SURVEY OF THE MOISTURE CONTENT OF WOOD IN USE IN CALIFORINA

By Harvey H. Smith, Eric L. Ellwood, and Robert W. Erickson

Introduction—

Information on the moisture content of wood in use throughout California has frequently been requested by the lumber producing and using industries. The primary value of such information is to establish the moisture content to which wood should be dried for use in California. Until the present study, the only comprehensive data aivailable was that published by the U.S.D.A. Forest Products Laboratory in Report No. 1655. This report, while very valuable on a regional basis, is not sufficiently detailed for California, particularly in view of the abrupt variations of topography and climate which exist within the State.

In 1956, the Southern California Lumber Seasoning Association commenced a local survey of wood moisture content in use. Subsequently, the California Forest and Range Experiment Station and the University of California Forest Products Laboratory undertook, on a cooperative basis, extension of the survey throughout California for both indoor and outdoor exposures. With the cooperation of the lumber using industries throughout the State, particularly those involved in kiln drying, 23 stations were set up to collect data on wood moisture content samples exposed under prescribed conditions.

Procedure

1. Wood Moisture Content Samples. As average values for wood in general were considered the most important, composite samples consisting of three hardwoods and four softwoods were used. These species represented were Douglas Fir, Ponderosa Pine, California redwood, white fir, Phillipine mahogany, red alder and red oak.

In each composite sample, duplicate samples of each species were represented totaling 14 blocks. Each set of 14 blocks was drilled and a wire cable inserted to facilitate weighing and handling.

All material from each species was cut from commercially supplied 1x6 inch boards. Attempts were made to match wood characteristics of each species between the different samples. The boards from which samples were cut had been dried under normal trade drying conditions. The individual blocks making up the composite sample were 5 inches wide, 3/4 inch thick, and 2 inches along the grain with no end coating.

During preparation of the samples, oven dry weights were calculated for each composite sample from moisture content sections to enable some approximate evaluation of wood moisture contents during the survey. Prior to exposure, all samples were conditioned to 12 per cent moisture in a controlled humidity room at 70 degrees F.

To ascertain the differences between species in response to exposure, provision was made at one station (Berkeley) to measure the moisture content changes of the individual species in addition to the composite sample throughout the period of the survey. In addition, at several stations the individual weights of each species were determined at the final weighing in the survey.

2. Conditions of Exposure. Twenty-three localities were selected to represent, as far as possible, regions of major interest. An ideal coverage of the State was not practical because of the difficulty in finding suitable cooperators in some areas. The actual locations used are listed in Tables 1 and 2.

At each location, two composite samples were exposed. One sample was exposed under sheltered outdoor conditions, i.e., exposed to outside atmospheric conditions but protected from rain and the direct rays of the sun. The other sample was placed indoors under conditions which were considered typical for the area. In some cases, indoor cooling — mechanical or water spray — was used in the summer; and in all cases heating was used in the winter.

3. Collection of Data. Beginning in the fall of 1956 and concluding in the spring of 1958 (for most stations), weekly weighings of the composite samples were made and the results forwarded monthly to the California Forest and Range Experiment Station. At the conclusion of the test period, all samples were shipped to the University of California Forest Products Laboratory for determination of oven dry weights and consequent calculations of moisture content.

4. Evaluation of Data. All data were put on IBM punched cards for calculation of wood moisture contents and tabulation and sorting of data.

Results and Conclusions

Because the data were relatively consistant between weeks of a month and between months of a season, it was decided that seasonal averages would afford an accurate and convenient method of grouping the data. Seasonal averages were therefore computed for each locality both indoor and outdoor with the following definitions of season.

March 21 - June 20 — spring
June 21 - Sept. 20 — summer
Sept. 21 - Dec. 20 — fall
Dec. 21 - March 20 — winter

At all stations, only one complete calendar year (1957) and parts of 1956 and 1958 were covered by the survey. However, the data for similar seasons in different calendar years were combined and averaged. Therefore, the resultant average seasonal values in most cases include the average of two fall seasons (1956 and 1957), two winter seasons (1956/1957) and 1957/1958), frequently two spring seasons (1957 and 1958), and very occasionally two summer seasons (1957 and 1958).

