NON-UNIFORM AIR YARD SPACING

A Panel Presentation by
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Introduction

Producing mills in the Redwood Region kiln dry between 250 and 300 million board feet of redwood annually. Of this total, approximately 70 per cent is heavy or sinker lumber with an excess of 150 per cent moisture content. This tremendous amount of water that has to be removed from the lumber costs the mills untold thousands of dollars. Minimizing this seasoning cost has been one of the big aims of the Redwood Seasoning Committee since it came into existence.

Air seasoning of sinker redwood lumber prior to final kiln drying has several advantages. It permits equalization of the moisture content around birds-eye and in those streaks which, in the green condition, are above the average moisture content. This resultant slower drying, during the high moisture content stage, which is oftentimes in excess of 250 per cent, reduces losses from open birds-eye and collapse. Air seasoning produces a final dry lumber product at a lower over-all cost than can be obtained by kiln drying redwood from the green condition. Air seasoning permits a larger volume of lumber to be dried with a minimum fixed investment in a kiln plant.

In years past and before World War II, little thought was given to the actual results of yard drying rates, air circulation, uniformity of drying and the amount of lumber deterioration. The so-called "dry yard" was, in most cases, unpaved and was more of a storage yard. Pile bottoms were very close to, or on, the ground. The stacks of lumber were so close together, one had difficulty going between them. Poor housekeeping was prevalent in most yards throughout the area. Naturally, except for the outside piles near the alleys, drying was very slow. Heavy 4/4 lumber stacked one year frequently had a moisture content in excess of 150 per cent. The moisture content of the lumber coming out of a block which would constitute a kiln charge varied from alley to the center by 100 per cent. Naturally the kiln schedule was set up to dry the wettest lumber in the charge. This meant that the lumber bordering the alleys was dry at least 10 days before the remainder of the charge. Valuable kiln time was lost in drying approximately 25 per cent of the charge 10 days longer than was necessary.

With the boom in building after the second World War, demand for redwood lumber forced a change in yard layout. To this end, members of the Seasoning Committee and the California Redwood Association set up a pilot kiln and experimental air yard at one of the mills in Humboldt County to try and shorten the time between sawmill and customer and improve lumber quality. Every phase of the seasoning process was carried on over a two-year period. Findings were consolidated into a booklet report and given to all interested.

Following the basic research in yard layouts, several methods of air yard spacing were tried. These were uniform 2 feet, 3½ feet and 5 feet spacings

(3) and later an experiment was conducted using a uniform 4 feet, 6 feet and 8 feet spacing (1). Findings of these experiments were that wider spacings definitely give a more uniformly air-seasoned product to kiln dry at less cost per M per acre per year. As the drying rate dropped sharply approaching the center of the block, it was felt that any device which would increase circulation in this area would achieve more uniform drying at a faster rate. Non-uniform pile spacing, wherein the spacing at the center of the pile was increased with a gradual decrease in spacing toward the main alley, seemed to offer definite possibilities.

While there still is no accepted standard for air yard spacing throughout a producing area with its varied climatic conditions, we believe that non-uniform air yard spacing achieves most uniform air drying at a faster rate, while utilizing the yard more economically.

At the completion of our discussion, we will show some slides of various yard layouts.

Tests Used for Deriving Non-Uniform Air Yard Spacing

Seasoning of redwood lumber starts with the segregation of green lumber into groups which are as nearly alike in drying properties as is practical. The better the segregation, the more uniform will be the response of the lumber to drying conditions. The recommended segregations in redwood are light, medium and heavy or sinker, based primarily on the green board weight but adjusted for ring count and specific gravity.

The efficiency and uniformity of air yard seasoning involves consideration of the following factors (1):

1. Width of lumber packages.
2. Height of piles.
3. Sticker thickness.
4. Orientation of piles in relation to the prevailing winds.
5. Spacing between piles.

The factor which has the most influence on the rate and uniformity of yard drying, other things being equal, is pile spacing.

