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CONTENTS OF A CORD OF EIGHT-FOOT PULPWOOD [1/]

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Although the pulp and paper industry of western Washington depends chiefly on logs for its wood supply, the use of pulpwood in cordwood lengths is steadily increasing. More than 75 percent of the 20 plants in the area are equipped to handle at least a part of their consumption in cordwood form. Many plants are remodeling their facilities to utilize additional wood supplies, and without exception greater dependence is placed upon cordwood.

Factors influencing this trend away from practically 100 percent dependence on logs are the reduced supply of old-growth timber, the increased demand by the lumber and plywood industries for available logs, and an increased supply of available second-growth material just reaching merchantable size. Many pulp and paper companies are acquiring second-growth timberlands, utilizing salvage following logging, and buying wood from truckers operating from small holdings. The supply of this small second-growth material will be increased still further from thinning and improvement cuttings as forest properties are placed under intensive management. Pulpwood produced from second-growth timber has superior quality and yield because of the greater proportion of sapwood, and this has also influenced the trend toward smaller-wood utilization. Such wood handles better in eight-foot lengths than in almost any other form.

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This cordwood is purchased in a round, unpeeled condition from numerous small independent operators. The need for peeling and splitting this material in the woods has been eliminated by installations at the mills of hydraulic and mechanical barkers and chippers that will handle large-sized bolts or logs.

Pulpwood is usually measured in terms of cubic-foot volume of stacked wood and then converted to standard cords of 128 cubic feet. The amount of solid wood per cord in a stack of round, unpeeled cordwood is always less than this maximum. Knowledge of how the solid wood contents of a cord varies will permit better estimates of actual wood content as well as more accurate conversion of tree and log volumes to equivalent stacked cords.

Actual wood content is affected by closeness of stacking, by straightness or roughness of the sticks, and by scaling practice employed. Such variants can be allowed for by a reasonable sampling of actual practices to determine the prevailing average of these conditions. Also, the volume of solid wood is affected by stick diameter, the number of pieces in the stack, and bark thickness. These factors differ from one operation to another, but they can be determined for any given cutting. To see what allowance should be made for these factors, a study of their effects was conducted in some typical operations during the summers of 1947 and 1948.

Method

This inquiry included observations at seven pulp and paper mills and three small sawmills in central-western and southwestern Washington and one pulp mill in northwestern Oregon that purchase a significant portion of their wood from independent producers. These men cut the wood from either their own or company timberlands, transporting the material directly from the woods to the mill by truck. Second-growth Douglas-fir and hemlock were observed in sufficient quantities to obtain reliable results when statistically analyzed. The material came chiefly from 30- to 70-year-old stands, although hemlock occasionally came from salvage operations following logging of older stands up to 150 years.

The loads for study were measured at each mill as rapidly as they could be checked without holding up the unloading. A total of 316 cords of stacked volume from 106 truckloads was measured, of which 65 was Douglas-fir and 41 hemlock. Several spruce and white fir loads were excluded because they were too few to be separately analyzed. Usually more than 50 percent of the trucks unloaded at each mill on a particular study day were observed. The dimensions and scale of each load were obtained from the company scaler. For each load the number of bolts, species, bark thickness to the nearest 1/20 inch at a random end, and diameter inside bark at both ends, were recorded to the nearest 1/10 inch. When possible (seven instances only) loads were weighed to determine green weight per cord.

Loads varied from 1-1/2 to 8 cords; most contained from 2 to 4 cords. Minimum bolt diameter inside bark was three inches at the small end in both species. Most pulp and paper mills accepted wood to a maximum diameter of 20 inches in round form. The loads were classified as Douglas-fir or hemlock. All loads were pure except hemlock, which had occasional light mixtures of true firs and Sitka spruce.

A summary of the data gathered and the variation between species of the elements studied are given in table 1.

Table 1.--Summary, average, and range of pulpwood data

Item	Douglas-fir	Hemlock
Number of truckloads	65	41
Number of standard cords	206	110
Average cords per load	3.2	2.7
Average cubic feet solid wood per cord	82.3	84.1
Average cubic feet bark per cord	10.3	10.2
Average cubic feet wood and bark per cord	92.6	94.3
Average number of bolts per cord	16.0	18.3
Average bolt diameter, inches	11.8	11.3
Range in bolt diameter, inches	3-27	3-30
Average board feet Scribner scale per cord	477	481
Average estimated weight per cord, pounds	4450	5115

The stacked volume in cubic feet and standard cords of 128 cubic feet each was computed for each load from the measurements as recorded by the company scaler. It is recognized that a certain amount of variation between scalers and scaling practices exists among mills. The average volume per load obtained represents a reasonable sample of commercial scaling practice in the western Washington area. The number of bolts per load was expressed in pieces per cord. The cubic volume of solid wood inside bark was next determined for each load by averaging the end area of each individual bolt and multiplying by 8 feet. This process was repeated to determine cubic volume of wood and bark, using the diameter of each bolt with double bark thickness added. The difference between the cubic volume outside bark and cubic volume inside bark was considered to be the cubic volume of bark. The average bolt diameter of each load was computed from the average end area of all bolts. Cubic volume of solid wood per cord was found to be related to diameter of the average bolt as shown in figure 1.

