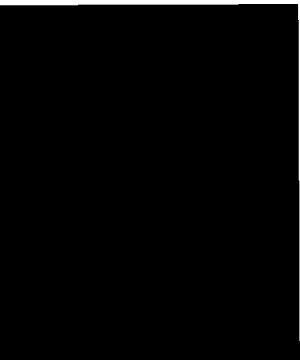




STATUS *of* TIMBER UTILIZATION on the PACIFIC COAST



John B. Grantham

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ABSTRACT

The need for additional sources of energy and **raw** material in the forest products industry enhances the opportunity to improve timber utilization by reducing logging residue. This is particularly true on the Pacific Coast where some 14 million tons of logging residue accumulate each year and where some 3 million tons of unused bark create a disposal problem at mills.

The need to replace natural gas and **oil** to generate process steam or for drying with hot gases has given impetus to improved wood and bark combustion to provide needed energy without violating air quality standards. Cylindrical furnaces burning finely ground (minus 1/8 inch) bark or wood are being installed for lumber and veneer drying. New emission control systems and predriers are being adapted to fire large furnaces with wood or bark.

The projected **annual** growth rate of 5 percent in U. S. and world pulp production has focused attention on forest residues as a source of fiber. Recent increases in chip prices **help** offset the high cost of **logging** residue, particularly if former disposal costs are credited to residue removal.

Changes in timber **sale** procedures to facilitate more complete timber utilization are considered essential. Such proposed changes as negotiated lump sum sales, service contracts, and compound contracts are described briefly to indicate types of sale modifications that have been proposed.

In summary, more complete timber utilization on the Pacific Coast may:

- (1) Add substantially to the available raw material supply--8.4 million tons additional raw material annually.
- (2) **Add** another energy source to that currently available as mill residue--4.0 million bone-dry tons for fuel annually.
- (3) Protect thin soils by restricting or eliminating the amount of slash burning required.
- (4) Decrease air pollution by reducing the **required** amount of slash burning.
- (5) Reduce the debris that could interfere with streamflow and affect water quality.
- (6) Improve scenic values by reducing visible debris.
- (7) Improve recreational opportunities by providing easier access and a more acceptable environment.
- (8) Reduce public criticism of land management policies and much of the basis for public pressure to restrict clearcutting.

KEYWORDS: Residues, logging residue, mill residue, timber utilization (- enterprise economics).

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ACKNOWLEDGMENTS

So many individuals helped the writer gain an overview of timber utilization on the Pacific Coast that any listing might omit some. However, the organizations that were especially generous in arranging visits, sharing experience, or in reviewing the initial draft of the report are listed below. The writer expresses sincere appreciation to the staff members of each for their contributions.

Bauman Lumber Company
British Columbia Forest Products, Ltd.
British Columbia Forest Service
Crown Zellerbach Corporation
MacMillan Bloedel, Ltd.
Mayr Brothers **Logging** Company, Inc.
Pacific Northwest Forest & Range Experiment Station
Pacific Northwest Region--National Forest System
Potlatch Forests, Inc.
Scott Paper Company
U. S. Forest Products Laboratory
Western Forest Products Laboratory, Canadian
Forestry Service
Weyerhaeuser Company

INTRODUCTION

Pressures are mounting for improved disposal of all residues, for greater national self-sufficiency in energy, and for more judicious use of our natural resources. These facts provide added incentives to improve timber utilization by reducing logging residue.

The Pacific Coast, in particular, has the need and the opportunity to emphasize more complete timber utilization. Here, harvesting the heavy stands of large, overmature timber on steep ground leaves immense quantities of wood and bark for subsequent disposal. Highly defective trees and steep, broken terrain can combine to produce heavy breakage and tremendous concentrations of debris.

This scenic region attracts a multitude of visitors, while its steepness increases the visibility of debris on cutover land. The combination tends to magnify the residue problem.

Fortunately, there are compensations. The Pacific Coast has major industries which depend largely or entirely on mill residue for raw material. The region's pulp industry obtains more than 85 percent of its raw material (1.1 million tons annually) from residue, and the board industry produces over 2 million tons annually of particleboard, insulation board, and hardboard entirely from mill residue. Both industries anticipate strong growth and will be seeking new raw material sources. Both, particularly the pulp industry, have the ability to effectively use substantial quantities of residue for energy production.

An overview of harvested timber flow on the Pacific Coast is given in figure 1 and table 1. The recent upturn in world pulp and paper demand and the strength of the domestic particleboard market are having a favorable effect on mill residue use but have had less impact on logging residue.

It is the aim of this paper to indicate the quantities and characteristics of logging and unused mill residues on the Pacific Coast and to point out changes or opportunities for more complete use of the forest resource. Because of the relatively greater quantities and problems associated with logging residue, the main emphasis will be on that material rather than on mill residue.

The report is directed primarily to those who are concerned with reducing logging residue to improve forest land management--and to supply added raw material in the process.

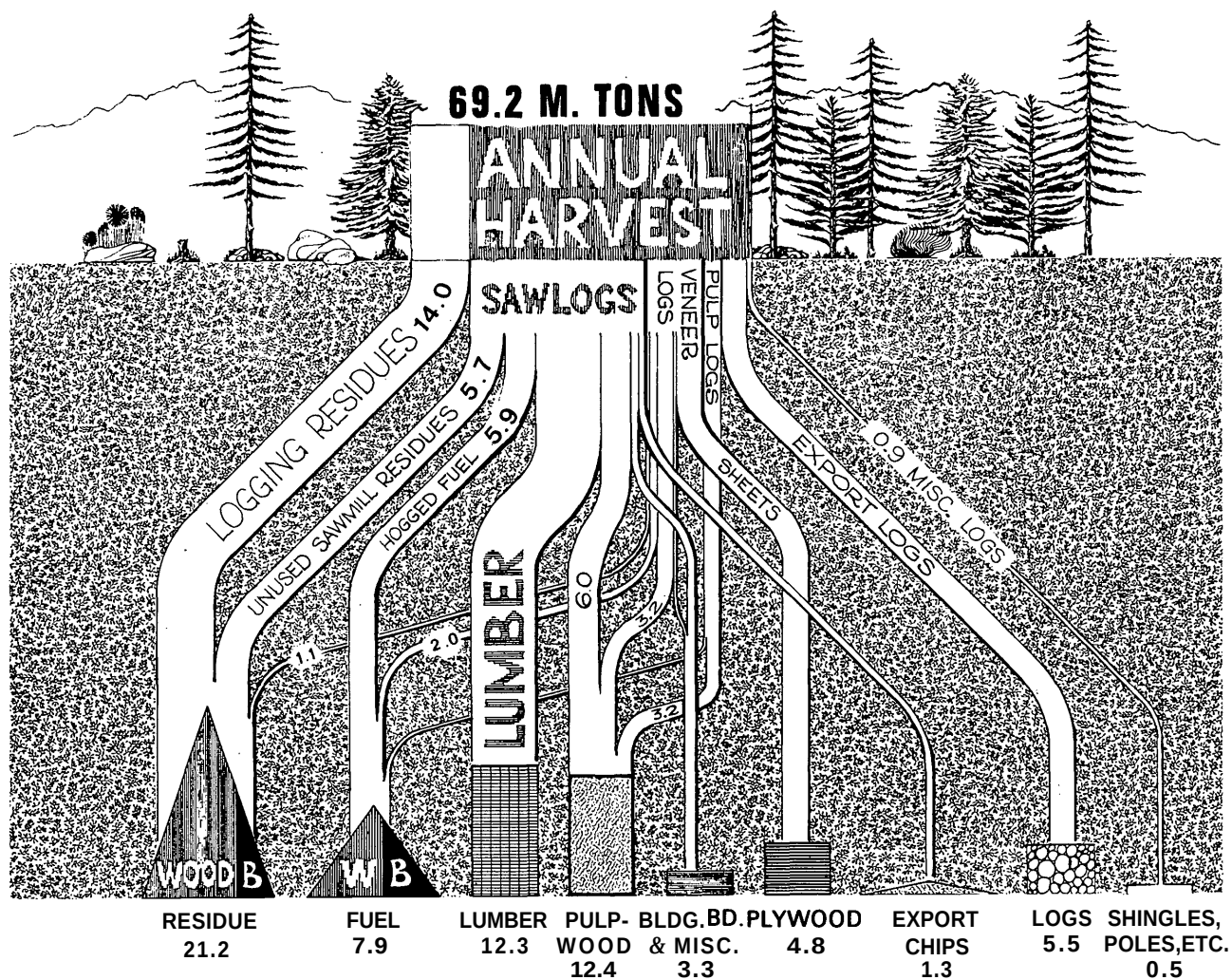


Figure 1.--Disposition of the timber harvest on the Pacific Coast in millions of bone-dry tons, 1968. Residue and fuel include wood and bark. Residue also includes 0.4 million tons of unused residue from manufacture of shingles, pilings, etc.

Table 1.--*Approximate material balance for Pacific Coast
Log production, 1968*
(Millions of bone-dry tons)

Item	Weight
Log production ^{1/}	55.14
Apparent log use	
Lumber	33.44
Veneer	12.10
Export	5.47
Pulp	3.22
Shakes and shingles	.71
Poles and piling	<u>.19</u>
Total	55.13
Output from lumber and veneer logs	
Lumber ^{2/}	12.25
Plywood ^{3/}	4.78
Pulp chips, etc., from residue	13.70
Fuel from residue	7.90
Unused mill residue	<u>4/6.90</u>
Total	45.53

^{1/} Logs are estimated to weigh 2.5 tons per thousand board feet, net Scribner scale, including defective wood and bark.

^{2/} Finished lumber is estimated to average 0.75 bone-dry ton per thousand board feet, lumber tally.

^{3/} Plywood 3/8 inch thick is estimated to weigh 0.425 bone-dry ton (exclusive of glue) per thousand square feet.

^{4/} Another 0.4 million tons of residue was developed in the manufacture of shingles, shakes, poles, and piling.

QUANTITIES AND CHARACTERISTICS OF WOOD RESIDUE AVAILABLE

Mill Residue

Detailed studies of mill residue development and disposition in California (Barrette et al. n.d.), Oregon (Manock et al. 1970), and Washington (Bergvall and Gedney 1970) have been made for the year 1968. Findings of these studies were used to summarize the types and quantities of unused mill residues available on the Pacific Coast in 1968 (table 2) and to reveal the overall disposition of mill residues in the region during that year (table 3). Since the general situation concerning log, lumber, and plywood production on the Pacific Coast remains rather stable, the 1968 illustration of wood flow in the region is still appropriate except for the substantial increase in mill residue use.

Table 2.--*Characterization of unused mill residue on the
Pacific Coast, 1968*
(Thousands of bone-dry tons)

Location and industry source	Wood			Bark
	Coarse ^{1/}	Medium ^{2/}	Fine ^{3/}	
California ^{4/}				
Veneer and plywood	73	--	6	113
Lumber	823	309	787	1,053
Other	--	--	5/3	1
Oregon ^{6/}				
Veneer and plywood	244	--	35	434
Lumber	463	176	602	908
Shake and shingle	28	--	60	40
Washington ^{7/}				
Veneer and plywood	89	--	4	104
Lumber	135	91	171	232
Shake and shingle	69	--	125	94
Total	1,924	576	1,793	2,979

^{1/} Veneer trim, cores, and panel trim from plywood plants; slabs, edgings, and trim from sawmills.

