section "route privée," chacune donnant lieu avantageusement à l'utilisation d'un matériel qui lui est bien adapté. FERIC poursuit ses recherches visant à mettre au point des méthodes pour améliorer le système global d'approvisionnement en bois dans la zone intérieure de Colombie-Britannique.

INTRODUCTION

FERIC's member companies in the Interior of British Columbia requested an examination and evaluation of the Central Processing Yard System (C.P.Y.) to help resolve questions of productivity and log handling.

Most harvesting in the Interior involves the direct hauling of log lengths to the mill. Processing (bucking, sorting, and delimbing) is done either at the felling site or on the bush landing. The alternate C.P.Y. System uses an intermediate semipermanent processing yard where full trees would be delivered on off-highway trucks. Delimbing and bucking to required lengths would be done here, and the logs might also be scaled, sorted and stored. The logs would be reloaded onto conventional highway trucks for the haul to the mill.

C.P.Y. Systems appear to offer advantages for some Interior operations. Users feel the larger processing location gives the delimber and buckerman more time and space to perform their tasks safely and more accurate lengths and better limbing quality result.

A second advantage of the system is a broader one: greater control and supervision over each phase of the harvesting. Removing the processing from landings could--with changes in skidding and loading techniques--improve the productivity of these two phases and reduce the size and cost of bush landings.

The main disadvantage of the C.P.Y. System is the increase in wood handling. The additional men and machinery required increase the cost of loading, unloading and processing. Another cited disadvantage is the cost of hauling limbs and tops to the central yard and the disposal of this material at the yard.

In the summer of 1978, FERIC visited established yards in the Cariboo and Okanagan. (Descriptions of these and other C.P.Y. Systems FERIC has seen in the past two years are given in Appendix I.) This preliminary examination established two facts. First, comparisons based solely on descriptions of operations using Conventional Systems and C.P.Y. Systems were not adequate without directly comparable productivity data for each phase. Second, cost and productivity comparisons between yards were not satisfactory because of differences in stated objectives and actual logging conditions. A system study of the two harvesting methods at the same operation was needed.

In December 1978, Crown Zellerbach Canada Ltd. in Kelowna offered their cooperation in a side-by-side test of the two systems. The objectives of this comparison were to quantify some of the stated advantages and disadvantages of the C.P.Y. System; to determine if phase productivity improved with the C.P.Y. System and if this improvement offset the increased handling of the wood; and to measure bucking quality and visually assess limbing under both systems.

Crown Zellerbach's operation in Peachland uses a central yard as a processing location. As a test, the company agreed to harvest one-half a timber block conventionally and the other half through their normal yard operation. This comparison was carried out in January 1979 and repeated for summer conditions in June and has provided the basic data for this report.

The first part of the report presents the information from the two test periods, the method of study, description of operations, and summaries of productivity and cost. These data are then interpreted to determine the probable effect of modifications on some basic variables and changes in the function of the yard.

A. Organization and Method of Study

The Interior Wood Supply and Products Division of Crown Zellerbach Canada Ltd. in Kelowna arranged the study with its Peachland contractor, Duncan Logging Ltd. Discussions between FERIC and Crown Zellerbach established study requirements and scheduling.

The following procedure was used in both winter and summer. Each timber block was divided into six strips serviced by three landings in the winter and four in the summer phase (to accommodate more difficult terrain). Alternate strips were harvested by C.P.Y. and Conventional Systems. The stratification of the block gave similar ground and timber conditions to both logging systems. Figure A shows the flow of wood for the two systems. The operation used feller-

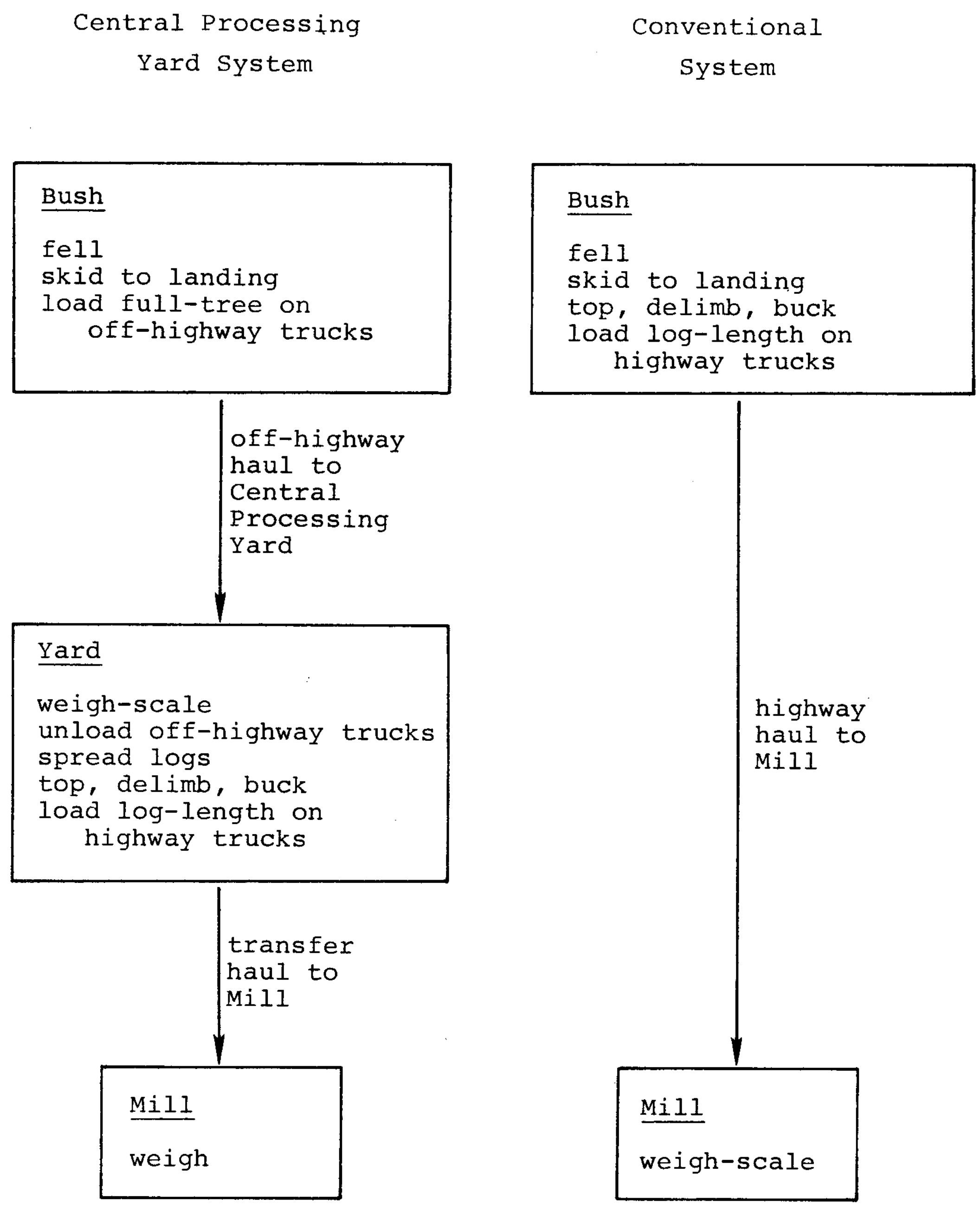


FIGURE A. Flow of wood for the Central Processing Yard and Conventional Systems bunchers and grapple-skidders. The same machinery and crew were used in both the Conventional and C.P.Y. Systems (with some changes between winter and summer). Table 1 outlines the machinery and labour used.

FERIC monitored the operations throughout the study. Table 2 shows the levels of study for each logging phase.

Table 3 describes the two blocks. Figures B and C illustrate the terrain differences. Unfortunately the steepness of the summer block complicated the basic comparison.

B. Productivity and Cost by Phase

This section presents the productivity and costs for each harvesting phase during the period of the study. The detailed cost calculations are found in Appendix II. The same hourly rates were used for both winter and summer phases.

In a systems comparison the relationship between the hourly costs for each phase is very important if the difference in total cost is small. We therefore encourage the reader to substitute his own costs to get the values representative of his operation. We are interested here primarily in delays caused by system function rather than by the specific machine or operator.

1. Volume Produced

Table 4 summarizes the weights and volumes removed from the two cut blocks. The weight figures were obtained from the B.C. Forest Service weight scale sheets and converted to volume using conversion ratios for the species type.

Table 4 shows several interesting comparisons. In the winter part of the study, 12.3% of the weight entering the yard did not leave as merchantable volume. This percentage increased to 17.6% in the summer. Hauling this "dead" weight composed of tops and branches is one of the disadvantages of the C.P.Y. System.

