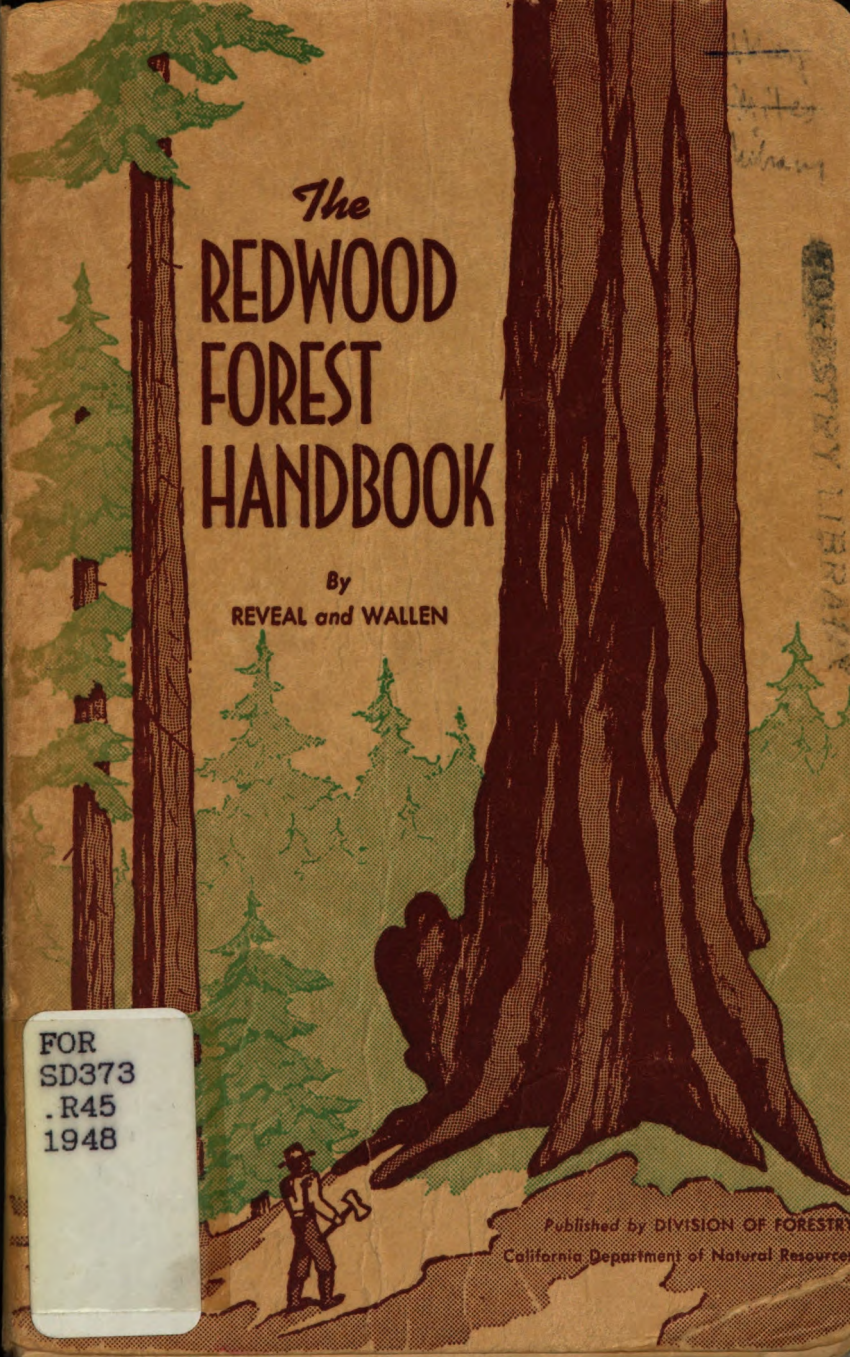


The
**REDWOOD
FOREST
HANDBOOK**

By
REVEAL and WALLEN

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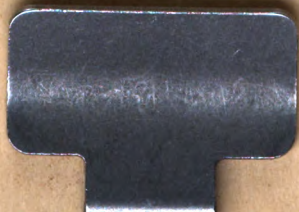
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THE REDWOOD FOREST HANDBOOK

by

JACK REVEAL

*Redwood Farm Forestry Project, Forest Service
U. S. Department of Agriculture*

and

ARNOLD WALLEN

*Redwood Forest District, Division of Forestry
California Department of Natural Resources*

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PREFACE

During the past two years as chairman of the Redwood Forest Practice Committee, I have been increasingly aware of a need for a better understanding by woods workers of the forest in which they work. A redwood forest handbook, written in a style which everyone can understand, has long been needed.

This handbook has been prepared by men who work in the redwood region and have first-hand knowledge of conditions which, many times, are peculiar to this region alone. It answers many questions asked by the man in the woods. It provides a source of useful information for woods-workers, operators and timberland owners.

As far as I know, there is no similar handbook for any of the other forest regions in the West. So we in the redwood area are fortunate in having a new aid for use in the woods.

GORDON MANARY
Logging Superintendent,
The Pacific Lumber Company
Chairman, Redwood Forest
Practice Committee

AUTHOR'S NOTE

This handbook is offered as a practical guide for woodsmen. It does not cover any one subject thoroughly, and it is not intended to be complete in any of its phases.

Information has been taken from many sources in the preparation of this handbook. Whenever possible the original source has been credited.

The authors are indebted to the many people who have contributed to the handbook, especially to Emanuel Fritz of the University of California, who offered numerous helpful suggestions, and to George Craig of the State Division of Forestry, for editing the work.

**JACK REVEAL
ARNOLD WALLEN
April, 1948**

Table of Contents

	Page
THE CALIFORNIA REDWOOD REGION.....	ii
FOREWORD	ix
THE TREE	1
The Tree's Structure.....	1
How a Tree Grows.....	3
Softwoods and Hardwoods.....	5
Wood and Bark.....	5
Sprouts and Burls.....	8
Cones and Seed.....	8
THE FOREST	10
Open-grown and Forest-grown Trees.....	10
The Forest—A Community of Trees.....	12
What Happens When Old Growth Is Clear-cut.....	13
What Happens When a Forest Is Partially Cut.....	16
Dollars and Cents and Partial Cutting.....	18
The Young Forests.....	21
Partial Cutting of Young Forests.....	24
Young Forests After Cutting.....	25
Example of Partial Cutting.....	27
FOREST PROTECTION	31
Fires Are Costly.....	31
Why Fires Start and Spread.....	31
Weather and Fire.....	32
Fire Prevention and Control.....	34
Decay in Forest Trees.....	36
Insects in Redwood Forests.....	38
SLASH DISPOSAL	40
Results of Broadcast Slash Burning.....	40
Spot Burning	41
Slash Burning Costs.....	43
Slash Disposal in Partially Cut Areas.....	43
Reducing the Slash Problem.....	44

Table of Contents—Continued

	Page
TIMBER CRUISING	46
Usefulness of Timber Cruises	46
Sampling—Basis of Cruising	46
Cruising Methods	47
Cruising Instruments and Equipment	49
Pacing and Chaining Distance	50
Measuring Diameter and Height of Trees	51
Measuring Diameter of Old Growth Redwood at 20-Foot Height	54
Tallying Cruise Data	57
Deductions for Visible Defect	61
The Cruising Party	62
Preparing for a Cruise	63
Cruising by the Strip Method	63
Cruising by Sample Plots	64
Calculating Timber Volume	65
Cruising Irregular-shaped Tracts	67
Varying the Width of Cruise Strips	67
Cruising by Timber Types	68
NOTES ON LAND SUBDIVISION	69
HOW TO MAKE A CRUISER'S STICK	72
LOG SCALING	75
Value of Log Scaling	75
Required Knowledge	75
Equipment Used	76
Log Rules in Common Use	76
The Scale Book	78
Where Scaling Is Done	78
Scaling Procedure	78
Deductions for Defect	82
Rule of Thumb for Interior Defects	84
STUMPAGE SALES	85
APPENDIX	89
Glossary of Lumber Terms	91
Tractor Production and Cost Estimation	99
Volume Tables and Their Use	124

List of Tables

	Page
1. Weights of Western Woods.....	6
2. Common Western Rots.....	39
3. Number of Plots Needed for Three Common Degrees of Accuracy.....	48
4. Corrections for Slope Measurement.....	50
5. Corrected Diameters at 20-Foot Height.....	56
6. Differences Between Diameter at 4½ Feet and 20 Feet.....	57
7. Tree Volume Distribution by Log Position.....	61
8. Graduations on Cruiser's Stick.....	73
9. How to Divide Long Logs for Scaling.....	81
10. Estimated Hourly Log Production, 113 Drawbar H. P. Tractor.....	102
11. Estimated Hourly Log Production, 80 Drawbar H. P. Tractor.....	103
12. Estimated Hourly Log Production, 55 Drawbar H. P. Tractor.....	104
13. Estimated Hourly Pulpwood Production, 43 Drawbar H. P. Tractor.....	105
14. Area of Circles in Square Feet.....	106
15. Units of Length and Area, Conversion Factors.....	107
16. Solid Cubic Contents of Logs.....	108
17. Pulpwood Measurement.....	110
18. Standard Specifications for Timber Piles.....	111
19. Fuel Value of Woods.....	111
20. Board Foot Scale of Lumber.....	112
21. Redwood Split Products.....	114
22. Logs per 1,000 Board Feet.....	114
23. Forest Products of the Redwood Region.....	115
24. Simplified Softwood Lumber Grades for Small Mills.....	116
25. Number of Trees per Acre.....	118
26. Second-growth Tanbark Oak Diameter Growth per Decade.....	118
27. Second-growth Redwood, Average Diameter Growth per Decade.....	119
28. Double Bark Thickness of Old-growth Redwood.....	119
29. Old-growth Redwood, Merchantable Length and Utilized Top.....	120
30. Size of Circular and Square Plots.....	120
31. Notes on Water Measurement.....	121
32. Approximate Average Weights of Logs and Cordwood.....	121
33. Native Trees of the Redwood Region and Adjacent Area.....	122
34. Old-growth Redwood Simplified Volume Table.....	125
35. Old-growth Redwood Volume.....	126
36. Second-growth Redwood Cubic Foot Volume.....	128
37. Second-growth Redwood Board Foot Volume.....	130
38. Old-growth Douglas Fir Volume.....	131
39. Second-growth Douglas Fir Board Foot Volume.....	132
40. Second-growth Douglas Fir Cubic Foot Volume.....	134
41. Second-growth Douglas Fir Cubic Foot Volume.....	135
42. Sitka Spruce Cubic Foot Volume.....	136
43. Sitka Spruce Board Foot Volume.....	138

List of Tables—Continued

	Page
44. Western Hemlock Board Foot Volume.....	139
45. Western Hemlock Cubic Foot Volume.....	140
46. White Fir Volume.....	142
47. Old-growth Port Orford Cedar Volume.....	143
48. Sugar Pine Volume.....	144
49. Ponderosa Pine Volume.....	145
50. Red Alder Volume.....	146
51. Tanbark Oak, Weight of Bark on Trees of Different Sizes.....	146
52. Tanbark Oak, Number of Trees to Yield One Cord of Bark.....	147
53. Old-growth Redwood Overrun With Humboldt Log Scale.....	147
54. Scribner Decimal C Log Rule.....	148
55. Spaulding Log Rule.....	150
56. Humboldt Log Scale.....	154

FOREWORD

A new tool is always welcome, especially if it has several uses. This handbook is a tool that should find wide use in an important part of California's vital forest area—the redwood region.

It is particularly gratifying to have a handbook prepared as an aid to owners and operators of redwood forest lands. The redwood region is not only an area which still contains a large volume of merchantable timber, but also one with an outstanding growth potential. More than 33 billion board feet of redwood saw-timber is presently available for commercial operation on about 1,700,000 acres. It has been estimated that the average redwood forest land can grow more than 700 board feet per acre each year.

The authors of the handbook are to be commended. They have spent much effort to make this publication a useful collection of facts on redwood forests and their use. They wisely begin with a description of the basic elements with which we are all concerned—the tree and the forest. Following sections describe in everyday language the principles of protecting, measuring and marketing the timber. The many tables, figures and other data of the appendix form a handy reference. This is truly a valuable tool for every woodsman in the redwood region.

The economic future of the State of California, as well as that of the timber landowners and operators, lies in good forest management. It is hoped that full use will be made of this handbook to help make that future a bright one.

DEWITT NELSON
State Forester

THE TREE

A tree is a tall woody plant, usually with a single main stem for some distance above the ground. It consists of roots, stem or trunk, branches, leaves and fruit, each of which performs the same vital function in all trees. Individual differences in these various parts in different kinds of trees determine the usefulness and value of the different species.

The Tree's Structure

Anchoring the tree in an upright position are the roots. The older roots are similar in structure to the trunk or branches. They are one of the storage places for plant food made in the leaves. The larger roots branch into smaller ones, many of which are hair-like. These root hairs absorb water and minerals that are conducted through the larger roots to the trunk on the way to the leaves. (Figure 1.)

The most valuable part of commercial timber trees is the trunk. It is important to all trees. It supports the leaves where they can receive sunlight and it acts as a system of pipe lines carrying raw material to the leaves and food from them. The inner portion of the wood of the trunk and branches is the heartwood, which is formed as the inner part of the sapwood dies and becomes filled with complex substances. In redwood, these substances make the heartwood remarkably resistant to decay. The lighter colored, outer wood is called sapwood. It is living and the water and minerals from the roots travel through it to the leaves.

Wood is formed in the cambium, or growth layer. This is a band of wood cells on the outside of the cambium and is so thin it cannot be seen without magnification. It is in this area also that the bark is formed.

Like the wood, the bark has both a dead and live section. The inner bark, the living portion, is a spongy,

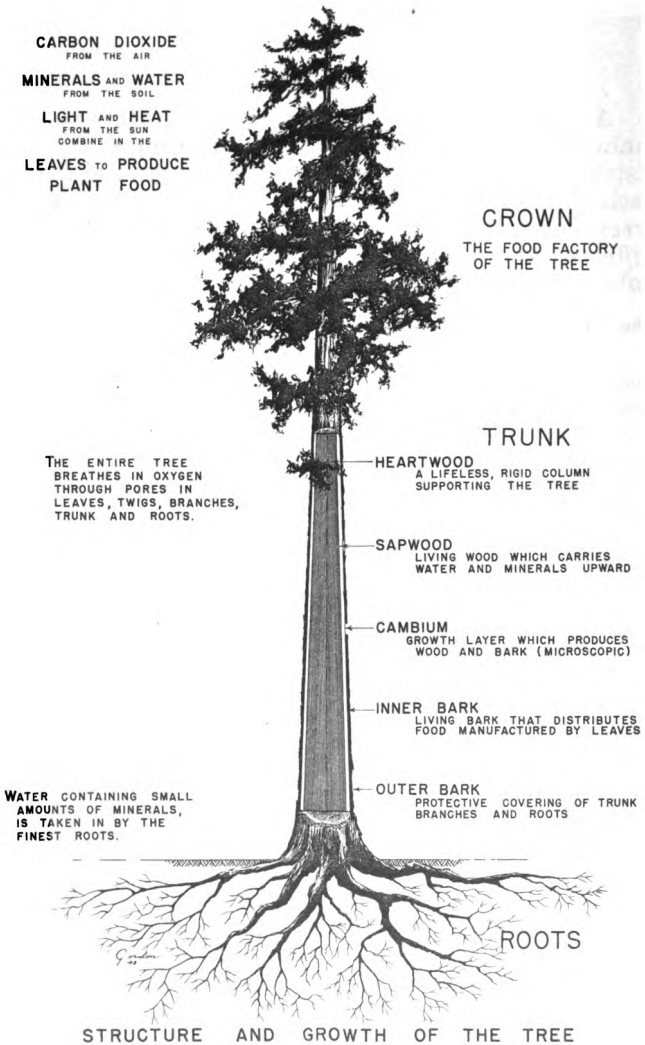


FIGURE 1

moist tissue between the outer bark and the cambium. It distributes the food manufactured by the leaves to the cambium layer and the growing points of the roots, branches and stem. The outer bark, dry and lifeless, protects the stem, branches and roots against fire, drying, and mechanical damage.

Various kinds of sugar are produced in the leaves of the tree. This plant food is made by the action of sunlight on water, minerals and a gas. The gas (carbon dioxide) is absorbed from the air through small openings in the leaves. The leaves give off oxygen as a by-product of food manufacture. Collectively the leaves, and the branches and trunk to which they are attached, make up the crown. Also in the crown are the flowers and fruit (cones). These actually are greatly modified twigs and leaves.

How a Tree Grows

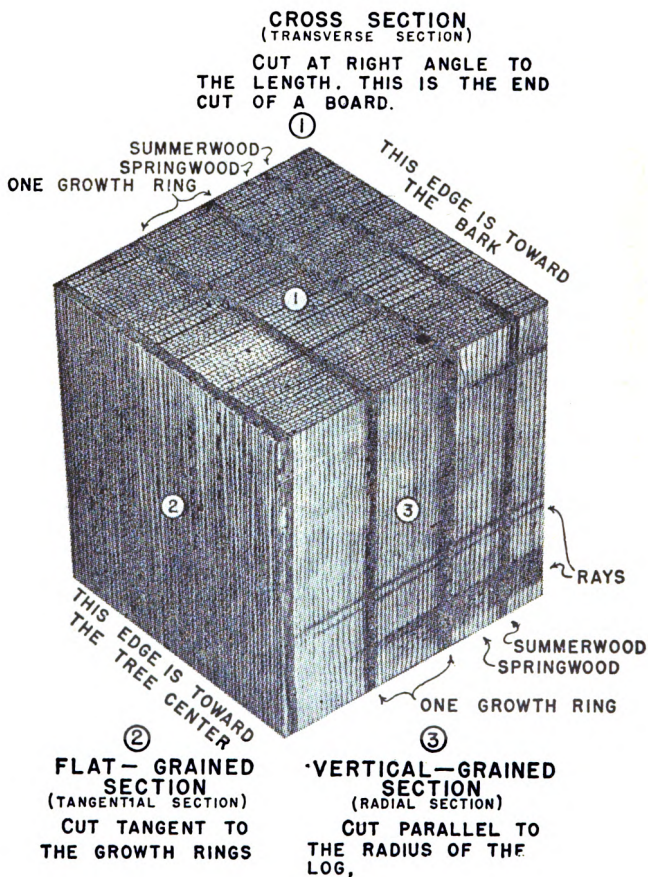
Each year the tree puts on a new shell of growth over its entire area just inside the bark. If a tree trunk were split lengthwise, the annual layers of growth would appear as many inverted V's, stacked one upon the other. On a stump or the end of a log these layers of wood appear as rings. Each year's ring of wood is made up of a light colored band of "springwood" and a dark colored band of "summerwood." The layer of springwood is usually widest. It is formed during the spring and early summer when there is plenty of water and sunlight to permit rapid growth. On fast growing trees the annual ring (springwood plus summerwood) is wide. (Figure 2.)