The content of each load was then converted to gross Scribner log scale using the equation for 16-foot logs, $V = \frac{0.79D^2 - 2D - 4}{2}$.

As the bolts were cut exactly 8 feet long, these figures do not include the customary trim allowance present in a commercial log scale. No scale was made for bolts less than 5.5 inches diameter inside bark at the small end. Board feet per cord was then plotted over the average bolt diameter of each load of Douglas-fir and hemlock separately as shown in figure 2. It was possible to draw a curve which fitted very closely the plotted data.

The final step in the analysis of pulpwood contents as related to stacked volume was to determine the green weight per cord for both species. It was not possible to get actual weights of the loads studied except for 7 loads of Douglas-fir. Weights were averaged out and determined as closely as possible on an inside bark cubic-foot basis. Douglas-fir, obtained from 7 loads weighed during the study and over 100 samples at an Olympic Peninsula mill, gave an average of 54 pounds per cubic foot of green wood. Hemlock, based on weights from two East Puget Sound mills, averaged out 60 pounds per cubic foot of green wood. These weights were then multiplied by the volume of solid wood for each diameter class for each species. These resulting figures should be useful for relative comparisons only, and should not be considered as absolute values. The weight of freshly cut green wood is quite variable, being influenced primarily by density of wood and its moisture content. Slow-growing softwoods are generally more dense than fast-growing, and timber with a high proportion of sapwood has a higher moisture content than that with little sapwood. Sapwood and heartwood proportion is of particular importance in cords of small bolts which have a greater proportion of sapwood. It was impossible with the data available to allow for this variant.