^{2/} Planer shavings.

^{3/} Sanderdust from plywood plants; sawdust.

^{4/} From Barrette et al. (n.d.).

^{5/} Source and class of residue not specified.

^{6/} From Manock et al. (1970).

^{7/} From Bergvall and Gedney (1970).

Table 3.--*Disposition of mill residue produced on the Pacific Coast, 1968*^{1/}

Disposition	Millions of bone-dry tons
Residue to pulp production:	
To export pulp chips	^{2/} 1.3
To domestic pulp from sawmills	6.0
To domestic pulp from plywood production	<u>3.2</u>
Total	10.5
Residue to building board production:	
From sawmills	1.4
From plywood production	<u>.3</u>
Total	1.7
Residue to fuel:	
From and at sawmills	5.9
From and at veneer and plywood plants	<u>2.0</u>
Total	7.9
Residue to miscellaneous use:	
Total	1.6
Residue unused:	
Wood	4.3
Bark	<u>3.0</u>
Total	7.3
All mill residues	^{3/} 29.0

^{1/} From Barrette et al. (n.d.), Manock et al. (1970), Bergvall and Gedney (1970).

^{2/} From Holt (1973).

^{3/} Includes 0.4 million tons of residue from shingle, shake, pole, and piling production.

Estimates of residue use for building board, domestic pulp, and export pulp chips during the period 1968-72 (table 4) indicate that all unused wood residue developed in primary manufacturing as recently as 1968 should have found an outlet. The picture, however, is clouded by the glut of mill residue that occurred during the period of high lumber and plywood prices in 1972-73--when processing of low-grade logs resulted in excessive quantities of mill residue. Also, pulp chips from British Columbia are available by barge to pulpmills on Puget Sound and at least one firm brings in chips from Idaho.

Many sawmills and veneer plants of the region have a bark disposal problem, and because of location, some have a sawdust disposal problem, even though all chippable wood is salable. Tighter air quality standards and increasing restrictions on land fills add to the severity of disposal problems. Thus, although this analysis emphasizes ways to encourage and facilitate the use of logging residue, there is a continuing need to find outlets for unused mill residue at remote locations.

Table 4.--*Consumption of residue for domestic pulp and building board production and for export chips, Pacific Coast, 1968-72*
(Thousands of bone-dry tons)

Year	Residue consumed			
	Domestic pulp ^{1/}	Building boards ^{2/}	Export chips ^{3/}	Total
1968	9,202	1,685	1,292	12,255
1969	9,548	1,890	1,704	13,142
1970	10,058	2,277	2,111	14,446
1971	10,361	2,024	2,229	14,614
1972	11,093	2,594	2,523	16,210

^{1/} 1968--Barrette et al. (n.d.); Manock et al. (1970); Bergvall and Gedney (1970). 1969-72--Derived from data of Census of Manufactures, U.S. Bureau of Census, through American Pulpwood Association.

^{2/} Annual Board Review issues (July) of *Forest Industries*, using following board production to wood consumption factors:

$$\text{1/2-inch insulation board} \quad \frac{\text{M ft}^2}{2.667} = \text{M bone-dry tons}$$

$$\text{1/8-inch hardboard} \quad \frac{\text{M ft}^2}{2.917} = \text{M bone-dry tons}$$

$$\text{3/4-inch particleboard} \quad \frac{\text{M ft}^2}{0.667} = \text{M bone-dry tons}$$

^{3/} From Holt (1973).

Logging Residue

Logging residue, which accumulates on the Pacific Coast at a rate of about 14 million tons (gross) annually, has found little sustained use because of its scattered origin and the cost of delivering it to a point of use.

In describing the logging residue that accumulated in 1969, Howard (1973) states that 10-1/2 million tons (about three-quarters of the total) is sound, chippable wood. Concentrations of residue varied from an average of nearly 57 tons per acre in the Douglas-fir region of western Oregon and Washington to as little as 4 tons per acre in the ponderosa pine region of the two States (table 5).

The logging residue accumulated annually in the Douglas-fir region (western Oregon and Washington) amounts to more than half of the total accumulation on the Pacific Coast. In the Douglas-fir region, too, 70 to 80 percent of the sound, chippable

Table 5.--Average net and gross weight of logging residue,^{1/}
by ownership and region, Pacific Coast, 1969
(Bone-dry tons per acre)^{2/}

Region and ownership	Gross weight	Net weight ^{3/}
<u>Oregon and Washington</u>		
Douglas-fir region:		
National Forest	57	39
Other public	33	25
Private	19	17
Ponderosa pine region:		
National Forest or private ^{4/}	5	4
<u>California</u>		
National Forest ^{4/}	18	15
Private	24	17

^{1/} Pieces at least 4 inches in diameter and 4 feet long.

^{2/} Derived from Howard (1973), using an average of 25 pounds per cubic foot as the bone-dry weight of residue.

^{3/} Includes sound portions of **all** pieces with at least 10 percent of gross volume suitable for pulp chips.

^{4/} Includes "other public."

wood is in pieces 8 inches and larger in diameter and 8 feet or longer. Further., about half of the chippable volume is in utility (pulp) logs.^{1/} The weight of chippable wood left on clearcut lands in the Douglas-fir region varies with the minimum diameter and length of pieces considered (table 6). For minimum dimensions of 8 inches in diameter and 8 feet in length, the chippable wood amounts to 0.6 bone-dry ton for each thousand board feet of logs harvested.^{2/} For the Pacific Coast as a whole, there is 0.5 bone-dry ton of chippable wood residue per thousand board feet logged.

The scattered origin of logging residue and its varying size and shape as compared with merchantable logs combine to bring the average per-ton cost of logging residue above \$30, delivered to point of use. By comparison, mill residue has been available at costs of about \$2.50, \$10, and \$20 per dry ton for hogged fuel, planer shavings, and pulp chips, respectively, delivered to a major center of use.

^{1/} A utility log has a minimum diameter of 6 inches, a minimum length of 12 feet, and contains at least 50 percent of its volume in sound, chippable wood.

^{2/} The corresponding gross weight of residue, including bark, is estimated to be 0.9 bone-dry ton per thousand board feet. The difference would be available for fuel, if all residue were brought out of the woods.

Table 6.--*Relationship of residue weight to Log volume harvested on National Forest clearcuts of the Douglas-fir region in 1969*^{1/}
(Bone-dry tons of residue per thousand board feet of logs harvested)

diameter			
	8 feet	12 feet	20 feet
8 inches	.90	.73	.42
12 inches	.80	.64	.38
<u>Net weight of residue suitable for chips</u>			
4 inches	0.65	0.52	0.29
8 inches	.60	.49	.27
12 inches	.50	.40	.23

^{1/} Derived from Howard (1973), using an average of 25 pounds per cubic foot as the bone-dry weight of residue.

^{2/} Does not include bark, estimated to add 10 percent.

Costs in the two classes of residue differ because the slabs, edgings, veneer cores, sawdust, etc., are not developed until primary processing occurs; therefore, the cost of transporting this material to the sawmill or veneer plant is borne by the primary product. In contrast, tops, slabs, cull log sections, broken chunks, etc., can be separated from the merchantable portions of trees in the woods. Once separated, they bear the full cost of collection and transportation to point of use. The per-ton costs of delivering merchantable and nonmerchantable wood from stump to plant are estimated in table 7; costs are based on some broad assumptions of current logging costs, since they vary so widely with time and conditions.

Table 7.--Costs of *delivering wood to forest industry plants*
under certain assumptions
(Dollars)

Cost item	Assumed cost per thousand board feet, net log scale	Assumed costs per bone-dry ton		
		Merchantable logs ^{1/}	Utility logs	Other residue ^{2/}
Stumpage	--	Full charge	Nominal charge	No charge
Road construction	12.00	4.80	--	--
Road maintenance	2.50	1.00	1.00	1.00
Fall and buck	6.00	2.40	2.00	.50
Yard	9.00	3.60	7.50	10.50
Load	3.00	1.20	1.20	1.50
General expense including overhead, depreciation, etc.	8.00	3.20	3.20	3.20
Total	40.50	16.20	14.90	16.70
Haul, 40 miles ^{3/}	14.00	5.60	5.60	6.00
Preprocess :				
Debark	--	1.50	--	--
Sort, debark, chip	--	--	3.50	7.00
Total	54.50	23.30	24.00	29.70

^{1/} Merchantable logs are assumed to weigh 2.25 tons per thousand board feet, gross, or 2.50 tons per thousand board feet, net, Scribner Decimal C scale.

^{2/} To 8-inch diameter, 8-foot length, minimum dimensions.

^{3/} Based on 3 round trips in 11-1/2 hours with loads averaging 5,000 board feet.

The decision to separate standard (merchantable) from substandard material in the woods is increasingly difficult. Application of the marginal log concept^{3/} is being challenged by the need to view the complete land management job and then decide the best harvesting practice to accomplish that job. Physical, environmental, silvicultural, and economic criteria should be considered in determining the best logging method,

There is growing sentiment to remove everything over a certain minimum size and later sort the logs for conversion to lumber, veneer, pulp, board, poles, fuel, etc. Within this concept, much of the former logging residue is removed as utility logs, and logging residue is limited largely to branches, tops, or completely defective material that may be well crushed and scattered by the close utilization. Some minimum size, such as 5 cubic feet or 30 board feet (10 inches x 10 feet; 9 inches x 12 feet; 6 inches x 24 feet),^{4/} would be set up as a requirement for removal.

The changes in energy and raw material needs, particularly the projected increases in domestic and worldwide pulpwood requirements,^{5/} give potential value to nearly all timber resources. It is appropriate, therefore, to consider ways of achieving more complete use of timber resource immediately.

WOOD RESIDUE USE ON THE PACIFIC COAST

As Raw Material

Nationally, domestic pulpwood use in 1970 was 4 billion cubic feet of roundwood (over 50 million bone-dry tons) and 1.6 billion cubic feet (20 million bone-dry tons) of mill residue (table 8). Use of mill residue is expected to increase significantly, to 35 million tons by 2000, but the use of roundwood, which may include logging residue as well as thinnings, salvage cuttings, and some sawtimber, is expected to increase dramatically to nearly 115 million tons.

On the Pacific Coast, mill residue already provides more than 85 percent of the pulp industry's raw material and between 15 and 20 percent of its energy needs. The quantity supplied by pulp logs was rather constant during the period 1961-70 but dropped sharply in 1971 and 1972 (fig. 2). Meanwhile, mill residue has supplied all of the material needed for the industry's growth of about 4.3 percent per year during the 1960's. Recent increases in mill residue use are detailed in table 4.

^{3/} The marginal log may be most easily defined as the log which an operator would like to leave, if he could. Stated another way, a logger works to maximize net return per day or season. He, therefore, concentrates on the higher grade and larger logs. He may leave low value or small logs on one area, if he can move to another sale area where higher grade logs are available.

^{4/} It is practical to run smaller material through whole tree chippers where the terrain permits their use, but this does not apply generally to those areas on the Pacific Coast where the heaviest concentrations of residue occur. Where the condition of the timber and the steepness of ground combine to create heavy residue (100 tons per acre or more), it may be necessary to burn the fine material remaining after recovery of the larger residue. However, the resulting fire should be less damaging to the site.

