THE AIR DRYING OF ENGELMANN SPRUCE

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Introduction

Within the Northern Rocky Mountain area there are large quantities of Engelmann spruce timber that should be cut. When cut, most of the logs will be sawed into boards and dimension and these products will require drying in order to render them suitable for construction purposes. It is the purpose of this report to discuss air-drying techniques most suitable for the region and the lumber.

General Principles of Air Drying

Air drying consists of the piling of lumber outdoors. The ability of the outdoor air to dry lumber depends on its temperature and relative humidity. In the air drying of a particular pile of lumber, it is approximately the average temperature and relative humidity that prevail over the drying period that determine the necessary length of the period and the ultimate moisture content that the lumber reaches. To utilize the outdoor air for drying, means must be provided to cause the air to move in and out of the yard area, in and out of the spaces between the piles, and in and out of the lumber piles themselves. Wind stimulates all of these types of air movement, and consequently accelerates drying.

The climatological conditions for the Northern Rocky Mountain area are shown in figure 1. This figure was plotted from "U. S. Department of Commerce, Weather Bureau, Climatological Data, National Summary" for the years 1950 and 1951 and from other data. The temperatures and relative humidities are monthly means for the cities of Spokane, Libby, and Missoula. The temperatures were adjusted to the normal values. The relative humidities are average values for the 2 years. The equilibrium moisture content curve in the lower portion of the chart was drawn by means of the monthly temperature and relative humidity and an equilibrium moisture content table.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

The year can be divided into periods of varying drying intensity on the basis of temperature and relative humidity. The 6 months from April 15 to October 15 are designated as a period of rapid drying. At the approximate middle of this period, July and August, there is a period of extremely rapid drying. From the latter part of November until the first part of March, the temperature averages below freezing. During this time little drying will occur, except from fresh green lumber. In between the two principal periods, there are two periods that have been designated as moderate drying periods. In addition to the variable rates of drying among the different periods, there are also variations in the final moisture content that the lumber can attain. During the slow-drying winter period, the equilibrium moisture content ranges from 15 to 18 percent. Lumber piled during or slightly prior to this period will not reach a moisture content of 15 percent. Lumber piled during the other periods can be expected to reach a moisture content of 10 to 17 percent. During the active drying period the lumber will reach a moisture content of about 10 percent.

Air-Drying Schedule

Air-drying schedules based on the climatological data and on air-drying data (3, 4)[2] are given in figures 2 and 3. The drying periods indicated tend to be conservative. For example, the shortest period required to dry 1-inch boards to 15 percent moisture content is given as 45 days, while it has been reported that 1-inch Engelmann spruce reaches a moisture content of 14 percent in 5 days. Another report stated that 1-inch lumber reached a moisture content suitable for dressing in about 10 days. These reports are not substantiated by data, but it is certain that there is rapid drying during the spring and summer. On the basis of a final moisture content of 15 percent, it is estimated that 1-inch lumber piled after September 15 will not reach 15 percent moisture content until the early part of the following April. Shorter drying periods are needed to reach a moisture content of 20 percent. It is estimated that lumber piled from May 1 to September 15 will reach a moisture content of 20 percent in 30 days. Lumber piled after October 15 will not reach 20 percent until the latter part of the following March.

The chart for 2-inch dimension was constructed on the same principles. Lumber piled from April 15 to August 15 will attain a moisture content of 15 percent in 60 days. Lumber piled from September 1 until February 15 will need to remain in the yard until the following April or May. The minimum time required to reach a moisture content of 20 percent is estimated to be 30 days. This period applies to lumber piled from June 1 to July 31. Lumber piled from September to the following January will have to remain in the yard until the following April to reach a moisture content of 20 percent.

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[2] Underlined numbers in parentheses refer to the list of numbered references at the end of the article.

These two schedules are intended to be used as general guides, applying to lumber that is piled so that the outdoor air has free access to the lumber in the piles. They also apply where yard layout and piling methods are designed for rapid drying, and not where means are taken to retard drying in order to reduce checking.

Air-Drying Yard

Site

It is preferable that the yard be located on high ground that is level and well-drained, and not adjacent to water bodies or wind-obstructing objects such as tall trees or buildings. A yard located on low ground is likely to be sheltered from the full sweep of the winds, and the ground surface is likely to be damp. These conditions retard drying and promote stain and decay in lumber.

Surface

The ground surface should be kept free from debris and vegetation. Debris harbors stain and decay organisms and obstructs the movement of air over the ground surface and beneath the lumber piles. Vegetation restricts the movement of air in the same manner as debris, but to a greater extent if the growth is luxuriant. Vegetation can be controlled by applying crude oil, salt, or weed killers. Covering the ground with cinders, gravel, or crushed stone retards the growth of vegetation. The yard surface should be firm and smooth for the operation of lumber-hauling and piling equipment. Materials such as cinders, gravel, crushed stone, blacktop, or concrete can be used to pave the alleys and other areas. Yards located on wet or swampy sites may require paving with heavy planking. Where hand-stacking is employed, only the main and cross alleys need be paved, but where lumber is piled in the form of unit packages for handling by fork-lift trucks, additional areas of the surface should be paved. Where lumber is transported in the form of stickered unit packages by straddle and fork-lift trucks, or piled with fork-lift trucks, it is important that the paving be maintained in good condition. Rough pavements cause wear and tear on the machines and may injure operators, and they are also likely to cause displacement of stickers and boards in unit packages being transported and to impede the accurate placement of the unit packages in piling. For efficient operation of fork-lift trucks all surfaces over which the truck wheels pass should be paved.

Layout

An air-drying yard consists of rows of piles arranged in various ways, with long, continuous openings called alleys between the rows. The alleys serve as routes for transporting the lumber, as pathways for the movement of air through the yard, and as protection against the spread of fire. The alleys

are generally classified as main, cross, and rear. Spaces between the piles may also form long, straight passages through the yard that are considerably narrower than the alleys. Main alleys, where hand-stacking is used, are generally 16 to 20 feet wide. Cross alleys for transportation and protection against spread of fire, spaced every 200 to 300 feet, may be 60 or more feet in width, and rear alleys should be at least 8 feet wide. The distance between the sides of the piles should be 2 to 6 feet.

Where the piles consist of unit packages piled by fork-lift truck, the main alleys must be wider than 20 feet. Twenty-four feet is about the minimum width that is feasible for the operation of the larger sizes of fork-lift trucks, and alleys for the operation of fork-lift trucks are often 30 feet wide. Yards consisting of unit-package piles usually do not have rear alleys. The piles are in rows running from one main alley to the next. The width and spacing of the cross alleys in a unit-package yard can be the same as in a hand-stacked yard.

Pile Foundations

Lumber-pile foundations should be mechanically strong, resistant to decay, and high enough off the ground to allow the escape from below the pile of air that has circulated through the lumber pile from top to bottom and to promote the general movement of air through the yard. Foundation piers are made of concrete, masonry, preservative-treated blocks or posts of any species, or untreated heartwood of such decay-resistant species as baldcypress, redwood, or the cedars. Concrete or masonry piers should extend into the ground below the frost line. Wood piers or posts may also be set into the ground, or they may rest on the yard pavement or on mud sills or sleepers laid on or slightly below the ground surface. Timbers in contact with the ground should be treated with a preservative unless they consist of the heartwood of a decay-resistant species. The tops of the piers or posts of a pile foundation should all be in a plane, either horizontal or sloped. If the foundation is sloped, the slope should be about 1 inch per foot of length from front to rear, with the rear piers of sufficient height to keep the underside of the boards in the first course at least 1 foot from the ground. Unless the posts are set into the ground, they should be braced against lateral tipping. It is preferable to support the pile foundations on piers or posts rather than on solid cribbing, because the piers or posts permit more air movement beneath the pile.

Figure 4 illustrates a suggested type of pile foundation for hand-stacked piles. The posts support stringers, running in the direction of the length of the pile, made from steel I-beams, railroad rails, or timbers. The timbers should be about 6 by 8 inches in dimension, set on edge, and treated with a preservative. The stringers carry the cross beams, which should be spaced so as to support tiers of stickers. The stringers and cross beams of foundations for hand-stacked piles are generally arranged so that the length of the piles is perpendicular to the alley. The foundation that is illustrated is designed for lumber up to 16 feet long. If there is a considerable amount of lumber longer than 16 feet, the foundations should be built longer.