1. Sheltered Outdoor Exposure. The combined data are presented as seasonal and yearly averages in Table 1. Isopleths representing the wood moisture contents of equal value were prepared for yearly, summer, and winter averages as shown in Figs. 2, 3, and 4. Although generally the highest wood moisture values were recorded in the winter and the least in the summer, there were some exceptions to this. Eureka, Ukiah, and Richmond showed highest moisture contents in the fall and Redding in the spring. However, the differences from the winter values in these cases were less than 0.5 per cent wood moisture content. For Bragg and Richmond showed lowest values in spring while East Los Angeles showed a minimum value in the fall. At Fort Bragg and Richmond only a slight difference between the minimal value and the summer value was apparent, while at East Los Aangeles the difference was 1.0 per cent wood moisture content.

In constructing the isopleths, it is necessary to give some consideration to topography, rainfall, temperature, and, where possible, humidity as there were insufficient stations in some areas to accurately locate the isopleths from moisture content data alone. In this regard, the isopleths should be interpreted in a general sense. Other possible errors involved are: a) The data were collected for a limited period. Therefore, if the period or season deviated from average, this will be reflected to some extent in the moisture content readings. In this connection, the winter of 1957/1958 was unusually wet for most of the State, but moisture content values for this season were not consistently higher than for the winter of 1956/1957 which was relatively normal. b) Local exposure conditions may not be typical of the surrounding area. In this connection, some judgment was used in locating the isopleths when observed moisture content values did not appear to be consistant with the topography or climate.

It was apparent that the particular conditions of outdoor exposure affected the moisture content values. For example the exposure site at Berkeley was on an eastern exposure in an area shaded by tall trees. The average moisture content values were therefore higher than recorded in two other sites in the Bay Area. Proximity to irrigation areas, rivers, and watered lawns also tended to increase average moisture content values.

The highest average yearly outdoor wood moisture contents were recorded in the North Coast Redwood Region with the Bay Area next highest. From season to season, the North Coast Redwood Regin (with the exception of Willits and Ukiah), the Bay Area, and East Los Angleles showed the least variation with maximum seasonal differences of generally not more than 2 per cent wood moisture content. By comparison, seasonal differences (between winter and summer) were as high as 7 per cent moisture content in the Sacramento-San Joaquin Valley where the summer values generally were the lowest in the areas surveyed.

2. Indoor Exposure. Table 2 shows the combined data presented as seasonal and yearly averages for indoor exposure. Isopleths were constructed for the yearly average moisture content values. (See Fig. 2). Again, it is necessary to regard the isopleths in a generalized sense of scarcity of

stations in some areas and variations in actual exposure. In addition, a further complication is that indoor exposure conditions included either cooling or no cooling systems during the summer.

As expected, the average yearly indoor wood moisture values were usually lower and less variable between seasons than for the outdoor specimens, and a maximum difference of 2 per cent moisture content was recorded between winter and summer. In most areas, the variation from season to season through the year was less than 1.5 per cent moisture content. (Similar values in the Midwest may be 4 or 6 to 14 or 16 per cent).

The effect of winter heating and summer cooling indoors tends to equalize the interior wood moisture contents over the year by dehumidifying in winter and humidifying in summer. This effect can be seen by comparing the wood moisture content values between Tables 1 and 2.

It is also of interest that in one locality where two sets of indoor specimens were exposed, one in a building cooled in the summer by a mechanical type cooler and the other in a similiar situation cooled with a water spray type cooler, no significant difference was observed in the wood moisture content behavior of the two sets of specimens.

3. Variation of Moisture Content Between Species. At Berkeley, where the moisture content of individual species was observed over the full period of the survey, substantial differences in species moisture content were apparent. The yearly average species moisture contents for both indoor and outdoor exposures are shown in Table 3 and the seasonal variations of selected species represented in Fig. 5.

It is seen from Table 3 that white fir and Phillipine mahogany showed the highest and California redwood showed the lowest average values. The range between the species was more pronounced under outdoor exposures which might be expected. These results were generally confirmed by the variation of moisture content between species observed at the final observation at several selected stations throughout the State.

While the reason for differences in the moisture absorption characteristics of different woods is outside the scope of this presentation, it is probable that the relatively low value shown by redwood is due to its extractive content. The extractives take the place of water within the fine structure of the cell walls.

