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Air-Drying of Robusta Eucalyptus Lumber

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ABSTRACT: A study of air-drying 4/4 *Eucalyptus robusta* lumber in Hilo, Hawaii showed that during typical summer weather it can be dried to below 20 percent moisture content in 2-1/2 months. Grade reduction in 36 percent of the lumber was caused by end splits, insect damage, warp, and surface checking.

Eucalyptus robusta, a tree native to Australia, is an important timber species in Hawaii. Robusta lumber has been produced in Hilo for several years. Little information is available, however, on the effects of air-drying on robusta lumber. Specifically, no accurate determinations have been reported of air-drying time in relation to climate, of the degrade due to drying, or of the variation in drying rate resulting from various pile spacings and piling methods.

This study was designed to evaluate the effects of different spacing between piles of 4/4 robusta eucalyptus boards to develop a piling design that would reduce drying time and drying degrade, yet sacrifice a minimum of valuable yard space.

The research was conducted in cooperation with Hawaiian Fern-Wood, Ltd., which provided the lumber, labor, and yard space; and with the Forestry Division, Hawaii Department of Land and Natural Resources. Statistical analyses were made by Rita R. Taylor, geneticist on the staff of the Pacific Southwest Station.

PROCEDURE

The robusta lumber studied was 4/4, random width (6-16 inches), 8 feet long in No. 1 common and better grades of the standard National Hardwood Lumber Association rules. It was selected and graded at the green chain and kept green by close piling until placed on stickers in the study piles. During grading, the assigned grade and the limits of end splits and other defects were marked on each board. Logs from which study lumber was cut came from three different areas on the island of Hawaii, and each board was marked by source. Study lumber totaled 3,312 board feet, with nearly equal representation of 1,100 board feet from each forest stand location--Wood Valley, Amauulu, and Hutchinson Plantation.

The study lumber amounted to 20 percent of the lumber in the piles. The piles were built on foundations 15-1/2 inches above the ground. Each pile consisted of four packages set one atop another--each package being 4 feet wide and 15 courses high. The packages were separated by 2- by 3-inch bolsters. Stickers were on 2-foot centers. The piles were roofed with corrugated aluminum.

There were 13 piles in the study, arranged side by side in a single row. The piles were set at increasing spacings. The three at the center were 2 feet apart, the next two at each end were 3 feet from the others, and so on up to 6 feet. Thus the four pile halves facing a particular spacing were used to replicate piles normally spaced at that distance (fig. 1). The pile at each end of the row was a buffer; only the central 11 piles contained study lumber.

Figure 1. Piles set at increasing spacing, 2 to 6 feet.

Study lumber was installed as the bottom three courses of the two lower packages of 15 courses, and the upper three courses of the two upper packages in each study pile. Twenty drying samples of randomly selected lumber were installed behind buffer boards in the bolstered space between the second and third packages. Each of the five pile spacings was represented by four drying samples. Each sample was weighed weekly throughout the drying period. The sample was also measured with an electrical moisture meter at each weighing after it had reached about 40 percent moisture content.

At the conclusion of air-drying, the study lumber was marked by pile and position in the pile, then regraded. Increase in length of end splits and total inches of surface checks were measured. If degrade occurred, the reason for it was recorded. The moisture content of each board was measured with an electrical moisture meter.

RESULTS

RATE OF DRYING

Drying was quite rapid at all pile spacings (fig. 2). By the end of 2-1/2 months, the lumber had dried to about 20 percent despite almost daily rain. In 3 months the lumber had reached essentially constant weight. No difference in drying rate attributable to spacing difference could be found--possibly because of the small number of drying samples used and the large variability in initial moisture content and drying rate among these samples. The initial variation in moisture content among the samples had little influence on variation in drying rate and almost no effect on final moisture content.