Figure 5. illustrates a permanent or fixed-beam type of foundation for unit-package piles built with fork-lift trucks. The foundation is designed to provide a ground clearance of 18 inches, and to accommodate 16- and 14-foot unit packages. Eighteen-foot unit packages can be piled by allowing 1 foot to project at either side. The two inner beams are placed 9 feet center to center thus providing a machine operating space of 8 feet, 6 inches. Removable supports to sustain the center of the pile are provided. The beams can run continuously throughout the length of the row, or they may be long enough to contain a certain number of piles. The drawing indicates a 2-foot spacing between piles. but this may be adjusted to suit any set of conditions.

Where lumber is handled and piled in unit packages by fork-lift truck, space for the insertion or removal of the forks must be provided. This space is usually about 4 inches wide, and is obtained by the use of bolsters or separators. Bolsters may be 4 by 4 inches in dimension, 2-by-4's placed on edge, or two 2-by-4's placed flatwise. When the pile is completed, the spaces caused by the bolsters form channels for air passage in or out of the pile.

Piling

Sorting Lumber

The Engelmann spruce lumber will naturally be sorted by grade and thickness. Whether or not it is sorted by length and width will depend on the amount of production and on piling and handling techniques. If the lumber is not sorted for lengths, it may be made into two length groups; 8-, 14-, and 16-foot lengths in one group, and 6-, 10-, and 12-foot lengths in the other group. The pile foundations that have been suggested for hand-stacked piles can accommodate any length of stock up to 16 feet. Eighteen-foot lumber will extend 2 feet beyond the rear cross beam. The proposed foundations will accommodate unit packages 10-, 14-, 16-, and 18-foot long, but will not be satisfactory for 8- and 12-foot unit packages.

Types of Piles

If the hand-stacked pile or the unit package contains boards or dimension mixed or random of lengths, then box-piling should be employed. A box pile is characterized by the square appearance of both pile ends, the support of all outer board ends and most inner board ends by stickers, and the support of the outer ends of stickers by boards. The type that is not box-piled is characterized by projecting and unsupported outer board ends, unsupported board ends within the pile, and poorly supported stickers. In a box pile of random-length lumber the longest boards or planks should be placed in the two outer tiers. If there are sufficient long boards, additional tiers of them should be uniformly distributed across the width of the pile or unit package. Tiers of shorter boards are placed between the tiers of long boards, and if possible, all the boards of a tier should be of the same length. The ends of the short boards may all be placed flush with the front of the pile, or they

may alternate between the front and rear in adjacent tiers. In relatively narrow unit packages, it is customary to place all boards with one end flush with one end of the unit package. Whatever the scheme, the boards within a tier should always be piled directly above one another.

Pile Spacings

Where lumber is hand-stacked in long rows of piles bordering the main alleys, with the piles themselves perpendicular to the alleys, it is necessary to provide spaces between the sides of the piles. These spaces contribute to air movement through the yard and adjacent to and within the piles. It is not possible to recommend the exact lateral spacing, but in general a space of 2 to 6 feet is considered satisfactory. The optimum spacing will vary with the thickness of the lumber, the width and height of the piles, and the chimney or flue area within the piles. Yards should be laid out with the piles of the various rows in alinement.

Since piles of unit packages are usually considerably narrower than hand-stacked piles, the lateral spacing can presumably be less, probably 2 to 3 feet. With hand-stacking, spaces between the ends of piles are provided by the rear alleys, which are often 6 to 8 feet wide. With unit-package piling, spaces between the ends of the piles are provided by spacing the rows. For 16-foot piles, a space of 3 to 4 feet is suggested.

Pile Widths

The width of a pile and the width of flues and chimneys affect the drying rate, mainly because of their effect on horizontal air movement. The width of hand-stacked piles of Engelmann spruce will probably be greater than those of machine-piled. The recommended width of hand-stacked piles, based on the use of special stickers, is 12 feet. If stock is used for stickers, the width will probably be 16 feet.

When lumber is piled for air drying in the form of unit packages, the width of the package may be determined by the seasoning process, whether the lumber is to be air dried only or air dried and kiln dried. Packages for yard drying only are likely to vary between 3 and 4-1/2 feet, with 4 feet the most common width. When the lumber is to go from the yard to the dry kiln, the widths vary from 3-1/2 to 8 feet, depending on the size of the kiln truckloads and the number of unit packages used to make up a truckload. Where narrow packages go to a cross-circulation dry kiln, they are doubled up in the lateral direction on the kiln trucks. Narrow unit packages are also used with unit-package kilns. The width of unit packages may be determined by the length of the forks and the capacity of the machine. It is evident that yard piles of unit packages are generally considerably narrower than hand-stacked piles. This feature would tend to increase the drying rate of lumber piled in the form of unit packages over that of lumber piled by hand.

Pile Heights

Increasing the pile height tends to retard drying, particularly in the lower parts of the pile. The air traveling downward in a pile becomes cooled and approaches saturation at a point higher up in a tall pile than in a short one, unless the air is replenished by horizontal movement, as it moves downward. Tall piles also tend to restrict general wind movement at the ground level of the yard. Piles stacked solely by hand range from 9 to 16 feet in height. Where mechanical aids are used in hand stacking, they may range from 20 to 30 feet in height. Piles made with fork-lift trucks may be six unit packages high, making a total height of 25 to 30 feet. The two top units are generally handled together. Tall piles, whether hand-stacked or unit-package, have other disadvantages in addition to retardation of drying. Added height means increased weight on foundations, stickers, bolsters, and boards in the lower parts of the pile. Sagging, breaking, and crushing of boards and stickers increase with increased loading. Additional height also increases the danger of tipping and falling, in the case of unit-package piles, because of the great height compared to the width, and particularly where there are poorly piled boards and stickers, or displaced stickers or boards, in the lower unit packages. Tipped piles are dangerous, difficult and costly to take down, and they may partially close the spaces between piles and thus retard air movement (fig. 6).

Board Spacings -- Flues and Chimneys

Since the vertical downward movement of air within wide hand-stacked lumber piles is one of the principal means of accomplishing drying, it is important that channels for this movement be provided. Vertical movement in itself accomplishes little drying, except in the case of squares or where stock is piled on edge, but vertical movement through interior spaces induces horizontal air movement across the faces of the boards, from which most of the evaporation of moisture occurs. Spaces for the downward movement of air are obtained by leaving spaces between the edges of the boards. The wider these spaces with respect to the total width of the pile, and the smoother the vertical sides of the spaces, the greater will be the passage of air through them. These spaces are arbitrarily called flues, chimneys, or vents, depending on their width. The sides of chimneys or vents may be straight up and down or tapered so as to be wider at the bottom and narrower at the top. Where lumber is sorted for width, it is easy to build a straight-sided flue between adjacent tiers of boards or, with narrow boards, between pairs of tiers. In the latter case, two tiers are placed edge to edge, with space left between the first pair and the next pair of tiers, the boards of which are also placed edge to edge. With random-width stock it is more practical to build fewer but wider chimneys or vents. The boards between these spaces are combined so that the total of their widths will be approximately the same from course to course and thus provide straight chimneys. A rough rule concerning the amount of flue or chimney space in hand-stacked piles is that it should equal in width about 20 percent of the width of the pile.

Boards piled in unit packages may be placed edge to edge or may be spaced. Edge-to-edge piling is probably satisfactory for air drying unit packages 3-1/2 to 4-1/2 feet wide, with good pile spacing in the rows. With 6- to 8-foot edge-to-edge piled packages, however, there is probably some retardation of air drying. Where unit packages of lumber are to be kiln dried following air drying, they should be constructed so that they are suitable for the kiln rather than for the yard.

Stickers

Special stickers, dressed 1 by 4 inches for hand-stacked piles, and 1 by 2 inches for unit-package piles, are recommended. The stickers should be made from air-dried or kiln-dried material. The basic sticker spacing shall be 4 feet. On this basis, 8-foot lumber will have three, 10- and 12-foot four, 14- and 16-foot five, and 18- and 20-foot six tiers of stickers. Deviations from the basic 4-foot spacing will have to be made in constructing the unit packages. The tier on each side of the center one should be 4-1/2 feet away. For 16-foot lumber, the two outer tiers should be 3-1/2 feet from the intermediate tiers. For other lengths, the spacing of the three central tiers should be identical, but the spacing of the tiers towards the ends should vary (fig. 7).