Non-uniform air yard spacing is the idea of staggered separation of lumber piles across a block. By spacing the piles near the alleys closer together and opening up the center piles across the block, the amount of moisture loss will be controlled on the outside and increased through the center. The net result is a more uniform pattern of moisture loss at a faster rate. If moisture loss is uniform and the segregation right, the kiln charge coming from this block will be as uniform in moisture content as can be obtained by air drying. The kiln operator can use a schedule that will apply to the entering moisture content of the charge and the resultant dry lumber will have a small range about the specified average.

How are the non-uniform spacings derived? Two methods have been used in the Redwood Region. The sample board method and the water pan method. For those who know the drying conditions in their yard, non-uniform spacing can be established by a "trial and error" method also.

To determine effectiveness of non-uniform pile spacing by the use of yard samples, the following procedure was employed.

One complete block or alley of the air yard was placed on the non-uniform spacing being evaluated in order to avoid restriction or distortions in the normal air flow which could be expected if more than one pile spacing were utilized in the test area.

Samples were selected from 1x8 redwood sinker stock and cut to 40 inches in length. Matched samples were used to eliminate, as much as possible, errors due to difference in drying characteristics. Test piles, as well as yard samples, consisted of green redwood sinker stock so as to minimize the effect which stock at various stages of air drying might have on the drying rate of the samples.

Yard samples were placed in sample pockets which were built into the approximate center of each test package. Sample blinds were used in an attempt to achieve, within reasonable limits, the drying conditions which would prevail at the interior of stock units.

All initial data regarding samples and test procedure were recorded prior to testing. Yard samples were weighed bimonthly for the first two months and every month thereafter for the duration of the test. At the completion of the test, drying rate curves were plotted for all samples and the information thus obtained was evaluated on the basis of past experience and current test results.

There are, of course, numerous other testing techniques, using sample boards, in addition to the one described which would give satisfactory results. The method employed will, to a large extent, depend on the particular operation and on the specific information desired.

The "water pan" method of measuring the amount of moisture evaporation can be used as an accelerated test to determine air yard spacing. This is accomplished by pouring a measured amount of water in shallow pans. The pans are then placed in the yard between the packages in a block. The water evaporation from these pans simulates the rate of evaporation of the water from the wood in the block. To evaluate the water loss, the pans can be left for a certain number of days and the amount of water left in each pan can be remeasured to determine the percentage of water loss. If moisture loss in the pans across the block is the same, we can assume that moisture loss across the block was uniform. A pan containing a high percentage of water remaining indicates poor drying ability of the air, compared to a pan which had a low percentage of water remaining.

For any test, all the evaporation pans will be exposed to the same daily changes in temperature and relative humidity. The daily variations will average out automatically and will not be a contributing factor in the differences observed in the amount of water evaporated from each pan.

Sinker lumber that has been in the air yard less than 3 months will have an influence on the drying capacity regardless of the position of the pile within the yard. This effect is due to the rapid loss of moisture from the wet surfaces of the lumber to the air. Therefore, it is advisable to conduct tests of this type after the period of rapid moisture loss when the diffusion rate of moisture through the board governs the amount of moisture available for evaporation from the surface of the board, other things being equal.

Properly applied, the water pan method of measuring the relative drying ability of the air, is a quick easy method of determining the comparative advantages and disadvantages of different pile spacings. The method may be effectively employed as a preliminary test to evaluate any major yard changes. Information may be gathered in a short time that would otherwise take months to obtain. However, it should be noted that this method provides only a relative measure of the drying ability of the air. An exact measure of the benefit gained by a yard change would, of course, depend on the drying rate of the lumber itself.

