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

Productivity of Five Coastal B.C. Log Sorting Systems

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PREFACE

FERIC would like to thank four member companies for their cooperation and assistance on this project:

British Columbia Forest Products Ltd.
Canadian Forest Products Ltd.
MacMillan Bloedel Ltd.
Pacific Forest Products Ltd.

In addition, the assistance of Kristi Knox, Tony Wong and Eric Phillips in data collection and analysis is acknowledged.

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SUMMARY AND CONCLUSIONS

This study was undertaken to establish the actual and potential productivities of five log sorting systems common to Coastal British Columbia. The information will be useful for log sortyard managers, operators and designers. In the sortyards selected for the study, the sorting machines are used primarily for sorting, not multipurpose functions.

We noted differences in the efficiency and productivity of the five systems. However, no recommendations are made as to which is the best system because that depends on site specific conditions which were not evaluated. The data collected will be used in the preparation of a sortyard design handbook.

The maximum theoretical productivities of the sorting machines, with 100% machine utilization, are given in Table S-1, together with observed productivities.

TABLE S-1. Summary of Sorting System Productive Capacity

System	Number of Sorting Machines	Total Pieces Sorted	Total Study Time (PMH)	Observed Pieces Per Shift	Productive Time/ Total Time	Sorting System Productive Capacity (Pieces/Shift)
A- Three front-end loaders	3	2 410	48.54	1 192[1]	0.79	1 508[2]
B- Two stationary log loaders	2	5 048	48.48	1 666	0.62	2 698
C- Front-end loader and mobile log loader with trailer	2	2 385	43.16	884	0.57	1 542
D- Front-end loader and mobile log loader	2	2 813	53.16	847	0.74	1 139
E- Front-end loader and stationary log loader at sorting table	2	2 314	31.00	1 194	0.72	1 662

[1] $\frac{2\ 410 \text{ pieces}}{48.54 \text{ SMH}}$ X 8 hours X 3 machines = 1 192 pieces/shift

[2] 1 192 pieces/shift ÷ 0.79 = 1 508 pieces/shift

The two stationary log loader system has the highest productive capacity. However, the operators will have the greatest difficulty achieving capacity because the yard does not have a log storage area to level the surges in log truck arrivals. The two sorting systems using mobile log loaders are different but it would appear that the addition of a sorting trailer increases the productive capacity by about 400 pieces per shift.

In this study it was noted that there was an imbalance in productivities between the log loaders sorting logs and the front-end loaders forwarding logs. A single front-end loader can not forward bunches of logs as fast as a mobile loader can sort and bunch logs and so the log loader has excessive idle time. However, if the mobile log loader is also putting some of the sorts into bunks as well as bunching them, the front-end loader has excessive idle time.

The overall productivity of all the log handling machines in the sortyards was calculated and is given in Table S-2.

TABLE S-2. Total System Productive Capacity

System	Number of Log Handling Machines	Total Productive Time (hrs)			Total Pieces Sorted	Total System Productive Capacity (Pieces/Shift)
		Sorting Machines	Other Machines	Total		
A- Three front-end loaders	4	38.4	12.1	50.5	2 410	1 526[1]
B- Two stationary log loaders	7	30.0	85.5	115.5	5 048	2 447
C- Front-end loader and mobile log loader with trailer	4	24.7	28.6	53.3	2 385	1 430
D- Front-end loader and mobile log loader	4	39.5	34.7	74.2	2 813	1 213
E- Front-end loader and stationary log loader at sorting table	4	22.3	22.3	44.6	2 314	1 661

[1] $\frac{2\ 410 \text{ pieces}}{50.5 \text{ PMH}}$ X 8 hours X 4 machines = 1 526 pieces/shift

The productivity of the log grading personnel was measured by random sampling and is given in Table S-3.

TABLE S-3. Productivity of Log Graders

System	Normal Number of Graders	Maximum Number of Sorts	Average Number of Sorts	Total Pieces Graded	Study Time (PMH)	Productive Time / Total Time	Observed Pieces Graded/ Grader/ Shift
A- Three front-end loaders	1	15	12	2 410	16.37	.664	1 178
B- Two stationary log loaders	2	14	6	5 048	25.77	.519	784[1]
C- Front-end loader and mobile log loader with trailer	2	18	10	2 385	21.37	.560	446
D- Front-end loader and mobile log loader	2	22	14	2 813	24.47	.413	456
E- Front-end loader and stationary log loader at sorting table	2	22	14	2 314	15.50	.360	597

$$[1]\ \frac{5\ 048\ \text{pieces}}{25.77\ \ \text{PMH}} \times \frac{8\ \text{hours}}{2\ \text{graders}} = 784\ \text{pieces/shift}$$

Idle time is relatively high for graders because log decks are graded in batches and unless there is a continual supply of logs and several grading areas there will be periods with nothing for the graders to do. As logging trucks arrive in surges and the area available for grading decks is expensive and limited, high idle time results.

The number of sorts and the amount of detail on the specification for each sort affect log grader productivity. This is partially reflected in Table S-3.

The overall sortyard manday productivity was calculated for the five sorting systems. The manday productivity includes all salaried and hourly sortyard personnel with the exception of the booming ground crew, rehaul drivers and heavy-duty mechanics. It is given in Table S-4.

TABLE S-4. Overall Sortyard Manday Productivities

System	Mandays/Shift	Pieces/Manday (Actual)	Pieces/Manday (Capacity)
A- Three front-end loaders	12	99	126[1]
B- Two stationary log loaders	16	104	169
C- Front-end loader and mobile log loader with trailer	11	80	140
D- Front-end loader and mobile log loader	7.75	109	147
E- Front-end loader and stationary log loader at sorting table	9.25	129	180

[1]Pieces/Manday (Capacity) =
Pieces/Manday (Actual) ÷ (Productive Time/Total Time)

The productivity study was done during March 1982. All yards reported that the log throughput would be greater later in the year and that some of the crews were just starting back to work after a three or four month winter closure. Consequently, the results of the study emphasize potential productive capacity rather than actual production during a period of low throughput.

This is an informational report and does not recommend one sorting system relative to another. The best sorting system for a company is determined by site specific conditions. However, existing and planned sorting systems can be compared with those studied to determine relative efficiencies.

SOMMAIRE ET CONCLUSIONS

La présente étude a été entreprise dans le but de déterminer les productivités réelles et potentielles de cinq systèmes de triage de grumes communément employés sur la côte de la Colombie-Britannique. L'information recueillie pourra être utile aux gérants des parcs à grumes, aux opérateurs et aux concepteurs de ces parcs. Dans les parcs à grumes choisis pour cette étude, les machines utilisées servaient principalement au triage et n'étaient pas multifonctionnelles.

Nous avons remarqué des différences dans l'efficacité et la productivité des cinq systèmes. Cependant nous ne faisons pas de recommandations quant au meilleur système à utiliser, car cela dépend des conditions particulières du site, lesquelles n'ont pas été évaluées. Les données recueillies serviront à la préparation d'un manuel portant sur la conception et l'agencement des parcs de triage.

Le tableau S-1 donne les productivités théoriques maximales des machines de triage, compte tenu d'un taux d'utilisation de 100%, de même que les productivités observées.

TABLEAU S-1. Sommaire de la capacité de production des systèmes de triage.

système	nombre de machines de triage	nombre total de pièces de bois triées	temps total de l'étude (HMP)	nombre de pièces de bois observées par poste	temps productif/ temps total	capacité de production du système de triage (pièces/poste)
A-trois chargeuses frontales	3	2 410	48.54	1 192[1]	0.79	1 508[2]
B-deux grues forestières stationnaires	2	5 048	48.48	1 666	0.62	2 698
C-chargeuse frontale et grue forestière mobile avec remorque	2	2 385	43.16	884	0.57	1 542
D-chargeuse frontale et grue forestière mobile	2	2 813	53.16	847	0.74	1 139
E-chargeuse frontale et grue forestière stationnaire à la table de triage	2	2 314	31.00	1 194	0.72	1 662

[1] $\frac{2\ 410 \text{ pièces}}{48.54 \text{ HMPv}}$ X 8 heures X 3 machines = 1 192 pièces de bois/poste de travail

[2] 1 192 pièces/poste ÷ 0.79 = 1 508 pièces de bois/poste de travail

Le système comportant deux grues forestières stationnaires est celui qui offre la plus grande capacité de production. C'est aussi celui où les opérateurs auront la plus grande difficulté à atteindre cette capacité, car le parc ne possède pas d'aire de stockage permettant de pallier au rythme irrégulier d'arrivage des camions. Les deux systèmes utilisant des grues forestières mobiles sont différents mais il semble que l'ajout d'une remorque de triage augmenterait la capacité de production d'environ 400 pièces de bois par poste de travail.