Another characteristic of species moisture content behavior, which is of interest, is that the rate of change of moisture content is similar for each species, at least based on the interval at which readings were taken (see Fig. 5).

4. Application of Wood Moisture Content Values. It is generally recognized that the optimum moisture content to which wood should be dried for use is midway between the extremes in moisture content likely to be achieved in service, or slightly less. In this way, difficulties due to changing

dimension with change in moisture content will be minimized. For California generally, the range of moisture content for indoor use is comparatively slight as seen from Fig. 1. In fact, the differences in average moisture content between all species (2.5 per cent) was approximately the same as the range of moisture content values of the composite samples throughout the State. A value of 7 to 8 per cent moisture content would be appropriate for most of the more densely populated areas. As California redwood was consistently lower in moisture content than the other species, it would be good practice to use moisture values 1 to 2 per cent lower than the average for all the species.

For outdoor exposure there is somewhat more variation throughout the State and more variation from season to season. However, an average value for the highly populated parts would be close to 12 per cent. For more precise values, reference should be made to Table 1 and Figs. 2, 3, and 4. The moisture content values obtained under exterior exposure should also be of value to operators concerned with the air drying of lumber. Figs. 2, 3, and 4 and Table 1 give some measure of the drying conditions throughout the State by season, as well as indicating the moisture content at which lumber piled for air-drying will cease to dry.

Acknowledgments

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TABLE 1

Wood Moisture Content Survey

(Sheltered outdoor exposure)

Region and Locality	Seasonal Wood Moisture Contents (per cent)				Yearly Av. Wood Moist. Cont. (per cent)	
	Spring	Summer	Fall	Winter	Locality	Region
East Side Sierra						11.7
Chester	11.5	11.5	11.6	12.4	11.8	
McCloud	11.0	9.3	13.1	13.1	11.6	
West Side Sierra						11.5
Greenville	11.5	8.5	14.4	15.3	12.4	
Martell	11.1	10.9	9.5	11.1	10.6	
Coast Range						11.7
Yreka	10.5	7.1	13.0	16.1	11.7	
No. Coast Redwood						13.7
Arcata	14.1	14.1	14.8	15.9	14.7	
Eureka	13.8	13.6	14.8	14.2	14.1	
Fort Bragg	15.4	15.6	15.9	16.0	15.7	
Korbel	13.9	13.0	15.7	15.7	14.6	
Scotia	12.9	11.7	13.2	14.6	13.1	
Ukiah	10.7	8.0	13.2	13.0	11.2	
Willits	11.1	8.6	11.4	14.3	11.3	
Los Angeles & So. Coast						10.3
E. Los Angeles	10.7	10.2	9.2	11.0	10.3	
Riverside	10.5	9.3	9.9	11.6	10.3	
Bay Area						13.4
Berkeley	14.1	13.8	15.3	15.6	14.7	
Oakland	12.7	12.6	12.9	14.1	13.1	
Richmond	11.8	13.0	12.5	12.8	12.5	
Sacramento Valley						11.4
Anderson	11.0	10.6	12.4	13.5	11.9	
Oroville	10.9	7.2	13.1	14.2	11.3	
Redding	10.0	7.3	9.1	9.6	9.0	
Sacramento	11.1	10.9	12.0	15.1	12.3	
San Joaquin Val.						11.3
Stockton	10.8	8.6	11.6	14.0	11.3	
Turlock	10.9	8.4	11.3	14.1	11.2	

TABLE 2

Wood Moisture Content Survey

(Indoor exposure)