While the wood is growing the bark is also growing. A new thin layer is added to the inside of the bark each year. The old bark is pushed out and becomes broken into characteristic ridges and troughs. It continually sloughs away.

A tree grows in height—and a branch grows in length—by adding wood to the tip. Terminal buds are formed each fall. In the spring, these buds produce shoots which grow mainly in a lengthwise direction. The

REDWOOD UNDER THE MICROSCOPE

(BLOCK, ORIGINALLY 3/16" ON SIDE)



FROM EMANNEL FRITZ
SCHOOL OF FORESTRY, BERKLEY, CALIFORNIA

FIGURE 2

amount of tip growth and the general appearance of the crown indicate the thriftiness of the tree. Thrifty, fast growing trees usually have long pointed crowns.

Our important trees never grow in height by shooting up from the ground like corn or bamboo. A nail driven into a tree will always remain exactly the same height from the ground.

Softwoods and Hardwoods

Trees are commonly referred to as softwoods and hardwoods. These terms lead to confusion, because the woods of some softwoods are harder than some hardwoods, and the woods of some hardwoods are softer than some softwoods. These two groups could better be called conifers and broadleaves. The conifers are the cone-bearing "softwoods" having needles or scale-like leaves. The broadleaves are the "hardwoods" which generally have broad, flat leaves. This latter group includes some trees with narrow, flat leaves, such as willow.

In the redwood region, it is common to speak of "redwoods" and "whitewoods." All the important conifers growing with the redwood are in the broad group called whitewoods.

Wood and Bark

Usually the most important consideration concerning a tree is the kind of wood that can be obtained from it. In the redwood region, redwood and Douglas fir are the most important conifers. Redwood is especially valuable because its wood is very durable and workable. Douglas fir is valuable because of the strength properties of its wood. Redwood owes its durability to a chemical substance formed in the heartwood. Douglas fir owes its strength and stiffness to the form and structure of its wood fibers.

Wood is made up of millions of microscopic fiber-like cells. Each cell is hollow and is sometimes as much as 100 times as long as it is wide. There are two systems of cells, a vertical system and a horizontal system. The vertical cells outnumber and are larger than the hori-

zontal cells. The horizontal cell system forms thin vertical plates that cause the effect of "silver" grain in conifers. Generally, these plates are called rays. The cells of the springwood are large and thin-walled and have large openings or cavities. The summerwood cells are smaller and have thicker walls. The arrangement of the cells in hardwoods is much more complicated than in conifers.

TABLE 1—WEIGHTS OF WESTERN WOODS

Species	Weight per cubic foot		Weight per M. Bd. Ft.
	Green Pounds	Air dry* Pounds	Air dry* Pounds
Alder.....	46	28	2,330
Oregon ash.....	46	38	3,160
Port Orford cedar.....	56	29	2,420
Western red cedar.....	27	23	1,920
Chinquapin.....	61	32	-----
Cottonwood.....	46	24	2,000
Douglas fir (Coast).....	38	34	2,830
White fir.....	46	27	2,250
Eucalyptus.....	70	52	-----
Madrone.....	60	46	-----
Big leaf maple.....	47	34	2,830
California laurel.....	54	39	-----
Sugar pine.....	52	25	2,080
Jeffrey pine.....	47	28	2,330
Ponderosa pine.....	45	28	2,330
Western white pine.....	35	27	2,260
Redwood			
Old growth.....	50	28	2,330
Second growth—open grain.....	43	21	1,760
Second growth—close grain.....	42	24	2,000
Sitka spruce.....	34	28	2,330
Black walnut.....	53	38	3,170
California black oak.....	66	40	3,320
Canyon oak.....	71	54	4,500
Garry oak.....	69	51	4,250
Black willow.....	62	-----	-----
Pacific yew.....	54	44	-----

From data by Forest Products Laboratory, U. S. Forest Service.

* Twelve percent moisture content.

The wood of a certain species of tree often varies a great deal. Redwood may be light and soft, or it may be relatively hard and heavy. Especially light or heavy redwood is graded out and used for special purposes. Douglas fir also varies. The fine-grained Douglas fir is

yellow colored and is sometimes called "Oregon pine" or "yellow fir." The coarse-grained Douglas fir is reddish and denser and heavier than fine-grained Douglas fir. It is sometimes called "red fir." Both kinds of wood can be cut from the same tree.



FIGURE 3. Redwood stump sprouts will partially restock a logged area. Groups as dense as this should be thinned.

Bark is also important in the redwood region. Redwood bark has valuable characteristics found in the bark of no other tree. Its remarkable fibers and chemical derivative have been found useful in many indus-

trial fields. Douglas fir bark can be shredded into a cork-like material for insulating purposes. The value and use of the bark of tanbark oak are known to every woodsman.

Sprouts and Burls

Another unusual characteristic of redwood is its ability to form sprouts, or "suckers." These sprouts are common in broadleaved trees but unusual in conifers. Nature has thus given the redwood a means of reproducing itself almost indefinitely without recourse to seed. Sprouts start from small buds which more or less automatically form under the bark when a redwood is cut or severely injured. They grow rapidly since a large root system is already established to supply abundant food materials.

The redwood's sprouting ability can be a disadvantage. Severe fires often cause sprouts to appear on the trunks of standing trees. These sprouts form many small knots which lessen the value of the lumber in the best portion of the tree.

Redwood burls grow on occasional trees for no apparent reason, much like warts appear on humans. A burl is nothing more than a bud which—instead of growing into a shoot—began an almost endless series of divisions upon itself. Thus a burl, in cross section, has a "birds eye" appearance formed by the countless divisions of a bud.

Cones and Seed

The ability of redwood to sprout is a definite advantage in the establishment of new forests in cut-over areas. However, the job cannot be done entirely from sprouts; to get good stocking, seed is necessary. Most conifers must depend entirely on seed for reproduction.

These important seeds are produced in the cones. In redwood cones there are four or five seeds under each scale, while Douglas fir cones have two seeds per scale. Each of these trees grows a new crop of cones and seeds each year. In the fall, when the cones are mature, the scales open and the seeds are released in large quanti-

ties. The average pound of redwood seed contains 116,000 seeds. About 6.4 pounds of redwood cones will yield a pound of seed. Douglas fir seed averages about 50,000 per pound; a bushel of its cones yields approximately one-half pound of seed.

With this large seed production each year, regeneration of the forest would appear a simple matter, provided a few trees were widely scattered in each cut-over area. However, not all seeds fall on soil. Of those that do, only part are fertile, and of those that germinate, only a few survive. Generally, 20 or 30 percent of redwood seed can germinate; usually about 70 percent of the Douglas fir seed is good. Only a small part of the seed which actually germinates ever grows into a tree. Most seedlings are killed by insects, disease, rodents, fire, drought, shade or some other cause. In the Pacific Northwest, it has been found that eight pounds of tree-borne seed are required to reforest an acre of logged-over land.

THE FOREST

The shape of a tree and its value are affected by the tree's relationship to its neighbors. The value of the forest after it is cut is largely determined by the type of cutting that was made. The method of cutting determines the quantity and quality of the timber available for the next cut.

Open-Grown and Forest-Grown Trees

When a redwood or a Douglas fir tree grows and matures in the open it assumes an extreme form which is easily recognized. The open-grown tree is very different from a forest-grown tree in these important respects:

1. The tree is extremely limby and would obviously yield low-grade lumber. Considering its diameter, the tree is not as tall as it would be if forest-grown.

2. The "taper" on the trunk is high, increasing slab waste and yielding sawlogs of low lumber scale considering gross volume and weight.

3. Logging and milling costs would be above average per thousand board feet.

4. Diameter growth is very rapid. Since annual rings are wide, the wood will be coarse grained.

5. The tree is very wind-firm.

6. The tree often produces a heavy crop of seed.

With this tree in mind, consider now a dominant tree grown in the forest in competition with other trees:

1. The crown is high; the lower portion of the trunk is fairly clear of branch-stubs. The tree will yield a high proportion of upper-grade lumber.

2. The tree is tall; height bears a better relation with diameter for the logger.

3. The "taper" is slight, yielding sawlogs with good lumber yield.

4. Logging costs will be below average per thousand board feet.
5. Diameter growth is relatively slow and annual rings narrow enough to yield good quality lumber.
6. The tree is not as wind-firm as an open-grown tree.
7. The forest-grown tree produces less seed.



FIGURE 4. There are high values in stands of redwood such as this. The amount of present and future returns from the area will vary greatly with the type of treatment it receives.

These facts make it clear that there exists an important relationship between tree *quality* and the *density* of a stand of trees. Open-grown trees are almost worthless. But trees growing in competition with others

develop a form and quality that make them desirable for lumber, more economical to log and profitable to mill.

The Forest—A Community of Trees

A forest is a community of trees. While each living tree in the forest community occupies a space of its own, it must always compete with others for room in which to continue to live and develop. As in a community of human beings, each tree is deeply affected by the others it competes with, and its final form is the end product of how well it fares in competition.

A young forest sometimes begins with all the trees about equal in age and vigor. But the competitive features of a forest community are soon felt. Certain trees will grow out ahead of all others. They enjoy every advantage. They become the *dominants*. Still others will lag a bit behind. These become the *codominants*. A still greater number will grow less rapidly than the *codominants*. They are the average individuals and are called the *intermediates*. Often there are a large number of luckless ones which lag so far behind they get nowhere. These are the *suppressed*.

By the time the forest approaches maturity, the *dominants* will be the largest and fastest growing trees. The *codominants* will be just behind the *dominants* in size and vigor and will probably be of somewhat better quality. The *intermediates* will be growing slowly, but steadily, laying high quality wood on trunks quite free of branches. *Suppressed* trees will still be hanging on in the shade of other trees.

Meanwhile a large number of trees will have died. An acre on which stood a thousand small poles, at maturity may have less than fifty trees. In maturing stands of redwood and Douglas fir, the ground is often laced with fallen dead trees that have lost out in competition.

Strangely enough, poor timber growing sites usually have more trees per acre than good sites. But the trees are smaller in height and diameter and contain less volume. Competition on good timber land is more severe;

the forest advances at a more rapid pace and produces a larger volume of wood on a fewer number of trees.

The forest community is always changing. If fire, cutting, insects, disease or natural competition removes a single tree, that removal definitely affects other trees. The degree to which other trees are affected depends, of course, on the position and importance of the tree that was removed. Cutting a badly suppressed redwood pole would have little effect on surrounding trees except perhaps to give a little additional root space to remaining trees. Cutting a dominant tree, on the other hand, would have a very noticeable effect on surrounding trees and on the soil as well. First, several smaller trees, which the larger tree overshadowed, would be given additional growing space. The growth rate on these several trees would be increased. (Figure 13.) After a few years the growth on these released trees will offset the growth lost when the dominant tree was felled. The floor of the forest where the dominant tree stood is now able to support several new seedlings in the partial shade.

In falling, the dominant tree might conceivably damage one or more trees with resulting effect on them and their immediate neighbors. A broken top on one of the damaged trees, would naturally upset the local competitive balance since this tree would lose some of its power to grow and compete with others. A skinned tree would affect—though slightly—the ultimate cull and degrade in the forest.

What Happens When Old Growth Is Clear-cut

Redwood forests have been growing in California for many hundred thousands of years. Except for natural catastrophes, these forests have grown undisturbed. A single tree would fall to be replaced by another which, in turn, would grow large, become decadent, and likewise fall. The forests always had the appearance of old growth forests. This natural process produced redwood forests composed of trees of many different ages and different sizes.

The redwood, able to grow under the shade of other trees, and with a life span measured in centuries, was

the master of the forest. Whitewoods were the lesser trees. They needed more sunlight. Their lives were relatively short. Thus it was necessary for them to live as transients in opportune holes, along the edges of the forest, or on sites less favorable to redwood.

To these forests which reproduced themselves by only occasional deletion and addition of individual trees, the logging that eventually came and almost cleared the land was a terrific shock. The forests, by nature, were unprepared for such a turn of events. Nevertheless, new forests of one kind or another were established after clear-cutting. Redwood showed remarkable ability to come back. Only on the poorest soils, or where there were repeated fires, did redwood fail.

An examination of redwood land just after the forest has been clear-cut and the slash burned reveals a number of interesting things:

1. The surface of the soil is much warmer and drier than ever before.
2. The growth of weeds and brush is greatly accelerated.
3. Tree seed is scarce or wholly absent.
4. There are practically no young trees present.
5. Growth in board-foot volume has been reduced to zero.
6. The only conifer growth appearing is redwood sprouts.

The net result of these six conditions is reflected in the new forest that follows slash disposal:

1. The warmer, drier soil hinders the establishment of conifer seedlings. On south slopes, the hot, dry conditions may prohibit seedling growth. In the north coast, exposed ash-covered forest soils may have a temperature 15 to 20 degrees above normal, which is high enough to kill 90 percent of the seedlings. The effect of heavy slash fires on seedling establishment is believed to last 10 years.

2. While weeds and brush help prevent the soil from washing away, they greatly hinder the early growth of seedlings. Fifteen to twenty years or longer are re-

quired for small trees to get their crowns above the brush.

3. The scarcity of seed, or the absence of a sustained seed source from standing trees, greatly lengthens the time required to get a dense stand of young timber. Ordinarily it means a loss of 20 or 30 years—or the time required for sprout redwood and Douglas fir to begin producing seed.

4. The absence of sound immature trees on an area that has been clear-cut means that natural reforestation is just that much slower. There are few trees left standing to provide the framework on which actual board-foot volume can immediately grow and thus give the new stand a running start. The absence of immature trees lengthens the time between cuts, and decreases the quality of the future timber.

Reserved trees also have the important job of providing seed to the cut-over area.

5. When a forest is clear-cut, growth in *board feet* is reduced to zero. Young trees for many decades put on only *cubic-foot* growth. This situation can be likened to a rancher who sold all his breeding cows and must wait until his calves grow up before he can again start raising beef. Although pulpwood and wood fiber are increasing in use and importance, the backbone of the redwood timber business is now and will always be lumber.

6. Redwood sprouts are unable to fully restock a cut-over area. Ordinarily, sprout growth alone gives only 20 to 30 percent stocking. Sprouts may eventually spread their crown until they cover the area with what appears to be a well-stocked forest. But actually the sprout-growth forest contains a relatively few number of trees. These are of poor quality, with many branches. In form and quality they may resemble the open-grown tree.

7. The large accumulation of slash that is associated with clear-cutting, when broadcast burned, makes a very hot fire. Heavy slash fires often kill remaining

trees—especially whitewoods—and leave the soil in a condition unfavorable to seedlings.

The answer to the question “What happens when old growth is clear-cut?” can be quickly summed up: After clear-cutting, redwood forest must regrow under extremely unusual and unnatural circumstances of soil and seed supply. Productivity in new forests, measured in board-foot growth, will be below normal, and quality of the timber will be inferior. From the dollar and cents point of view, the new forests will require many years to reach merchantable size.

What Happens When a Forest Is Partially Cut

When a forest is partially cut the area is left in a condition more nearly resembling the virgin state. Partial cutting may be light, or it may be quite heavy.

If the cut is light, only a few of the largest trees are cut. The natural conditions in the forest are not greatly disturbed. Reproduction comes about naturally. Growth rate in board feet may be, and usually is, accelerated. Slash accumulation is light and creates no great problem.

If a fairly heavy partial cut is made, a substantial part of the volume is cut, but a relatively large number of small trees is left. While conditions on the cut-over area differ considerably from virgin conditions, there are certain features about it which make reforestation much more positive.

First, the trees that are left (the “leave trees”), can supply seed and some protection to the soil. Second, the leave trees are there to *grow*. Growth on these residual trees is surprisingly good. They provide a continuous board-foot income from the land while seedlings and sprouts are growing to tree size. By the time the young growth reaches merchantable size, the trees left by the first cut will form a good portion of the second cut.

Heavy partial cutting leaves a fairly large amount of slash scattered among trees which must be saved. What to do with the slash, and how to do it is a diffi-

cult problem. It is discussed in another section of this manual.



FIGURE 5. Old-growth redwood logging operation using a system of partial cutting in which more than 30,000 board feet were left per acre. Residual trees will provide seed for the openings that will be left between stump sprouts. They will also add considerable growth before "sweetening" the second cut. (Photo courtesy of Arcata Redwood Co.)

Early loggers, who logged with jack-screws and later with bull teams, actually made partial cuts in old growth. They left trees, singly or in groups, which were considered uneconomical at the time.

Their casual logging methods did not destroy all the residual trees. Thus—by accident rather than design—they left much of the cut-over in fair condition. The

best young-growth stands today occur on land logged with jack-screws and bull teams. This young timber is now 40 to 90 years old. The best and oldest "river logged" areas on one large holding were cruised and found to average 82,000 board feet per acre. On the same holding, dense young timber on slopes, averaging 50 years old, was cruised at 30,500 board feet per acre. Of this volume, over one-fourth of the present volume was contained in trees left behind the bull loggers.

These examples show what partially cut redwood land has done, but they do not show what it could do. Actually the areas cruised were understocked and the average annual board-foot growth about half what it could be.

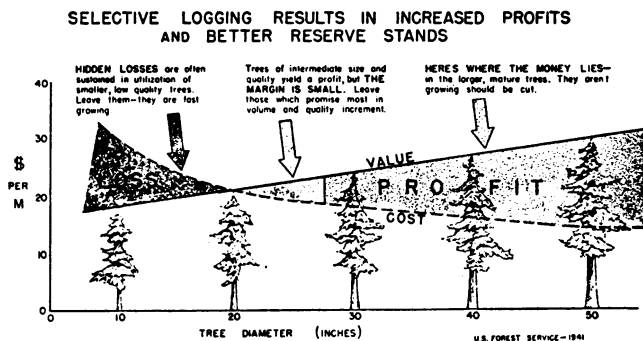


FIGURE 6

Dollars and Cents and Partial Cutting

Logging and timber growing are a business whether large or small tracts are involved. As such, they are subject to the same economic considerations as farming or storekeeping.

Partial cutting not only leaves forest land in better condition to regrow; it has definite dollar and cent advantages as well:

1. Partial cutting maintains volume growth. This growth is no different than interest on money or on a capital investment.

2. Cutting larger trees and leaving smaller ones increases the average log size on an operation. Log size has a very marked effect on logging costs.

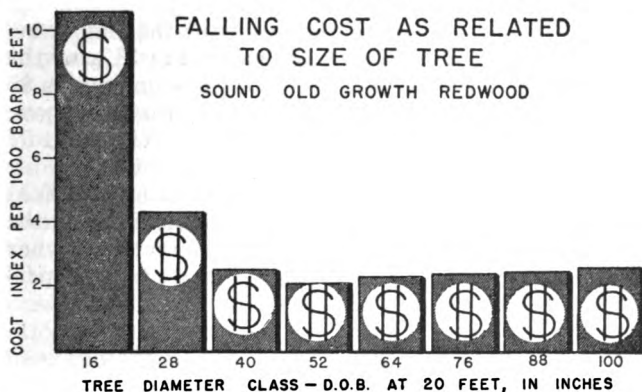


FIGURE 7

Figure 7 shows how falling costs per MBM* are affected by size of tree. On the logging show where these costs were kept, a 52-inch redwood cost the least per MBM to fall. Generally, between a 40-inch tree and a 100-inch tree there was only a small difference in falling costs. For trees under 40 inches falling costs increased sharply.