On nota au cours de l'étude qu'il existait un déséquilibre entre la productivité des grues forestières qui triaient les grumes et celle des chargeuses frontales qui les transportaient. Une seule chargeuse frontale ne peut pas apporter les tas de grumes aussi vite que la grue mobile peut les trier et les mettre en lots; la grue forestière a donc des temps morts beaucoup trop forts. Par contre, si en plus de mettre les grumes en lots, la grue forestière sert également à déposer certains lots dans des plateaux, c'est alors la chargeuse frontale qui éprouve des temps morts trop forts.

On trouvera au tableau S-2 la productivité globale de toutes les machines de manutention des billes dans chaque parc à grumes.

TABLEAU S-2. Capacité de production globale du système

système	nombre de machines de manutention des grumes	temps productif total/heure			nombre total de pièces de bois triées	capacité globale de production du système (pièces de bois/poste)
		machines de triage	autres machines	total		
A-trois chargeuses frontales	4	38.4	12.1	50.5	2 410	1 526[1]
B-deux grues forestières stationnaires	7	30.0	85.5	115.5	5 048	2 447
C-chargeuse frontale et grue forestière mobile avec remorque	4	24.7	28.6	53.3	2 385	1 430
D-chargeuse frontale et grue forestière mobile	4	39.5	34.7	74.2	2 813	1 213
E-chargeuse frontale et grue forestière stationnaire à la table de triage	4	22.3	22.3	44.6	2 314	1 661

[1] $\frac{2\ 410 \text{ pièces}}{50.5 \text{ HMP}}$ X 8 heures X 4 machines = 1 526 pièces de bois/poste de travail

La productivité du personnel affecté au classement des grumes a été mesurée par un échantillonnage aléatoire et les résultats apparaissent au tableau S-3.

TABLEAU S-3. Productivité des classificateurs de grumes.

système	nombre normal de classificateurs	nombre maximum de classes	nombre moyen de classes	nombre total de pièces classifiées	temps de l'étude (HMP)	temps productif / temps total	nombre de pièces classifiées/ classificateur/poste
A-trois chargeuses frontales	1	15	12	2 410	16.37	.664	1 178
B-deux grues forestières stationnaires	2	14	6	5 048	25.77	.519	784[1]
C-chargeuse frontale et grue forestière mobile avec remorque	2	18	10	2 385	21.37	.560	446
D-chargeuse frontale et grue forestière mobile	2	22	14	2 813	24.47	.413	456
E-chargeuse frontale et grue forestière stationnaire à la table de triage	2	22	14	2 314	15.50	.360	597

[1] $\frac{5\ 048 \text{ pièces}}{25.77 \text{ HMP}} \times \frac{8 \text{ heures}}{2 \text{ classificateurs}}$ = 784 pièces de bois/poste de travail

Les temps morts sont relativement élevés chez les classificateurs parce que les empilements sont classifiés en lots et à moins qu'il y ait un approvisionnement continu de grumes et plusieurs aires de classement, il se trouvera des périodes où les classificateurs n'auront rien à faire. Comme les arrivages des camions grumiers sont plutôt irréguliers et que les espaces disponibles pour la classification sont coûteux et restreints, il en résulte des temps morts élevés.

Le nombre de classes et les détails dont il faut tenir compte pour chaque classe affectent la productivité du classificateur de grumes. Ceci se reflète partiellement dans le tableau S-3.

On a calculé la productivité globale du parc par jour-homme pour chacun des cinq systèmes de triage. La productivité par jour-homme inclut tous les employés du parc, salariés ou payés à l'heure, à l'exception de l'équipe affectée à l'assemblage du bois en radeaux, des conducteurs de camions qui transportent le bois trié au bord de l'eau et des mécaniciens de machinerie lourde. Les résultats sont donnés au tableau S-4.

TABLEAU S-4. Productivité globale de chaque parc par jour-homme.

système	nombre de jours-homme / poste de travail	nombre (réel) de pièces de bois/ jour-homme	nombre (théorique) de pièces de bois/ jour-homme
A-trois chargeuses frontales	12	99	126[1]
B-deux grues forestières stationnaires	16	104	169
C-chargeuse frontale et grue forestière mobile avec remorque	11	80	140
D-chargeuse frontale et grue forestière mobile	7.75	109	147
E-chargeuse frontale et grue forestière stationnaire à la table de triage	9.25	129	180

[1]Nombre (théorique) de pièces de bois/jour-homme =
nombre (réel) de pièces/jour-homme ÷ (temps productif/temps total)

L'étude de productivité a été effectuée en mars 1982. Tous les parcs ont mentionné que les arrivages de grumes seraient plus élevés plus tard dans l'année et que quelques-unes des équipes ne faisaient que reprendre le travail après une fermeture hivernale de trois ou quatre mois. Conséquemment les résultats de l'étude s'attachent davantage à faire ressortir la capacité potentielle de production plutôt que la production réelle à un moment de faible activité.

Le présent rapport ne vise qu'à servir de source d'information et ne recommande pas plus un système de triage que l'autre. Le meilleur système pour une entreprise donnée dépend des conditions spécifiques du site. Cependant les systèmes actuels ou projetés pourront être comparés avec ceux qui ont été étudiés afin d'en déterminer l'efficatité relative.

INTRODUCTION

This report describes five different sorting systems commonly used in B.C. Coastal dryland sortyards and presents the results of productivity studies. The data collected will be used in a sortyard design handbook which will be published by FERIC in late 1982. This report gives more detail on the sorting systems than will be in the design handbook.

Sortyards were selected where the sorting machines spend the majority of their time on the basic sorting and forwarding functions. All B.C. Coastal sortyards employ sorting systems similar to the five documented in the report but in some sortyards the sorting machines spend a greater proportion of the time unloading and loading trucks, dumping logs and transporting logs to storage.

Productivity results are given for the sorting and non-sorting machines and for the log graders and yard crew.

TEST METHOD

Observers spent two or three days in each sortyard. One observer would continuously time the sorting machines and record the duration of all the sorting elements. The other observers would randomly sample the performance of the other machines, the ground personnel and the condition of the log decks. In addition, a record was kept of the number of loads and number of pieces processed.

During continuous timing, the time of a sorting element was recorded to the nearest half minute. The random sampling program, which was designed for statistical accuracy, required more than 300 observations at each operation (an average of one observation every three minutes).

Prior to the start of the study, a meeting was held with the yard crew to explain the objectives of the study and to ask for their cooperation.

The study was made in March 1982 and all operators stated that the production through the yard would be higher later in the year. Consequently, in our analysis we have calculated the productive capacity of the system disregarding idle time.

SORTING SYSTEM DESCRIPTION

A. SORTING WITH FRONT-END LOADERS

MacMillan Bloedel Ltd., Shawnigan Division
Study Period: Two days.

Trucks are unloaded by a Le Tourneau 2794 stacker (Figure A) or a Caterpillar 980 front-end loader. The stacker transfers the logs to unsorted log storage or to a grading, bucking and scaling area. Here the logs are laid out on the asphalt surface in one of three sub-areas or decks. A grader paints a sort mark on the log, then a bucker trims log ends and bucks to improve the grade and finally scalers scale the higher grades of logs (pulp and gang mill grades of logs are weighed to determine their volume). Once a deck has been scaled it is pushed by the stacker or front-end loaders to an adjacent, asphalt-surfaced sorting area. Here, two Caterpillar 966 front-end loaders sort the logs (Figure B) and forward them to log bunks. On the average, twelve sorts are made but as many as fifteen may be made at one time. Once a bunk is full the logs are loaded onto a truck or put into sorted log storage. The loaded trucks are weighed before leaving for the 20 kilometer round trip to the booming ground in Cowichan Bay. A plan of the Shawnigan sortyard is given in Figure D.

