United States
Department of
Agriculture

Forest Service

Forest
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Research
Paper
FPL-RP-504

Regional Softwood Sawmill Processing Variables as Influenced by Productive Capacity

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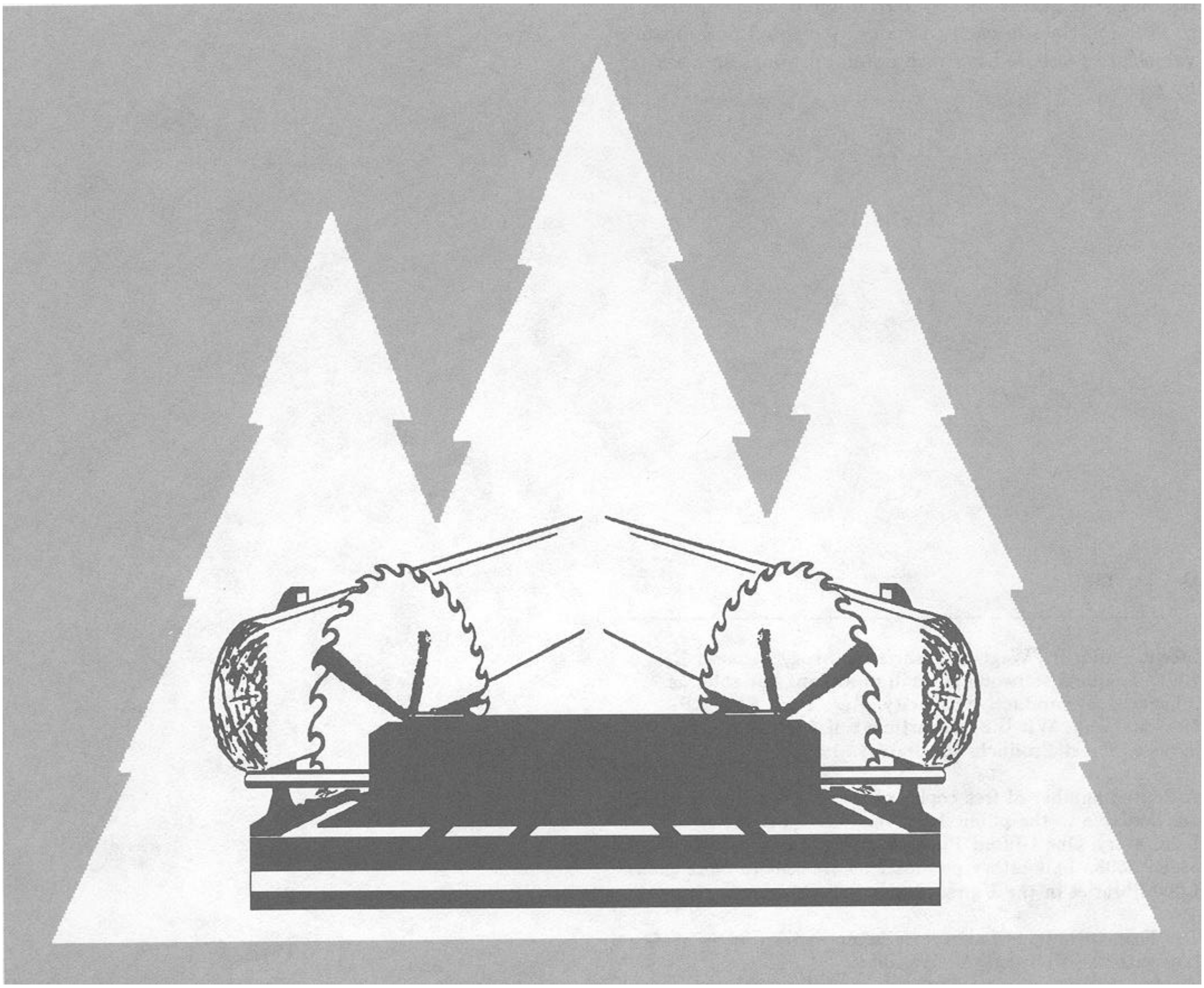

Abstract

The relationship between annual softwood sawmill production and lumber processing variables was examined using data from Sawmill Improvement Program (SIP) studies of 650 softwood mills. The variables were lumber recovery factor (LRF); headrig and resaw kerf width; total sawing variation, rough green size, and oversizing-undersizing for 4/4 and 8/4 lumber; planer allowance; and average log diameter and length. All variables except planer allowance and average log diameter were significantly influenced by annual sawmill production.

The conversion efficiency of the mills in terms of most of these variables increased as sawmill size increased but decreased at annual production levels approaching or exceeding 100 million board feet.

Study sawmills were grouped by geographic region and annual production class. Weighted values of LRF, sawing, and resource variables were calculated for each region by weighting by the percentage of mills of that production class in each category. Weighted and mean values are presented for each annual production class by region.

October 1991

Steele, Philip H.; Wagner, Francis G.; Skog, Kenneth E. 1991. Regional softwood sawmill processing variables as influenced by productive capacity. Res. Pap. FPL-RP-504. Madison, WI: US. Department of Agriculture, Forest Service, Forest Products Laboratory. 12 p.

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Clarifications

Page 2, column 2, paragraph 3

The nominal thicknesses of 4/4 lumber and 8/4 lumber are 25 and 51 mm, respectively. The actual thickness varies by the degree of processing-green or dry, rough or surfaced.