^{5/} John R. McGuire. Meeting prospective timber demands. Paper presented to North Carolina Pulp & Paper Foundation, Raleigh, N. C., Nov. 1973.

Table 8.--*Domestic roundwood and mill residue consumption in the United States in 1970 compared with projected consumption in 2000*^{1/ 2/}

(Millions of cubic feet)

Product group	Reported 1970 consumption		Projected 2000 consumption	
	Roundwood	Residue ^{3/}	Roundwood	Residue ^{3/}
Saw logs	6,100	--	7,600	--
Veneer logs	1,200	--	2,000	--
Pulpwood	4,000	1,600	9,100	2,800
Miscellaneous products ^{4/}	400	600	400	1,200
Fuelwood	500	700	500	700
Total	^{5/} 12,200	2,900	19,600	4,700

^{1/} Based on medium level of projected demand and prices 10 to 30 percent above 1970 levels.

^{2/} From USDA Forest Service (1973, tables 149 and 150).

^{3/} Residue developed in converting roundwood to such primary products as lumber and plywood. It is used chiefly for pulp, particleboard, and fuel.

^{4/} Includes roundwood for cooperage, poles, piling, mine timbers, shingles, and some board products; it also includes the residue used primarily for building boards.

^{5/} The totals include an estimated 7,900 (1970) and 10,400 (2000) million cubic feet of sawtimber. The balance in each case is roundwood from such sources as cull and dead trees, trees less than 5.0 inches in diameter, and hopefully will include much logging residue.

In 1972, both the pulp and the board industries on the Pacific Coast anticipated that their annual raw material needs would increase by 1 million tons and 1.8 million tons, respectively, by 1980 (Austin 1973). Both expected that the modest increase in raw material needs could be supplied entirely by mill residue. However, the burgeoning markets for paper and board that now prevail worldwide require that both industries include logging residue in their raw material plans.

An annual growth rate of 5 percent is now forecast for the pulp industries of both the United States and Japan; the particleboard industry is expected to grow even more rapidly. As indicated previously, all chippable wood residue available at Pacific Coast mills will soon be committed. Thus, the 10-1/2 million tons of chippable logging residue accumulating annually on the Pacific Coast deserves increased attention.

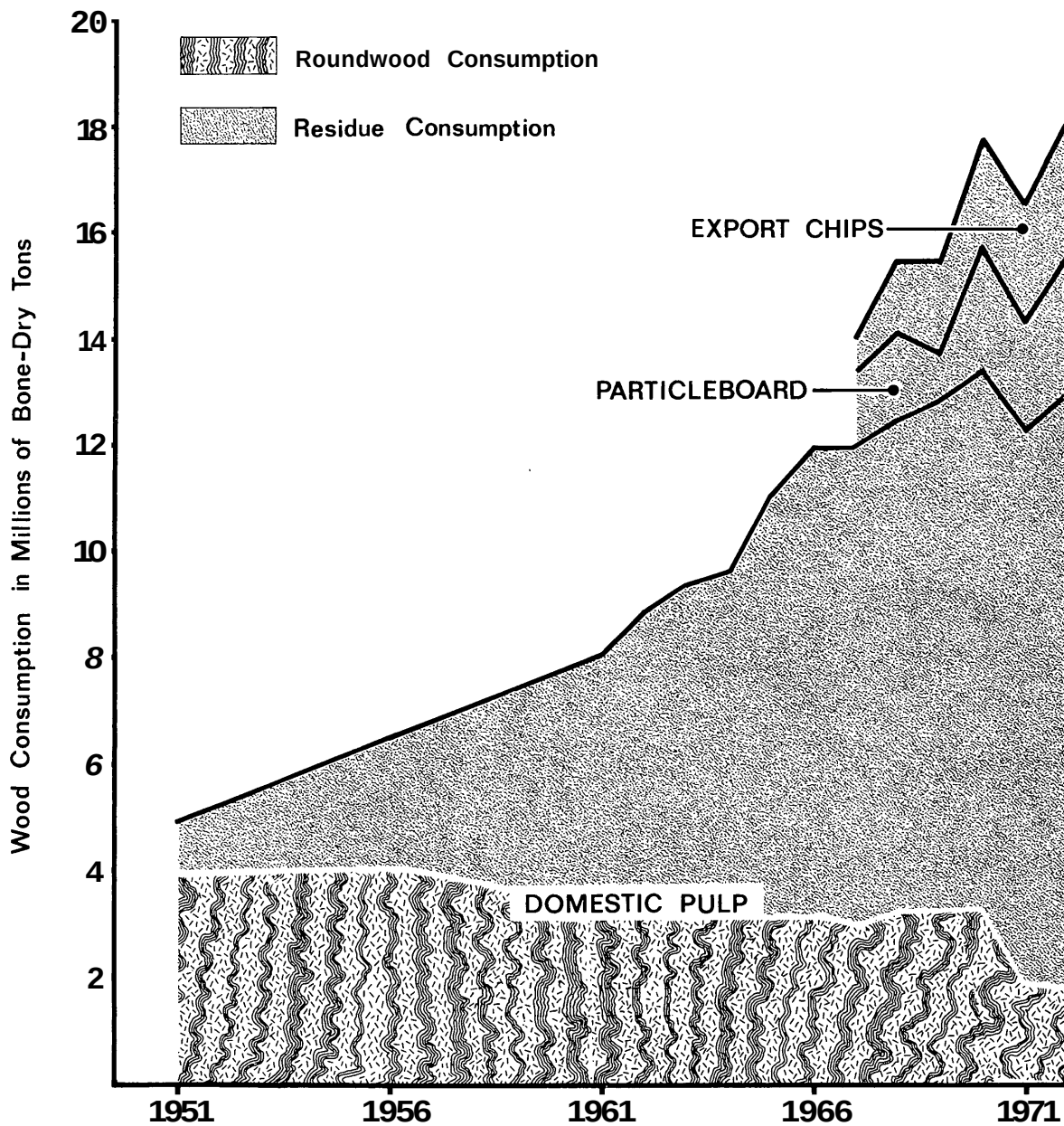


Figure 2.--Trends in the consumption of roundwood and mill residue on the Pacific Coast by the pulp and particleboard industries. (Sources are those shown in table 4, plus Northwest Pulp and Paper Association 1973.)

As Fuel

The Pacific Coast, along with other parts of the United States, suffers increasing power deficits as growing demand outstrips new sources. The potential contribution of wood and bark residue to the energy crisis is substantial but not so great as that of coal. For example, the total annual timber harvest in the United States is less than half the domestic production of coal on a dry weight basis. Wood's greatest contribution to satisfying domestic energy needs could be made through expanded use of wood and bark residue as a replacement fuel for oil or gas in forest industry plants--particularly in pulp plants where energy needs are so great. Wood residue can best be used for energy at forest industry plants because these plants:

- (1) Have facilities for transporting and handling wood.
- (2) Can use residue as raw material or fuel and thereby increase its average value.
- (3) Can use steam to generate power and then use the remaining heat in drying or other processing. This can double thermal efficiency.
- (4) Can use residue at many locations and avoid additional transportation costs needed to concentrate residues at central points.

In 1968, the Nation's pulp industry used 2 percent of the Nation's total purchased energy of 60,500 trillion Btu's (table 9). These purchases of fossil fuels and electricity amounted to 6 percent of the Nation's industrial demand.^{6/} Energy recovered from burning spent cooking liquor to recover chemicals and that recovered by burning the

^{6/} Ronald J. Slinn. Sources and utilization of energy in the U. S. pulp and paper industry. American Paper Institute, New York, Mar. 1973.

Table 9.--*Energy consumption in the United States, 1968*^{1/}
(Trillions of Btu's)

Sector	Coal	Natural gas	Petroleum products	Hydro and nuclear power	Subtotal	Purchased electricity
Residential		4,600	3,200		7,800	1,400
Commercial	600	1,800	3,400		5,800	1,100
Industrial	5,600	9,300	4,500		19,400	2,000
Transportation		600	14,500		15,100	0
Electric utility	7,100	3,200	1,200	900	12,400	(-4,500)
Total	13,300	19,500	26,800	900	60,500	0

^{1/} Adapted from Stanford Research Institute (1972). From the reported average annual growth rate of 4.5 percent, consumption of 69,000 trillion Btu's was predicted for 1971.

bark received with pulpwood provides 37 percent of the industry's energy requirements. The industry is giving serious study to reducing energy requirements in pulping, bleaching, and drying. Major effort is being given to reducing water use by operating at higher consistencies and in a more nearly closed system. However, reduced water use creates numerous side problems that require solution. Meanwhile, stricter standards of air quality in an unbleached kraft mill require 13-15 percent more energy and may require an equivalent increase in the future.^{7/}

The pulp industry's vast energy requirements are summarized by source in table 10. The gas and oil used in 1971 were equivalent to 160 million barrels of oil at 6.3 million Btu's per barrel. To replace this 160-million-barrel equivalent would require 80 million tons of hogged fuel at the commonly used ratio of 2 barrels of oil per ton, but even partial replacement will help reduce oil demand.

The heat value of hogged fuel varies with its composition and its moisture content. In general, good hogged fuel should produce 11,000 pounds of steam per unit,^{8/} whereas poor (extremely wet) hogged fuel should produce about 9,000 pounds of steam per unit. Stated another way, one unit of hogged fuel will produce 8 to 10.5 million Btu's in older boiler installations or up to 12.5 million Btu's in modern boiler installations. A rule of thumb is that a unit of hogged fuel will produce 10,000 pounds of steam or 10 million Btu's. A unit of wood which produces 10 million Btu's is roughly equivalent to 2 barrels of oil (6.3 million Btu's per barrel) when the oil is burned at average efficiency of 80 percent.

Unfortunately, it was easier and less costly for forest industry plants to change from hogged fuel to gas or oil some 25 years ago than it is now to revert to solid fuel with attendant higher furnace costs and more cumbersome fuel storage and handling. However, growing scarcities of natural gas and low-sulfur oil threaten production losses and strongly favor residue-fired power boilers.

Increased emphasis on wood residue burning should lead to improvements in fuel handling, combustion efficiency, and emission control. Predrying fuel to give greater furnace capacity also helps reduce the high investment cost in residue-fired furnaces. Technological progress in residue use for fuel is considered later in this report.

Possibilities of producing methanol, methane, oil, or other versatile fuels from forest residue are not discussed, because these would be produced in large plants outside the forest industry. Considering that coal, lignite, or a variety of organic wastes are also suitable raw materials and considering the huge capacities proposed for methanol plants, for example, it is unlikely that forest residues will be so used. Instead, wood and bark are considered too valuable to the forest industry for raw material or fuel.

^{7/} James E. Roberson. Energy and air emissions in the pulp and paper industry 1973. Talk at the University of Wisconsin Extension Division short course, "Energy and the Pulp and Paper Industry," Milwaukee, Wis., Oct. 1973.

^{8/} The unit applied to bulk measurement of fine wood residue such as hogged fuel or sawdust is the quantity occupying 200 cubic feet of bulk volume. The bone-dry weight of a unit will vary with compaction and species density but, for this report, is considered to be roughly equivalent to 1 ton. A bone-dry unit of pulp chips generally is considered to be equivalent to 2,400 pounds, based on Douglas-fir and high compaction.