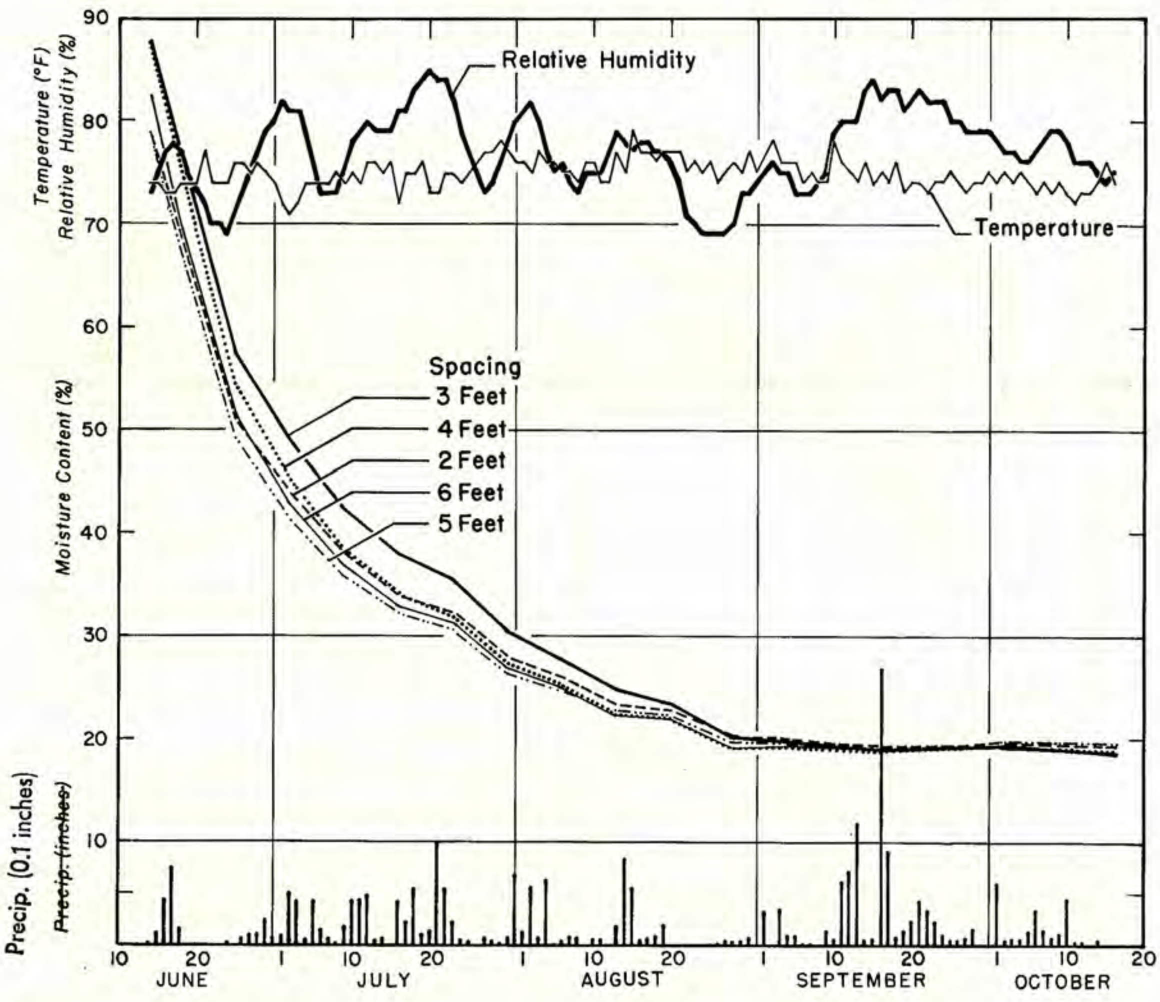


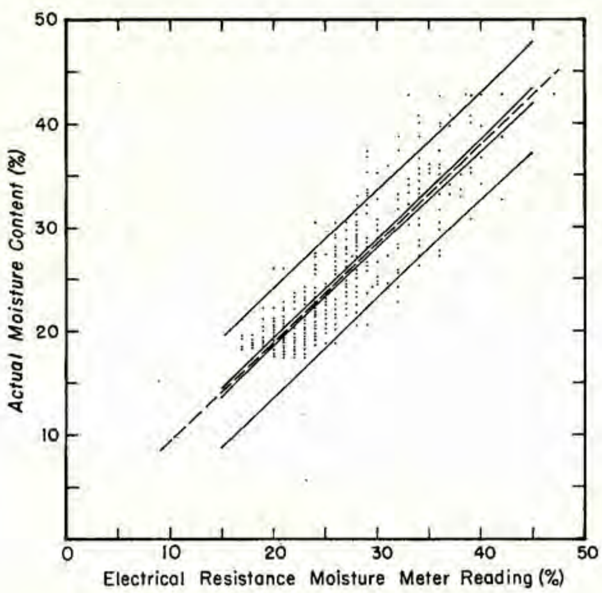
Figure 2. Drying rates of samples with average temperatures, relative humidity (running 5-day average), and precipitation.

The weather during the drying period was typical of normal summer weather in Hilo, Hawaii. Weather observations were obtained from a U. S. Weather Bureau station one-fourth mile from the drying yard and at the same elevation.

Just as during the winter and spring drying of silk-oak, studied earlier,[1] the wind reversed daily during this period. It swept in from the Pacific Ocean from the northeast quadrant during daytime and off the mountains from the southwest at night.

MOISTURE CONTENT

A highly significant correlation was found between the electrical moisture meter readings of the drying samples and their actual moisture content. The curve of this relationship (fig. 3) will serve as a calibration chart for robusta eucalyptus until more accurate calibration--now in progress at the U. S. Forest Products Laboratory, Madison, Wis.--is completed.



CONFIDENCE BELTS

Narrow limits - 0.95 confidence limits for average moisture content indicated by average meter readings.

Wide limits - 0.95 confidence limits for true moisture content based on single meter reading.

Figure 3. Relationship of electrical resistance type moisture meter readings to actual drying sample moisture content.

At the conclusion of the study, the lumber had reached an average moisture content of 18.5 percent based on corrected moisture meter readings (table 1). Lumber in the top three courses of the piles was significantly drier than that lower down. But the bottom courses did not have a higher moisture content--indicating that foundation height was quite adequate. There was no significant difference in final moisture content for piles at different spacings or for lumber at different positions in the piles except for that at the pile tops.