Results

The results discussed in this paper are based on averaging 3000 actual kiln samples over a four-year period, 1952 and 1953 for the 5-foot uniform spacing, 1955 and 1956 for the non-uniform spacing, at two redwood air drying yards in the Humboldt Bay area of Northwestern California. In making a comparison over different years of drying conditions, it was found that no abnormal weather conditions prevailed in any of these years to alter air drying rates appreciably. The spacings studied and tabulated in this paper are:

Mill A -- Uniform, 6 piles wide, 5-foot spacing between piles.
Mill A -- Non-uniform, 6 piles wide, $3\frac{1}{2}$, $5\frac{1}{2}$, 8, $5\frac{1}{2}$, and $3\frac{1}{2}$ foot spacing between piles.
Mill B -- Uniform, 10 piles wide, 5-foot spacing between piles.
Mill B -- Non-uniform, 9 piles wide, 4, 5, 8, 8, 8, 8, 5, and 4 foot spacing between piles.

Mill A has a 40-inch package width while Mill B has a 50-inch width. Both mills pile 5 packages high across the block.

The drying rate curve shown in Figure 1 was made by going through the kiln records of the two mills being studied. Sample board moisture content was tabulated for the number of months that the lumber had been in the air yard. Data were taken only from the heavy or sinker segregation.

Figure 1 shows the effect which pile spacing has on the time required to reduce the slowest drying samples in a block to various moisture contents. As these samples are picked to be the slowest drying pieces in the block, it can be assumed that they represent the maximum for the block.

The curves shown in Figure 1 indicate that the lumber dried much faster on non-uniform spacings. As an example, Mill A with a 5-foot uniform spacing, took about 10 months to dry to 40 per cent moisture content while the same mill only requires 6.5 months to dry to the same moisture content on a non-uniform spacing.

The second consideration that was taken was the effect of pile spacing on volume of lumber dried per acre per year. Figure 2 shows the relationship between rate of turnover and moisture content to which the lumber is dried for 1 inch sinker on uniform and non-uniform spacing. This graph was prepared using time requirements taken from Figure 1. These curves indicate that a much greater

FIGURE 1. CURVES SHOWING THE MOISTURE CONTENT TO WHICH 1 INCH SINKER REDWOOD LUMBER WILL DRY AS A FUNCTION OF TIME IT IS IN THE DRYING YARD IN BLOCKS WITH 5 FOOT UNIFORM AND NON-UNIFORM PILE SPACINGS.

