DRYING DOUGLAS-FIR JUVENILE WOOD: THE STAND MANAGEMENT COOPERATIVE STUDY

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Juvenile wood (JW) is the bane (one of many) of the kiln operator's existence. This pith-associated wood is noted for dimensional instability. Although many Douglas-fir producers avoid this issue by selling green dimension lumber, some potentially valuable product options are closed to green lumber producers. The problem may be overstated: Douglas-fir juvenile wood seems to be more stable than the juvenile wood of most other species, and kiln schedules that work well for other species seem to work extremely well for Douglas-fir.

Two major studies have been completed recently that deal with the problems and properties associated with juvenile wood. The (SMC) Stand Management Cooperative study of wood quality from managed stands was designed to test the effect of various stand developmental characteristics on the quality of the wood produced from these stands. In Canada the (DFTF) Douglas-fir Task Force at Forintek (Kellogg 1989) approached a similar problem from a different angle. In both studies, lumber was kiln dried, and at least some of the lumber degraded because of warp. This report will be mainly concerned with the SMC study with a brief reference to the DFTF study results.

METHODS

Sample Selection

SMC sample trees were selected from 15 stands in western Oregon and Washington (Figure 1, Table 1). Three characteristics--tree dbh, limb size in the butt 16-foot log, and the anticipated amount of juvenile wood in the tree--were used as stratification variables. Sampling by these tree characteristics provided a sample of logs with a wide range of log and limb sizes, and proportion of juvenile wood. Our objective was to develop models that predict lumber and veneer recovery for logs cut from young-growth trees.

All sample logs were hauled to the Simpson Timber Co. mill 3 at Shelton, WA. Logs were sawn into a limited product line, only 2 by 4s and 2 by 6s were cut during the study. This was done because we wanted to assess the inherent quality of the wood, rather than the ability of the sawyer to choose the most suitable product to saw based on the log characteristics. We also wanted to grade all lumber based on (MSR) Machine Stress Rating and nearly all the lumber marketed under these rules is in 4-inch and 6-inch widths.

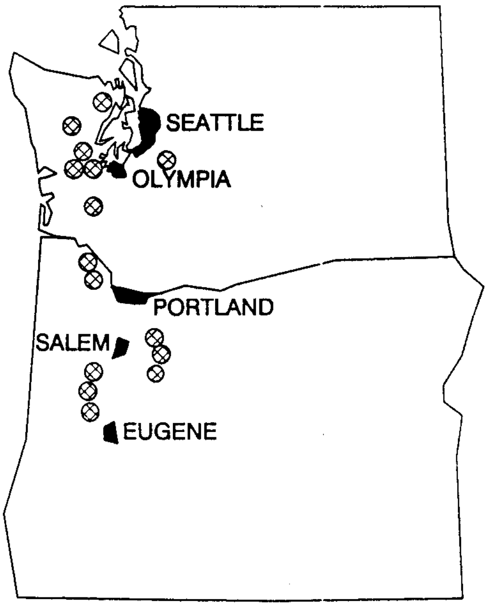

Figure 1. Approximate location of stands used for selection of sample trees.

Table 1. Characteristics of trees selected from sample stands (SMC study).

Area	Age[1]	Number of trees	Dbh Range	Large knot[2] Range	Large knot[2] Average	Juvenile[3] wood average percent
				--- inches ---		
1	44	5	20-26	1.7-2.8	2.2	44.5
2	46	9	10-21	0.6-1.3	0.9	45.2
3	46	20	14-27	1.3-3.0	2.0	45.2
4	49	9	20-27	1.1-3.0	2.2	34.8
5	39	22	9-24	0.5-2.5	1.2	63.4
6	36	11	11-25	0.8-3.8	1.9	63.4
7	45	14	12-25	0.8-2.3	1.6	45.7
8	25	33	9-18	0.9-3.0	1.5	97.6
9	56	8	18-28	1.2-3.2	2.5	30.0
10	61	26	10-23	0.5-1.2	0.8	30.0
11	85	8	18-26	0.6-1.2	0.8	20.7
12	49	17	10-24	0.5-1.9	1.1	48.1
13	29	23	10-17	0.7-1.5	1.1	90.5
14	56	12	10-24	0.5-2.6	1.1	28.1
15	65	19	10-22	0.5-2.0	0.8	26.5

[1]Stand age was measured at stump height.
[2]Large knot is the largest knot in the butt 16-feet of the tree.
[3]Percent juvenile wood is the proportion of log volume 0 to 20 years.