Region and Locality	Seasonal Wood Moisture Contents (per cent)				Yearly Av. Wood Moist. Cont. (per cent)	
	Spring	Summer	Fall	Winter	Locality	Region
East Side Sierra						7.6
Chester	5.9	5.7	6.0	5.9	5.9	
McCloud	9.2	9.1	8.9	9.5	9.2	
West Side Sierra						6.6
Greenville	7.8	6.8	7.3	7.0	7.2	
Martell	6.2	5.9	6.4	5.6	6.0	
Coast Range						8.0
Yreka	7.6	7.4	9.4	7.8	8.0	
No. Coast Redwood						8.5
Arcata	9.4	9.8	10.1	9.3	9.6	
Eureka	8.9	9.6	9.4	8.3	9.1	
Fort Bragg	8.3	8.7	8.5	8.0	8.4	
Korbel	8.1	8.3	8.7	7.9	8.2	
Scotia	7.4	8.1	7.1	6.2	7.2	
Ukiah	8.7	8.3	9.4	9.8	8.8	
Willits	8.3	8.2	8.5	8.0	8.2	
Los Angeles & So. Coast						8.6
E. Los Angeles	10.8	10.2	8.4	10.0	9.8	
Riverside	7.1	7.9	7.2	6.8	7.3	
Bay Area						9.2
Berkeley	9.3	9.9	10.1	9.2	9.6	
Oakland	9.2	9.0	9.1	9.2	9.1	
Richmond	8.9	9.2	9.0	8.6	8.9	
Sacramento Val.						7.9
Anderson	7.8	7.4	8.2	7.0	7.6	
Oroville	8.8	7.3	9.0	9.1	8.6	
Redding	7.7	8.3	7.5	7.3	7.7	
Sacramento	7.2	7.5	7.5	7.6	7.5	
San Joaquin Val.						8.3
Stockton	9.2	10.0	8.8	8.6	9.2	
Turlock[4]	7.4	7.5	7.6	7.4	7.5	

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TABLE 3

Yearly Average of Exposure Samples by Species at Berkeley

Species	Moisture Content (per cent) Outdoor exposure	Indoor exposure
White fir	16.7	10.3
Philippine mahogany	16.3	10.1
Red alder	15.6	9.8
Ponderosa pine	15.1	10.0
Douglas fir	14.5	10.1
Red oak	14.4	8.7
Redwood	12.9	7.8
Composite sample	15.3*	9.7*

* Note that the arithmetic mean of the moisture content of each species was calculated in this case, thus accounting for the slight difference between these values and those recorded in Tables 1 and 2 which were obtained directly from composite samples.