FIGURE A. Stacker Unloading Truck

FIGURE B. Front-End Loaders Sorting Logs

The yard processes 250 000 m^3 of logs per year at a forecasted piece average of 0.91 m^3. The yard operates 213 days per year with 12 men. At the time of the study the piece average was 0.99 m^3 (Figure C) and the yard was forecasted to process 1 175 m^3 per day. This yard was processing the smallest-sized logs seen in the five sorting systems studied.

FIGURE C. Log Size at Shawnigan Sortyard

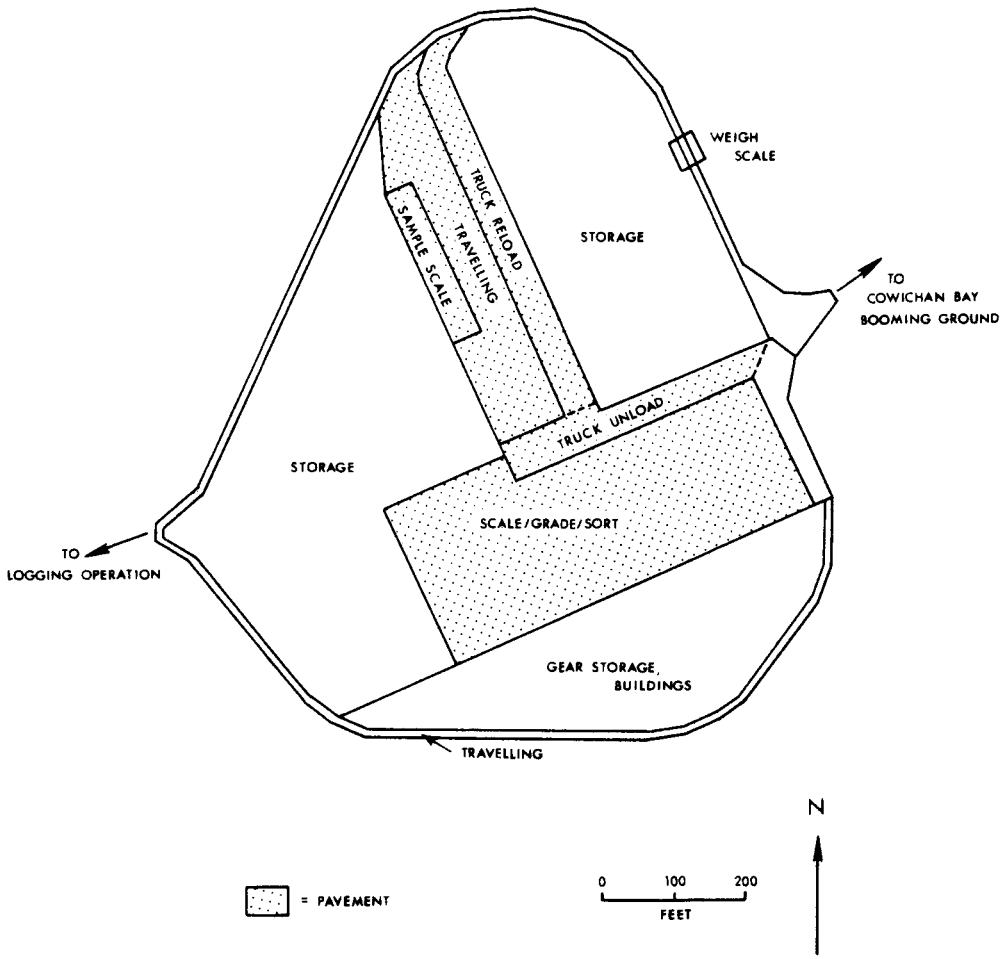

FIGURE D. Plan of Shawnigan Sortyard

B. SORTING WITH TWO STATIONARY LOG LOADERS

British Columbia Forest Products - Cowichan-
Nitinat Division (Caycuse)
Study Period: Three days.

Logs are pulled off of the log trucks and onto ramps by a L120 Raygo Wagner stacker (60 ton capacity) fitted with a 100-ton capacity log grapple (Figure E). The stacker releases some logs onto the ramp and then transfers what logs it can lift from the ramp to a grading and scaling area. Once the logs have been spread on the asphalt surface, two graders paint sort marks on the logs and then three scalers scale the logs. One of two L90 Raygo Wagner stackers or a Caterpillar 980 front-end loader forwards the logs to one of the two stationary Chapman 1825 log loaders (Figure F). The log loaders sort most of the logs into the six bunks and bunch the remainder. The bunches are forwarded to bunks by the Caterpillar 980 front-end loader. A mobile, fully automated banding machine travels to full bunks to band the logs together. A Raygo Wagner L90 stacker then moves the log bundles to the dumping area. A Clark 275 B front-end loader assists in log forwarding, serves as a utility machine and removes debris from the yard. Figure G is a plan of the yard.

FIGURE E. Pull-Unloading Trucks at Caycuse Sortyard

The Caycuse sortyard normally processes 764 700 m^3 in 190 operating days. They use a partially-staffed second shift to unload late trucks, sort scaled logs left from the day shift, spread logs from late trucks and dump presorted truck loads from the Port Renfrew Division. The forecasted piece average for 1982 is 1.6 m^3. The piece average during the study was 2.0 m^3 and the forecasted production was 3 100 m^3 per day. The yard can make up to 14 sorts at one time but the majority of the logs go into six sorts for shipment across the lake to the Youbou sawmill. The normal crew is 17. This yard uses the spare operator concept which permits continuous machine operation.