TABLE 1. Equipment and Labour on Site

	Winter		Summer	
	C.P.Y.	Conv.	C.P.Y.	Conv.
Feller-bunchers	2	2	1	1
Grapple skidders	3	3	3	3
Line skidders*	-	-	2	-
Loaders-bush	1	2	1	2
Loaders-yard	2	-	3	-
Buckermen	2	3	3	3
Bulldozer	1	1	1	1
Flail	-	-	2 alternately	1
Off-highway trucks	3	-	3	-
Av loads/day	12	-	9	-
Highway trucks	variable	variable	variable	variable
Av loads/day	25	23	17	18

*The line skidders are not included in the data because they were involved in only one section of very difficult terrain. The system of logging was not a variable; therefore the volume and costs were omitted.

TABLE 2. Study Method by Phase

Phase	Level of Study
Felling	Not studied
Skidding	Shift level - Servis Recorder
Bucking, limbing (bush & yard)	Work sample
Loading - bush	Work sample
Hauling	Detailed timing of loading in bush and yard, unloading in yard. B.C. Forest Service scale sheets for weight, volume, cycle time, travel time and time at millyard.
Unloading, reloading in yard	Work sample
Handling of wood in yard by loader	Work sample

TABLE 3. Description of Study Blocks

	WINTER		SUMMER	
	Central Processing Yard System	Conventional System	Central Processing Yard System	Conventional System
Dates of logging	January 16 to 24, 1979	January 23 to 31, 1979	July 3 to 17, 1979	June 21 to July 5, 1979
Average volume per day*	Bush 835 m^3 Yard 820 m^3	Bush 820 m^3	Bush 540 m^3 Yard 575 m^3	Bush 630 m^3
Block size	Total 28 hectares		Total 37 hectares**	
Forest type	Lodgepole Pine occasional Spruce		Lodgepole Pine Aspen pocket occasional Spruce, Balsam, Douglas-fir	
Terrain	0 to 15% slope, regular		0 to 45% slope, occasional pitches exceeding 100% slope. Steepest area on one C.P.Y. strip.	
Landings	three		four	

* These averages are based on days worked for each part of the system, excluding start-up or overlap days.

** This was the intended block size. Small areas (less than a hectare) were aspen and were not felled. The steepest portions of the Central Processing Yard strips were line-skidded and the time and volume were not included in the study.

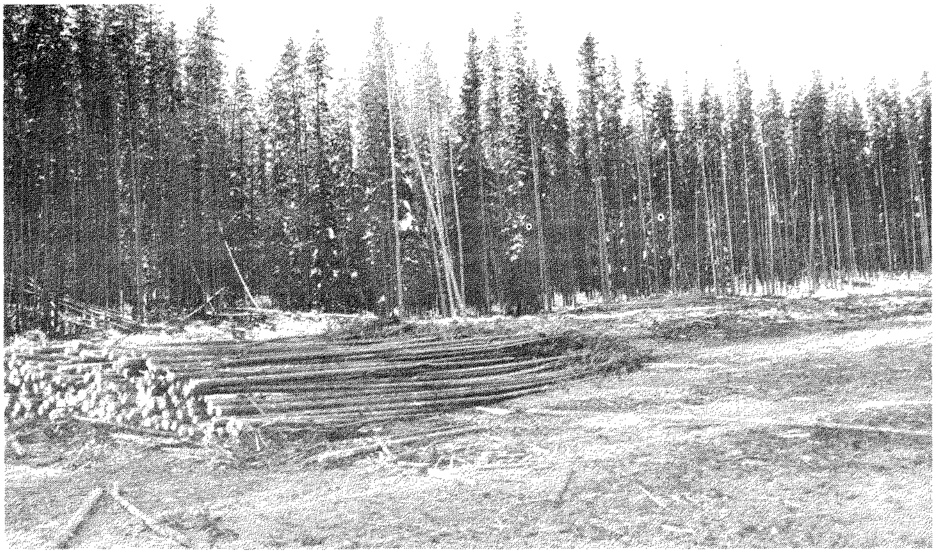


FIGURE B. Winter block showing stand and terrain. The logs are decked for full-tree hauling (Central Processing Yard System).

FIGURE C. Summer block showing stand and terrain. The Conventional System is in progress.

TABLE 4. Summary of Weights and Volume

Season	System	No. Loads	Total Weight kg	Av Weight per Load kg	Total Volume m^3	Average Load Size m^3
WINTER	C.P.Y.	Off-highway 73	4 778 800	65 463	5 072*	69.5
		Transfer 152	4 190 530	27 662	5 257*	34.7
	Conventional	Highway 118	3 346 520	28 360	4 198	35.6
SUMMER	C.P.Y.	Off-highway 87	5 119 260	57 650	5 342*	60.2
		Transfer 153	4 218 740	27 392	5 200*	33.8
	Conventional	Highway 114	3 239 820	28 419	3 993	35.0

The averages in this table do not always equal total divided by number of loads. Some part loads were hauled.

* Off-highway and transfer volumes are slightly different because different conversion factors were used for full-tree and log-length wood.

The average weight per off-highway load decreased about 12% from the winter phase to the summer phase. This reduction is at least partially due to the inexperience of the loader operator and the use of new trucks during the summer phase.

The average weight and volume per highway load was consistently higher for the trucks originating in the bush than for those originating in the yard, by 3 percent to 4 percent. The reason for this is not clear. Inaccuracies of bunk scales on uneven ground at bush landings may have led to slightly larger loads than intended.

2. Felling

As a rule, the differences between these two systems have no effect on felling pattern or felling productivity; however, during this study the sectioning of the block into strips interfered with the normal felling pattern, so productivity for both systems was probably reduced. During the summer part of the study, some hand felling was necessary on the steeper areas and for the bigger trees. To complete the costing, we used average figures given to us by the company: \$5.00/cunit (\$1.77/m^3) on the easier terrain of the winter block and \$5.50/cunit (\$1.94/m^3) for the steeper summer block.

3. Skidding

Mixed makes and models of grapple skidders were used in this operation. The hourly rate presented here is based on the price average for these machines. The important figures in this study are productive hours, total volume, volume per productive hour, and cost per unit volume. As Table 5 shows, the skidders produced more during the C.P.Y. System part of the study than during the Conventional System. The difference was minimal during the winter but 10% more in the summer. The productivity for both systems was much less in the summer (by more than 25%), reflecting the problems with more difficult terrain.

Reduced congestion in the C.P.Y. landings reduced the delay time of the skidder. Figure D shows the conventional landing with the skidder, flail, buckerman and loader present. Compare this to the bush landing in Figure E, where the skidder operator using the C.P.Y. System was required to deck the logs but did not work with a buckerman.

TABLE 5. Skidding Productivity and Cost

		Total Hours	Prod. Hours*	Volume m^3	Volume/ Prod. Hr m^3	Cost/Hour	Cost/m^3
WINTER	C.P.Y.	171.9	151.6	5 033	33.2	$53.47	$1.61
	Conven-tional	148.9	130.1	4 179	32.0	$53.47	$1.67
SUMMER	C.P.Y.	251.9	184.4	4 554	24.7	$53.47	$2.16
	Conven-tional	210.4	178.5	3 993	22.4	$53.47	$2.39

*Productive hours are obtained from the Servis Recorder charts. These figures are the sum of moving time plus short delays. Service, repair, lunch and major delays are removed. Terminal delays which may have been caused by landing congestion were included in Productive Hours. Right-of-way skidding (hours and volumes) are not included in this Table.

FIGURE D. Conventional System landing illustrating concentration of activity (summer phase)

FIGURE E. Central Processing Yard System landing (winter phase)

Time and volume figures for skidding the wood on landings and rights-of-way are not included in Table 5. The right-of-way wood was skidded at the beginning of the study and removed during the C.P.Y. System. For complete costing, estimates of $0.03/m^3 for the winter and $0.05/m^3 for the summer were included in the per-volume cost of the wood under both systems.

Line skidding was necessary on one steep section of the summer block during the C.P.Y. System. Because this skidding was very slow and was not required in the Conventional System, the volume and time are not included in the study.

4. Loading, Unloading, Processing and Reloading

These phases are included under one heading because the loader time is assigned to all four functions.

Table 6 summarizes the hours for loaders, buckermen, and flail. Although the volume produced in each of the seasons is roughly equal, the equipment and labour hours required to handle the wood are much greater in the summer phase for both systems. The addition of the flail to the summer phase accounts for part of the increase. More loader and buckerman time was required for processing, however. The logs were limbier and more debris was produced. The volume through the yard was also less than the designed daily volume. This created more idle time which had to be distributed among the functions.

a) Buckermen

Table 7 outlines the results of the work sampling and shows the calculation of the buckerman costs. The buckermen working in the central yard in both summer and winter were more productive than those working on the bush landings. Improved productivity resulted from reduced interaction with machinery and a larger volume supplied to the buckermen.

The related values of productivity per hour and cost per volume are also important. In the winter study the volume per manhour was almost 100% higher for the central yard with a corresponding reduction in cost. This dropped to 50% in the summer when the yard was under-utilized.