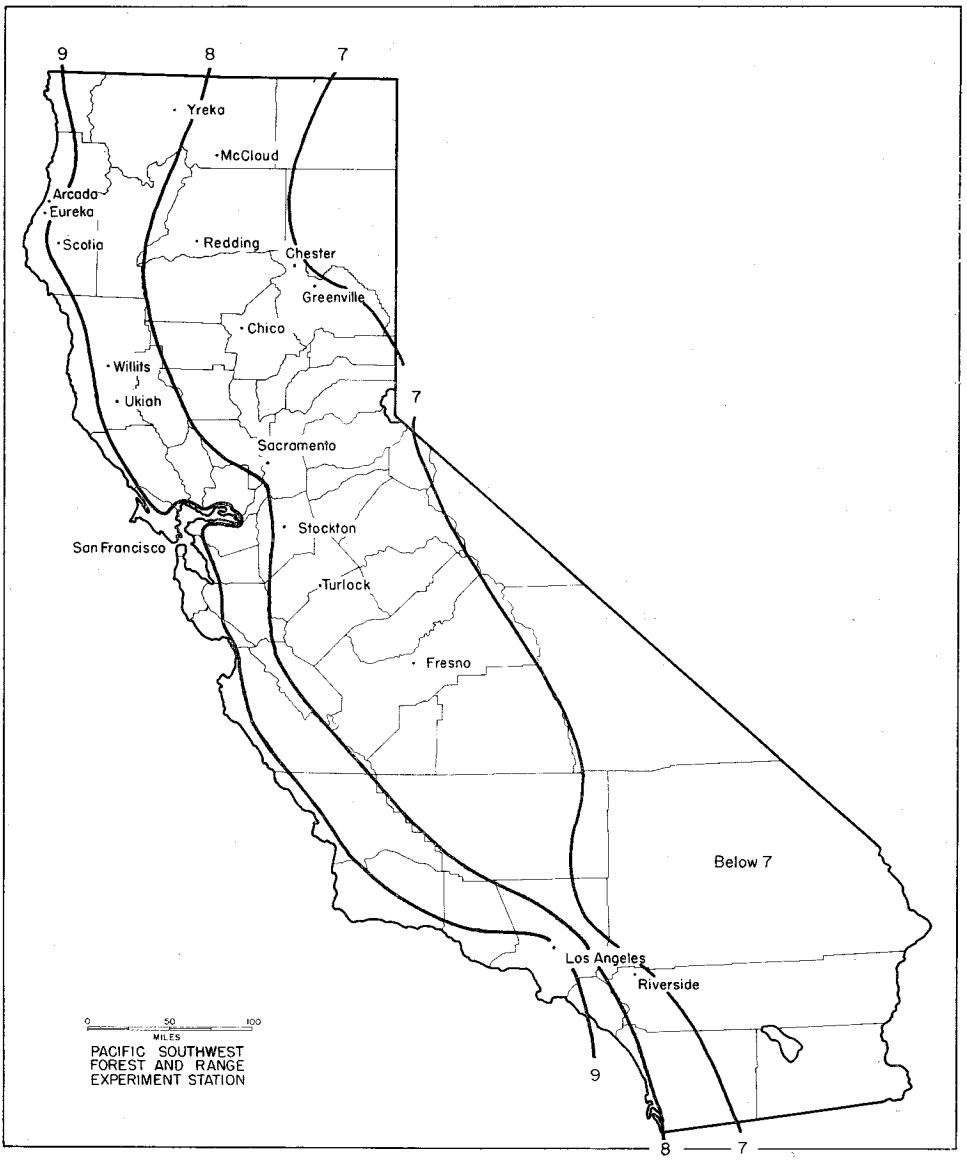

FIG. 1 Average Yearly Moisture Content of Wood for Indoor Exposure

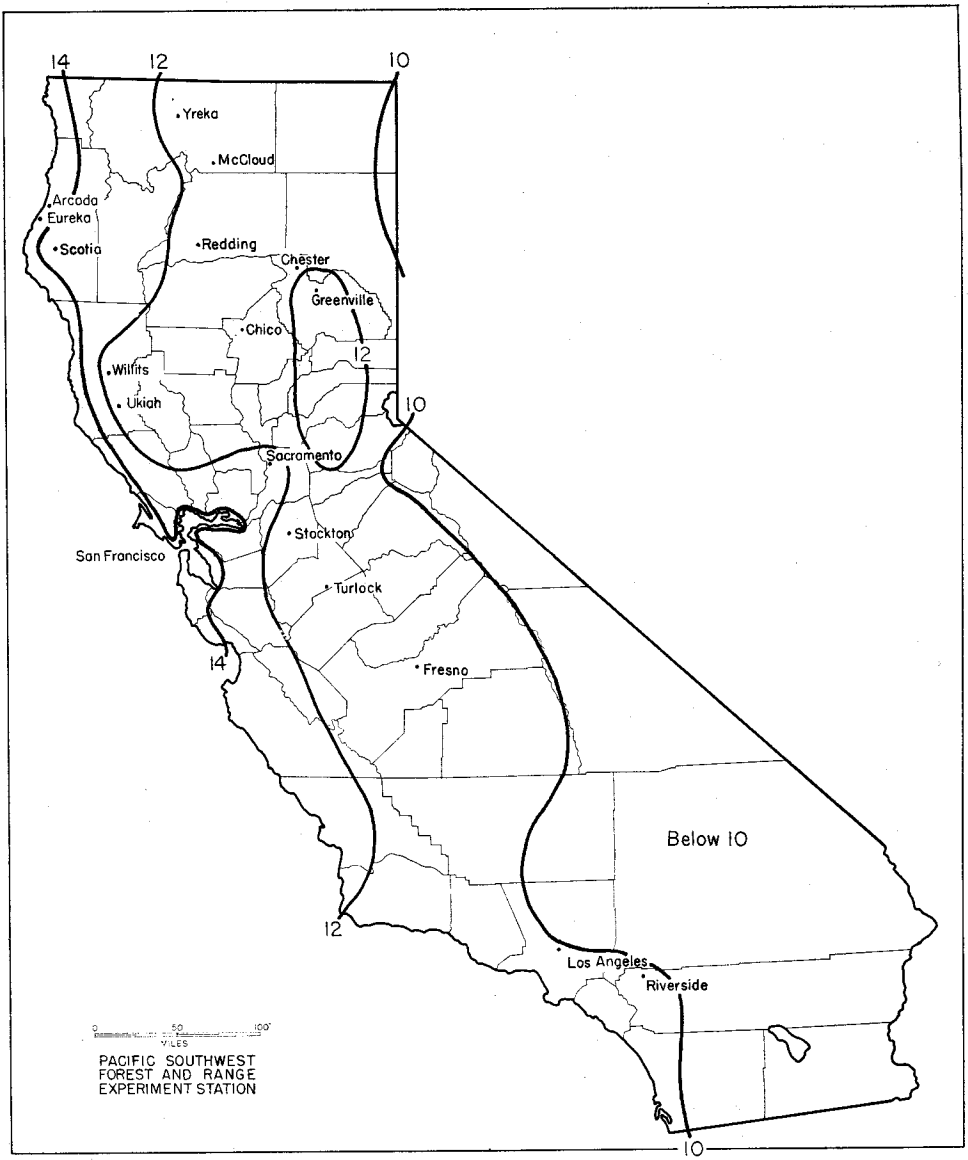