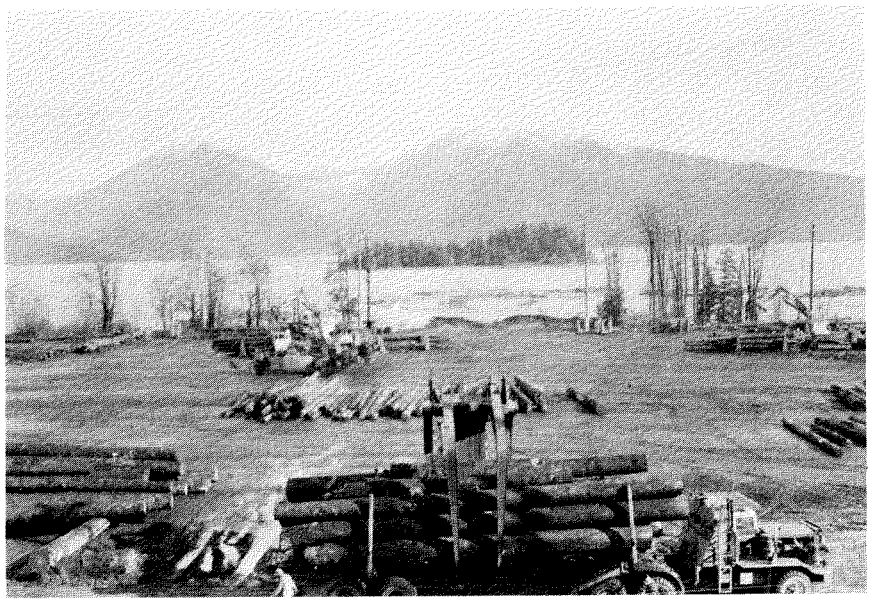

FIGURE F. Chapman 1825 Stationary Log Loaders

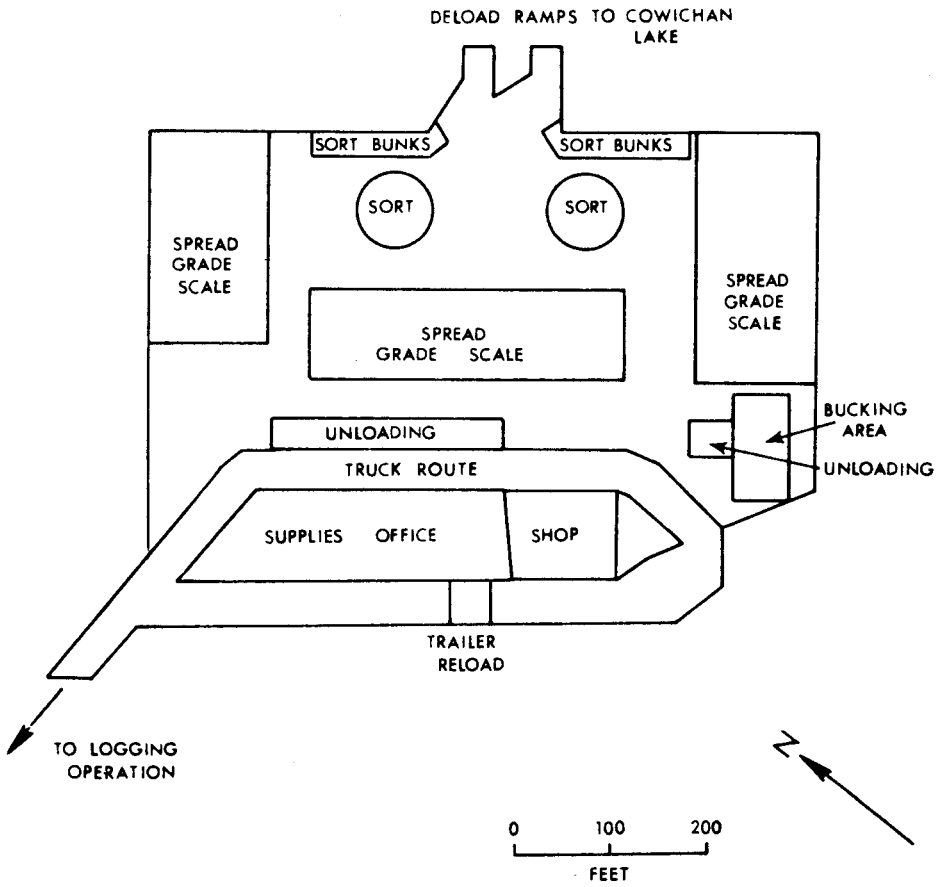

FIGURE G. Plan of Caycuse Sortyard

C. SORTING WITH A FRONT-END LOADER AND A MOBILE LOG LOADER WITH A TWO-BUNK LOG TRAILER

Pacific Forest Products Ltd., Sooke Division
Study Period: Three days.

Trucks are unloaded by a Le Tourneau 2794 stacker (Figure H). The stacker transfers the logs to one of three grading, bucking and scaling areas and spreads them on the asphalt surface. Once in a deck, the logs are marked by a grader. A bucker then trims shattered log ends and bucks any logs that can be up-graded. Following this, tags are attached and the logs are scaled by two scalers. A Linkbelt 5800 TL log loader sorts and bunches the logs. The smaller logs and/or high volume sorts are sorted into the two trailer bunks (Figure I) while the larger logs and/or lower volume sorts are bunched. The bunched logs are forwarded to bunks by a Caterpillar 988B front-end loader. A Le Tourneau 2694 stacker periodically removes logs from the trailer. A three-man crew in a mobile wire-strapping machine travel to full bunks to strap the logs. The two stackers then put the bundles into a sorted log storage area. The bundles are reclaimed from storage during the afternoon shift, loaded onto trucks and transported 3 kilometers to the booming ground. Figure J is a plan of the Sooke sortyard.

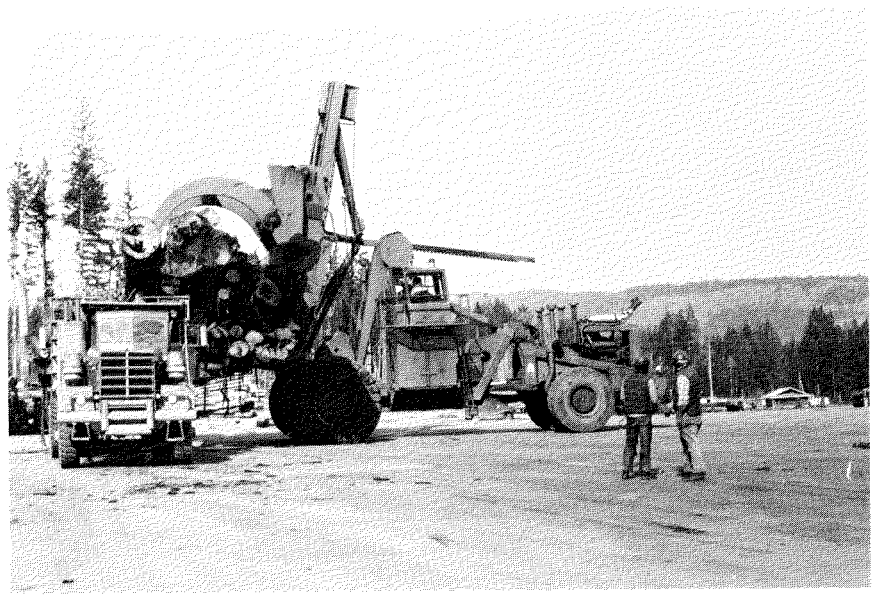

FIGURE H. Stacker Unloading Truck at Sooke

The Sooke sortyard is budgeted to process 306 000 m^3 in 160 operating days. During the study, the forecasted daily production was 1 865 m^3 with a piece average of 1.66 m^3. The annual piece average is forecasted at 1.36 m^3. Although the sortyard can make up to 18 sorts at one time, it was making 10 sorts during the study. The normal crew is 11 men.