That peeling costs per MBM decrease steadily as log size increases is shown in Figure 8. When cutting is confined to the larger trees, logs will have a greater average volume, and the all-over peeling cost per MBM will be less.

Yarding and loading cost less per MBM for moderately large logs than for small ones. Figure 8 shows this relationship.

Hauling costs per MBM likewise decrease as average size of logs increases up to a certain point.

3. Partial cutting results in greater depletion allowances for income tax purposes. First, a study is required

* Thousand board measure.

to find the market value of the products that can be made from trees of different size, quality and species. Suppose, for example, the study shows that a cut taking 70 percent of the *volume*, removed 92 percent of the *value* of the stand. The actual value of the timber removed, then, is not the average value, but $\frac{92}{70}$ of the same. Thus, if the average value of the stumpage is \$5 per M, the owner can, for timber depletion purposes, claim \$6.57 per M ($\frac{92}{70} \times \$5 = \6.57). This is \$1.57 more than the average stumpage value set up in his books. The \$1.57 per M on an annual cut of 10,000 M feet is \$15,700 extra depletion to be deducted from the taxable income. If the tax rate is 25 percent the owner would pay currently \$3,925 less in income tax (25 percent of \$15,700).

TOTAL COSTS OF BARK PEELING, YARDING, & LOADING AS RELATED TO LOG DIAMETER

BASED ON GREEN REDWOOD LUMBER TALLY
FROM DATA BY R & WAGNER

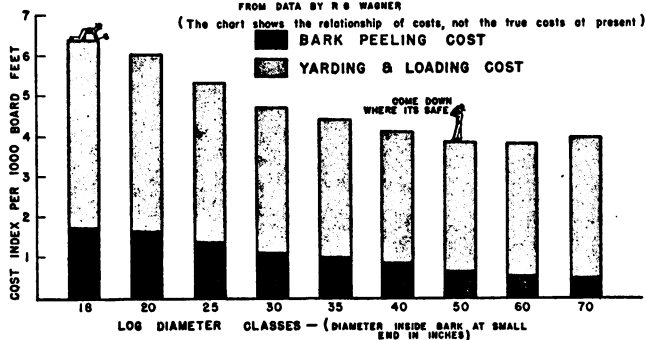


FIGURE 8

4. Partially cut areas, which are adequately restocking and actually growing timber, have positive values. As virgin timber becomes less and less abundant, the value of new growth timber will gradually increase. In all probability, the good regrowth on redwood lands will some day be more valuable than old growth today. In every timber growing region in the United States where virgin timber is now depleted, the "second

growth" has a higher stumpage value than had the virgin timber.

In an ideal situation, sawlog operators could make light cuts. They could cut only the ripest trees or the ripest groups of trees, returning to the area every 20 or 30 years for another light cut.

However, as in other businesses, such factors as property taxes, risk of fire loss and costs of production must be considered. Because timber growing is a long term business, the importance of the property tax is real. In California at least 70 percent of the trees 16 inches in diameter must be cut to remove the tax on the timber of an area. The land continues to be taxed. The risk of loss from fire is greater in the timber business than in most other enterprises. Logging operations increase the hazard. Usually the owner must bear the cost of the additional fire protection required to safeguard the timber values left by partial cutting. One of the important costs of producing saw logs in the redwood region is the construction and maintenance of logging roads. Partial cutting results in an increase in road costs per thousand board feet of lumber cut.

These factors tend to discourage partial cutting. Actually they are only important enough to require that something more be cut than what would be left under ideal conditions. The amount that should be left will vary with the individual operation. Almost without exception, the economic advantages of partial cutting more than outweigh the disadvantages.

The Young Forests

The young "second growth" forests of today differ from the virgin forests in several important respects:

1. They are composed of trees of about the same age, but of all sizes and quality.
2. They are usually understocked—annual growth and gross volume being less than it should be.
3. The stands will become merchantable, under future standards, at an early age—about 80 to 100 years.

4. The stands will yield a much higher percentage of the common lumber grades than did virgin redwood.

5. The stands contain a large amount of inferior material for which uses—other than lumber—must be found.

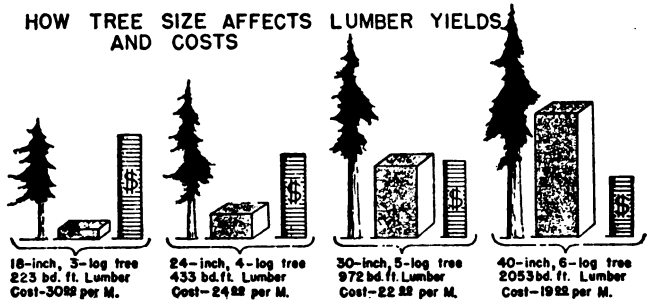


FIGURE 9. It is necessary to cut more than four 18-inch trees to get as much lumber as is yielded by one 30-inch tree. The lumber from the 18-inch tree costs almost half again as much per 1,000 board feet to produce as does the lumber from the 30-inch tree and it will have less quality lumber per 1,000 board feet. Costs are prewar and are used only to make the comparison between tree sizes.

The character of these young forests will largely determine what should be done with them. Consider, for a moment, the character of a rather typical stand of dense 60- to 80-year-old timber on river bottoms. About 1,300 acres were cruised and the *average acre* was found to contain:

1. A gross volume of 82,083 board feet in trees over 17" in diameter.
2. An average of 47.3 trees 8" to 16" in diameter, with a volume of 1,180 cubic feet.
3. An average of 52.5 trees 17" to 30" in diameter, with a volume of 33,934 board feet.
4. An average of 15.8 trees 31" to 40" in diameter, with a volume of 30,656 board feet.
5. An average of 3.4 trees 41" to 50" in diameter with a volume of 11,599 board feet.

6. An average of 1.8 residual trees, left by early loggers, having a volume of 5,894 board feet.

7. An average of 94 percent of the volume was redwood, the balance whitewoods.

Note that trees 31" and over in diameter contain 48,149 board feet, or 60 percent of the total board-foot volume. Yet this volume is contained in 21 trees—a little over 16 percent of the total number of trees.

Thus, 60 percent of the board-foot volume (48,149 board feet) of this stand could be harvested by cutting 16 percent of the trees. Such a cut would probably get 75 percent of the values in the stand.

Consider, now, dense young growth averaging about 50 years old growing on slopes. Based on a cruise of about 5,800 acres of this kind of young growth, the *average acre* was found to contain:

1. A gross volume of 30,571 board feet in trees over 17" in diameter.

2. An average of 50.9 trees 8" to 16" in diameter with a volume of 1,648 cubic feet.

3. An average of 43 trees 17" to 30" in diameter with a volume of 17,645 board feet.

4. An average of 3.1 trees 31" to 40" in diameter with a volume of 5,160 board feet.

5. An average of 3.5 residual trees, left by early loggers, with a volume of 7,765 board feet.

6. An average of 67 percent of the volume is redwood, the balance whitewoods.

If this stand were partially cut to remove trees over 30" in diameter, 42 percent of the board-foot volume (12,925 board feet) could be cut by selecting only 7 percent of the trees. A 70 percent cut, by volume, would leave 70 percent of the number of trees.

Cruises on a large area of average to densely stocked 40- to 60-year-old second growth showed an average per acre volume of 15,200 board feet. Fifty-three percent of the board-foot volume, 8,036 board

feet, was in trees over 31" in diameter. Two-thirds of this volume was in residual trees left on the area when the virgin timber was cut. The volume was contained in only 8 percent of the trees. Redwood made up nearly 90 percent of the volume. On this average acre, there were over 1,100 cubic feet of small material.

Partial Cutting of Young Forests

The foregoing descriptions of several kinds of young redwood timber show how well these stands are adapted to selective cutting. Under such a plan it is possible to get a substantial cut in volume and value and yet leave a large portion of the trees upon which growth can continue.

Selective cutting, in fact, is the only way to cut the new growth. Clear cutting would result in the waste of the small diameter trees which are needed to maintain board-foot production after the larger trees are cut. Generally, the trees removed in a selective cut are the largest in the stand, including old growth residuals. Their removal releases the smaller trees from competition and permits them to grow at a higher rate. Under selective cutting, board-foot volume growth is a continuing process.

The selective system of cutting young redwood is adaptable to nearly all stands. The volume of the cut and what trees should be removed, must be determined for each operation. In any event, the cut should result in an all-over improvement in the *quality* of trees in the stand. This can be done by taking the inferior trees in the initial cut. If the inferior trees are left to occupy space to the exclusion of better trees, a so-called selective cut becomes little else than "high grading."

In new forests there may always be the problem of disposing of low-grade material. These forests contain an immense volume of wood that will never make saw logs. It is assured that much of this volume will find future use in the pulp and pressed wood industry. A small amount will be used for posts and poles after being treated with wood preservatives.

Sometime in the future, thinning young stands for pulpwood may be entirely possible, especially on good sites. Thus, these stands can be cleaned of inferior trees early in life which will result in increased growth on better trees and a greater volume recovery. The old saying: "A penny saved is a penny earned" applies here. Volume saved is volume earned.

Pruning branches off the butt-log of a few of the best young trees on each acre may be necessary some day in order to increase the amount of upper-grade lumber in the stand.

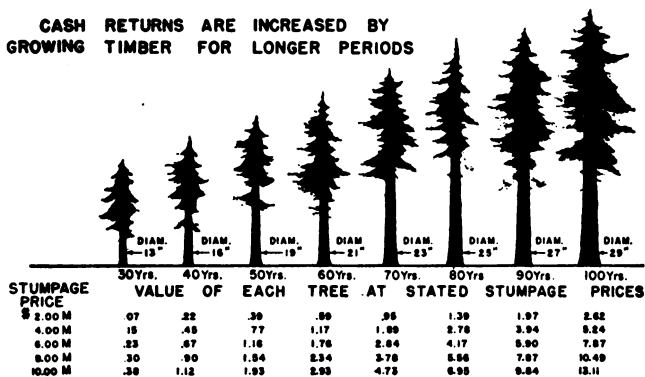


FIGURE 10. Permitting a tree to grow from 21 inches in diameter to 29 inches may take 40 years. However, the return on this investment for the future is equivalent to nearly 4% compound interest. If 13-inch trees are left for 70 years the value is increased 35 times, a return of better than 5% compound interest.

Young Forests After Cutting

Selective cutting of young growth forests will gradually develop stands that have trees of all ages and sizes. In this respect they will be similar to old growth timber. The stands will then be much better adapted to selective cutting than they are now.

Prolonged cutting will also develop redwood forests composed chiefly of sprout growth. This is sure to follow. Stands now containing sprouts plus redwood

seedlings after one or two cuts will be composed almost entirely of sprout redwood.

This forthcoming condition brings up an important point regarding the felling of young growth: the falling-cut must be made as close to the ground as possible. Sprouts on high stumps are not well-seated. If high stumps are cut, each succeeding generation will grow higher off the ground, which will make for difficult falling and poorer sprout growth.

Example of Partial Cutting

The pictures on the following two pages illustrate moderately heavy partial cutting in a second-growth redwood-Douglas fir forest.

The first picture shows an actual stand 60 years old growing on about one-fifth acre and having a volume of 8,150 board feet, plus 92 cubic feet in small trees. Of the board-foot volume, 4,500 board feet is contained in the one large residual redwood; the balance, 3,650 board feet, is second-growth redwood and Douglas fir. There are 22 trees.

The cut takes out nine trees :

4,500 board feet in old growth
2,720 board feet in second growth
22 cubic feet cordwood

Left standing are 13 trees which contain :

930 board feet
70.2 cubic feet

After 20 years the stand will look similar to the second picture. It may have 27 trees ranging in size from four to 24 inches in d.b.h. and containing :

3,370 board feet
118 cubic feet in small trees

The stand now, after 20 years, has almost the same gross volume (board foot plus cubic foot) as was present in the stand before cutting, excluding the old growth tree. Also the gross volume 20 years later exceeds the second growth volume cut, even though the cut removed nearly 80 percent of the original second growth volume.

The growth rate for the 20 years following cutting has been about 700 board feet per acre per year. During the first 60 years, the average annual growth per acre was about 600 board feet.



FIGURE 11. This land owner and his son are considering which trees in their second-growth stand should be harvested. They have decided to cut the larger Douglas fir at the left and the large, fire-scarred, old-growth redwood. The group of sprout grown trees around the large redwood stump need thinning and the largest of these is suited for saw logs. Two other dominant redwoods, behind the man, have grown to economic maturity. The many branched, highly tapered, wolf tree should be removed as should the spike-top at the right.

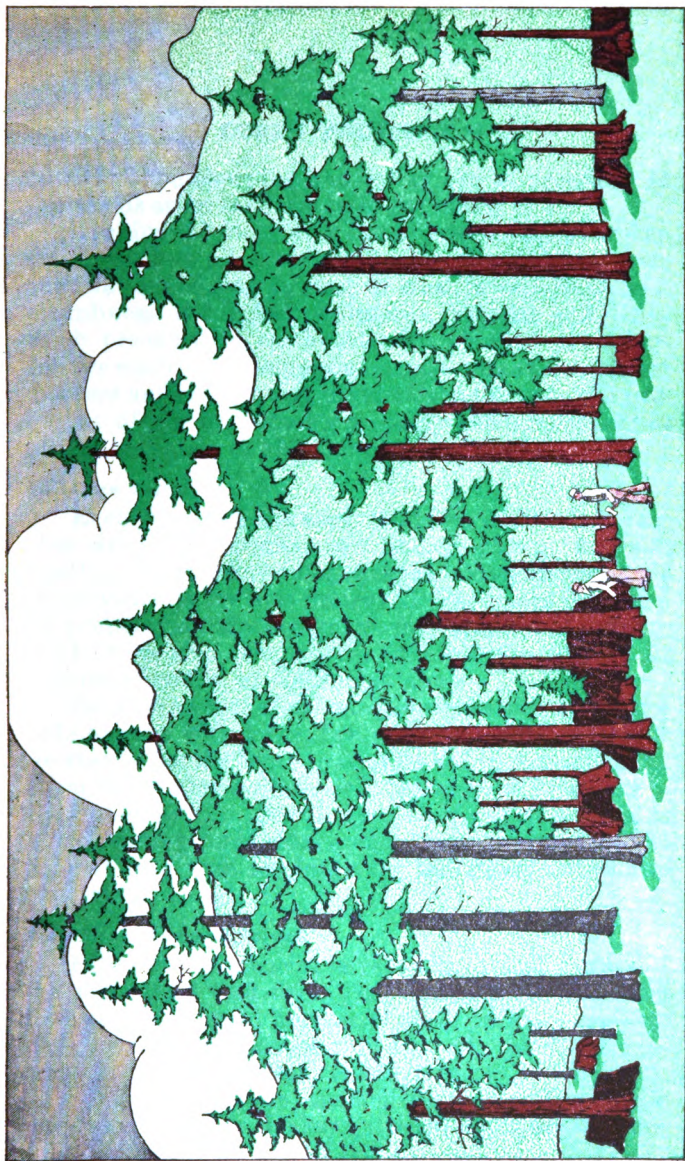
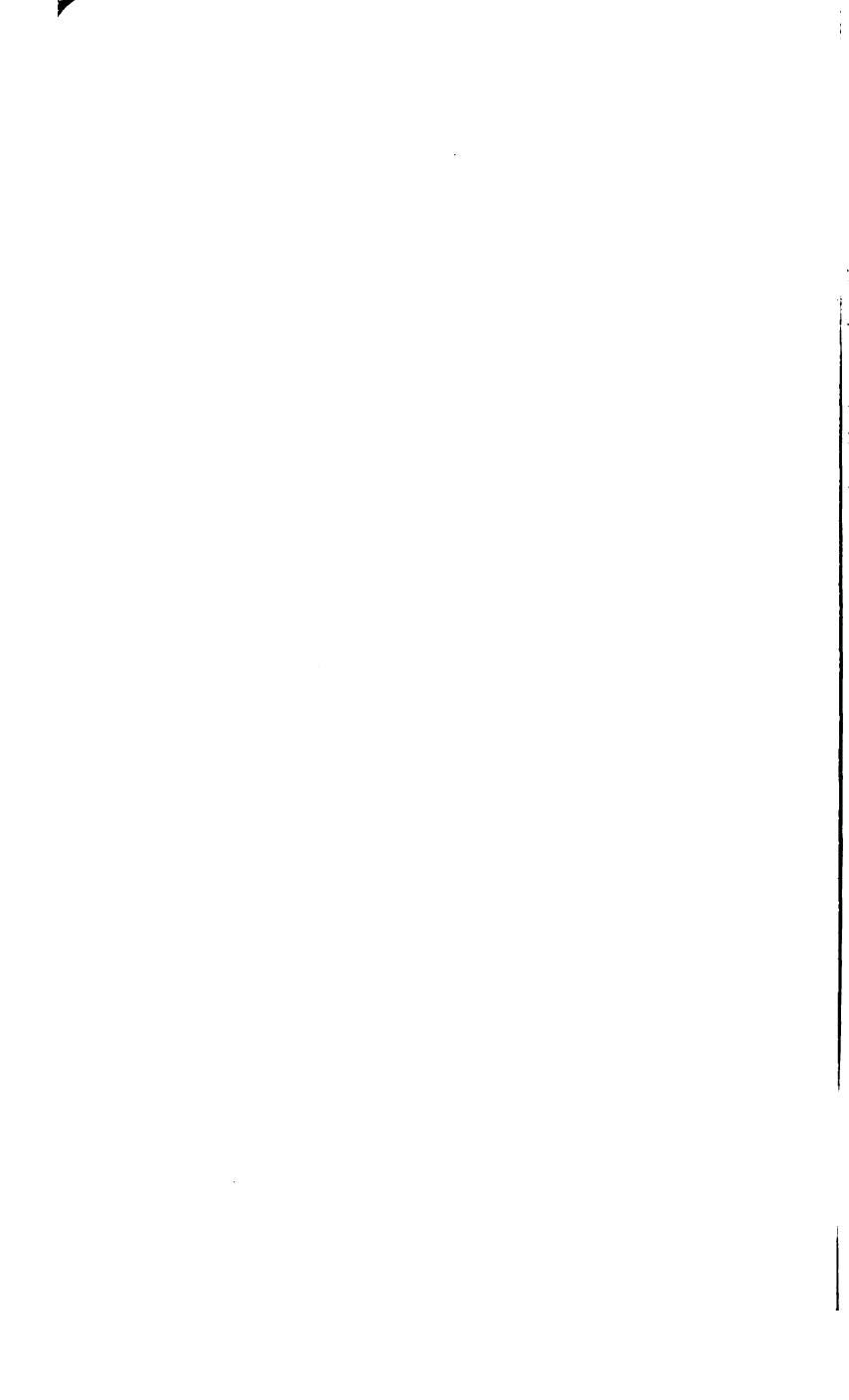


FIGURE 12. The results of planned partial cutting are evident several years later. The removal of the larger and poorer trees has made it possible for the healthy, well formed residual trees to grow rapidly into another valuable crop.