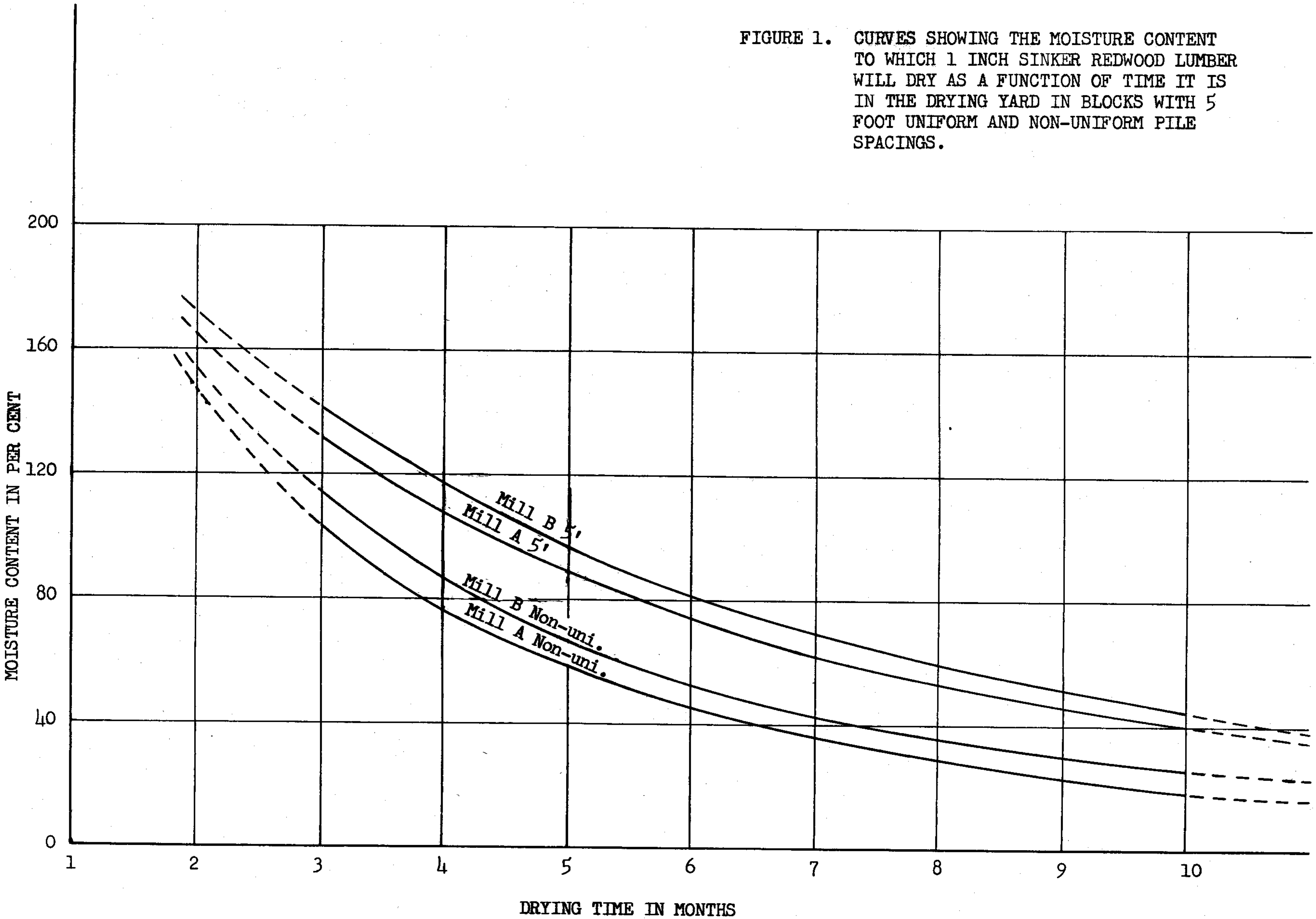
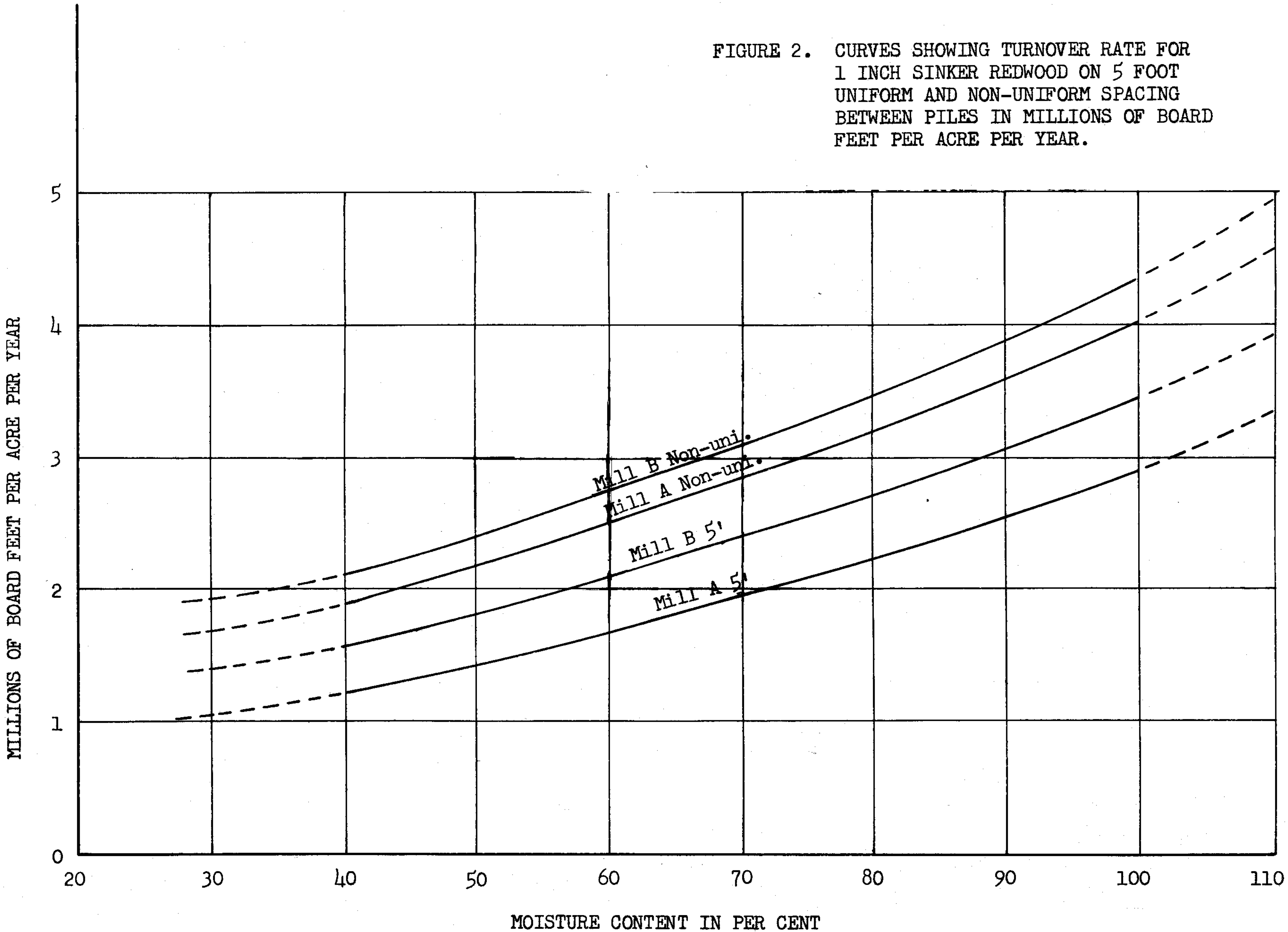