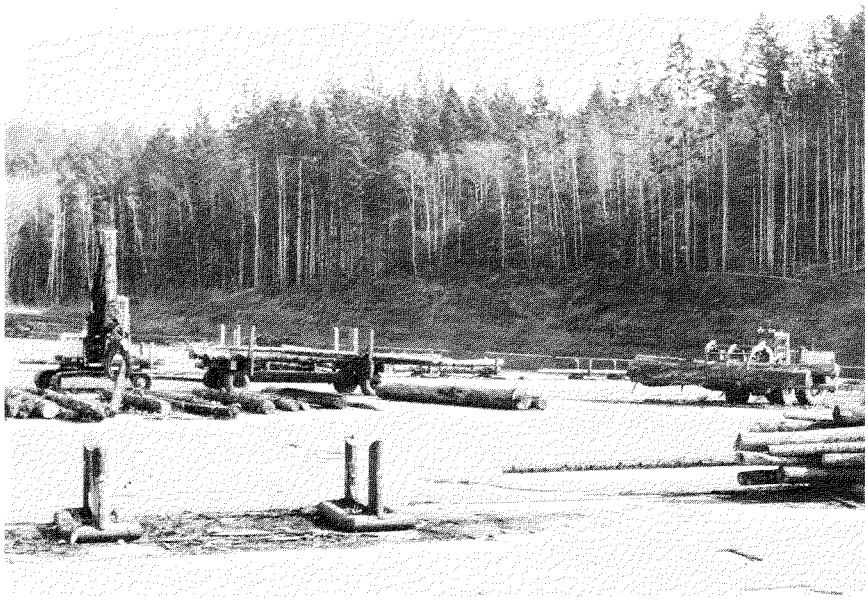

FIGURE I. Log Loader and Trailer

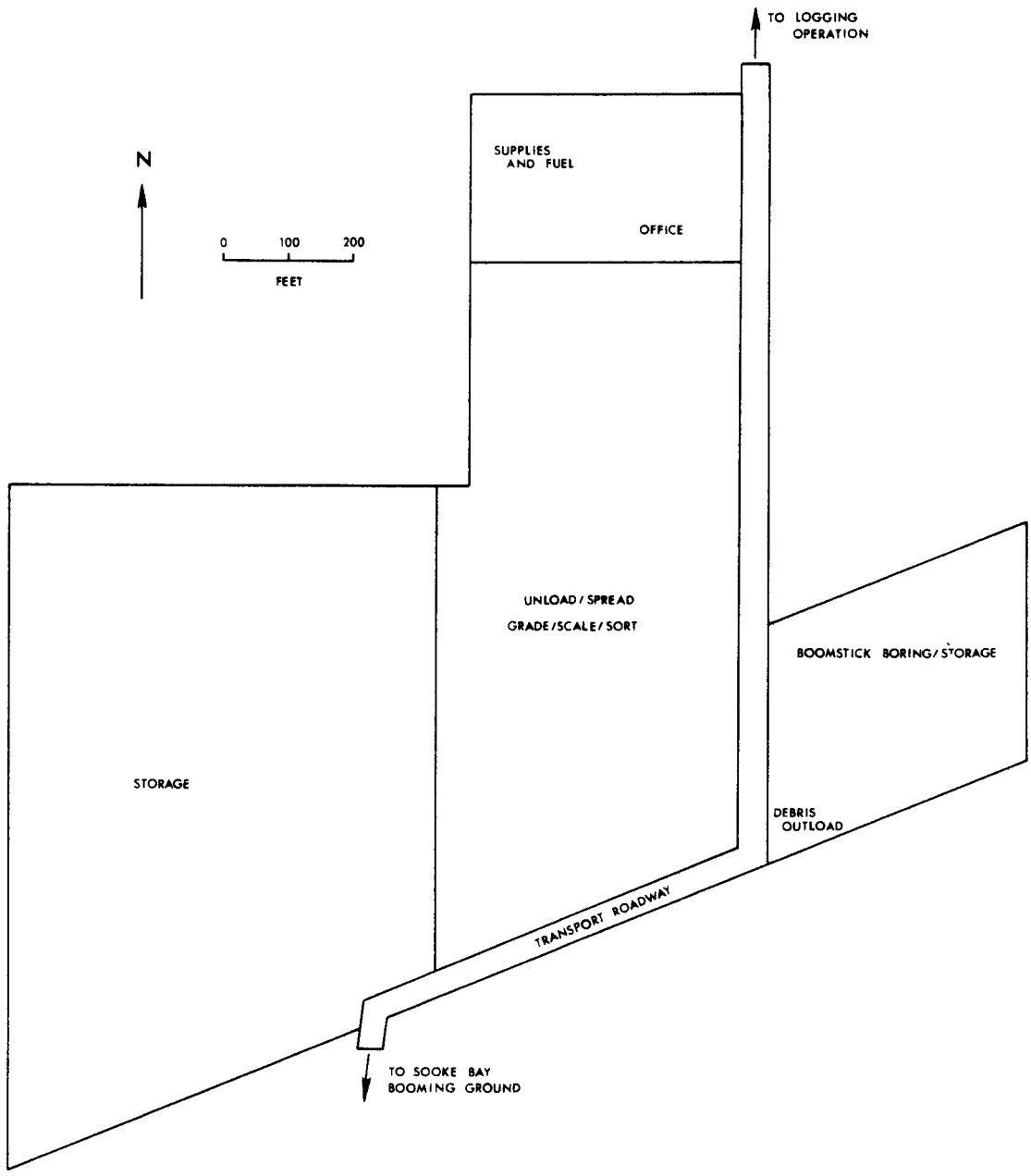

FIGURE J. Plan of Sooke Sortyard

D. SORTING WITH A FRONT-END LOADER AND A MOBILE LOG LOADER

Canadian Forest Products Ltd., Englewood Division
Study Period: Three days.

The yard processes 1 360 000 m^3 per year in 217 double-shifted days. The budgeted daily production during the study was 6 320 m^3 with a piece average of 1.57 m^3. The yearly piece average is forecasted at 1.38 m^3. The total sorting crew is 35 men.

This yard has two distinct sorting systems. The three day study of the mobile log loader which sorts approximately half the production is described here and the sorting table system is described in Section E following.

A Raygo Wagner L120 stacker unloads railway cars or log trucks (Figure K). The stacker and load is then weighed by the B.C. Forest Service. The load can then be spread in the B.C. Forest Service sample scale area, taken to unsorted log storage or spread in one of three decks in the spread sort area. Logs placed in the spread sort area are marked for sorting by two graders. A Barko 550 log loader moves along a graded log deck and sorts and bunches the logs into piles (Figure L). A Caterpillar 980C front-end loader forwards the sorted piles to log bunks

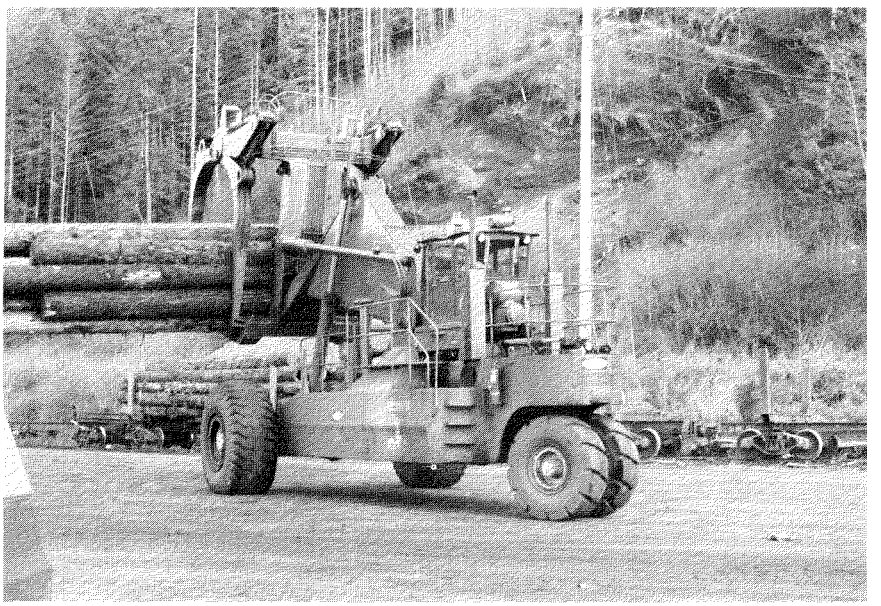

FIGURE K. Stacker Unloading Railway Car

located in a U-shaped area at the end of the log decks. If the front-end loader can not process the bunches quickly enough then a second front-end loader will assist. The logs are moved by a stacker from the bunks to a company scaling area or to a bundling area. The bundles are weighed and dumped into the booming ground. Logs used within the company are weigh scaled in metric units and logs that are to be traded or sold are stick scaled in board feet. Figure M is a plan of the Beaver Cove sortyard.

FIGURE L. Barko 550 Log Loader Sorting and Bunching Logs

E. SORTING WITH A STATIONARY LOG LOADER, A FRONT-END LOADER AND A LOW-PROFILE GRADING AND SORTING TABLE

Log loads are removed from logging trucks or railway cars by a Raygo Wagner L120 stacker, weighed for stumpage and royalty charges and transported to the sorting table. After being spread on the table the logs are graded and marked (Figure N). The chains advance the logs to the sorting area of the table. A Caterpillar 245 stationary log loader makes four different log sorts into bunks and sorts and bunches the remaining logs on the sorting table (Figure O). A Caterpillar 980C front-end loader forwards the sorted bunches to log bunks set in a U-shape around the end of the table. When a bunk is full a L120 Raygo Wagner stacker removes the logs for stick scaling or bundling. The stacker then transports the bundle for weighing and dumping into the booming ground.

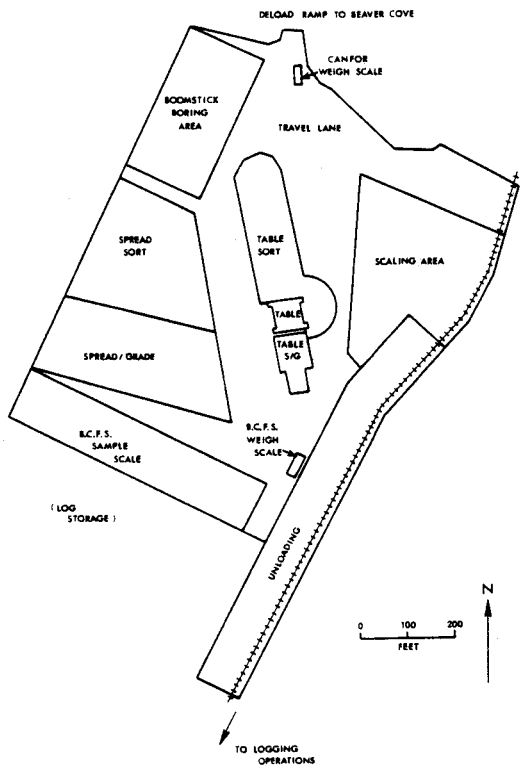

FIGURE M. Plan of Beaver Cove Sortyard

FIGURE N. Grading on the Table

FIGURE O. Caterpillar 245/980 Sorting System

F. SUMMARY OF MACHINES STUDIED

A summary of the sorting and non-sorting machines in each of the systems studied is given in Table 1.