FOREST PROTECTION

Good housekeeping and safety are as necessary in the woods as on the farm or in the home.

Keeping the forest area clean of fallen snags, broken trees, sawdust piles, bark and slab piles and heavy accumulations of logging slash or trash is important, as is cleanliness of logging equipment, vehicles and mills. Such precautions, combined with planned provisions for fire control and suppression, and reduction of forest diseases and insects, pay dividends not only in the protection of the landowner's property and employees but also in the safety of his neighbors' property.

Fires Are Costly

Each year there are many wild fires in forested areas that damage or destroy saw timber, young trees and seedling growth. Sawmills, ranches, houses and valuable improvements are also destroyed. The losses sustained by property owners are staggering. The cost of fighting wild fire is also tremendous, running into millions of dollars annually in California alone.

Because owners of private properties are usually not able to cope with large, fast-spreading wild fires, it is necessary for the State to lend its aid in extinguishing them before they do damage to resources so necessary to the public welfare. For this reason the State maintains a fire-fighting force. Emergency funds are provided to combat wild fires too large for individual citizens to control.

Why Fires Start and Spread

Fire control agencies have made careful studies of the records of wild fires. They have found that most fires start or spread because of some person's carelessness, or because someone failed to take safety precautions in the management of his property.

Some of the more common sources of fire in the woods are tractors, donkeys, trucks, warming fires, un-

screened debris burners, open fire pits, burning tobacco, matches and friction. Dry lightning storms occasionally start fires in the redwood region.

The studies of wild fires have also indicated that an accumulation of slash, bark piles and other debris makes it very difficult to put out a wild fire or keep it from spreading. In the redwood region this holds true even twenty to thirty years after logging. For this reason many fires spread rapidly and stubbornly, and do extensive damage before they can be controlled.

In their virgin state, before man cuts the trees or disturbs the forest, timberlands are not considered hazardous. As soon as the chopper starts work and machinery is taken into the woods to remove the logs, man provides the *risk* of starting wild fires. As the trees are cut, a *hazard* is then created by the accumulation of slash, broken trees, and new growth of weeds and brush. The removal of trees usually opens up a forest, allowing more movement of dry air through fuels close to the ground, causing them to dry more thoroughly and rapidly than if there existed a protective cover. Even lightning, which man cannot control, starts fires which spread rapidly because of the newly created hazardous conditions.

Weather and Fire

Weather and climate are important factors in the starting and spread of wild fires. The wind velocity and amount of moisture in the air are perhaps the most decisive weather agents in this respect. The air contains varying amounts of moisture at various seasons and even during different times of the day and night. The relative amount of moisture the air contains compared to what it can hold at any given temperature is called "relative humidity." A relative humidity of less than 30 percent combined with wind will usually result in a hazardous condition during the summer or fall months when fuel is dry.

When the air is drier than such fuels as vegetation debris, slash, sawdust and other inflammable material,

they give up their moisture to the air. A strong movement of dry air causes the fuels to dry out more rapidly. The amount of this moisture in forest fuels is termed "fuel moisture" and, like relative humidity, is used to help determine how dangerous fire conditions are. It is measured by weighing specially treated sticks after exposure to the air. The difference in weight between their "dry" state and that after exposure provides a measurement for determining the amount of moisture in all fuels of the same area. A fuel moisture of 8 percent or less is usually unsafe if the relative humidity is low.

There are a number of instruments used by the Weather Bureau, fire control agencies and lumber companies for gauging fire weather conditions. These instruments are available at reasonable cost.

The combination of drying winds, high temperatures and dry fuels sets the stage for a wild fire. All that is needed to set it off is the tiny spark which will heat some particle of fuel to the point of ignition. Although this condition does not occur during many months of the year in the redwood region, it can be expected in varying degrees after early July, with increasing frequency into the latter part of September. These critical conditions may last until the fall rains, extending into October and even November.

In the State of Washington where weather and logging conditions are similar to those of the redwood region the following guide has been prepared for woods operators for use during the fire season :*

"When relative humidity at 7 a.m. is 60 percent, be prepared to shut down when it goes to 30 percent.

"When relative humidity at 7 a.m. is 55 percent, be prepared to shut down when it reaches 35 percent.

"When relative humidity at 7 a.m. is 50 percent, be prepared to shut down at 40 percent relative humidity.

"When in addition to the above two latter basic factors the wind is from the east, it is better not to

* From West Coast Lumberman.

open up the operation on that particular day. If the wind is in the north quadrants, west to north, or north to east, and reaches 20 miles per hour—shut down. If you do start a fire, you haven't a chance if it gets to be bigger than a quarter acre."

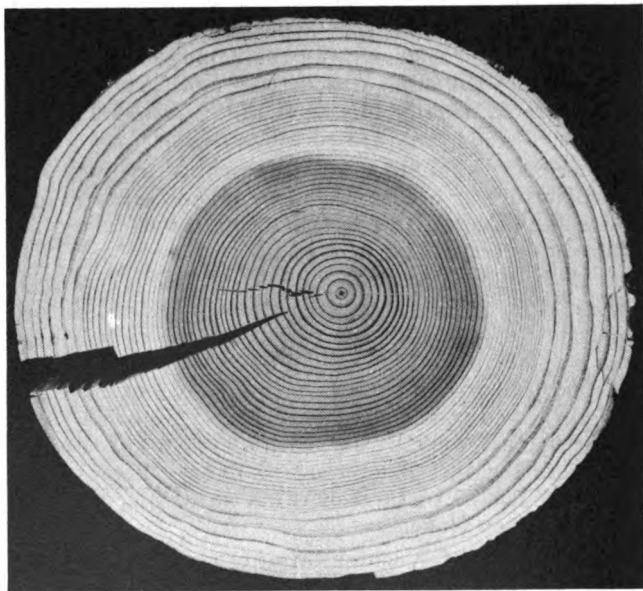


FIGURE 13. This redwood, left after logging, greatly increased its rate of growth when the competing trees were removed. If protected from fire, trees such as this will reach merchantable size much sooner than those in uncut stands. (Photo from E. Fritz)

Fire Prevention and Control

It is not always easy to prevent fires from starting, even when care and safety measures are used. It is recognized that machinery and men are necessary in the woods to conduct a lumbering business; that it is not always possible economically to eliminate all of the hazardous conditions during and after a logging operation; and that under certain conditions the use of fire

is also necessary. The main problem facing the forest owner and operator is to minimize the fire hazard and fire risk.

There are, in the main, three precautions that can be taken by the timber operator.

The first includes recognition and control of the fire risk. As noted previously, this is concerned with the use of machinery or apparatus capable of making sparks or flame; friction; and the general habits of the workmen through smoking and warming fires. The control of this factor can be attained by the use of spark arresting equipment such as spark arresters on tractors, trucks, automobiles and engines; and strict control of workmen's smoking habits and warming fires. It is not necessarily recommended that smoking be prohibited in the woods, but rather that smoking be controlled and restricted to safe places at safe times. The use of lands by the general public for recreation or by trespassers constitutes a risk which places an extra burden upon the owner. The owner's responsibility here lies in sincerely trying to control both the authorized and unauthorized use of his lands. This can usually be accomplished by a friendly public relations attitude requiring only authorized use of the land by permission, with the provision that care be taken to prevent damage to the property through smoking, camp fires or otherwise.

The second precaution is one of keeping hazardous conditions to a minimum through good housekeeping practices. It is recommended that the reader carefully review the California Fire Prevention Laws and the Redwood District Forest Practice Rules. They may be obtained from your local State Division of Forestry office. These laws and rules set forth the *minimum precautions* to be taken by timber owners and operators. There are, of course, many things not mentioned in the laws and rules, such as keeping machinery free of hazardous materials like grease and sawdust; clearing away inflammable material along roads; and clearing secondary fire breaks around extra hazardous places

(such as debris burning devices, etc.) where the risk of fires starting is high.

The third precaution is being prepared to extinguish any fire that should start. This requires well-placed tool caches, adequate and efficient fire fighting equipment with well-trained personnel. There have been numerous cases where untrained personnel have been instrumental in spreading fire through improper attack and using the wrong equipment. Cases have also been reported where improperly placed hose and tool caches have burned before a crew could reach them. Such occurrences can be avoided with proper planning.

By thoroughly examining his fire problems and preventing the start and spread of fire, the property owner is, in great measure, insuring himself against a very real liability. In addition to protecting his own investment he must see that his neighbor does not suffer because of fire escaping from his property due to his having created a hazardous condition and serious fire risk.

The cost of providing an adequate system of fire protection depends on the existing circumstances. The condition of the timber land, whether virgin growth or cut-over; the extent of accumulated hazardous conditions; the type and amount of vegetative cover; the amount of public use; and the logging method used all contribute to variable costs. With good planning most of the fire prevention measures can be included in the general operations costs. The cost of maintaining fire protection facilities, fire patrols, watchman service, and removal of special hazards should be kept within the scope of the operation. The best available estimate for fire protection cost is \$1 per acre for the initial outlay of equipment plus an annual cost of 15 to 20 cents per acre for operation, depreciation and hazard removal or other prevention measures.

Decay in Forest Trees

If defective trees are regularly removed in the cutting operations on a forest that area will suffer less loss of merchantable timber from decay.

Redwood and whitewoods alike are subject to wood rot or decay. Rot is the most common form of defect. Sometimes nearly a fourth of the gross volume is lost through rot. In most old growth forests, the volume lost currently by decay equals the growth rate of sound wood. Thus, such forests have little net growth and are storehouses, rather than producers, of wood.

In redwood there are few indications of decay externally visible. For that reason the Humboldt log rule is used to allow for unseen defects, including rot. Brown heartrot is the common rot in redwood trees.

Douglas fir usually shows visible signs of decay. Three rots are found on Douglas fir: top rot, butt rot, and the common conk rot which occurs in the main part of the trunk.

It was once thought that wood decayed in much the same manner as iron rusts. Now it is known that wood decay is caused by various low forms of plant life called fungi. These fungi live in the wood, feeding upon certain wood substances and leaving behind the brown, punky material of decayed wood.

Wood destroying fungi spread by means of microscopic spores. The spores usually enter new wood through wounds in the tree such as broken branch stubs, fire scars, skinned places and the like. There, if conditions are favorable, it begins to grow, sending through wood cells the countless, minute fibers which cause the wood to decay.

The spores of wood rots are borne in the holes or gills of "conks" and mushroom-like growths on the tree or on the floor of the forest. "Conks" are common indicators of the so-called conk rot in Douglas fir. Redwood, however, does not show conks as signs of rot.

Early stages of decay in wood show on the cross section of a log as irregular discolored areas generally in the heartwood. The advance stage of wood rot is reached when the wood is wholly or partially reduced to the typical soft or brittle waste.

Wood rots that work on living trees do not continue to destroy wood after the infected material is

made into finished products. Lumber, posts and timbers are decayed by other forms of fungi like those found on down logs in the woods. Wood preservatives, such as creosote, protect wood from decay because the preservatives are poisonous to the fungi.

Insects of Redwood Forests

Although redwood is not seriously bothered by insects, its associate, Douglas fir, is subject to fatal attacks by the fir engraver beetle. This small, black beetle kills small trees and the upper portions of large ones. It mines between the bark and wood, girdling the tree and leaving characteristic butterfly-shaped engravings.

Good housekeeping is at least a partial answer to this pest. The engraver beetle sometimes develops large broods in fresh slash. They then move from the slash into the trees. Prompt slash disposal will hold such occurrences to a minimum. Where a large number of young trees appear to be dying in one area it may be necessary to have them felled and burned.

The most important insect pest of redwood is the termite, which does relatively little damage.

The alder bark beetle kills alder along stream channels, occasionally wiping out stands of merchantable trees.

Leaf eating caterpillars damage various kinds of oak. Sometimes large areas of oaks are defoliated in a spectacular manner, but trees are seldom killed.

TABLE 2—COMMON WESTERN ROTTS

Name of rot	Species of trees infected	External indicators		Type of rot	Shape on end of log
		Positive	Probable		
Conk rot or Tremetes pini	All conifers	Sporophores or conks (brown) swollen knots	Resin flow. Injury scars	Honey comb	Crescent shape to circular
Brown heart rot or Poria sequoia	Redwood	Sporophores (white) rarely found	Fire scars	Friable	Patches of irregular shaped areas
Brown stringy rot or Echinodontium tinctorium	Hemlocks; true firs; Englemann spruce	Sporophore (grey) and rusty and swollen knots	Injury scars	Stringy	Circular
Red brown butt rot or Polyporus schweinitzii	All conifers	Sporophores (brown) rarely found	Injury scars, resin flows	Friable	Circular unless around fire scars
Brown trunk rot or Fomes laricis	Sugar pine; ponderosa pine; Douglas fir	Sporophores (white) rarely found	Injury scars, resin flows	Friable	Circular
Brown top rot or Fomes roreus	Douglas fir	Sporophores (grey)	Injury scars. Sharp crook	Friable	Circular

EARL G. MASON in "Forest Mensuration."

SLASH DISPOSAL

The purpose of slash disposal is to reduce the immediate hazard to freshly chopped areas, and to provide protection so that a new forest may grow.

Since the method of slash disposal greatly affects the starting and growth of the new forest, the practices used must be carefully considered. The effect of hazard reduction on forest soil and future protection is also of primary importance. In addition, the cost of slash disposal is an economic factor to be considered by owners of timberland.

Results of Broadcast Slash Burning

Hot, broadcast slash burning as practiced in the past had little to recommend it. This type of burn reduces future forest production in a number of ways. These can be cited as the disadvantages of broadcast slash burning:

1. The method destroys enormous amounts of organic material reducing the fertility of the soil.

2. Blackened soil produced by hot fires will raise surface soil temperatures as much as 15-20 degrees above unblackened soil. Direct-seeding experiments on broadcast burned areas in Humboldt County have shown that 56 percent of the germinated seedlings on the north slopes, and 90 percent on south exposures, are killed by drying out of the soil.

3. Broadcast burning destroys most of the seed remaining on the ground after logging. Seed remaining on clear cut areas has often been responsible for a good young growth stand. Some people have wondered how the area could be so densely forested when no seed trees remain.

4. It stimulates growth of fireweed, other weeds and brushy plants. A dense growth of weeds and brush prevents seedling establishment.

5. It kills or severely damages residual trees. Fire columns, so common in the redwood region, are caused by the sprouting of fire damaged redwoods. Generally all of the whitewoods are killed. Little is gained if a partial cut leaves a considerable volume of young trees only to have them burn in a slash fire.

6. If redwood stumps have started sprouting, new growth is killed and the area is set back several years.

7. This type of slash disposal does not lend itself to a selective or partial cut.

8. While a hot broadcast slash burn temporarily reduces the fire hazard, studies show that after six years fires spread faster on burned than on unburned areas.

The advantages of broadcast slash burning are :

1. A hot broadcast slash burn immediately reduces the hazard. Adjacent "chopping" and operating areas are made safe from fires starting in the slash.

2. It removes a portion of the heavy fuel, reducing subsequent fire control work should the area reburn at a later date.

3. Broadcast slash burning is suitable for large clear-cut areas of slash where few residual trees remain. This type of cutting is on its way out. Truck and tractor logging methods, and the new Redwood Forest Practice Rules, contribute toward this trend.

There is little if any difference between a hot broadcast slash fire and a "wild" fire. Both do a great amount of damage, killing seed trees and reproduction and often escaping into chopping and uncut areas.

Spot Burning

Spot burning is a modified slash disposal method which obtains practically the same effect as a broadcast burn but with less damage to the residual stand.

In the spot-burning method, burning is confined to :

1. Heavy accumulations of slash and bark around landings.

2. The bottoms of gulches and draws where slash accumulates during logging.

3. Other places containing heavy slash.

Existing skid roads and logging roads are cleaned out and the area broken up into as many small, isolated units as possible. Pumping equipment, a few men, and a bulldozer on the burning job, will reduce the damage to the residual stand.



FIGURE 14. Partial cutting of this redwood stand should result in continuous production from the area, provided fire can be kept out. In such areas, it is advisable to be especially careful in slash disposal work in order to minimize damage to the reserve trees.

By breaking up the area, keeping logging roads open and maintaining a patrol during hazardous periods, spot burning becomes an effective fire prevention tool.

A bulldozer can more than pay its way during the burning job. Much of the heavy slash accumulation surrounds some of the best trees in the stand. These future crop trees can be saved by a few minutes' bulldozer work. Removal of the slash from around the base of these trees will see them through the slash disposal period.

Much has been written about the spot-burning method of slash disposal. Weather, time of year, experience of the men doing the burning all contribute to the success of the job. But the most important factor in slash disposal is a common sense approach to the prob-

lem which is shown, for example, in burning down rather than up the slopes.

Slash Burning Costs

In the Pacific Northwest, lumber companies engaged in the business of growing trees, estimate that an initial outlay of \$1 to \$2 per acre and an annual cost of 15 to 30 cents per acre will hold fire losses to 0.25 of 1 percent per year.

Actually slash burning costs very little. Adequate preparation of the area reduces the trouble often encountered in the burning job. A good plan for slash disposal reduces the annual protection costs while the timber is growing.

It is not good economy to dispose of slash without considering possible damage to residual trees and reproduction. A loss of \$10 in 1948 in volume, quality, or future growth, means a loss of \$71.07 in 1998, figuring interest at 4 percent.

A burned area in the forest, if it must be restocked from distant seed sources, fills in slowly. A poorly stocked forest costs as much in taxes, protection and administration as one fully stocked and fast growing. It is poor business to burn any forest area to decrease fire control costs that may never materialize. The forest owner is engaged in the business of growing trees. Fire protection is a means to this end.

Slash Disposal in Partially Cut Areas

The trend in the redwood region during the past few years has been toward a selective type of logging. With the progress toward a lighter initial cut comes the problem of how to dispose of the slash.

Slash in partially cut or selectively logged stands is difficult to burn without serious damage or total destruction of the residual trees and reproduction. "Hot burning" selectively logged areas creates snags, stimulates brush growth and increases annual fire protection costs.

The wholesale burning of partially cut areas is not good business. Fire damage to residual trees and repro-

duction more than offsets any good derived from burning. The use of fire may often increase hazard by adding to the amount of dead wood and slash fuels which fall to the ground for many years after the slash fires.

In some cases slash disposal is necessary even in partially cut areas. But this does not necessarily mean indiscriminate burning. On the contrary, slash burning should follow one, or a combination of, the following forms:

1. Burning a strip 100-200 feet wide around slash on an area adjacent to chopping or down timber.
2. Bulldozing trails around and through a slash area, breaking it into small units and making it accessible to firefighting equipment.
3. Spot burning of heavy accumulations.
4. Maintaining patrols during bad fire weather.