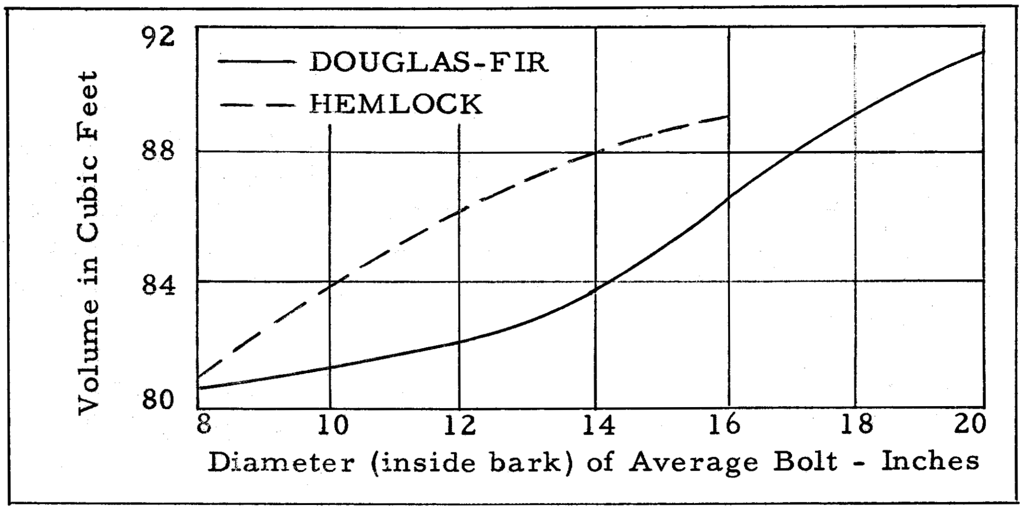

Figure 1. Solid wood volume per cord as influenced by diameter of average bolt

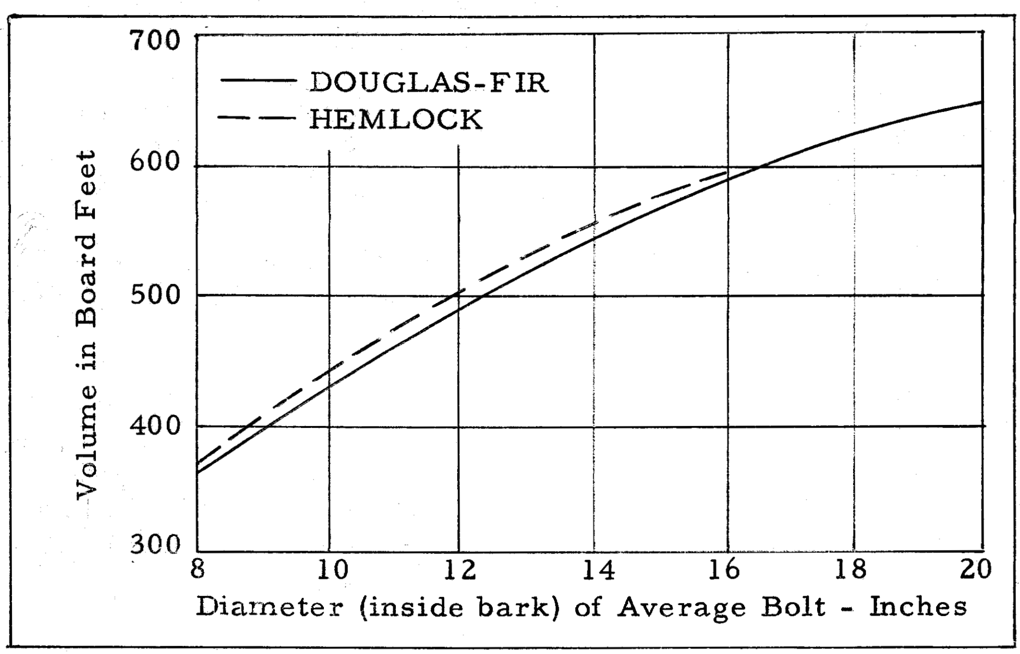

Figure 2. Board foot volume (Scribner rule) per cord as influenced by diameter of average bolt.

Table 2 indicates the volume of wood contained in a standard cord, by diameter of the average bolt. The number of bolts per cord was computed by plotting the bolts per cord in each load over the average bolt diameter of each load. The board foot-cubic foot ratio for each diameter class was determined by dividing its Scribner board-foot contents by its cubic contents as read from the table.

Discussion of Results

This study of the solid contents of eight-foot stacked pulpwood in western Washington has indicated that for Douglas-fir and hemlock, there is a definite relation between both the solid wood and wood-and-bark contents of a cord of pulpwood and the diameter of the average stick. Table 2 will give a much better estimate of volumes than the use of a single average.

Bark volume, greater in Douglas-fir, amounted to approximately 11.1 percent, and 10.8 percent in hemlock, of the total volume of wood and bark.

The Scribner log volume equivalents ranged from an extreme of 365 board feet per cord at 8 inches average diameter to 650 board feet at 20 inches. At any given diameter, Douglas-fir and hemlock have nearly the same board-foot volume per cord.

The estimated green weight of a cord of pulpwood varied from 4,300 pounds to 5,350 pounds, depending upon species and bolt size. Hemlock is significantly heavier than is Douglas-fir.

Board foot-cubic foot ratios for Douglas-fir and hemlock are substantially the same, reflecting their close approximation in both cubic-foot and board-foot volumes.

Further investigation of the influence of stick diameter on solid wood volume, board-foot contents, and weight per unit volume will be needed as the proportion of smaller wood is augmented through early thinnings of the dense Douglas-fir, hemlock, and spruce stands and the importance of round cordwood in pulp production is thus still further increased.

Table 2. --Volume equivalents for a stacked cord of 8-foot pulpwood 1/ in western Washington

Mid-diameter of average bolt (i.b.)	Douglas-fir						Hemlock					
	Bolts	Cubic feet		Bd. ft. Scribner 2/	Bd. ft. - cu. ft. ratio	Approx. green weight 3/	Bolts	Cubic feet		Bd. ft. Scribner 2/	Bd. ft. - cu. ft. ratio	Approx. green weight 3/
		Solid wood	Bark					Solid wood	Bark			
Inches	No.					Pounds	No.					Pounds
8	28.8	81	11	365	4.5	4,350	29.0	81	10	370	4.6	4,850
9	23.0	81	11	400	4.9	4,350	23.4	82	10	405	4.9	4,900
10	18.5	82	10	430	5.3	4,450	19.0	84	10	440	5.3	5,050
11	15.5	82	10	460	5.6	4,450	16.1	85	10	470	5.5	5,100
12	13.0	82	10	490	6.0	4,450	13.7	86	10	500	5.8	5,150
13	11.2	83	10	520	6.3	4,500	11.8	87	10	530	6.1	5,200
14	9.8	84	10	545	6.5	4,550	10.3	88	11	555	6.3	5,300
15	8.6	85	10	570	6.7	4,600	9.0	89	11	580	6.5	5,350
16	7.7	86	10	590	6.8	4,650	8.0	89	11	595	6.7	5,350
17	6.9	88	11	610	7.0	4,750						
18	6.3	89	11	625	7.0	4,800						
19	5.7	90	11	640	7.1	4,850						
20	5.2	91	12	650	7.1	5,000						

1/ Based on 106 truckloads (Douglas-fir - 65, hemlock - 41) as scaled at eight pulp mills and three sawmills.

2/ Gross scale with no trim allowance, no scale for bolts under six inches.

3/ Based on a green weight per cubic foot of solid wood plus bark of 54 pounds for Douglas-fir and 60 pounds for hemlock.