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

TN#
39

EVALUATION AND ECONOMIC ANALYSIS OF TWENTY-SIX LOG-SORTING OPERATIONS ON THE COAST OF BRITISH COLUMBIA

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FOREWORD

The cooperation of the forest products companies and their suppliers was needed to obtain the costs and data which formed the basis of this report. The cooperation was excellent. We would like to acknowledge the help of the companies and people in those companies who made this project possible to complete:

- B.C. Forest Products
- Crown Zellerbach
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- MacMillan Bloedel
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- Benwest Logging
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- Rayonier
- Pacific Logging
- Rivtow Straits
- Jackson Bros. Logging
- L & K Lumber
- Ladysmith Log Sorting
- Elk River Timber
- Weldwood
- Butler Tire
- Finning Tractor
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- Mantle Industries
- Gulf Oil
- Pacific Equipment
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SUMMARY

This report presents the results of a study conducted by the Forest Engineering Research Institute of Canada (FERIC) for the Council of Forest Industries of British Columbia (COFI) Subcommittee on Foreshore and Estuary Use. This was part of a larger joint study by the government of Canada, the British Columbia government, and COFI, on foreshore and estuary use for log sorting and storage on the coast of British Columbia.

FERIC's study documented the log-sorting systems, areas, manpower, machines and costs prevailing in the coastal forest industry.

The following objectives were set for FERIC by the COFI subcommittee:

1) Identify and discuss alternative modes and systems for the handling, storage and transportation of logs, both in the water and out of the water.

2) Identify physical and operational constraints to various log handling, storage, and transportation methods.

3) Analyse the relative economics, in terms of comparative costs and benefits, of the various options identified.

Data from 26 sorting operations were collected and analyzed. In most cases, data in metric units were not available for the study and imperial units were used.

The report shows the following costs for the sorting operations and comparison figures for the two basic systems, water-sorting and land-sorting.

TABLE S-1. Costs

Type of Operation	Number in Sample	Total Annual Cost/Cunit Annual Volume (Cunits x 1 000)				
		0-60	61-160	161-260	261-500	All
1. Water Sorting Ground	8	-	$ 8.18	$ 6.38	$ 6.63	$ 6.82
2. Dryland Sortyard	18	$10.04	$12.25	$11.61	$ 9.38	$10.41
Difference (2-1)	-	-	$ 4.07	$ 5.23	$ 2.75	$ 3.59

TABLE S-2. Sorting System Comparison

Data or Ratio	Average, Dryland Sortyard	Average, Water Sorting Ground
Average annual volume sorted (CCF)	182,625	210,393
Average cunits/shift	680	832
Percentage volume bundled	96	48
Average number of log sorts	12.5	12
Land acreage used	16.3	2.2
Water acreage used	29.4	102
Foreshore acreage used under lease	64.8	157
Cunits/manday	33.63	33.29
Cunits/sorting machine hour	18.77	-
Cunits/boat hour	-	9.04
Total cost/cunit	$10.41	$ 6.82
Total capital invested/cunit	$19.50	$ 7.61

The FERIC study led to the following conclusions:

1. Larger operations are more efficient and economical than smaller operations, considering that larger operations have more log sorts, more bundling, fewer presorted bundles and less weigh-scaling.

2. The area required for sorting increases with the number of sorts, the cunits and pieces processed per shift, the use of stick scaling, and the amount of batch processing. Presorting of log bundles or truckloads reduces the sorting area required.

3. The area of water required for storage increases when logs are received by water or shipped by barge or flat raft. Flat rafts require 72% more area than bundle booms for storage at the same volume.

4. The volume of logs stored at a dryland sortyard is less dependent on incoming volume than on mill requirements, booming ground capacity, and the water transport system used.

5. The capital costs of log storage on land are about twice the capital cost of $16.42 per cunit per acre for logs stored in the water.

6. Weigh-scaling interfered less with the sorting process than stick-scaling and it also resulted in greater productivity and lower costs.

7. Logs are scaled before sorting on the land and after sorting in the water. From a systems point of view, the difference in order of sequence of the scaling and sorting functions is the essential difference between water-sorting and land-sorting.

8. Land sortyards require less total water and land area than water sorting grounds. They cost more in all functions except operating labour. Because dryland sortyards bundle more production, fewer logs are lost as sinkers and this saving is the major economic justification for the sortyard. Other justifications include greater accuracy in scaling and sorting and reduced effects on the aquatic environment.

9. When a sortyard could not be located adjacent to a booming ground, the additional operating costs of rehauling were from $1.91 per cunit to $5.07 per cunit.

10. Water or land sorting area requirements are more dependent on pieces per shift than on volume per shift. If the piece size average continues to diminish on the B.C. Coast, more area will be required to process the same volume.

11. Log upgrading is not practical in water sorting grounds with their present configuration. As log values continue to increase, the capability to remanufacture logs is a significant benefit of the dryland sortyard.

We collected a large amount of data during this survey of 26 sorting operations. Only the factors relative to costs, productivities and area requirements are given in this report. Further reports from FERIC will discuss machine capabilities, operation techniques, and yard layouts, and will be of special interest to the operators and designers of sorting operations.

INTRODUCTION

This report is a summary of a study on log-sorting operations on the coast of British Columbia made for the Council of Forest Industries of British Columbia (COFI). It is part of a joint Government of Canada, B.C. Provincial Government and industry study on present and future use of the foreshore and estuary areas of Coastal B.C.

The request from COFI to FERIC stated the following objectives:

1) Identify and discuss alternative modes and systems for handling, storage and transportation of logs, both in the water and out of the water.

2) Identify physical and operational constraints to various log handling, storage and transportation methods.

3) Analyse the relative economics in terms of comparative costs and benefits, of the various options identified.

Twenty-six operations representative of the more than one hundred log-sorting locations on the coast of B.C. were visited. Two days were spent at most operations during the field visits.

This report describes the types of sorting systems and presents information on the area requirements for sorting and storage, men and machinery needs, and owning and operating costs for sorting logs. In most cases, data in metric units were not available for the study and imperial units were used.

DESCRIPTIONS OF WATER SORTING GROUNDS AND DRYLAND SORTYARDS

Water Sorting Grounds

A water sorting ground receives unsorted logs by land or by water and then sorts them with boats or floating log loaders into grades and species. The sorted logs are then assembled into booms or loaded on a barge for water transportation to mill or market. The water-transport method used will depend on the distance and water conditions. The logs may be scaled before or after booming. Figure A is a photograph of a typical water sorting ground.

Water sorting grounds have been used on the coast of B.C. since the early 1900s. The men with pike poles who moved and sorted the logs in those days have been replaced by powerful boats or float-mounted log loaders. Figure B gives a flow diagram characteristic of a larger size water sorting grounds.

Dryland Sortyards

A dryland sortyard can carry out the same functions on land as a water sorting ground does in the water, but the logs are still assembled in the water for water transportation. Figure C shows a typical flow diagram for the larger size dryland sortyards.

The first dryland sortyards on the coast of B.C. were built in 1960 and many others have been built since at new operations or to replace existing water sorting grounds. Dryland sortyards are popular because of reduced sinkage loss and because accurate grading, scaling and sorting are facilitated. Figure D illustrates a dryland sortyard.

Booming Grounds

Booming grounds are usually used to make up booms of sorted logs from dryland sortyards or to make up booms of unsorted logs for shipment to central sorting locations. Figure E is a photograph of a typical booming ground associated with a dryland sortyard.

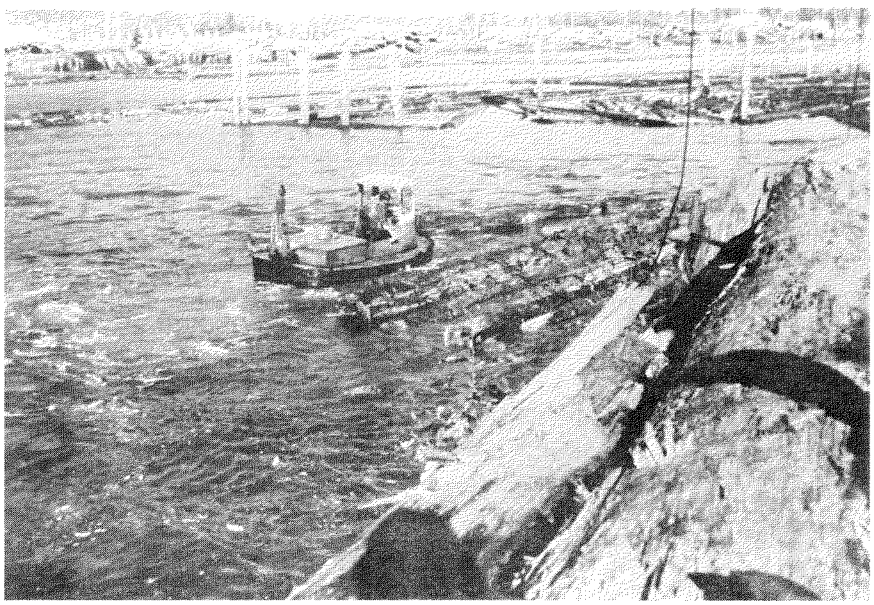
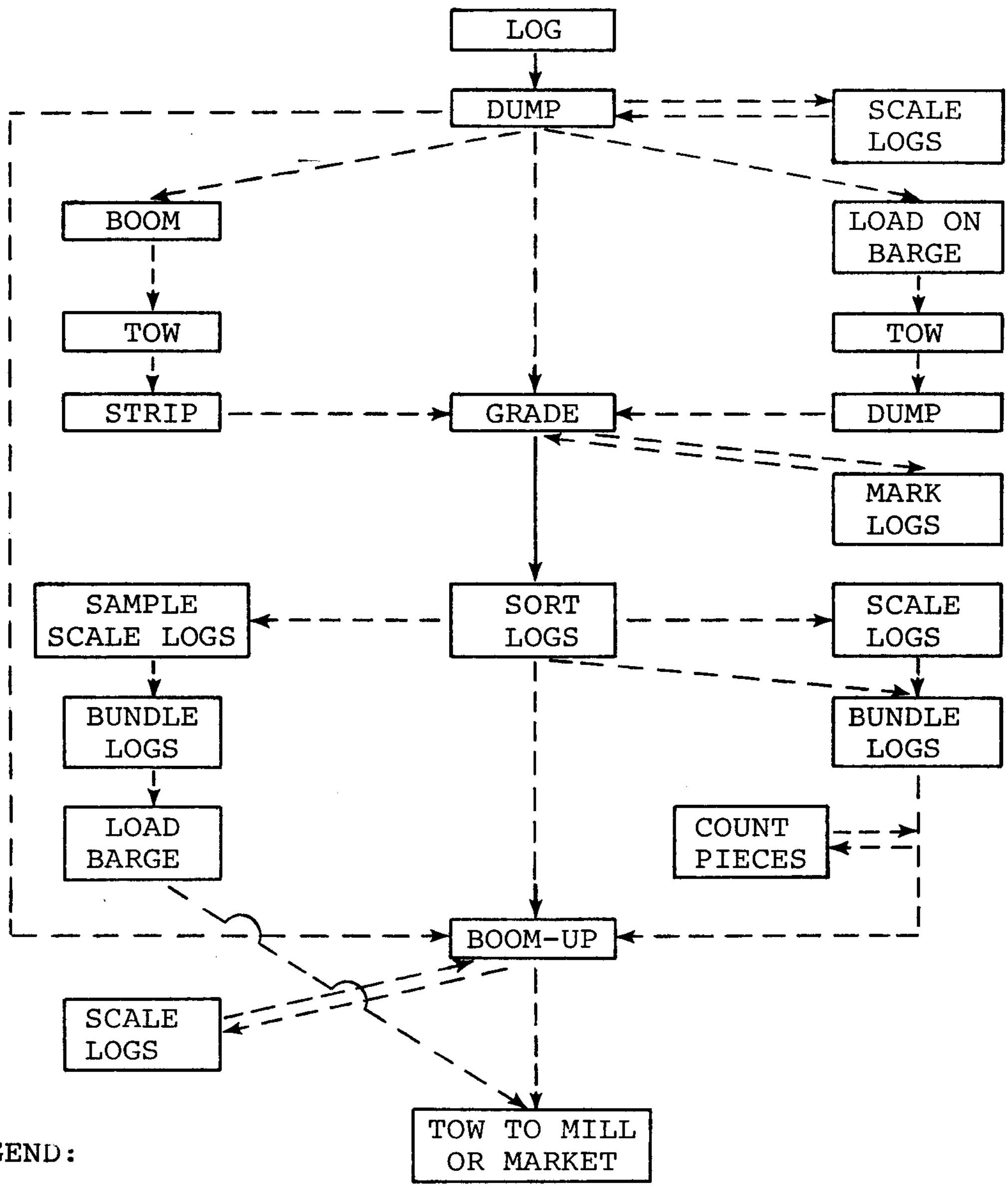