The percentage of time spent by the buckerman in travelling within the work area (yard or cut block) is slightly greater

TABLE 6. Summary of Man and Machine Hours (Loading, Unloading and Processing)

		Loaders Bush	Loaders Yard	Buckermen	Flail	Total
WINTER	C.P.Y.	55.2	120.4	90.3	-	265.9
	Conventional	103.3 (9.5*)	-	149.5	-	252.8
SUMMER	C.P.Y.	90.8	201.7	197.0	68.1	557.6
	Conventional	116.8	-	221.7	52.5**	391.0

* Loader broken down

** Flail only operating part of the time. Under full conventional system with the flail utilized full time, it would have worked an additional 20 hours.

TABLE 7. Activity and Cost of Buckermen

	Winter		Summer	
	C.P.Y.	Conventional	C.P.Y.	Conventional
<u>% of time during study</u>				
Tape	8.4	2.2	5.0	5.1
Top/delimb/buck	47.0	35.6	43.2	38.5
"Productive" -Processing	55.4%	37.8%	48.2%	43.6%
Travel, move	4.5	2.3	5.9	3.5
Machines in working area	4.5	9.5	6.7	11.1
"Idle"-no work	19.3	36.1	18.5	23.6
Service, repair	9.7	6.1	11.9	7.1
Assist others	0.7	4.1	0.4	1.4
Lunch/coffee	4.9	3.0	7.0	7.7
Misc.	1.0	1.1	1.4	2.0
Total	100.0%	100.0%	100.0%	100.0%
<u>Production</u>				
Hours	90.3	149.5	197.0	221.7
Volume m^3	5 072	4 198	5 342	3 993
m^3/hour	56.2	28.1	27.1	18.0
<u>Cost</u>				
Wage/hour	$12.06	$12.06	$12.06	$12.06
Chainsaw rental	$ 1.25	$ 1.25	$ 1.25	$ 1.25
Total	$13.31	$13.31	$13.31	$13.31
Cost/m^3	$ 0.24	$ 0.47	$ 0.49	$ 0.74

for the central yard. The interaction with machinery (loaders and skidders) was greater for the Conventional System, however.

b) Flail

The flail was not needed in the winter because the cold temperatures made the limbs brittle and most broke off during skidding and loading. During the summer, however, the limbs were more resilient and the flail was used in both systems.

Only 20% of flail time was classified "productive" in the Conventional System, and using a flail may not have been necessary during this experiment (as shown by the work sample information, Table 8). In the C.P.Y. System, 57.3% of the flail time was productive.

c) Loaders

One bush loader was used to load full trees on off-highway trucks in the C.P.Y. System. Different loader-operators were used in the winter and summer phases. The yard itself used two loaders in the winter and three in the summer. One loader loaded highway trucks almost fulltime. This loader also performed other functions when the other yard-loaders were busy and it had no trucks to load. The second and third loaders unloaded the off-highway trucks, spread and butt-indexed full trees, sorted and decked processed wood, and cleaned the debris from the yard.

The two loaders in the bush loaded log-length on the highway trucks in the Conventional System. When time permitted, they helped to process the wood. The two operators used in this part of the study normally worked in the yard and were present both winter and summer for both systems.

Table 9 details the results of the work sampling and the productivities and costs for each system and location. For each phase the nonproductive time was proportioned by percentage to give the total hours costed for each.

i. Loading--Bush

All of the bush loader's time and cost was attributed to off-highway loading. The cost of the two loaders in the Conventional System was divided proportionally between loading and processing.

TABLE 8. Activity and Cost of Flail

	Winter	Summer	
		C.P.Y.	Conventional
% of time during study			
Flail		38.6	9.3
Align butts		12.5	-
Tape/deck/spread/ handlimb		1.7	2.9
Clean area	Not Present	-	3.3
Travel		4.5	4.5
"Productive"		57.3%	20.0%
Wait wood		17.2	26.9
Wait machines		1.6	15.9
Service/repair		7.9	16.2
Miscellaneous		16.0	21.0
		100.0%	100.0%
Production			
Hours		68.1	52.5
Volume m^3		5 342	3 993
Cost			
Cost/hour		$50.00	$50.00
Cost/m^3		$ 0.64	$ 0.66

TABLE 9. Activity and Cost of Loaders

	WINTER			SUMMER		
	C.P.Y.		Conventional	C.P.Y.		Conventional
	Loaders-Bush	Loaders-Yard	Loaders-Bush	Loaders-Bush	Loaders-Yard	Loaders-Bush
<u>% of time during study</u>						
Load	48.8	39.2	51.6	72.7	28.8	58.6
Unload	-	7.3	-	-	6.7	-
Sort/deck	3.6	7.3	13.0	2.7	8.6	11.1
Spread/butt-index	-	20.1	-	0.6	18.1	1.3
Clean area	6.2	12.1	11.4	8.4	15.5	9.3
Hold trees for buckerman	-	-	-	-	8.8	0.9
Travel in yard, between landings	2.3	0.4	1.3	4.0	0.9	2.3
Service, repair, fuel*	9.4	0.9	6.6	4.5	2.4	3.4
Machine idle**	27.0	7.6	14.0	5.7	9.4	10.4
Miscellaneous	2.7	5.1	2.1	1.4	0.8	2.7
	100%	100%	100%	100%	100%	100%
Time attributed to:***						
Loading	100%=55.2 hr	43.5%=52.4 hr	67.9%=70.1 hr	100%=90.8 hr	33.3%= 67.2 hr	72.2%=84.3 hr
Unloading		8.1%= 9.7 hr			7.7%= 15.5 hr	
Processing		48.4%=58.3 hr	32.1%=33.2 hr		59.0%=119.0 hr	27.8%=32.5 hr
Cost/hour	$57.17	$57.17	$57.17	$57.17	$57.17	$57.17
Volume - m^3	5 072	5 072	4 198	5 342	5 342	3 993
Cost/m^3						
Loading	$ 0.62	$ 0.59	$ 0.95	$ 0.97	$ 0.72	$ 1.21
Unloading		$ 0.11			$ 0.17	
Processing		$ 0.66	$ 0.45		$ 1.27	$ 0.46
Total	$ 0.62	$ 1.36	$ 1.40	$ 0.97	$ 2.16	$ 1.67

* Only included when performed during the day.
** Stationary, not performing tasks.
*** "Nonproductive" time is proportioned among the productive activities.

In the winter section of the study, both conventional and off-highway loaders spent roughly 50% of their time actually loading trucks. Because the conventional loaders also had buckermen on their landings, they spent part of the remaining time assisting in spreading wood, cleaning debris, and decking. They sorted and redecked wood from the skidder decks to facilitate loading. These tasks were not necessary for the off-highway loader and it had more idle time between trucks. In both systems loading bays were used. Figures F and G show the bush-loading for the two systems.

In the summer part of the study, the loader time distribution for the Conventional System was similar to the winter distribution with slightly more time spent loading.

The off-highway loader spent a larger part of its time loading in the summer because the operator was not as experienced as the winter operator. The extra average loading time in the bush (see Table 10) caused increased delay times for the trucks, increased cycle times and reduced volume delivered to the yard. This resulted in a snowballing effect throughout the system and increased the per-volume cost at each phase.

ii. Unloading--Yard

Unloading was required in the C.P.Y. System but not in the Conventional System. Wood was pushed off trucks near the processing area after full-tree loads were weigh-scaled. In both summer and winter, the percentage of loader time was similar but in the summer it involved a larger number of manhours and an increased cost. Figure H shows the loader backing from the truck after the straps have been removed from the load.

iii. Processing--Bush and Yard

The processing functions of the loaders included helping the buckermen, spreading the wood, butt-indexing the logs, decking and sorting, and cleaning the yard or landing.

Processing was not a primary part of the loaders' activity in the Conventional System because the skidders were expected to perform most of these tasks. The total time attributed to processing (spread, deck, clean, sort) in the Conventional System was 24.4% in the winter and 21.7% in the summer. The cost per unit volume remained the same.

FIGURE F. Loading off-highway truck at bush landing--
Central Processing Yard System, winter phase

FIGURE G. Loading highway truck at bush landing--
Conventional System, summer phase

TABLE 10. Detailed Timing of Hauling Cycles

	WINTER		SUMMER	
	Central Processing Yard System (minutes)	Conventional System (minutes)	Central Processing Yard System (minutes)	Conventional System (minutes)
<u>Off-highway Truck Phase</u>				
Travel empty	40.2	not present	36.3	not present
Delay at landing, truck preparation	12.0		24.1	
Load	17.0		43.2	
Truck preparation, delay	3.8		6.2	
Travel loaded	55.7		50.1	
At scales (empty and loaded)	3.8		4.5	
Delay in yard	0.6		0.8	
Time in yard	13.5		13.1	
Total Cycle Time* (leave scale to leave scale)	145.0		176.5	
Haul distance (one way)	30 km		26 km	
<u>Highway Truck Phase</u>				
Travel empty	33.1	66.1	34.1	67.2
Delay in yard or landing	4.9	16.1	3.5	4.6
(exclude last day)		(2.3)		
Load	14.5	23.0	18.6	31.1
Position and truck preparation	9.0	9.3	9.1	11.5
At scales in yard	0.2	-	0.7	-
Travel loaded	38.3	82.8	40.0	76.3
Time in mill yard	13.1	13.4	15.5	13.2
Total Cycle Time* (leave scale to leave scale)	112.5	212.0	119.7	201.8
(exclude last day)		(193.0)		
Haul distance (one way)	34 km	64 km	34 km	60 km

* The elements do not sum exactly because this figure is calculated from scale sheets; the others are calculated from on-site timing.

