

Trends in Lumber Processing in the Western United States. Part III: Residue Recovered versus Lumber Produced

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Abstract

This article presents changes in proportions of wood fiber residue or by-products generated in lumber production in the western United States over the last 40 years. The results show the proportion of logs remaining as residue has dropped from 59 percent in the 1970s to 51 percent in the 2000s. Technology and its improved application have led to decreased proportions of wood fiber residue in lumber production even as log size has decreased. West wide the proportion of the log converted to both sawdust and planer shavings has decreased substantially over the last 40 years with no change in the proportion recovered in coarse residue. Coarse residue was 31 percent of log volume processed in the 1970s and 2000s. Sawdust generated was 15 percent of log volume in the 1970s and 11 percent in the 2000s, with planer shavings moving from 13 to 9 percent.

Processing logs at sawmills yields lumber and at least equally large volumes of wood fiber in the form of wood by-products or mill residue. Increasing interest in bioenergy, bioproducts, and carbon sequestration raises questions about the volume and disposition of these residues. Previous articles outlined trends in cubic foot-to-board foot ratios for logs processed by western sawmills and the volume of lumber recovered per unit volume of log input measured in board feet Scribner and cubic feet (Keegan et al. 2010a, 2010b). Results from those articles showed that technology had increased the proportion of logs recovered in lumber and decreased the mill residue volume despite decreases in log size over time. This article examines how the proportions of logs recovered in various types of by-products have changed over the last 40 years in the western United States. It also provides the first comprehensive summary of changes in the overall use of logs in the production of sawn wood products over the past 40 years. The results are primarily for the production of softwood lumber, which accounts for over 98 percent of lumber output from the western states. “Lumber” as used in this article is defined according to *The Dictionary of Forestry* (Society of American Foresters 1998) as “sawn product from a tree” (p. 109). The overwhelming volume of sawn

products produced in the western United States is 1 and 2 inches in thickness up to 12 inches in width.

Methods

For the purposes of this analysis, manufactured lumber is measured as green finished lumber; mill residue is the remaining portion of the log. Mill residue is of four types: coarse residue, sawdust, planer shavings, and bark. Coarse or chippable residue is generated from large pieces and is suitable for use as clean chips by the pulp and paper

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industry. It consists of ends and short pieces from merchandizing logs, slabs as logs are squared, and edgings and trim from lumber manufacturing. Sawdust is generated from sawing in the initial log break down and in trimming and edging lumber. Planer shavings result from finishing lumber to proper size and smoothness. Coarse residue is the residue component produced in the largest quantities and generally exceeds the volume of sawdust and planer shavings combined. This analysis deals only with the solid wood portion of the log processed by sawmills and does not include bark, which is typically removed prior to sawing.

The primary sources of data for this project are periodic forest industry surveys and censuses (Morgan et al. 2004a, 2004b, 2005a, 2005b, 2006; Brandt et al. 2006, 2009; Schoorl et al. 2008; Spoelma et al. 2008; Halbrook et al. 2009) as described in Keegan et al. (2010a, 2010b). The mill surveys provided statewide data on the volume of timber received by sawmills in 1,000 board feet (MBF) Scribner log rule, log size, total lumber production, mill residue volume, and disposition of residue. This information enabled precise estimates of the cubic foot volume of wood fiber in the processed logs.

The steps in calculating volume and percentage of logs processed into finished lumber and residue are summarized below:

1. Total cubic volume of wood fiber in logs processed by sawmills was assumed to equal the cubic volume of finished green lumber, plus the cubic volume of coarse residue, sawdust, and planer shavings from the log. Bark volume was not included.
2. The cubic volume in green finished lumber was calculated based on the actual dimensions produced in the West. The cubic volume in a given scaled board foot of lumber varies by lumber thickness and width (Hartman et al. 1976, Briggs 1994). The mix of lumber sizes shifts somewhat from year to year and differs somewhat by state and region (Western Wood Products Association [WWPA], various dates) but was in the range of 59 to 61 cubic feet solid wood equivalent per MBF of green finished lumber. In this analysis it was assumed there were 60 cubic feet of solid wood in 1,000 board feet of green finished lumber. We examined the impact of variations in lumber size mixes produced and, as discussed in Keegan et al. (2010b), found shifts in lumber size and related increases or decreases in cubic feet per board foot lumber tally would result in only slight changes in the percentage of residue versus percentage of finished lumber.
3. The mill surveys referenced provide mill residue factors, which indicate the production of mill residue by residue type per MBF of lumber produced. Mill residue was commonly reported in bone dry units (BDU; 1 BDU equals 2,400 lb of oven-dry wood). Mill residue factors were used to calculate the number of BDU generated in the production of 1,000 board feet of lumber. The weight of wood was used to translate BDU into a volumetric measure: cubic feet. Based on the volume-weighted species mix of logs used to produce lumber in the western United States, the average oven-dry weight of wood in a cubic foot of green wood ranged from more than 24 pounds to less than 26 pounds (WWPA, various dates; Forest Products Society 1999). In this analysis it was assumed the weight of the oven-dry wood in a cubic foot of green wood was 25 pounds. This, in turn, results

in a 96 cubic feet yield of 2,400 pounds of oven-dry wood per BDU. A sensitivity analysis indicated that the variation in weight due to differences in species among regions and over time had virtually no impact on estimates of the proportion of the log in lumber and residue.

4. With all components of the wood fiber in a log expressed in common volumetric units, the following relationship was used for each time period and geographic region to calculate the percentage of the log processed into lumber and the residue by-products.

total log cubic volume

$$= \text{cubic volume (lumber + coarse residue + sawdust + planer shavings)}$$

5. The calculations are illustrated as follows for Oregon in the 2000s. One thousand board feet (1 MBF) of lumber equals 60 cubic feet of solid wood. In manufacturing lumber, Oregon's sawmills produced 0.37 BDU of coarse residue and 0.13 and 0.08 BDU of sawdust and planer shavings, respectively, for a total of 0.58 BDU/MBF of lumber. Given 96 cubic feet of solid wood per BDU, the 0.58 BDU would contain 55.7 cubic feet. Because the residue and lumber account for the total volume of the log, the log volume required to produce an MBF of lumber would contain 115.7 cubic feet (60 + 55.7). Of that log, 52 percent would be recovered in lumber and 48 percent in the three residue categories.

Results

As the proportion of the log used for lumber has increased (Keegan et al. 2010b) the proportion the log converted to mill residue has dropped from 59 percent in the 1970s to 51 percent in the 2000s (Table 1). Overall, Pacific Coast mills consistently produced more finished lumber and less residue per unit log input than mills in the Northern Rockies and Four Corners (Fig. 1). Between the 1970s and 2000s, the largest decrease in residue production occurred in the Pacific Coast states, which moved from 58 to 50 percent. During the 1970s the Northern Rockies and Four Corners regions consistently converted over 55 percent of processed logs into residue. By the 2000s, mills in the two regions had 56 and 54 percent of sawn logs, respectively, in residue.

West wide the proportion of the log recovered in both sawdust and planer shavings decreased substantially over the last 40 years with no change in the proportion recovered in coarse residue. Sawdust generated was 15 percent of logs processed into lumber in the 1970s and 11 percent in the 2000s; planer shavings generated fell from 13 to 9 percent of log volume. All regions showed reduced proportions of sawdust and shavings. West wide the proportion of coarse residue produced remained at an estimated 31 percent of log volume in the 1970s through the 2000s. Both the Four Corners and Northern Rockies regions have shown small increases in the proportion of coarse residue. Coarse residue increased from 31 to 32 percent in the Four Corners and increased from 30 to 32 percent in the Northern Rockies.

Discussion

The proportion of lumber produced per cubic foot of log input is influenced by a range of factors including technology, log size, lumber size and grade, and market conditions for lumber and residue—particularly for coarse residue. Sawing technology improvements over the past four decades include

Table 1.—Proportion of cubic log volume (excluding bark) recovered in lumber and mill residue in the western United States.