Table 10.--*Energy sources in U.S. pulp and paper manufacture, 1971*

Source	Energy equivalent	Percent of total
<i>Trillions of Btu's</i>		
Spent cooking liquor (recovery furnace)	667	28.5
Bark and wood (power furnace)	197	8.5
Natural gas (power furnace)	569	24.0
Oil (power furnace)	440	19.0
Coal (power furnace)	374	16.0
Purchased electricity ^{1/}	94	4.0
Total energy ^{2/}	2,341	100.0

^{1/} Equivalent to 27.6 billion kWh at 3,413 Btu/kWh.

^{2/} Equivalent to nearly 43 million Btu's of energy per ton of paper produced (or 27 million Btu's of purchased energy, which amounts to about 2 percent of the U.S. total).

PROGRESS TOWARD MORE COMPLETE TIMBER UTILIZATION

Diversified Outlets for Residue

The continuously increasing use of wood residue on the Pacific Coast (table 4) and projected demand for wood raw material by 2000 (table 8) improve the opportunity to use logging residue as a raw material source. The need for new energy sources and the pulp industry's high energy requirements (table 10) provide a valuable outlet for that portion of logging residue that is unsuited for products. For illustration, a million tons of logging residue might yield 300,000 tons of logs, blocks, or cants for lumber and veneer production, 500,000 tons of chips for pulp or particleboard, 200,000 tons of wood fines, and 100,000 tons of bark. Bark, amounting to about 10 percent of the wood residue weight, is not included in estimates of residue quantities and represents an added source of energy.

There is a need for log sorting or segregation yards, complete with some sawing or log-breakdown equipment and chipping facilities. Saw logs or portions of cull logs suitable for lumber or veneer could be diverted to such relatively high value use; whereas chips, hogged fuel, bark mulch, etc., produced at the sorting center could be sold or transshipped for final processing and marketing. Log sorting will be discussed more fully in "Development of Log Sorting Centers."

The diversified uses of residue emphasize the fact that the focus should be on complete timber utilization rather than residue recovery. In complete timber utilization, the entire timber stand is used to the best possible advantage at that time and place. The schedule of payment for services and the bid offer for merchantable timber produced will reflect in part the optional uses of the complete stand that are available to the contractor. Where one area has limited use opportunities, some provision for public help to provide additional facilities may be considered.

Advances in Materials Handling

Advances in materials handling that should help reduce logging residue are forecast by Lysons and Twito (1973) and amplified by Lysons (1974). The authors point out the importance of defining any timber harvesting problem in terms of timber size and condition, ground profile, cutting treatment, residue handling, environmental requirements, and access to the area. Constraints such as the availability of skilled manpower, capital, markets, and fuels must also be considered. Once the problem is defined in terms of specific needs and applicable constraints, there is a sounder basis for deciding the logging method.

SELECTING THE YARDING SYSTEM

Selecting the yarding method that best meets the requirements and constraints of a specific timber sale will benefit both the logger and the land manager: the logger by more favorable costs, the land manager by easier contract administration. For example, if it is necessary to clean log a defective, overmature stand on steep ground, grapple yarding with a running skyline may be the best system (fig. 3).

Grapple yarding. --Grapple yarding which uses remotely controlled grapples in place of hand-set chokers to move logs or chunks from stump to road is often more suitable than conventional systems to log difficult settings. As practiced to date, grapple yarding generally has been limited by machine characteristics to short distance, but good interlock drum systems are overcoming this limitation. Lysons (1974) envisions yarding distances up to 1,500 feet with grapples on a running skyline. Mobility of the yarder will be facilitated by a tractor-mounted tail spar moving along a perimeter firebreak. Logs would be windrowed for later loading unless some intermediate transfer were required because of the number of pieces yarded at one machine setting.

Grapples cannot be used in high-lead yarding because the system does not provide an operating line to control the grapples.

The adoption of grapple yarders, especially those with a good interlocking drum system, will be hastened by the great economy of the system. Operator experience with grapple yarding indicates higher production and lower daily cost (because of small crew size). Production in grapple yarding may be 100 pieces per day greater, and the cost \$200 per day less, than for high-lead yarding. The difference in yarding cost is particularly important with small pieces (fig. 4).

Although grapple yarders require high capital investment, they are often worked two shifts to reduce capital costs and payout periods.



Figure 3.—Grapple used for yarding on Vancouver Island.

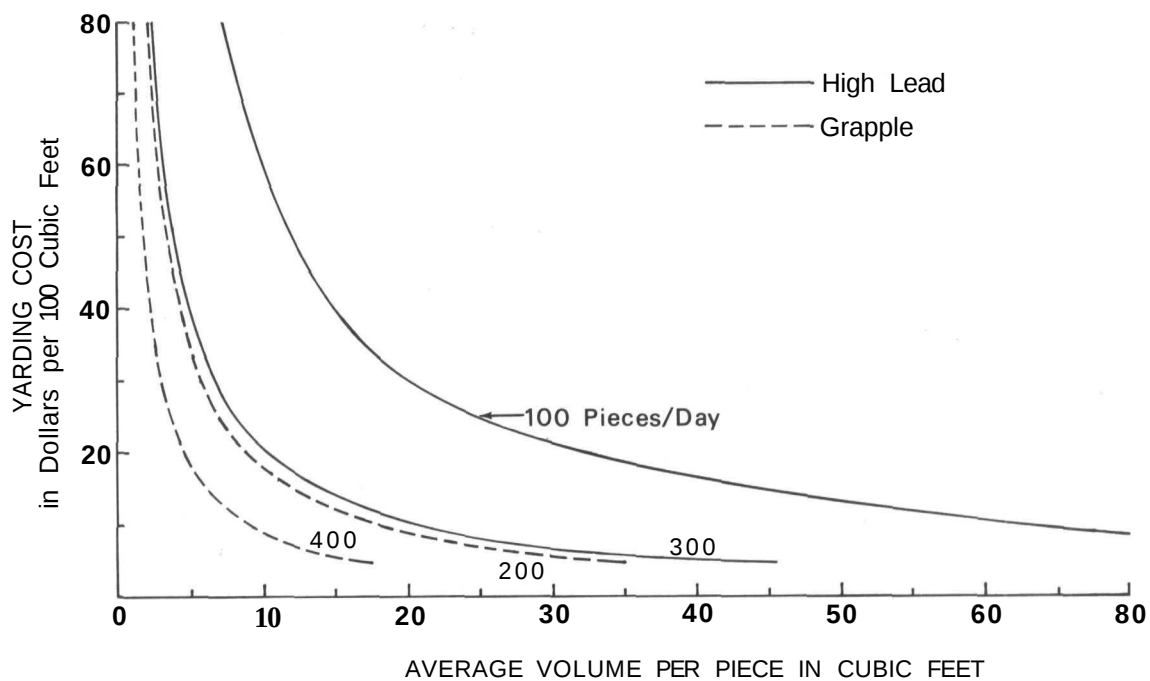


Figure 4.—Relationship of yarding costs to volume per piece for high-lead and grapple yarding at two assumed rates of production. High-lead yarding (daily cost \$600 for equipment and labor) at 100 and 300 pieces per day. Grapple yarding (daily cost \$350 for equipment and labor) at 200 and 400 pieces per day.

The added sorting required by the greater mix of logs produced in clean logging could be simplified in the woods by use of a grapple skidder to transfer logs from the landing to a nearby sorting-loading point. This would also have the advantage of divorcing the loading operation somewhat from the yarding operation. Developments in grapple loaders provide additional gains in residue handling as, once a bunk load is built, the grapples can pick up one or several pieces depending upon their size and arrangement (fig. 5).



Figure 5.--Grapple loader at work on Vancouver Island.

Other considerations.--One operator is considering two-stage logging as an alternative to clean logging--with initial logging taking all pieces over a given size regardless of quality. Secondary yarding would be conducted later by a different crew or by a subcontractor using lighter equipment. The operator believes this may help overcome the aversion of production-minded loggers to handling small-diameter material. At the same time, it leaves responsibility for the complete job with the primary logger.

FALLING AND BUCKING PRACTICES

A serious limitation to the recovery of logging residue has been the short length of the pieces. Short lengths not only reduce the average volume per piece and raise the per-ton cost of logging (fig. 4) but create special handling problems throughout the logging, loading, and processing operations. Many processing machines, such as ring barkers, are not suited to handling lengths less than 12 feet. It is important, therefore, to avoid breakage in falling as much as possible. Thus, Burwell's (1972) method of line falling may have merit for older timber stands on steep slopes where the higher proportion of defect and greater weight of the trees contribute to extensive breakage losses.

Where possible, bucking in the woods should be minimized to reduce the number of pieces to be yarded and loaded. This has a beneficial effect on per-ton logging cost

and provides additional opportunity to scan the log before determining the proper log lengths for optimum value. Shattered ends should be bucked only enough to square one end of the log. In this way, chippable material available in the break can be recovered along with the merchantable part of the log. Granted, this complicates scaling and grading practice, but the benefits and costs of doing this should be considered carefully. The log bucking instructions issued by one company to insure close timber utilization follow.

Bucking breaks and ends: (1) Clean square break--either buck through center of the break to separate the logs, or buck to give sufficient surface for adequate marking if the other end of either log is not suitable; (2) diagonal break or shattered break--buck only to provide an area for marking and to minimize further breakage in yarding; (3) broken chunk ends--buck only one end to provide an area for adequate marking.

Bucking tops: Consider shortening the saw-log portion to upgrade the first or second log and to increase the length of the top pulp log (for better handling). Buck top to 6-inch minimum unless already broken at smaller diameter,

DEVELOPMENT OF LOG SORTING CENTERS

General.--Most simple log sorting facilities now in operation segregate saw logs from pulp logs with little or no processing equipment. However, the yard may combine log storage with sorting where, for example, pulp logs can be held in inventory while saw logs are sold as they accumulate (fig. 6).

Sorting at these log yards is generally done with log stackers that unload incoming trucks and lay the logs out on skids for scaling, if not previously scaled. The same



Figure 6.--Merchantable and substandard logs at a log sorting yard in western Washington.

machines then pile the marked logs for storage or set them aside for shipment. Utility grade logs (pulp logs) may be rebucked to yield short, higher value segments for sawing or peeling.

The second class of log yard combines sorting and some processing. These yards vary widely in complexity from a yard which merely adds a barking and chipping facility to its sorting capacity to a so-called merchandising center that diverts sorted logs to adjacent centers of use, including facilities for the production of lumber, plywood, building board, pulp, or fuel.

In the sorting yards, woods-run logs can be upgraded, particularly if these are brought to the yard in maximum length (fig. 7). This permits using the most experienced judgment in bucking for grade and value. However, this discussion is directed primarily to the handling of utility logs or other residue that may include portions suitable for lumber or veneer.



Figure 7.--Logs up to 66 feet long can be rebucked and sorted into 10 classes with this drop sorter.

Surfacing log yards.-- Sorting yards must have a heavy rock base to withstand the movement of loaded 30- or 60-ton log stackers in wet weather. Even so, considerable mud and rock accumulate and mix with bark, wood, and other debris. This mixture cannot be burned readily because the rock will damage furnace grates. The cost of hauling the debris to a landfill site is substantial, and the loss of rock may be even more serious. Operators of log yards favor blacktopping as much of the log yard as possible, even though this adds to the initial investment.

