Chapter 4. **Lumber**

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Nominal and Manufactured Lumber Sizes

To avoid confusion in interpreting information in this chapter, terminology must be clarified regarding the dimensions (thickness, width, and length) of lumber. The term *nominal* is used for dimensions as customarily communicated in commerce, such as referring to a piece of softwood lumber as a 2x4. The term *manufactured* refers to the dimensions in product specifications that correspond to nominal dimensions. Manufactured dimensions depend on the state of manufacture; a surfaced-dry softwood 2x4 is required by the American Softwood Lumber Standard (USDC 1970) to be a minimum of 1.5 inches by 3.5 inches. *Actual* dimensions are obtained by measuring individual pieces with calipers. Actual dimensions will differ slightly from the manufactured dimensions required in specifications due to minor variations in drying shrinkage and milling accuracy. Information and examples in this chapter are based on nominal and manufactured dimensions. A mill could substitute its own actual dimensions for the manufactured dimensions required by product specifications.

As discussed in Chapter 2, the manufactured sizes of North American lumber are generally different from the nominal sizes. Exceptions are special orders and some lumber exports, particularly those manufactured to metric specifications. The board foot measure of lumber volume is, however, based on the nominal size. Consequently there can be a significant discrepancy between the cubic volume of lumber implied by board foot measure and the true cubic volume of wood present in the corresponding manufactured size. In many other parts of the world lumber is measured in metric units, with negligible difference between the nominal and manufactured size.

Softwood Lumber Sizes

Softwood lumber is marketed by species, grade, and form of manufacture. For many products, the American Softwood Lumber Standard is a basic reference. Softwood lumber can be viewed as falling into two broad categories of use: construction lumber and lumber for remanufacture.

Construction Lumber. Softwood construction lumber falls into three general categories: stress rated, nonstress rated, and appearance. The first two are used where structural integrity is the prime consideration. In the latter group, structural function, while important, is secondary to aesthetic considerations. Construction lumber is typically used in the form (sawn, planed, dried) and grade it receives at the sawmill.

Table 4-1 shows nominal and minimum manufactured thickness and width required of green and surfaced-dry softwood construction lumber. The nominal and manufactured lengths, in one-foot increments, are the same. Even, two-foot lengths are the most common. Also shown are metric equivalents and nomenclature.

Lumber for Remanufacture. There are numerous groups (Factory or Shop, industrial clears, molding stock, etc.) of remanufacture lumber. To become integral parts of other products, these often undergo major transformation by secondary manufacturing after leaving the primary sawmill. Grading for remanufacture attempts to describe the yield obtainable from subsequent operations, and the lumber is offered in sizes needed to fit the particular end product requirements.

Table 4-2 shows thickness standards for one group of softwood remanufacture lumber. Note that the manufactured thickness required for a given nominal size is different and generally greater than for construction lumber (Table 4-1). Factory lumber is usually random width and random length. The notes at the end of Table 4-2 indicate some of the variations that occur in practice.

The appropriate lumber grading agency (Appendix 5) should be contacted for the size requirements of other specialized lumber products.

Hardwood Lumber Sizes

Most hardwood lumber is produced for remanufacture into products such as furniture and cabinets or is made directly into flooring, paneling,

Table 4-1. *American Lumber Standard sizes for stress-graded and nonstress-graded softwood lumber for construction.*[a]

	Thickness							Face width						
		Minimum dressed				Metric nomenclature			Minimum dressed				Metric nomenclature	
		Dry		Green					Dry		Green			
Item	Nominal (in)	(in)	(mm)	(in)	(mm)	Dry (mm)	Green (mm)	Nominal (in)	(in)	(mm)	(in)	(mm)	Dry (mm)	Green (mm)
Boards	1	3/4	19.05	25/32	19.84	19	20	2	1-1/2	38.10	1-9/16	39.69	38	39
	1-1/4	1	25.40	1-1/32	26.19	25	26	3	2-1/2	63.50	2-9/16	65.09	64	66
	1-1/2	1-1/4	31.75	1-9/32	32.54	32	33	4	3-1/2	88.90	3-9/16	90.49	89	91
								5	4-1/2	114.30	4-5/8	117.47	114	117
								6	5-1/2	139.70	5-5/8	142.87	139	143
								7	6-1/2	165.10	6-5/8	168.28	165	170
								8	7-1/4	184.15	7-1/2	190.50	185	190
								9	8-1/4	209.55	8-1/2	215.90	210	216
								10	9-1/4	234.95	9-1/2	241.30	235	242
								11	10-1/4	260.35	10-1/2	266.70	260	267
								12	11-1/4	285.75	11-1/2	292.10	285	293
								14	13-1/4	336.55	13-1/2	342.90	335	345
								16	15-1/4	387.35	15-1/2	393.70	385	395
Dimension	2	1-1/2	38.10	1-9/16	39.69	38	39	2	1-1/2	38.10	1-9/16	39.69	38	39
	2-1/2	2	50.80	2-1/16	52.39	51	52	3	2-1/2	63.50	2-9/16	65.09	64	66
	3	2-1/2	63.50	2-9/16	65.09	64	66	4	3-1/2	88.90	3-9/16	90.49	89	91
	3-1/2	3	76.20	3-1/16	77.79	76	78	5	4-1/2	114.30	4-5/8	117.47	114	117
	4	3-1/2	88.90	3-9/16	90.49	89	91	6	5-1/2	139.70	5-5/8	142.87	139	143
	4-1/2	4	101.60	4-1/16	101.19	102	104	8	7-1/4	184.15	7-1/2	190.50	185	190
								10	9-1/4	234.95	9-1/2	241.30	235	242
								12	11-1/4	285.75	11-1/2	292.10	285	293
								14	13-1/4	336.55	13-1/2	342.90	335	345
								16	15-1/4	387.35	15-1/2	393.70	385	395
Timbers	5 and greater			1/2 less than nominal				5 and greater			1/2 less than nominal			

Source: USDC (1970); metric values from Western Wood Products Association.

Example: A nominal 2x4 is a metric 38x89, a nominal 4x16 is a metric 89x387, and so forth.

[a]Nominal sizes in the table are used for convenience. No inference should be drawn that they represent actual sizes.

Table 4-2. *Standard nominal and dressed sizes for Factory and Shop lumber under Western Wood Products Association rules.*

Nominal (in)	Nominal (quarters)	Dry dressed (in)	ALS[b]	Metric nomenclature (mm)[d]	
1	4/4[a]	3/4	S4S[c]	19.05	19
1-1/4	5/4	1-5/32	S2S	29.37	29
1-1/2	6/4	1-13/32	S2S	35.72	36
1-3/4	7/4	1-19/32	S2S	40.48	40
2	8/4	1-13/16	S2S	46.02	46
2-1/4	9/4	2-3/32	S2S	53.18	53
2-1/2	10/4	2-3/8	S2S	60.32	60
2-3/4	11/4	2-9/16	S2S	65.09	65
3	12/4	2-3/4	S2S	69.87	70
4	16/4	3-3/4	S2S	95.25	95

Source: WWPA (1981) and USDC (1970); metric values added by author.