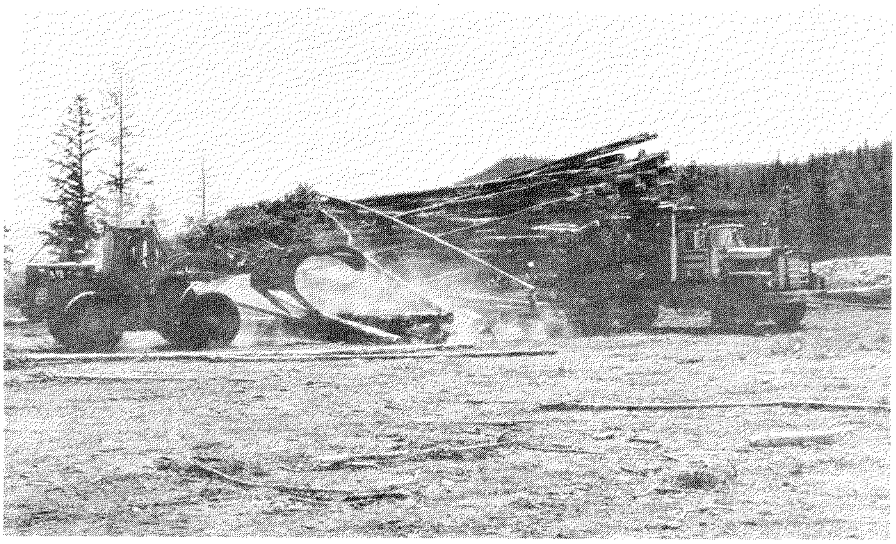


FIGURE H. Unloading off-highway truck at the yard, Central Processing Yard System

The portion of the loader activity attributed to processing in the C.P.Y. System increased from 48% in the winter to 59% in the summer. The per-volume cost was double in the summer, however, because the total number of hours was greater. This increase was due to a reduced volume throughput and increased debris handling.

Figure I illustrates the sequence of processing activities in the yard. In the bottom right the wood is being taped, topped, bucked and limbed. The loader is spreading tree-length logs from the off-highway piles. Note the lift logs used to assist the buckermen. Three other off-highway loads lie in the background. Debris piles line the edge of the yard. The activity progresses across the yard repeatedly.

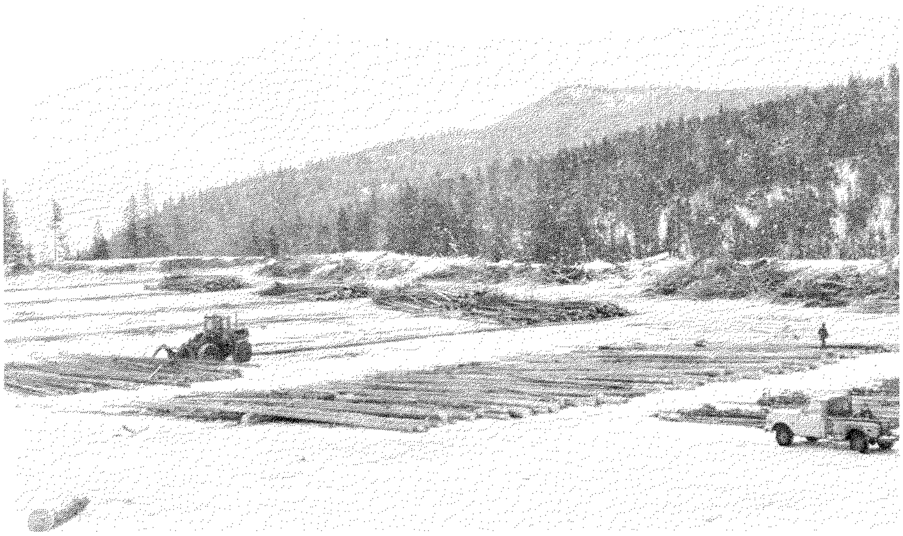


FIGURE I. Processing in yard, Central Processing Yard System, winter phase

5. Hauling

Table 10 presents the detailed timing of the hauling phases for the two systems.

a) Central Processing Yard System

i. Off-highway phase

The positioning and preparation times for the off-highway trucks are included in the delay time at the landing. The off-highway trucks had self-load trailers. The drivers often positioned and prepared the trailers away from the active landing and the observer was unable to separate the elements.

Loading took 2½ times longer in summer than it did in winter. Part of this increase was also reflected in the increased delay time prior to loading. Some increase would normally be expected in the summer. The limbiness of the material reduced the volume the loader could handle in one pass and made the positioning of the wood on the truck more difficult.

The average total cycle time shows an overall increase of 22% from the winter to the summer. This extra time translates into an increased per-volume cost (see Table 11). The travel times, both empty and loaded, were lower in the summer, reflecting the reduced hauling distance.

ii. Transfer phase

Delays, truck preparation and loading at the yard were timed for the transfer (highway) phase of the system. The remaining data were obtained from entries on the B.C. Forest Service scale sheets. "Travel Empty," "Travel Loaded," and "Mill Terminal" times were calculated from these figures. Figure J illustrates the loading of a transfer truck.

The average times for each activity increased slightly (except delay time) and loading time increased 28% from winter to summer. No reason for this difference was observed. The travel times increased slightly, perhaps related to summer traffic congestion. No effect from winter ice was observed.

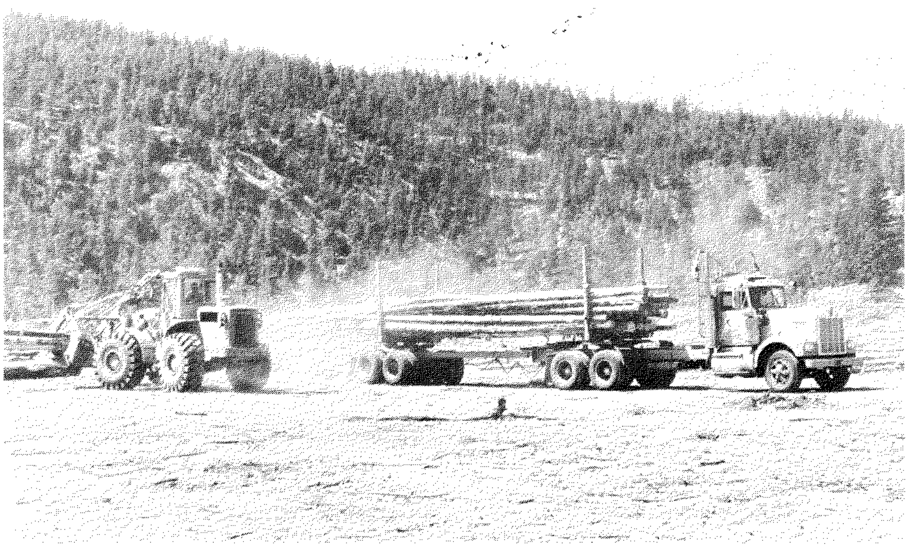


FIGURE J. Loading highway truck in the C.P.Y. System yard (summer phase)

TABLE 11. Summary of Hauling Cost

Season		No. of Loads	Cycle Time min	Cost/ Hour	Total Volume m^3	Average Load Size m^3	Cost/m^3
WINTER	Central Processing Yard System						
	Off-highway haul bush to yard	73.1	145.	$53.73	5 072	69.5	$1.86
	Transfer haul yard to mill	152.1	112.5	$38.01	5 072	34.7	$2.13
	Total bush to mill						$3.99
	Conventional System						
	Highway haul bush to mill	117.7	193.	$38.01	4 198	35.6	$3.43
SUMMER	Central Processing Yard System						
	Off-highway haul bush to yard	88.6	176.5	$53.73	5 342	60.2	$2.62
	Transfer haul yard to mill	154.3	119.7	$38.01	5 342	33.8	$2.19
	Total bush to mill						$4.81
	Conventional System						
	Highway haul bush to mill	113.7	201.8	$38.01	3 993	35.0	$3.64

b) Conventional System

One of the loaders broke down on the last day of the Conventional System during the winter part of the study (see Table 6). The delay times from this day increased the average delay from 2 minutes to 16 minutes. The calculated cycle time omits this day because the breakdown was not specific to the system.