Partially cut areas must be given additional protection from fire until the closing of the forest canopy eventually returns the area to its original condition. In most cases the best way to grow a new forest is to give adequate fire protection during hazardous years immediately following cutting.

Reducing the Slash Problem

The large number of damaged trees following slash disposal has always posed a problem for the operator. Damage occurs during all phases of the logging operation. A few special precautions will effectively reduce damage to trees not harvested in the current cut.

Perhaps the best way to reduce logging damage is to mark future crop trees. This can be done with paint or any other way that will show up well in the woods.

These crop trees can then receive special treatment from choppers, the yarding crew, and during subsequent slash disposal. The particular care paid to these marked crop trees will automatically reduce damage to the remainder of the stand.

Relogging the heavy slash areas also pays dividends. Much of the waste material in cut-over areas consists of short logs, broken chunks and other pieces of

high quality material not able to pay its way into the mill. This material can be converted into shingles, split products and lumber on the ground.

There is a definite trend toward using more of this previously wasted material in the redwood region. Wood chip and fiber plants may soon find it economical to use woods waste.

As ways are found to utilize more and more of the heavy slash, and to minimize logging damage, the problem of slash disposal will be measurably reduced.

TIMBER CRUISING

Timber cruising is the art of estimating the volume of standing timber. This section describes two cruising methods which, if carefully applied, can be used to estimate timber volumes on tracts having fairly uniform forest conditions.

Usefulness of Timber Cruises

A cruise, in effect, is an inventory of the different forest products growing on a particular unit of land. Such an inventory is essential to the business-like purchase, sale or use of timberland or timber products.

The cruiser's report gives an estimate of board-foot volume by species; the size and number of trees making up the volume; and, in addition, the amount of other products such as piling, cordwood and tanbark. The report also contains information on terrain, with emphasis on the features that would affect the value or the harvesting of timber products.

Sampling—Basis of Cruising

A cruise is made by actually measuring, on regularly spaced strips or plots, a representative area of timber. Usually this portion—called a sample—varies from 5 percent to 20 percent of the area depending on the accuracy required. Sometimes, where high accuracy is required, 50 percent to 100 percent of the trees are measured.

The percent of cruise required for reasonable accuracy varies with different kinds of timber and different sizes of tracts. Large, uniform timberlands can be estimated with a 5 to 10 percent cruise. A small woodlot in which the density, size, and quality of the trees varies a great deal, must be cruised 50 to 100 percent for good results. The same thing is true of small tracts

of old growth redwood in which each merchantable tree must be measured to get an accurate estimate of volume.

Table 3 is a useful guide in determining the percent of cruise required for three degrees of accuracy on tracts of various size and uniformity.

A 20 percent cruise is usually sufficient for most purposes. For a 20 percent cruise, the cruiser measures the timber on only eight acres of a 40-acre tract, 20 acres on a 100-acre tract, and so on. These measurements are made on circular plots or strips which are run back and forth through the timber. The volumes obtained on the sample strips or plots are representative of the volume on the entire tract and are used to estimate total volume.

Cruising Methods

There are two cruising systems in general use today: strip cruising and plot cruising.

In the strip method, the trees are measured on strips which are run grid-fashion through the tract at right-angles to, or across, main ridges or drainages. The strip lines are run out with a compass. They are one or two chains wide. (A chain is 66 feet. See Table 14.) One-chain wide strips are adapted to dense young timber while two-chain strips are used in open, mature stands. Since an acre is equal to ten square chains, a one-chain strip, ten chains long, gives one acre of sample. Likewise, a strip two chains wide, five chains long, also gives one acre of sample. Thus if a cruiser wishes to make a 20 percent cruise of 80 acres using strips one chain wide, he must have a 16-acre sample, (20 percent of 80 acres is 16 acres). This is equivalent to 16 strips 10 chains long. How these strips are spaced over the area to be cruised will be explained later.

In the plot method, a series of circular plots are used instead of strips. The timber standing within these plots is measured. Plots vary in size from one-tenth of an acre to one acre, but one-fifth acre plots are most commonly used. The circular plot method of cruising is practical for all kinds of forest land except old

TABLE 3—NUMBER OF PLOTS NEEDED FOR THREE COMMON DEGREES OF ACCURACY
One-fifth Acre Plots, Uniformly Spaced

CONDITION OF STAND Stocking area in acres	UNIFORM			AVERAGE			PATCHY	
	Good	Medium	Poor	Good	Medium	Poor	Medium	Poor
Plus or minus 5% accuracy								
40----	57	109	160	89	133	171	160	185
160----	73	185	400	133	267	480	400	600
640----	78	223	640	152	356	873	640	1,371
5,000----	80	238	775	159	394	1,145	775	2,190
10,000----	80	239	787	159	397	1,172	787	2,290
100,000----	80	240	799	160	400	1,197	799	2,389
Plus or minus 10% accuracy								
40----	18	46	100	33	67	120	100	150
160----	20	56	160	38	89	218	160	245
640----	20	59	188	40	97	274	188	305
5,000----	20	60	198	40	100	291	198	308
10,000----	20	60	199	40	100	298	199	303
100,000----	20	60	200	40	100	300	200	300
Plus or minus 20% accuracy								
40----	5	14	40	10	22	55	40	86
160----	5	15	47	10	24	69	47	126
640----	5	15	49	10	25	73	49	143
5,000----	5	15	50	10	25	75	50	149
10,000----	5	15	50	10	25	75	50	150
100,000----	5	15	50	10	25	75	50	150
STOCKING UNIFORMITY								
Plus	GOOD ($\frac{3}{4}$ to full) (f)		MEDIUM ($\frac{1}{2}$ to $\frac{3}{4}$ full) (f)		POOR (less than $\frac{1}{2}$ full) (f)			
Uniform (less than 20% in patches)	0.2		0.6		2			
Average (20% to 40% in patches)	0.4		1		3			
Patchy (40% or more in patches)	-----		2		6			

5% plus or minus accuracy—for land value appraisal in extremely high value stands of species.

10% plus or minus accuracy—for lump sum sales based on estimated volume and for detailed management plans.

20% plus or minus accuracy—for control of cutting policy on timber sales where payment is to be made on basis of measurement of material cut.

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U. S. FOREST SERVICE

growth redwood. It is especially suited to dense young growth and is the easiest of the two methods to apply.

In the example given above, if the cruiser wished to make the 20 percent cruise of the 80-acre tract using one-fifth acre sample plots, he would still have to take a sample totaling 16 acres. Since each acre of sample would contain five plots, there would be a total of 80 plots (5 x 16).

Circular plots are spaced along compass lines and are arranged so as to checker-board the tract. The arrangement and spacing of circular plots will be discussed later.

Cruising Instruments and Equipment

Like any job, cruising requires certain tools and equipment. The cruiser's requirements are few for general cruising jobs. He needs, as a minimum, only a compass and a graduated stick or a diameter tape.

The compass is used to run cruise strips on straight lines. While an elaborate instrument is not necessary, the compass should be one graduated in degrees and provided with facilities to correct the arc for the magnetic variance from true north. The woodsman should be thoroughly familiar with the instrument before attempting to use it in cruising. Considerable care must be used to avoid errors of line direction:

First, the correct magnetic declination must be used. The declination varies as a person moves north or south in the redwood region. It also changes slightly each year. The isogonic lines on the map (Frontispiece) shows the declination at various places in this part of California.

Second, foresights must be carefully determined and remembered as the cruiser works ahead on his line.

A tree-measuring stick, called a cruiser's stick, is a useful tool for measuring size of trees up to 50 inches in diameter and nine 16-foot logs, in height. A cruiser's stick can be purchased or one can be made in a few hours. See "How to Make a Cruiser's Stick," at the end of this section of the handbook.

A diameter tape is a special tape 20 to 50 feet long, graduated so that it reads directly the diameter of a tree in inches. The 20-foot tape is most commonly used.

Equipment, other than instruments, required by a cruiser are:

1. A small pocket notebook in which to keep tree tally and notes.
2. Pencils with pocket clips.
3. Volume tables of species cruised.
4. A clip board to hold map sheet if a sketch map is to be made.
5. When cruising in wet weather, a special celluloid notebook should be used. The day's notes can be erased, after they have been copied, so the celluloid notebook can be used again and again.

TABLE 4—CORRECTIONS FOR SLOPE MEASUREMENT

For Each Chain of Slope Distance

CORRECTION IN FEET		CORRECTION IN LINKS	
Slope, percent	Add, per chain	Slope, percent	Add, per chain
10.....	0.3	10.....	0.4
20.....	1.4	20.....	2.1
30.....	3.0	30.....	4.5
40.....	5.0	40.....	7.5
50.....	7.9	50.....	12.0
60.....	11.0	60.....	16.7
70.....	14.5	70.....	21.9
80.....	18.4	80.....	27.9
90.....	22.8	90.....	34.5
100.....	27.5	100.....	41.6

Pacing and Chaining Distances

When high accuracy is not required, cruise lines are measured by pacing. The "pace" is two steps. The average man pacing on level ground, measures off about six feet per pace, or eleven paces per chain. Persons who have never done any pacing should determine the length of their pace, and the number of paces they take per chain, by pacing known distances.

The pace is a natural walking step, not a deliberate step. So in learning to pace, use a natural gait.

Distance on land is measured as *horizontal distance*, not slope or ground distance. Horizontal distance is always equal to or *less* than ground distance.

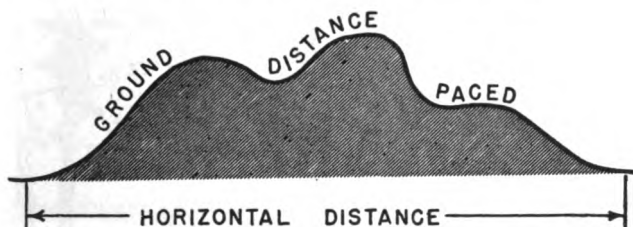


FIGURE 15

The above diagram shows that ground distance on slopes is always greater than horizontal distance. Therefore, on sloping ground, the cruiser must take additional paces to correct ground distance to horizontal distances. Slope corrections per chain for different degrees of slope is shown in Table 4. An Abney level can be used to measure differences in slope. After some experience, the cruiser learns the distance he must add per chain on different slopes.

For more accurate measurement of distance, the two-chain steel tape is commonly employed in cruising.

Measuring Diameter and Height of Trees

The volume of standing trees is determined from tree volume tables which give the volume in trees of different diameters and heights. Volume tables for the important tree species of the redwood region are given in the appendix.

Since volume is based on diameter and height, accurate measuring and recording of these two factors is essential in cruising.

In all species except old growth redwood, diameter is measured at breastheight, or $4\frac{1}{2}$ feet above ground. This measurement is called d. b. h. (diameter breast

high). It is measured, and so recorded on the tally sheet, to the nearest even-numbered inch—such as 22, 24, 26, 28, 30, etc.

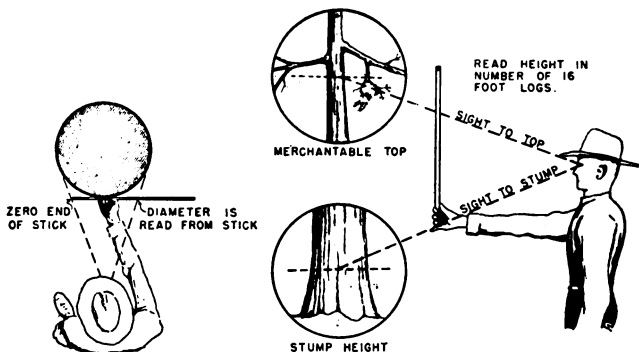


FIGURE 16. Reading the diameter of a standing tree with a Biltmore stick (left) and estimating tree heights with a cruiser stick (right).

Tree height is estimated in number of logs, or in feet to the nearest ten feet, depending on the table used. Tree height must be estimated to the top diameter for which the table was prepared.

The diameter (d. b. h.) of trees under 50 inches is easily measured with the *cruiser's stick*. Larger diameter trees should be measured with a tape. To use the stick, hold it in the right hand between the thumb and fingers. Place the beveled edge against the tree 4½ feet above ground. Hold it at right-angles to your body and 25 inches from the eye. Sight over the zero (left) end of the stick and move it left or right until it is even to the line of sight to the left side of the tree. Now, without moving your head, sight over the stick to the right side of the tree and read on the scale the diameter to the nearest even-numbered inch. Two measurements are usually made at right-angles to each other, and these averaged, to care for oddly-shaped trunks. (Figure 16.)

Tree height in 16-foot logs can be estimated by the Merritt Hypsometer scale on the *cruiser's stick*. The

cruiser stands one chain from the tree to measure heights up to six logs, using the left-hand scale; or he stands $1\frac{1}{2}$ chains distant to measure trees up to nine logs high, using the right-hand scale. (Figure 16.)

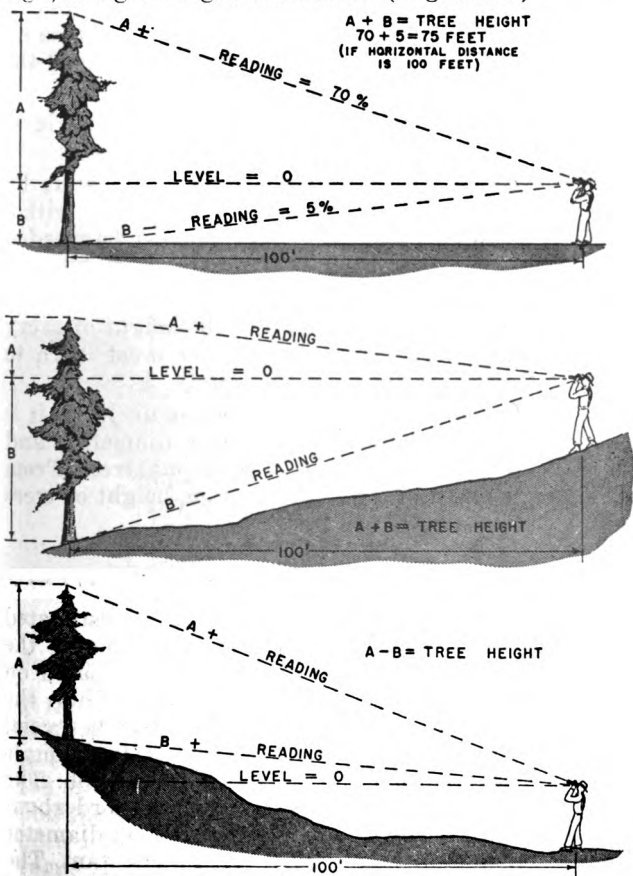


FIGURE 17. An Abney hand level, calibrated in percent, can be used to measure tree heights.

To use the hypsometer, pace or measure out 1 or $1\frac{1}{2}$ chains from the base of the tree as its height requires.

Select the point in the crown to which height must be estimated. Hold the stick vertical at a point 25 inches from your eye. Bring the zero end even with a line of sight between the eye and the stump-height on the tree to be measured. Be sure the stick is vertical and that it doesn't lean away from or toward you. Now glance up to the point selected as the top diameter, and read the number of 16-foot logs on the stick.

Tree heights may be measured with an Abney level as shown in Figure 17.

Experienced cruisers often estimate diameters by eye, checking their estimates several times daily with a diameter tape or cruiser's stick. Cruising can be speeded up materially by learning to estimate diameters accurately.

It is seldom possible to measure the height of every tree in a cruise. Therefore, the cruiser must learn to estimate heights rapidly and accurately.

When the timber on a tract is rather uniform, it is sometimes practical to tally only tree diameters and obtain heights by measuring only occasional trees. From these height measurements, the average height of trees in each d. b. h. class can be figured.

Measuring Diameter of Old Growth Redwood at 20-Foot Height

The diameter of old growth redwood is estimated at 20 feet above the ground in order to get above the butt-swell. Most redwood volume tables are based on measurements made at the 20-foot point. While the measurement of diameter at this height presents special problems, these are solved by the use of two simple tools; a long, graduated stick and a plumb-bob. The plumb-bob is provided with a strong, light cord about four feet long. It is used to project the 20-foot diameter down to the measuring stick held by an assistant. The measuring stick, 8 or 10 feet long, is made of light wood three-quarters of an inch thick and two inches wide. Graduate the stick in two-inch diameter classes—18, 20, 22, 24, etc., with zero on the left.

The 20-foot diameter is estimated in the following way: An assistant, carrying the measuring stick, stands

MEASURING DIAMETER OF OLD GROWTH REDWOOD

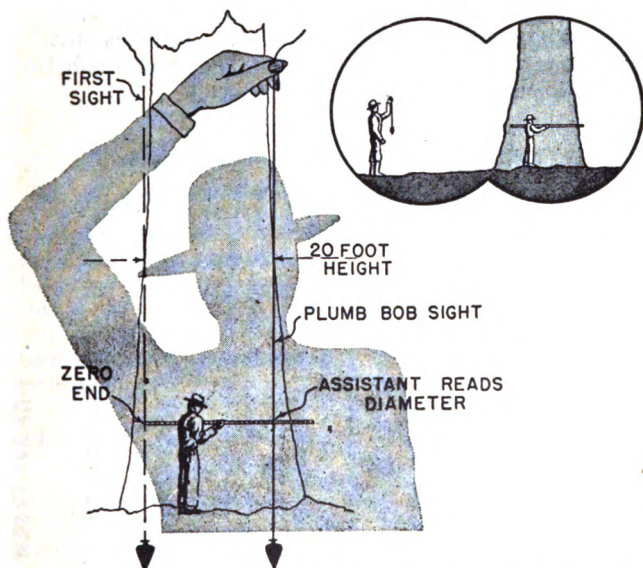


FIGURE 18. Measuring the diameter of an old-growth redwood at 20-foot height with a plumb-bob and graduated stick.

at the base of the tree to be measured. The cruiser moves to a point about 60 feet away where he can get clear view of the lower part of the tree. The assistant then holds the stick vertically above his head to help the cruiser find the 20-foot point on the trunk. When this point has been located, the stick is lowered. The assistant now turns facing the tree and holds the stick against the bark at about eye level. The stick is held horizontal and at right angles to the line-of-sight between the cruiser and the tree.

The cruiser holds the plumb-bob at arm's length and, sighting past string to the left side of the tree at the 20-foot point, he directs his assistant to move the zero end of the stick until it is even with this line of sight. The cruiser then takes a sight on the right side of the tree at the 20-foot diameter and projects this point down to the graduated stick. The assistant moves the index finger of his right hand along the stick until it intersects the cruiser's sight through plumb-bob line. He then reads the diameter off the stick.

TABLE 5—CORRECTED DIAMETERS AT 20-FOOT HEIGHT

Corrections Made for Errors in Measurement Due to the Wide Angle of Sight of an Observer Close to a Tree When Cruising With Plumb-bob and Graduated Stick

Observed diameter at 20-foot height, inches	Observer's distance from the tree's center				
	20'	30'	40'	50'	60'
	Corrected diameter at 20-foot height (inches)				
24.....	25	25	25	24	24
30.....	32	31	31	31	30
36.....	39	38	37	37	36
42.....	46	44	44	44	43
48.....	53	51	50	50	50
54.....	60	58	57	56	56
60.....	67	65	64	63	63
66.....	75	72	71	70	69
72.....	83	79	77	76	76
78.....	91	86	84	83	82

If measurements are made from points less than 60 feet from the tree, a correction should be added to the measured diameter to prevent under-estimating of diameter. These corrections are given in Table 5.