[1]Skolmen, R. G., and Smith, H. H. Drying of silk-oak in Hawaii. U.S. Forest Serv. Pacific SW. Forest and Range Expt. Sta. Tech. Paper 65, 11 pp., illus. 1962.

Table 1. --Moisture content of lumber at completion of air-drying, by position in pile

Position in pile	Pile spacing					Average
	2 ft.	3 ft.	4 ft.	5 ft.	6 ft.	
Top	17.8	17.9	17.1	17.9	17.4	17.6
Upper	19.1	18.8	18.5	18.5	18.5	18.7
Lower	19.1	19.0	19.1	18.9	18.6	18.9
Bottom	19.0	18.7	18.7	18.7	18.5	18.7
Average	18.8	18.6	18.4	18.5	18.3	18.5

DEGRADE DUE TO DRYING DEFECTS

Standard grades of the National Hardwood Lumber Association were used in grading with one exception--stained sapwood that would not dress out was not counted a defect. Of 355 boards containing sapwood, 251 boards--71 percent--had stained sapwood.

A total of 1,310 board feet, or 39.6 percent of all sample lumber, was degraded after drying. Causes of degrade, in order of board footage affected, were: end splitting--36.1 percent of the degraded lumber; beetle damage--27.5 percent; warp --18.6 percent; grader error--10.1 percent; and surface checking--7.7 percent (table 2).

Table 2. --Causes of degrade in drying, by position in pile and source of lumber

Position or source	End splits	Surface checks	Warp	Grader error	Insects
	Board feet				
Position:					
Top	122	30	144	24	29
Upper	67	11	55	28	102
Lower	157	33	6	50	95
Bottom	127	27	39	30	134
Total	473	101	244	132	360
Source:					
Amauulu	228	22	70	40	154
Hutchinson	102	36	98	32	38
Wood Valley	143	43	176	60	168

Of the defects, warp generally caused more reduction in grade of the boards in which it occurred. It caused more than half the boards to be knocked down two or three grades (table 3). Beetle damage, another major defect, also often caused downgrade of more than one grade. The principal defect, end splitting, most commonly caused a reduction of only one grade, but affected more boards than did other degrading defects.