FIG. 2 Average Yearly Moisture Content of Wood for Sheltered Outdoor Exposure

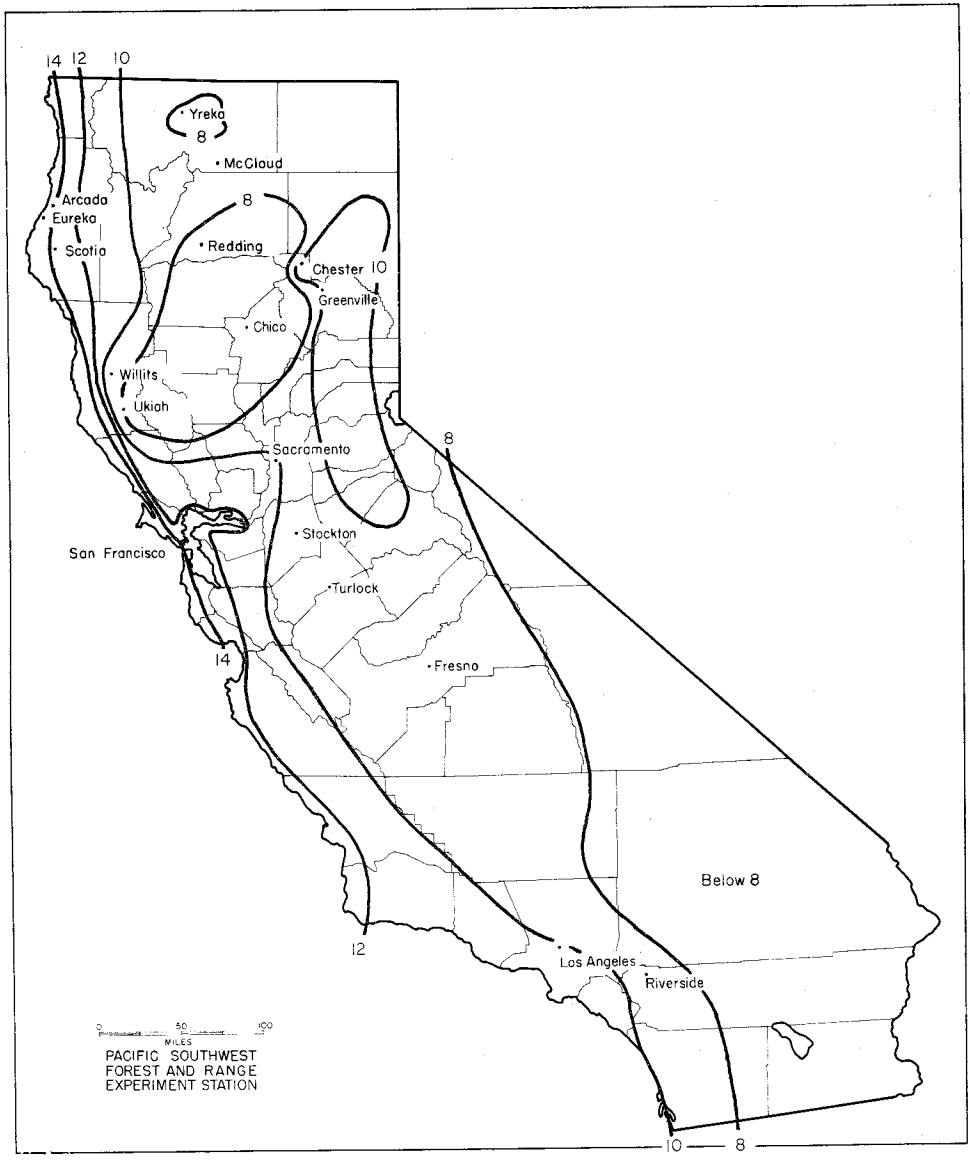

FIG. 3 Average Summer Moisture