When, for some reason, it is not practical to estimate the 20-foot diameter in the manner described above, the cruiser may measure the diameter at breast-height with a diameter tape. The d.b.h. is then reduced to corresponding 20-foot diameters by use of Table 6. These values should be checked and adjusted, if necessary, to fit local conditions.

TABLE 6—DIFFERENCES BETWEEN DIAMETER AT 4½ FEET AND 20 FEET

Average for Old-growth Redwood Outside Bark

Mendocino, Sonoma, Santa Cruz, San Mateo		Humboldt, Del Norte	
Diameter, breast high inches	Diameter o. b., at 20 ft., inches	Diameter, breast high, inches	Diameter o. b., at 20 ft., inches
24.....	17	32.....	26
28.....	21	36.....	28
32.....	24	40.....	30
36.....	27	44.....	33
40.....	30	48.....	36
44.....	33	52.....	39
48.....	36	56.....	42
52.....	39	60.....	46
56.....	42	64.....	49
60.....	45	68.....	50
64.....	48	72.....	56
68.....	50	76.....	59
72.....	54	80.....	63
76.....	57	84.....	66
80.....	60		
84.....	63		
88.....	66		
92.....	72		

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Tallying Cruise Data

A simple tally method speeds up cruising and the later figuring of the volume of timber products. Professional cruisers and public foresters have developed numerous tally sheets to suit their own needs. Such a tally sheet is shown in Figure 19.

For most purposes, a specially printed tally sheet is not necessary. Tallying can be done on a lined pocket-size notebook upon which appropriate columns are drawn in pencil. Figure 20 shows tally sheets that are adapted to strip and plot cruises.

An examination of these sheets will show that each tally sheet provides space for the following information:

1. Number of the plot or strip.
2. Location of plot or strip by legal subdivision.
3. Size of plot or length and width of the strip on which the tally was made.

tions and numbers on this map. Otherwise, make a rough sketch on a notebook page.

It is usually desirable to tally five one-fifth acre plots on a single sheet thus getting a one-acre sample on a single sheet. This practice makes for easier figuring of the cruised volume.

In cruising by the strip method, record on each tally sheet the trees on one acre of strip: that is 10 chains of strip one chain wide, or five chains of strip two chains wide.

Each tree is tallied in one of two ways: by dots, or by writing-in the number of logs in the tree tallied so that the number itself represents the tree.

In the latter method a tally written:

36	6678	

represents four trees 36" d.b.h.—two six-log trees, one seven-log tree and one eight-log tree.

The first method is used when only the number of trees of the various diameters is recorded. A dot count is made as follows:

•	••	•••	••••	—	┌	□	□	▣	⊠	⊠	• etc.
1	2	3	4	5	6	7	8	9	10	11	

Thus, fourteen 24-inch trees would be shown on the tally sheet as:

24 ⊠ : :

A dot or a line is made to represent each tree as it is encountered in the cruise.

Tree names can be abbreviated as follows: RWD (redwood); DF (Douglas fir); WF (white fir); SS (Sitka spruce); TO (tanbark oak); MD (madrone); CP (chinquapin); HW (various hardwood species).

The back of each tally sheet may be used to make notes pertaining to the timber, ground conditions, and so forth.

The test of a good tally sheet is that it must show clearly all the facts required by the cruiser.

TABLE 7—TREE VOLUME DISTRIBUTION BY LOG POSITION

Log position	Percentage distribution of volume for trees of indicated 16-foot logs per tree											
	2	3	4	5	6	7	8	9	10	11	12	13
Butt.....	67	50	40	33	29	25	22	20	18	17	15	14
2.....	33	33	30	27	24	21	19	18	16	15	14	13
3.....		17	20	20	19	18	17	16	15	14	13	12
4.....			10	13	14	14	14	13	13	12	12	11
5.....				7	9	11	11	11	11	11	10	10
6.....					5	7	8	9	9	9	9	9
7.....						4	6	7	7	7	8	8
8.....							3	4	5	6	6	7
9.....								2	4	5	5	6
10.....									2	3	4	4
11.....										1	3	3
12.....											1	2
13.....												1

Example: 10-log tree has catfaced butt and dead top. One-half of eight foot section or one-fourth of butt log and three top logs are cull. $\frac{18 + 5 + 4 + 2}{4} =$

15.5% of the volume table volume of the tree is cull.

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Deductions for Visible Defect

Allowance must be made for visible defect in trees tallied. Partly cull butts, broken tops and "conky" fir are the defects most commonly encountered. Deductions for these defects require skill. The cruiser must observe the felling, bucking and sawing of defective trees so he can develop judgment in estimating cull.

A simple method for making deductions for defect employs the use of Table 7. This table gives the average volume (in percent) contained in each log of trees of various heights. Thus, if the butt log of a six-log Douglas fir is all cull, the cruiser deducts 29 percent from the gross volume in the tree as obtained from the tree volume table. If the butt log was one-fourth cull, he would deduct one-fourth of 29 percent or 7 percent from the tree volume. Likewise, if the two upper logs in a five-log tree were cull, he would deduct 20 percent (7 percent plus 13 percent) from the gross scale.

These deductions are related only to tree height and not to diameter.

Defect is tallied by writing the amount to be deducted next to the number representing the tree:

40	7 6 6 ^{B1/2}
42	7 4/6
44	7 8 6/7 ^{B2}
46	

The above example shows how to tally (1) a 40-inch, six-log tree having a butt log one-half defective; (2) a 42-inch six-log tree with the top two logs cull or missing—written as 4/6; (3) a 44-inch, seven-log tree with top log cull and the butt and second logs cull.

The Cruising Party

Cruising can be done by one man alone, in which case he must run the compass line, pace distances, estimate heights and diameters, keep the tally and, perhaps, make a map as well. This is a difficult task for even an experienced cruiser.

If a cruise must be made alone, the plot method of cruising is easiest to do and should be used whenever the method is applicable.

When it is necessary to work alone on a strip cruise, a one or two chain steel tape may be dragged behind to mark the center of the strip. The cruiser paces ahead one or two chains, drops the tape, then walks back to do the estimating.

Any cruise goes best with two men. One man runs the compass, does the pacing and tallying. The other measures heights and diameters. If the compassman and estimator work about one chain or so apart, the compassman is in position to help estimate heights.

Preparing for a Cruise

Before the actual cruising work is begun the cruiser must make certain preparations:

1. Assemble the necessary tools and equipment.
2. Scout out the area to be cruised and determine the boundaries of the tract if these are not already known. Unless roads, fences, streams, ridges or some other definite features are to be used as tract boundaries, it will be necessary to blaze boundary lines so they can be easily identified later. At the same time, section corners, quarter-section corners, or other land subdivision corners bearing on the tract to be cruised, must be located and flagged.
3. Decide upon the percent of cruise to make, using a 20 percent cruise as a standard.
4. Decide upon the width of the cruise strip or size of sample plot.
5. Decide on the spacing of strips or plots and the direction of cruising lines. Also decide where to begin the first strip and plan how the job can be done with a minimum amount of walking and lost motion.
6. Decide the species of trees to be tallied.
7. Decide upon the minimum diameter to be tallied.
8. Prepare tally sheets fitted to the job.
9. Secure proper volume tables for species to be cruised.

Cruising by the Strip Method

For purpose of illustration, assume a square 40-acre tract is to be cruised by the strip method. A 20 percent cruise, using strips one chain wide is to be made. This requires an eight-acre sample; that is, 80 linear chains of strip. Since a 40 is 20 chains on each side, four strips will have to be run across the 40. These strips are spaced as shown in the diagram on page 64.

To begin, locate the starting point of the first strip through the 40 by pacing (or chaining) $2\frac{1}{2}$ chains in from a convenient corner. From this point run across the 40 on the selected compass bearing. The lines are

generally run in a cardinal direction—north, south, east or west—so as to cut across ridges and drainages. Along this line, tally the trees on a strip 33 feet on each side of the compass line. The width of the strip should be carefully determined by pacing or measuring with a tape. When the other side of the 40 is reached, offset five chains and run a strip back across. Continue until the four strips have been completed.

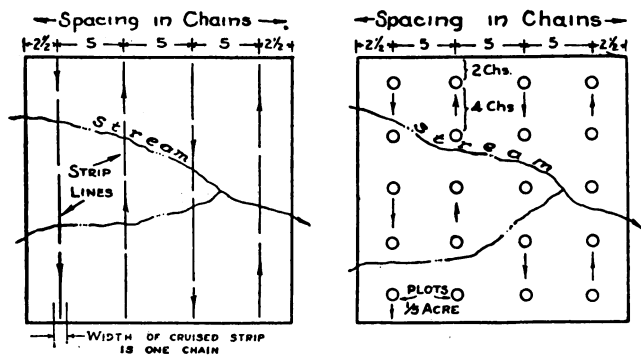


FIGURE 21. Location of samples in cruising by strips (left) and circular plots (right).

Cruising by Sample Plots

Assume a 10 percent cruise is to be made of a square, 40-acre tract, using one-fifth-acre circular plots. Ten percent of 40 acres is four acres of sample; therefore 20 one-fifth-acre plots are required. For good distribution of the 20 plots, these will be equally spaced along four lines running across the 40 on a compass bearing in the same manner as in strip cruising.

The beginning point is located and the first strip is run on the predetermined course. The distance along the line must be carefully paced (or measured with a steel tape) to locate the plots at proper intervals along the line. The first plot in each line is located two chains in from the tract boundary; others are spaced four chains apart along the compass line.

When the center of a plot is reached, mark the location with the compass staff or have the man doing the tallying stand at the plot center. The boundary of the circular plot is then determined by pacing or measuring out 52.7 feet (radius of one-fifth-acre plot) in four or more directions as required. The trees inside the plot can now be tallied.

It is good practice to calculate the timber volume on the plot before proceeding to the next. In this way the cruiser can develop an "eye" for standing timber volume and can also check for errors before leaving the plot.

Calculating Timber Volume

The job of calculating the timber volume on a cruised tract can be broken down into six progressive steps:

STEP I

Calculation of the volume, by species, on each cruise sheet.

To figure the volume on a tally sheet, find, in the volume table for each species, the board-foot volume for each tree tallied. Figure one diameter and species at a time. After the total volume of each diameter class and each species has been determined, add the vertical columns and find the total volume by species. If trees below sawlog size have been tallied, keep their volume separate from sawlog volume.

STEP II

Calculation of the total volume on all cruise sheets.

When each tally sheet has been worked up, copy these volumes onto a sheet of paper and add up the figures to find total volume, by species, in all the sample plots or strips.

STEP III

Determination of the total number of acres on all strips or plots.

This is done by adding the number of plots or chains of strip and multiplying by a conversion factor. This factor will depend upon the size of the plots or the width of the strip.

STEP IV

Calculation of the average volume per acre.

Divide the volumes determined in Step II by the number of acres in Step III to get the average volume of each species per acre.

STEP V

Determination of the total number of acres in the cruised tract as accurately as possible.

The area of irregular tracts can be determined by using a square grid ruled off on any transparent material. For maps having a scale of four inches and over per mile, a grid of one-quarter inch squares is adequate.

First, figure the map area represented by each square. For example if one is to use a quarter-inch square grid on an eight inch to the mile map, each square would represent .625 acres.

To estimate area, lay the grid over the map and count the number of squares and fraction of squares inside the irregular tract. Multiply this number by the acres per square to find acres in the tract.

STEP VI

Calculation of the total volume.

Total volumes are found by multiplying the average volumes per acre (from Step IV) by the total area (from Step V).

If piling or poles have been included in the cruise, they are figured as number of pieces of different lengths or as total linear feet.

The volume of trees below sawlog size should be given in cords or cubic feet. Board-foot estimates of small diameter trees are not truly representative of their actual volume. As pulp wood markets develop, the

estimating of small-diameter material will become increasingly important.

Cruising Irregular-shaped Tracts

The cruising of irregularly-shaped tracts requires that, first, the area of the irregular shaped tract be accurately determined, and second, that the length of cruise strips be carefully measured or paced. Unless the area of the tract and the size of the sample cruised is known, a reliable estimate of volume cannot be made. If the area of an irregular tract has not been previously determined, the cruiser must prepare an accurate scale map of the timber. In any event, he must measure, as he goes, the length of his strips in order to figure the size of the sample he has taken.

One advantage to plot cruises is that high accuracy in line lengths is not required, since the area of the sample is determined by simply multiplying the number of plots taken by the size of the sample plot used.

Varying the Width of Cruise Strips

In the examples used above, strips one chain wide were used. This width is easy to use and is specially adapted to the dense young stands of trees which characterize the redwood region.

Strips two chains wide (one chain on each side of the compass line) are often used in more open mature timber. The two-chain strip should be used whenever practicable to do so, since the length of strip required for a certain percent of cruise is cut in half. For example, only two strips through a 40 are required for a 20 percent cruise when a two chain strip is used. The strips are run five chains in from the edge of the 40, leaving 10 chains between strips.

If a map must be made of the tract, its accuracy can be increased by using one-chain wide strips. The greater number of strips across a 40 allows the cruiser to see more of the terrain and, therefore, to make a better map.

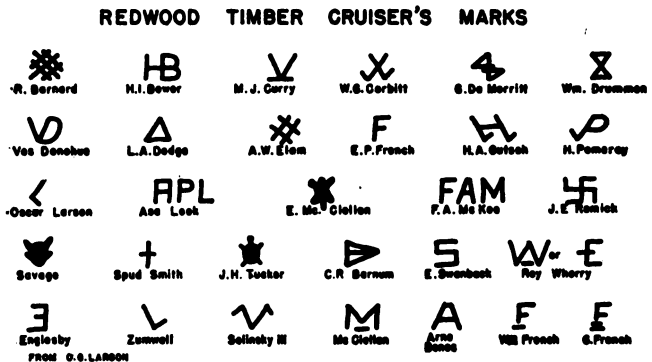


FIGURE 22. Cruisers often leave their marks on or near section corners. These marks are an endorsement of the corner location.

Cruising by Timber Types

Sometimes there are conspicuous differences in the timber stands inside the tract to be cruised. These differences may be due to differences of age, size, quality, species or condition.

The accuracy of the cruise can be increased by recognizing these differences and keeping separate tally for the two or more different stands composing the tract. To keep a separate tally, the cruiser changes tally sheets when the strip or line of plots enters a different stand. Each different stand must be given a descriptive name such as "old second-growth," "dense young-growth," "very open old growth." The tally sheets for the different stands must be identified by the name the cruiser gives the stand.

The cruiser must make an accurate map so that the area of each of the several stands can be determined. If a strip cruise is used, the length of cruise strip in each stand must be carefully paced, or measured with a steel tape. Since the length of cruise strips in different stands must be known to figure the total volume, the length of strip should be shown on the tally sheet.

NOTES ON LAND SUBDIVISION

The General Land Office of the United States has established the system of rectangular surveys for subdivision of western lands.

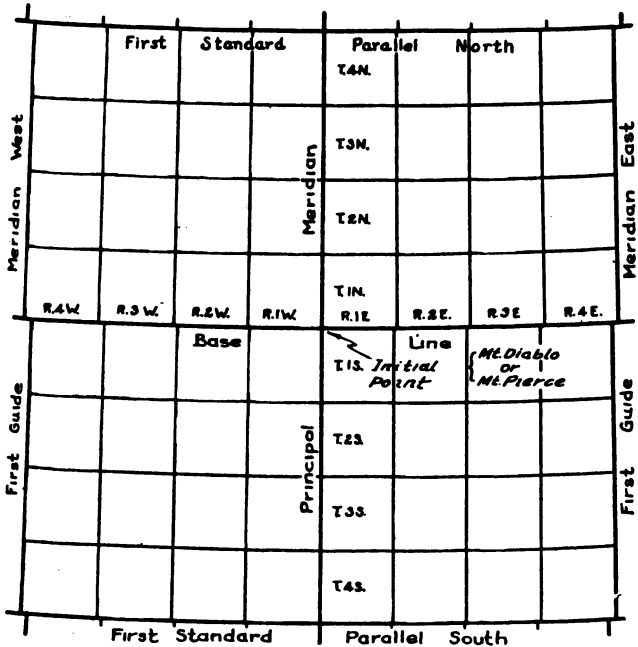


FIGURE 23. Land subdivision by the U. S. General Land Office.

Figure 23 shows how the lands in California are subdivided.

The *initial point* is the point established from which subdivision originates. In the north coast, Mt. Diablo near San Francisco and Mt. Pierce in Humboldt

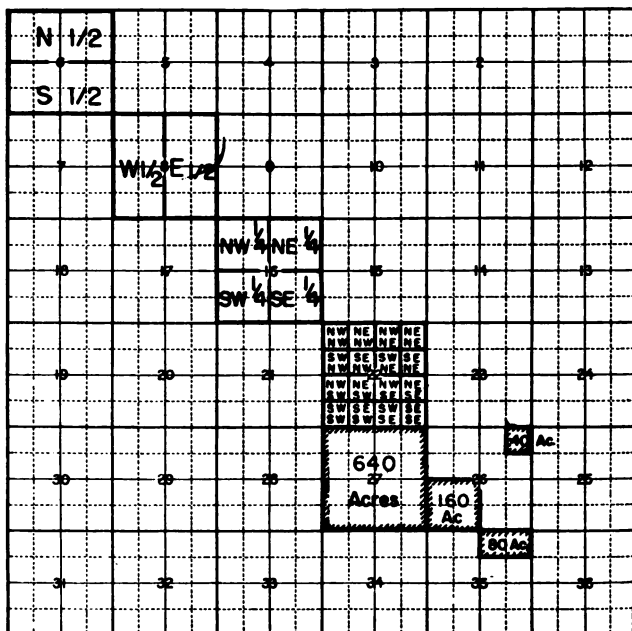


FIGURE 24. Normal subdivision of township and sections.

County, are the initial points through which principal meridians are projected.

The *principal meridian* is a north-south line through the initial point.

The *base line* runs through the initial point in an east-west direction.

Guide meridians, established at 24-mile intervals east and west, run in a north-south direction paralleling the *principal meridian*.

Standard parallels are established every 24 miles north and south of the initial point. These lines parallel the *base line*.

Township lines every six miles north and south of the initial point run in an east-west direction.

Range lines bound the township on the east and west. The range and township lines, located six miles apart, form the township.

Township and range lines for the redwood region are shown on Frontispiece.

The *township* is six miles square generally containing 36 sections, each one mile square. The township and section are subdivided as shown in Figure 24.

Section corners and quarter section corners are marked on the ground by various kinds of monuments. Where rocks are plentiful they are used. In timber country wooden stakes are customary.