The loading time increased by 35% between winter and summer phases of the study. The loaders performed more sorting activities within the loading phase to improve the load structure and to set aside logs needing further delimbing or bucking.

c) Discussion

Loading time for highway trucks in the bush is longer than loading time for transfer trucks in the yard. The yard had better loading conditions (i.e., more opportunity for the truck to be positioned for good access from the log decks).

Table 11 summarizes the hauling costs in each system. Costs per volume were higher in summer than in winter and reflected increased cycle times and in some cases, reduced volume per load. The combined truck hauling cost for the C.P.Y. System is greater than the cost of hauling in the Conventional System.

The largest per-volume cost increase, from winter to summer, was 40% for off-highway hauling. Cycle time increased and volume per load dropped to contribute to this large increase.

6. Bulldozer Costs

We assumed bush landing construction costs to be equal for both systems. Twenty-six bulldozer hours in the winter and 40.5 hours in the summer were required to construct the necessary landings for the blocks. The bulldozer's hourly rate of \$58.52 gave costs of \$0.17/m^3 winter and \$0.25/m^3 summer for both systems.

The time the bulldozer spent on the site was also measured. During the winter the terrain was good and debris was not a major problem on the bush landings. The bulldozer spent several hours per day handling debris in the Conventional System. The presence of the bulldozer on the site in winter accounted for 18.0 hours ($0.55/m^3$) for the C.P.Y. System and 44.0 hours ($0.61/m^3$) for the Conventional System.

The bulldozer was utilized more fully for both systems during the summer. The steepness of the summer block made it necessary for both systems to use the bulldozer for trail building. In addition, the machine had more debris to pile in the summer--especially in the Conventional System. On-site hours in the summer totalled 45.8 at a cost of $0.50/m^3$ for the C.P.Y. System, and 34.2 at a cost of $0.50/m^3$ for the Conventional System.

7. Landing Rehabilitation and Debris Handling and Disposal

The costs included here are estimates only. The figures reflect the increase in debris to be handled and burned: $0.06/m^3$ for the C.P.Y. System in winter and $0.13/m^3$ for the Conventional System; $0.07/m^3$ for the C.P.Y. System in summer and $0.18/m^3$ for the Conventional System.

8. Travel Time Cost Estimates

A daily travel time of one hour was allocated to the operators who were required on the bush landings. The estimated costs are contained in Table 12. The additional manpower in the bush landing resulted in additional travel cost in the Conventional System.

TABLE 12. Estimated Travel Costs

WINTER	Central Processing Yard System	Loader operator and bulldozer operator	12 hours	$0.03/m^3$
WINTER	Conventional System	Two loader operators, three buckermen, and bulldozer operator	33 hours	$0.09/m^3$
SUMMER	Central Processing Yard System	Loader operator and bulldozer operator	15 hours	$0.03/m^3$
SUMMER	Conventional System	Two loader operators, three buckermen, flail operator, and bulldozer operator	50 hours	$0.15/m^3$

9. Summary of Productivity and Costs

a) Productivity

General summary statements can be made about the difference in productivity of the phases.

1. Felling. Although felling was not studied, it does not appear to be affected by the system used.
2. Skidding. Because terminal time at the bush landing was reduced, skidding productivity definitely increased with the C.P.Y. System. A 10% improvement over the Conventional System was measured in the summer study. The magnitude of the increase depends upon the season, the amount of debris, the presence and activity of a flail, and the size of the landing. Size of landing may be the most critical variable because it affects organization and interaction of the activities. Although skidding directly to roadside rather than to spaced landings was not done in this operation, the shorter average skidding distance with this technique would increase productivity.
3. Loading. Total loading time per volume was greater for the C.P.Y. System which required loading both off-highway and highway trucks. The loading time for the highway trucks was less in the yard than in the bush landing, however.
4. Unloading. Unloading was not a large component; it occurred only in the C.P.Y. System.
5. Processing. The buckermen and flail were significantly more productive in the yard than in the bush landing. They were supplied with a larger volume and utilized their time more effectively. The loaders had more processing functions in the yard, however, and spent more time in this capacity.
6. Hauling. The doubling of terminal times (loading and unloading) in the C.P.Y. System was partly offset by reduced delay times and larger loads on the off-highway trucks. The actual truck time per unit-volume was similar for both systems, but some of this time involved more costly off-highway trucks.

b) Costs

The costs calculated for the winter and summer study periods are summarized in Table 13. Some of the figures are estimates only (indicated by asterisks).

During the winter phase, the cost of the Conventional System was 7% less than the cost of the C.P.Y. System. This difference increased to 14% in the summer phase. The cost per volume increased significantly for both systems from the winter to the summer season--35% for the C.P.Y. System, and 25% for the Conventional System.

The cost relationships will change with the per-hour rates used in calculating each phase. Hauling costs may be affected most because the size and type of truck and trailer used in the off-highway haul can alter the specific costs significantly. The hourly rates used for the off-highway trucks in this report are based on the large heavy duty trucks used in this operation. The difference in costs for individual phases can be compared directly in Table 13. In general the costs follow the same trends described in "Productivity."

C. Log Quality

Although improved bucking quality is frequently cited as a major advantage of the C.P.Y. System, the importance and feasibility of this objective need to be examined for each operation. There are four main considerations that affect bucking-to-length objectives.

1. The length and diameter of the full trees being processed affect the number of logs that will actually be taped. If most of the processing involves topping at the minimum diameter, only a small percentage of the volume will be affected by the length standards.
2. The mill may specify differing log lengths, and produce different products for changing market conditions.
3. Improvement of log length accuracy may add significant value depending on the products.
4. Better training and supervision on a bush landing may achieve the same results as switching to a C.P.Y. System.

The mill produced peeler and chip'n'saw bolts in this operation. The main objective was to prevent peeler-grade wood

TABLE 13. Summary of Calculated Costs ($\$/m^3$) for Study Period

	WINTER		SUMMER	
Phase	Central Processing Yard System	Conventional System	Central Processing Yard System	Conventional System
* Landing construction	$ 0.17	$ 0.17	$ 0.25	$ 0.25
* Felling	1.77	1.77	1.94	1.94
Skidding - block	1.61	1.67	2.16	2.39
* - R/W	0.03	0.03	0.05	0.05
Loading - bush	0.62	0.95	0.97	1.21
Hauling - off-highway	1.86	-	2.62	-
Unloading - yard	0.11	-	0.17	-
Processing - buckermen	0.24	0.47	0.49	0.74
- loader	0.66	0.45	1.27	0.46
- flail	-	-	0.64	0.66
Reloading - yard	0.59	-	0.72	-
Hauling - highway	2.13	3.43	2.19	3.64
* Pile debris after logging	0.02	0.08	0.03	0.13
* Yard debris disposal	0.11	-	0.11	-
* Landing debris disposal	0.04	0.05	0.04	0.05
* Travel time	0.03	0.09	0.03	0.15
Bulldozer at landing	0.55	0.61	0.50	0.50
Total	$10.54	$ 9.77	$14.18	$12.17

*Estimated costs

from being degraded to sawlog or chips. Logs with peeler potential (usually butt logs of two-log trees) were the logs requiring accuracy in taping and bucking. Overlength logs and logs with large projecting limbs were unacceptable to the mill.

Five highway loads were spread and scaled to compare load composition and accuracy of bucking for each system and each season. Table 14 summarizes the findings.

The conventional loads included fewer tops and chunks but more cull logs than the yard loads during the winter. This reversed during the summer phase--the yard loads then had fewer tops and chunks and more cull logs. The summer loads had more pieces of non-merchantable material in both systems.

Small top diameters (less than 9 cm) do not affect the operation of the mill. The small diameter wood is suitable for chips and is of low value. During the winter phase, the C.P.Y. loads contained 15% small tops compared to 7% in the Conventional loads. The figures dropped to 2% and 3% in the summer.

The Conventional System produced a large number of overlength logs during the winter. The buckermen were not familiar with working on the bush landings and the problem could have been corrected with a period of closer supervision. Overlength logs were not as prevalent in the summer.

A comparison was made of the measured length of the butt-logs with the nearest desired length. Top-logs (i.e., the second log of a tree-length) were not included because they were not taped by the buckermen and were not expected to be a preferred length. As shown in the table, the C.P.Y. System produced more logs within the tolerances. In both systems, however, the percentage of logs within a 15-cm tolerance was small. Many short trees contained only one log and were topped at 10-cm diameter regardless of length.

In addition to the comparison scaling, several of Crown Zellerbach's mill personnel measured and visually examined a subsample of two loads from each group. The results were inconclusive. Bucking and delimbing quality varied with the loads examined and both good and poor quality were present in both systems.