[a]4/4 is generally produced S4S in widths the same as listed for dimension in Table 4-1. All other thicknesses are generally produced S2S in random width; the *average* width is the nominal width plus 1/8 inch. For example, S2S 6-inch wide 8/4 actually ranges from 5.5 to 6.5 inches wide; the average width is 6.125 inches.

[b]The surfaced-dry thicknesses are based on the American Lumber Standard (ALS) thicknesses; in grading pieces under this rule, planer skip is not allowed. However, industry practice is to produce 5/4 and 6/4 stock as "heavy." Heavy means that these items are produced to be full-sawn (manufactured size = nominal size) when surfaced but grading this stock allows planer skip.

[c]S4S = surfaced on all four sides. S2S = surfaced on two sides (faces).

[d]Length in meters begins at 1.3 m and increases in 0.3 m multiples.

Table 4-3. *Nominal and manufactured thicknesses of hardwood lumber.*

Nominal rough-dry (in)	Nominal rough-dry (quarters)	Manufactured rough-green (in)	Surfaced-dry (S2S) (in)	Tolerance (in)
3/8	4/4		3/16	1/8
1/2	4/4		5/16	1/8
5/8	4/4		7/16	3/16
3/4	4/4		9/16	3/16
1	4/4	1-3/16	13/16	1/4
1- 1/4	5/4	1-7/16	1-1/16	1/4
1- 1/2	6/4	1-11/16	1-5/16	1/4
1- 3/4	7/4	1-15/16	1-1/2	1/4
2	8/4	2-7/16	1-3/4	3/8
2- 1/2	10/4	2-9/16	2-1/4	3/8
3	12/4		2-3/4	3/8
3- 1/2	14/4		3-1/4	3/8
4	16/4		3-3/4	5/8
4- 1/2	18/4		—[a]	5/8
5	20/4		—[a]	5/8
5- 1/2	22/4		—[a]	5/8
6	24/4		—[a]	5/8

Source: NHLA (1987). The manufactured sizes are taken from Wengert (1988). Equivalents in mm can be found by multiplying by 25.4 and rounding to the nearest whole number.

[a]Finished size is not specified in the rules; it is subject to contract conditons.

millwork, and so forth. The three principal market categories are factory lumber, dimension parts, and finished market products. In addition, several hardwood species can be marketed under the procedures outlined in the American Softwood Lumber Standard; currently the volume produced is quite small.

This section focuses on factory lumber, which dominates hardwood production. Details on sizes required for other hardwood products are contained in the grading rules obtainable from the National Hardwood Lumber Association (NHLA 1987).

Factory Lumber Thickness. The nominal thickness of a piece of hardwood factory lumber is the specified thickness in the NHLA rules for the *rough-dry* state of manufacture. The standard for surfaced-dry (S2S) manufacture is also specified in the rules. The manufactured thickness for green lumber is not specified in the rules but is generally specified in contracts. For example, 2 inch thick hardwood lumber, also known as 8/4 (eight-quarter), would exceed 2 inches in manufactured green thickness. The manufactured dimension required of rough lumber expected to meet a nominal size also is commonly specified in contracts. Table 4-3 shows the standard nominal thickness of hardwood lumber in both inches and quarters along with examples of manufactured thickness (Wengert 1988) and thickness when surfaced two sides (S2S).

Since hardwood factory lumber is intended for remanufacture into cuttings for furniture, thickness is always measured as the thinnest point in the cutting used for grading the board. Therefore, the thickness cannot be measured until the board is graded, since one must know where the cuttings are located in establishing grade in order to get the required thickness measure. Portions of the board not in the required cuttings may be scant in thickness. When thickness varies in a board, the thickest and thinnest locations within the grade cuttings are measured. If the difference exceeds the tolerance shown in Table 4-3, the piece is labeled miscut. But this labeling does not change the grade.

Factory Lumber Width and Length. Hardwood factory lumber is not usually manufactured to standard widths, hence a piece 6-3/4 inches wide is left in that form. This is why hardwood lumber is often referred to as *random width*. While grades do not specify standard widths, there is a minimum width associated with each grade. When a board is tapered, width is measured one-third of the length from the narrow end.

Length of hardwood lumber generally ranges from 4 to 16 feet in one-foot steps. However, standards do not permit more than 50% of pieces to be odd lengths. In measuring length, any fraction of a foot is dropped.

Lumber Measurement

Board Foot Lumber Volume

In North America, the standard unit measure of lumber volume is the board foot (BF) calculated from the nominal dimensions. A board foot is a hypothetical piece that is 1 inch thick, 12 inches wide, and 12 inches long. Theoretically, this implies that a board foot represents 144 cubic inches of wood, that there are 12 BF per cubic foot (hence 424 BF per cubic meter), and that 1,000 BF equals 83.33 cubic feet or 2.36 cubic meters.

Although these conversion factors are commonly used by statistical reporting agencies, this chapter will show that because of the difference between nominal and manufactured sizes, an assumption of 12 BF/CF may not be a correct conversion factor to use. The procedures for calculating board foot lumber volume in this chapter measure lumber as it is tallied by the sawmill. This should not be confused with the board foot when used for log scaling (Chapter 2).

Many countries using the metric system saw lumber with negligible difference between nominal and manufactured size and therefore use the nominal dimensions to determine volume in cubic meters. Metric calculations and conversions are discussed below (p. 65).

Softwood Board Measure. To find the BF measure of a softwood board, multiply its nominal thickness (Tn) in inches by its nominal width (Wn) in inches by its length (L) in feet, then divide by 12:

$$BF = (Tn * Wn * L) / 12.$$

For example, the board foot volume of an 8 foot 2x4 is

$$BF = (2'' \times 4'' \times 8') / 12 = 5.33.$$

Column 1 of Table 4-4 shows BF contents per lineal foot for selected construction lumber cross section sizes from Table 4-1. Multiply the value