The tiers of stickers should be in alinement with the cross beams of the pile foundation and in unit-package piles, with the bolsters also. In the sloped and pitched hand-stacked piles, the tiers of stickers should follow the pitch of the piles. In the unit-package piles, they should be vertical.

Unit-packages are usually built in stacking racks or jigs (fig. 8). The jigs are equipped with sticker guides, generally on one side only. Jigs equipped with guides are constructed so that they can be readily moved to permit the removal of the unit package when it is completed by straddle or fork-lift trucks. Sticker guides are essential where lumber is made into unit packages, because guides not only assure good sticker alinement within a unit package, but regulate the sticker spacing so that it will be uniform from package to package. Uniform sticker spacing is necessary if good alinement of stickers, bolsters, and cross beams is to be obtained in a pile consisting of several unit packages. Good alinement of stickers is needed to prevent sagging and breaking of boards. Semiautomatic or mechanical stackers for building unit packages are coming into use.

Stickers can be made to perform another function; that of reducing end checking and splitting of boards in air-yard piles. Placing the stickers close to the ends of the boards eliminates overhanging board ends. Overhanging or projecting board ends are susceptible to end checking, splitting, surface checking, and warping. It has generally been considered that placing stickers flush with the ends reduces the amount of end checking and splitting. Stickers that project slightly beyond the board ends retard drying and shield the ends from sunshine and rain. Rapid end drying and alternate drying and wetting invite end checking.

Unit packages of 4/4 softwood lumber are often too limber to be handled by straddle or fork-lift trucks without drooping or sagging. To stiffen the unit package, extra short tiers of stickers are often placed in the lower courses of lumber, directly above the bolsters or bunks used with straddle trucks or the forks of the fork-lift trucks (figs. 9, 10, and 11). Steel straps can also be used to keep unit packages of this type intact during handling and piling (fig. 12).

Pile Roofs and Sheds

A good pile roof has always been considered an essential feature of good air-drying practice, except where very low-grade lumber is involved. A roof shields the pile from direct sunshine and precipitation, particularly the upper lumber courses, and, to a lesser extent, the lower part of the pile. Without a roof, the upper courses of lumber become warped and checked, and rain is permitted to penetrate the pile from the top or to drive in from the ends and sides. Rain penetrating the pile may retard drying and contribute to the development of blue stain and to the formation and growth of surface checks. A leaky roof will afford protection against direct sunshine, but it will permit water to wet the upper lumber courses and to penetrate the pile. To afford maximum protection, a roof should project beyond the ends and sides of the pile. For a hand-stacked sloped pile, the roof should project about 1 foot at the front, about 2-1/2 feet at the rear, and about 6 inches at the sides. For a level pile of unit packages, the roof should project at both front and rear ends. A roof should be pitched so that the water will run from front to rear and drip off the rear edge. The extension of the roof 2 to 2-1/2 feet over the rear end of the lumber pile allows the drip to fall free. With hand-stacked piles, the pitch of the roof should follow the slope of the pile, if the roof is reasonably tight. If the roof is not tight, the pitch should be increased to about 1 in 9 rather than 1 in 12. With horizontal unit-package piles, the roof should be elevated at one end or in the middle in order to obtain a pitch.

Various methods are used on constructing and placing pile roofs. Roofs are commonly made from loose boards of low-grade lumber. The boards are often laid in a double-layer, double-length manner. If it is necessary to fasten down the roof as a precaution against its being blown off by wind, tie pieces of 2 by 4 or 4 by 4 inches may be laid crosswise at the front, middle, and rear and should be fastened by wires or springs to the pile about 10 courses below the top. Loose-board roofs are not recommended for horizontal unit-package piles because of the difficulty of obtaining sufficient pitch. The roofs on horizontal unit-package piles should project an equal amount at both ends, or 1 to 2 feet. A roof for a unit-package pile can be placed on the top unit package while it is still at ground level.

Building paper or roll roofing may be combined with a double layer of boards to form a pile roof. The paper or roofing provides watertightness, while the boards support the paper or roofing in a flat sheet and permit the roof to be anchored to the pile. Since this type of roof is tight, the pitch can be flatter than in one composed of a double layer of overlapping boards only. The use of a combination of building paper or roll

roofing and boards is probably more applicable to piles of unit packages than to hand-stacked piles. There is a wide variety of papers and roofing on the market, and the choice of a suitable material should be based on the life of the material with reference to the length of time the pile is to stand in the yard. It is probable that the most economical scheme would be to discard the paper or roofing when the pile is taken down. Boards and roofing may also be combined with a wood framework to form roof panels. The panels may be used singly or doubly in the length of the pile (fig. 13). The roll roofing in this panel may be replaced by battens nailed over the cracks between the boards.

Drying Defects

The defects that develop during the air drying of Engelmann spruce are those caused primarily by shrinkage and its variations, and not those caused by fungus attack, such as mold, stain, and decay. The principal defects are end and surface checking, end splitting, and warping. Other defects or causes of downgrading are the falling out of knots and splitting while planing. The general cause of end and surface checking is the sudden drying of the surface to a low moisture content under severe air-drying conditions. A chief cause of end checking in boards or dimension is the prior end checking of the logs while in the woods, in transit, or when dry-yarded at the mill. The chief causes of warping are poorly made piles, from the mechanical standpoint, and exposure of the upper courses of lumber to sunshine and wetting. This exposure to alternate drying and wetting also contributes to checking. An alternative to the use of pile roofs to protect the upper courses of lumber from warping and checking, is to make the top course from low-grade boards. The splitting during planing is caused by the flattening of a cupped board under the pressure of the rolls. Low moisture content and the presence of end splits or surface checks contribute to splitting during planing. The falling out of knots during planing is caused by the relative looseness of certain types of knots after drying, their projection above the surface of the board, and their resistance to the knives of the planer.

For each of these defects, there is a remedy or partial remedy. End checking might be reduced by end coating the logs soon after felling (2, 4, 1). End checking while in the yard piles may be reduced by end coating the lumber, or by retarding end drying by projecting stickers. End checking and splitting can be reduced by box piling, thus avoiding projecting board ends. Reducing end checking automatically reduces end splitting. The extension of end splits can presumably be influenced by the position of the last tier of stickers. It has generally been held that the placing of the last sticker at the very end, or projecting beyond the end, reduces the extension of end splits. Surface checking caused by rapid surface drying during the hot, dry periods may be controlled by modifying the pile spacing and piling techniques. Unit-package piles erected from April to August can be crowded in the rows, thus restricting the horizontal movement of air through the piles. It is also possible, but probably infeasible, to use thinner stickers during this period. Another possibility is to restrict

the movement of air within the piles by attaching boards or building paper to the sides of the pile. Warping can be reduced by building the piles with the foundation beams, tiers of stickers, and bolsters, in good alinement. Protection by pile roofs, and the elimination of projecting board ends by box piling, also reduces warping. The splitting of boards in the planer will be reduced if end and surface checking and splitting have been minimized. Planer splitting can be reduced also by taking down the yard piles before the lumber has become completely dry. If the lumber has become too dry for satisfactory planing, spraying with or dipping in water just prior to planing helps in reducing planer splitting. Fewer knots are lost in planing if the lumber is planed at a relatively high moisture content, or before it has become thoroughly air dry.