FIGURE A. Typical water sorting ground

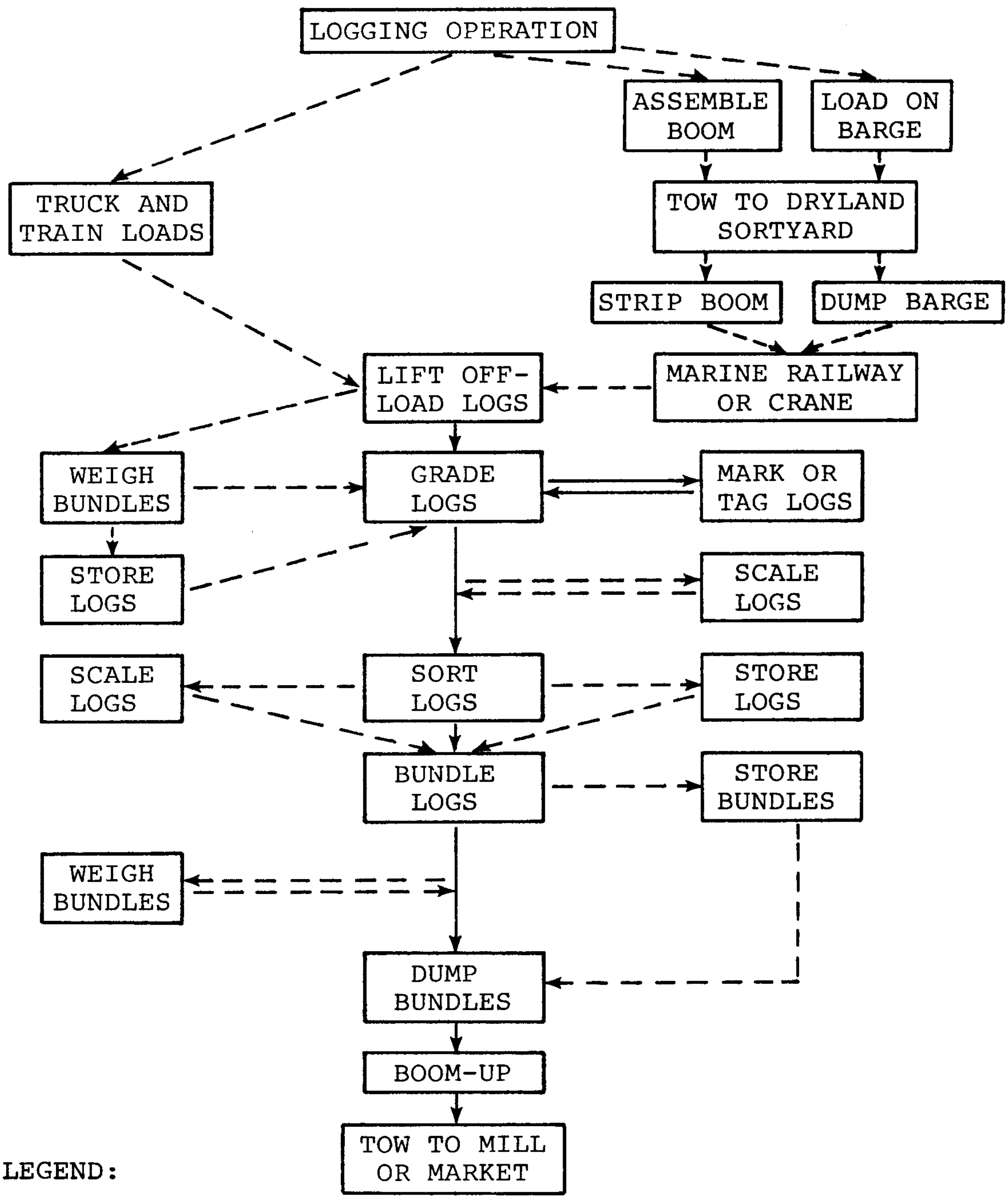


LEGEND:

———————— Functions common to all grounds.

— — — — — Functions not common to all grounds but done in one or more grounds.

FIGURE B. Flow diagram of larger-sized water sorting grounds



LEGEND:

____________ Functions common to all yards.

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FIGURE C. Flow diagram of larger-sized dryland sortyards

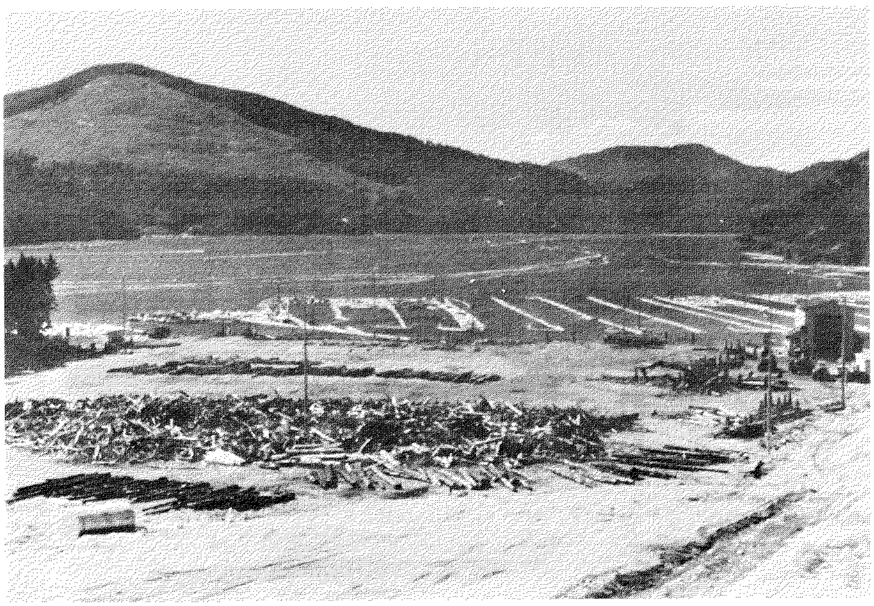

FIGURE D. Dryland sortyard

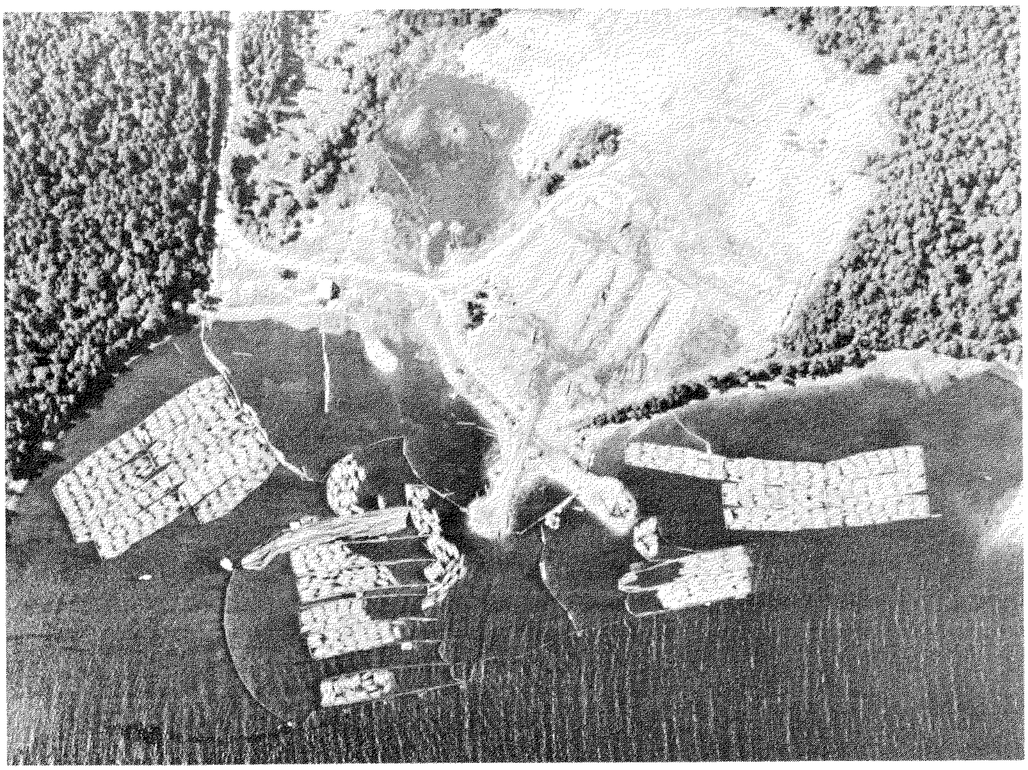

FIGURE E. Aerial photograph of dryland sortyard and water booming ground

STUDY METHOD

Sample Choice and Description

The total population of log-sorting facilities on the Coast was established by telephone survey. It was separated into dryland sortyards and water sorting grounds and classified into volume size classes (Table 1).