Page 2, footnote 1; Tables 2 to 4, Figure 1

The nominal volume of 1 million board feet of lumber is 2,359 m^3. The actual volume is less and varies by the actual manufactured dimensions of lumber pieces.

Erratum

Page 5, table 1

Asterisks should appear before the column entries Oregon and Washington. Many mill studies were conducted in these states.

Regional Softwood Sawmill Processing Variables as Influenced by Productive Capacity

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Introduction

Formulation of forestry policy requires accurate information on timber supply and demand. The Forest Service provides this information through periodic assessment of timber supply and demand factors (U.S. Department of Agriculture, Forest Service 1990). The single most important use of wood fiber from the nation's forests is for softwood lumber (U.S. Department of Agriculture, Forest Service 1990). Therefore, accurate information on current softwood sawmill conversion is crucial for assessing the adequacy of standing timber supplies for meeting the increasing demands for lumber and other forest products in the United states.

Adams and Haynes (1980) published the procedures used to establish supply and demand relationships for the USDA Forest Service 1989 Assessment (1990). Their projections relied on current Timber Assessment Market Model (TAMM) assumptions as to regional conversion efficiency. The intent of these regional conversion factors was to measure the impact of sawmill technology on the timber resource.

Steele and Risbrudt (1985) demonstrated that the annual production of softwood sawmills appears to influence manufacturing efficiency in the South. For large sawmills, the sawing variables that influence conversion efficiency were lower in magnitude than the sawing variables for small sawmills; therefore, conversion efficiency was higher for large sawmills. Steele and Risbrudt hypothesized that the greater capitalization of large sawmills allows them to use machines with reduced kerf and sawing variation as well as to implement more effective quality control programs.

Cardellichio (1989) came to a similar conclusion based on an econometric analysis of Washington State Sawmill Survey data. He found that mill capacity has a significant influence on unit log use, with large sawmills using less log volume per unit of lumber produced. Based on these results, Cardellichio suggests that large sawmills use more efficient technologies to convert logs to lumber.

Steele and Risbrudt (1985) found no clear difference in size of resource (log diameter and length) processed by sawmills with different annual productive capacity. However, their data were limited to a single region and were subjected to limited statistical analysis.

Steele and others (1991) found that large sawmills are more efficient processors of sawlogs than small sawmills because the large mills use less fiber for resaw kerf and manufacture lumber to closer tolerances. The authors found that manufacturing efficiency tends to increase with increasing sawmill size unless the mills are very large. Very large operations use wider resaw kerfs and produce thicker lumber than do sawmills of intermediate size. Large sawmills also process longer logs than do small sawmills, although long sawlogs are not processed at very large sawmills.

Because large sawmills are generally more efficient and/or process a different size resource than do small sawmills, the published values (Steele and Risbrudt 1985; Steele and others 1986, 1988, 1991) of simple means of conversion efficiency, unweighted by annual production, may not be accurate indicators of timber utilization. Large sawmills, with high productive capacity, consume more timber than do small sawmills, and their impact on timber supply is correspondingly greater. Obtaining an accurate estimate of the true impact of sawmill size on timber supply may require the weighting of conversion efficiency by productive capacity. Because large sawmills (except very large mills) have significantly higher conversion efficiency than do small sawmills, smaller, less efficient sawmills may have undue weight in a simple average value; such average values would consistently underestimate conversion efficiency in terms of the drain on the timber resource.

Projections of future timber demand require estimates of conversion efficiency as a result of assumed technological change over time. A model recently added to TAMM (Skog 1989) estimates the impact of technological change by simulating the effect of changing sawing variables on lumber recovery and manufacturing costs. Part of the expected change in sawing variables may be due to changes in sawmill size. The average size of sawmills has increased (Granskog 1989; U.S. Department of Commerce, Bureau of the Census 1989). Information about the link between sawmill size and sawing variables may lead to more accurate projections of lumber recovery and manufacturing costs.

The objective of this study was to provide regional values of conversion efficiency, sawing variables, and resource size weighted by sawmill productive capacity. Table 1 shows the study regions.

Analytical Procedures

Data on sawmill performance as determined by annual production were obtained from the Sawmill Improvement Program (SIP) studies of 650 softwood sawmills. The SIP was a cooperative effort of the State and Private Forestry staff of the Forest Service and state forestry organizations. The studies of conversion efficiency were made at the request of sawmills and included measurements of log diameter, length, and taper. Lumber was measured for thickness variation.

Sawmill machine characteristics were measured in each SIP study. Average headrig and resaw kerf widths were obtained for all machines by measuring at least 10 randomly selected teeth from each sawblade. Rough green size, total sawing variation, and lumber oversizing-undersizing were obtained by measuring maximum and minimum thicknesses of each study board.

Total sawing variation was calculated from measurements made during a SIP study of within- and between-board variation. Calculations of within- and between-board sawing variation values were based on measurements of maximum and minimum board thickness. A current method used by the sawmill industry to calculate total lumber variation is to measure thickness at several (usually four) random locations on each board. Within-board, between-board, and total sawing variations are then calculated by an analysis of variance (ANOVA) procedure (Brown 1982). The SIP sawing variation values based on maximum and minimum board thickness measurement were adjusted by a procedure described by Peterson and Ermer (1981). This produced sawing variation values comparable to those that would have been obtained by the ANOVA method if four measurements per board had been made.