Table 4-4. *Volumes per lineal foot for softwood construction lumber.*

Nominal			Cubic feet				
Thickness (in)	Width (in)	BF (1)	S-Dry (2)	R-Dry (3)	S-Grn (4)	R-Grn (5)	Target (6)
1	4	0.3333	0.0182	0.0220	0.0193	0.0232	0.0326
1	6	0.5000	0.0286	0.0342	0.0305	0.0362	0.0496
1	8	0.6667	0.0378	0.0448	0.0407	0.0480	0.0644
1	10	0.8333	0.0482	0.0570	0.0515	0.0606	0.0813
1	12	1.0000	0.0586	0.0691	0.0624	0.0732	0.0983
2	4	0.6667	0.0365	0.0409	0.0387	0.0432	0.0548
2	6	1.0000	0.0573	0.0635	0.0610	0.0674	0.0833
2	8	1.3333	0.0755	0.0832	0.0814	0.0894	0.1082
2	10	1.6667	0.0964	0.1058	0.1031	0.1128	0.1367
2	12	2.0000	0.1172	0.1284	0.1248	0.1362	0.1652
3	4	1.0000	0.0608	0.0661	0.0634	0.0688	0.0845
3	6	1.5000	0.0955	0.1025	0.1001	0.1073	0.1283
3	8	2.0000	0.1259	0.1344	0.1335	0.1423	0.1667
3	10	2.5000	0.1606	0.1709	0.1691	0.1796	0.2106
3	12	3.0000	0.1953	0.2074	0.2046	0.2170	0.2545
4	4	1.3333	0.0851	0.0913	0.0881	0.0944	0.1141
4	6	2.0000	0.1337	0.1416	0.1392	0.1472	0.1734
4	8	2.6667	0.1762	0.1857	0.1855	0.1953	0.2252
4	10	3.3333	0.2248	0.2360	0.2350	0.2465	0.2845
4	12	4.0000	0.2734	0.2863	0.2845	0.2977	0.3437

Source: Calculated by the author. S-Dry = surfaced-dry. R-Dry = rough-dry. S-Grn = surfaced-green. R-Grn = rough-green.

0.6667 BF/lineal foot for an 8 foot 2x4 to get 5.33 BF. Similarly, a 16 foot 2x4 contains 10.67 BF. Some references give the board foot contents of sawn lumber with these fractional units (Giellis 1949), while others round to the nearest board foot (Forbes and Meyer 1955). Individual mills may differ as to which method is used. In large, mixed orders, differences due to rounding are negligible.

Softwood Surface Measure. Surface measure is calculated without regard to the thickness of the piece. In other words, multiply the length in feet by the width in inches and divide by 12. Lumber less than one inch nominal thickness is tallied on the basis of surface measure unless otherwise agreed by buyer and seller.

Softwood Lineal Measure. Lineal footage (Lf) is the total length in feet of a piece or all pieces in a shipment and is used largely for specialty items such as moldings:

$$\text{Lineal feet/MBF (Lf)} = 12{,}000 / (T * W).$$

Conversion to lineal meters/MBF (Lm):

$$Lm = Lf / 3.23.$$

Hardwood Board Measure. The standard measurement of volume for hardwood factory lumber is the board foot, and the same basic formula is used as for softwood lumber. In practice, there are important differences in how board foot volume is measured. If the width (W) is measured in feet rather than inches, the board foot formula becomes

$$BF = (L * W) * T.$$

The value in parentheses is the board's surface measure (SM), in square feet, which is rounded to the nearest whole number. If the fraction before rounding is 1/2, SM is alternately rounded up or down. In calculating board foot volume, the thickness used is always the standard nominal thickness in quarters. It is important to note that pieces thinner than one inch are considered to be one inch (4/4) for the purpose of measuring board foot volume. See Example 1.

Table 4-5, column 1, presents BF volume per lineal foot for a selection of hardwood lumber thicknesses. In these calculations the width used was the midpoint of each random width range (i.e., random width 6-inch lumber represents actual widths from 5.5 to 6.4 inches, inclusive).

Table 4-5. *Volumes per lineal foot for hardwood factory lumber.*

Nominal				Cubic feet			
Thickness (in)	Thickness (qtr)	Width (in)	BF (1)	S2S-Dry (2)	R-Dry (3)	R-Grn (4)	Target (5)
0.5	1/2	4	0.3333	0.0087	0.0139	0.0174	0.0222
0.5	1/2	6	0.5000	0.0130	0.0208	0.0260	0.0324
0.5	1/2	8	0.6667	0.0174	0.0278	0.0347	0.0426
0.5	1/2	10	0.8333	0.0217	0.0347	0.0434	0.0528
0.5	1/2	12	1.0000	0.0260	0.0417	0.0521	0.0630
0.8	3/4	4	0.3333	0.0156	0.0208	0.0260	0.0306
0.8	3/4	6	0.5000	0.0234	0.0313	0.0391	0.0446
0.8	3/4	8	0.6667	0.0313	0.0417	0.0521	0.0587
0.8	3/4	10	0.8333	0.0391	0.0521	0.0651	0.0727
0.8	3/4	12	1.0000	0.0469	0.0625	0.0781	0.0868
1.0	4/4	4	0.3333	0.0226	0.0278	0.0330	0.0389
1.0	4/4	6	0.5000	0.0339	0.0417	0.0495	0.0568
1.0	4/4	8	0.6667	0.0451	0.0556	0.0660	0.0747
1.0	4/4	10	0.8333	0.0564	0.0694	0.0825	0.0927
1.0	4/4	12	1.0000	0.0677	0.0833	0.0990	0.1106
1.5	6/4	4	0.5000	0.0365	0.0417	0.0469	0.0557
1.5	6/4	6	0.7500	0.0547	0.0625	0.0703	0.0813
1.5	6/4	8	1.0000	0.0729	0.0833	0.0938	0.1069
1.5	6/4	10	1.2500	0.0911	0.1042	0.1172	0.1325
1.5	6/4	12	1.5000	0.1094	0.1250	0.1406	0.1581
2.0	8/4	4	0.6667	0.0486	0.0556	0.0677	0.0703
2.0	8/4	6	1.0000	0.0729	0.0833	0.1016	0.1027
2.0	8/4	8	1.3333	0.0972	0.1111	0.1354	0.1350
2.0	8/4	10	1.6667	0.1215	0.1389	0.1693	0.1673
2.0	8/4	12	2.0000	0.1458	0.1667	0.2031	0.1997
2.5	10/4	4	0.8333	0.0625	0.0694	0.0712	0.0871
2.5	10/4	6	1.2500	0.0938	0.1042	0.1068	0.1271
2.5	10/4	8	1.6667	0.1250	0.1389	0.1424	0.1671
2.5	10/4	10	2.0833	0.1563	0.1736	0.1780	0.2071
2.5	10/4	12	2.5000	0.1875	0.2083	0.2135	0.2472

Source: Calculated by the author. S2S-Dry = dried and surfaced on two sides. R-Dry = rough-dry. R-Grn = rough-green.

Example 1

1. A 5/4 piece is 8' 3" long and 6-1/2" wide

   SM = (8 * 6.5) / 12 = 4.33 = 4

   BF = 4 * 5/4 = 5

2. An 8/4 piece is 10' 9" long and 8-1/4" wide

   SM = (10 * 8.25) / 12 = 6.875 = 7

   BF = 7 * 8/4 = 14

3. A 1/2 inch piece is 7' 2" long and 5-3/4" wide

   SM = (7 * 5.75) / 12 = 3.35 = 3

   BF = 3 * 4/4 = 3

Hardwood Surface Measure. In actual practice, board foot volume of individual pieces often is not calculated separately and summed. Instead, surface measure (SM) of all pieces of a given thickness is accumulated and the total SM is multiplied by the nominal thickness. Thus a stack of 8/4 No. 2 Common maple lumber might have a total SM of 350. The board foot volume of the stack is

350 * 8/4 = 700 BF.