	Coarse	Sawdust	Shavings	Total residue	Finished lumber
1970s					
Four Corners	0.31	0.15	0.13	0.59	0.41
Northern Rockies	0.30	0.16	0.14	0.59	0.41
Pacific Coast	0.31	0.15	0.12	0.58	0.42
West wide	0.31	0.15	0.13	0.59	0.41
1980s					
Four Corners	0.33	0.15	0.11	0.59	0.41
Northern Rockies	0.33	0.14	0.12	0.58	0.42
Pacific Coast	0.31	0.14	0.11	0.56	0.44
West wide	0.31	0.15	0.11	0.57	0.43
1990s					
Four Corners	0.33	0.15	0.12	0.60	0.40
Northern Rockies	0.34	0.14	0.10	0.57	0.43
Pacific Coast	0.31	0.12	0.10	0.53	0.47
West wide	0.32	0.13	0.10	0.55	0.45
2000s					
Four Corners	0.32	0.12	0.12	0.56	0.44
Northern Rockies	0.32	0.12	0.10	0.54	0.46
Pacific Coast	0.31	0.11	0.08	0.50	0.50
West wide	0.31	0.11	0.09	0.51	0.49

- log size (diameter and length) sensing capabilities linked to computers to determine the optimum sawing patterns for logs to recover either the greatest volume or greatest value from each log;
- curve sawing technology, which increases recovery from logs with sweep and crook;
- improved sawing accuracies, which reduces the amount of size variation in sawn lumber, thus increasing solid wood recovery and allowing rough green lumber sizes to be produced closer to desired finished sizes;
- thinner kerf saws reducing the proportion of the log that becomes sawdust; and
- edging and trim optimization techniques, better quality saws, and improved drying techniques, all of which reduce lumber loss.

Technology and log size have had major and opposing effects over the past four decades (Keegan et al. 2010b). With the exception of parts of the Four Corners region and Alaska, which account for only about 2 percent of the lumber produced in the West (WWPA, various dates), there has been a substantial decline in average log size since the 1970s. If all factors except log size were held constant, the proportion of the log becoming coarse residue would increase because smaller logs generally yield a lower proportion of the log recovered into lumber. However, results for all three regions show that even with substantial decreases in log size, there is an increase in lumber recovery accompanied by almost no increase in the proportion of coarse residue. These trends present strong evidence of improved sawing technology through time (Keegan et al. 2010a).

The impact of technology on sawdust and planer shavings can be seen clearly by examining the volume of these types of residue per unit volume of lumber produced. In the

Pacific Coast



Northern Rockies



Four Corners



Figure 1.—US states included in the three geographic regions.

1970s, western sawmills generated approximately 370 cubic feet of sawdust and 320 cubic feet of planer shaving per 1,000 cubic feet of lumber produced. By the 2000s, 1,000 cubic feet of lumber generated 225 cubic feet of sawdust and 185 cubic feet of planer shavings.

The differences in the proportion of residue among regions are certainly influenced by log size, especially when comparing the Pacific Coast and Northern Rockies (Fig. 1). In the Pacific Coast states, where a substantially higher proportion of log volume is recovered as lumber, an estimated 56 percent of logs processed by sawmills exceeded 10 inches small-end diameter, while in the Northern Rockies approximately 37 percent by volume of logs processed exceeded 10 inches small-end diameter (Table 2). Recent data on the Four Corners region are not currently available.

Shifts in lumber grade and sizes, which are strongly related to decreasing log size, have also impacted the proportion of residue produced by western sawmills, but these are modest and somewhat offsetting, with the lumber mix moving to somewhat narrower, but thicker grades with a lower proportion of wide 1-inch boards and an increase in 2-inch-thick but narrower grades of dimension lumber (Keegan et al. 1998, 2010b).

Since the 1970s, there has been a substantial shift toward narrower widths in the various lumber grades, with mills producing a greater proportion of 8-inch and narrower lumber and less of wider 10- and 12-inch lumber (WWPA, various dates). Narrow lumber has more surface area per cubic foot and per board foot of scaled lumber than wider lumber, requiring more saw cuts and surfaces to plane. Generally, the move to narrower lumber tends to increase the proportion of sawdust and shavings while decreasing coarse residue. The shift in production into narrower boards and dimension lumber often represents a move to produce lumber in place of coarse residue (Keegan et al. 1998, 2010b).

