

CHANGE OF GRADE AND VOLUME OF DOUGLAS-FIR
SHOP AND BETTER LUMBER DURING KILN DRYING

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During the last 10 years many changes have taken place in the manufacturing and marketing of old-growth, coast range Douglas-fir lumber in northern California. The Forest Service's mill scale studies of 1950 and 1952 became obsolete, and researchers saw a need for a new lumber grade recovery study in that area. In 1960 the Forest Service in cooperation with the Ralph L. Smith Lumber Company of Wildwood, California, conducted such a study of old-growth Douglas-fir.

The part of the recovery study reported here sought to determine, for Shop and Better grades of Douglas-fir lumber: (a) the extent of, and reasons for the changes in grade and volume that result from commercial kiln drying and (b) the relationship of these changes in grade and volume to lumber thickness, lumber width, log grade, and log size.

PROCEDURE

The general field procedure for collecting the data has been used by the Forest Service in previous studies with only minor variations. First, 53 trees were selected from the Klamath, Shasta-Trinity, and Six Rivers National Forests (table 1). Each tree was numbered, felled, and bucked into lengths in accordance with industry practice. Most logs ranged in length from 28 to 40 feet. All logs were numbered in sequence from bottom to top of the tree and identified with tree number. Minimum log size taken was 10 feet long, 10 inches d.i.b. with a net scale of 33 1/3 percent of gross scale. Cull logs were left in the woods.

Table 1.--Origin of study logs

Area	: Number : of trees	: Number : of logs
Klamath	17	81
Six Rivers	10	50
Shasta-Trinity	26	100
Local	--	148
Total	53	379

At the mill deck, each long log was bucked, diagramed, and identified by tree number, long log number, and short log number. The short log number gave the relative position of the bucked log in the long log. The logs were graded by using peeler-sawmill log grading rules. They were assigned mill log numbers at the mill deck, beginning with number 1 and continuing through the study to 596. Only those logs producing Shop and Better lumber are included in this analysis. The 53 trees selected for study yielded 231 short logs which met this specification. An additional 148 logs, each producing Shop and Better lumber, were selected from local sources so that the study included an adequate sample of logs in a wide range of grades and sizes (table 2).

Table 2.--Number of logs in each size and grade

Log grade	Log size ^{1/}					Total
	10-19	20-29	30-39	40-49	50-59	
1 Peeler	0	0	5	7	3	15
2 "	0	1	9	4	0	14
3 "	1	25	17	6	1	50
1 Sawlog ^{2/}	--	--	--	--	--	--
2 "	35	88	50	11	4	188
3 "	16	59	28	8	1	112
Total	52	173	109	36	9	379

^{1/} In inches d.i.b. at small end.

^{2/} In the sample no logs were graded 1 Sawlog.

Each log was sawed to yield the maximum recovery of the standard lumber grades. The sawing practices followed during the study period conformed to general industry practice in the coast range area and was geared to produce Select, Shop, Dimension, and Common lumber. Shop lumber was sawed to meet Western Pine Association specifications, all others to West Coast Lumbermen's Association specifications.

All lumber from each log was marked with its mill log number during the sawing operation and grade marked on the green chain. All lumber was tallied by mill log number, green grade, width, length, and thickness.

This phase of the study is concerned with the following Shop and Better grades:

<u>Select</u>	<u>Shop</u>
B & Better (B)	3 Clear (3C)
C Select (C)	1 Shop (1S)
D Select (D)	2 Shop (2S)
Moulding (Mldg.)	3 Shop (3S)

These grades of lumber were cut in random widths in thicknesses of 4/4, 5/4, 6/4, and 7/4. Dimension and Common lumber were remanufactured and handled separately and not included in the analysis. Shop and Better lumber was pulled into two thickness groups and stacked for kiln drying.

The 4/4 and 5/4 lumber was dried in a modern, single-track, internal-fan, cross-circulation kiln to an average final moisture content of about 10 percent by using the following time-temperature schedule:

<u>Time (hours)</u>	<u>Temperature, °F.</u>		
	<u>Dry bulb</u>	<u>Wet bulb</u>	<u>Wet bulb depression</u>
0 - 24	130	122	8
25 - 36	136	126	10
37 - 48	140	130	10
49 - 60	150	136	14
61 - 72	160	140	20
73 - 96	170	140	30
97 - 104 (conditioning)	160	152	8

Total drying time including conditioning - 104 hours.

We used a resistance-type electrical moisture meter to spot check the moisture content after the lumber had been pulled from the kiln and stacked on sticks for 1 to 4 days. This check showed the 4/4 lumber as 2 to 3 percent drier than the 5/4 lumber or as having about 7 to 8 percent moisture content.