TABLE 1. Summary of Machines Studied

Machines	System				
	Front-End Loaders (A)	Stationary Log Loaders (B)	Front-End Loader & Mobile Log Loader With Trailer (C)	Front-End Loader & Mobile Log Loader (D)	Front-End Loader & Stationary Log Loader With Sorting Table (E)
Sorting					
CAT 966-Sized	2	-	-	1	1
CAT 980-Sized	1	-	-	-	-
CAT 988-Sized	-	-	1	-	-
CAT 235-Sized	-	-	-	1	-
CAT 245-Sized	-	2	1	-	1
Sub Total	3	2	2	2	2
Non-Sorting					
60 Ton Size	1	1	1	1.5	1.5
45-50 Ton Size	-	2	1	-	-
CAT 966-Sized	-	-	-	-	-
CAT 980-Sized	-	2	-	0.5	0.5
Sub Total	1	5	2	2	2
GRAND TOTAL	4	7	4	4	4

RESULTS AND DISCUSSION

A. SORTING MACHINE TIME DISTRIBUTION

The time distribution of the five different sorting systems is given in Table 2. It is based on the continuous timing results.

TABLE 2. Percentage Distribution of Sorting Machine Time

	System				
	Front-End Loaders (A)	Stationary Log Loaders (B)	Front-End Loader & Mobile Log Loader With Trailer (C)	Front-End Loader & Mobile Log Loader (D)	Front-End Loader & Stationary Log Loader With Sorting Table (E)
Productive Time (%)					
Sort & Bunch	--	61.5	27.8	33.4	35.9
Sort & Forward	63.7	--	--	--	--
Forward Bunches	--	--	21.0	37.8	33.6
Forward Bundles	--	--	1.9	--	--
Reload Trucks	5.5	--	--	--	--
Debris Cleanup	9.2	--	3.7	3.1	2.4
Other	0.1	--	2.9	--	--
Productive Total (%)	78.5	61.5	57.3	74.3	71.9
Non-Productive Time (%)					
Wait - no wood	5.9	17.3	22.4	11.8	12.6
Personal	11.8	--	17.8	12.7	15.5
Idle - other	3.2	20.9	2.5	1.1	--
Non-Productive Total (%)	20.9	38.2	42.7	25.6	28.1
GRAND TOTAL (%)	100.0	100.0	100.0	100.0	100.0

Appendix I gives individual breakdowns of the sorting machine's time distribution.

There is a basic imbalance in time distribution between the mobile log loaders sorting logs and the front-end loaders forwarding them from the sorting area (Appendix I). If the mobile log loader is only sorting and bunching logs (Beaver Cove - spread sort) then the front-end loader can not keep up and a second front-end loader must assist in forwarding the sorted bunches of logs. If the log loader (mobile or stationary) is sorting, bunching and putting some sorts in bunks (Beaver Cove - table, Sooke) then the front-end loader can forward bunches faster than they can be bunched and has idle time. To reduce idle time in the latter case, the volume of the sorts being made into the bunks and being bunched should be examined. In the former case, the location and layout of the sorting bunks should be examined to see if travel time of the front-end loader can be reduced.

B. PRODUCTIVITY OF SORTING MACHINES

From the piece count of logs sorted and the continuous timing results the productivities of the five sorting systems (Table 3) were calculated.

The system productive capacity is an estimate of what the production would be if the machines worked 100 percent of the available time. The stationary log loader system has the highest capacity. However, it will have the most difficulty achieving maximum capacity because the storage area for incoming logs is too small to level the production surges caused by the irregular logging truck arrivals. With a varying input rate and no surge capacity, idle time on sorting machines is higher or the truck queue is longer. The other four systems all have storage for incoming logs and can level the flow of logs to the sorting machines more easily. However, incoming log storage requires more land and investment and the logs are handled an additional time.

The two sorting systems using mobile log loaders are different but it would appear that the addition of a sorting trailer at Sooke has increased the productive capacity by 400 pieces per shift in comparison to Beaver Cove's mobile log loader system.

TABLE 3. Productivity of Sorting Machines - Continuous Timing Results

	System				
	Front-End Loaders (A)	Stationary Log Loaders (B)	Front-End Loader & Mobile Log Loader With Trailer (C)	Front-End Loader & Mobile Log Loader (D)	Front-End Loader & Stationary Log Loader With Sorting Table (E)
Total Pieces Sorted	2 410	5 048	2 385	2 813	2 314
Total Machine Time (hrs)	48.5	48.5	43.2	53.2	31.0
Total Productive Time (hrs)	38.4	29.9	24.7	39.5	22.3
Utilization (Productive Time/ Total Time)	0.79	0.62	0.57	0.74	0.72
Pieces/Total Hour	49.6	104.1	55.2	52.9	74.6
Pieces/Productive Machine Hour	62.8	168.6	96.4	71.2	103.8
Number of Sorting Machines	3	2	2	2	2
Sorting System Productive[1] Capacity (Pieces/Shift)	1 508	2 698	1 542	1 139	1 662

[1]System Productive Capacity = Pieces/productive machine hour X 8 hours X number of sorting machines.

C. PRODUCTIVITY OF NON-SORTING MACHINES

The productivity of the machines used to unload trucks, spread logs, reclaim logs, transport logs and bundles, dump bundles and clean up the yard surface was measured by random sampling and is given in Table 4.

The productivity of the stacker at Shawnigan is overstated somewhat because it is assisted from time to time by the front-end loaders. Caycuse has very little storage capability and it needs additional equipment to turn the logging trucks around quickly and minimize the queue. The result is a lower-than-normal productivity on the Caycuse equipment.

TABLE 4. Productivity of Non-Sorting Machines - Random Sampling Results

	System				
	Front-End Loaders (A)	Stationary Log Loaders (B)	Front-End Loader & Mobile Log Loader With Trailer (C)	Front-End Loader & Mobile Log Loader (D)	Front-End Loader & Stationary Log Loader With Sorting Table (E)
Number of Non-Sorting Stackers & Front-End Loaders	1	5	2	2[1]	2[1]
Pieces Processed	2 410	5 048	2 385	2 813	2 314
Total Time Observed (hrs) - Total Machine Time	16.4	25.8[2]	21.4	24.5	15.5
Machine Utilization (%)					
Stacker 1	74	73	67	71[3]	72[3]
Stacker 2	--	68	--	72	71
Stacker 3	--	64	--	--	--
FEL 1	--	60	--	--	--
FEL 2	--	72	--	--	--
Average	74	67	67	71	71
Pieces/Total Machine Hours	147	196	112	115	149
Pieces/Productive Machine Hour[4]	199	292	167	162	208
Observed Production (Pieces/ Shift/Machine)	1 176	314	448	460	596
Maximum Production (Pieces/ Shift/Machine)[5]	1 592	467	668	648	832
Non-Sorting System Productive Capacity (Pieces/Shift)	1 592	2 335	1 336	1 296	1 664

[1]Beaver Cove has three stackers and one front-end loader on reclaiming, spreading, etc. duties. Allocate half of the machines to one sorting system and half to the other.
[2]Front-end loader #1 was observed for 1 414 minutes not 1 546 minutes.
[3]It was only possible to sample the unloading stacker at Beaver Cove. Assume the other machines have the same utilization ratios.
[4]Pieces/Productive Machine Hour = Pieces processed/average productive hour.
[5]Maximum production = pieces/production shift/machine.

D. OVERALL SYSTEM MACHINE PRODUCTIVITY

When the results of the sorting machine productivities (Table 3) are merged with the productivities of the non-sorting machines in the sort-yard (Table 4) an overall system capacity can be estimated (Table 5).