TABLE 1. Coastal B.C. Log Sorting Operations by Type and Size

Type	Size Class (Cunits/Year x 1000) 0-60	61-160	161-260	261-500	Total
Dryland Sortyard	51	19	6	6	82
Water Sorting Ground	8	16	7	4	35
Total	59	35	13	10	117

A representative sample of 26 water and land sorting operations was chosen for detailed study.

Characteristics of the sample are given in Table 2.

TABLE 2. Sorting Operations Selected for Detailed Study

Type	Size Class (Cunits/Year x 1000)				
	0-60	61-160	161-260	261-500	Total
Dryland Sortyard	6	6	3	3	18
Water Sorting Ground	-	3	2	3	8
Total	6	9	5	6	26

Field Visits

The sorting operations visited were located on Vancouver Island and the Mainland Coast south of Powell River. The logs processed were reasonably uniform and averaged 55 cubic feet per piece. Most of the logs had been bucked to length before entering the sorting operation. Figure F shows typical logs being processed.

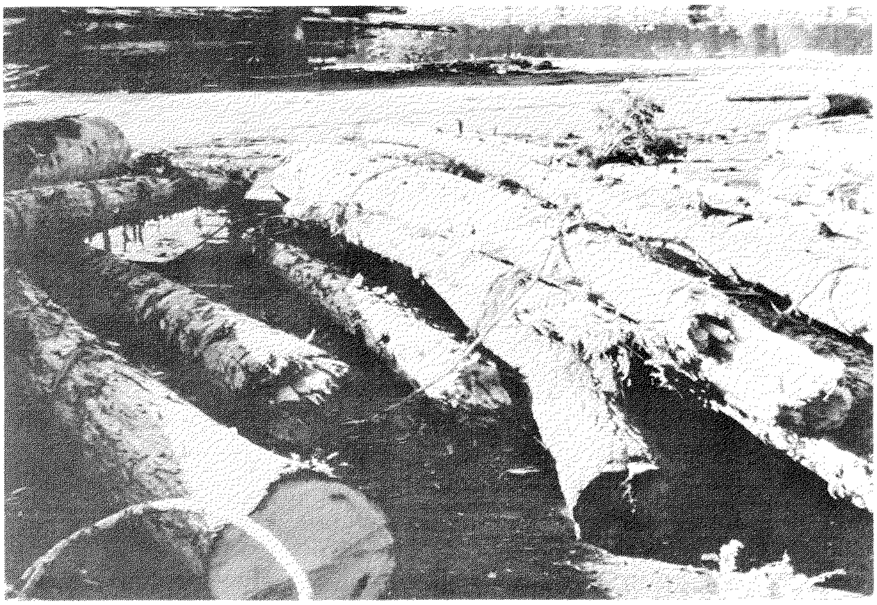

FIGURE F. Size of logs processed in sorting operation

Three of the 26 operations visited were adjacent to mills where some of the logs were consumed. Most operations shipped barges or booms of logs more than 50 miles by water to the mills, however. Four of the sortyards used trucks or a railway to haul logs from the yard to a booming ground for shipment to mills.

Costs and Data

Standard labour rates and standard costs of owning and operating machines were used in the analysis. Actual costs collected were used to establish costs of specific items and to check standard costs. The job functions included in the sorting costs were also standardized so that all the operations could be compared on an equal basis. This excluded functions that some companies might normally include. The reader is cautioned to refer to the cost details in Appendix I before he uses these costs for comparison with actual costs.

STUDY RESULTS

Water Sorting Grounds

The data, results and costs for each size class of water sorting ground were averaged (Table 3).

The larger volume water sorting grounds made more sorts than the smaller volume grounds.

The total area increased as the volume of logs sorted increased (Figure G). The volume sorted per sorting acre and the volume processed per storage acre decreased, but the volume boomed per booming acre increased as the annual volume of logs increased.

Labour productivity was highest in the larger water sorting grounds and cost per piece sorted was lowest.

Booms of bundled logs contained 70% more volume than the same size boom of loose logs. The volume stored per acre of storage ground increased with the percentage of logs bundled.

One of the water sorting grounds was the old type where men sorted logs with pike poles. It required the greatest total area of water per cunit of logs sorted and had the lowest cunit-per-manday productivity in its size class, but had the highest machine productivity.

When presorted bundles of logs were part of the incoming wood, less sorting area was required, manday productivities were higher, and total costs per cunit and piece were lower than when all incoming production was in the form of loose logs.

TABLE 3. Comparison Sheet of Water Sorting Grounds--
All Size Classes and Overall Averages

Size Class (CCF/Year)	60,000-160,000	161,000-260,000	261,000-500,000	All
Number in Sample	3	2	3	8
1. Annual Volume (CCF)	103,167	165,000	363,013	210,393
2. Operating Shifts/Year (Shift = 8 hours)	216	201.5	341	252.8
3. Operating Hours/Year	1,725	1,685	2,731	2,023
4. Percentage of Annual Volume Bundled	31	66	44	48
5. Average Bundle Size Out (CCF/Bundle)	12.5	10.6	11.8	11.4
6. Section* Average - Bundle Booms (CCF/Section)	94.2	79.2	90.5	88
7. Section Average - Flat Rafts (CCF/Section)	42.5	58.4	53	51.3
8. Average Number of Sorts	7.3	10.5	18.3	12
9. Percentage of Annual Volume "Camp run" Output	13.6	0	0	2
10. Percentage of Annual Volume "Presorted" Input	18.5	6	0	3
11. Total Land Acres - Used	2.61	2.2	1.91	2.24
12. Total Water Acres - Used (Sorting, Booming & Storage)	36.36	81.8	187.9	102
13. Water Acreage - Sorting	3.37	6.9	16.67	9.0
14. Water Acreage - Booming	16.90	20.20	28.05	21.8
15. Water Acreage - Storage	15.56	56.35	142.57	71.5
16. Cunits Sorted/Sorting Acre	30,613	23,913	21,776	23,377
17. Cunits Processed/Booming Acre	6,105	8,168	12,942	9,696
18. Cunits Processed/Storage Acre	6,630	2,928	2,546	2,943
19. Average Cunits Stored/Storage Acre	258	582.5	402	414
20. Number of Men	16	24.1	32.3	24.1
21. Manhours/Year	27,296	39,584	84,815	50,565
22. Cunits/Manday	30.24	33.35	34.24	33.29
23. Pieces/Manday	56.24	55.58	67.14	62.12
24. Number of Sorting Machines	5.5	11.5	17.7	11.6
25. Pieces/Sorting Machine Hour	18.90	14.35	17.59	16.74
26. Annual Manhours/Sorting Machine Hour	2.68	2.07	2.10	2.17
27. Piece Average	0.54	0.60	0.51	0.54
28. Average CCF/Shift (Shift = 8 Hours)	477	818.9	1,065	832
29. Average Pieces/Shift (Shift = 8 Hours)	884	1,364.8	2,087	1,514
30. Operating Cost/CCF	$ 5.65	$ 5.33	$ 5.38	$ 5.41
31. Custom Sorting Cost/CCF	$ 1.38	-	-	$ 0.23
32. Ownership Cost/CCF	$ 1.15	$ 1.05	$ 1.25	$ 1.18
33. Total Cost/CCF	$ 8.18	$ 6.38	$ 6.63	$ 6.82
34. Total Cost/Piece	$ 4.42	$ 3.83	$ 3.38	$ 3.68
35. Total Capital Invested/Cunit	$ 8.88	$ 6.38	$ 7.77	$ 7.61

* A section is a portion of a floating log raft measuring 66 feet by 66 feet.

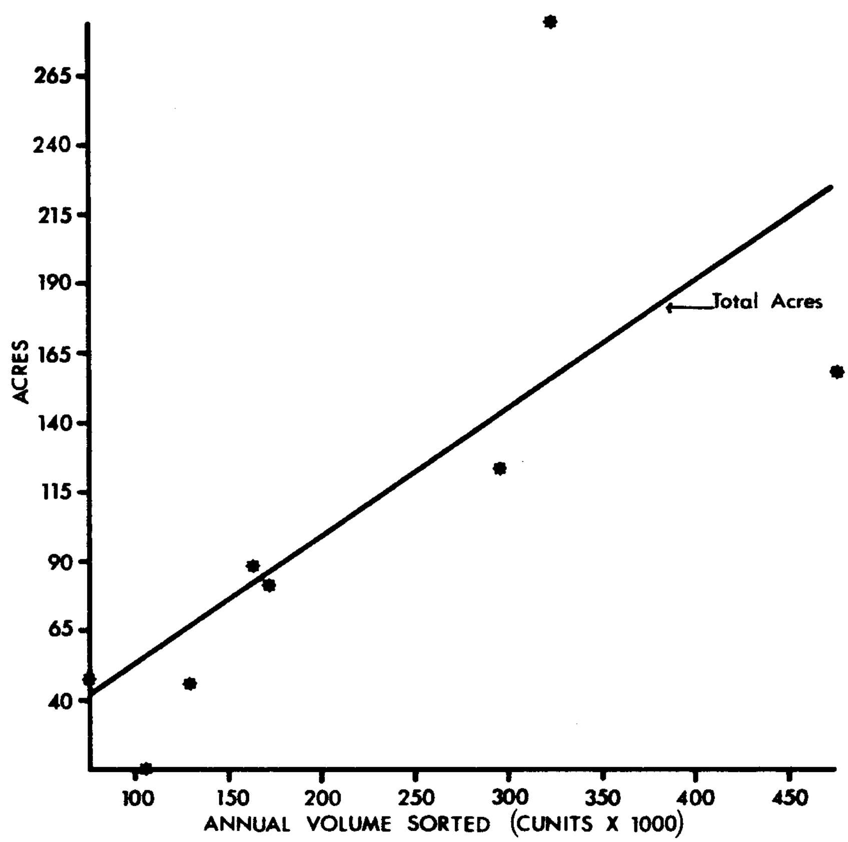

FIGURE G. Total water acreage increases with the volume sorted

Productivity per manday decreased and area required increased with the addition of extra log sorts. Bundling in the water also reduced productivity and required extra area. Cost per cunit also increased.