The 6/4 and 7/4 lumber was dried in a similar kiln to an average final moisture content of about 12 percent by using the following time-temperature schedule:

<u>Time (hours)</u>	<u>Temperature, °F.</u>		
	<u>Dry bulb</u>	<u>Wet Bulb</u>	<u>Wet bulb depression</u>
0 - 24	130	122	8
25 - 36	136	126	10
37 - 48	140	130	10
49 - 72	150	136	14
73 - 96	160	140	20
97 - 120	170	140	30
121 - 128 (conditioning)	160	152	8

Total drying time including conditioning - 128 hours.

A moisture meter check of this lumber on the dry chain showed the 6/4 lumber about 3 percent drier than the 7/4.

After drying, the same grader that evaluated the lumber in the green condition regraded and marked the lumber on the dry sorting chain. He used the following code in recording any change in grade:

1. Grader's evaluation of the piece is different.
2. Logging and manufacturing damage.
3. Shake.
4. Warp.
5. Checks and splits.
9. No change.

We then tallied the boards by mill log number, thickness, width, length, green grade, dry grade, and reason for change in grade.

DATA PROCESSING

Machine operators transferred the data for each board from tally sheets to punch cards for mechanical processing. A detailed matching was made of all boards from rough green to rough dry for each log. Some discrepancies in board identity were found. This discovery made it necessary to remove cards for 459 rough green boards and 413 rough dry boards. The remaining 4,440 boards were analyzed for changes in grade and volume from rough green to rough dry.

RESULTS

GRADE AND VOLUME CHANGE

The volume of lumber that held to grade during kiln drying ranged from 53 to 96.2 percent of green volumes in the several individual grades (table 3). The upper grades of lumber (B - D) degraded consistently more than the lower grades (Mldg. - 3S).

About 22 percent of the total volume of lumber was recovered as moulding stock and another 20 percent was graded as 2 Shop. About equal amounts (15 percent) were recovered as C Select, D Select, and 1 Shop, the remaining volume being distributed among the other three grades. Nearly 76 percent of the lumber went through the drying schedule without a change in grade, nearly 16 percent degraded, and over 6 percent up-graded.

As might be expected the greater part of the degrade in the three upper grades was regraded as Moulding.^{1/} Such defects as shake, warp, and checks and splits caused most of the shift in grade (table 4). The change to Moulding also may be associated with the relatively large amount of grade change attributed to the grader.

Influence of Lumber Thickness

Within four thickness groups, the 5/4 lumber had the least amount of degrade (8.5 percent) as the result of drying (table 5). Each of the other lumber thicknesses (4/4, 6/4, and 7/4) had a much higher amount of degrade (15 - 22.5 percent). Thinner lumber tended to degrade less than thicker lumber, but why was the percentage of degrade for 4/4 lumber nearly double that of the 5/4 stock? The reason may be that all the green 4/4 lumber was in the higher grades (Moulding and Better) whereas the 5/4 consisted mostly of lower grades. A greater part of the volume of 6/4 and 7/4 green lumber was also in the upper grades, which tended to degrade more than the lower grades.

Forty percent of the 4/4 lumber was regraded to a higher grade after drying (table 6). The least amount of upgrading occurred in the 5/4 stock, which had only a 0.4 percent upgrade.

Influence of Log Grade

The amount of degrade of lumber cut from the higher grades of logs (1, 2, and 3 Peeler grade) was about twice that of lumber cut from the lower log grades (2 and 3 Sawlog) (table 6). This difference in degrade is closely associated with the amount of upper and lower grades of lumber cut from different log grades (table 7).

^{1/} Western Pine Association standard grading rules, January 1, 1961, p. 100, par. 450.

Table 3.--Volume of Shop and Better grades of Douglas-fir lumber recovered from various green grades after drying (all sizes)

Rough green lumber grade	: Green volume	Rough dry volume as percent of green volume											: Volume
		: Upgraded	: B	: C	: D	: Mldg.	: 3C	: 1S	: 2S	: 3S	: Unchanged	: Down-grade	
	<u>Bd. ft.</u>	<u>Percent</u>											
B	2,619.8	0	59.4	13.6	4.0	22.0	--	--	--	--	59.4	39.6	1.0
C	12,187.9	5.3	5.3	69.8	6.1	16.3	--	0.2	0.1	0.4	69.8	23.1	1.8
D	20,780.1	17.3	1.0	16.3	53.0	24.8	0.1	0.7	0.8	1.3	53.0	27.7	2.0
Mldg.	11,200.7	4.1	0.8	2.3	1.0	88.8	0.5	0.5	1.7	1.7	88.8	4.4	2.7
3C	2,553.3	5.2	0.6	--	--	4.6	81.1	10.3	0.7	--	81.1	11.0	2.7
1S	14,176.0	0.4	0.1	--	0.1	0.2	--	85.3	10.9	0.6	85.3	11.5	2.8
2S	16,732.0	1.6	--	--	--	1.1	--	0.5	89.7	6.1	89.7	6.1	2.6
3S	2,960.3	2.1	--	0.1	--	1.8	--	--	0.2	96.2	96.2	0	1.7
Average	83,210.1	6.3	3.0	15.0	14.4	21.7	2.6	15.2	20.4	5.4	75.7	15.7	2.3