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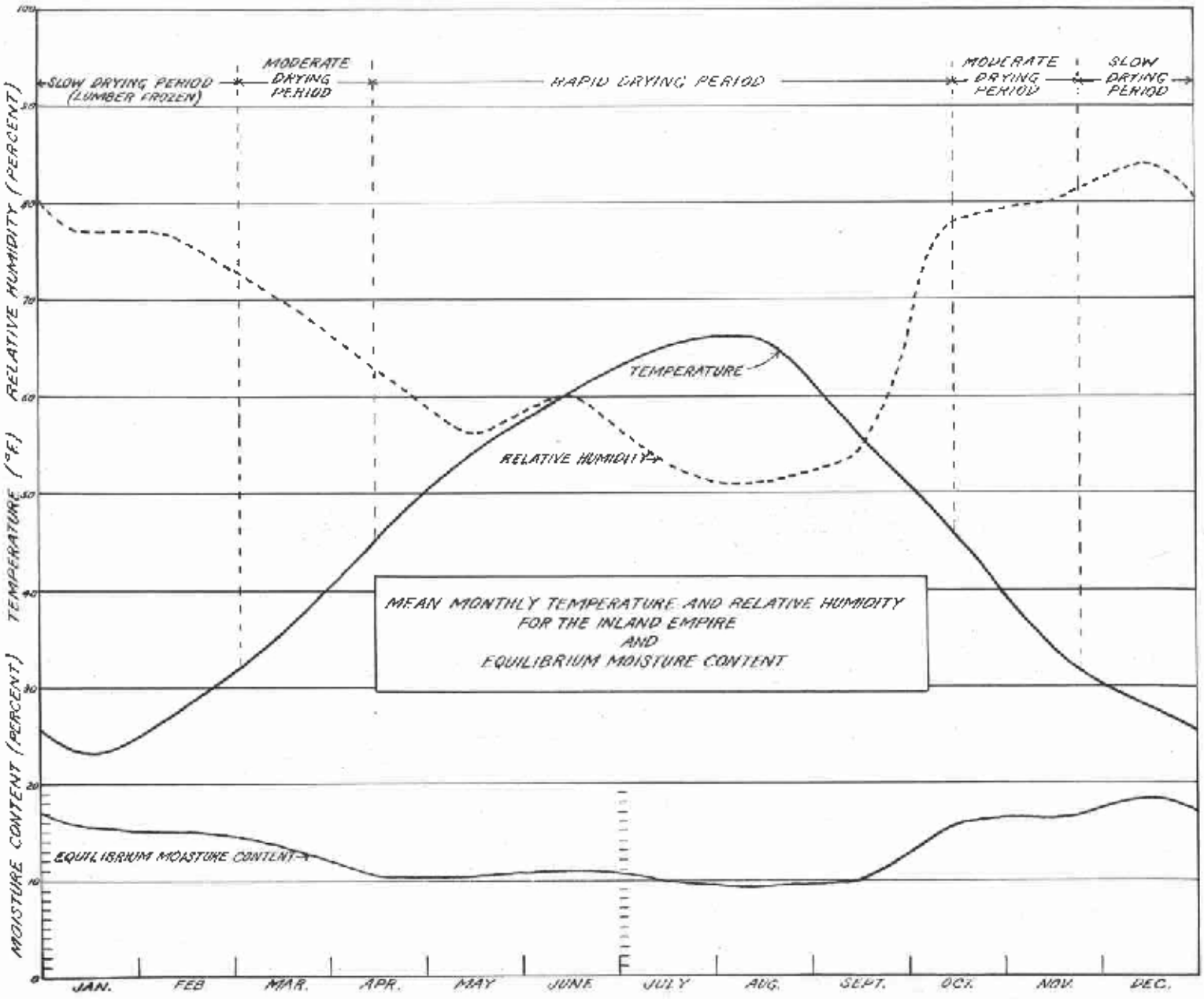

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Figure 1.--Climatological data for the Northern Rocky Mountain area.

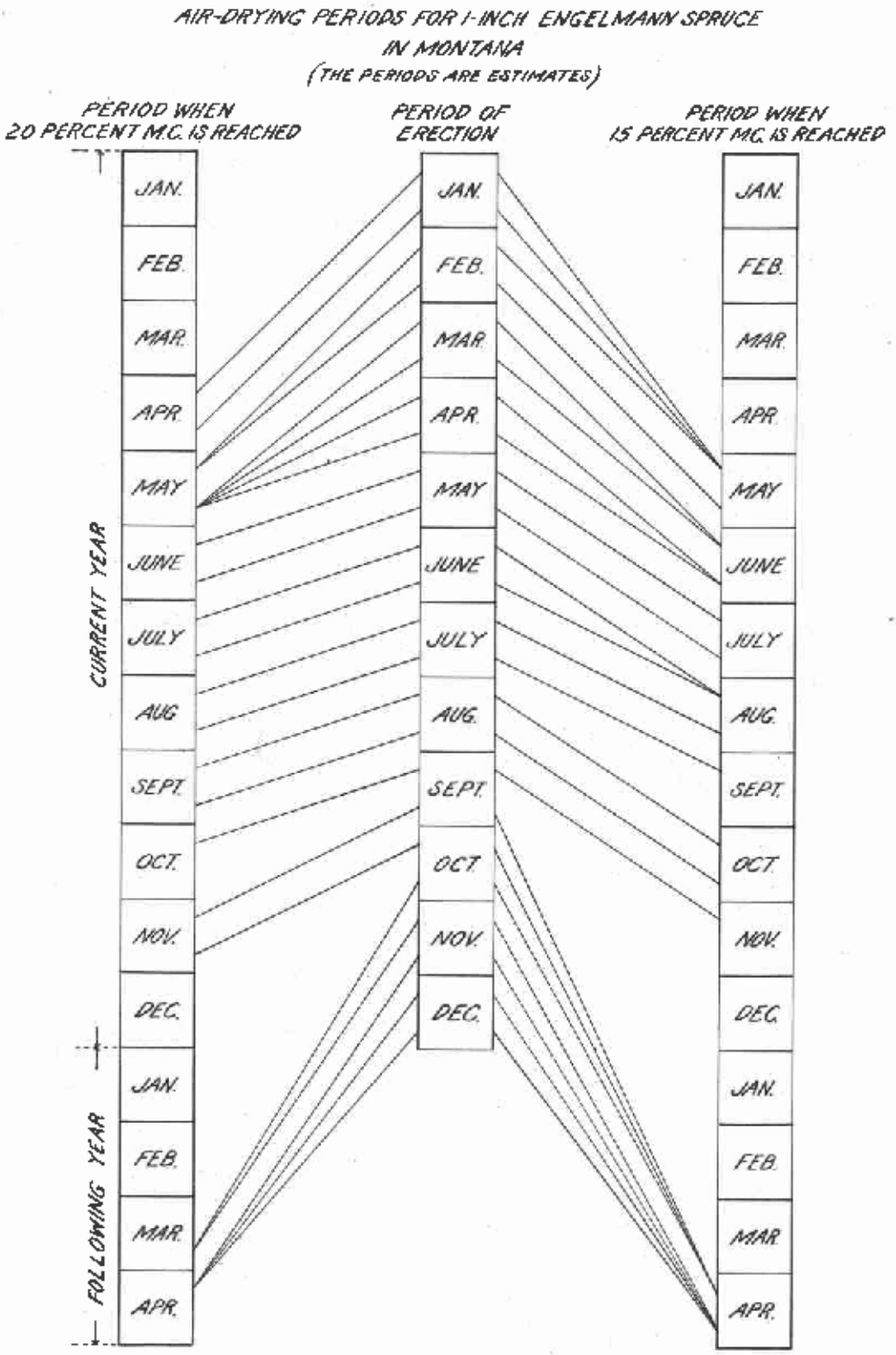

Figure 2. --Air-drying schedule for 1-inch Engelmann spruce.