Determining the conversion efficiency of each sawmill was based on lumber volume yield from 100 study sawlogs. The measure of conversion efficiency used in the SIP was the lumber recovery factor (LRF), which is the nominal board feet[1] of lumber recovered per cubic foot (0.0283 m^3) of log sawn. Straight, sound logs were selected for the studies; therefore, their LRF values were higher than those for mill-run logs. The LRF values for logs in SIP studies are estimated to average about 15 percent higher than the values for mill-run logs. The LRF was the only variable that would be influenced by nonrandom selection of study logs.

Analysis of SIP studies conducted from 1973 through 1983 was restricted to initial studies and to sawmills that sawed lumber to American Lumber Standard (National Bureau of Standards 1970) 4/4 and 8/4 thickness (4/4 lumber is approximately 25 mm thick and 8/4 lumber approximately 51 mm thick). Followup studies have been conducted at many sawmills to substantiate changes in milling efficiency over time. Only initial studies were included in the present analysis to prevent double counting of some sawmills.

Data on percentage of production by annual production class were estimated using a sawmill database compiled by the Forest Products Laboratory[2]. The database is a compilation of information from regional and national directories. Information on the number and individual production of sawmills was used to estimate the proportion of production in five classes: 0-5, 6-25, 26-50, 51-100, and 101+ million board feet capacity per year. Table 2 provides estimated percentage of production in each class. Table 2 also shows the number of sawmill studies in each region by annual production class.

Graphs showing the value of LRF, sawing, and resource variable values by annual production class are shown in

[1] 1 million board feet = 2,359 m^3.

[2] Unpublished database compiled in 1987 by D. B. McKeever, U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Madison, Wisconsin.

Figures 1 to 8. (These figures are simple averages from study sawmills in each production class.) These graphs indicate that a relationship exists between the variables and annual production. Steele and others (1991) previously employed graphical and regression analysis to determine the nature of the relationship of four of these variables to annual production. They found a significant second-order relationship (squared annual production term) for headrig kerf, resaw kerf, 8/4 rough green lumber size, and average log length. Steele and others (1991) found that resaw kerf width and 8/4 rough green lumber size decreased as annual production increased (except for very large mills), which indicates that for most mills manufacturing efficiency increases with sawmill size. For very large sawmills, these authors showed that resaw kerf and 8/4 rough green lumber size increased after reaching a minimum value at 130 and 90 million board feet of annual production, respectively. Average log diameter was also found to be linearly and inversely related to annual production in a simple regression relating the two variables. However, this relationship was not found to be significant when tested in a more accurate simultaneous equation model. Average log length was found to increase significantly as annual production of sawmills increased up to 90 million board feet. Sawlog length decreased with annual production >90 million board feet. If all else is equal, increased log length results in decreased conversion efficiency (Steele 1984).

Steele and others (1991) did not test the relationship of annual production to LRF, 4/4 and 8/4 total sawing variation, 4/4 rough green size, 4/4 and 8/4 oversizing-undersizing, and planer allowance. Regression tests of this relationship were therefore performed for the study reported here. Because the location of sawmills was previously shown to have a significant influence on magnitude of saving variables, the region of study was included as an explanatory variable. The regression tests showed a second-order relationship between annual production and LRF, 4/4 and 8/4 total sawing variation, 4/4 rough green size, and 8/4 oversizing-undersizing. A significant linear relationship was found between annual production and 4/4 oversizing-undersizing. For those variables whose relationship to annual production was of the second order, signs of coefficients showed that manufacturing efficiency increased as annual production increased, except for very large sawmills. Although the data were not consistent for each variable, manufacturing efficiency usually decreased at annual production levels near or greater than 100 million board feet. Table 3 shows the annual production values for the calculated inflection points at which conversion efficiency declined as sawmill production increased. Planer allowance was not found to he significantly related to annual production.

The relationship of LRF to annual production was also tested in a more complex model (Steele and others 1991) to remove the possible influence of differences in the size of logs processed by sawmills of differing annual production (Table 4). Average log length was shown to differ for larger sawmills, which processed significantly longer logs. Average log diameter was shown to significantly differ as sawmill production changed in a simple model but not in the more complex model (Steele and others 1991). To remove the possible influence of processed log size on LRF, average log diameter and average log length were included as covariates in Model 1 shown below. Average log length was included in Model 1 because this variable was previously shown (Steele and others 1988) to have a second-order relationship to LRF. Region was included as an explanatory variable as previously described. The relationships of variables to LRF are given in Model 1 as

$$LRF = \beta_0 + \beta_i R_i + \beta_7 P + \beta_8 P^2 + \beta_9 D + \beta_{10} L + \beta_{11} L^2$$

where

$R_{i=1,6}$ is the indicator variable representing the six regions included in the study,

P annual production,

D average log diameter,

L average log length, and

β_i intercept values and values of other variable coefficients.

All variables tested in Model 1 were significant. Thus, sawmill conversion efficiency, as measured by LRF, truly differs by sawmill production class regardless of the size of sawlog processed. Signs of coefficients indicated that LRF increases as annual production increases.