Provision for Log scaling.-- To permit wood delivery from several sources (and thereby attain outputs that will justify the necessary log yard investment), it is important to provide a means of scaling log loads not previously scaled. This may be done by laying the load on skids for scaling by Bureau scalers. Additionally, there may be need for weighing each truckload and applying a factor or value developed through random sample scaling of many loads.

Log yard functions and equipment needs.--In addition to log sorting and bucking equipment, designers of log segregation yards may consider such equipment as: (1) barkers, (2) chippers, (3) screens, (4) hogs, (5) storage and loading bins for chips or hogged fuel, (6) splitters to size large logs for the chipper, (7) saws to break down oversize logs and recover lumber or cants where possible, (8) chipping headrigs to increase returns from small-diameter logs, (9) auxiliary equipment to handle sawdust, shavings, bark mulch, and hogged fuel separately, and (10) a drum barker to bark short or broken ends, slabs, split logs, etc., prior to chipping. The drum barker displays remarkable ability to keep the log yard free of debris and recover salable chips from much of this (fig. 8).



Figure 8.--Broken ends, swelled butts, etc., can be split and barked in a drum barker.

The more complete the yard, the higher the potential return but the higher the investment and operating cost. It is anticipated, therefore, that generally **only** those yards that are adjacent to a manufacturing center and which handle the equivalent of 100 million or more board feet of logs per year can justify a complete installation. On the other hand, few yards should be limited to barking **and** chipping equipment alone.

Currently operated log yards vary from those intended for sorting only to those that do a complete merchandising job. Some examples of each are described below.

(1) Sorting only

In its simplest form, sorting may be combined with scaling on skids. Logs are marked for segregation as they are scaled, and the log stacker makes the correct distribution when scaling is completed. Scott Paper co. operates yards of this type at Hamilton and Lester, Washington, with pulp logs being shipped on to its more complete Riverside sorting-chipping facility in Everett.

For logs that are weight-scaled or scaled on the truck at some point, sorting may

be facilitated by use of a drop sorter providing for several sorts on each side along its length. This type of sorter can be conveniently combined with a cutoff saw and the rebucking operation performed with the sorting. A limitation is that the sorter operator does not have a good opportunity to see both ends of the log before deciding where to buck it. MacMillan Bloedel uses a drop sorter to sort saw logs and pulp logs into 10 classes at Northwest Bay on Vancouver Island (fig. 9).

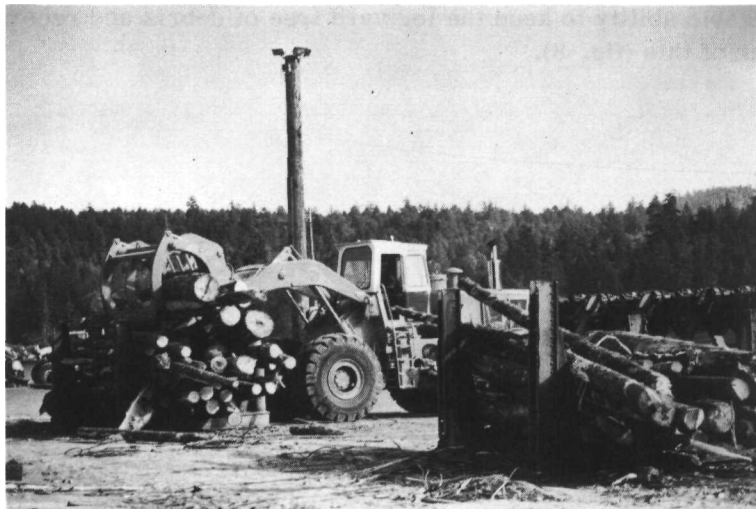


Figure 9.--Handling pulpwood sorts behind a drop sorter on Vancouver Island.

A sorting table composed of live transfer chains is slower but allows more adequate time to scan a log before marking it for final use or for rebucking. Logs are carried to and from the sorting table by log stacker or front-end loader. The transfer table does not provide for convenient rebucking with the sorting, but does a good job otherwise for Scott Paper Co. at its Riverside log yard.

Mayr Brothers Logging Co. diversified its large log sorting yard on the Washington coast about **1965** by installing a splitter, drum barker, and chipper to utilize chippable logging residue. In **1973**, this same yard was diversified further by opening a new band sawmill to increase return from unmerchantable and merchantable logs. The operator's experience may well provide guidelines for others in the industry as logging residue assumes increased importance.

(2) Chipping centers

Those log yards designed to facilitate chip production may provide little in the way of sorting. Thus, logs delivered to such a yard are practically committed to pulp production. However, the operators of these yards are aware of opportunities to increase timber value by segregation. Scott Paper Co., which operates two chip producing centers in **Idaho**, has space at one location for log sorting and storage. The firm may incorporate some sorting provision at this yard.

The chipping plant established by the Burlington Northern Railroad at Cle Elum, Washington, has been handicapped by a limited log supply and by a lack of alternate processing equipment. As prices at the pulpmill for utility logs rose in comparison with the price of chips, the operation of a remote chipping plant at Cle Elum lost meaning. The plant was maintained on a standby basis until rising chip prices in early **1974** prompted a resumption of operation.

Diamond International Corporation established a log chipping facility adjacent to its sawmill operation in Albeni Falls, Idaho. Initially the chipping plant and sawmill were operated as almost separate enterprises. This limited opportunity to divert logs or log segments from one to the other, but integration of the units is planned.

Mountain Fir Lumber Company which has built a new chipping facility on the Columbia River will transport logs or log segments suitable for sawing to its existing sawmill several miles away. The firm expects that its new venture into chip production will attract a substantial volume of additional sawable material. Furthermore, the firm regards the chipping plant as a first step in a more diversified timber utilization program.

The most elaborate log sorting-chipping center observed was the Riverside log yard of Scott Paper Co. in Everett, Washington (Davis **1971**). This yard, which is designed to handle some **150** million board feet of logs per year has a log sorting table, **two** ring barkers (fig. 10), and a drum barker, plus chippers but no sawing equipment. Instead, sawlogs segregated from logs brought to the yard were sold for export or to an adjacent sawmill. Recently, Scott Paper Co. has purchased this sawmill and may develop a new, more integrated system of selecting logs for lumber production to maximize return.

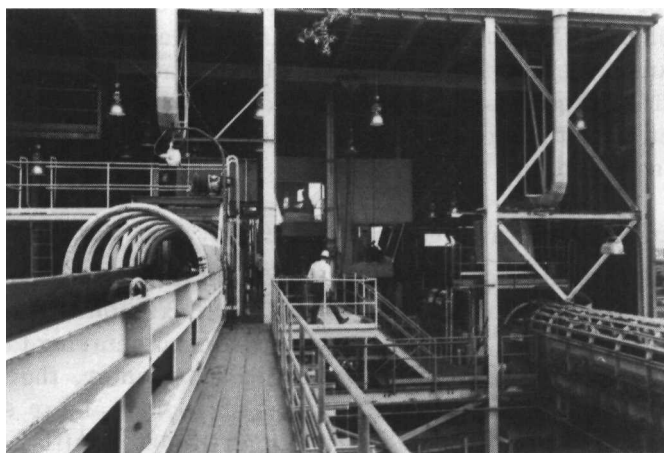


Figure 10.--Two ring barkers operated at a log sorting yard.

(3) Sorting-sawing-chipping systems

Many sawmills have experience in sawing low-grade logs and in producing chips for the pulp industry. Only a few mills that have specialized in sawing utility logs will be mentioned here to illustrate another approach to log sorting and processing facilities.

Several sawmills in Oregon, notably the Bauman Lumber Co. in Lebanon, are particularly experienced in sawing utility logs and in marketing the lumber, chips, shavings, sawdust, and hogged fuel produced. Bauman Lumber Co., in particular, is also experienced in maintaining accountability of logs from several sources. This firm's annual 60-million-board-foot operation might well be expanded into a major log segregation center with the additional barking and chipping facilities and equipment for sawing small logs.

At the West Coast Cellulofibre plant in New Westminster, British Columbia, all logs pass through a hydraulic barker. Logs then go directly to a 150-inch whole log chipper or to the band headsaw for lumber production or a breakdown of the log into pieces small enough to fit the chipper. The mill provides easy access from any point to a large central residue conveyor. That conveyor takes all solid wood scrap directly to the chipper. Sawdust is stored separately for sale to pulp companies, while bark is hogged for sale as fuel. Chips are screened and loaded directly on barges or stored in one of four open piles (depending on species) for later shipment.

The benefits of combining sawing and chipping of southern pine pulp logs have been analyzed by Kaiser and Anderson (1972). Their production simulation model added a chipping headrig, trimmer, lumber sorter, and associated equipment to a typical pulp-wood chipping yard supplied by logs 6 to 14 inches in diameter and 16 feet long. The added investment would amount to about \$500,000. Revenue over straight chip production could be increased by \$250-\$700 per hour with no increase in log supply or by \$500 to more than \$900 per hour, if log supply were increased by 40 percent to take advantage of the increased capacity. Estimated hourly cost for the added equipment and labor was \$85. The above example represents a much simpler situation than that of processing utility logs with a wide range in size and type of defect. Nevertheless, the analysis illustrates the potential gain in revenue by diversification and lists some constraints which can limit the actual gain.

(4) Complete log merchandising center

The Weyerhaeuser Company continues to build on its experience by installing improved log sorting systems that will help obtain the maximum return from each log. Since few have the raw material, the capital, and the manufacturing facilities to realize the maximum return on investment in a log segregation center, there appears need for simpler versions of log merchandising yards. The potential for simpler log merchandising centers may exist at some strategically located mills, particularly those that have experience in sawing utility logs. Mills sawing utility logs generally exist because of a need to make more complete use of an area's timber resource. It is logical, therefore, to think of these operations as a possible base for an expanded utilization center.

Research and Development Toward Further Residue Use

PRODUCT TECHNOLOGY

New pulping technology .-- A major development affecting forest residue use for pulp is the growing acceptance of chips from unbarked wood. Historically, the ground-wood and sulfite processes required strict limitations on bark, but the kraft and neutral sulfite semichemical processes are quite tolerant of bark (Seaton et al. 1973, Appendix K).

Horn and Auchter (1972) report the technical feasibility of producing acceptable bleached and unbleached pulp from unbarked chips of 12 western softwoods. Their work confirmed previous studies on southern pine, oak, and Douglas-fir that indicated pulp of satisfactory strength could be produced from unbarked chips. Although digester capacity is somewhat reduced in pulping unbarked chips (the fiber yield from bark is about 20 percent, compared with about 46 percent from wood), the pulping of unbarked wood offers several advantages, including:

(1) Fiber yield is increased by perhaps 10 percent. Roughly half of the increase is the fiber yield from the bark fraction and the balance is the saving of wood that is normally lost in barking.

(2) Wood that is difficult to bark because of shape is no longer a problem and now becomes available for fiber.

(3) Chipping may be done in the woods or at a remote chipping plant where bark disposal would have been a problem.

(4) Bark use as fiber and as fuel in the recovery boiler may be preferable to disposal in a landfill or to burning in a power boiler. About 75 percent of the bark is dissolved in cooking and becomes available as a source of energy. This conversion may or may not be preferred to 100-percent bark use as fuel in the power boiler, but the operator now has an added option.