Hardwood Lineal Measure. As for softwoods, lineal footage measure may be used for some specialty hardwood items.

Cubic Foot Lumber Volume

Using Sizes in Commercial Standards. The cubic foot volume of a piece of lumber, in terms of the true amount of wood present, is obtained by multiplying the *manufactured or actual* sizes, converting from inches to feet as needed. The following discussion is based on using manufactured dimensions. Table 4-1 shows that the manufactured dimensions of a surfaced-dry 2x4 are 1.5 by 3.5. The cubic volume of a surfaced-dry 8 foot 2x4 is

$$ft^3 = (Tm/12) * (Wm/12) * L$$

where Tm and Wm are manufactured thickness and width

$$= (1.5/12) * (3.5/12) * 8 = 0.292.$$

Columns 2 through 5 of Table 4-4 present cubic foot contents per lineal foot of length for four states of manufacture of softwood construction lumber. For a surfaced-dry 2x4, the cubic foot volume per lineal foot is 0.0365; thus for an 8 foot length, the cubic foot volume is

$$0.0365 * 8 = 0.292 \ ft^3.$$

The cubic foot volume of a piece of hardwood lumber is similarly obtained. Since hardwood factory lumber is produced random width, there is no single value of the cubic foot content of a nominally sized board. For example, a nominal 6-inch wide piece can range from 5.5 to 6.4 inches in actual width. With a 1-inch rough thickness, the cubic foot content per lineal foot will range from 0.0310 to 0.0367, a change of 18.4%; the midpoint of this range, corresponding to 6 inches, is 0.0339. Table 4-5 presents such midpoint cubic foot contents per lineal foot for rough-dry, surfaced-dry (S2S), and rough-green hardwood factory lumber.

The cubic content figures in Tables 4-4 and 4-5 make no allowance for wane or other defects. Within a single mill, where actual measurements can be taken and the wane percentage estimated, more refined cubic content values can be developed.

Using Green Target Sizes. While these cubic contents at different states of manufacture are useful to represent sizes entering commerce, a sawmill is often concerned with the sizes it must implement on its machinery in order to meet required sizes.

When a sawmill processes logs into lumber, the required standard size is regarded as the minimum allowed. These minimum dimensions are increased to allow for surfacing, shrinkage during drying, and statistical variation in the sawing equipment. The dimensions derived from these considerations are called *green target* sizes and these reflect machinery settings needed so the finished product does not violate the specified minimum sizes. The formula for calculating green target sizes is

$$T = (F + P) / (1 - S/100) + SV * Z$$

where

T = green target thickness or width, in inches

F = final thickness or width required, in inches

P = planing allowance, in inches

S = shrinkage percent from green to final MC_{od} (see Chapter 1 for definitions). Tangential shrinkage values are often used, to be conservative.

SV = sawing variation of the particular machine, obtained from statistical quality control procedures

Z = an undersize or skip allowance factor based on the normal curve. With a 5% undersize allowed, this factor is 1.65. Contracts specify the maximum percentage of pieces allowed to be undersize.

The following average and best sawkerf width, sawing variation, and planing allowance are based on Sawmill Improvement Program (SIP) studies of softwood dimension mills (USFS 1980):

Specification (in)	Average	Best
Sawkerf width	0.180	0.100
Sawing variation	0.160	0.050
Planing allowance	0.100	0.040

Williston (1988, chap. 23) presents more detailed information for various types of headrigs and edgers. Machine type and piece size (depth of cut) are more influential on these items than type of mill per se.

Column 6 of Table 4-4 and column 5 of Table 4-5 show cubic foot per lineal foot values obtained by applying a surfacing allowance of 0.100 inch, sawing variation of 0.160 inch, and a 5% change in dimension during drying. This represents the amount of wood fiber initially required in each size in order to meet the surfaced-dry specifications. Calculations for meeting any other state of manufacture are similarly made.

Table 4-6. *BFFR for softwood construction lumber.*

Nominal		Board feet per lineal foot divided by cubic feet per lineal foot				
Thickness (in)	Width (in)	S-Dry (1)	R-Dry (2)	S-Grn (3)	R-Grn (4)	Target (5)
1	4	18.29	15.13	17.25	14.36	10.22
1	6	17.45	14.63	16.38	13.82	10.09
1	8	17.66	14.88	16.38	13.89	10.36
1	10	17.30	14.63	16.17	13.76	10.25
1	12	17.07	14.47	16.03	13.67	10.18
2	4	18.29	16.30	17.25	15.43	12.16
2	6	17.45	15.75	16.38	14.84	12.00
2	8	17.66	16.02	16.38	14.92	12.32
2	10	17.30	15.75	16.17	14.78	12.19
2	12	17.07	15.58	16.03	14.68	12.11
3	4	16.46	15.13	15.77	14.53	11.84
3	6	15.71	14.63	14.99	13.98	11.69
3	8	15.89	14.88	14.99	14.05	12.00
3	10	15.57	14.63	14.79	13.92	11.87
3	12	15.36	14.47	14.66	13.83	11.79
4	4	15.67	14.61	15.13	14.12	11.69
4	6	14.96	14.12	14.37	13.58	11.54
4	8	15.13	14.36	14.37	13.66	11.84
4	10	14.83	14.12	14.18	13.52	11.72
4	12	14.63	13.97	14.06	13.44	11.64

Source: Calculated by the author. S-Dry = surfaced-dry. R-Dry = rough-dry. S-Grn = surfaced-green. R-Grn = rough green.

Note: Reciprocal of BFFR is the number of cubic feet of actual wood contained in a board foot of lumber of the indicated size and state of manufacture. These values are often multiplied by 1,000 to indicate the actual cubic feet present in one MBF of lumber. Thus 1 / 18.29 * 1,000 = 54.67 ft^3/MBF of surfaced-dry 2x4s.

Board Foot to Cubic Foot Ratios (BFFR)

Previously, it was found that a surfaced-dry 2x4 contains 5.33 BF and 0.292 cubic foot. Dividing yields 18.25 BF/ft^3 for this state of manufacture. A value of 18.26 BF/ft^3 is obtained by dividing 0.6667 BF per lineal foot by 0.0365 cubic foot per lineal foot. Tables 4-6 and 4-7 present the *board foot fiber ratio* (BFFR) for various states of manufacture. Values presented in Tables 4-4 to 4-7 were calculated on a computer and differ slightly from the examples in the text, due to rounding. Notice that for softwoods, these ratios are much higher than the theoretical 12 BF/ft^3 based on nominal sizes. This theoretical value would be correct only for lumber manufactured so that there is no difference between nominal and manufactured sizes. For hardwoods, the BFFR is unusually high for thicknesses less than one inch because of the practice of considering these to be one inch thick for purposes of calculating board foot volume. Also, the BFFR for hardwood sizes one inch thick and larger is typically smaller than those for softwood counterparts, since hardwood standards require lumber to be cut thicker for a given nominal size. It should be noted that BFFR is not constant, does not change consistently across the range of sizes, and is dependent on the degree of manufacture. BFFR values for any state of manufacture or for green target sizes of a specific mill are similarly calculated. It should also be apparent that BFFRs would be different for the Shop lumber sizes shown in Table 4-2.