The results from previous studies and the tests conducted in the study reported here clearly showed that LRF, sawing variables, and resource variables (except planer allowance and average log diameter) are first- or second-order functions of annual sawmill production. Because annual production significantly influenced all variables except average log diameter and planer allowance, values of these variables were weighted by annual production. For comparison, values of the two variables not significantly influenced by annual production were also weighted by annual production. These weighted values provided more accurate estimates of resource use by region. Tables 4 to 15 provide data for all variables by annual production class for each region; the tables include weighted means. Simple means are also given for comparison.

Production classes for some regions lacked enough sawmill studies for estimates to he considered valid. At least three observations were considered necessary for a reliable estimate. An estimated value was required for categories (region by lumber production class) with a percentage production value. The best available estimate was considered to be the estimate nearest the annual production class for that region. Estimated values obtained by this method are indicated by asterisks in Tables 4 to 15. For all sawing variables except total sawing variation and oversizing-undersizing of 4/4 lumber, only seven categories required- such estimates. Those seven, however, also had rather low percentage production values. Apparently, these categories were not sampled because relatively few existed in the population. There were two exceptions: the percentage production value of the Pacific Southwest 101+ (million board feet) class was 12.55 percent and that of the Rocky Mountain 51-100 class was 30.14 percent. In general, however, we think that this estimation procedure had little adverse influence on final weighted regional values.

Simple means were calculated using only the actual means by production class. When a category for a particular variable was absent for a production Class, a value was not estimated for this category; the value was calculated using values from the remaining categories.

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Table 1—Study regions[a]

Region	States	Region	States
Southeastern	*Florida	Eastern	*Connecticut
	*Georgia		*Delaware
	*North Carolina		Illinois
	*South Carolina		Indiana
	*Virginia		Iowa
			Kansas
South-central	*Alabama		Kentucky
	*Arkansas		*Maine
	*Louisiana		*Maryland
	*Mississippi		*Massachusetts
	*Oklahoma		Michigan
	*Tennessee		Missouri
	*Texas		Nebraska
			*New Hampshire
Rocky Mountain	*Arizona		*New Jersey
	*Colorado		*New York
	*Idaho		North Dakota
	*Montana		Ohio
	*Nevada		Pennsylvania
	*New Mexico		Rhode Island
	*South Dakota		*Vermont
	*Utah		West Virginia
	*Wyoming		*Wisconsin
Pacific Northwest	Oregon	Pacific Southwest	*California
	Washington		

[a] Asterisk indicates states in which studies were conducted.

Table 2—Sample sizes and estimated production by region and annual production classes[a]

	Annual production per production class[b]									
	0-5		6-25		26-50		51-100		101+	
Region	Sample size	Production (percent)	Sample size	Production (percent)	Sample size	Production (percent)	Sample size	Production (percent)	Sample size	Production (percent)
Eastern	10 (8)	61.44	17 (16)	29.52	4 —	4.49	*	4.55	—	—
Pacific Northwest	*	1.08	29 (18)	14.46	39 (28)	41.71	16 (12)	27.77	6 (4)	14.98
Pacific Southwest	*	0.07	9 (8)	10.60	15 (14)	55.03	11 —	21.75	*	12.55
Rocky Mountain	11	11.60	69 (64)	25.81	21 —	23.95	*	30.14	*	8.50
South-central	15	12.43	124 (116)	37.71	45 (41)	25.01	9 (7)	22.82	*	2.03
Southeastern	46 (45)	38.02	120 (113)	43.26	26 (21)	10.60	3 —	8.12	—	—

[a] Values in parentheses are for total sawing variation and oversizing-undersizing of 4/4 lumber. Asterisks indicate that fewer than three studies were conducted. Dashes indicate no production in the class.
[b] Production classes are expressed in million board feet (1 million board feet = 2,359 m^3).

Table 3—Annual production at calculated inflection points at which conversion efficiency declined for significant processing variables[a]

Variable	Inflection point (million board feet)[b]
Lumber recovery factor	112
Headrig kerf	90
Resaw kerf[c]	134
Average log length[c]	111
4/4 rough green size	97
8/4 rough green size[c]	91
4/4 total sawing variation	42
8/4 total sawing variation	79
8/4 oversizing-undersizing	114

[a] Variables significantly influenced by annual production and squared annual production.
[b] 1 million board feet = 2,359 m^3.
[c] Inflection points for these variables were calculated from coefficients developed in a more complex model developed by Steele and others (1991).

Table 4—Lumber recovery factors by annual production class and region[a]

	Lumber recovery factor						
	Lumber production class					Simple	Weighted
Region	0-5	6-25	26-50	51-100	101+	mean	mean
Eastern	6.15	6.48	6.35	6.35*	—	6.33	6.27
Pacific Northwest	8.29*	8.29	8.56	7.73	8.63	8.30	8.30
Pacific Southwest	9.02*	9.02	9.11	9.23	9.23*	9.12	9.14
Rocky Mountain	7.29	7.77	8.18	8.18*	8.18*	7.75	7.97
South-central	6.06	6.20	6.49	6.59	6.59*	6.34	6.35
Southeastern	5.53	5.74	5.57	6.24	—	5.77	5.68

[a] Production classes are expressed in million board feet (1 million board feet = 2,359 m^3). Asterisks indicate that fewer than three studies were conducted; the values were estimated from values in the closest production class. Dashes indicate no production in the class. Simple means were computed from values without asterisks.