The foregoing advantages are obtainable without loss in pulp strength or brightness.

The growing acceptance of unbarked chips in the pulp industry is typified by a reported experience of several firms.^{9/} Portable chippers can be moved to the woods on the level ground typical of the South, Lake States, and many parts of the West. In this way, entire hardwood trees can be fed to the chipper, and hardwood chip yields are double what they are in conventional harvesting. Unfortunately, this particular approach of woods chipping has more limited application to the softwood stands growing on the rugged terrain of western California, Oregon, and Washington where logging residues are most heavily concentrated.

Structural products .-- New technology that permits making structural products from wood residues will extend the forest resource and help solve disposal problems. Production of structural building materials such as particleboard sheathing from logging residue or tubular framing from recycled paper add to the value and versatility of the forest resource.

^{9/} American Pulpwood Association. Lake States full tree harvesting. Tech. Release 71-R-63, Dec. 1971.

The potential conversion of logging residue to particleboard for structural use is one of the more promising ways of increasing residue's utility and will be used to illustrate the importance of new technology. It has been demonstrated that particle geometry and particle alignment strongly influence the strength characteristics of the consolidated product. Research indicates that a preferred particle (flake) size (2 inches by 0.02 inch and of varying width) can be produced from logging residue, although the design of a preferred "flaking" machine has not been determined.

Strength properties and dimensional stability of the particleboard are responsive to changes in particle alignment and provide a way of achieving desired properties in a reconstituted panel by the method of forming.

The advantages gained through preferred particle geometry and alignment place the resulting product in a "**structural**" category, as compared with a less demanding and consequently less valuable classification. Thus, residue which is suitable for structural particleboard, as well as pulp, has an added opportunity to pay its way and escape the "disposal" category.

Other product technology .--New technology that permits increased product recovery by more accurate sawing, peeling, trimming, etc., **will** reduce the quantity of residue developed from processed logs. Users of chips from slabs, edgings, or trim, or users of sawdust, shavings, or sanderdust, may require additional sources of raw material. This, in turn, should encourage the recovery of more material from the woods to augment the supply of material for pulp and board production.

WOOD COMBUSTION TECHNOLOGY^{10/}

Increasing shortages and rising costs of gas and oil, together with stricter limitations on residue disposal, focus attention on the energy available from wood residue. Two areas of new technology are of interest:

(1) The technology of converting wood residue (unsuited for other use) to process steam and electricity by direct combustion at large wood utilization centers without violating air quality standards.

(2) The technology of burning wood residue in a fluidized bed or in a highly turbulent furnace is being developed by several organizations. A major advantage is the potential ability to meet clean air standards without expensive emission controls. A disadvantage to date is the limited size or capacity of available units.

Potential applications of a turbulent wood-fired furnace (Energex) to veneer dryers, rotary dryers, and direct-fired kilns have been described recently by Vranizan.^{11/} A prototype wood-fired, fluidized-bed furnace has operated at Coeur d' Alene, Idaho, and is now obtainable in capacities of 3 to 40 million Btu's per hour.

^{10/} The author is grateful to the fuels and combustion section, Construction Engineering Department of Weyerhaeuser Co., for much of the information contained here.

^{11/} John M. Vranizan. Utilization of wood waste to offset energy demands in the plywood mill. Presented at the "Plywood Clinic," Portland, Oreg., Feb. 1974.

Burning in a fluidized bed or in a turbulent airstream is of interest to individual forest industry plants having moderate energy requirements for lumber or veneer drying or to plants with high energy demands that seek an alternate means of controlling particulate emissions.

Fuel preparation. -- Clean, dry, uniformly sized hogged fuel offers several advantages over conventional hogged fuel, including:

- Improved combustion control and boiler response to load variation
- Improved emission control by more complete combustion in the furnace
- Increased furnace heat capacity and reduced size and cost of the installation
- Increased options in fuel firing with suspension systems, stokers, traveling grates, etc.

(1) Sizing--To obtain satisfactory control of combustion and particulate emission, it is advisable to size fuel to a maximum particle size of 3/8-inch (like coarse sawdust from a circular headsaw). Some tangentially fired furnaces require a smaller particle size (e.g., 1/8-inch maximum).

A combination sizing-drying method, known as a "hot" hog, is available. A unit sized for a production of 15 tons of wet fuel per hour might use a 100-hp motor on the hog and a 200-hp fan to move hot gases through the hog. Thus, the energy required for hogging would be about 14 hph per bone-dry ton. By comparison, about 8 hph per ton are required to produce softwood pulp chips.

(2) Drying--redrying can be accomplished more efficiently in a dryer than in a boiler furnace because the exit temperature from the dryer may be as much as 150°-400° F lower than stack gas temperature. Fines and dirt can be removed after predrying and before burning, thus aiding control of combustion for higher efficiency and better air quality control.

There are a variety of drying systems available for predrying wood or bark fuel, including presses, rotary dryers, flash dryers, hot **hogs**, and heated conveyors.

Rotary dryers, such as those used for drying wood particles for board production, foodstuffs, lime, etc., are among the most efficient. The Heil dryer is well known in the particleboard industry, and the Steams-Rogers dryer is widely used in the food industry. The latter has the advantage of being available in larger capacities capable of drying 200,000 to 300,000 pounds of material per hour. The latter dryer also operates at a lower overall temperature which favors more uniform drying.

An auxiliary furnace is recommended to provide the hot gas for the dryer. Fines from a cyclone separator on the dried-fuel output line will provide the auxiliary furnace fuel. Although this may require 10-15 percent of the hogged fuel input, there may be an overall saving of 5 percent in fuel because of improved efficiency. Also, two-thirds of the gas, dust, and fumes from the cyclone may be recycled to the auxiliary furnace. Flue gas from the boilerhouse stack is not always suited or available for fuel drying. It is desirable to hold stack gas temperatures between 400° and 450° F, and this is too low for good controlled drying. Flue gas does have the advantages of being free and

noncombustible. Unfortunately, it may be uneconomical to bring the gas from the stack to the point where the fuel is to be dried, or the total heat available in the stack gas may not be sufficient to do the required drying.

The rotary dryer is well suited to predrying coarse fuel, as the fuel has a residence time of 10–20 minutes.

The hot hog, a form of flash dryer, is well suited for a fine fuel output and may encourage development of lower cost furnaces that fire fuel in suspension. Its operation is similar to that of the pulverizers that have been used to grind and dry coal for many years. The hog can react quickly to fluctuations in fuel requirements. Fines from a cyclone on the dry fuel line are returned to the air heater as fuel. Gas goes from the air heater to the hog at 700°–1,000° F. Outlet temperature of gas from the hog is about 200° F.

Hot conveyors may be used to remove surface moisture and dust from hogged fuel. Wet wood is conveyed on a vibrating, moving screen over a pressurized plenum. The plenum is heated with boiler stack gas at 400°–600° F or with gas from a dust-fired, air heater at 600° F. Dust and fines pulled off through a stack in the conveyor hood may fuel the air heater. Fuel may be dried from 50- to 70-percent moisture to the moisture level desired for the firing equipment available.

Furnaces for direct combustion.--Wood-burning furnaces which have been described by Corder (1973) may be of several types, including:

- (1) Deep bed, pile burners, such as the Dutch oven;
- (2) Thin bed burners with stationary pinhole grates, inclined grates, dump grates, step grates, or traveling grates;
- (3) Suspension burners such as those used for pulverized coal, the register type, or the newer "cyclone" types, including the Combustion Equipment Associates (CEA double vortex furnace) and the Energex furnace.

A wood-fired furnace and boiler may cost \$10–\$20 per pound of steam per hour capacity but will vary with the size of the installation. For example, an installation producing 125,000 pounds of steam per hour may cost \$18 per pound of steam (vs. about \$4 per pound for a gas- or oil-fired packaged boiler) or \$13 per pound of steam for a 250,000-pound boiler (vs. about \$3 per pound for gas-fired),

The added cost of the wood-fired boiler results from such things as:

- (1) The need for grates and other ash handling equipment,
- (2) Higher fuel storage and handling cost,
- (3) Increased surface for heat transfer due to lower furnace temperatures resulting from high water content of the fuel,
- (4) Particulate control equipment which adds increasingly to the total installation cost. Roberson (see footnote 7) estimates that air emission controls have added 13–15 percent to the energy requirements of a kraft pulpmill and will have added about 25 percent when SO₂ and NO_x flue gas removal systems are installed.

- (5) The need to field-erect the wood-fired furnace and boiler (vs. assembly of packaged boilers or modules). Capacity of packaged boilers for wood is limited to 10,000 to 100,000 pounds per hour. Modular types for wood are available in 50,000 to **350,000** pounds per hour, although one major manufacturer has produced shop parts for a boiler with a capacity of 800,000 pounds per hour.
- (6) Hot gases must travel at lower velocity because of entrained ash that can erode tubes or other boiler surfaces.

Particulate emission control.--Control of particulate emissions to meet air quality standards may be achieved by optimizing combustion, by cleaning the stack gases, and by avoiding reinjection of fly ash into the furnace.

(1) Combustion is optimized by proper design, operation, and maintenance of the unit. Proper operation includes sizing, cleaning, and drying the fuel. Additionally, the vertical furnace velocities may be lowered--to reduce carryout of particles--by predrying the fuel to decrease the volume of flue gas or by installing a larger furnace.

(2) Stack gases may be cleaned to comply with air quality standards by installing such equipment as: multiclone (cyclone) collectors; wet scrubbers (which are not fully developed for wood); bag houses (which are widely used in metallurgical industries for fine dust, but which only recently have been applied to a bark-fired furnace); or electrostatic precipitators.

When used to clean stack gases from a recovery boiler at an 800-ton-per-day pulpmill, a bag house would cost about the same as electrostatic precipitators. Fiber-glass bags are good for temperatures to 500° F and should last 6 to **24** months. Adams^{12/} favors a bag house wherever an efficiency of greater than 99 percent is required.

Electrostatic precipitators are used in combination with multiclones, but even then they may not achieve the planned efficiency, if over 99 percent is required. Experience with precipitators on wood-fired furnaces is very limited, and there is some concern about an explosion hazard with finely divided carbon where arcing is possible. Collection efficiency is assumed to be lower than on recovery boilers where salt cake is present.

New collection methods, which are being studied, may provide a better means of cleaning stack gases than systems currently available.

(3) Avoid reinjection of fly ash into the main furnace by burning it in a small fluidized bed or suspension burner.

Electric power generation.-- A pulp-and-paper mill will require from 15,000 to 20,000 pounds of steam per ton of product and from 700 to 1,400 kWh of electric power per ton. Thus, much of electrical needs can be produced by byproduct power generation (see footnote 7).

^{12/} A. B. Adams. Energy for mill operations--chemical recovery, recausticizing and lime burning. Talk at University of Wisconsin Extension Division short course, "Energy and the Pulp and Paper Industry," Milwaukee, Wis., Oct. 1973.

Assuming average boiler efficiency, plant heat rates are 10,000 **Btu** per kWh for an oil- or coal-firing utility and 12,000 **Btu** per kWh when firing wood. Comparable heat rates at a pulp mill are 4,500 **Btu** per kWh firing oil and 6,000 **Btu** per kWh firing wood or spent cooking liquor (see footnote 7).