TABLE 14. Summary of Scale Information--Sample Loads

	WINTER		SUMMER	
	C.P.Y.	Conven-tional	C.P.Y.	Conven-tional
No. of loads	5	5	5	5
Total weight, kg	138 136	144 895	141 140	146 230
No. of logs	727	610	579	639
No. of chunks	30	25	53	69
No. of tree tops	30	23	30	32
No. of cull logs	0	5	21	11
Volume of logs, m^3	180	194	186	198
Av vol butt log, m^3	0.29	0.35	0.37	0.35
Av vol top log, m^3	0.13	0.19	0.19	0.15
Av log length, m	10.5	11.4	10.3	10.5
Av butt diameter, cm	19	21	22	22
No. of top diameters, <9 cm	112 (15%)	43 (7%)	14 (2%)	21 (3%)
No. of logs, >15.75 m	27 (4%)	65 (11%)	28 (5%)	17 (3%)
No. butt logs*	537	487	413	502
No. & % within 7.6 cm of desired length	134 25.0%	83 17.0%	112 27.1%	112 22.3%
No. & % within 15.2 cm of desired length	211 39.3%	126 25.9%	142 34.4%	159 31.6%
No. & % outside 15.2 cm of desired length	326 60.7%	361 74.1%	271 65.6%	343 68.4%

* In this operation, only the butt logs of two-log trees were taped to specified length, although this figure includes untaped one-log trees.

D. Ways to Improve the Central Processing Yard System

1. Adjustment of Loading Time and Yard Throughput--Summer Phase, C.P.Y. System

The daily throughput of the yard in the summer phase was lower than the designed capacity of the system. The loading time for off-highway trucks was much higher than expected. A reduction of ten minutes would not be unreasonable to achieve. An improvement in loading time would also reduce the delay time for the trucks in the bush and produce the planned volume of 700 m^3 (12 off-highway loads).

Assuming that skidding was not a limiting factor (another machine would be added if it were), the bush and yard loaders and the buckermen could handle the 12 off-highway loads in the same number of hours. Working the costs through would give a reduction in cost of $0.24/$m^3$ for off-highway hauling, $0.12/$m^3$ for bush loading, and $0.48/$m^3$ for processing. Men and machinery could be utilized more effectively without increasing total hours.

Short-term reductions in volume from the bush can be buffered by an inventory in the yard in the C.P.Y. System. Over a sustained period, however, the additional equipment necessary in this system requires full bush production to operate economically.

2. Effect of Length of Haul and Yard Location on Hauling Cost

For each of the three truck fleets--off-highway, transfer, and conventional highway--the terminal times and travel times can be calculated from Table 10. The calculations are made for the winter phase of the study, using an average volume per load of 70.0 m^3 for off-highway and 35.0 m^3 for highway. The travel times for highway trucks are separated for pavement and gravel road and reflect the road conditions for the two types of road.

Three values are calculated: cost of terminal time, cost of travel time per km on pavement, and cost of travel time per km on gravel road.

	Cost of Terminal Time	Cost of Travel Time (Loaded and Empty) (Gravel)	Cost of Travel Time (Loaded and Empty) (Pavement)
Off-highway fleet	$0.63/m^3$	$0.041/m^3$ km	--
Transfer fleet	$0.74/m^3$		$0.038/m^3$ km
C.P.Y. System	$1.37/m^3$		
Conventional highway fleet	$0.80/m^3$	$0.047/m^3$ km	$0.038/m^3$ km

The terminal cost of the C.P.Y. System (combining both fleets) is significantly higher than for the Conventional System, $1.37/m^3$ compared to $0.80/m^3$. The off-highway terminal time is the least expensive on an individual basis.

The travel cost was least expensive for the highway trucks on pavement (over the specific road section our trucks travelled), and most expensive for highway trucks on gravel. Off-highway trucks took larger loads (twice the highway truck volume) and this offset their higher hourly rate.

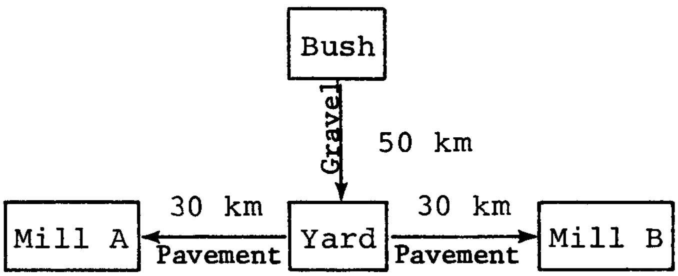
The yard should be located as close as possible to the end of the pavement. As the gravel haul increases, the difference decreases between the C.P.Y. System's total hauling cost (the combined cost of off-highway and highway hauling) and the Conventional System's hauling cost. The doubling of C.P.Y. System terminal costs (for two truck fleets instead of one) could be offset by the lower cost of off-highway travel on gravel roads. The equal point (regardless of pavement haul distance from the mill) is 102 km gravel.

The relationship between the truck fleets will differ, particularly with road quality and truck sizes, costs, and capacities. This will affect hauling cost and influence optimum yard location. Other objectives may also influence where the yard is constructed.

3. Destination Sorting--Effect on Hauling Cost

Central processing yards are often described as "Central Sorting Yards." If in fact the yard functions as a sorting area, the sorting activity has been removed from the bush landing or the mill. The mill may process all of the logs within its operation but a sort may be necessary before the logs enter the system. Lack of space may make sorting in the millyard difficult.

In other situations, the wood may be processed at different mill locations. If the terrain and landings in the bush do not lend themselves to good quality sorting a central yard may provide this service. The example below compares the hauling costs for a yard operation with those in a Conventional System. It shows there is a potential for cost saving as well as for convenience when different mills are involved.



50% of wood goes to Mill A

50% of wood goes to Mill B

Using the per-m^3 terminal costs and per-m^3-km travel costs from the previous section, we calculated the following figures for the two systems.

"Central Sorting Yard" System		Conventional System	
Off-highway to yard	\$2.69/m^3	Highway, bush to Mill A	\$4.10/m^3
Transfer to Mill A	\$1.88/m^3	Transfer Mill A to Mill B	\$3.08/m^3
Transfer to Mill B	\$1.88/m^3		
Average Hauling Cost	\$4.55/m^3	Average Hauling Cost	\$5.61/m^3

This example shows you can save 19% in hauling cost by using the Central Processing Yard. The establishment of a C.P.Y. System might even decrease the overall cost of delivering the wood to the mill.

4. Other Advantages Offered by the Central Processing Yard System

The concentration of volume in a C.P.Y. System offers the opportunity to change the method of bucking and delimbing. In most operations the use of a mechanical processor is not justified because the space and volume throughput on a bush landing does not meet the capacity of the machine. Machines of this type have failed in many trials because the potential volume is not achieved in a Conventional System. The environment offered by a yard--large available volume, a semipermanent installation, and the opportunity for double-shifting--might allow delimbing or bucking machines to be effective. This concept is being investigated by Crown Zellerbach.

The second major opportunity offered by a C.P.Y. System is utilization of limbs, tops, and broken material. This function should not be overlooked although it may not be the primary objective. Such volume can be used as an energy source by firewood cutters, hogged and trucked to be used in a mill, or converted into posts or other small dimension material. Firewood and post cutting are both being undertaken in existing yards.

The separation of gravel (off-highway) and pavement (highway) hauls provide an opportunity for using specialized transportation equipment. Off-highway trucks (or even forwarders) may be used in the bush. Vehicles designed specifically for highway transport may be used for the transfer phase.

Sorting specialty products, house logs, and poles is easier in a yard situation and occurs in many of them. While no single factor may be enough to justify a system change, a series of such factors may make a change worthwhile.

CONCLUSION

The study did not show any distinct advantages of either system, indicating that the choice of central processing must be made locally, considering the specific timber condition, logging chance, haul route and mill requirements.

The following is a comparison of the results of the experiment with some of the commonly held advantages and disadvantages of central processing yards.

1. The belief that central processing would improve log quality by providing better work conditions and supervision was not proved in the experiment. The yard processed pine and small spruce trees with low potential for quality improvement. If more valuable trees had been processed there might have been more significant improvement.

2. The belief that better utilization of men and equipment in the yard would lead to lower costs was not proved. Utilization was better in the C.P.Y. System but total hours increased. In the winter the total cost was 7% higher using the yard and in the summer 14% higher. The summer production was too low for efficient yard operation.

3. The belief that the elimination of processing from the bush would improve skidding productivity was shown to be true. Skidding production increased 3.8% in the winter and 10.1% in the summer. Both systems tested worked from the same bush landings. There is usually less equipment on C.P.Y. bush landings, however, and this system alone would not normally require the large landings used during this test.

4. The belief that separation of the bush haul from the highway haul in the C.P.Y. System would reduce total hauling cost was not found to be true in the experiment. Total winter hauling costs rose from $3.43/m^3 for the Conventional System to $3.99/m^3 when the C.P.Y. was used. Using the terminal and travel times derived from the winter data, we found that hauling cost savings for the C.P.Y. System would occur only for off-highway hauls over 102 km. Summer hauling costs were $3.64/m^3 for the Conventional System compared to $4.81/m^3 for the C.P.Y. System.