FIGURE 2. CURVES SHOWING TURNOVER RATE FOR 1 INCH SINKER REDWOOD ON 5 FOOT UNIFORM AND NON-UNIFORM SPACING BETWEEN PILES IN MILLIONS OF BOARD FEET PER ACRE PER YEAR.



turnover per acre per year was accomplished with the non-uniform spacing. This increased turnover in the case of Mill B results from the fact that although narrow spaced yards will hold more lumber per acre, the faster rate of drying which results from the increase in center spacing more than compensates for the decrease in volume of lumber per acre of yard. The net result being an increase in turnover rate.

In analyzing Figure 2, Mill A, which has the same volume per acre on both spacings, when air drying to 40 per cent moisture content before kiln drying, has increased its rate of turnover from 1,200 M board feet per acre per year on uniform spacing to over 1,800 M board feet per acre per year on non-uniform spacing.

To further study the effect of pile spacing on drying rates, a yard drying cost analysis was made. Cost data and the method of using it in the preparation of air drying cost curves are shown in Table I (3).

In analyzing Table I, it can be seen that the largest part of the expense of air seasoning are those costs based on the value of the lumber in the yard. It is therefore very desirable to shorten the time that the lumber is in the air yard. Minimizing air yard time greatly reduces seasoning expenses.

Costs of air drying 1 inch sinker redwood to various moisture contents using uniform and non-uniform spacings are shown graphically in Figure 3. By using these curves, the cost of drying to a given moisture content can be compared in relation to a given spacing type.

In any air yard that has a turnover of, for example, 25,000 M.b.m. per year, the reduction in air drying cost being experienced by Mill A in changing from 5 foot uniform to non-uniform spacing would constitute a savings of $3.20 per M or a total of $80,000 for the year.

In addition to a faster drying rate, while utilizing a minimum of space, is the uniformity of moisture content across the block after the initial fast drying rate period has elapsed. Figure 4 shows relative uniformity of moisture content across a block of 1-inch sinker redwood on 5-foot uniform and non-uniform spacing after 6 months in the yard. The data used to derive the 5-foot uniform curves are based on actual samples placed in the yard for this specific purpose. In this end view there is a very definite pattern of horizontal and vertical moisture gradients. The end view of non-uniform spacing is based on kiln samples and shows very little pattern within the block.