Also, capital costs may be much less for power generation at a forest industry plant (e.g., \$150/kW of rated capacity vs. \$300/kW for a utility).

*Systems for generating power from wood residue.--*Some possible combinations of fuel preparation-combustion systems and of combustion-power generation systems have been described by Johnson (see footnote 10). Some such systems are illustrated in the appendix. Johanson and Sarkanen, ^{13/} after reviewing many gasification systems, recommended a system that is illustrated in the appendix.

The technology of gasification systems, including the fluidized bed, is not fully developed. However, Combustion Power Company has a pilot unit that is close to commercial production. This pilot program, designed for solid waste disposal, has been supported by funds from the Department of Health, Education, and Welfare but appears adaptable to moderate-sized, wood-fired *units* where it could help improve the technology of fluidized bed combustion. More recently, a prototype fluidized-bed furnace burning wood residue at Coeur d' Alene, Idaho, has provided a basis for commercial production.

*Application of new combustion technology in forest industry plants.--*It seems increasingly evident that the bulk of the forest residue consigned to energy production will be burned at forest industry plants rather than outside the industry (Grantham et al. 1974). This is because of the industry's stronger competitive position as compared with electric utility companies or plants converting wood to energy by way of methanol, methane,, oil, etc.

In short, a forest industry plant already established to manufacture wood-based products does not require a long-term commitment of residue to insure amortization of a multimillion-dollar plant investment. Although the investment in a residue-fired furnace, boiler, and auxiliary equipment is substantial, this will enable a forest industry plant to divert bark and low quality wood to fuel. This provides annual savings in fuel cost; but more important, it reduces reliance on gas and oil and avoids the possible loss of revenue through a forced shutdown.

ADMINISTRATIVE CHANGES FOR FULLER TIMBER UTILIZATION

In 1972, the Close Timber Utilization Committee of the Forest Service provided a series of recommendations designed to make forest land management responsive to current and foreseeable needs. These include five recommendations for change in contract specifications (or standards) and procedures. ^{14/}

^{13/} L. N. Johanson and K. V. Sarkanen. Means of converting wood residues to energy other than through combustion. Contract report to Pacific Northwest Forest and Range Experiment Station, Dec. 1972.

^{14/} Report of Close Timber Utilization Committee, USDA Forest Service, Washington, D. C. , Apr. 1972.

To meet the changing situation, the Forest Service has experimented with various means of obtaining more complete timber utilization. One means has been to make only a nominal per-acre charge, or no charge, for removal of timber smaller or more defective than the minimum contract requirements; another has required yarding of unmerchantable material to reduce the fire hazard of scattered heavy residue and to improve land management generally. Per-acre costs of yarding unutilized material (YUM) have been high and have reduced stumpage return substantially. Dowdle (1973) has questioned the basis on which a decision is made to yard unutilized material on a particular timber sale.

The Bureau of Land Management uses lump sum timber selling on its lands in western Oregon as a means of achieving closer timber utilization. It was reasoned that timber purchasers would have greater incentive to remove everything that would pay its way out of the woods and that they would have greater flexibility in falling and bucking practices since no log scaling was required. The advantages and disadvantages of lump sum selling have been debated extensively, but to date other major public timberland managers have made only limited use of the system.

The close utilization policy adopted by the British Columbia Forest Service in 1966 was designed to improve utilization by lowering the minimum stump diameter (tree size) from 14 to 10 inches and the stump height from 18 to 12 inches. The minimum top diameter was decreased from 8 to 6 inches.

The policy was adopted primarily for the interior forests of the Province, where the timber is smaller and the ground flatter than on the coast. To encourage adoption of the new policy, the B. C. Forest Service provided two incentives. First, the operator or licensee was permitted to increase his annual allowable log harvest by the indicated difference in cruised timber volume--using the old and new utilization standards. Second, this additional cruised volume was charged at a nominal stumpage of \$0.55 per cunit and prorated with normal appraised stumpage to give an adjusted stumpage rate. This adjusted rate applied to all logs harvested.

Since the large timber on the steep terrain west of the Coast Mountains presented more difficulty in logging, a 5-year moratorium, and later, a 1-year extension, was granted on adoption of close utilization standards. Only recently has the B. C. Forest Service begun to enforce an accounting of every piece with minimum dimensions of 6 inches in diameter and 8 feet in length, providing the piece contains 50 percent or more of firmwood (chippable wood). Companies are still experimenting with modifications in their forestry and logging practices to determine the best means of meeting the new standards.

Attempts to improve timber utilization on public lands west of the Cascade Mountains in the United States or west of the Coast Mountains in British Columbia have met with limited success. Thus, there is a seeming need to better inform the public, the industry, and key public officials about forest land management goals. Frear (1973) has described the importance of agency communication vs. confrontation in gaining public support of land management programs. There is a need for forest land managers and owners to better inform the general public, environmentalists, key public officials,

and forest industry representatives of the importance of complete timber utilization to forest land management, plus long-term gains in resource value, employment, and expansion of the tax base.

Forest Land Management or Service Contracts

There have been many proposals for changes in timber sale procedures to help achieve land management goals, but there are both economic and political obstacles to procedural changes. These obstacles slow adoption of such changes as those summarized below:

(1) Use simplified estimating procedures and negotiated lump-sum contracts for residue sales where appraised values are small. This procedure might be more useful if the authorized limit on negotiated sales were raised from \$2,000 to \$10,000 as has been proposed.^{15/}

(2) Use a service contract with free salvage rights to remove logging residue (as recommended by the Close Timber Utilization Committee, see footnote 14). The contract would specify the degree of removal required and leave the contractor free to recover such values as he can. It has been suggested that any service contract be so written that the contractor has maximum flexibility in his choice of equipment and methods to meet the contract requirements. Understandable and enforceable contract specifications are essential. It is also necessary to enforce contract compliance uniformly and consistently to emphasize a commitment to forest land management goals.

(3) Use a compound contract, which combines a logging contract with a product sale contract, as proposed by the President's Advisory Panel on Timber and the Environment (Seaton et al. 1973). The logging contract describes services to be provided by the contractor and a payment schedule for such services; the product sale contract provides for purchase of merchantable timber produced in the logging contract by the same contractor under a payment rate established by bid.

Suggested Changes in Sale Procedures

In considering changes in sale procedure, some suggestions of the industry are pertinent:

(1) Although measurement of standard (merchantable) and substandard wood should be simplified in every way possible, there is advantage in scaling both standard and substandard material to provide wood accountability for all parties, including land managers, contractors, subcontractors, loggers, truckers, and log purchasers.

(2) Sale procedures should be modified to provide for a quick response to market changes. For example, (a) respond to an increased demand for chips from substandard material by offering formerly marginal sale offerings quickly through temporary transfer of personnel and employment of outside help to be paid from receipts; (b) extend contract without penalty, if the chip market declines temporarily.

(3) One other suggested change is for required removal or early release of the residue on each cutting unit to facilitate possible salvage through a new sale.

^{15/} Comptroller General's report to U. S. Congress. More usable dead or damaged trees should be salvaged to help meet timber demand. Oct. 1973.

Current Research on Contractural Procedures.

Responding to the expressed need for new contractual procedures to encourage more intensive timber utilization, the Pacific Northwest Forest and Range Experiment Station is conducting four related studies that should be useful to contract writers.

The studies include:

(1) Effects of forest residue and residue treatments on the environment: a compendium of current knowledge to aid in establishing interim forest management guidelines (Cramer 1974).

(2) Guidelines for forest residue management. ^{16/} This study, based on the above compendium, aims at setting forest residue management guidelines that are scientifically sound and administratively achievable.

(3) Alternative sale arrangements--a cooperative study with the Bureau of Land Management to give its district managers more timber sale options to achieve land management objectives. The guidelines developed in (2) should be valuable in drafting pilot contract procedures.

(4) Shelton cooperative residue utilization study. The cooperative sustained yield unit at Shelton provides an opportunity to evaluate such measures as line tree felling or modified bucking practice and log sorting for highest value use that have been proposed to improve timber utilization. This 3-year cooperative study between Simpson Timber Co. and the Forest Service was begun in the spring of 1974.

^{16/} Paper being prepared by Pacific Northwest Forest and Range Experiment Station.

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APPENDIX

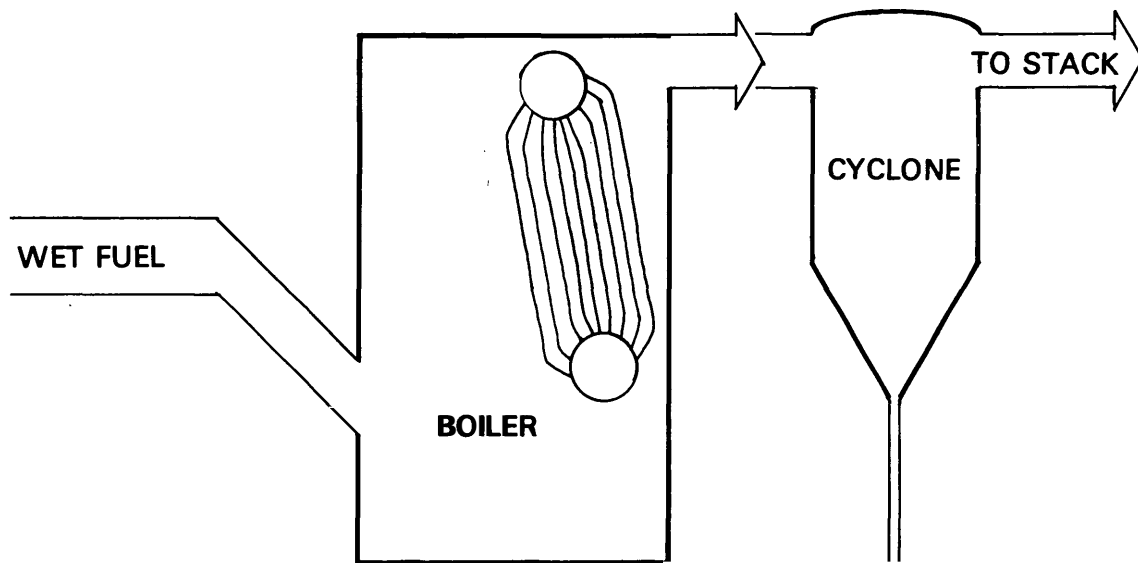


Figure 11.--Conventional wood-fired boiler.