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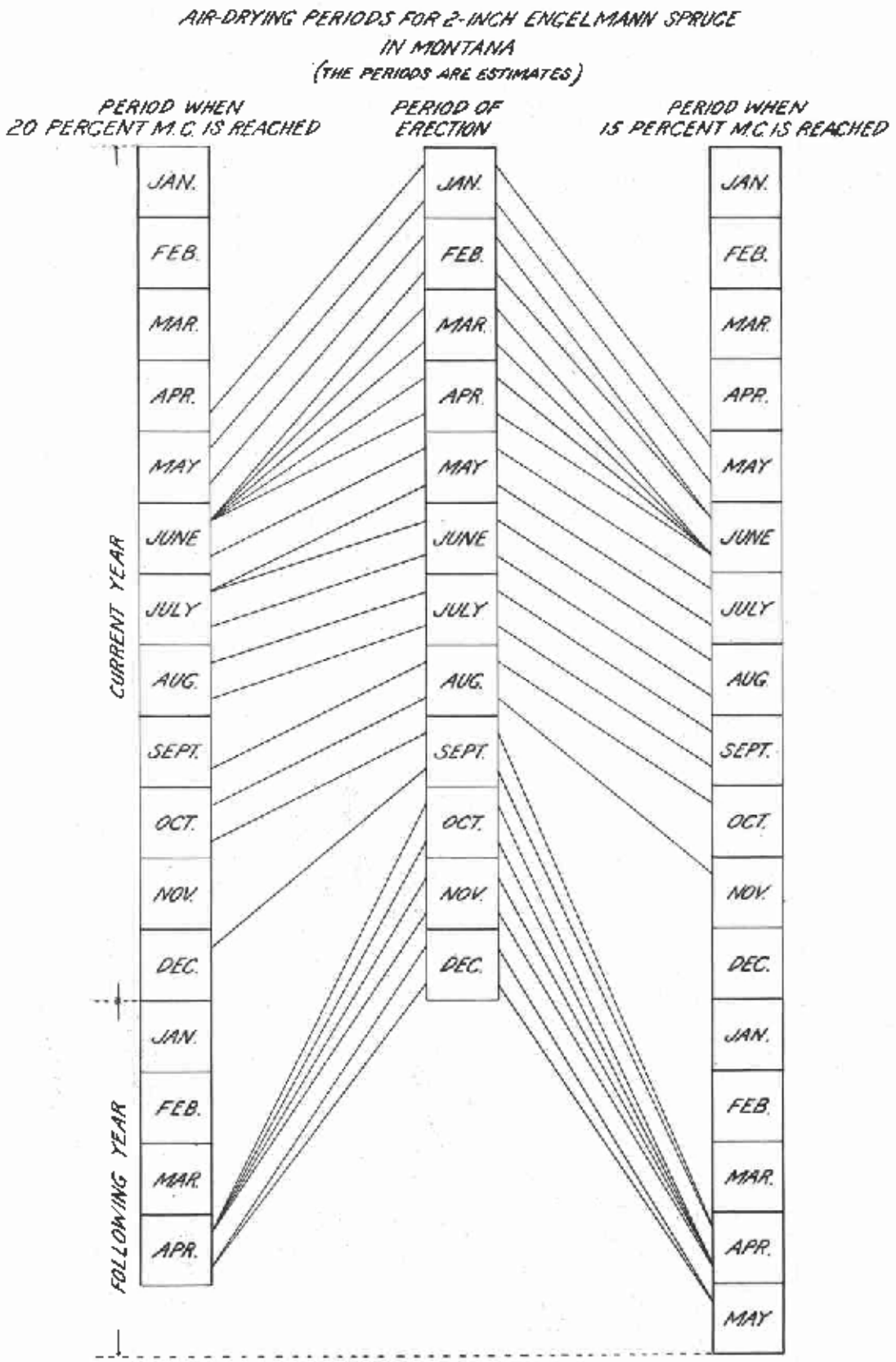

Figure 3. --Air-drying schedule for 2-inch Engelmann spruce.

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FOUNDATION FOR HAND-STACKED PILE

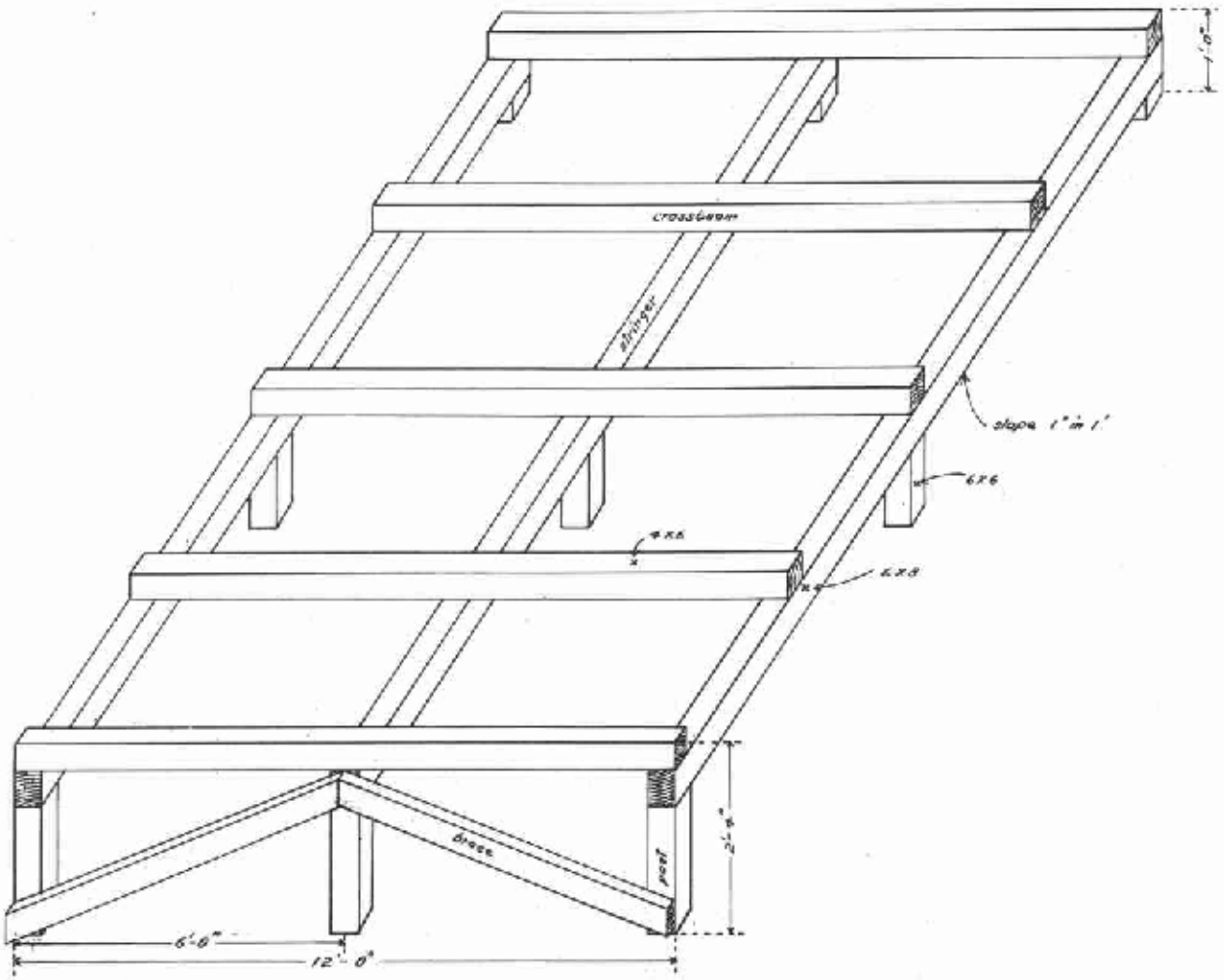

Figure 4. --Pile foundation for hand-stacked yard piles of Engelmann spruce. The posts may be set in the ground or may rest upon sleepers.

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FOUNDATION FOR PILES BUILT WITH FORK-LIFT-TRUCK UNIT PACKAGES 4 FEET WIDE AND 14 OR 16 FEET LONG