TABLE 5. Overall System Productive Capacity

	System				
	Front-End Loaders (A)	Stationary Log Loaders (B)	Front-End Loader & Mobile Log Loader With Trailer (C)	Front-End Loader & Mobile Log Loader (D)	Front-End Loader & Stationary Log Loader With Sorting Table (E)
Total Pieces Sorted	2 410	5 048	2 385	2 813	2 314
Productive Time (hrs)					
Sorting Machines	38.4	29.9	24.7	39.5	22.3
Non-Sorting Machines	12.1	85.5	28.6	34.7	22.3
Total Productive	50.5	115.4	53.3	74.2	44.6
Non-Productive Time (hrs)					
Sorting Machines	10.2	18.5	18.4	13.6	8.7
Non-Sorting Machines	4.3	42.6	14.1	14.2	9.0
Total Non-Productive	14.5	61.1	32.5	27.8	17.7
Grand Total	65.0	176.5	85.8	102.0	62.3
Pieces/Total Machine Hour	37.1	28.8	27.8	27.6	37.1
Pieces/Productive Machine Hour	47.7	43.7	44.7	37.9	51.9
Total System Productive Capacity (Pieces/Shift)	1 526	2 447	1 430	1 213	1 661[1]

[1]The Beaver Cove Table productivity per machine hour is overstated somewhat because the sorting table results in less area being required to spread logs and this reduces travelling time for the stackers.

Comparison of Table 3 and 4 with Table 5 will show whether the sorting or non-sorting machines limit the total system productive capacity given in Table 5.

E. GRADER PRODUCTIVITY

For safety and other reasons most logs are graded when a deck is full and no machines are working in the immediate area. Consequently, grading becomes a batch process and unless there is a continual supply of logs and large grading decks, idle time is high. Also, most logging trucks arrive in surges and unloading is given priority. Table 6 lists the results of the random sampling of the graders.

TABLE 6. Random Sampling Results - Graders

	System				
	Front-End Loaders (A)	Stationary Log Loaders (B)	Front-End Loader & Mobile Log Loader With Trailer (C)	Front-End Loader & Mobile Log Loader (D)	Front-End Loader & Stationary Log Loader With Sorting Table (E)
Total Pieces Graded	2 410	5 048	2 385	2 813	2 314
Total Observed Time (mins)	982	1 546	1 282	1 468	930
Normal Number of Graders	3	2	2	2[1]	2[1]
Production					
Grading (%)	66.4[2]	51.9	56.0	41.3	36.0
Idle (%)	33.6	48.1	44.0	58.7	64.0
Total (%)	100.0	100.0	100.0	100.0	100.0
Number of Graders In Deck At One Time (%)					
0	33.6[2]	48.1	44.0	58.7	64.0
1	14.9	20.8	17.8	22.4	2.0
2	22.4	31.1	38.2	11.0	31.0
3	25.8	--	--	7.9	1.0
4	3.3	--	--	--	1.0
Pieces/Total Hour	147	196	112	115	149
Pieces/Productive Hour	222[3]	378	198	276	414
Pieces Graded/Grader/Shift[4]	1 178[3]	784	446	456	597
Average Number of Sorts	12	6	10	14	14
Maximum Number of Sorts	15	14	18	22	22

(TABLE 6 continued)

[1]Graders are fully qualified as "Licensed Scaler - Industrial Grader".
[2]Sampled contract scalers not graders. Shawnigan has one grader.
[3]Assumes grader has same productive time to total time ratio and works the same amount of time as the scalers.
[4]Includes idle time and assumes 2 graders. Shift = 480 minutes.

The time required for grading depends on several factors including grader proficiency, grading standards, number of log sorts and end destination quality requirements. Some of the sortyards require that their graders be fully licensed, experienced scalers while others do not. Some end destinations require very specific grading while others accept estimates of grades.

F. LOG AVAILABILITY

To illustrate the log throughput in the sortyards the relative degree of fullness of the grading and scaling decks was measured by random sampling. Table 7 shows the results of random sampling.

TABLE 7. Random Sampling Results - Log Volume in Deck

Condition of Log Deck (%)	System				
	Front-End Loaders (A)	Stationary Log Loaders[1] (B)	Front-End Loader & Mobile Log Loader With Trailer (C)	Front-End Loader & Mobile Log Loader (D)	Front-End Loader & Stationary Log Loader With Sorting Table (E)
Full	--	--	--	4.9	6.0
> 1/2 full	35.5	--	17.1	67.9	50.0
< 1/2 full	64.5	--	78.7	16.9	36.0
Empty	--	--	4.2	10.4	8.0
Total	100	--	100	100	100

[1]It was not possible to measure the condition of the log decks at Caycuse.

As can be seen from Table 6, there were times when wood was not available for processing at Beaver Cove and Sooke (this was true at Caycuse also but not documented). Although productive capacity is calculated in the report, lack of logs has an effect on the crew's productivity by interrupting the rythmn that develops. This affected our measurements and if we had studied the yards later in the year we may have found higher productive capacities.

G. MANDAY PRODUCTIVITY

The productivity per manday of the various sorting systems is shown in Table 8. Personnel associated with boomstick boring, debris disposal, booming and bundling were not included. Superintendants were excluded but foremen were included.

TABLE 8. Manday Productivity Comparison

	System				
	Front-End Loaders (A)	Stationary Log Loaders (B)	Front-End Loader & Mobile Log Loader With Trailer (C)	Front-End Loader & Mobile Log Loader (D)	Front-End Loader & Stationary Log Loader With Sorting Table (E)
Man Power					
Foreman	1	1	1	0.75[1]	0.75[1]
Machine Operators	4	9	4	4	4
Graders	1	2	2	1	2
Scalers	3	3	2	1	1.5
Weighmasters	1	-	-	1	1
Buckers	1	1	1	-	-
Handymen	1	-	1	-	-
TOTAL	12	16	11	7.75	9.25
Mandays/Shift	12	16	11	7.75	9.25
Productive Capacity (Pieces/ Shift)	1 508	2 698	1 542	1 139	1 662
Pieces/Manday @ Productive Capacity	126	169	140	147	180
Pieces/Manday (Actual)	99	104	80	109	129

[1]Beaver Cove crew is spread over two systems and two shifts. Allocation made after conversations with Beaver Cove manager. Includes scaling and grading supervisor.

APPENDIX I. INDIVIDUAL BREAKDOWN OF SORTING MACHINE'S TIME DISTRIBUTION - CONTINUOUS TIMING RESULTS

1. Continuous Timing Results - Shawnigan Division (A)

	966C Loader (L20)		966C Loader (L89)		980B Loader	
	minutes	%	minutes	%	minutes	%
1. Productive Time:						
A. Sort & Forward	734.5	75.1	659.5	68.2	462.0	47.7
B. Reload Trucks	39.0	4.0	59.0	6.1	61.5	6.4
C. Debris Cleanup	56.5	5.8	55.0	5.7	156.0	16.1
D. Travel Empty	1.5	0.1	2.0	0.2	15.5	1.6
Productive Total	831.5	85.0	775.5	80.2	695.0	71.8
2. Non-Productive Time:						
A. Idle (No Wood)	36.0	3.7	32.0	3.3	104.0	10.7
B. Idle (Coffee/Lunch)	88.0	9.0	133.0	13.8	124.0	12.8
C. Idle (Other)	22.5	2.3	26.0	2.7	45.0	4.6
Non-Productive Total	146.5	15.0	191.0	19.8	273.0	28.2
Grand Total	978.0	100.0	966.5	100.0	968.0	100.0

2. Continuous Timing Results - Caycuse (B)

	Chapman 1825 Loader (#1)		Chapman 1825 Loader (#2)	
	minutes	%	minutes	%
1. Productive Time:				
A. Sorting & Bunching	1 097.5	70.8	692.5	51.0
B. Forwarding	--	--	--	--
C. Debris Cleanup	5.0	.3	1.5	.1
D. Travel Empty	--	--	--	--
Productive Total	1 102.5	71.1	694.0	51.1
2. Non-Productive Time:				
A. Idle (No Wood)	262.0	16.9	240.5	17.7
B. Idle (Coffee/Lunch)	2.5	.2	--	--
C. Idle (Other)	184.0	11.9	423.5	31.2
Non-Productive Total	448.5	28.9	664.0	48.9
Grand Total	1 551.0	100.0	1 358.0	100.0