Table 4.--Reasons for degrade (number and volume of boards) during kiln drying Shop and Better grades of Douglas-fir from rough green to rough dry (all sizes)

Rough : green : grade :	Reasons for degrade - based on green volume							Total volumes	
	Grader	Logging	Shake	Warp	Checks	Total	Dry	Green	
Upgrade	Degrade	and mfg.			and splits	degrade			
----- Percent -----							- -Board feet - -		
B	0	11.9	0.3	4.0	13.3	10.1	39.6	2,594.7	2,619.8
C	5.3	4.8	0.9	2.7	6.2	8.5	23.1	11,975.5	12,187.9
D	17.3	3.9	1.8	4.7	8.0	9.3	27.7	20,358.2	20,780.1
Mldg.	4.1	0	0.5	0.5	0.4	3.0	4.4	10,901.7	11,200.7
3C	5.2	4.0	2.5	--	1.7	2.8	11.0	2,485.3	2,553.3
1S	0.4	2.8	1.5	--	1.7	5.5	11.5	13,784.3	14,176.0
2S	1.6	1.5	1.0	0.4	0.7	2.5	6.1	16,299.0	16,732.0
3S	2.1	0	--	--	--	--	0	2,911.9	2,960.3
Average	6.3	2.8	1.2	1.9	3.9	5.9	15.7	81,310.6	83,210.1

Table 5.--Distribution of Shop and Better grades and volumes for various lumber thicknesses

Thickness	Green volume		Degrade
	Upper grade (B, C, and D)	Lower grade (Mldg., 3C, 1S, 2S, and 3S):	
	Percent		
4/4	86.5	^{1/} 13.5	15.3
5/4	10.4	89.6	8.5
6/4	72.2	27.8	22.6
7/4	72.6	27.4	22.4

^{1/} All Moulding.

Table 6.--Green volume and volume change in grade of Shop and Better grades of Douglas-fir lumber after kiln drying

Item	Green volume Bd. ft.	Rough-dry volume as percent of green volume			Total changed:	Volume loss
		Upgraded	Unchanged	Degraded		
		Percent				
Rough green lumber thick- ness						
4/4	1,266.7	40.0	44.1	15.3	55.3	0.6
5/4	39,995.9	0.4	88.7	8.5	8.9	2.4
6/4	29,506.8	10.3	64.9	22.6	32.9	2.2
7/4	12,440.7	12.1	63.1	22.4	34.5	2.4
Log grade						
1P	10,230.8	11.6	65.6	21.2	32.8	1.6
2P	8,075.8	5.8	63.2	28.8	34.6	2.2
3P	15,583.6	10.5	66.1	21.1	31.6	2.3
2S	35,339.4	4.9	82.0	10.6	15.5	2.5
3S	13,980.5	1.4	85.9	10.9	12.3	1.8
Log size						
10-19	736.3	8.3	73.5	16.2	24.5	2.0
20-29	15,851.7	5.3	81.7	11.2	16.5	1.8
30-39	38,385.3	4.8	78.0	14.7	19.5	2.5
40-49	21,792.6	8.7	70.1	18.8	27.5	2.4
50-59	6,444.2	8.7	66.4	22.6	31.3	2.3
Average	83,210.1	6.3	75.7	15.7	22.0	2.3

Table 7.--Distribution of Shop and Better grades and volumes cut from various log grades

Log grade	Number of logs	Green volume		
		Upper grade (B, C, and D)	Lower grade (Mldg., 3C, 1S, 2S, and 3S)	Degrade
		-----Percent-----		
1P	15	68.4	31.6	21.2
2P	14	73.8	26.2	28.8
3P	49	70.6	29.4	21.1
2S	188	29.3	70.7	10.6
3S	112	9.1	90.9	10.9

About 70 percent of the study lumber cut from the peeler grade logs was graded B, C, or D; 70 to 90 percent of the lumber cut from saw grade logs was graded Moulding and lower. Since upper grades of lumber degrade more during drying than the lower grades, the difference in degrade between the lumber cut from the better logs and that cut from the poorer logs can be explained. The grade of log probably does not directly affect the amount of degrade, but may indirectly affect it through the grade of lumber it produces.