Section averages for bundle booms increased with the volume of wood in the bundle. Operations near a mill bundled fewer logs.

More water storage area was required when incoming logs were received by water and when logs were shipped by barge. Sorting grounds receiving logs one truckload at a time required less area than grounds receiving logs accumulated into bag booms. Floating log loaders are more efficient than boomboats and require less area.

Dryland Sortyards

The results for each size class of dryland sortyard were totalled and averaged (Table 4).

The land area required for sorting logs (those functions taking in unloading, spreading, grading, scaling, sorting, bundling and dumping) increased with the annual volume of logs sorted (Figure H). The volume sorted per acre also increased. The larger yards made more sorts than the smaller yards.

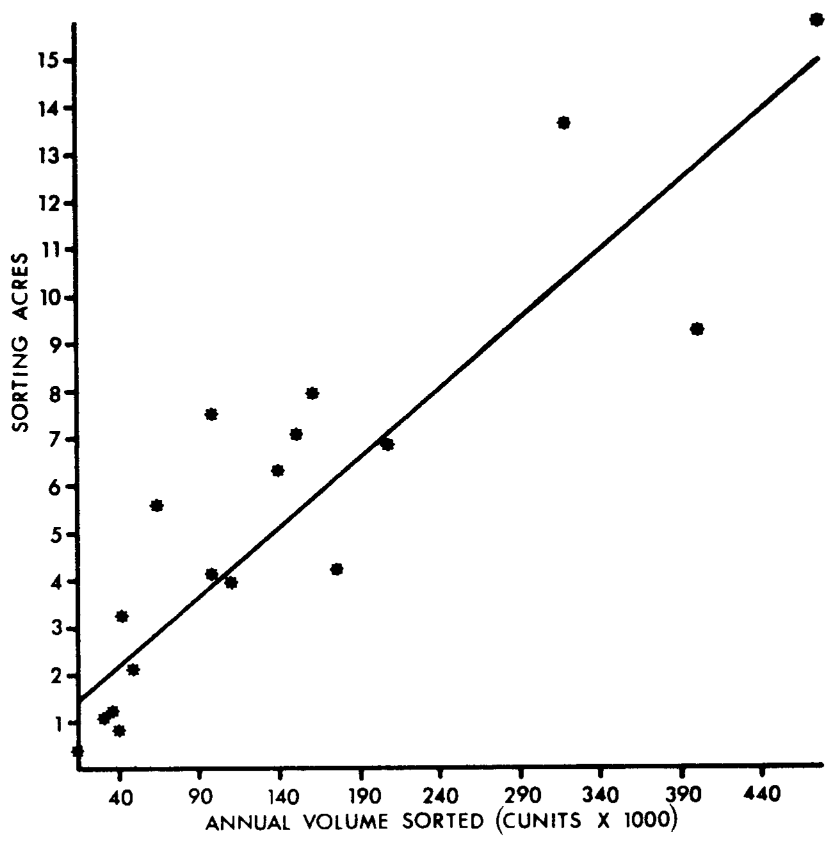

FIGURE H. Land sorting acreage compared with annual volume sorted

TABLE 4. Comparison Sheet of Dryland Sortyards-- All Size Classes and Overall Averages

Number in Sample	6	6	3	3	18
Size Class (CCF/Year)	0-60,000	61,000-160,000	161,000-260,000	261,000-500,000	All
1. Annual Volume (CCF)	34,167	112,667	182,333	401,333	182,625
2. Operating Shifts/Year (Shift = 8 hours)	199	225	252	398	268.5
3. Operating Hours/Year	1,590	1,802	2,013	3,181	2,147
4. Percentage of Annual Volume Bundled	93.7	83	99	99	96
5. Average Bundle Size Out (CCF/Bundle)	11.2	10.3	14.0	12.3	12.2
6. Section Average (CCF/Section) (Bundle Boom)	88.6	95.8	95	89	92.1
7. Average Number of Sorts	6.8	13	12.3	18	12.5
8. Percentage of Annual Volume "Camp run" Output	18.1	0	0	0	1
9. Percentage of Annual Volume "Presorted" Input	0	1	0	7	4
10. Total Land Acres Used	3.88	19.7	22.06	19.63	16.32
11. Land Acres - Sorting	1.48	5.8	6.3	13.02	6.65
12. Land Acres - Log Storage	0.73	10.1	13.36	4.07	7.07
13. Cunits Sorted/Sorting Acre	23,086	19,509	28,942	30,824	27,462
14. Cunits Sorted/Total Land Acre	8,806	5,719	8,265	20,445	11,190
15. Cunits Stored/Land Storage Acre	896	1,097	567	1,287	962
16. Boom Acres Used	5.49	9.97	9.78	20.77	11.50
17. Water Storage Acres Used	13.08	20.1	9.12	29.39	17.92
18. Cunits Processed/Boom Acre	6,223	11,301	18,643	19,323	15,880
19. Cunits Stored/Water Storage Acre	619	673	794	642	682
20. Number of Men	4.4	18.1	29.7	44.4	24.2
21. Manhours/Year	6,782	29,814	52,079	85,112	43,447
22. Cunits/Manday	40.30	30.23	28.01	37.72	33.63
23. Pieces/Manday	79.02	65.72	41.04	71.17	61.15
24. Number of Boomboats	1.1	2.3	2	3.7	2.3
25. Number of Sorting Machines	1.3	3.6	4.7	6	3.9
26. Cunits/Sorting Machine Hour	15.97	15.39	17.95	20.80	18.77
27. Pieces/Sorting Machine Hour	31.32	33.46	26.40	39.18	34.37
28. Annual Manhours/Boat & Sorting Machine Hour	1.89	2.62	3.37	3.22	3.06
29. Piece Average (CCF/Piece)	0.51	0.46	0.68	0.53	0.55
30. Average CCF/Shift (Shift = 8 hours)	172	501	723.5	1,008	680.2
31. Average Pieces/Shift (Shift = 8 hours)	337	1,089	1,064	1,902	1,236.7
32. Operating Cost/CCF	$ 6.76	$ 8.71	$ 8.29	$ 6.84	$ 7.49
33. Custom Sorting Cost/CCF	$ 0.87	$ 0.13	-	-	$ 0.06
34. Ownership Cost/CCF	$ 2.41	$ 3.41	$ 3.32	$ 2.54	$ 2.86
35. Total Cost/CCF	$10.04	$12.25	$11.61	$ 9.38	$10.41
36. Total Cost/Piece	$ 5.12	$ 5.64	$ 7.89	$ 4.97	$ 5.73
37. Rehaul Cost/CCF	$ 5.07	$ 2.74	$ 2.48	-	-
38. Total Capital Invested/Cunit	$14.73	$25.06	$21.82	$17.30	$19.50

The acreage required for sorting increased with the number of sorts. Figure I shows this relationship.

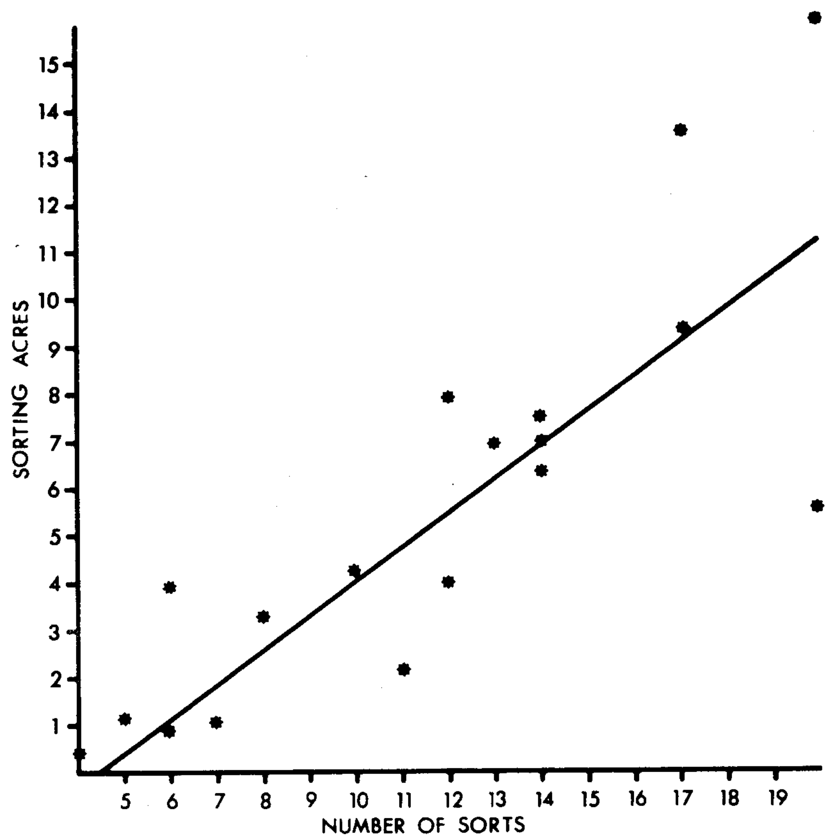

FIGURE I. Land sorting acreage compared with the number of log sorts

The volume of logs stored on land does not increase with the volume sorted because it is controlled by other factors such as mill requirements, booming ground capacity, and water transportation efficiency. Figure J shows the lack of consistency between volume sorted and storage area. An average of 960 cunits per acre was stored on land.