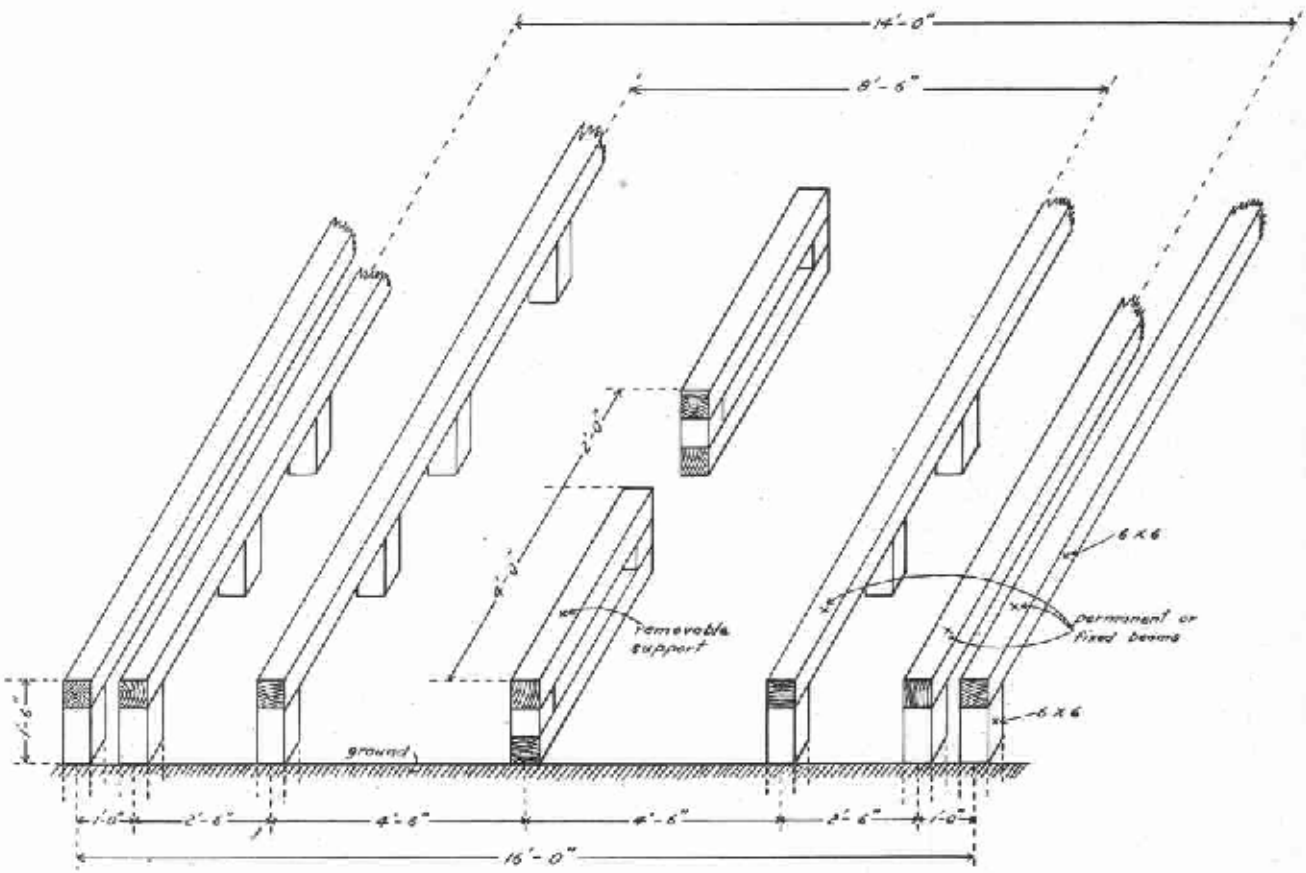

Figure 5. --Pile foundation for unit-package piles of Engelmann spruce. The posts may be set in the ground or may rest upon sleepers.

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Figure 6. --Several unit-package piles that have become tipped, closing the lateral spaces.

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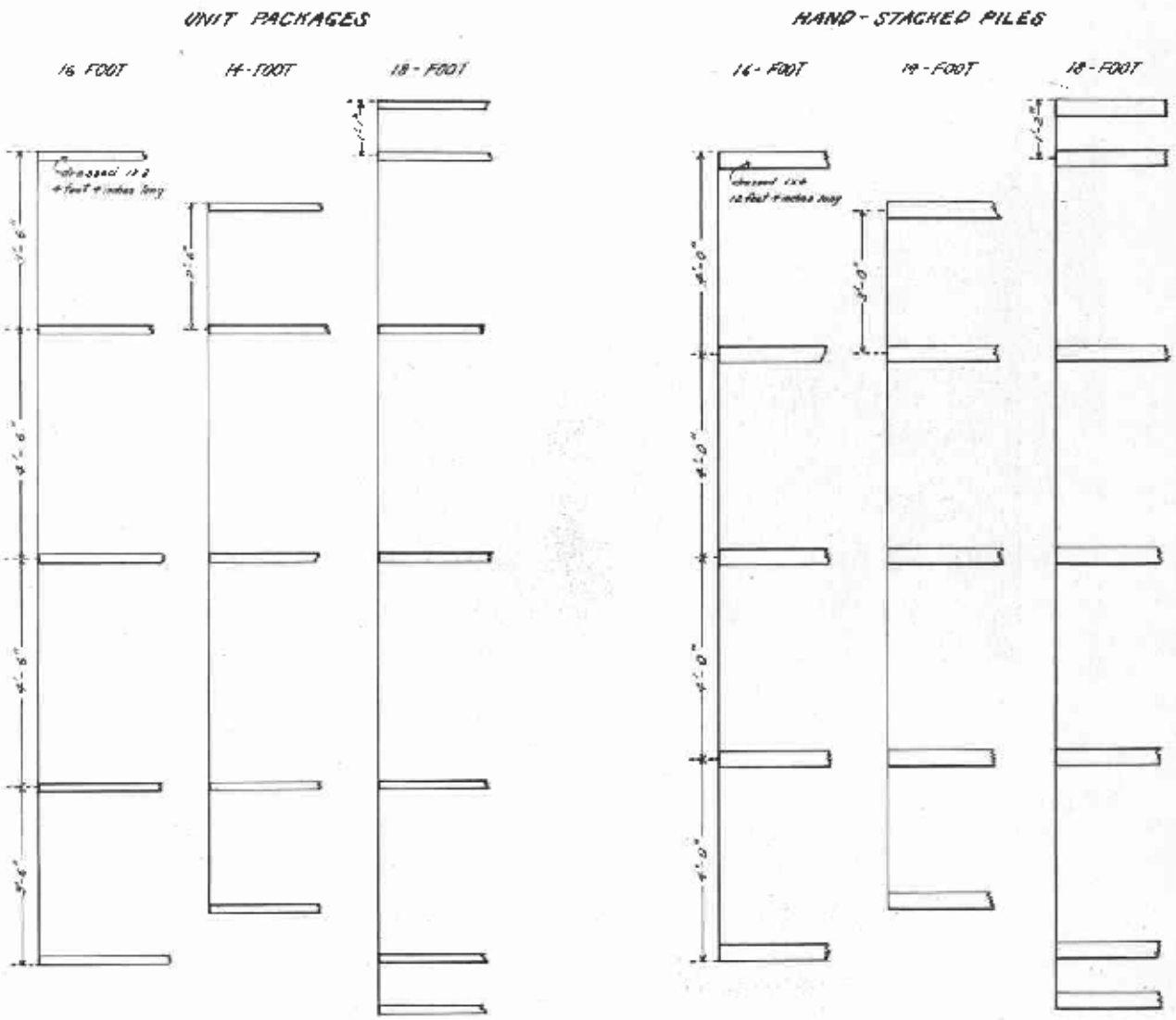

Figure 7. --Diagram of sticker spacing for both unit-package and hand-stacked piles of Engelmann spruce.

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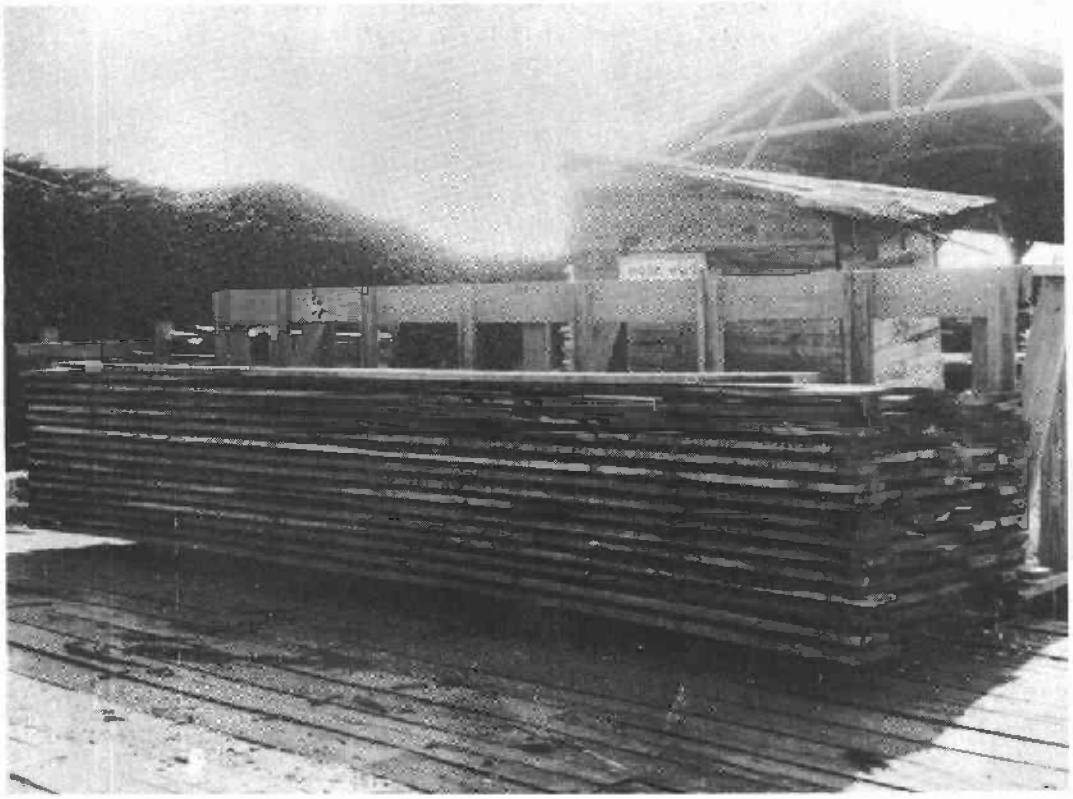

Figure 8. --Sticker guide used in building unit packages. The guide can be rolled back when the package is to be picked up by a straddle or fork-lift truck.