The USFS timber assessment uses BFFR of 16.67 and 12.00 for softwood and hardwood lumber, respectively (Appendix 2). The reader should carefully note the comments at the beginning of Appendix 2.

The BFFR, which measures the true amount of wood fiber contained in a given board footage, can also be used as a measure of mill recovery efficiency. If a mill tightens up its sawing variation and planing allowance, a higher BFFR can be realized, since it can cut smaller green target sizes (less cubic volume) for the same nominal board foot size. This is illustrated in Table 4-8 for 2x4s

Table 4-7. *BFFR for hardwood factory lumber.*

Nominal			Board feet per lineal foot divided by cubic feet per lineal foot			
Thickness (in)	(qtr)	Width (in)	S2S-Dry (1)	R-Dry (2)	R-Grn (3)	Target (4)
0.5	1/2	4	38.40	24.00	19.20	15.01
0.5	1/2	6	38.40	24.00	19.20	15.43
0.5	1/2	8	38.40	24.00	19.20	15.64
0.5	1/2	10	38.40	24.00	19.20	15.77
0.5	1/2	12	38.40	24.00	19.20	15.86
0.8	3/4	4	21.33	16.00	12.80	10.90
0.8	3/4	6	21.33	16.00	12.80	11.20
0.8	3/4	8	21.33	16.00	12.80	11.36
0.8	3/4	10	21.33	16.00	12.80	11.46
0.8	3/4	12	21.33	16.00	12.80	11.52
1.0	4/4	4	14.77	12.00	10.11	8.56
1.0	4/4	6	14.77	12.00	10.11	8.80
1.0	4/4	8	14.77	12.00	10.11	8.92
1.0	4/4	10	14.77	12.00	10.11	8.99
1.0	4/4	12	14.77	12.00	10.11	9.05
1.5	6/4	4	13.71	12.00	10.67	8.98
1.5	6/4	6	13.71	12.00	10.67	9.23
1.5	6/4	8	13.71	12.00	10.67	9.36
1.5	6/4	10	13.71	12.00	10.67	9.44
1.5	6/4	12	13.71	12.00	10.67	9.49
2.0	8/4	4	13.71	12.00	9.85	9.48
2.0	8/4	6	13.71	12.00	9.85	9.74
2.0	8/4	8	13.71	12.00	9.85	9.88
2.0	8/4	10	13.71	12.00	9.85	9.96
2.0	8/4	12	13.71	12.00	9.85	10.02
2.5	10/4	4	13.33	12.00	11.71	9.57
2.5	10/4	6	13.33	12.00	11.71	9.84
2.5	10/4	8	13.33	12.00	11.71	9.97
2.5	10/4	10	13.33	12.00	11.71	10.06
2.5	10/4	12	13.33	12.00	11.71	10.11

Source: Calculated by the author. S2S-Dry = dried and surfaced on two sides. R-Dry = rough-dry. R-Grn = rough-green.

Note: Reciprocal of BFFR is the number of cubic feet of actual wood contained in a board foot of lumber of the indicated size and state of manufacture. These values are often multiplied by 1,000 to indicate the actual cubic feet present in one MBF of lumber. Thus 1 / 13.71 * 1,000 = 72.94 ft^3/MBF of surfaced-dry 8/4 hardwood lumber.

assuming the surfaced green dimensions in Table 4-1. As a mill tightens its process, the BFFR increases, thus reflecting the smaller quantity of wood fiber needed to make the same piece.

As the S-Dry 2x4 example in Table 4-9 shows, in addition to not being constant for a given cross section and state of manufacture, BFFR may vary with length. This will occur when board foot volumes are rounded to the nearest whole number.

While the BFFR, using the rounded BF, vary between lengths, the average is the same result obtained for each length when the BF rounding rules are ignored. Individual mills may wish to calculate BFFR with the rounding rules in order to examine trade-offs between lengths. For simplicity, this effect is ignored in Tables 4-6 and 4-7. This is not considered a major problem, since statistical data are often aggregated across lengths, and thus the average factor is appropriate.

The reader may note a small difference between the values calculated in Table 4-9 and values in the text and Table 4-6. This is because the cubic foot per lineal foot factor of 0.0365 was carried to more places during computer calculations in Table 4-6.

Table 4-8. *Effect of sawing variation and planing allowances on BFFR.*

Planing allowance (in)	Sawing variation (in) 0.00	0.10	0.16
0.0625	16.58	15.20	14.45
0.10	16.21	14.87	14.15
0.125	15.97	14.66	13.96
0.15	16.21	14.46	13.77
0.1875	15.40	14.17	13.50

Source: Calculated by the author.

Table 4-9. *Example of variations in BFFR with length.*

2x4 length (ft)	S-Dry volume[a] (ft^3)	Without rounding BF	Without rounding BFFR	With rounding BF	With rounding BFFR
8	0.292	5-1/3	18.26	5	17.12
10	0.365	6-2/3	18.26	7	19.18
12	0.438	8	18.26	8	18.26
			Average		18.26

[a]Multiply the 2x4 S-Dry factor in column 2 of Table 4-4 (i.e., 0.0365) by the length.

Other Measures

Cubic Feet per MBF for Various Lumber Sizes. The true cubic foot volume of wood in 1,000 BF of lumber is often of interest. Two methods for making these estimates are given below. The number of cubic feet per MBF depends on the size of the particular lumber item and its state of manufacture.

1. Using BFFR

The reciprocal of BFFR is the number of cubic feet of solid wood present in a board foot of lumber. For example, the BFFR of 16.67 used in the USFS timber assessment for softwoods implies that there are 0.060 ft^3 of solid wood per BF or 60 ft^3/MBF. The BFFR of 12.0 for hardwoods translates into 83.33 ft^3/MBF. These figures are often *incorrectly* interpreted as the cubic foot volume of roundwood logs needed to produce a BF (or MBF) of lumber.

The easiest way to estimate cubic feet/MBF is to find the BFFR for the appropriate state of manufacture (Table 4-6 or 4-7) and simply divide it into 1,000. See Example 2.

Example 2

To find how many cubic feet of surfaced-green 2x4s are in 1,000 BF, divide the BFFR of 17.25 in Table 4-6 into 1,000 to get 57.97 cubic feet.