Table 5—Headrig kerf by annual production class and region[a]

	Headrig kerf (in.)[b]						
	Lumber production class					Simple	Weighted
Region	0-5	6-25	26-50	51-100	101+	mean	mean
Eastern	0.232	0.218	0.160	0.160*	—	0.203	0.221
Pacific Northwest	0.218*	0.218	0.182	0.178	0.185	0.191	0.187
Pacific Southwest	0.191*	0.191	0.204	0.171	0.171*	0.189	0.191
Rocky Mountain	0.299	0.236	0.187	0.187*	0.187*	0.241	0.213
South-central	0.257	0.236	0.202	0.175	0.175*	0.218	0.215
Southeastern	0.288	0.267	0.233	0.180	—	0.242	0.264

[a] See explanatory footnote for Table 4.
[b] 1 in. = 25.4 mm.

Table 6—Resaw kerf by annual production class and region[a]

	Resawf kerf (in.)						
	Lumber production class-					Simple	Weighted
Region	0-5	6-25	26-50	51-100	101+	mean	mean
Eastern	0.226	0.201	0.179	0.179*	—	0.202	0.214
Pacific Northwest	0.167*	0.167	0.151	0.168	0.150	0.159	0.158
Pacific Southwest	0.184*	0.184	0.159	0.146	0.146*	0.163	0.157
Rocky Mountain	0.268	0.190	0.169	0.169*	0.169*	0.209	0.186
South-central	0.241	0.208	0.192	0.172	0.172*	0.203	0.199
Southeastern	0.261	0.213	0.207	0.211	—	0.223	0.230

[a] See explanatory footnote for Table 4.

Table 7—Rough green size of 4/4 lumber by annual production class and region[a]

	Rough green size of 4/4 lumber (in.)						
	Lumber production class					Simple	Weighted
Region	0-5	6-25	26-50	51-100	101+	mean	mean
Eastern	1.040	1.036	1.036	1.036*	—	1.038	1.038
Pacific Northwest	0.954*	0.954	0.977	0.952	0.991	0.969	0.969
Pacific Southwest	1.010*	1.010	0.993	0.978	0.978*	0.994	0.990
Rocky Mountain	1.073	1.035	0.998	0.998*	0.998*	1.035	1.016
South-central	1.095	1.055	1.023	1.006	1.006*	1.045	1.040
Southeastern	1.095	1.073	1.024	1.037	—	1.057	1.073

[a] See explanatory footnote for Table 4.

Table 8—Rough green size of 8/4 lumber by annual production class and region[a]

	Rough green size of 8/4 lumber (in.)						
	Lumber production class					Simple	Weighted
Region	0-5	6-25	26-50	51-100	101+	mean	mean
Eastern	1.852	1.833	1.739	1.739*	—	1.808	1.836
Pacific Northwest	1.733*	1.733	1.754	1.762	1.701	1.738	1.745
Pacific Southwest	1.741*	1.741	1.767	1.696	1.696*	1.735	1.740
Rocky Mountain	1.905	1.784	1.709	1.709*	1.709*	1.799	1.751
South-central	1.930	1.839	1.788	1.747	1.747*	1.826	1.815
Southeastern	1.933	1.826	1.757	1.751	—	1.817	1.853

[a] See explanatory footnote for Table 4.

Table 9—Total sawing variation in 4/4 lumber by annual production class and region[a]

	Total sawing variation in 4/4 lumber (in.)						
	Lumber production class					Simple	Weighted
Region	0-5	6-25	26-50	51-100	101+	mean	mean
Eastern	0.043	0.067	0.113	0.113*	—	0.075	0.056
Pacific Northwest	0.047*	0.047	0.059	0.057	0.123	0.072	0.066
Pacific Southwest	0.061*	0.061	0.069	0.078	0.078*	0.069	0.071
Rocky Mountain	0.091	0.063	0.061	0.061*	0.061*	0.072	0.065
South-central	0.096	0.077	0.078	0.068	0.068*	0.080	0.077
Southeastern	0.088	0.077	0.071	0.070	—	0.077	0.080

[a] See explanatory footnote for Table 4.

Table 10—Total sawing variation in 8/4 lumber by annual production class and region[a]

	Total sawing variation in 8/4 lumber (in.)						
	Lumber production class					Simple	Weighted
Region	0-5	6-25	26-50	51-100	101+	mean	mean
Eastern	0.051	0.068	0.046	0.046*	—	0.055	0.056
Pacific Northwest	0.059*	0.059	0.059	0.059	0.066	0.061	0.060
Pacific Southwest	0.058*	0.058	0.065	0.068	0.068*	0.064	0.065
Rocky Mountain	0.115	0.071	0.053	0.053*	0.053*	0.080	0.065
South-central	0.083	0.072	0.062	0.045	0.045*	0.066	0.064
Southeastern	0.093	0.061	0.043	0.054	—	0.063	0.071

[a] See explanatory footnote for Table 4.

Table 11—Oversizing-undersizing in 4/4 lumber by annual production class and region [a]

Region	Oversizing-undersizing in 4/4 lumber (in.)						
	Lumber production class					Simple mean	Weighted mean
	0-5	6-25	26-50	51-100	101+		
Eastern	0.069	-0.008	-0.008*	-0.008*	—	0.031	0.039
Pacific Northwest	-0.030*	-0.030	-0.040	-0.063	-0.122	-0.064	-0.057
Pacific Southwest	-0.007*	-0.007	-0.026	-0.049	-0.049*	-0.027	-0.032
Rocky Mountain	-0.025	-0.013	-0.028	-0.028*	-0.028*	-0.022	-0.024
South-central	-0.004	-0.022	-0.063	-0.064	-0.064*	-0.038	-0.041
Southeastern	0.017	0.011	-0.033	-0.026	—	-0.008	0.006

‘See explanatory footnote for Table 4.