Influence of Log Size

The degrade occurring in lumber cut from different log sizes tended to increase as log diameter increased (table 6). One could infer from these results that the larger logs are in the higher grades while the smaller ones are in the lower grades, and that an increasing amount of higher grade lumber is produced from the higher log grades, resulting in a corresponding increase in drying degrade. An examination of the grades of lumber produced from logs of different diameters (table 8) proved the foregoing inference to be only partly correct.

Table 8.--Distribution of Shop and Better grades and volumes cut from various log sizes

Log diameter, inches	Number of logs	Green volume		
		Upper grade (B, C, D)	Lower grade (Mldg., 3C, 1S, 2S, 3S)	Degrade
		-----Percent-----		
10-19	52	54.0	46.0	16.2
20-29	172	42.9	57.1	11.2
30-39	109	37.2	62.8	14.7
40-49	36	46.3	53.7	18.8
50-59	9	62.4	37.6	22.6

An increase in diameter did not necessarily result in a corresponding increase in production of upper grades of lumber. Log size 10-19 inches for example had a higher ratio of Select to Shop grades than all other log sizes but the largest. Select grades include considerably narrower widths than do the Shop grades, hence we might expect to get more Select grades than Shop from the smaller logs. Log size 30-39 inches had the lowest percentage of upper grades produced (37.2 percent). Not all large diameter logs were high grade logs. Many were in the sawlog grades (table 2). But the larger diameter classes had increasing proportions of higher grade logs (table 9).

Table 9.--Distribution of log grades in different log size groups

Log diameter, inches	Peeler grade (1P, 2P, 3P)	Sawlog grade (2S, 3S)
----- Percent -----		
10-19	2	98
20-29	15	85
30-39	28	72
40-49	49	53
50-59	44	56

The increase in degrade associated with the increase in log diameter cannot be fully explained on the basis of the production of high grades of lumber alone. Differences in the production of high grade lumber found in log size 30-39 inches (table 8), which did not follow the pattern of the other log sizes, suggest that other factors influence the pattern of degrade.

Influence of Lumber Width

One factor affecting pattern of degrade is board width. The amount of degrade tended to increase with board width (table 10). Since larger logs usually produced wider boards, we may attribute the increase in degrade associated with an increase in log size in part to the greater degrade of the wider boards.

Board thickness may be another factor that affects the degrade pattern. We found that 4/4 and 5/4 lumber degraded less than 6/4 and 7/4 lumber (table 6). Though we did not make an analysis, we would expect the proportion of thicker lumber to increase with log diameter. This would explain in part the increase in degrade.

Table 10. -- Change in grade of rough green 6/4 grade D lumber when kiln dried, by board widths

Width group	: Rough green volume	: Rough dry volume as percent of rough green volume			: Volume loss
		: Upgraded	: Remained in grade	: Degraded	
	<u>Bd. ft.</u>	<u>Percent</u>			
4- 8	3,027.1	16.0	56.0	27.4	0.6
9-13	3,499.9	16.7	48.7	32.9	1.7
14-18	2,693.4	23.7	41.7	32.2	2.4
19-23	1,856.0	15.0	38.8	43.9	2.3
24-28	108.0	42.6	0	55.6	1.8
Total	11,184.4				
Average		18.1	46.9	33.3	1.7

REASON FOR CHANGE IN GRADE

About 76 percent of all the lumber examined held its grade during kiln drying (table 3). Another 16 percent of the study lumber dropped one or more grades and 6 percent increased one or more grades. The 2.3 percent volume loss was due mainly to trimming and shrinkage.

Warp, checks, and splits accounted for the greatest amount of degrade: about 4 percent because of warp, and 6 percent because of checks and splits (table 4). Shake accounted for only 1.9 percent of the degrade, and logging and manufacturing damage for 1.2 percent.

The amount of degrade because of the grader's re-evaluation was higher for the upper than for the lower grades of lumber. The grader probably had more difficulty in appraising the Select grades. Change is more likely to occur in these higher grades than in the Moulding and Shop grades. In the lower grades inaccuracies in evaluating the green grade may have little effect on the grade after drying.

CONCLUSIONS

This study indicates a considerable loss of grade during the kiln drying of Shop and Better Douglas-fir lumber. Of the 83,000 board feet of green lumber included in this part of the recovery study, 15.7 percent lost one or more grades when regarded as rough-dry lumber. This degrade included 12.9 percent from actual drying defects and 2.8 percent due to the judgment of the grader.

Based on the findings of this study, the following conclusions concerning the change of grade and volume of Douglas-fir Shop and Better lumber during kiln drying appear to be valid.

- . High grade lumber degrades more than lower grade lumber.
- . Thick wide lumber degrades more than thin narrow lumber.
- . Lumber from large logs degrades more than lumber from small logs because large logs produce more wide, high quality lumber.
- . Lumber from high grade logs degrades more than lumber from low grade logs because high grade logs produce more wide, high quality lumber.