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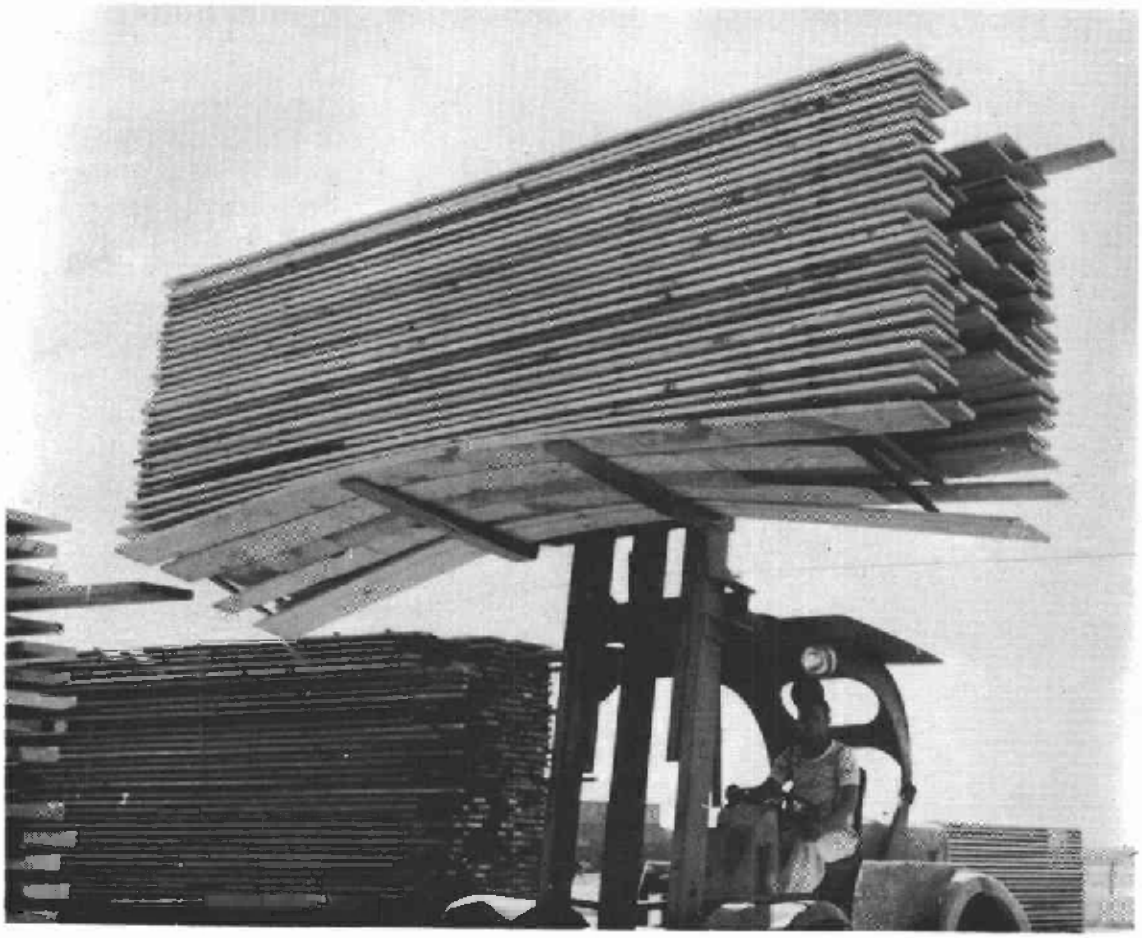

Figure 9. --A unit package of thin softwood lumber drooping or sagging on the forks of a fork-lift truck. The stickers near the ends are likely to be lost during transporting and piling.

Z M 98511 F

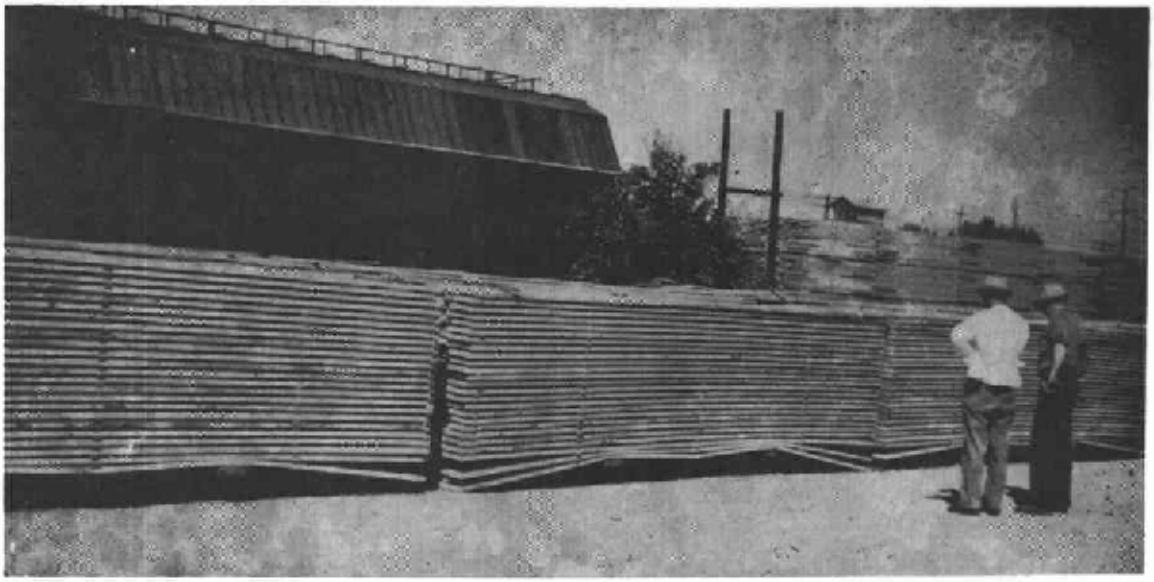

Figure 10. --A unit package of thin softwood lumber resting on straddle truck bunks or bolsters. Notice that the several lower boards are badly distorted because of lack of support over the bolsters. Short tiers of stickers directly over the bolsters would alleviate this condition.