Lighter "highway-only" trucks or truck-trains might perform well on the transfer haul from the yard to the mill. Heavy-duty trucks would be suitable for the off-highway haul. This specialization of transportation systems might reduce total transportation costs.

No sorting was required in the study operation. Where sorting is required and logs are transported to several destinations, the yard provides an opportunity to reduce overall hauling costs by eliminating double-hauling of some of the wood.

5. The belief that the large weight of debris carried by the off-highway trucks would reduce the cost-efficiency of these larger trucks was not proved. The weight of debris was 12.3% in the winter and 17.6% in the summer. Compared to the cost of hauling merchantable volume with highway trucks, the direct cost of hauling using off-highway trucks on the gravel roads was 13.5% less in winter and only 2.3% more in summer. The potential hazard of very large loads of full trees could present a problem on some haul routes.

6. The belief that the yard provides an opportunity to utilize forest debris for minor products (fence posts, chips or hog fuel) was not tested in the experiment because the material was not utilized for profit. The cost of disposal of debris was higher than the value of the firewood cut. Byproducts did produce revenue in one other yard observed. This advantage of central processing yards will become more important as the demand for forest residues increases.

7. Other assumed advantages of central processing yards were not tested:

a) safety will be improved if the buckerman is removed from the congestion of the landing. In view of the improved working environment, this appears to be true.

b) improved working conditions and reduced travel time will attract a better and more stable crew. The crew preferred the Central Processing Yard System.

c) the yard provides a buffer between the bush and mill to even out the highway haul. Log storage at the mill can be reduced, but this was not a critical factor during the experiment.

d) there may be differences in log breakage between the two systems. Observation during the study period favoured the C.P.Y. System for reduced breakage but corroborative measurements were not made.

The data collected in this study can be used as a base by operators considering the installation of a central processing yard. Although the cost attractiveness of the system is marginal at this time, it may increase in the future. Central processing yards permit greater use of forest debris for byproducts and fuel, provide an opportunity for fully mechanized processing, and divide the truck haul into "bush" and "highway" where specialized equipment could be used to advantage. FERIC is continuing to explore methods to improve overall wood supply systems in the Interior of British Columbia.

APPENDIX I

Descriptions of Central Processing Yard Systems

1. Crown Zellerbach Canada Ltd., Kelowna Division
   <u>Peachland Yard</u>

Establishment: November, 1976

Objectives:

1. to improve the quality of limbing and bucking; to maximize the peeler wood coming from the operation by providing the correct lengths in larger wood
2. to eliminate or reduce the size of landings
3. to improve the safety of the processing phase by removing it from the landing

Stands:

Lodgepole pine and spruce, average volume 315 m^3/ha to 350 m^3/ha (45 cunits/acre to 50 cunits/acre); 0.34 m^3/piece to 0.38 m^3/piece (12 ft^3/piece to 13 ft^3/piece); terrain mainly flat, gentle slopes, some broken with steep sections.

Bush Operation:

Feller-bunchers and grapple skidders are used on most sites with hand-felling and line skidders where necessary. The wood is skidded to small landings and decked. Twelve off-highway loads (12-ft bunks) per day provide the target production of 700 m^3/day to 790 m^3/day (250 cunits/day to 280 cunits/day). The off-highway haul ranges from 25 km to 58 km.

In the summer of 1980, the 966 front-end loader was replaced by a Barko with a Weldco grapple. This system of loading allows skidding to roadside and eliminates landings.

Yard Operation:

The full-tree wood is weigh-scaled for volume at the yard. Two front-end loaders and two buckermen process the wood in the winter with an additional loader, buckerman, and flail in the summer. Two-log trees are taped and bucked; the others are topped. Occasionally pole sorting is done. The yard is 4 hectares (10 acres) in size. The highway loads are hauled 34 km to the mill in Kelowna (20 loads/day to 25 loads/day). The annual production is 127 000 m^3 (45,000 cunits).

During the processing activities, the debris is pushed to the perimeter of the yard. Firewood cutters reduce the amount of debris and the rest is burned in the fall.

A Hahn harvester was introduced to the yard operation in 1980. It performed the limbing, topping and bucking functions and eliminated the need for spreading and cleaning functions previously necessary to the yard operation.

2. Crown Zellerbach Canada Ltd., Kelowna Division
<u>Four-Mile Yard</u>

Establishment: June, 1978

Objectives:

1. to improve the quality of limbing and bucking; to maximize the peeler wood coming from the operation by providing the correct lengths in larger wood
2. to eliminate or reduce the size of landing
3. to improve the safety of the processing phase by removing it from the landing

Stands:

Lodgepole pine at 350 m^3/ha (50 cunits/acre); 0.42 m^3/piece (15 ft^3/piece); spruce balsam at 315 m^3/ha (45 cunits/acre); 0.71 m^3/piece (25 ft^3/piece); variable terrain.

Bush Operation:

The wood is felled by feller-buncher, with hand-felling where necessary. One side consists of a Washington 078 yarder with a heel-boom loader (Prentice 600RT). Grapple skidders with a 980 front-end loader handle the remaining volume. The bush haul ranges from 13 km to 50 km. One self-loading truck, four off-highway trucks with 12-ft bunks, and 3 heavy-duty highway trucks with 10-ft bunks carry the volume.

Yard Operation:

900 m^3/day to 1 250 m^3/day (320 cunits/day to 440 cunits/day) enter the yard, depending on the bush operations. The full-tree wood is weigh-scaled in the yard. Two buckermen, one flail, and three loaders handle the unloading, processing and loading onto transfer trucks. The manpower and number of loaders adjust with the volume entering the yard. Two highway trucks transfer the wood 6.7 km to the lake. The yard is 11 hectares (28 acres) in size and has capacity for storage when it is needed. There is no sorting. The debris is piled in a ditch in the center of the yard and burned.

3. Crown Zellerbach Canada Ltd., Armstrong Division
Monte Lake Yard

Establishment:

Operated in the 1960s as a mill-site processing tree-length logs.

Since 1974 it has been run as a reload and processing yard, first by Crown Zellerbach and now by a contractor; it has not operated continuously.

Objectives:

1. to manufacture and sort poles, chip-and-saw logs, large sawlogs, and peeler logs
2. to improve log quality
3. to provide seasonal log storage capacity for the Armstrong and Lumby mills by decking scaled logs

Stands:

Primarily lodgepole pine 280 m^3/ha (40 cunits/acre); occasionally spruce balsam 350 m^3/ha (50 cunits/acre); and Dry-Belt Douglas-fir 175 m^3/ha to 210 m^3/ha (25 cunits/acre to 30 cunits/acre).

Bush Operation:

Felling is by feller-buncher with hand-felling where necessary. The wood is skidded by three grapple-skidders with two line-skidders for long corners, hand-felled, and right-of-way wood. Full-trees are loaded on off-highway trucks by a 966 front-end loader. A buckerman is on site for trimming the loads. Six medium-weight off-highway trucks with 10-ft to 14-ft bunks are used for the 33-km to 50-km haul to the yard. Twelve loads are brought into the yard per day for unloading and spreading with a 988 front-end loader. Highway trucks are used for the bush run when the roads won't handle the size and weight of the off-highway trucks.

Yard Operation:

The wood is weigh-scaled at the yard and unloaded and spread with a 966 front-end loader. Four front-end loaders are used in the yard, one using a flail attachment when necessary. Four men handle the taping, grading, bucking, and topping, with an additional man when the volume is higher. The transfer loads (25/day) go 75 km into Armstrong or 115 km into Lumby. The yard itself is 14 hectares (35 acres) with a storage capacity of about 56 600 m^3 (20,000 cunits). The daily throughput for the yard is 650 m^3 to 850 m^3 (230 cunits to 300 cunits) with an annual volume of 113 000 m^3 to 184 000 m^3 (40,000 cunits to 65,000 cunits). Debris is burned once a year. The yard is accessible to firewood cutters.

Post Operation:

A post operation is run adjacent to the yard, by the same contractor who operates the yard. Posts are cut from the tops, using the portion 5-cm diameter to 10-cm diameter. Eighty percent of the tops yield one or more posts. About 150,000 posts are produced annually.

4. Jacobson Brothers Forest Products Ltd.
   <u>Horsefly Yard</u>

Establishment: Spring of 1976

Shutdown: Fall of 1979

Objectives:

1. to use the heel-boom line-loader with the highlead system. The loader would not only reduce the need for landings (if loading full-tree) but also retrieve logs sliding below the road.
2. to provide the space for grading and sorting cedar and for quality bucking cedar and white wood.
3. to eliminate or reduce the necessity for landings. The terrain offered few landing locations and increased the construction costs. Skidding and hauling were interacting on the same roads.