Bearing trees are located near the section corner. In timber country the corner stone or post is usually located by several "bearing trees" located near the corner. These trees are generally blazed and scribed indicating the section in which the tree is located. A "bearing tree" may be marked—

T 17 N

R 16 W

S 13

B.T.

The original field notes indicate the compass bearing and distance from the bearing tree to the corner. Corners can be reestablished quite easily if bearing trees are present. In any land location work the original field notes are very helpful.

Distances, in all original surveys, are given in chains and links, 80 chains being one mile. Original Land Office corners and subdivision lines are the only ones accepted by courts in settling land disputes. Exceptions to this can be found in portions of Sonoma and the southern redwood counties. Here original Spanish land grant lines, measured in varas and often irregular in shape, take precedence over subsequent surveys.

HOW TO MAKE A CRUISER'S STICK

Make a hardwood stick—preferably of birch, maple, ash or white oak— $38\frac{1}{2}$ inches long, one inch wide, and one-half inch thick. Bevel one edge as shown in Figure 25.

On the beveled edge carefully lay off inch and half inch graduations. Etch full-lines and half-lines with a sharp knife or a carpenter's chisel.

On the narrow face, lay off the graduations for the Merritt Hypsometer. The measurements are given in Table 8. The left half of this face has the scale to be used in estimating tree height (in 16-foot logs) when the observer is standing one chain (66 feet) from the tree. The right-half has graduations for estimating height in logs when the observer is standing one and one-half chains (99 feet) from the tree. Etch in the graduations with knife or chisel.

On the wide face, lay off and etch the graduations for the Biltmore scale. Lengths to be measured off from the zero end are given in Table 8. See the drawing for details.

Measure graduations on the stick carefully with a good ruler or flexible steel tape.

The numerals can be stamped on the stick with steel stamping dies available on ranches and in local blacksmith and machine shops. They can be made more visible if filled with black ink.

If die stamps are not available, the numerals can be put on with a smooth steel pen using black India drawing ink.

On the hypsometer, identify the two different scales by stamping "1 chain—16 ft. logs" on left scale for six logs, and " $1\frac{1}{2}$ chains—16 ft. logs" on right-hand scale for nine logs.

Bore a small hole on the upper (38-inch) end of the stick and use a piece of leather boot lace to make a loop to slip the hand through.

Apply several coats of varnish or clear lacquer.

TABLE 8—GRADUATIONS ON CRUISER'S STICK *

BILTMORE SCALE

Diameter of tree	Distance from zero end inches	Diameter of tree	Distance from zero end inches
6.....	5 ¹ / ₁₆	42.....	25 ¹¹ / ₁₆
8.....	7	44.....	26 ¹ / ₂
10.....	8 ¹⁵ / ₃₂	46.....	27 ⁵ / ₁₆
12.....	9 ¹⁵ / ₁₆	48.....	28 ¹ / ₈
14.....	11 ¹ / ₄	50.....	28 ⁷ / ₁₆
16.....	12 ¹⁷ / ₃₂	52.....	29 ²¹ / ₃₂
18.....	13 ¹⁵ / ₁₆	54.....	30 ¹⁵ / ₃₂
20.....	14 ¹⁵ / ₁₆	56.....	31 ¹ / ₈
22.....	16 ³ / ₁₆	58.....	31 ¹⁷ / ₃₂
24.....	17 ⁹ / ₁₆	60.....	32 ³ / ₁₆
26.....	18 ⁹ / ₁₆	62.....	33 ⁹ / ₁₆
28.....	19 ¹ / ₄	64.....	33 ²¹ / ₃₂
30.....	20 ⁹ / ₁₆	66.....	34 ⁵ / ₁₆
32.....	21 ⁹ / ₁₆	68.....	35 ¹⁹ / ₃₂
34.....	22 ⁹ / ₁₆	70.....	35 ¹⁵ / ₁₆
36.....	23 ¹ / ₁₆	72.....	36 ²¹ / ₃₂
38.....	23 ¹⁵ / ₃₂	74.....	37 ⁹ / ₁₆
40.....	24 ¹⁵ / ₁₆		

HYPSONETER

Number of logs on stick	Distance from zero end, inches	
	1 ¹ / ₂ Ch. Dist.	1 Ch. Dist.
1.....	4 ¹ / ₈	6 ³ / ₁₆
2.....	8 ¹ / ₄	12 ³ / ₈
3.....	12 ³ / ₈	18 ⁹ / ₁₆
4.....	16 ¹ / ₂	24 ³ / ₄
5.....	20 ⁵ / ₈	30 ¹⁵ / ₁₆
6.....	24 ³ / ₄	37 ¹ / ₈
7.....	28 ⁷ / ₈	-----
8.....	33	-----
9.....	37 ¹ / ₈	-----

* This stick is designed for a reach of 25 inches and must be used 25 inches from the eye.

HOW TO MAKE A CRUISER'S STICK

NARROW FACE $13/16$ " WIDE

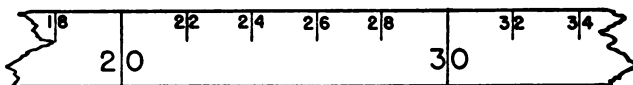
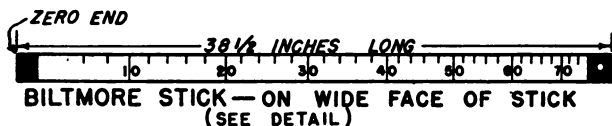
BACK EDGE
 $1/2$ " WIDE



BEVELED EDGE

WIDE FACE = 1" WIDE

CROSS-SECTION OF CRUISER'S STICK



DETAIL OF BILTMORE STICK

THE NUMBERS ARE FOR THE DIAMETER OF THE TREE IN INCHES, WHEN THE STICK IS HELD AGAINST THE TREE AT A SPECIFIED DISTANCE (USUALLY 25") FROM THE EYE.

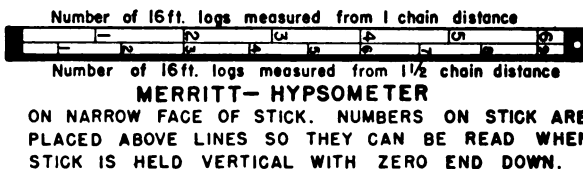


FIGURE 25

LOG SCALING

Scaling is the art of determining the volume of logs. Log volume may be expressed in board feet or cubic feet.

Value of Log Scaling

Log scaling is one of the routine jobs in the complex operation of converting the standing tree into the finished product. Log scaling is done for one or both of the following reasons:

1. As a basis for paying choppers, buckers, contract loggers, and contract log haulers.
2. To make or receive payment for timber cut.

For most purposes log volume is expressed in board feet. In the redwood region, the Spaulding log rule is generally the basis for log volume. Unless timber is sold on the tree estimate or cruise each log is scaled to determine value to be paid for the timber.

Required Knowledge

In addition to the skill needed to measure and record log volume the scaler should be able to:

1. Recognize tree species from bark and wood characteristics. Logs of different species have different values and should be separated on the scale sheet.
2. Recognize different log defects and make the proper deduction.
3. Determine the merchantable portion of the log and know how logs are sawed at the mill.
4. Understand scaling principles and the log rule used.

The only way to get much of the knowledge required to scale logs is through experience. Basic scaling principles can be set down, but recognition of tree species, log defects, and merchantability comes through observing these things on the job.

Equipment Used

Scaling requires certain necessary tools:

1. A scale stick for measuring log volume. The stick is graduated in inches and log lengths. Log volume can be read directly from the stick. Some scalers measure log diameter in inches with a conventional rule and refer to a log rule table for the log volume.
2. A notebook for recording measurements and volume.
3. A piece of lumber crayon to check the logs as scaled or mark the log volume or number on the end of the log.
4. A tape for checking log lengths.
5. An axe to check bark thickness and defect.

Log Rules in Common Use

A board foot is a piece of lumber one inch thick and one foot square. There are not 12 board feet in one solid cubic foot, because a portion is lost in slab and saw-kerf. The lumber recovery is usually about eight board feet per cubic foot of wood.

Log rules provide a means of measuring the actual board foot volume in the log by allowing for waste in slabs and sawdust. There are many different log rules used. Of these, only three are in common use in the redwood region.

The Spaulding rule is the statute log rule of California. It was constructed by N. W. Spaulding in 1878 from diagrams of logs measuring 10 to 96 inches in diameter. An 11/32-inch saw-kerf and 1-inch lumber was assumed.

The size of the slab was varied according to the size of the log. This error of construction gives an over-run for large logs. The table is prepared for logs from 12 to 24 feet long. Longer logs are scaled by doubling the value in the table. By doing this, taper in logs is again ignored. This feature is the most serious defect in the rule. There is considerable over-run when the modern band saw is used, because of the large saw-kerf used in the rule.

The Spaulding rule is used throughout the redwood region either in its original form or as the Humboldt Log Rule.

PURCHASER _____			END MARK _____			WHERE SCALED _____			SEC. T. R. 12
DATE OF SALE _____			SCALER _____			DATE _____ 19__			
SPICES	IN Length	Post S. M.	SPICES	IN Length	Post S. M.	SPICES	IN Length	Post S. M.	
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logs. It gives a large over-run for small logs and for logs longer than 16 feet.

The Scribner rule is used on all National Forest timber scales. It is also more generally used on fir and pine timber.

The Scale Book

Some form is necessary to record log scale. There are many different types of scale sheets and scale books. The sample form included in the text should prove satisfactory for most needs. (Figure 26.)

On all scale sheets log number, log length, volume, and type of defect should be entered.

Sometimes log scale is kept in duplicate. The carbon copy being given to the logging contractor, log haulers, or others interested in the log scale. Individual log loads can be tallied on a storekeeper's billing pad.

Where Scaling Is Done

Log scaling may be done at a number of places during the logging and milling operation.

1. In the woods after the logs have been bucked. The choppers are paid on the basis of this scale.

2. At the woods landing before being loaded on trucks or railroad cars.

3. On the trucks or cars.

4. In the pond or in the cold deck.

5. On the mill deck.

The average log is scaled three times before it hits the head saw. It is scaled in the woods, on the truck and on the mill deck. The chopper is paid on woods scale, the log hauler on truck scale, and the logging contractor on the mill scale.

Scaling Procedure

The general practice in scaling is to measure log diameter at the small end in inches, the log length in feet and determine the volume of the log from a log rule. The volume of any defect is then deducted from the gross volume giving the net board-foot log scale.

There are two scaling methods in general use. The U. S. Forest Service method and the methods used by commercial scaling bureaus. Forest Service scale will average from 7 to 15 percent higher than bureau scale.

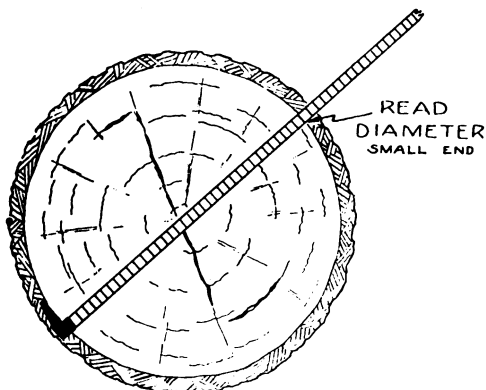


FIGURE 27. Measurement is made inside bark at small end of the log.

This difference is due to the different methods used in measuring logs. The method described in this section will follow Forest Service standards.

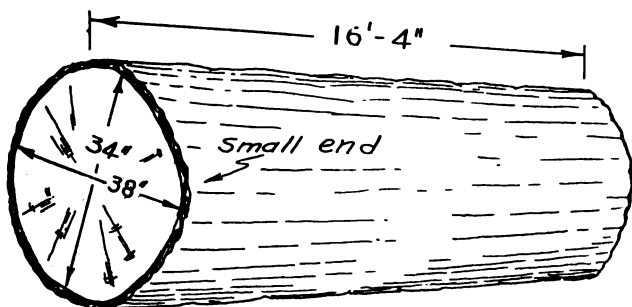


FIGURE 28. Logs less than 20 feet long are usually scaled as one log, using average diameter at small end.

There are only a few things that a scaler has to do to obtain the gross scale of a short log. Assuming a

sound Douglas fir log 36 inches in diameter, 16 feet long, volume is determined as follows:

1. Place scale stick across small end of log. (Figure 27.)
2. Measure average diameter inside bark. (Figure 28.)
3. Opposite inch graduation, in this case 36, read volume of log.
4. A 36-inch log, 16 feet long, contains 950 board feet, Spaulding scale.

If the scaler does not have a scale stick, diameter can be measured in inches and the volume looked up in the log rule tables in the appendix of this handbook.

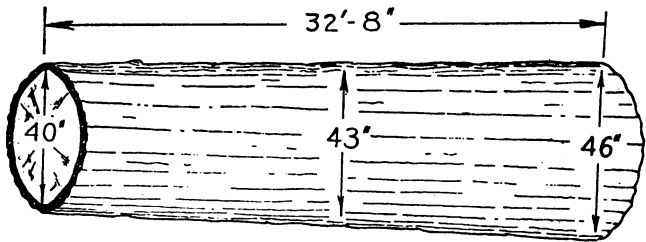


FIGURE 29. Long logs are scaled as two or more logs.

Logs over 20 feet are measured as two or more logs. For example, a log 32 feet long, 40 inches in diameter, at the small end, and 50 inches at the other, would be scaled as follows: (Figure 29.)

1. Measure average diameter for each end of the log.
2. The small end measures 40 inches and the large end 50 inches.

3. Average the two ends, $\frac{40 + 50}{2} = 45$.

4. Forty-five inches is the middle diameter of the log.

5. Therefore there are two 16-foot logs, one a 40-inch, the other, a 45-inch.

6. Refer to table or scale stick for the volume of each.

7. Spaulding rule values are:

40-inch log, 16 feet long----- 1,185

45-inch log, 16 feet long----- 1,512

Total volume ----- 2,697 board feet

TABLE 9—HOW TO DIVIDE LONG LOGS FOR SCALING

Length of long log in feet	SCALE AS		
	Log number 1 ¹	Log number 2	Log number 3
20.....	10	10	-----
22.....	10	12	-----
24.....	12	12	-----
26.....	12	14	-----
28.....	14	14	-----
30.....	14	16	-----
32.....	16	16	-----
34.....	10	12	12
36.....	12	12	12
38.....	12	12	14
40.....	12	14	14
42.....	14	14	14
44.....	14	14	16
46.....	14	16	16
48.....	16	16	16

¹ The first log at the small end of the long log. For example: A 34-foot log is scaled as a 10-foot and two 12-foot logs.

In the case of butt logs, a two-inch taper is assumed for the large log. A butt log 32 inches in diameter at the small end, 32 feet long, would be scaled as a 32-inch and a 34-inch log.

Logs over 32 feet are generally scaled as three logs. (See table 9.) For example, a 36-foot log is scaled as three 12-foot logs, end-diameters are averaged and each log given a diameter. A log 36 feet long with a small-end diameter of 24 inches and a large-end diameter of 36 inches would be scaled as follows:

1. The difference between the two ends is 12 inches (36 minus 24).

2. Divide 12 inches by the number of logs. $12 \div 3 = 4$.

3. Increase the diameter of each 12-foot log by 4. This gives a 24", a 28" and a 32" log, all 12 feet long.

4. The Spaulding log rule shows the following volumes:

24-inch	12-foot log	309 board feet
28-inch	12-foot log	427 board feet
32-inch	12-foot log	561 board feet

Total volume of the
36-foot log is ----- 1,297 board feet

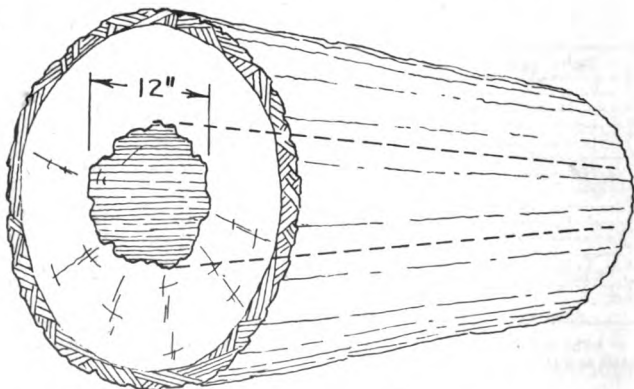


FIGURE 30. Circular defect may be deducted by using the rule of thumb. For example: this 40-inch, 16-foot log scales 1,185 board feet, gross. It has a rotten section 12 inches in diameter, 16 feet long. Twelve inches plus four inches (one-third of the diameter of the defect) total 16 inches. The Spaulding log scale shows 161 board feet for a 16-inch log 16 feet long. Deducting this from the gross volume of the log gives a net volume of 1,024 board feet. If it had been estimated that the defect was only in one-fourth of the long length, only 40 board feet ($\frac{1}{4}$ of 161) would have been deducted.

Deductions for Defect

The effect of rot and other defects on logs varies greatly within the redwood region. On one operation most of the logs may be sound, while a few miles away, logs may be as much as one-third defective. The scaler

must exercise good judgment when deducting for defect from the gross log-scale.

Defects may be classified as follows:

1. Interior defects, which cause waste in the interior of logs. These are generally rot, shake, or riff cracks.
2. Side defects, which cause waste on the outside of logs.
3. Defects from curve or sweep.
4. Defects from crotches.
5. Defects from an excessive number of knots in top logs.

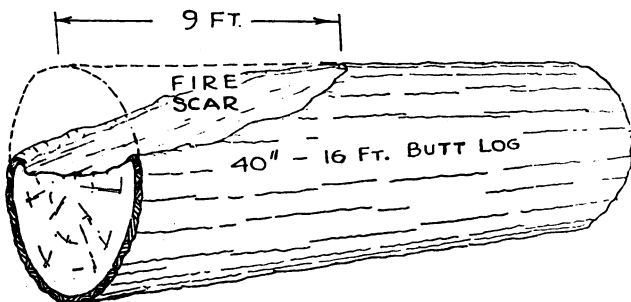


FIGURE 31. Fire scars are the most common type of exterior log defect. To make the deduction in this example, it is first estimated that about one-third of half of the log is affected. The 40-inch log scales 1,185 board feet. One-half of this is 592 board feet. One-third of this is 197 board feet. The net volume is 1,185 minus 197 equals 988 board feet.

The best way to deduct for interior defects showing on one or both ends of the log is to treat the defects as squares or rectangles. The substance of this method is to deduct 80 percent of the solid board-foot contents of a piece of timber having the same dimensions as the defect. Defect should always be figured using the largest end diameter visible. Eighty percent is deducted because the other 20 percent is generally lost in sawkerf.

Defect from shake requires special treatment as shown in Figure 32.