Z M 93315 F

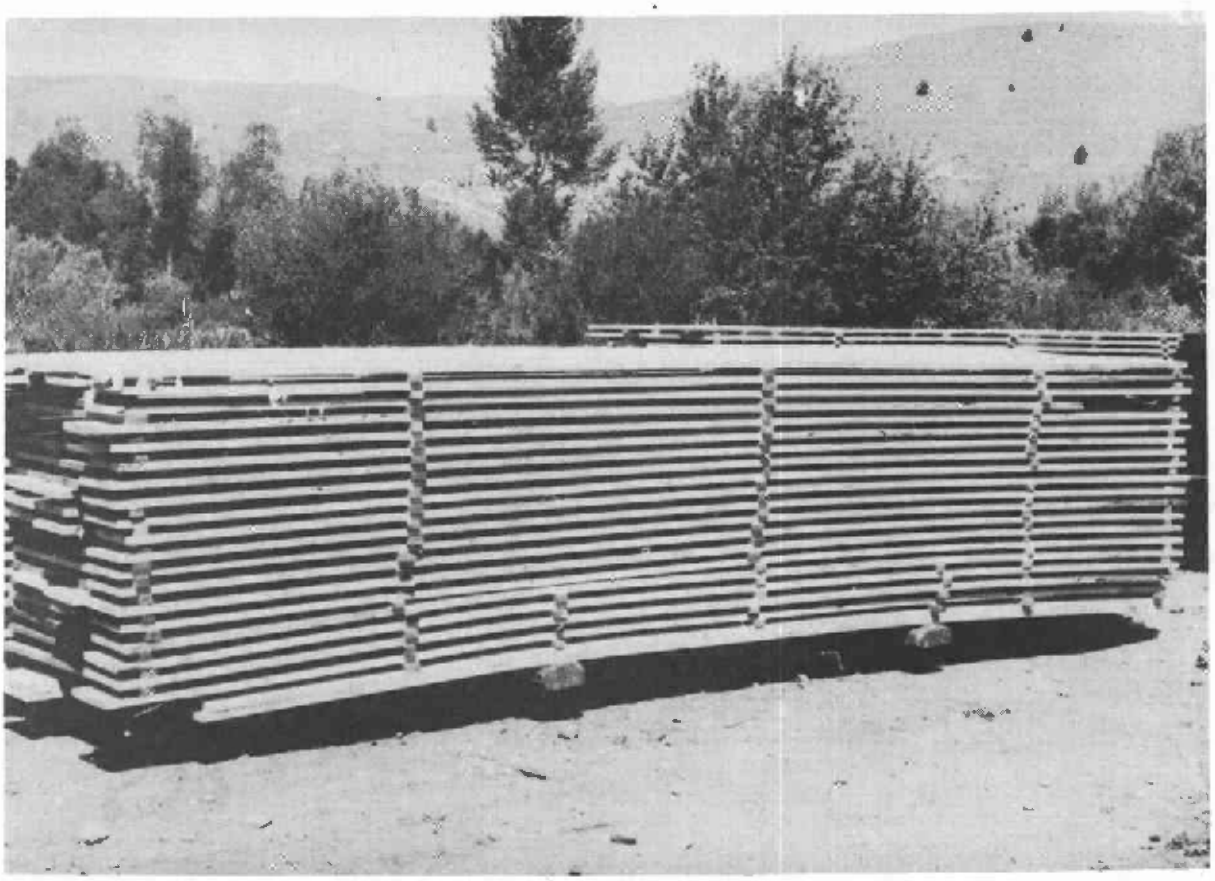

Figure 11. --A unit package resting on bolsters for use with a straddle truck, with short tiers of stickers directly over the bolsters.

Z M 98464 F

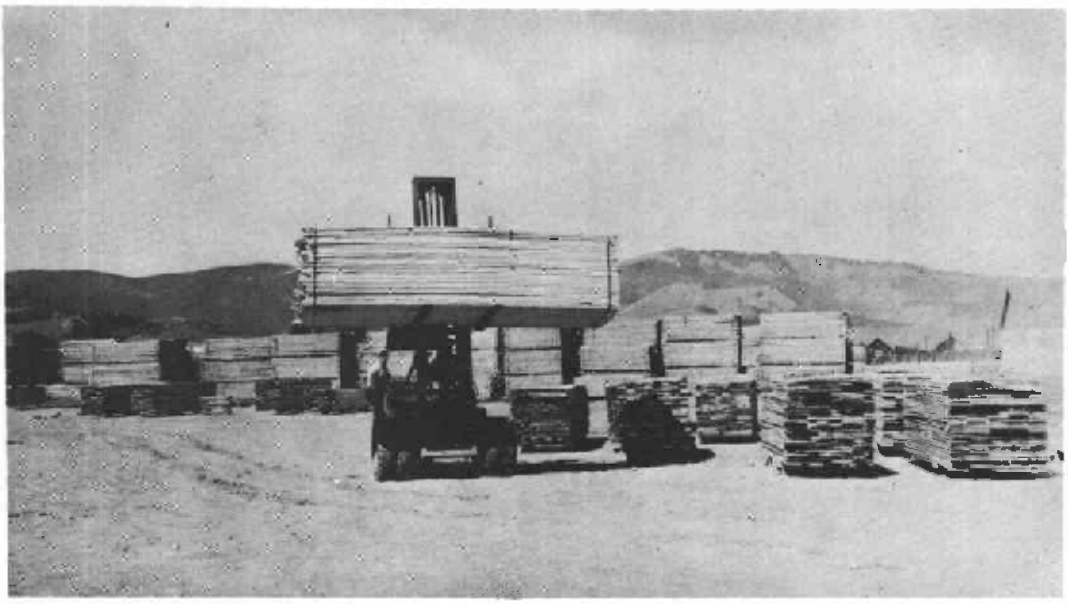

Figure 12. --Strapped unit package being transported by lift truck. Straps reduce end flair and tendency for sticks to kick out when moved over rough ground.

Z M 93314 F

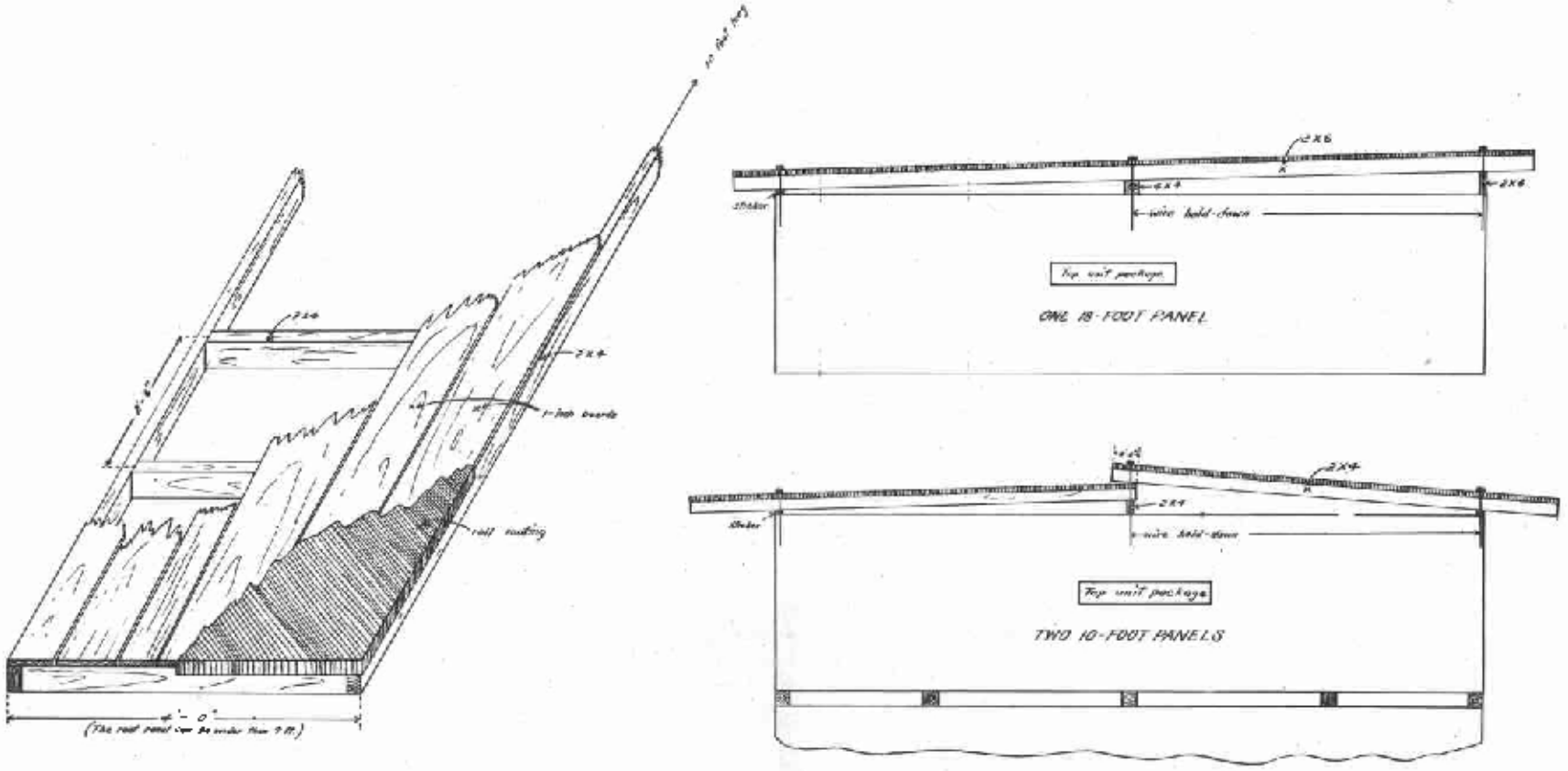

Figure 13. --Roof panels for unit-package piles of Engelmann spruce.

Z M 92586 F