4. to extend the logging season by as long as a month. The inventory built up in the yard after highway restrictions were enforced could be removed to feed the mill before the bush operations could resume in the spring.

Stands:

Mixed stands, mainly spruce and balsam, 315 m^3/ha to 385 m^3/ha (45 cunits/acre to 55 cunits/acre); broken ground, high elevation, slopes 10% to 80%, some rock outcrops.

Bush Operation:

The felling is completely by hand. The Skagit GT-3 yarder, double-shifted, produces an average of 500 m^3/day (180 cunits). Bush loading was full-tree, without landings, by an American 599 line-loader. Lighter weight off-highway trucks with 12-ft bunks were found to be most successful for the bush haul. The average load size was 59 m^3 (21 cunits). Off-highway haul distance ranged from 27 km to 38 km.

Yard Operation:

The wood was weigh-scaled for volume at the yard. Two 966 front-end loaders and three buckermen handled the volume with two buckermen working exclusively on grading and bucking cedar. The highway haul to the mill in Williams Lake was 83 km of gravel road and 53 km of pavement.

Cedar and white wood were sorted and hauled separately. Sixteen to 18 transfer loads per day were hauled using long-log highway trucks for the white wood and hay-rack trailers for the cedar. Debris was burned in the winter and early spring.

Reasons for Shutdown:

1. The cedar volume decreased. White wood has few defects and doesn't need the yard's quality bucking.
2. The line-loader was experiencing breakdowns. It was not possible to get an acceptable operator.

The yard has not been shut down permanently. It may be reopened if the volume of cedar increases and quality bucking is again necessary. At present, the wood from the yarder is skidded down the road to a landing where it is processed and loaded with a front-end loader onto highway trucks.

5. Ainsworth Lumber Ltd.
   Chasm Division

Established: Winter of 1979

Objectives:

1. to improve the quality of the wood delivered to the mill and therefore improve mill productivity
2. to aid the move into phase contracting
3. to eliminate the need for landings

Stands:

Primarily lodgepole pine on gentle slopes.

Bush Operation:

The operation uses feller-bunchers and grapple-skidders. Since the beginning of the yard operation, productivity of the skidding phase has increased noticeably. At the time FERIC visited the operation in January 1980, full-trees were loaded by a front-end loader. Two off-highway trucks with 12-ft bunks carried the wood 5 km to the yard. The bush loader has since been replaced by a Barko with a Weldco grapple.

Yard Operation:

The yard (about 4 hectares (10 acres) in size) handles a daily throughput of 850 m^3 to 990 m^3 (300 cunits to 350 cunits). It maintains a buffer inventory of about 2 800 m^3 (1,000 cunits). Overlength and Douglas-fir logs are bucked; the remainder are topped. Three front-end loaders and three buckermen process the wood and load the transfer trucks. The transfer trucks are mixed size with 8-ft and 10-ft bunks. The transfer haul is 55 km on gravel road. Weigh-scaling is done at the mill yard. Debris is burned continuously in the winter.

6. Weldwood Canada Ltd.
Wells Operation

Established: 1977

Objectives:

1. to reduce or eliminate landings as the terrain makes landing construction very costly
2. to provide short logs for the Quesnel mill

Stand:

Spruce balsam primarily; occasional Douglas-fir; some difficult terrain with steep slopes or flat swampy stands.

Bush Operation:

Felling is done by hand. The skidding is mixed line-skidding, yarding by Ecologger, and skidding by FMC. A Barko heel-boom loads full-tree on off-highway trucks. The bush haul is 20 km to 33 km and 10 to 12 loads are delivered to the yard daily.

Yard Operation:

The yard (about 3.2 hectares (8 acres) in size) handles an average of 700 m^3 (250 cunits) per day. Two loaders and two buckermen work in the yard. An average of twelve short-log loads leave for Quesnel each day on a 97-km trip. Weigh-scaling is done at the mill yard. Debris is burned in the fall.

APPENDIX II

Machine Rates

Hourly Machine Rates

1. The machine rates calculated for this report are based on the purchase price of new equipment; estimated machine life; I.W.A. rates plus 30% fringe benefits for the operators and crew; and estimates for repair and maintenance, and fuel. No profit or risk margin is included. The figures are for January 1979 conditions, to correspond to the study period.

2. This logging operation is contracted. The phase costing done by FERIC was without access to the contract rates in order to provide completely independent figures. The rates for felling and debris disposal were based on company experience.

3. The productivity and volume information is presented in sufficient detail to allow the reader to substitute his own local costs.

4. The same hourly figures were used for the winter and summer phases.

Calculation of Skidder Cost

Purchase Price (I)	$103,000 f.o.b. Vancouver
Residual Value (R) (10%)	$ 10,300
Depreciation Period (N)	5 years straight line
Interest and Insurance (i)	0.13 (13% of average investment)
Operator's Wages (W)	$12.06 per SMH (including 30% F.B.)
Fuel, Lubricant, etc. (F)	$ 4.50 per PMH
Maintenance Cost (M)	100% of owning cost $13.56 per SMH
Machine Life (L)	10,000 hours
Utilization (U)	80%

$$\$/PMH = \left(\frac{I-R}{L}\left[1 + \frac{i(N+1)}{2}\right] + \frac{iRN}{L} + M + W\right)\frac{100}{U} + F = \$53.47/PMH$$

The purchase price is an average of the prices of the three grapple-skidder models used during the study--Clark 667, John Deere 640 and John Deere 740. The cost is expressed per Productive Machine Hour in order that the per cunit costs reflect the differences in productivity for the two systems.

Calculation of Loader Cost

Purchase Price (I)	$165,000 f.o.b. Vancouver
Residual Value (R) (25%)	$ 41,250
Depreciation Period(N)	5 years straight line
Interest and Insurance (i)	0.13 (13% of average investment)
Operator's Wages (W)	$12.71 per SMH (including 30% F.B.)
Fuel, Lubricant, etc. (F)	$ 4.70 per SMH
Maintenance Cost (M)	100% of owning cost $19.88 per SMH
Machine Life (L)	10,000 hours

$$\$/SMH = \frac{I-R}{L}\left[1 + \frac{i(N+1)}{2}\right] + \frac{iRN}{L} + M + W + F = \$57.17/SMH$$

Purchase price is for a Caterpillar 966C loader equipped for loading trucks.

Calculation of Off-Highway Truck Cost

Purchase Price (I)	$175,000 f.o.b. Vancouver
Residual Value (R) (40%)	$ 70,000
Depreciation Period (N)	5 years straight line
Interest and Insurance (i)	0.14 (14% of average investment)
Operator's Wages (W)	$12.71 per SMH (including 30% F.B.)
Fuel, Lubricant, etc. (F)	$ 8.00 per SMH
Maintenance Cost (M)	100% of owning cost $16.51 per SMH
Machine Life (L)	12,000 hours

$$\$/SMH = \frac{I-R}{L}\left[1 + \frac{i(N+1)}{2}\right] + \frac{iRN}{L} + M + W + F = \$53.73/SMH$$

Purchase price is for a Pacific P10 off-highway truck with a Pacific 12-ft bunk trailer. In some Interior operations the off-highway hauling is done by highway trucks with some modifications to handle bigger loads. This less expensive alternative would not have the same load capacity as this example.

Calculation of Highway Truck Cost

Purchase Price (I)	$92,000 f.o.b. Vancouver
Residual Value (R) (40%)	$36,000
Depreciation Period (N)	3 years straight line
Interest and Insurance (i)	0.15 (15% of average investment)
Operator's Wages (W)	$12.35 per SMH (including 30% F.B.)
Fuel, Lubricant, etc. (F)	$ 7.86 per SMH
Maintenance Cost (M)	100% owning cost $ 8.90 per SMH
Machine Life (L)	10,000 hours

$$\$/SMH = \frac{I-R}{L}\left[1 + \frac{i(N+1)}{2}\right] + \frac{iRN}{L} + M + W + F = \$38.14/SMH$$

Purchase price is for an average Pacific P500 series highway truck and a standard Columbia trailer.

Calculation of Bulldozer Cost

Purchase Price (I)	$170,000 f.o.b. Vancouver
Residual Value (R) (25%)	$ 42,500
Depreciation Period (N)	5 years straight line
Interest and Insurance (i)	0.13 (13% of average investment)
Operator's Wages (W)	$12.06 per SMH (including 30% F.B.)
Fuel, Lubricant, etc. (F)	$ 4.50 per SMH
Maintenance Cost (M)	100% of owning cost $20.48 per SMH
Machine Life (L)	10,000 hours

$$\$/SMH = \frac{I-R}{L}\left[1 + \frac{i(N+1)}{2}\right] + \frac{iRN}{L} + M + W + F = \$58.52/SMH$$

Purchase price is for a Caterpillar D7G bulldozer with a winch and earth-moving blade.

Flail Cost

The chain-life figures varied considerably and have the largest bearing on the cost. A figure of $50.00/hour for the flail was used in the calculations.