The increase in the proportion of thicker lumber in western production has had an offsetting impact of narrower grades over time. For example, the proportion of lumber that was nominally 2-inch-thick dimension lumber in the West has increased, with 1-inch-thick Shop and Better and Common boards lumber decreasing (WWPA, various dates). Dimension lumber with its greater thickness has less surface area requiring fewer saw cuts and planing and therefore less sawdust and planer shavings per scaled volume of lumber. The trend away from these grades to thicker dimension lumber would decrease sawdust and shavings per volume of lumber produced. Evaluating the precise effect of shifts in lumber grades and sizes is beyond the scope of this article, but given the offsetting effects of increased proportions of thicker but narrower lumber grades and the dramatic decreases in output of planer shavings and sawdust over the past 40 years (31% and 27%, respectively, of residue per board foot of lumber produced), it is clear that much of the reduced volume of sawdust and planer shavings is the result of improved sawing technology.

Conditions in lumber and residue markets also impact the production and disposition of mill residues. Shifts in lumber markets can impact both the supply and the price of residue. The price of all types of residue varies as available supply varies, with the highest prices often occurring in years of low lumber production. Many of the users of mill residue (such as pulpmills, reconstituted board plants, and power plants) are not as cyclic as the lumber industry, have high fixed costs, and often do not curtail operations as readily as sawmills. This can lead to strong demand when lumber production is down (Keegan et al. 1998).

Table 2.—Proportion of logs processed by sawmills by small-end diameter.^a

	Sum					
	0–7 in.	>7–10 in.	≤10 in.	>10 in.	>10–24 in.	>24 in.
Eastside scale						
California						
2006	0.08	0.18	0.26	0.74	0.56	0.18
Idaho 2006	0.29	0.26	0.55	0.45	0.39	0.05
Montana						
2004	0.54	0.26	0.80	0.21	0.20	0.01
Wyoming						
2005	0.42	0.13	0.55	0.45	0.45	— ^b
Westside scale						
Alaska						
2005	0.01	0.23	0.24	0.76	0.36	0.39
Oregon						
2003	0.14	0.32	0.47	0.54	0.49	0.05
Washington						
			0.53	0.47		

^a Westside scale refers to the Westside variant of the Scribner log scale commonly used in Alaska and the area west of the Cascade Mountains in Washington and Oregon. Eastside scale refers to the Eastside variant of the Scribner log scale used east of the Cascade Mountains in Washington and Oregon and throughout the rest of the western United States.

^b —, less than 5 percent.

Swings in lumber and chip markets have an impact on the proportion of the log generated into all types of residue, but often in offsetting directions. Coarse residue in the form of chips used by the pulp and paper industry is the sawmill residue component that can be most efficiently produced in greater or lesser amounts in response to changing market conditions. As lumber markets decline, sawmills tend to target chip production over additional recovery of marginal, lower valued lumber grades. The opposite happens when lumber markets are very strong. An increase in the proportion of the log recovered in chips leads to a lower portion of lumber from the log and a corresponding decrease in the proportion of sawdust and shavings produced. The increase in coarse residue production would be greater than the decrease in shavings and sawdust. It is not reasonable to manipulate milling operations to produce more low-valued sawdust or shavings; this would reduce a mill's overall production efficiency and lead to a loss in income generated from recovery of lumber.

Conclusions

It is clear that the improved application of technology has led to decreased proportions of wood fiber residue in lumber production at sawmills throughout the western United States, and as technology advances this trend should continue. In part, this trend has increased western sawmills' ability and the inclination to use smaller and less valuable trees, making more of the available timber resource financially feasible for lumber production. The increased use of smaller trees may also position western sawmills to compete more directly with other small roundwood users in the region. Forest landowners benefit as the pool of potential bidders for timber grows; higher stumpage prices allow harvest of small trees that were previously unfeasible to cut because of the limited value for pulpwood or other small roundwood uses. In turn, society benefits as forest landowners perform the timber stand improvement, thinning, and fire hazard reduction treatments that help ensure

that western forests remain healthy and productive into the future.

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