Content of Wood for Sheltered Outdoor Exposure

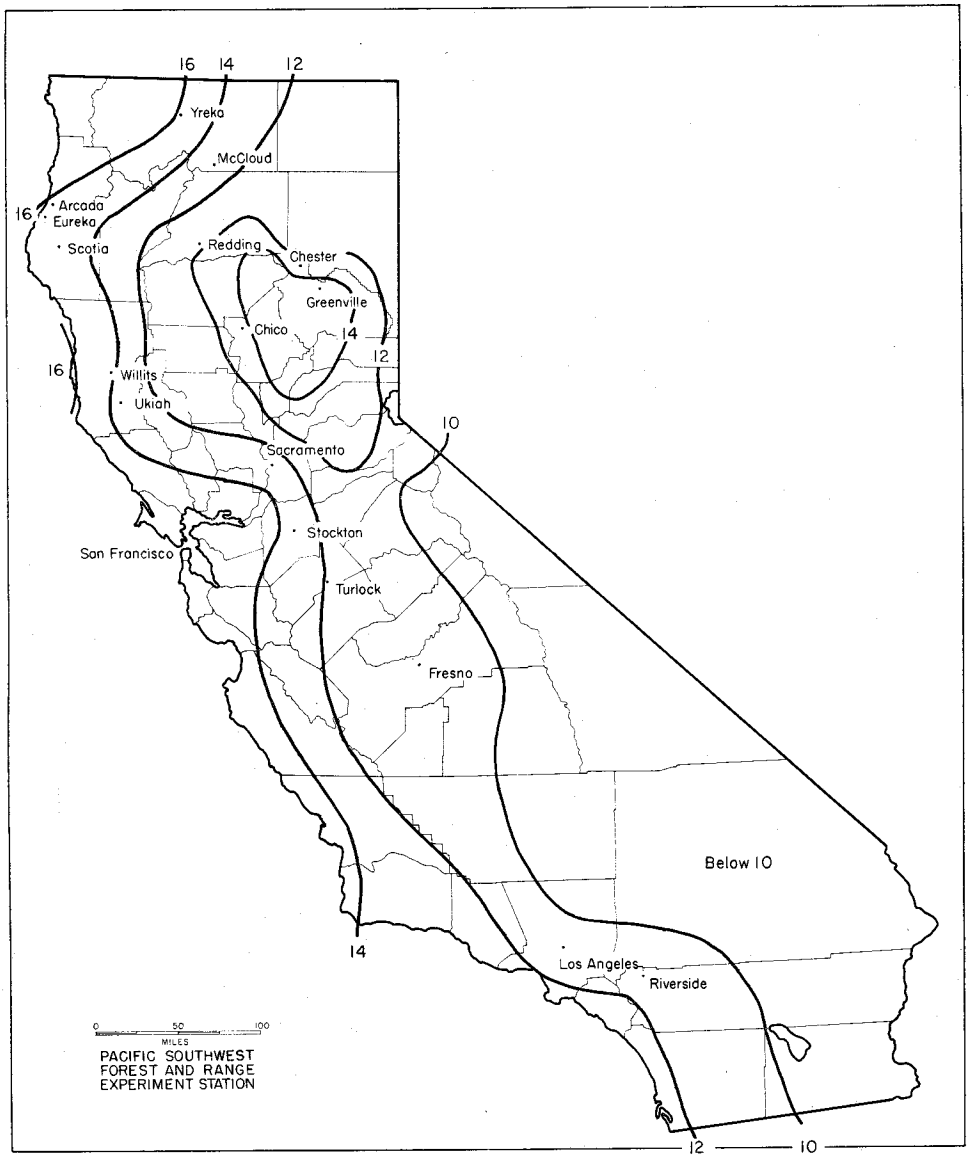

FIG. 4 Average Winter Moisture Content of Wood for Sheltered Outdoor Exposure