Example 3

To find how many cubic feet of surfaced-green 2x4s are in 1,000 BF:

$ft^3/MBF = [83.33 * (1\text{-}9/16 * 3\text{-}9/16)] / (2 * 4) = 57.98.$

$ft^3/MBF = 12{,}000 * [0.0387 / (2 * 4)] = 58.05.$

The slight difference from the previous calculation is due to rounding.

2. Using piece-size data

In this approach first divide 1,000 BF by the BF of the lumber size of interest to get the number of pieces per MBF:

$$\text{number of pieces} = 1{,}000 / [(Tn * Wn * L) / 12]$$

where Tn and Wn are the nominal thickness and width, and L is the length.

Next, multiply by the true cubic volume of the lumber size:

$$ft^3/MBF = \text{number of pieces} * [(Tm/12) * (Wm/12) * L]$$

where Tm and Wm are the manufactured thickness and width, and L is the length.

These expressions can be combined and simplified into the following equivalent forms

$$ft^3/MBF = 83.33 * (Tm/Tn) * (Wm/Wn)$$
$$ft^3/MBF = 12{,}000 * [CFLF] / (Tn * Wn)]$$

where CFLF = cubic feet per lineal foot factor for the desired state of manufacture (Table 4-4). See Example 3.

Cubic Meters per MBF for Various Lumber Sizes. Divide the result of Example 3 by 35.315; thus 1,000 BF of surfaced green 2x4s is

$$(57.97\ ft^3/MBF) / (35.315\ ft^3/m^3) = 1.64\ m^3/MBF.$$

The USFS timber assessment values of 60 and 83.33 ft^3/MBF for softwoods and hardwoods, respectively, translate into 1.70 and 2.36 m^3/MBF.

Number of Pieces per MBF. Number of pieces per MBF of a given lumber size can be estimated by dividing the cubic feet per MBF for that piece size by the cubic feet per piece. The result will vary depending on the state of manufacture.

Measures of Mill Recovery Efficiency

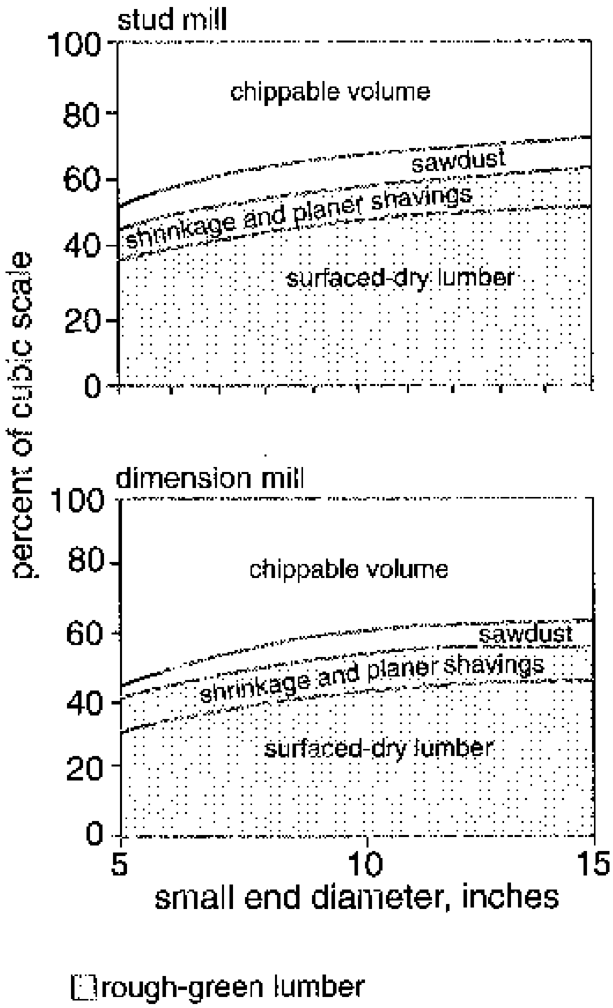
Cubic Recovery Ratio (CRR)

Material balances for many western species can be obtained from mill studies conducted by the Timber Quality Research Unit of the USDA Forest Service Pacific Northwest Research Station in Portland, Oregon. Material balances and effects of changes in technology, saw pattern, and product line can also be estimated by simulating the processing of logs with the best-opening-face (Hallock and Lewis 1971) or similar computer program.

Material Balance for Rough-Green Lumber. Figure 4-1 presents a material balance as a function of log small-end diameter (Fahey 1983). It shows the fraction of the *cubic* log volume that is converted into rough-green lumber, sawdust, and chippable residue by a stud mill and a dimension mill. The fraction of log cubic volume recovered as lumber is called the *cubic recovery ratio* (CRR). Usually this is based on the net log scale. It is an accurate and consistent measure of conversion efficiency that is becoming more popular with the use of scanners that can measure log and lumber dimensions very accurately. As log diameter increases, the fraction recovered as rough-green lumber increases, the chip fraction decreases, and the sawdust fraction increases slightly. In addition to diameter, some of the key factors influencing recovery are:

- *Milling technology*. Figure 4-1 demonstrates the difference in yield between mill types. Actual yield varies between mills but is usually within 5% of the average. Differences are due to cutting pattern, sawkerf, and machinery. Mills using thin-blade band saws generally have the highest CRR.
- *Log length and taper*. Generally longer logs with greater taper have a lower CRR.
- *Amount of defect present*. Logs with sweep, rot, and many limbs usually yield less lumber. However, some of the impact may be mitigated

Figure 4-1. *Lumber material balance as a percentage of cubic log volume, by small-end diameter, for a stud mill and a dimension mill. Source: Fahey (1983).*



if the cubic volume basis is net rather than gross log scale. (See Chapter 2.)

- *Product line*. Sawing large dimension timbers produces more lumber and less sawdust than sawing small dimension boards.
- *Lumber salvage policy*. Mills that choose to saw slabs into small lumber cross sections and salvage short lengths rather than chip them will have higher lumber recovery.
- *Market values and mill location*. These factors affect the marginal decisions as to what is converted to lumber and what is chipped. A mill that has no chip market will attempt to cut small and low grade pieces of lumber that would be chipped by a mill close to a good chip market.

The average CRR for various types of mills processing a mix of log sizes is about 55%. About 9% of the log becomes sawdust and another 36% becomes chips. These by-products are generally sold to other wood industries, such as pulp and particleboard producers.

Adjusting for Surfacing and Drying. Figure 4-1 shows the reduction of the rough-green lumber recovery to account for losses due to shrinkage during drying, surfacing, and dry trimming. An overall average for these losses is about 6% of the original log volume. Thus the green CRR of 55% becomes a surfaced-dry CRR of about 49%. The actual change varies somewhat among mills depending on species, products being cut, and drying requirements.

Two different methods of calculating surfacing and drying estimates are given below. Since each lumber size will yield a different result, an adjustment factor should be estimated for each size and a weighted average obtained using the proportion of each size in total production.