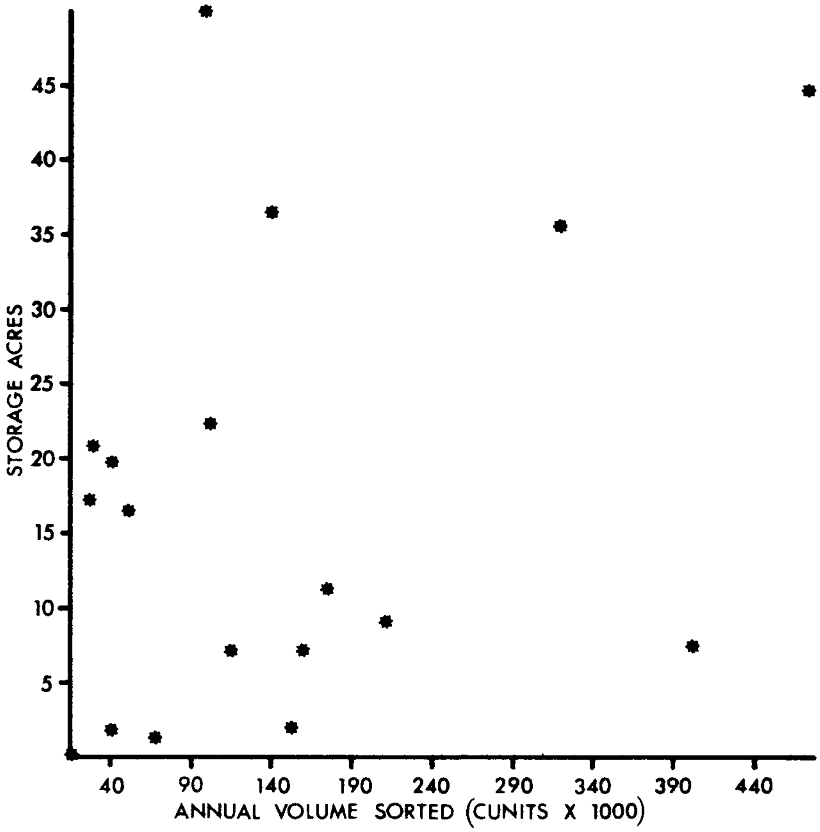

FIGURE J. Land storage acreage compared with volume sorted

The total water booming-ground area for the land sort increased as the volume sorted increased but so did the cunits boomed per water acre. The sortyards with limited water area and which assembled only one or two booms at a time had the highest rates for cunits boomed per booming ground acre (Figure K).

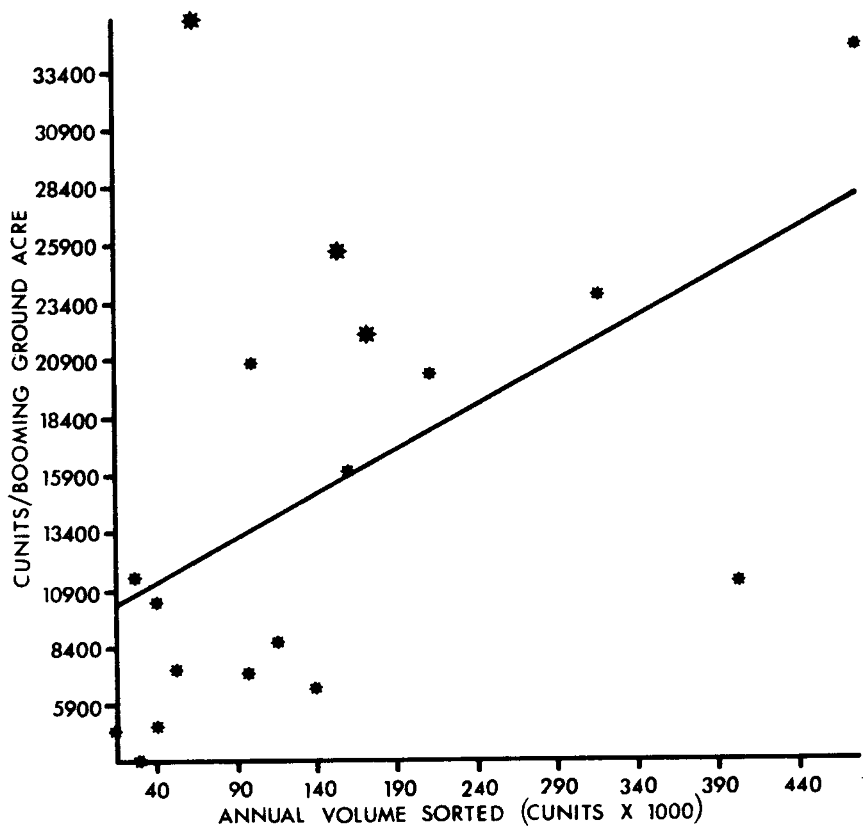

FIGURE K. Cunits processed per water-acre of booming ground compared with annual volume sorted. (Large asterisks indicate grounds with limited usable water.)

The land acres required for sorting increased with the pieces per shift sorted (Figure L). If the piece size on the B.C. Coast continues to diminish, sorting acreage will have to increase if cunit per shift production schedules are to be maintained.

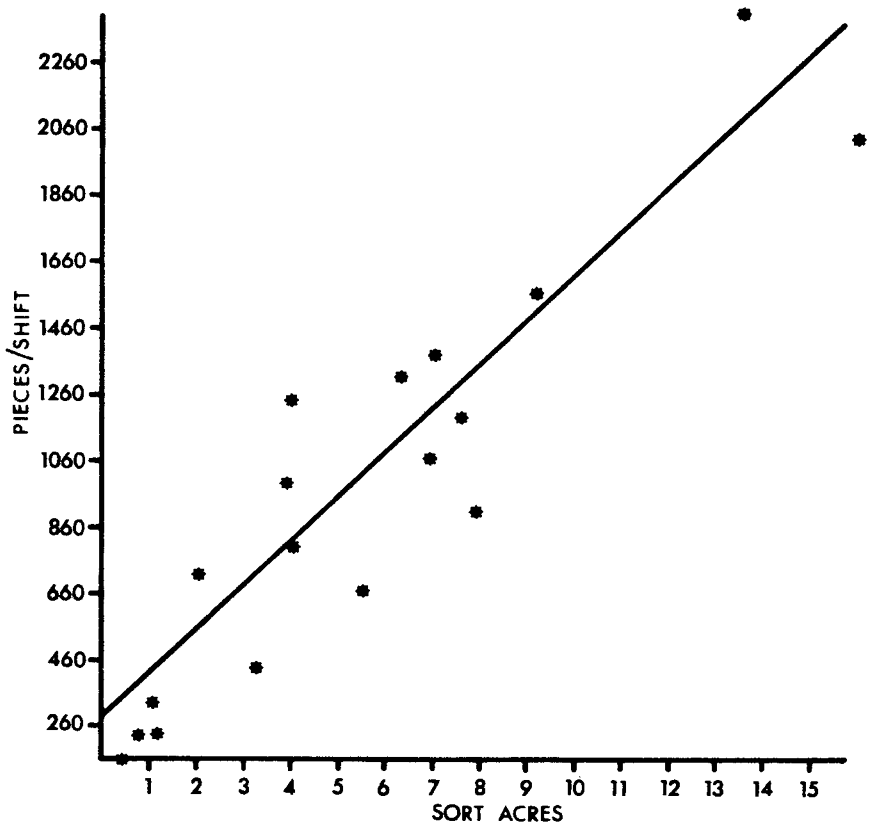

FIGURE L. Pieces processed per shift compared with land sorting acres. (Average piece size 55 cubic feet.)

The larger yards made more sorts than the smaller yards and had the lowest costs per cunit and the highest machine productivity. The smaller yards had the highest labour productivity.

Rehaul costs--or the costs of transporting logs from an inland dryland sortyard to tidewater for booming and shipment to end user--added from 21% to 50% to the total cost of sorting and booming.

Weigh scaling interfered less with the sorting process than stick scaling and resulted in greater labour and machine productivity and lower operating costs.

Yards that stored a significant number of logs on land had lower machine and labour productivities and higher costs. They also had lower rates for cunits processed per total land acre.

Comparison of Water Sorting Grounds with Dryland Sortyards

Tables 3 and 4 were combined into Table 5 so that the data and costs for water sorting grounds and dryland sortyards could be compared.

The average number of sorts, annual volume, operating shifts, cunits per shift and pieces per shift were nearly the same for both systems.

Dryland sortyards produce more bundled logs and therefore use less water storage area.

The volume of presorted logs entering--or unsorted logs leaving--is low for both systems. Both conduct a complete sort.

Dryland sortyards require less total land and water acreage in order to process the same volume of logs.

Both systems have similar labour productivity. The dryland sort has higher machine productivity, but because the machines and the facilities are more expensive, the total cost of sorting and booming using a dryland sort is 53% higher than for an all-water system.

TABLE 5. Comparison of Data and Costs Between the Average Water Sorting Ground and Dryland Sortyard

Data or Ratio	Average Dryland Sortyard	Average Water Sorting Ground
1. Annual Volume (CCF)	182,625	210,393
2. Operating Shifts/Year (Shift = 8 hours)	268.5	252.8
3. Piece Average (CCF/Piece)	0.55	0.54
4. Average Cunits/Shift (Shift = 8 hours)	680.2	832
5. Average Pieces/Shift (Shift = 8 hours)	1,236.7	1,541
6. Percentage of Annual Volume Bundled	96	48
7. Average Bundle Size Out (CCF/Bundle)	12.2	11.4
8. Section Average, Bundle Booms (CCF/Section)	92.1	88
9. Section Average, Flat Rafts (CCF/Section)	-	51.3
10. Average Number of Sorts	12.5	12
11. Percentage of Annual Volume "Camp run" Output	1	2
12. Percentage of Annual Volume "Presorted" Input	4	3
13. Total Land Acres Used	16.32	2.24
14. Total Water Acres Used	29.42	102
15. Cunits Sorted/Sorting and Booming Acre (Land and Water)	12,261	7,156
16. Average Cunits Stored/Water Storage Acre	682	414
17. Number of Men	24.2	24.1
18. Manhours/Year	43,447	50,565
19. Cunits/Manday	33.63	33.29
20. Pieces/Manday	61.15	62.12
21. Number of Boats	2.3	11.6
22. Number of Sorting Machines	3.9	-
23. Cunits/Boat Hour	-	9.04
24. Pieces/Boat Hour	-	16.74
25. Cunits/Sorting Machine Hour	18.77	-
26. Pieces/Sorting Machine Hour	34.37	-
27. Annual Manhours/Boat and Sorting Machine Hour	3.06	2.17
28. Operating Cost/CCF	\$ 7.49	\$ 5.41
29. Custom Sorting Cost/CCF	\$ 0.06	\$ 0.23
30. Ownership Cost/CCF	\$ 2.86	\$ 1.18
31. Total Cost/CCF	\$10.41	\$ 6.82
32. Total Cost/Piece	\$ 5.73	\$ 3.68
33. Total Capital Invested/CCF	\$19.50	\$ 7.61

KEY FACTORS AFFECTING COST AND EFFICIENCY

During field visits we observed factors which affected cost, efficiency, and area requirements.

Pieces and Piece Size

Although logging companies normally measure the performance of a sorting operation on the basis of volume, volume is actually less significant than the number of pieces. If the average piece-size drops, then the operation and equipment must work longer and use more area to process the same volume. A smaller piece size will also mean less volume per bundle of logs and lower storage volume per acre of water.