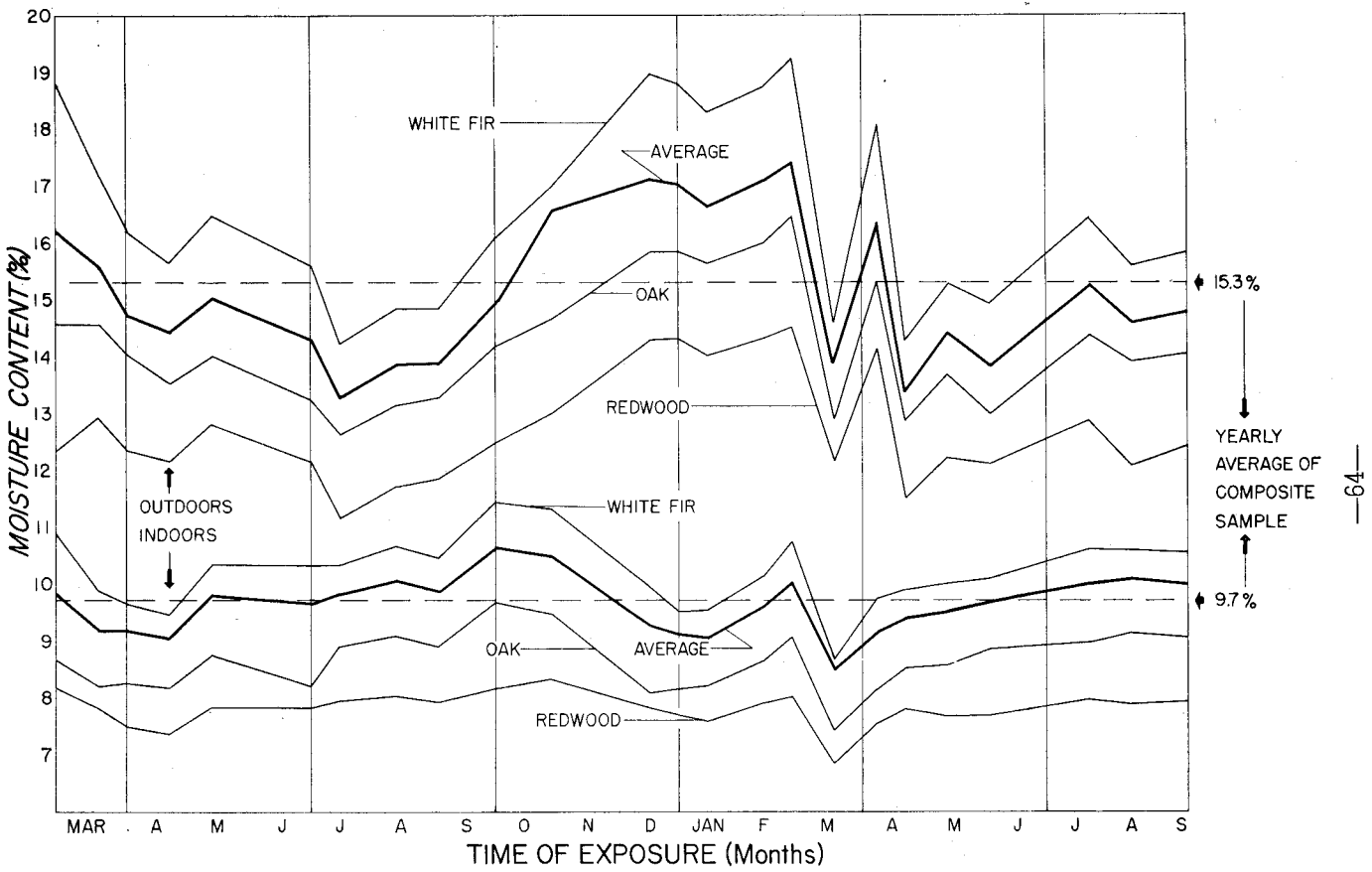

FIG. 5 Average Moisture Content of Wood by Species for Sheltered Outdoor Exposure and Indoor Exposure