Green planer shaving yield: Method 1

Calculate cubic volume from the rough-green or green target dimensions. Calculate cubic volume from the surfaced-green dimensions. Subtraction gives the solid wood equivalent of planer shavings. If desired, convert the solid wood planer shavings to the volume of loose planer shavings with the expansion factor in Table 7-1 or 7-2. Since length of pieces does not change during surfacing, the cubic foot calculations can be simplified to result in an estimate of the cubic feet of shavings per lineal foot of lumber of a given size:

$$ft^3 \text{ solid wood shavings/lineal ft} = (T_{rg} * W_{rg}) - (T_{sg} * W_{sg}) / 144$$

where the subscripts $_{rg}$ and $_{sg}$ refer to the rough-green and surfaced-green thickness and width respectively.

Green planer shaving yield: Method 2

Assume that the true cubic foot volume of the rough-green lumber (V_{rg}) is known. The percentage decrease in cross section area of a given lumber size multiplied by the rough-green lumber volume also gives the cubic feet of shavings:

$$ft^3 \text{ solid wood shavings/lineal ft} = V_{rg} [1 - (T_{sg} * W_{sg}) / (T_{rg} * W_{rg})].$$

Shrinkage and dry planer shaving yield

In adjusting to surfaced-dry condition, shrinkage loss and surfacing loss (dry planer shaving yield) must be considered. Chapter 1 presents the method for calculating shrinkage when wood is dried to a given MC_{od}. Simply reduce the rough-green dimensions or rough-green volume by the appropriate shrinkage percentage to obtain the rough-dry dimensions or rough-dry volume.

Substitute the dry dimensions or dry volume into either of the procedures outlined above for estimating green planer shavings. This will give an estimate of the solid wood equivalent of dry planer shavings.

Cubic Recovery Ratios for Different States of Manufacture. As demonstrated in Figure 4-1 and the preceding sections, cubic recovery ratio can be calculated for different stages of manufacture. For example, the USFS timber assessment uses average CRR of 0.362 and 0.499, respectively, for softwoods and hardwoods (Appendix 2). These values are overall averages of all regions and all states of manufacture as lumber enters commerce. The national average CRR for softwood lumber is lower than that of hardwoods, since much softwood lumber is dried and surfaced before leaving the sawmill. The higher national average hardwood CRR reflects the common practice of shipping rough, and often green, lumber by hardwood mills. Thus these CRRs represent two completely different states of manufacture. When compared at the same state of manufacture, the softwood CRR is usually greater than that for hardwoods.

The green target cubic recovery ratio (CRR_{gt}) is the cubic foot volume of green lumber as sized by the mill's machinery (green target sizes) divided by the cubic foot log volume. The rough-green recovery in Figure 4-1 is the CRR_{gt}. Suppose that a mill processed a 5" x 6" x 8.5' log into two 2x4 studs. According to the green target column of Table 4-4 (column 6), each 2x4 has 0.0548 cubic foot volume per lineal foot. Thus the studs use 0.8768 cubic foot of wood fiber. The log volume is 1.437 cubic foot based on Smalian's formula. Therefore

$$CRR_{gt} = AF_{gt} / V = 0.8768 / 1.437 = 0.61$$

where

AF_{gt} = true fiber content of lumber, green target basis, ft^3

V = log volume, ft^3.

The surfaced-dry cubic recovery ratio (CRR_{sd}) is calculated as follows. After the sawmill dries and surfaces the two 2x4s, they have been reduced in size to 1.5 by 3.5 inches. According to Table 4-4 (column 2), each contains 0.0365 cubic foot per lineal foot, thus totaling 0.584 cubic foot. Therefore

$$CRR_{sd} = AF_{sd} / V = 0.584 / 1.437 = 0.41$$

where

AF_{sd} = true fiber content of lumber, surfaced-dry basis, ft^3

V = log volume, ft^3.

These calculations are indicative of the changes that can occur in the cubic recovery ratio between the primary sawing and the surfaced-dry state. The surfaced-dry recovery in Figure 4-1 is CRR_{sd}. Similar calculations can be made for intermediate stages of manufacture.

Roundwood Log Required per Cubic Foot of Lumber. The reciprocal of the CRR is the number of cubic feet of roundwood log needed to produce a cubic foot of lumber in the particular manufactured state. For example, for the U.S. timber assessment CRR (Appendix 2), the 0.362 CRR for softwood lumber translates into 2.76 cubic feet of log input needed for each cubic foot of mostly surfaced-dry softwood lumber produced. Similarly the 0.499 CRR for hardwood lumber translates into 2.00 cubic feet of log input needed for each cubic foot of mostly rough-green hardwood lumber produced. (See the next section for roundwood log required per MBF of lumber.)

Lumber Recovery Factor (LRF)

When the volume of recovered lumber, measured in BF, is divided by the cubic foot log volume (usually net scale), another commonly used measure of mill efficiency, called LRF, is obtained. Continuing the example, the two 2" x 4" x 8' studs represent 10 BF. Therefore,

$$LRF = BF_{mt} / V = 10.67 / 1.437 = 7.4 \ BF/ft^3.$$

where BF_{mt} is the mill's actual lumber tally, in BF (see Chapter 2, p. 24).

Figure 4-2 presents LRF relationships for the same mills shown in Figure 4-1 (Fahey 1983). LRF is sensitive to the same factors discussed previously for CRR, but is more sensitive to changes in product mix, because the actual amount of wood present in a BF of lumber varies for different lumber sizes. For

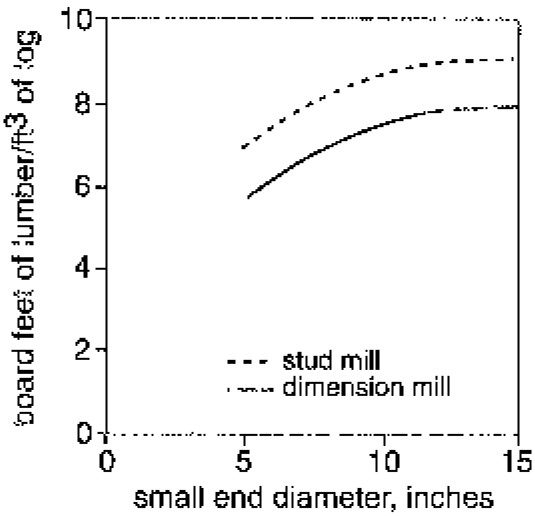


Figure 4-2. *Lumber recovery factor, by small-end diameter, for a stud mill and a dimension mill. Source: Fahey (1983).*

example, 1,000 BF of rough-green 2x4s contains about 64.8 cubic feet of wood while 1,000 BF of rough-green 4x4s contains about 70.8 cubic feet.