Table 12—Oversizing-undersizing in 8/4 lumber by annual production class and region”

Region	Oversizing-undersizing in 8/4 lumber (in.)						
	Lumber production class					Simple mean	Weighted mean
	0-5	6-25	26-50	51-100	101+		
Eastern	0.075	-0.005	-0.047	-0.047*	—	0.008	0.040
Pacific Northwest	-0.032*	-0.032	-0.035	-0.028	-0.108	-0.051	-0.044
Pacific Southwest	-0.046*	-0.046	-0.015	-0.101	-0.101*	-0.054	-0.048
Rocky Mountain	0.000	-0.043	-0.069	-0.069*	-0.069*	-0.037	-0.054
South-central	0.069	-0.007	-0.046	-0.037	-0.037*	-0.005	-0.015
Southeastern	0.062	0.017	-0.034	-0.016	—	0.007	0.026

[a] See explanatory footnote for Table 4.

Table 13—Average log diameter by annual production class and region [a]

Region	Log diameter (in.)						
	Lumber production class					Simple mean	Weighted mean
	0-5	6-25	26-50	51-100	101+		
Eastern	10.15	10.69	7.73	7.73*	—	9.52	10.09
Pacific Northwest	11.60*	11.60	13.22	11.29	9.83	11.49	11.91
Pacific Southwest	12.97*	12.97	14.60	13.70	13.70*	13.76	14.12
Rocky Mountain	10.81	10.29	10.80	10.80*	10.80*	10.63	10.67
South-central	10.72	10.89	10.36	9.08	9.08*	10.26	10.29
Southeastern	9.40	10.26	8.64	9.97	—	9.57	9.74

[a] See explanatory footnote for Table 4.

Table 14—Average log length by annual production class and region[a]

Region	Log length (ft)[b]						
	Lumber production class					Simple mean	Weighted mean
	0-5	6-25	26-50	51-100	101+		
Eastern	13.78	14.67	11.75	11.75*	—	13.40	13.86
Pacific Northwest	12.92*	12.92	17.19	17.91	18.25	16.57	16.89
Pacific Southwest	14.34*	14.34	16.83	17.24	17.24*	16.14	16.70
Rocky Mountain	12.99	13.45	14.11	14.11*	14.11*	13.52	13.81
South-central	14.29	15.95	15.97	15.70	15.70*	15.48	15.69
Southeastern	14.06	15.24	15.66	16.43	—	15.35	14.93

[a] See explanatory footnote for Table 4.
[b] 1 ft = 0.3048 m.

Table 15—Planer allowance by annual production class and region[a]

Region	Planer allowance (in.)						
		Lumber production class				Simple mean	Weighted mean
	0-5	6-25	26-50	51-100	101+		
Eastern	0.036	0.075,	0.053	0.053*	—	0.055	0.049
Pacific Northwest	0.056*	0.056	0.059	0.064	0.063	0.061	0.061
Pacific Southwest	0.056*	0.056	0.049	0.047	0.047*	0.051	0.051
Rocky Mountain	0.076	0.082	0.069	0.069*	0.069*	0.076	0.073
South-central	0.063	0.081	0.087	0.076	0.076*	0.077	0.079
Southeastern	0.078	0.072	0.069	0.057	—	0.069	0.073

[a] See explanatory footnote for Table 4.

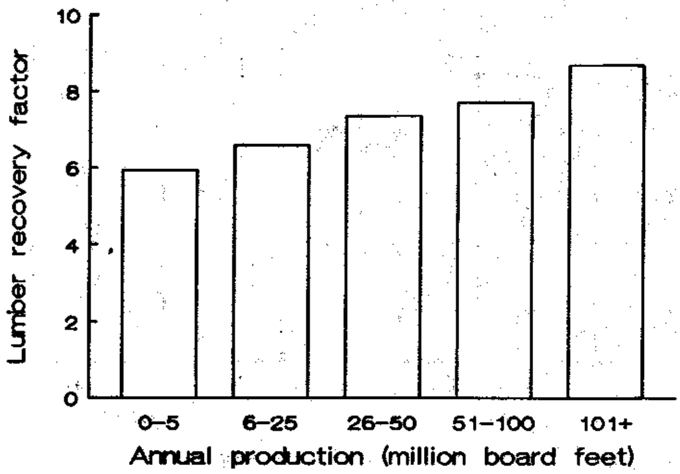

Figure 1—Lumber recovery factor by annual poduction class. 1 million board feet = 2,359 m^3.