To further substantiate uniformity across the block, a recent test using package or unit weights indicated approximately 5 per cent moisture content variation between packages after 10 months in the air yard.

Uniform dryness within a block is extremely important when the lumber is to be further dried in a kiln. The wettest packages determine the length of time that the entire block, which constitutes a charge, is actually in the kiln. If the consistency of the charge varies considerably in moisture content, much of the lumber will be dried longer than is necessary. The resultant range of final moisture contents will also vary and chances of pieces being above specified moisture content will be increased.

TABLE I

YARD DRYING COST ANALYSIS

LUMBER COSTS
(Based on rough green lumber @ $125 per M.b.m.)

Interest	$ 7.50 per year
Taxes	1.14 per year
Insurance	1.00 per year
Total Cost per M.b.m.	$ 9.64 per year
Total Cost per M.b.m.	0.0264 per day

YARD COSTS
(Based on land and improvements @ $12,000 per acre)

Depreciation and interest	$1,325 per year
Taxes	240 per year
Total Cost per acre	$1,565 per year
Total Cost per acre	$ 4.26 per day

COST OF YARD DRYING

	Yard Spacing			
	Mill A 5 feet	Mill B 5 feet	Mill A Non-unif.	Mill B Non-unif.
Yard Cost per acre per day	$4.26	$4.26	$4.26	$4.26
M.b.m. per acre	1040	1400	1040	1270
Yard Cost per M.b.m. per day	$0.00410	$0.00305	$0.00410	$0.00336
Lumber Cost per M.b.m. per day	$0.0264	$0.0264	$0.0264	$0.0264
TOTAL YARD DRYING COSTS per M.b.m. per day	$0.03050	$0.02945	$0.03050	$0.02976