3. Continuous Timing Results - Sooke Division (C)

	Travelling Log Loader (5800 T.L. Linkbelt)		988B Loader	
	minutes	%	minutes	%
1. Productive Time:				
A. Sort & Bunch	720.5	55.8	--	--
B. Forward Bunches	--	--	544.5	41.9
C. Forward Bundles	--	--	49.0	3.8
D. Travel	68.0	5.3	--	--
E. Unload Trailer	6.0	.5	--	--
F. Debris Cleanup	--	--	96.0	7.4
Productive Total	794.5	61.5	689.5	53.1
2. Non-Productive Time:				
A. Idle (No Wood)	228.5	17.7	350.5	27.0
B. Idle (Coffee/Lunch)	237.0	18.4	223.5	17.2
C. Idle (Other)	31.0	2.4	35.0	2.7
Non-Productive Total	496.5	38.5	609.0	46.9
Grand Total	1 291.0	100.0	1 298.5	100.0

4. Continuous Timing Results - Beaver Cove Spread Sort (D)

	Barko 550 Loader		980 Loaders	
	minutes	%	minutes	%
1. Productive Time:				
A. Sort & Bunch	1 065.0	72.6	--	--
B. Forward	--	--	1 207.0	70.1
C. Debris Cleanup	--	--	99.5	5.8
Productive Total	1 065.0	72.6	1 306.5	75.9
2. Non-Productive Time:				
A. Idle (No Wood)	188.5	17.8	188.5	10.9
B. Idle (Coffee/Lunch)	195.5	13.3	209.5	12.2
C. Idle (Other)	18.5	1.3	17.5	1.0
Non-Productive Total	402.5	27.4	415.5	24.1
Grand Total	1 467.5	100.0	1 722.0	100.0

5. Continuous Timing Results - Beaver Cove Table (E)

	980 Loader		245 Loader	
	minutes	%	minutes	%
1. Productive Time:				
A. Sort & Bunch	--	--	667.0	72
B. Forward	625.0	67	--	--
C. Debris Cleanup	33.5	4	11.5	1
Productive Total	658.5	71	678.5	73
2. Non-Productive Time:				
A. Idle (No Wood)	122.5	13	112.0	12
B. Idle (Cofee/Lunch)	149.0	16	139.5	15
C. Idle (Other)	--	--	--	--
Non-Productive Total	271.5	29	251.5	27
Grand Total	930.0	100	930.0	100

APPENDIX II. DETAILS ON RANDOM SAMPLING RESULTS

1. Random Sampling Details - Shawnigan Division (A)

Stacker (LW 2794)	Events	%
Productive Time	242	73.6
Non-Productive Time:		
Idle (No Wood)	72	21.9
Idle (Coffee/Lunch)	7	2.3
Idle (Other)	8	2.4
Non-Productive Total	87	26.6
Grand Total	329	100.0

Grading & Scaling Decks	Events	%
Full	--	--
>1/2 Full	117	35.5
<1/2 Full	213	64.5
Empty	--	--
Total	330	100.0

Scalers	Events	%
Scaling	219	66.4
Not Scaling	109	33.0
Other	2	0.6
Total	330	100.0

Total Elapsed Time: 16 hours 22 minutes.

Shawnigan Division (A) continued

Statistical Significance

	Observed idle time during study:	We are 95% confident idle time lies between:
Stacker	26.4%	21.7% - 31.1%
Scalers	33.6%	28.5% - 38.7%

2. Random Sampling Results - Caycuse (B)

	Stacker #1 L120		Stacker #2 L90		Stacker #3 L90	
	Events	%	Events	%	Events	%
Productive Time	374	72.8	352	68.1	330	64.2
Non-Productive Time:						
Idle (No Wood)	126	24.5	155	30.0	159	30.9
Idle (Coffee/Lunch)	--	--	--	--	1	.2
Idle (Other)	14	2.7	10	1.9	24	4.7
Total	514	100.0	517	100.0	514	100.0

FEL (275B)	Events	%
Productive Time	309	72.0
Non-Productive Time:		
Idle (No Wood)	120	28.0
Idle (Coffee/Lunch)	--	--
Idle (Other)	--	--
Total	429	100.0

Caycuse (B) - continued

Scalers	Events	%
Scaling	201	39.1
Not Scaling	313	60.9
Total	514	100.0

Graders	Events	%
Grading	267	51.9
Not Grading	247	48.1
Total	514	100.0

Banding Machine	Events	%
Productive Time	179	34.6
Non-Productive Time:		
Idle (No Wood)	71	13.7
Idle (Coffee/Lunch)	--	--
Idle (Other)	267	51.6
Total	517	100.0

Total Elapsed Time: 25 hours 46 minutes.

Statistical Significance

	Observed idle time during study:	We are 95% confident that the idle time lies between:
Stacker #1	27.2%	23.4% and 31.0%
Stacker #2	31.9%	27.9% and 35.9%
Stacker #3	35.8%	37.7% and 39.9%
275 B	28.0%	23.8% and 32.2%
Banding Machine	65.4%	61.3% and 69.5%
Scalers	60.9%	56.7% and 65.1%
Graders	48.1%	43.8% and 52.4%

3. Random Sampling Details - Sooke Division (C)

Stacker (2794)	Events	%
Productive Time	290	67.1
Non-Productive Time:		
Idle (No Wood)	87	20.2
Idle (Coffee/Lunch)	54	12.5
Idle (Other)	1	.2
Total	432	100.0

Stacker (2694)	Events	%
Productive Time	290	67.1
Non-Productive Time:		
Idle (No Wood)	84	19.5
Idle (Coffee/Lunch)	58	13.4
Idle (Other)	--	--
Total	432	100.0

Graders	Events	%
Grading	242	56.0
Not Grading	169	39.1
Other	21	4.9
Total	432	100.0

Sooke Division (C) - continued

Grading & Scaling Decks	Events	%
Full	--	--
>1/2 Full	74	17.1
<1/2 Full	340	78.7
Empty	18	4.2
Total	432	100.0

Total Elapsed Time: 21 hours 22 minutes.

Statistical Significance

	Observed idle time during study:	We are 95% confident idle time lies between:
Stacker 2794	32.9%	28.5% - 37.3%
Stacker 2694	32.9%	28.5% - 37.3%
Graders	44.0%	39.3% - 48.7%

4. Random Sampling Results - Beaver Cove Spread (D)

Unloading Stacker	Events	%
Productive Time	350	71.1
Non-Productive Time:		
Idle (No Wood)	96	19.5
Idle (Coffee/Lunch)	40	8.1
Idle (Other)	6	1.2
Total	492	100.0

Beaver Cove Spread (D) - continued

Spread Area	Events	%
Full	24	4.9
>1/2 Full	334	67.9
<1/2 Full	83	16.9
Empty	51	10.4
Total	492	100.0

Graders	vents	%
Grading	203	41.3
Not Grading	289	58.7
Total	492	100.0

Total Elapsed Time: 24 hours 27.5 minutes.

Statistical Significance

	Observed idle time during study:	We are 95% confident that the idle time lies between:
Stacker	28.8%	24.8% - 32.8%
Graders	58.7%	54.3% - 62.1%

5. Random Sampling Results - Beaver Cove Table (E)

Unloading Stacker	Events	%
Productive Time	230	72
Non-Productive Time:		
Idle (No Wood)	54	17
Idle (Coffee/Lunch)	32	10
Idle (Other)	5	2
Total	321	101

Graders Grading	Events	%
Number At Table		
0	207	64
1	7	2
2	100	31
3	4	1
4	3	1
Total	321	99

Sorting Table	Events	%
Full	19	6
3/4 Full	100	31
1/2 Full	121	38
1/4 Full	55	17
Empty	10	3
Mechanical Downtime	16	5
Total	321	100

Beaver Cove Table (E) - continued

Total Elapsed Time: 15 hours 30 minutes.

Statistical Significance

	Observed idle time during study:	We are 95% confident that idle time lies between:
Unloading Stacker	28%	24.0% - 34.0%
Graders	64%	58.7% - 69.5%