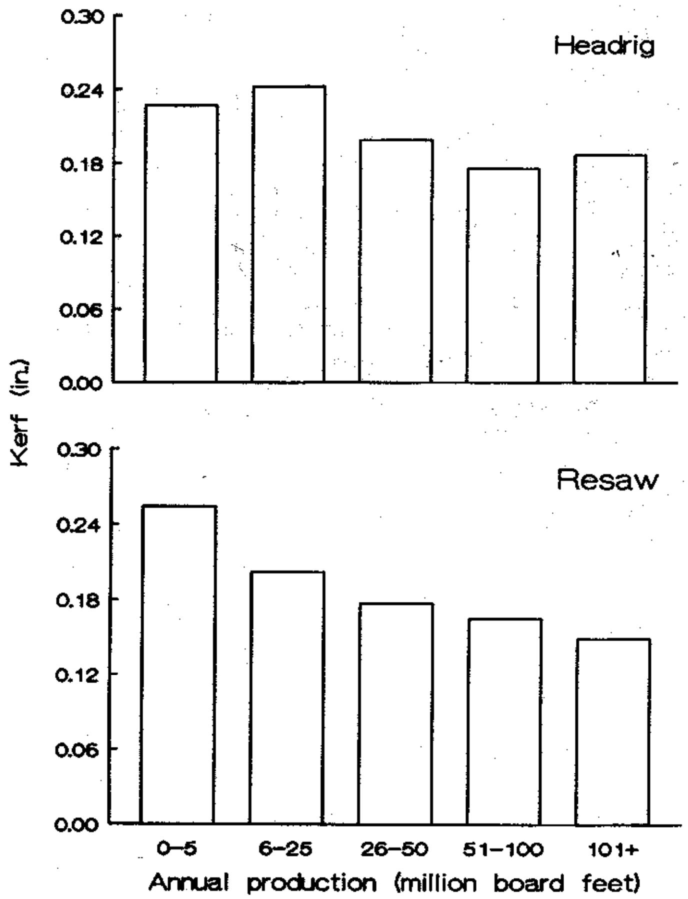

Figure 2—Headrig and resaw kerf by annual production class. 1 in. = 25.4 mm.

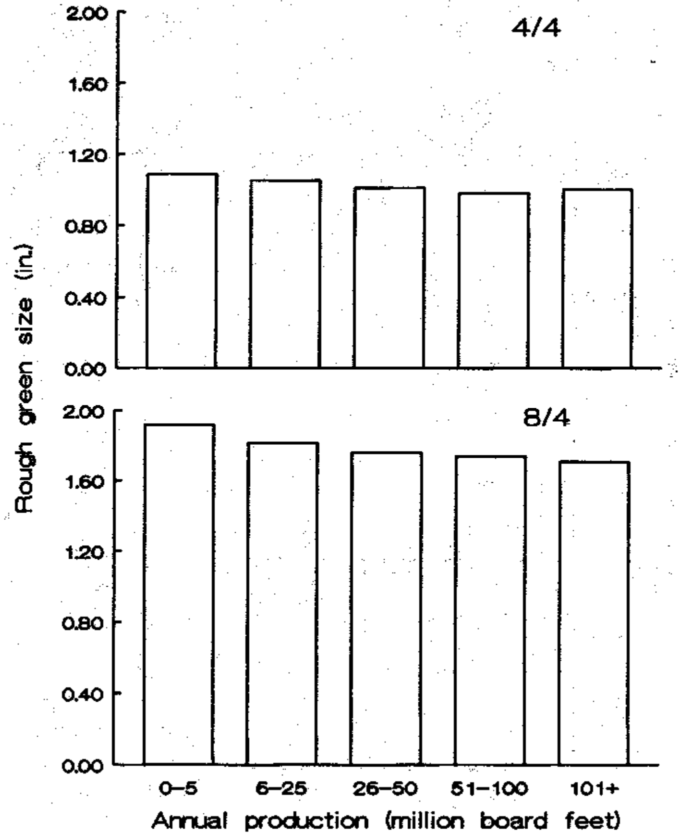

Figure 3—Rough green 4/4 and 8/4 lumber size by annual production class.

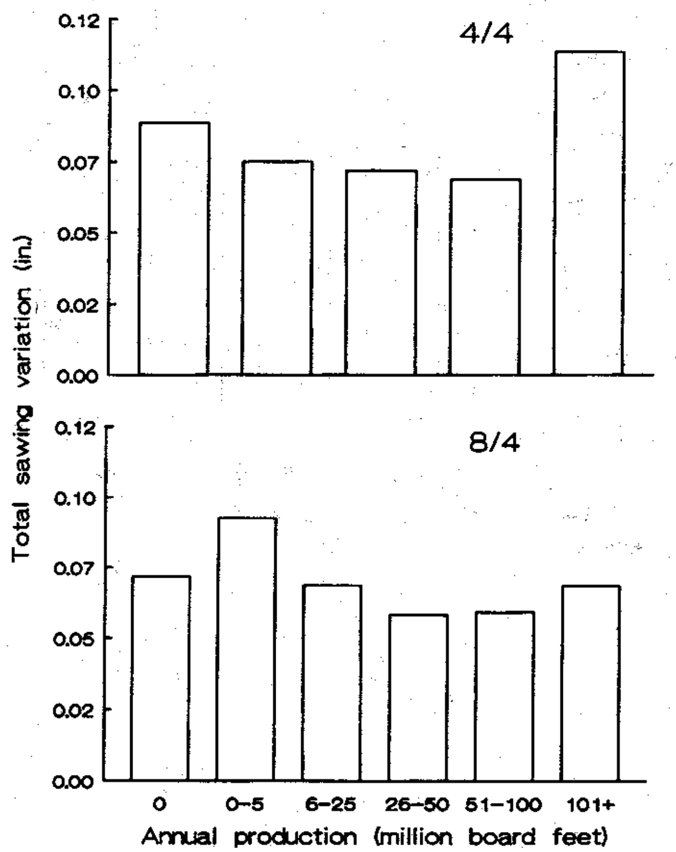

Figure 4—Total sawing variation of 4/4 and 8/4 lumber by annual production class.