Supervisors at every yard commented that log sizes are diminishing each year. Smaller pieces will require more machines or more hours-per-machine to process the same volume. Costs per cunit will increase. A smaller piece size will mean that scalers will have to spend more time with the logs if accuracy is to be maintained.

Eventually, log uniformity may make it feasible to rely more heavily on weigh scaling. If smaller piece size is accompanied by more uniformity, then smaller and less expensive sorting machines can be used and the chances for successful mechanical sorting will improve.

Low Volume Log Sorts

The volume of logs in some sort categories is so low that it is not economical to sort them at the ground or yard adjacent to the logging operation. Often these sorts are for high-value grades of logs which would not ordinarily get adequate attention. Added investment in log inventory and storage area at the operation often costs more than custom sorting in a central location. Consequently, there will be a need for central water-sorting or land-sorting operations where low-volume or specialty log sorts can be made more economically and effectively.

Small Yards

Small yard production is controlled more by input to the yard than by capacity to process. High logging production may overstress the yard and logging delays may starve it. To achieve production efficiencies, the small yards must be small in area, and simple in sorting functions. The men must perform several sortyard jobs and the machines must be multifunctional and mobile. Figure M shows a small yard.

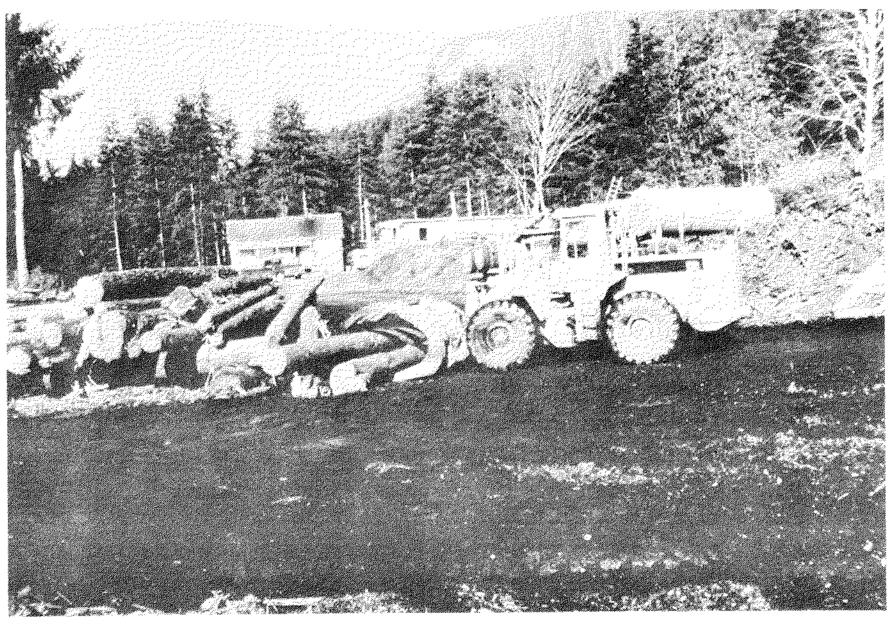

FIGURE M. Typical small dryland sortyard

Water and Land Storage

Comparing water storage with land storage involves several tradeoffs. The log transport system on the B.C. Coast is water-based. The water routes are closed at times because of storms and tides, so log storage is needed within the system and at both ends. Figure N shows a log storage ground for barges.

FIGURE N. Storage for barge shipment

The suppliers of logs do not always produce the volumes, species and grades users require. Consequently, log storage areas are needed to balance the supply and demand schedules.

Storage areas near mills are needed to eliminate the chance of weather delays and to give the mill the flexibility to choose the logs from its inventory to suit its current sales orders. Most B.C. Coast mills have no available land-storage facilities.

We found that water sorting grounds store 414 cunits of sorted logs per water-acre of storage ground, and dryland sortyards store 682 cunits of sorted logs per water-acre. The dryland sortyards store an average of 962 cunits of logs per land-acre.

The standing boom for an acre of water storage will cost about $9,000 for material and labour. The land for an acre of unpaved land storage will cost about $30,000 to develop. The capital costs (exclusive of land prices, foreshore leases, upland consents, etc.) average $16.42 per annual cunit per acre for water storage and $31.19 per annual cunit per acre for land storage.

Logs stored in water are subject to teredo attack, marine growth, and storm loss. Logs stored as flat rafts are subject to sinker loss. Logs in land storage suffer ambrosia-beetle attack, checking and fire risk and are also subject to breakage and downgrading as a result of mechanical damage from the machines. In addition, land storage creates debris and consequent debris-disposal problems.

Log Bundling

Many dryland sorts were installed simply to facilitate bundling. Log bundling greatly reduces log losses from sinkage and escape, and reduces towing costs and the area required for storage. Although it is possible to bundle logs in the water it is easier to bundle them on land and less area is required for the process.

Log Remanufacturing

Several dryland sortyards were actively involved in the remanufacture of logs. This is not practical with the present configuration of water sorting grounds. Most of the sortyards were only trimming ends and removing branches. This reduces mill operating costs but does not increase sortyard revenue significantly. A few sortyards had full-time buckers upgrading logs as well as trimming ends and removing branches. One progressive operation reported that by making only 20 to 30 upgrading cuts each day yard revenue increased as much as $2,000 per day. Figure O shows log remanufacturing in a dryland sortyard.

FIGURE O. Log remanufacturing

Area Restriction

Some of the water sorting grounds visited worked in areas restricted by local geography. In our analysis, these operations showed higher-than-average rates for cunits processed per acre of water, but lower labour and machine productivities and higher costs. If there is not enough area for sorting and booming for the volume to be processed at the site, then more men and machines have to be put into the area than would be efficient. In some cases of area restriction, unsorted logs are sent elsewhere for resorting. This relieves the pressure on the local site but increases it somewhere else.

Grade and Scale Information

There are four basic reasons for scaling logs in sorting operations:

1) to determine payments of stumpage and royalty to the Crown
2) to determine payments to logging contractors

3) to determine the volume and grade of logs for sale, trade or transfer
4) to determine divisional, departmental, or area production

In the past when the British Columbia Forest Service stick-scaled all production, their scale bills were used for log trading and log sales. The scale bills contained the grade and scale of all the logs in the boom. Weigh scaling does not provide such specific information.

From a log-handling point of view, weigh scaling is more efficient than stick-scaling. Fewer machines, fewer men and less area are required and the cost is lower.

Statistically and over a period of time, weigh scaling is as accurate as stick scaling.

Some of the companies that consume a large portion of their logs internally have converted to weigh scaling. Many companies, however, use two or three scaling systems in their operations to satisfy the log users.

The log-scaling function controlled the productive capacity in most of the operations. If the scaling function is rushed, the quality of scaling may diminish.

Presorting Before the Sorting Operation

Sorting operations are part of a total production and transportation system. Logging terrain, species distribution, and relative location of the parts of the total system determine the economics of presorting logs in woods landings. Presorting can reduce the areas required and the costs of final sorting.

If a bundle of presorted logs can be kept intact, it can be treated as an individual log in a sorting operation.

Presorting works best when there are predominant species or log grades in the timber resource, when landing construction costs are relatively low, and when quality control can be exercised over log sorting in landings.

CONCLUSIONS

1. Larger operations are more efficient and economical than smaller operations, considering that larger operations have more log sorts, more bundling, fewer presorted bundles and less weigh-scaling.

2. The area required for sorting increases with the number of sorts, the cunits and pieces processed per shift, the use of stick scaling, and the amount of batch processing. Presorting of log bundles or truckloads reduces the sorting area required.

3. The area of water required for storage increased when logs are received by water or shipped by barge or flat raft. Flat rafts require 72% more area than bundle booms for storage of the same volume.

4. The volume of logs stored at a dryland sortyard is less dependent on incoming volume than on mill requirements, booming ground capacity, and the water transport system used.

5. The capital costs of log storage on land are about twice the capital cost of $16.42 per cunit per acre for logs stored in the water.

6. Weigh-scaling interfered less with the sorting process than stick-scaling and it also resulted in greater productivity and lower costs.

7. Logs are scaled before sorting on the land and after sorting in the water. From a systems point of view, the difference in order of sequence of the scaling and sorting functions is the essential difference between water-sorting and land-sorting.

8. Land sortyards require less total water and land area than water sorting grounds. They cost more in all functions except operating labour. Because dryland sortyards bundle more production, fewer logs are lost as sinkers and this saving is the major economic justification for the sortyard. Other justifications include greater accuracy in scaling and sorting and reduced effects on the aquatic environment.

9. When a sortyard could not be located adjacent to a booming ground, the additional operating costs of rehauling were from $1.91 per cunit to $5.07 per cunit.

10. Water or land sorting area requirements are more dependent on pieces per shift than on volume per shift. If the piece size average continues to diminish on the B.C. Coast, more area will be required to process the same volume.

11. Log upgrading is not practical in water sorting grounds with their present configuration. As log values continue to increase, the capability to remanufacture logs is a significant benefit of the dryland sortyard.

We collected a large amount of data during this survey of 26 sorting operations. Only the factors relative to costs, productivities and area requirements are given in this report. Further reports from FERIC will discuss machine capabilities, operation techniques, and yard layouts, and will be of special interest to the operators and designers of sorting operations.

APPENDIX I

DETAILS ON PRODUCTIVITY AND COST CALCULATIONS

A. VOLUME INFORMATION

The field test work was done from August 15, 1979 to December 15, 1979. Production data collected were for the last complete year (1978). An exception to this was made in a few cases of new water sorting grounds or dryland sortyards which did not have complete or representative data for 1978. In these cases 1979 budgeted production data were used.

All other data collected (such as bundle sizes, section averages, percent volume bundled, etc.) were developed from current experience.

B. LAND AND WATER AREAS

Land and water areas were determined through the use of site maps and actual field measurements. Sub-areas used for different sorting functions were determined by physically measuring the sub-area.

Field drawings, site maps and modified site maps were planimetered using a Hewlett Packard 9845 computer and digitizer. Graphical plots were printed for each location by use of the computer's plotter.

Water depths in the various sub-areas of the water sorting grounds were determined from sounding maps or from the water sorting ground operators. Comments regarding the effect of tidal action, prevailing winds, storms and tides on the water sorting grounds were recorded.

C. MANPOWER

The standard staffing, the daily hours worked and the days worked per year were determined. Partially-staffed shifts and significant weekend work were taken into account.

Mechanics, rehaul truck drivers, maintenance supervisors, debris disposal contractors, custom sorting crews, outside tugboat crews and administrative or clerical staff were not included in determining the crew at a sorting operation. All other people associated with the operation, including contract and B.C. Forest Service scalers, were accounted for in the crew.