Lumber was kiln dried to an average moisture content of 12.4 percent by using the elevated-temperature, low-humidity, kiln schedule tabulated below:

Dry-Bulb Temperature	Wet-Bulb Temperature	Time
--- Degrees (F) ---		(hours)
190	140	0-6
190	135	6-11
190	130	11-16
190	125	16-21
190	120	21-26
190	115	26-31
190	110	31-32.5

Surfaced-dry lumber was graded under the supervision of a Western Wood Products Association (WWPA) inspector. Lumber was graded by using the visual lumber grades and pieces that met minimum specifications were machine stress rated; specific details of the visual grades are given below.

Visual Lumber Grades

The 2 by 4s were graded under the structural light framing rules; the 2 by 6s under rules for structural joists and planks (WWPA 1981). Each board was assigned the highest grade for which it qualified. Grade designations were Select Structural, No. 1, No. 2, No. 3, and Economy.

Visual Lumber Grades Ignoring Warp and Wane

Study lumber was also graded ignoring warp and wane, as defined in the current grading rules (WWPA 1981). Warp is any deviation from a true or plane surface, including bow, crook, cup, and twist. In general, warp is a concern in the young-growth resource because of reported dimensional instability of juvenile wood (McKay 1989, Senft et al. 1985). Wane is the absence of wood or the presence of bark in lumber caused by curvature of the log surface. Wane was monitored to assure that degrade due to wane was not a major factor in grade recovery.

Lumber was tallied (width, length, and lumber grades) after drying, surfacing, grading, and final trim. About 108,000 board feet of lumber in lengths ranging from 8 to 24 feet were produced during the study. All individual board data including the specific log from which the board was cut, and all the log and tree data from study trees are on file in the SMC database maintained at the University of Washington, Seattle.

RESULTS

The main objective of recording wane was to monitor the manufacturing process; some wane is permitted on all grades of dimension lumber. Many boards had some degree of wane, but the grade was not affected; their grade was determined by characteristics other than wane. Our objective was to assure that grade recovery was not being adversely affected by excessive wane. Fifteen percent of lumber that was potentially No. 1 and better degraded to No. 2 because of wane. This could be a serious problem at a mill that sold most of its production on a No. 1 and better basis, but would not be a problem to a mill that sold No. 2 and better, or to one that sold MSR lumber. Lumber degraded to No. 3 represents a serious loss, no matter how the lumber is normally marketed.

Warp caused far less degrade than wane as shown in Table 2 for the SMC study. Less than 1 percent (70 boards) of the study lumber degraded due to warp. Of the boards that degraded, nearly half changed from No. 1 or better grade to No. 2 grade because warp exceeded one-half of medium, but did not exceed light as defined in section 752.00 of the lumber grading rules (WWPA 1981). For a 16-foot 2 by 4, warp could be as follows:

Type of warp	Maximum warp allowed by grade	
	No.1	No.2
cup	1/32"	1/32"
twist	3/4"	1"
crook	3/4"	1"
bow	2 1/2"	3 1/4"

Less than one half of 1-percent of all boards degraded from No. 2 and better grades to No. 3 grade, because warp exceeded the upper limits for No. 2 in one or more measurements. A few boards had severe warp problems exceeding the amounts allowed in No. 3 grade. Lumber that degraded to economy or cull could have been upgraded if resawn to 1-inch thick lumber. We believe warp in these cases was at least as much related to compression wood around large knots as to the presence of juvenile wood. In general, warp was not a significant factor causing degrade in this sample of lumber. Evidently, the kiln schedule caused no severe warp. This reduced the impact of juvenile wood on volume and grade recovery of visually graded lumber. The impact of warp would have been even less severe on MSR lumber grades; the biggest single group of boards degraded to No. 2 grade, which is not a grading defect for MSR lumber.