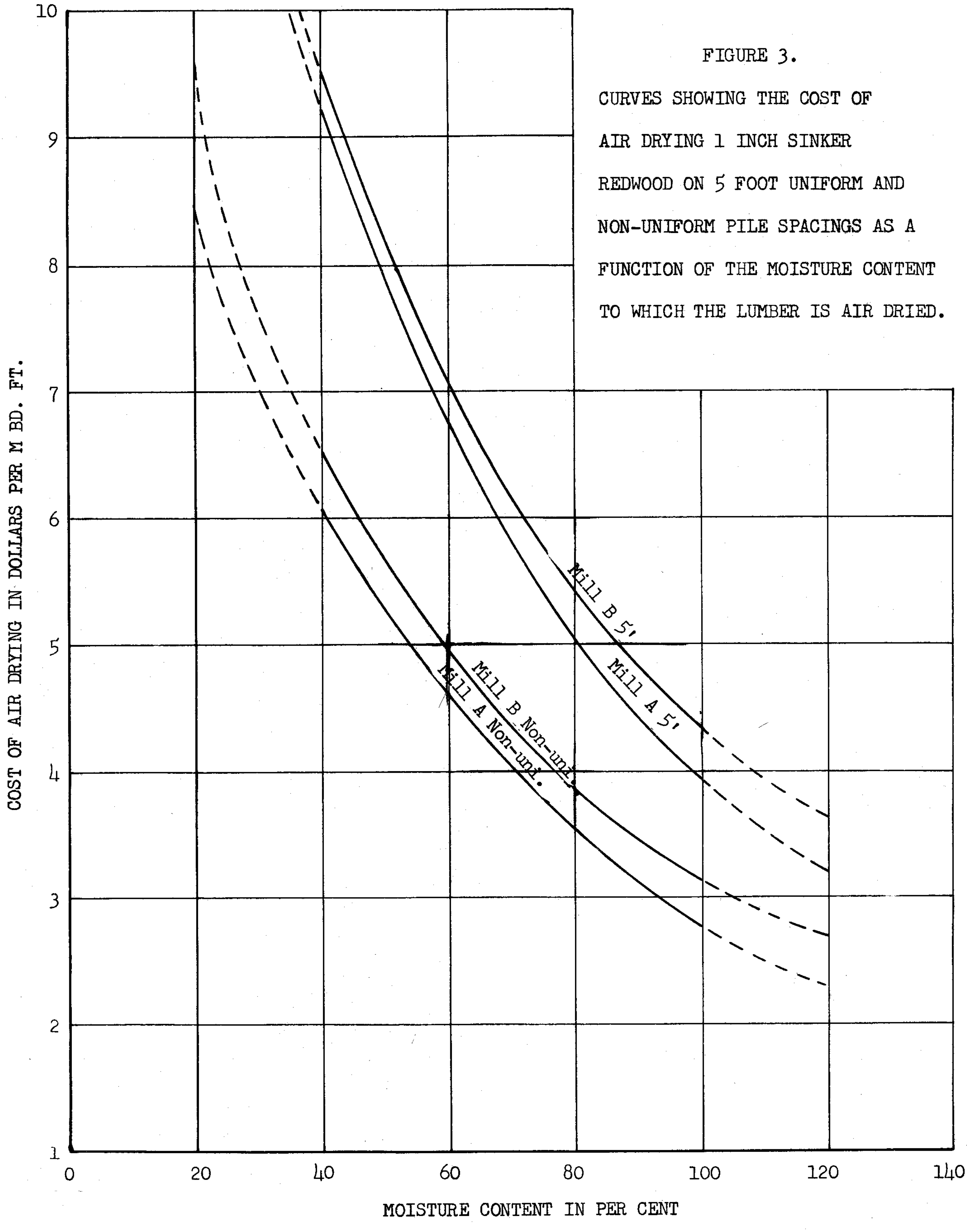
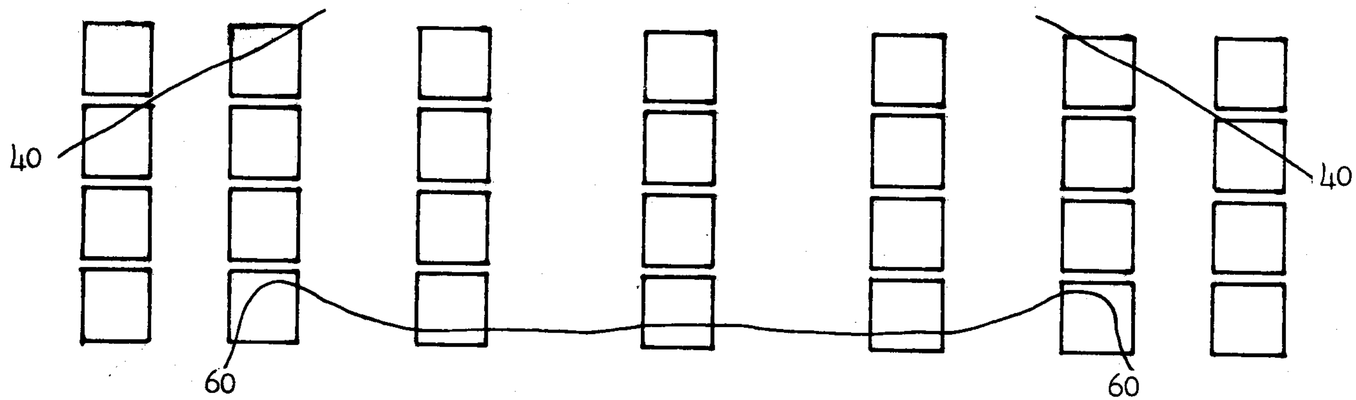
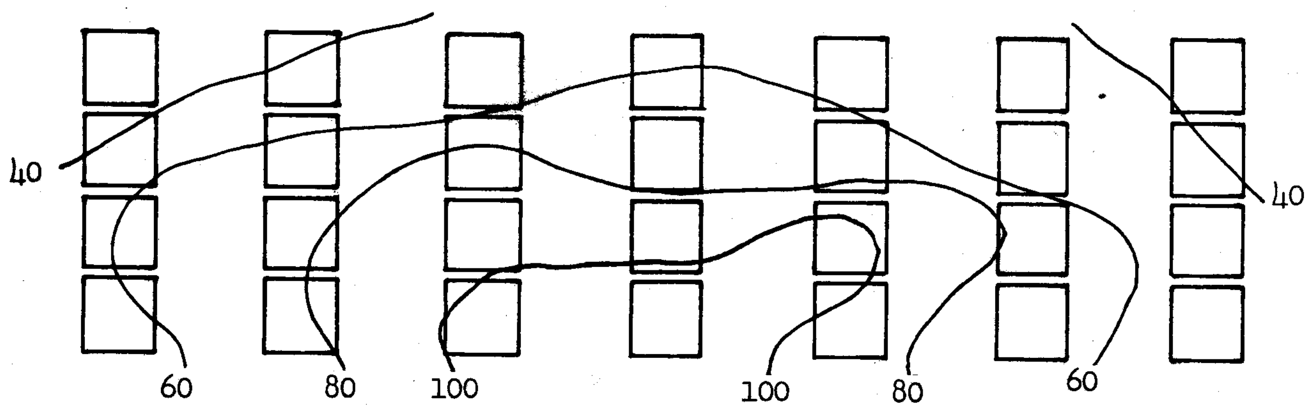