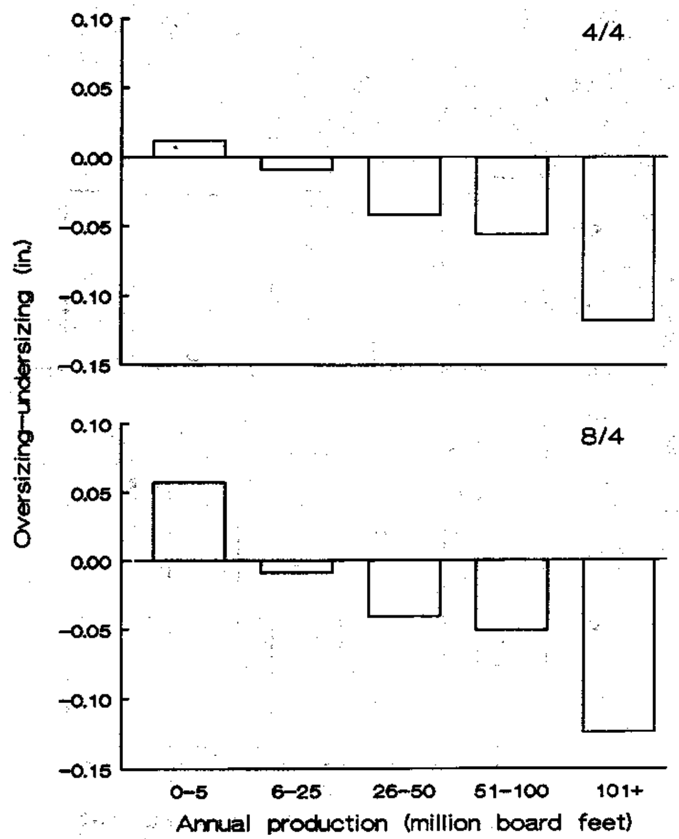

Figure 5—Oversizing-undersizing of 4/4 and 8/4 lumber by annual production class.

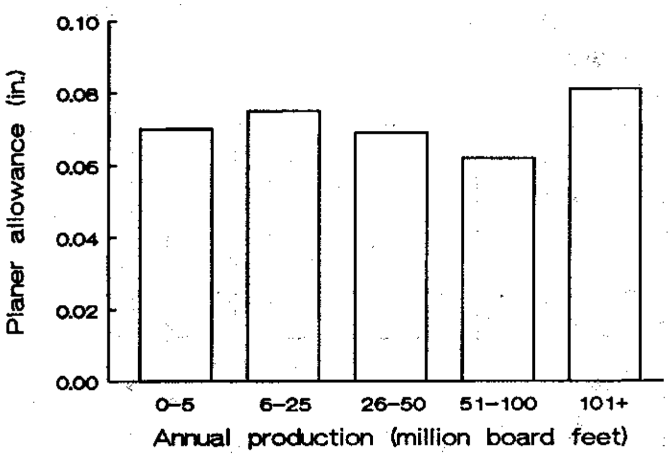

Figure 6—Planer allowance by annual production class.

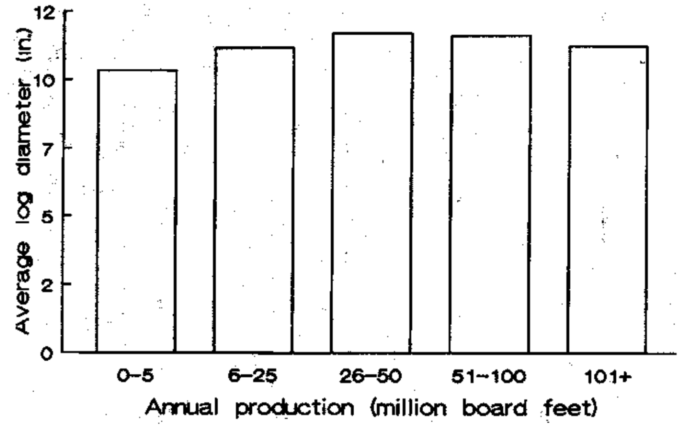

Figure 7—Average log diameter by annual production class.

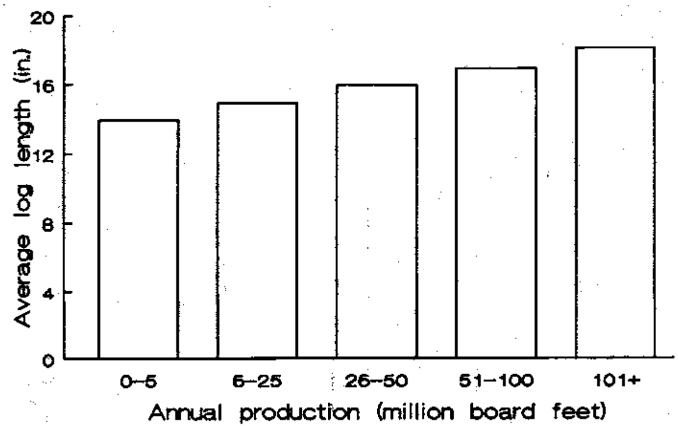

Figure 8—Average log length by annual production class.

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