Grader error is simply a reevaluation of the green grade based on the second examination after drying. As such, it is not a defect and is included only to account for all degrade that occurred. In all cases of grader error, the grade was reduced rather than raised.

Table 3. --Number of boards downgraded, by defect and number of grades reduced

Defect	Number of grades reduced			Total
	1	2	3	
End splits	61	17	0	78
Surface checks	8	3	4	15
Warp	22	16	7	45
Grader error	19	3	0	22
Insects	39	23	5	67
Total	149	62	16	227

End splitting was a defect that had occurred during drying and not in the lumber as it came from the saw. Most end splits measured were extensions of splits caused by growth stress that had been present in the green lumber, but only the portion of these splits that had occurred during drying was measured. The splits were measured as a cumulative total of linear inches for both ends and both sides of each board. An analysis of the data showed no significant difference in end splitting between piles at different spacing, between different locations of lumber in the piles, or between lumber from the three different forest stands--when the board footage, width of boards, or number of boards represented in these three stands were taken into account.

That no difference occurred in end splitting between forest stands is of special interest. It might be expected that trees of different age grown under different conditions would differ in growth stress, which in turn would cause a difference in initial end splits. Although we do not know if this difference in initial end splits existed, we do know that end splits in lumber from the three stands had a similar tendency to increase during drying.

Beetle damage, due entirely to the ambrosia beetle (*Xyleborus semigranosis* Bldf.), was confined mostly to sapwood, rarely in heartwood directly adjacent to infested sapwood. Though a little of this damage developed in logs before milling, most occurred in the piles during drying. Lumber from the upper three courses of the piles showed much less beetle damage than that lower down. This difference can probably be attributed to the more rapid drying of the upper lumber and consequently its shorter exposure time to beetle attack. The lower lumber took a longer time to air-dry. Lumber from the bottom three courses of the piles, which probably dried the slowest, had the most beetle damage. For unknown reasons, lumber from Hutchinson Plantation logs received less attack than lumber from other sources.

Warp that occurred in drying was mostly cupping. Occasional boards were twisted or crooked enough to cause degrade as well. Though warp caused degrade in lumber from all pile positions, it was far more frequent in lumber from the top three courses of the piles. Evidently the weight of the upper courses greatly reduced warp lower down in the piles.

Surface checking did not vary by pile spacing, position in the piles, or source of lumber. It was a relatively minor defect, amounting to an aggregate of only 0.35 linear inches of checking per board foot of lumber and only 7.7 percent of the degrade.

CONCLUSIONS AND RECOMMENDATIONS

During typical summer weather conditions in Hilo, 4/4 robusta lumber can be air-dried to 20 percent moisture content in about 10 weeks by using 4-foot wide, covered piles spaced as closely as 2-feet apart.

Unless common remedial measures are taken, a high percentage of degrade will occur in air-drying robusta eucalyptus lumber in Hilo. Defects that occurred for which there may be some control measure were end splitting, beetle damage, and warp. Stain, a serious degrading factor not included in this study, is also controllable. To reduce degrade, we recommend the following treatments:

1. End splitting may be reduced to some extent by end coating the lumber with a moisture-resistant barrier. Since most of the end splitting resulted from extension of already present splits caused by growth stress, it is doubtful that the treatment would eliminate the problem--it would merely reduce it.

2. Stain and beetle damage in lumber can be controlled by dipping the lumber fresh from the saw in a suitable fungicide-insecticide solution. Benzene hexachloride (BHC) sprayed on barked logs is a widely used chemical control for ambrosia beetle damage. Continuous water spraying of decked logs might reduce stain and beetle damage in the logs before milling. This treatment deserves study.

3. Warp, which occurs mostly in upper courses, may be reduced by weighting of piles.

4. A manufacturing method that would improve grade both before and after drying would be to produce longer lengths. Though splits caused by growth stresses would increase in longer boards, the degrading influence of end splits and other drying defects would be reduced because it would be applied to a larger surface measure.

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