FIGURE 3.

CURVES SHOWING THE COST OF AIR DRYING 1 INCH SINKER REDWOOD ON 5 FOOT UNIFORM AND NON-UNIFORM PILE SPACINGS AS A FUNCTION OF THE MOISTURE CONTENT TO WHICH THE LUMBER IS AIR DRIED.



NON-UNIFORM SPACING BETWEEN TIERS



5' SPACE BETWEEN TIERS

FIGURE 4.

RELATIVE UNIFORMITY OF DRYING 1 INCH SINKER REDWOOD ON 5 FOOT UNIFORM AND NON-UNIFORM SPACING BASED ON INITIAL MOISTURE CONTENT OF 200% and 6 MONTHS IN THE DRYING YARD.

FIGURES ARE IN PER CENT MOISTURE CONTENT

Summary

The data and figures you have seen and heard are based on drying in the Humboldt Bay area of Northwestern California. This area, according to Peck (2), has no active drying period. Air yard spacing in areas that have active drying periods would be less than those used in the Humboldt Bay area if the species being dried is subject to defects caused by fast air yard seasoning. Air yards in areas of active summer drying and inactive winter drying can be made flexible with the use of portable pile bottoms. By doing this, it may be possible to use non-uniform spacings with a wide center spacing during the inactive months and a narrower spacing during the active drying months.

Non-uniform air yard spacing is achieving three important results in the Humboldt Bay area. These are:

1. Rapid air seasoning with a minimum of degrade. Survey data show at least a 20 per cent increase in drying rate.

2. More economical use of air yard. The volume of lumber that can be seasoned per acre per year will be increased or the same volume can be dried in a smaller space.

3. Uniformity of drying across a block giving kiln charges of uniform entering moisture contents that dry faster and require less equalization time.

While the data you have seen are only taken from two drying yards and the length of time that is involved is relatively short for drawing absolute conclusions, we feel that it is quite reliable. Two other mills in the region are in the process of changing their yards to non-uniform spaced yards and early indications substantiate the data shown in this report.

The facts for this report were taken from a specific area using a specific species and should be applied directly only to yards in areas of similar conditions. The methods described for determining the best conditions for, and relative advantages of, air drying, can be used in studying any yard.

LITERATURE CITED

(1) Clausen, V. H. Air Drying of California Redwood. Research Report No. 3.21411. California Redwood Association. San Francisco, 1953.

(2) Peck, E. C. Air Drying of Lumber. U.S. Dept. of Agriculture Technical Bulletin No. R 1657. 1950.

(3) Pratt, W. E. Drying Cost Study. Research Report No. 3.20300. California Redwood Association. San Francisco, 1951.