D. EQUIPMENT

All equipment used at a site for sorting and processing logs was identified. Contract debris disposal equipment, tugboats and rehaul equipment were not included. Log sorting equipment included boomboats, front-end loaders, hydraulic and cable log loaders and log stackers.

To determine machine operating hours we assumed that if an operator worked eight hours then the machine worked eight hours. Machines that worked for part of a shift (with an operator who did other work for the rest of the shift) were accounted for on a partial-shift basis. In-shift mechanical downtime and under utilization of machines were not accounted for. Spare machines were not included in the operating hours but their costs were accounted for in the ownership cost calculation.

E. OPERATING COSTS

Operating costs were subdivided into six classes. The classes used were operating labour, supervision, supplies and services, rehaul, custom-sorting, and equipment repairs. By class, the costs were based on

1. Operating Labour

   a) Hourly wages included fringe benefits at 30 percent of the existing December 31, 1979 I.W.A. rate. For example, the I.W.A. rate for a stacker operator was $10.78 per hour. The hourly wage charged to the job class was $10.78 x 1.3 = $14.01 per hour.*

*Shift differentials were not charged for two-shift operations.

b) Machine operators' wage rates included 0.7 of an hour, at overtime rates, for machine servicing. For example, the stacker operator's hourly rate for eight hours was calculated as:

$$\$14.01 \times 8 = \$112.08$$

$$\frac{\$112.08 + (0.7 \times \$14.01 \times 1.5)}{8} = \$15.85 \text{ per hour}$$

c) Overtime rates were at time and one-half. For example, the stacker operator's rate when working overtime was $14.01 x 1.5 = $21.02 per hour.

d) Local conditions, labour supply, etc. can result in different rates between locations for very similar jobs in the sorting operations. It was beyond the scope of the study to determine the different rates. The following rates were established and used consistently.

Job	Base Hourly Rate	Hourly Rate Used	Overtime Hourly Rate Used
Machine Operator	$10.78	$15.85	$21.02
Bundling	9.51	12.36	18.54
Hydraulic Auger Operator	10.01	14.72	19.52
Log Grader	10.45	13.59	20.39
Utility Man	10.23	13.30	19.95
Chargehand	11.00	14.30	21.45
Weighmaster	10.45	13.59	20.39
Scaler	11.82	15.37	23.06
Boom Man	9.61	12.49	18.74
Boring Machine Operator	9.71	14.28	18.93
Log Dump Operator	10.01	14.72	19.52
Boomboat Operator	10.01	14.72	19.52

The same scaling rate was used whether the scaler was employed by the company, by the B.C. Forest Service or by a scaling service. Chargehand rate was used only when it was evident the chargehand was supervising. Utilityman rate was used for buckers or when it was evident that an employee was in a utility role. No mechanic's time was charged directly to operating costs as mechanical labour costs appear in the equipment repair costs section. No differentiation was made in labour costs between head and second boomman, head bundler and bundler, etcetera.

2. Supervision Costs

A salary charge of $45,500 per year was charged for each person directly involved in supervising the yard or ground. No distinction was made between foremen, superintendents or managers. As long as a man was spending 100 percent of his time responsible for the yard or ground then the rate was charged.

No charges were made for divisional administration, head office allocations, clerical costs, maintenance supervision or warehouse wages.

3. Supplies and Services Costs

During our one- or two-day field visits the supplies and services used in the grounds were carefully noted. The charges applied to these supplies and services:

a) Bundling material

i) Steel banding (per Acme Steel)

- 10 cunit to 11 cunit bundles
- 2 bands per bundle
- 2 long or 3 short seals per band
- no recycling

Width	Thickness	Cost/Cunit Bundled
1¼"	0.050"	$0.66
1¼"	0.057"	$0.71
1¼"	0.065"	$0.80
2"	0.044"	$0.87
2"	0.050"	$0.96
2"	0.065"	$1.22

ii) Continuous wire (per Tree Island Steel)

- 10 to 11 cunit bundle
- two seals per wire
- two wires per bundle
- three trips per wire before wire is discarded

Diameter	Wraps	Cost/Cunit Bundled
9/32"	Single wrap	$0.33
9/32"	Double wrap	$0.55
3/8 "	Single wrap	$0.57

iii) Bundle wires (per Jack Pacey, C.F.P.)

- bundle average is 17 cunits.
- the costs used are the actual costs incurred and reflect initial cost, shrinkage, repairs, handling and transportation. Costs are for a 5/8 inch wire and two wires per bundle.
- costs are $0.387 per cunit bundled.

b) Swifters

i) Swifter logs

After discussions with log trading managers it was decided not to charge any material costs for swifter logs. The managers felt that premiums were not paid for swifter logs.

ii) Swifter wires

Jack Pacey of Canadian Forest Products estimated a cost of $0.107 per cunit for supply, shrinkage, culling, and transportation of swifter wires.

On West Coast-style booms a 50 percent premium was added to the $0.107 per cunit for heavier gear--(heavier swifter wires, more wires, lag bolts, clamps, and brackets).

c) Boomchains

Jack Pacey of Canadian Forest Products estimated a cost of $0.299 per cunit for boomchains. The cost included initial purchase, transportation, culling and shrinkage.

d) Chainsaws

When chainsaws were used on a regular basis in a sortyard they were charged at $20 per day per saw. This rate was suggested by Pacific Equipment.

Chainsaws were not charged for in the sorting grounds as they were not used as much per day as in sortyards.

e) Personal and Safety Gear

A charge of $200 per man per year was made to cover personal, safety and miscellaneous supplies used by the crew.

f) Electricity

Where applicable the rate charged for the smallest users was $100 per month but rates varied up to $1,800 per month for the largest users. Whenever the annual charge was significant actual costs were checked.

g) Log Marking

The spray paint used in the yards and grounds was accounted for. Charges were based on annual pieces sorted or annual volume processed, whichever was more appropriate.

If chalk was used for log marking, an allocation of 2,000 per year was made.

If log tags were used for log marking or identification then a charge of either $0.01 or $0.02 per tag was made. The rate used depended on the type of tag used in the operation.

h) Sortyard Surface Repairs

i) Asphalt surfaces

A charge of $2,000 per acre per year was made at asphalted yards for asphalt repairs. The rate reflected the average experience in the yards visited.

ii) Gravelled surfaces

A charge of $1,100 per acre per year was made at yards that had gravel surfacing. The charge was made to cover the costs of ongoing repairs and annual resurfacing.

i) Repair Material--Standing Booms

Depending on the size of the boom, the annual volume processed and teredo infestation experience, we estimated the quantities of sticks, piling and dolphins that would be replaced annually. Sticks were charged at $150 each and other charges added if significant.

j) Debris Disposal

Debris-disposal costs were allocated at $0.35 per cunit of logs sorted unless special local conditions applied. For example, a longer haul to a landfill site raised the charge to $0.45 per cunit, use of open, pit or pipe burning reduced the charge to $0.20 per cunit and in unique situations the actual costs were charged.

k) Dredging

The level of dredging-cost allocations was based on the volume of logs dumped and on the water depth at the dump. If special conditions existed then actual costs were used. The basic allocation was $5,000 per year for the smaller operations and $15,000 per year for the larger operations.

l) Weigh Scale Repairs

A basic annual charge of either $2,000 per set of load cells or $3,000 per scale was made for servicing and repair of equipment and associated printing and readout units.

m) Trailer Reloads Repairs

A basic charge of $500 per year per reload was made for repairs to trailer reloads.

n) Repairs to A-frame Dumps or Dump Ramps

Depending on the size and complexity of the dumps and the volume dumped per year, we made a charge of $2,000 to $30,000 per year.

o) Repair Marine Railway

Marine railway systems were charged $30,000 for repair parts and materials and line costs. Operating costs for fuels and lubricants were charged in the equipment repair cost section.

p) Repair Materials and Labour for Weigh Bunks and Sorting Bunks

A charge that varied from $1,000 to $30,000 per year was made. The amount of the charge depended on the type of bunk, the number of bunks and the volume processed through the bunks.

q) Mobile Augers

If a mobile auger was used in a yard then it was charged to the operation at Truck Loggers Association (TLA)-suggested rates for a skidder (less operator wages and profit margin). The rate was applied to the number of hours used annually for boring sticks. No attempt was made to account for the age and variety of equipment used.

Operator wages for this function and others he might perform were accounted for in the operating labour section.

r) <u>Sorting Table Repairs</u>

For yards using a log sorting table a charge of $70,000 per year was allocated for repair material, labour and supplies.

s) <u>Poly Rope</u>

Some of the booming grounds used poly rope as temporary swifters. When these were used (and depending on the volume of logs processed), we applied a charge that varied from $2,000 to $10,000 per year.

t) <u>Repairs to Pile Driver</u>

Some of the sorting grounds with dolphins had their own pile drivers for repairs to the standing boom. An operating and repair charge for the pile driver of $5,000 per year was applied.

u) <u>Costs Not Included</u>

The costs not included:

> i) <u>Isolation costs</u> - The extra work hours and fringe benefits required to attract workers to isolated sorting operations were not included.
>
> ii) <u>Crew transportation</u> - No allowances were made for the cost of transporting the crew or travel time labour costs.
>
> iii) <u>Foreshore leases</u> - No allowances were made for foreshore lease costs or for the cost of controlling the upland. These costs can be significant, particularly on the lower coast of B.C.
>
> iv) <u>Camp costs</u> - The costs of building and operating a camp for the workers was not included in the cost analysis. Operating costs of a camp may be $30 per manday.
>
> v) <u>Administration costs</u> - Overhead charges for accounting, warehouse supervision, maintenance supervision, computer services, log trading and divisional management were not included.

vi) Cutoffs

Certain boundaries or cutoffs were made when the costs of operation of the yards and grounds were established. Costs were accounted once the logs arrived at the yard or ground. That is, no costs were charged for pre-sorting, for pulling truck-binders. We stopped accounting for costs when the boom was ready to be towed to storage. This last cutoff was difficult to identify.

4. Rehaul Costs

A cost was included for the yards that hauled sorted logs from the yard to tidewater. TLA-suggested rates for logging trucks were used and the rates chosen reflected the truck sizes used on the rehaul. We determined the number of trucks and the hours operated per truck in the field visits. The operating hours and the appropriate rate were combined to calculate the cost of the rehaul.

For railway rehauls we used the actual operating cost per cunit in 1978, plus a capitalized rolling-stock cost to determine the total cost of the rehaul.

Road and railbed construction and maintenance costs were not included in the calculation of rehaul costs.