The DFTF study in Canada was different in intent, in techniques, and very different in results from the SMC study. To paraphrase their drying research, they selected 2 by 6 lumber 12 feet and longer stratified three ways: by percentage of juvenile wood (0-10, 40-60, and 90-100 percent), by green lumber grade (Select structural or No.2 and No.3 combined), and by geographic location (east or west side of Vancouver Island).

Boards were cut back to 8 feet and dried according to the following schedule:

Dry-Bulb Temperature	Wet-Bulb Temperature	Time
--- Degrees (F) ---		(hours)
180	165	0-8
210	190	8-24
220	190	24-32
230	190	32-48
200	190	48-52

This kiln schedule was deliberately chosen because it was considered fairly severe and likely to exacerbate any problems that would occur. No measures to limit warp (reduced sticker spacing, top loading) were taken in conjunction with the study. Amount of cup, crook, bow, and twist were measured on each board, both before and after drying, as was the moisture content of each board. Degrade was

Table 2. Number of boards degraded due to warp and wane (SMC study).

Potential grade	Boards in grade	Final grade	warp	wane
			--- percent ---	
No. 1 or Better	1970	No. 2	1.7	15.0
		No. 3	0.1	2.6
		Economy	0.1	1.6
		Cull	0.0	0.1
No. 2	3677	No. 3	0.3	4.0
		Economy	0.2	1.8
		Cull	0.0	0.1
No. 3	1747	Economy	0.6	3.6
		Cull	0.0	0.0
Economy	237	Cull	0.4	0.0
All grades	7631		0.9	9.6

Table 3. Number of pieces of each grade and juvenile wood class that were reduced in grade due to twist (DFTF study).

Percent juvenile wood	Original grade	Total pieces dried	Percent of pieces reduced to these lower grades. #2	#3	Econ.
90-100	SS	226	9.7	8.4	2.3
90-100	2 & 3	147	---	---	8.1
40-60	SS	167	1.8	1.2	0.0
40-60	2 & 3	81	---	---	1.2
0-10	SS	147	0.0	0.7	0.7
0-10	2 & 3	73	---	---	1.4

determined by comparing the measured warp to the standard for the grade.

The results of the DFTF study are summarized in Table 3. Roughly 20 percent of the boards that were select structural grade when green but contained 90 percent or more JW lost grade. Much of this degrade was to No. 2, which affects value for visual grades, but does not affect use for MSR grades. Slightly more than 10 percent of the boards degraded to No. 3 or Economy grade because of warp. Grades 2 and 3 lumber with a high proportion of JW also had 8 percent of boards that degraded to Economy. Boards with 40 to 60 percent JW experienced minor amounts of degrade while lumber composed of less than 10 percent JW had almost no degrade.

Degrade experienced in the DFTF study was considerably greater than the degrade of the SMC study. The two studies cannot be compared directly because the techniques were dissimilar. The SMC study was a production run with a schedule chosen for drying young-growth Douglas-fir with little degrade; the DFTF was a laboratory run with a schedule chosen to point up the problems if they did occur. Recent tests run at Oregon State University (Milota 1990) tend to confirm the SMC results. Taken together the studies indicate that although some warp is associated with JW, it is apparently not as severe as with other species. Kiln schedules and conditions that result in relatively little degrade are available and are in commercial use.

We do not want to leave anyone with the impression that JW is not a problem; there are serious problems with the strength properties which fail to meet the standards for the species. The best reason to specify Douglas-fir lumber is that it is stronger than many other softwood species. There is a large and growing body of literature to the effect that JW does not have the strength properties associated with mature wood.

Most studies deal with fairly standard measures of wood performance; (MOE) modulus of elasticity, (MOR) modulus of rupture, and tensile strength. A measure of stiffness, MOE is fairly easy to measure and if defects are limited, is correlated with (Fb) extreme fiber stress in bending, MOR and tensile strength. The DFTF (Barrett and Kellogg 1989) found that MOE was reduced by 9 to 21 percent for JW and MOR was reduced by 18 to 36 percent. Douglas-fir 2 by 4s (Bendtsen et al. 1988) containing 100 percent JW had MOEs equal to roughly 70 percent, and tensile strengths roughly equal to 80 percent of mature wood from the same logs. The SMC study did not identify JW in individual boards, but logs with high proportions of JW produced had low recovery in the higher MSR grades (Fahey et al. 1990).

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