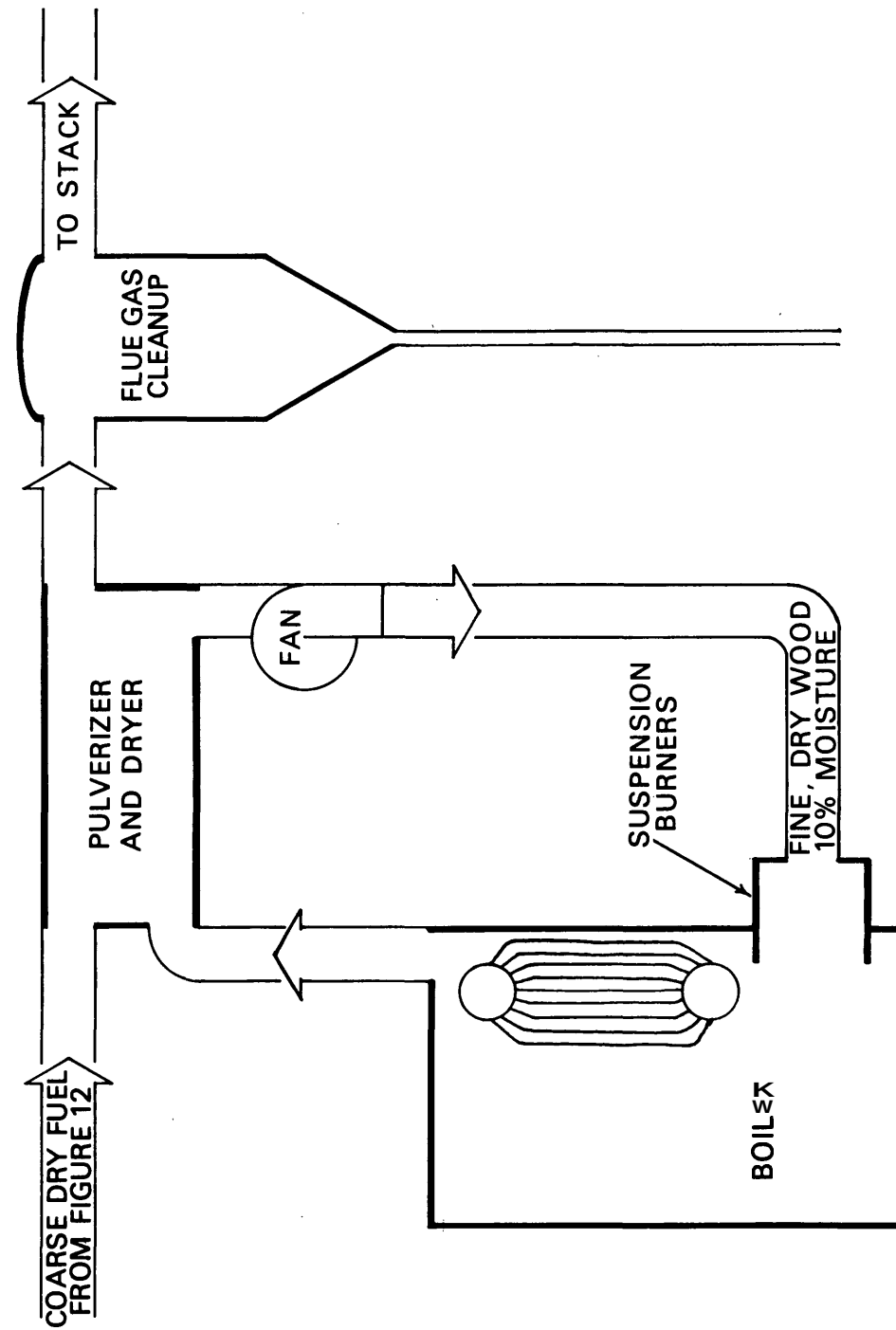


Figure 13.--Boiler with suspension firing of wood at 10-percent moisture content.

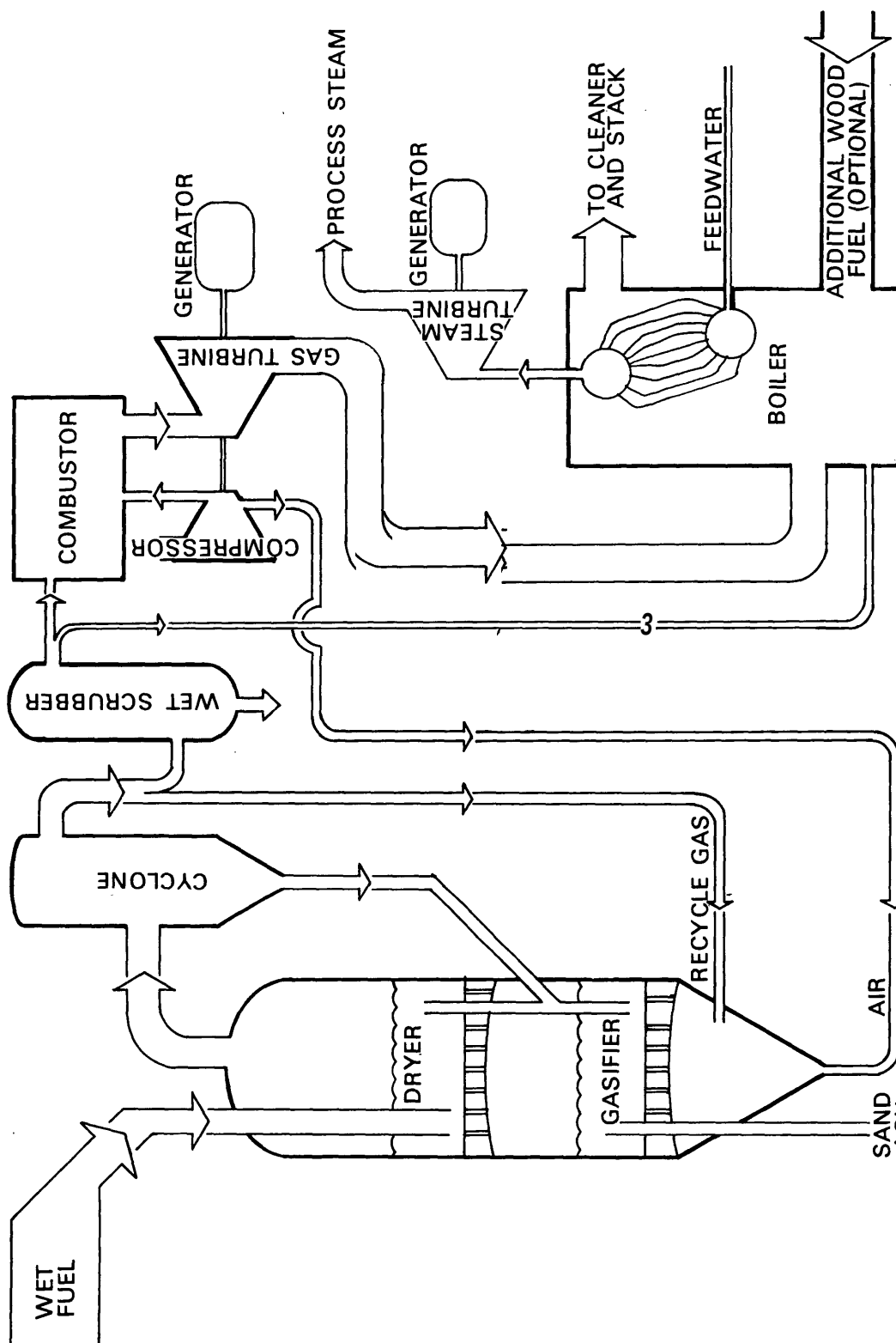


Figure 14.--Wood gasification and combined gas turbine-steam turbine electric power generation (as conceived by Johanson and Sarkanen, see footnote 13).

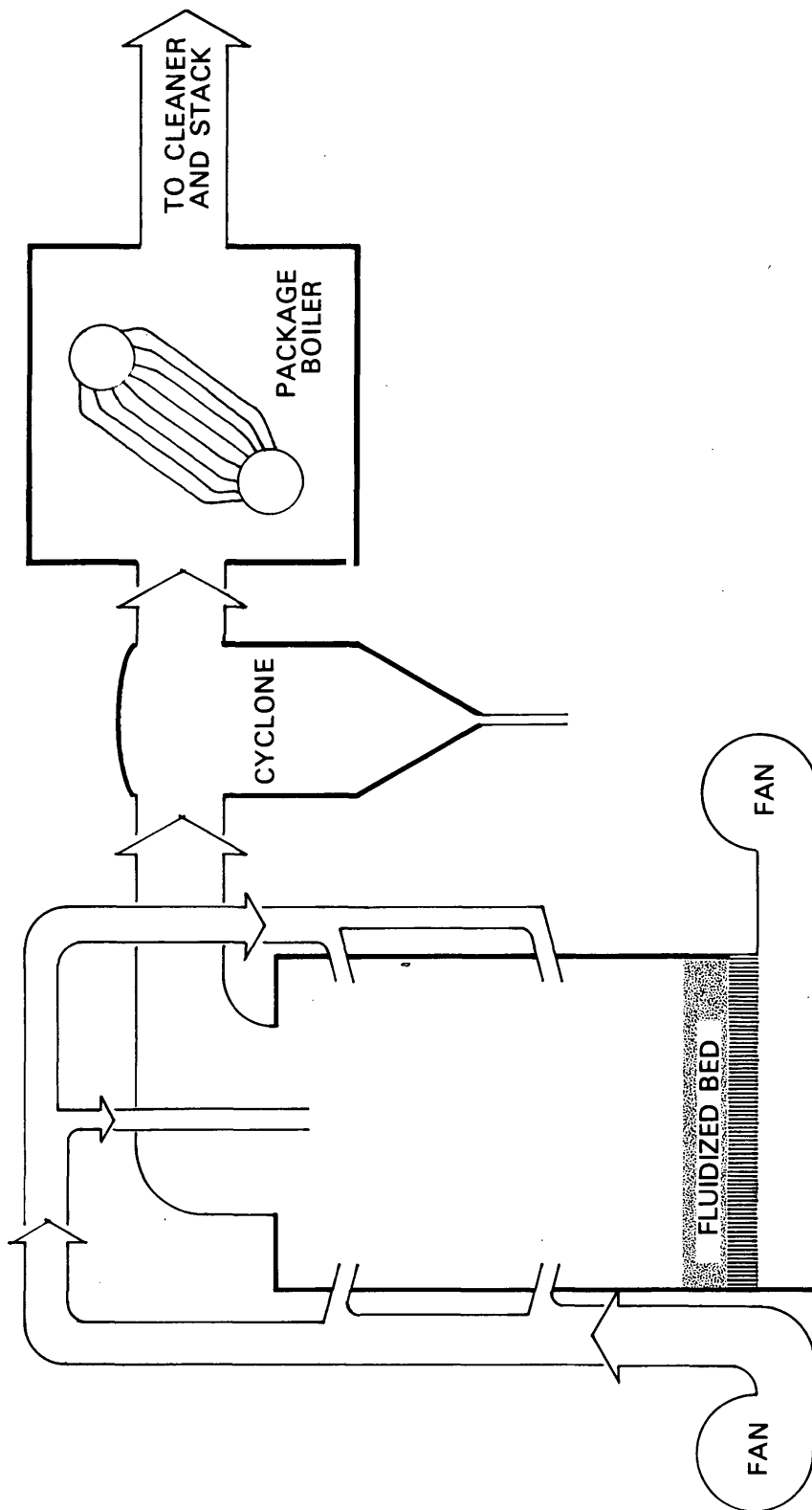


Figure 15.--Fluidized-bed furnace for hot gas or steam generation.

The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

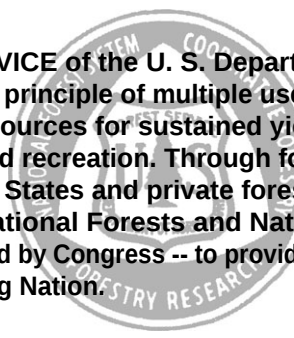
Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Development and evaluation of alternative methods and levels of resource management.
3. Achievement of optimum sustained resource productivity consistent with maintaining a high quality forest environment.

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