Therefore, it is often possible to recover more board feet of 2x4s from a given log than of 4x4s, even allowing for extra saw lines to produce the 2x4s. If a mill changes from sawing large timbers to sawing dimension lumber, LRF may increase even though conversion efficiency, measured by CRR, decreases. Comparison of Figures 4-1 and 4-2 shows that the LRF difference between the two mill types is greater than their CRR difference. This widening is due to the effect of the different product lines of the two types of mills.

The reciprocal of LRF is the number of cubic feet of roundwood log needed to produce one BF of lumber. Since lumber is often expressed in thousands of board feet (MBF), the reciprocal is often multiplied by 1,000. Therefore, the 7.4 LRF translates into 0.1351 cubic feet of log needed per BF, or 135.1 ft^3/MBF.

The USFS timber assessment uses LRFs of 6.44 (155.1 ft^3 log/MBF) and 5.26 (189.9 ft^3 log/MBF), respectively, for softwood and hardwood lumber (Appendix 2).

Example 4

1. Assume that a mill is receiving 10 inch logs and cutting 2x4s. The CRR_{gt} is 0.56 (from Figure 4-1) and the BFFR is 15.43. Thus

   LRF = (0.56) * (15.43) = 8.64.

2. Assume the same 10 inch logs but now the mill is cutting a product mix of 30% 2x4s, 40% 2x6s, and 30% 2x8s, each with its associated BFFR. To find the overall BFFR a weighted average is used:

Size	%	BFFR	% * BFFR
2x4	30	15.43	4.63
2x6	40	14.84	5.94
2x8	30	14.92	4.48
Total			15.05

   LRF = (0.56) * (15.05) = 8.43.

3. Now assume not only a mix of products but also a mix of incoming log diameters. Each diameter class has a different CRR_{gt}, thus a weighted average can be calculated. Using the same product mix as in number 2 above, and incoming logs of 50% 8 inch and 50% 10 inch diameters, with CRR_{gt} of 0.54 and 0.56 respectively:

Diameter	% of logs	CRR_{gt}	% * CRR_{gt}
8 inch	50	0.54	0.27
10 inch	50	0.56	0.28
Total			0.55

   LRF = (0.55) * (15.05) = 8.28.

Each of these values of LRF estimates a different amount of BF of lumber for the same cubic foot of log input. Assume 10,000 ft^3 of logs coming into the mill. Number 1 above will yield 86,400 BF; number 2 will yield 84,300 BF; and number 3 will yield 82,800 BF of lumber.

Relationship Between LRF, CRR, and BFFR

LRF has units that are BF mill tally per cubic foot log input. CRR has units that are cubic feet of true wood in lumber per cubic foot log input. BFFR has units that are BF mill tally per cubic foot of the true wood in the lumber. Careful study of these ratios reveals the following relationship:

$$CRR = LRF / BFFR = (BF_{mt} / ft^3 \text{ log}) / (BF_{mt} / ft^3 \text{ lumber}).$$

Therefore, these three measures are interrelated and any one can be calculated from the other two.

$$LRF = CRR * BFFR \text{ and } BFFR = LRF / CRR.$$

See Example 4.

Overrun

Overrun, the difference (or ratio) between board feet of lumber actually obtained from a log and yield in board feet predicted by a log scale, is often used as a measure of mill efficiency. In reality it merely measures the percentage of error that occurs in using a board foot log rule to estimate the actual mill recovery. Overrun is discussed more fully in Chapter 2 (p. 24), and since it is very sensitive to many factors unrelated to milling, it is not a recommended measure of recovery efficiency.

Estimating Lumber Weight

In most cases, shipping weights of lumber of various sizes and species can be obtained from appropriate lumber grading agencies, trade associations, or freight companies. In the absence of this information, estimates can be made by combining the actual cubic lumber volumes presented above (p. 58) with estimates of species specific gravity and lumber moisture content. Chapter 1 presents an example (p. 10).

Expressing Lumber in Metric Units

Metric Countries

The normal basis for lumber volume in countries on the metric system is the cubic meter. This is based on nominal dimensions and *shipping dry* (14-20%) moisture content. With the thickness (T) and width (W) in millimeters and length (L) in meters, cubic meter volume is

$$m^3 = T / 1{,}000 * W / 1{,}000 * L.$$

Hence a 120 mm x 90 mm x 4 m piece equals 0.0432 cubic meters. This calculation applies only where the differences between nominal and manufactured sizes are negligible. It would not be appropriate in a case where the American Softwood Lumber Standards were converted directly to metric equivalents, retaining the differences between nominal and manufactured sizes.

North American Export Lumber

Three possibilities exist: (1) lumber produced in standard foreign metric sizes; (2) lumber in Imperial sizes produced "full sawn" for export; and (3) standard North American lumber.

Standard Foreign Metric Sizes. In this case, the above discussion for metric countries applies.

Imperial Sizes "Full Sawn" for Export. The lumber, typically measured in board feet and shipped green, is produced with the Imperial nominal dimensions as manufactured sizes. The lumber is often remanufactured by the foreign buyer. In this case, the conversion factors

$12\ BF = 1\ ft^3 \quad 424\ BF = 1\ m^3 \quad 1{,}000\ BF = 2.36\ m^3$

are used. A discrepancy of about 5% occurs because this lumber is shipped green whereas metric countries measure on the shipping dry basis. This shrinkage adjustment would change the 424 BF/m^3 to about 450 and the 2.36 m^3/MBF to about 2.22 (Williston 1988).

Standard North American Lumber. In this case the standard North American board foot tally, called *gross MBF*, is converted to the board footage that would be obtained using manufactured lumber sizes, called *net MBF*. An example for 2x4s will illustrate the procedure. Multiply the nominal thickness and width: $2 * 4 = 8$. Multiply the manufactured thickness and width: $1.5 * 3.5 = 5.25$. Divide the latter by the former and express as a percentage:

$$(5.25 / 8) * 100 = 66\%.$$

Use this percentage to convert gross to net. Thus, 100 MBF gross tally 2x4s becomes 66 MBF net. The Western Wood Products Association has a publication entitled *Gross to Net Lumber Footage Tables for Export* (WWPA 1983) that provides these percentages for all softwood lumber sizes.

Board Feet to Cubic Meters. Using the tables cited above (WWPA 1983), convert the nominal (gross) board foot tally (BF_g) to net board feet as shown in the section above. This net volume can be converted to cubic feet using 12 BF/ft^3 and then to cubic meters using 35.315 ft^3/m^3. These two conversions can be combined into 424 net BF/m^3. The procedure can be summarized as

$$m^3 = BF_g * f / 424 = 100{,}000 * (0.66) / 424 = 155$$

where f = gross to net factor for the appropriate state of manufacture.

Or, using BFFR, multiply the BFFR by 35.315 ft^3/m^3 and divide this into BF_g:

$$m^3 = BF_g / (BFFR * 35.315 = 100{,}000 / (18.29 * 35.315) = 155.$$