5. Custom Sorting Costs

When a yard or ground had a significant volume of logs sorted or bundled at another location we applied a custom sorting charge. The charge applied was an average of what the custom-sorting grounds are charging. For sorting ten ways and booming, a charge of $4.43 per cunit sorted and boomed was used. An end charge of $2.92 per cunit was used for sorting two ways and bundling.

6. Equipment Operating & Repair Costs

The equipment operating and repair costs used are the average costs that will occur over the life of the machines. The use of average costs avoided the problem of comparing operations with machines of different ages. The average equipment costs were established in meetings with Westcoast Salvage, Wajax Equipment and Finning Tractor. The Caterpillar Performance Handbook was used for fuel and lubricant consumption. Butler Tire gave estimates of tire costs under different operating conditions. MacMillan Bloedel, B.C. Forest Products and Canadian Forest Products supplied cost information on fuel and consumables usage. The averages used for equipment operating and repair costs are shown in Table A-1.

TABLE A-1. EQUIPMENT OPERATING & REPAIR COSTS USED IN THE ANALYSIS

Machine Type	R & M Parts & Supplies ($/Hr)	Fuel ($/Hr)	Lubes Greases Supplies ($/Hr)	Tires ($/Hr)	Grapple Repairs ($/Hr)	Total Cost ($/Hr)
Sidewinder	3.01	2.74	-	-	-	5.75
Dozer Boat	4.44	3.95	-	-	-	8.39
Swifter Winch	0.75	1.52	0.10	-	-	2.37
Double-ended Bundler	2.50	3.04	-	-	-	5.54
Single-ended Bundler	1.75	3.04	-	-	-	4.79
Boomstick Borer	0.50	1.00	0.25	-	-	1.75
235 Size Log Loader						
paved yard	21.58	5.32	1.17	-	9.23	37.30
unpaved yard	22.59	5.32	1.17	-	9.23	38.31
245 Size Log Loader						
paved yard	31.98	6.84	1.50	-	9.23	49.55
gravelled yard	33.48	6.84	1.50	-	9.23	51.05
L90 Size Stacker						
paved yard	18.72	4.85	0.82	4.19	1.48	30.06
gravelled yard	21.34	4.85	0.82	6.00	1.48	34.49
mud yard	21.34	4.85	0.82	9.87	1.48	38.36
L120 Size Stacker						
paved yard	21.30	6.46	0.90	7.58	1.48	37.72
gravelled yard	24.27	6.46	0.90	9.33	1.48	42.44
mud yard	24.27	6.46	0.90	15.34	1.48	48.45
2694 Size Stacker						
paved yard	14.20	5.32	0.82	4.19	1.48	26.01
gravelled yard	14.20	5.32	0.82	6.00	1.48	27.82
mud yard	14.20	5.32	0.82	9.87	1.48	31.69
2794 Size Stacker						
paved yard	30.89	6.08	0.90	7.58	1.48	46.93
gravelled yard	30.89	6.08	0.90	9.33	1.48	48.68
mud yard	30.89	6.08	0.90	15.34	1.48	54.69
966 Size Front-end Loader						
paved yard	10.88	3.80	0.48	2.21	1.94	19.31
gravelled yard	12.78	3.80	0.48	3.26	1.94	22.26
mud yard	12.78	3.80	0.48	5.36	1.94	24.36
980 Size Front-end Loader						
paved yard	13.07	5.32	0.56	3.69	1.94	24.58
gravelled yard	15.41	5.32	0.56	5.12	1.94	28.35
mud yard	15.41	5.32	0.56	8.43	1.94	31.66
988 Size Front-end Loader						
paved yard	16.54	8.36	0.74	4.28	1.94	31.86
gravelled yard	19.52	8.36	0.74	6.09	1.94	36.65
mud yard	19.52	8.36	0.74	10.03	1.94	40.51
Banding/Watering Truck	1.00	0.45	-	0.25	-	1.70
A-Frame Dump & Marine Railways	-	4.31	-	-	-	4.31

7. Ownership Costs

Ownership costs were subdivided into equipment and facility costs.

a) Equipment Costs

Finning Tractor, Wajax Equipment and Westcoast Salvage assisted us greatly by estimating what the loss in resale value and what the economic life of their equipment would be under various working conditions. From these estimates an annual ownership cost was calculated for the equipment. The formulae used:

i) Annual cost of loss in resale value[1]

$$R = \frac{P - T}{Y}$$

where:

R = annual cost of loss in resale value
P = initial purchase price (taxes included)
T = trade-in value
Y = the years for trade-in value to be reached

ii) Annual cost of interest and insurance

$$I = \left(\frac{P + T}{2}\right) \frac{i}{Y}$$

where:

I = annual cost of interest and insurance
P = initial purchase price (taxes included)
T = trade-in value
Y = years until trade-in value reached
i = interest and insurance costs expressed as a percentage (15%)

Use of the formulae gave the following equipment ownership costs.

[1] Does not allow for any recapture of Capital Cost Allowance.

TABLE A-2. Annual Equipment Ownership Costs

Machine Type	Annual Cost of Loss in Resale Value	Annual Interest & Insurance Cost	Annual Ownership Cost
Sidewinder	$ 5,646	$ 3,105	$ 8,751
Dozer Boat	8,323	4,578	12,901
Swifter Winch	2,500	1,125	3,625
Double-ended Bundler	8,333	3,750	12,083
Single-ended Bundler	5,833	2,625	8,458
Boomstick Borer	1,667	750	2,417
235 Size Log Loader			
single shift	46,550	38,903	84,453
double shift	106,400	35,910	142,310
245 Size Log Loader			
single shift	61,833	51,675	113,508
double shift	141,333	47,700	189,033
L90 Size Stacker			
single shift	26,989	33,833	60,822
double shift	55,520	31,230	86,750
L120 Size Stacker			
single shift	33,056	41,438	74,494
double shift	68,000	38,250	106,250
2694 Size Stacker			
single shift	32,744	41,048	73,792
double shift	67,360	37,890	105,250
2794 Size Stacker			
single shift	40,841	51,197	92,038
double shift	84,016	47,259	131,275
966 Size Front-end Loader			
single shift	19,367	16,185	35,552
double shift	44,267	14,940	59,207
980 Size Front-end Loader			
single shift	29,750	24,863	54,613
double shift	68,000	22,950	90,950
988 Size Front-end Loader			
single shift	42,583	35,588	78,171
double shift	97,333	32,850	130,183
Banding/Watering Truck	1,333	900	2,233

When a machine worked more than an eight-hour shift, its annual ownership cost was increased proportionately. Spare machines were charged to the operation at the single shift rate.

b) Facility Costs

All facility costs were at current replacement values. Facilities were normally charged standard costs. The standard costs were established from actual cost data supplied by manufacturers and installation contractors of new facilities. Actual constuction costs, adjusted for inflation, were used for recently constructed operations.

Annual costs were established by writing off site preparation costs over fifty years and all other facility costs over 15 years.

The standard costs used for facilities:

i) Asphalt surface and crushed base course

- site near asphalt plant: $65 per yard of asphalt in place
- site distant from asphalt plant or asphalt plant moved onto site: $85 per yard of asphalt in place
- soil cement: $83,000 per acre

ii) Sorting grounds

- anchor and line standing boom: $400 per stick used in the standing boom
- dolphin boom $600 per stick used in the standing boom and pilings

iii) Site preparation

- blasting job: $40,000 per acre
- fill job: $60,000 per acre
- cut and fill job: $30,000 per acre
- cut and fill job on old site: $20,000 per acre
- clear and expand on old site: $10,000 per acre

iv) Railway spurs and major access roads

- at actual construction cost plus inflation at 10 percent per year

v) Debris burners

- pit burner: $60,000
- FERIC pipe burner: $10,000

vi) Trailer reload

- installed cost: $15,000

vii) Bunk scales, load cells and truck scales (installed)

- bunk scales and printer: $40,000
- 100-ton platform scale and printer: $60,000
- 175-ton platform scale and printer: $90,000
- load cell and printer: $4,000

viii) Sorting bunks

- 6-cunit size: $5,000 per set
- 8-10 cunit size: $7,000 per set
- 16-18 cunit size: $15,000 per set

ix) A-frame dumps

- A-frame dump for off-highway logging trucks: $150,000
- A-frame dump for highway logging trucks: $100,000

x) Night lighting

- the charge allocated varied with the amount of lighting and ranged from $10,000 to $50,000 for sites with lights for night operation.

xi) Dump ramps

- $2,000 to $70,000 was charged per dump ramp site, depending on the type and whether or not a tripping-bunk was involved.

xii) Compressor, hoses and crimpers

- $3,000 to $5,000, depending on the number of crimping stations required to seal the steel bands or continuous wire

xiii) Offices, buildings, shops, etc.

- $5,000 to $50,000 was allowed depending on the type and number of buildings.
- A facility cost was charged for a shop only if the shop was used entirely for servicing the sorting equipment. The charge varied with the size and quality of the shop.

xiv) Water piping systems

- A standard cost of $15,000 to $50,000 was applied depending on the size of the system. Water supply, ambrosia beetle control, fire protection and dust suppression systems were included.

xv) Special marine equipment

Pile drivers were treated as a facility cost and charged at $35,000.

Old log loaders that were used for deadhead recovery were charged at $60,000.

Breakdown floats used for loosening bundle wires were charged to the facility at $25,000 each.

Submersible scaling grids used for sample scaling were charged at $87,000 each.

8. <u>Total Costs</u>

$$
\begin{aligned}
\text{Total costs} = {} & \text{operating labour} \\
& \left.\begin{array}{l} + \text{ supervision costs} \\ + \text{ supplies \& services cost} \\ + \text{ equipment repair costs}\end{array}\right\} \text{operating costs} \\
& + \text{ custom sorting costs} \\
& \left.\begin{array}{l} + \text{ equipment costs} \\ + \text{ facilities costs}\end{array}\right\} \text{ownership costs}
\end{aligned}
$$

Rehaul costs were not included in total costs. It was decided to present them separately.

9. <u>Total Capital Invested</u>

The equipment and facilities costs that were annualized to establish an ownership cost were also added to determine the total capital invested in the sorting operations. The total capital invested was divided by the annual cunits processed to determine a ratio that measured the capital investment required to process a given volume of logs by the various sorting systems.

APPENDIX II

METRIC CONVERSION

1 cm (centimetre)	0.39 inch
1 m (metre)	3.28 feet
1 km (kilometre)	0.62 mile
1 ha (hectare)	2.47 acres
1 m^3 (cubic metre)	0.353 cunit