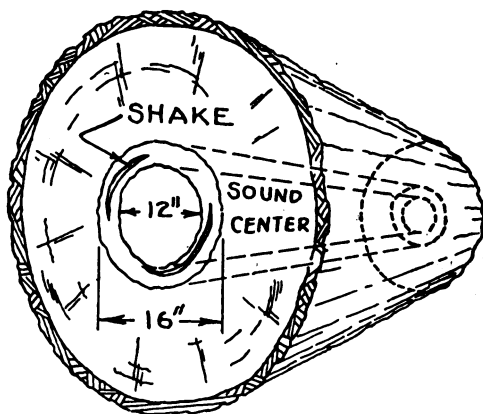


FIGURE 32. Logs with shake often have solid wood at the center of the log. In this example the log is 40 inches in diameter and 16 feet long. Its gross volume is 1,185 board feet. The deduction for defect is made as follows:

Use rule of thumb to get 21 inches as outside diameter of defect ($16 + 5$). This scales 308 board feet for the 16-foot length. The 12 inches of sound wood will scale 77 board feet. The deduction for defect equals 308 minus 77, or 231 board feet. The net volume of the log is 1,185 minus 231, or 954 board feet.

Rule of Thumb for Interior Defects

In actual practice the following rule of thumb is used by many experienced scalers for interior defects.

1. Obtain the average diameter of the rot.
2. Add to the average diameter—
 - One-half, if it is nine inches or less.
 - One-third, if it is from 10 to 19 inches, inclusive.
 - One-fourth, if it exceeds 19 inches.
3. Obtain the scale of a log of this diameter the same length as the defect.
4. Deduct this from the gross log scale.

STUMPAGE SALES

The sale of stumpage should be covered by an adequate contract which sets forth the conditions of the sale. A contract makes it necessary for the buyer and seller of stumpage to agree upon certain important points, in the interest of each, before any timber is cut and before any money changes hands. It also serves as a record of the agreed-to conditions. When a detailed agreement is prepared it is advisable that a qualified attorney be consulted.

The following form of a timber sale agreement will serve as a guide in preparing contracts :

SAMPLE TIMBER SALE AGREEMENT

Agreement entered into this _____ day of _____ 19____,
between _____, hereinafter
called the **SELLER** and _____,
(Name of seller)
(Name of purchaser)
of _____, hereinafter
(Post office) (State)
called the **PURCHASER**, Witnesseth :

ARTICLE 1: The **SELLER** agrees to sell and the **PURCHASER** agrees to buy, upon the terms and conditions hereinafter stated, the marked or designated timber, located in: Sub-division _____, Sec. _____, Twp. _____, Range _____.

Additional description of location _____,

<i>Species of Product</i>	<i>Estimated Volume M, cord, or pieces</i>	<i>Stumpage Rate Per M, cord, or piece</i>
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The PURCHASER shall make payment prior to cutting in the amount of \$_____ as _____
(Down payment, payment in full, etc.)

Additional payments shall be made as follows : _____

_____, but in no case shall timber be cut until paid for.

ARTICLE 2: The scaling, measurement, counting, etc., shall be handled and recorded as follows : _____

(Who should scale, location of scaling, record of scale, what log rule)

(Omit this article when timber is sold on cruised or marked volume rather than log scale).

ARTICLE 3: The title to the timber and other products shall remain in the SELLER until paid for by the PURCHASER.

ARTICLE 4: The PURCHASER further agrees to cut and remove said timber in strict accordance with the following conditions: (a) Only marked or designated timber shall be cut. Excessive damage to standing unmarked or undesignated timber shall be paid for at the rate of \$_____ per _____. (b) Stumps shall be cut as low as possible, but not to exceed _____ inches in height. Material _____ feet or more in length, and _____ inches or more in diameter inside the bark at the small end, and ___ percent or more sound shall be considered merchantable. Logs over ___ feet in length shall be scaled as two or more logs. Merchantable material left in the woods shall be paid for at the rate specified in Article 1. (c) PURCHASER shall use existing roads; new roads shall be located only with the consent of SELLER. (d) PURCHASER shall not haul across fields, pastures, orchards, etc., except by written consent of the SELLER. (e) PURCHASER shall protect fences, telephone, light and power lines, buildings, ditches, etc., against unnecessary injury, and shall repair damage caused by him by restoring them to the condition found prior to damage. (f) PURCHASER shall exercise all possible precaution against fire; abide by and conform to the State forest fire laws; exercise all possible protection to young growth; and abide by and conform to the Forest Practice Rules for the _____ Forest District.

ARTICLE 5: The PURCHASER and SELLER agree that only the following types of logging equipment shall be used:

(Team, size of tractor, etc.)

ARTICLE 6: The disposal of slash shall be agreed upon between the SELLER and PURCHASER as follows: -----

ARTICLE 7: Special Requirements are: -----

ARTICLE 8: This agreement, or any interest therein, may not be assigned by the PURCHASER without prior written consent of the SELLER.

ARTICLE 9: Unless extension of time is granted, all timber shall be cut and removed and the requirements of this agreement satisfied on or before ----- 19----.

ARTICLE 10: This agreement shall be binding upon the heirs, administrators, executors, successors, or assigns of both parties.

ARTICLE 11: In the event the PURCHASER fails to comply with the terms and conditions herein set forth, the SELLER may terminate this agreement and the PURCHASER shall be divested of all rights in the property without any right in the PURCHASER for refund of any money paid hereunder.

IN WITNESS WHEREOF, This agreement has been executed by the parties hereto on the date first written above.

(Witness)

(Seller)

(Witness)

(Purchaser)

APPENDIX



GLOSSARY OF LUMBER TERMS *

- Air-dried.** Dried by exposure to the atmosphere without artificial heat.
- American lumber standards.** American Lumber Standards embody basic provisions for softwood lumber dealing with recognized classifications, nomenclature, basic grades, seasoning standards, sizes, uniform workings, description, measurement, tally, shipping provisions, grade marking, tally cards, and inspection of lumber. The primary purpose of these standards is to serve as a guide or basic examples in the preparation or revision of the grading rules of the various lumber manufacturers' associations; their use as a framework for such rules will eliminate differences often existing.
- Annual growth ring.** (See Ring, annual growth.)
- Bastard sawn.** Hardwood lumber in which the annual rings make angles of 30 to 60 degrees with the surface of the piece.
- Beams and stringers.** Lumber of rectangular cross section, 5 or more inches thick and 8 or more inches wide, graded with respect to its strength when loaded on the narrow face.
- Bird's-eye.** A small central spot with the wood fibers arranged around it in the form of an ellipse so as to give the appearance of an eye.
- Boards.** (See Lumber.)
- Bow.** A deviation flatwise from a straight line drawn from end to end of a piece. It is measured at the point of greatest distance from the straight line.
- Boxed pith.** When the pith is between the four faces on an end of a piece.
- Brashness.** A condition of wood characterized by low resistance to shock and by abrupt failure across the grain without normal splintering.
- Broad-leaved trees.** (See Hardwoods.)
- Burl.** A large wart-like excrescence on a tree trunk. It contains the dark piths of a large number of buds, which rarely develop.
- Cambium.** The layer of tissue just beneath the bark from which the new wood and bark cells of each year's growth develop.
- Cell.** A general term for the minute units of wood structure. It includes fibers, vessels, and other elements of diverse structure and functions.
- Cellulose.** The carbohydrate that is the principal constituent of wood and forms the framework of the cells.

* From "Wood Structural Design Data," Vol. I, National Lumber Mfgs. Assoc.

- Check.** A lengthwise separation of the wood, which usually occurs across the rings of annual growth.
- Close grain.** (See Grain.)
- Coarse grain.** (See Grain.)
- Conifer.** (See Softwoods.)
- Connectors.** (See Timber Connectors.)
- Crook.** A deviation edgewise from a straight line drawn from end to end of a piece. It is measured at the point of greatest distance from the straight line.
- Cross break.** A separation of the wood cells across the grain, such as may be due to tension resulting from unequal shrinkage or mechanical stress.
- Cross grain.** (See Grain.)
- Cup.** A curve in a piece across the grain or width of a piece. It is measured at the point of greatest deviation from a straight line drawn from edge to edge of a piece.
- Decay.** Disintegration of wood substance due to the action of wood-destroying fungi.
- Incipient decay.** The early stage of decay in which the disintegration has not proceeded far enough to soften or otherwise impair the hardness of the wood perceptibly.
- Typical or advanced decay.** The stage of decay in which the disintegration is readily recognized because the wood has become punky, soft, and spongy, stringy, pitted, or crumbly.
- Density.** The mass of a body per unit volume. It is commonly although erroneously considered synonymous with specific gravity.
- Density rule.** Rules for estimating the density of wood based on percentage of summerwood and rate of growth.
- Diagonal grain.** (See Grain.)
- Diffuse-porous woods.** Hardwoods in which the pores are practically uniform in size throughout each annual ring, or decrease slightly in size toward the outer border of the ring.
- Dimension.** (See Lumber.)
- Dimension stock.** Squares or flat stock usually in pieces under the minimum sizes admitted in standard lumber grades, rough, dressed, green or dry, cut to the approximate dimension required for the various products of woodworking factories.
- Dote.** "Dote," "doze," and "rot" are synonymous with "decay."
- Dry rot.** A term loosely applied to many types of decay but especially to that which, when in an advanced stage, permits the wood to be easily crushed to a dry powder. The term is actually a misnomer for any decay, since all fungi require considerable moisture for growth, and the wood must have been moist at the time the "dry rot" occurred.
- Durability.** A general term for permanence or lastingness. Frequently used to refer to the degree of resistance of a species or of an individual piece of wood to decay. In this connection "resistance to decay" is a more specific term.

Edge grain. (See Grain.)

Empty-cell process. Any process for impregnating wood with preservatives or chemicals in which air is imprisoned in the wood under the pressure of the entering preservative and then expands, when the pressure is released, and drives out part of the injected preservative.

Encased knot. (See Knot.)

Extractives. Substances in wood, not an integral part of the cellular structure, that can be dissolved out with inert solvents.

Equilibrium moisture content. The moisture content at which wood neither gains nor loses moisture when surrounded by air at a given relative humidity and temperature.

Face width. The width of the face of a piece of dressed and matched or shiplapped lumber, not including the width of the tongue or lap. The amount of flooring, ceiling, siding or other matched items required to cover a given area should be computed on the basis of the face width of the pieces. (See Over-all width.)

Factory and shop lumber. (See Lumber.)

Fiber. A wood fiber is a comparatively long ($1/25$, or less, to $\frac{1}{2}$ inch), narrow, tapering cell closed at both ends.

Fiber-saturation point. The stage in the drying or in the wetting of wood at which the cell walls are saturated and the cell cavities are free from water.

Figure. The pattern produced in a wood surface by irregular coloration and by annual growth rings, rays, knots, and such deviations from regular grain as interlocked and wavy grain.

Fireproofing. Making wood resistant to fire to a degree that makes it difficult to ignite and keeps it from supporting its own combustion.

Flat grain. (See Grain, Plain sawn, also drawing.)

Flitch. A thick piece of lumber with wane (bark) on one or more edges.

Full-cell process. Any process for impregnating wood with preservatives or chemicals in which a vacuum is drawn to remove air from the wood before admitting the preservative.

Grade. Any of the quality classes into which products are segregated.

Grain. The direction, size, arrangement, appearance, or quality of the fibers in wood.

Close-grained wood. Wood with narrow and inconspicuous annual rings. The term is sometimes used to designate wood having small and closely spaced pores, but in this sense the term "fine textured" is more often used.

Coarse-grained wood. Wood with wide and conspicuous annual rings in which there is considerable difference between springwood and summerwood. The term is also used to designate wood with large pores, but in this sense the term "coarse textured" is more often used.

- Cross grain.** Wood in which the cells or fibers do not run parallel with the axis or sides of a piece.
- Diagonal grain.** Annual rings at an angle with the axis of a piece as a result of sawing at an angle with the bark of the tree.
- Edge grain (vertical grain).** Lumber in which the rings (so-called grain) form an angle of 45 degrees or more with the surface of the piece.
- Flat grain.** Lumber in which the rings form an angle of less than 45 degrees with the surface of the piece.
- Heartwood.** The inner core of the tree trunk comprising the annual rings containing nonliving elements; usually darker in color than sapwood.
- Interlocked grained wood.** Wood in which the fibers are inclined in one direction in a number of rings of annual growth, then gradually reverse and are inclined in an opposite direction in succeeding growth rings, then reverse again.
- Open-grained wood.** Common classification of painters for wood with large pores, also known as "coarse textured."
- Plain sawn.** Another term for flat grain, and used generally in hardwoods.
- Quarter sawn.** Another term for edge grain, and usually generally in hardwoods.
- Spiral grain.** A type of growth in which the fibers take a spiral course about the bole of a tree instead of the normal vertical course. The spiral may extend right handed or left handed around the tree trunk.
- Vertical grain.** Another term for edge grain.
- Wavy-grained wood.** Wood in which the fibers collectively take the form of waves or undulations.
- Green.** Unseasoned, wet.
- Growth ring.** (See Ring, annual growth.)
- Hardwoods.** The botanical group of trees that are broadleaved. The term has no reference to the actual hardness of the wood.
- Heart, heartwood.** The wood, the cells of which no longer participate in the life processes of the tree, extending from the pith to the sapwood. Heartwood is usually darker in color than sapwood.
- Imperfect manufacture.** Includes all defects or blemishes which are produced in manufacturing, such as chipped grain, loosened grain, raised grain, torn grain, skips in dressing, hit or miss, variation in sawing, miscut lumber, machine burn, machine gouge, mismatching, and insufficient tongue or groove.
- Interlocking grain.** (See Grain.)
- Joists and planks.** Lumber of rectangular cross section, 2 inches to but not including 5 inches thick and 4 or more inches wide, graded with respect to its strength in bending when loaded either on the narrow face as joist or on the wide face as plank.
- Kiln dried.** (See Seasoning.)

Knot. A branch or limb, embedded in the tree, which has been cut through in the process of lumber manufacture. Knots are classified according to size, form, quality and occurrence. To determine the size of a knot average maximum length and maximum width unless otherwise specified.

Encased knot. One whose rings of annual growth are not intergrown and homogeneous with those of the surrounding wood. The encasement may be partial or complete; of pitch or bark.

Intergrown knot. A knot whose rings of annual growth are completely intergrown with those of the surrounding wood.

Laminated wood. An assembly of wood built up of plies or laminations that have been joined either with glue or with mechanical fastenings. The term is most frequently applied where the plies are too thick to be classified as veneer and when the grain of all plies is parallel.

Lignin. A principal constituent of wood, second in quantity to cellulose. It incrusts the cell walls and cements the cells together.

Lumber. Lumber is the product of the saw and planing mill not further manufactured than by sawing, resawing, and passing lengthwise through a standard planing mill, cross-cutting to length and working. Lumber of thickness not in excess of $\frac{1}{4}$ " to be used for veneering is classified as veneer.

Factory and shop lumber. Lumber intended to be cut up for use in further manufacture. It is graded on the basis of the percentage of the area which will produce a limited number of cuttings of a specified, or a given minimum, size and quality.

Yard lumber. Lumber of all sizes and patterns which is intended for general building purposes. The grading of yard lumber is based on the intended use of the particular grade and is applied to each piece with reference to its size and length when graded without consideration to further manufacture.

Strips. Yard lumber less than 2 inches thick and less than 8 inches wide.

Boards. Yard lumber less than 2 inches thick, 8 or more inches wide.

Dimension. All yard lumber except boards, strips and timbers; that is yard lumber from 2 inches to but not including 5 inches thick, and of any width.

Timbers. Lumber 5 or more inches in least dimension.

Millwork. Generally all building materials made of finished wood and manufactured in millwork plants and planing mills are included under the term millwork, i.e., doors, window and door frames, sash, blinds, porch work, mantels, panel work, stairways, and special woodwork. It does not include finish dressed four sides, or siding, or partition, which are items of yard lumber.

Moisture content of wood. Weight of the water contained in the wood usually expressed in percentage of the weight of the oven-dry wood.

Moisture Gradient. A condition of graduated moisture content between the inner and outer portions of a material, such as wood, due to the losing or absorbing of moisture.

Moisture-proofing. Making wood resistant to change in moisture content, especially to entrance of moisture.

Open-grain. (See Grain.)

Over-all width. The total of a wide piece of dressed and matched or shiplapped lumber including the width of the tongue or lap. The amount of such lumber required to cover a given area should not be computed on the basis of the over-all width since the tongue or lap is the means of joining the pieces and does not "cover" any surface. (See Face width.)

Peck (found in cedar and cypress). Channeled or pitted areas or pockets of localized decay.

Pitch pocket. A well defined opening between rings of annual growth, usually containing, or which has contained, more or less pitch, either solid or liquid. Bark also may be present in the pocket.

Pith. The small soft core occurring in the structural center of a log. The wood immediately surrounding the pith often contains small checks, shakes, or numerous pin knots, and is discolored; any such combination of characteristics is known as heart center.

Plywood. A piece of wood made of three or more layers of veneer joined with glue, and usually laid with the grain of adjoining plies at right angles. Almost always an odd number of plies are used to secure balanced construction.

Plain sawn. (See Grain)

Planing mill products. Products worked to pattern, such as flooring, ceiling, and siding.

Pocket rot. Typical decay which appears in the form of a hole, pocket, or area of soft rot usually surrounded by apparently sound wood.

Pore. (See Vessel)

Posts and timbers. Lumber of square or approximately-square cross section, 5 by 5 inches and larger, graded primarily for use as posts or columns carrying longitudinal load but adapted for miscellaneous uses in which strength in bending is not especially important.

Preservative. With reference to wood, any substance applied to or injected into wood to protect it from attack of fungi, insects, or marine animals.

Quarter sawn. (See Grain)

Radial. Coincident with a radius from the axis of the tree or log to the circumference.

- Rate of growth.** The rate at which a tree has laid on wood, measured radially in the trunk or in lumber cut from the trunk. The unit of measure in use is the number of annual growth rings per inch.
- Rays, wood.** Strips of cells extending radially within a tree and varying in height from a few cells in some species to 4 inches or more in oak. The rays serve primarily to store food and transport it horizontally in the tree.
- Ring, annual growth.** The growth layer put on in a single growth year.
- Ring-porous woods.** A group of hardwoods in which the pores are comparatively large at the beginning of each annual ring and decrease in size more or less abruptly toward the outer portion of the ring, thus forming a distinct inner zone of pores known as the springwood and the outer zone with smaller pores known as the summerwood.
- Rot.** (See Decay)
- Sap.** All the fluids in a tree, special secretions and excretions, such as oleoresin, excepted.
- Sapwood.** The outer layers of growth in a tree, exclusive of bark, which contains living elements; usually lighter in color than heartwood. Under most conditions sapwood is more susceptible to decay than heartwood; as a rule, it is more permeable to liquids than heartwood. Sapwood is not essentially weaker or stronger than heartwood of the same species.
- Seasoning.** The evaporation or extraction of moisture from green or partially dried wood.
- Air dried or air seasoned.** Dried by exposure to the atmosphere usually in a yard, without artificial heat.
- Kiln dried.** Dried in a kiln with the use of artificial heat.
- Second growth.** Timber that has grown after the removal by any means of all or a large portion of the previous stand.
- Shake.** A separation along the grain, most of which occurs between the rings of annual growth.
- Shop lumber.** (See Lumber)
- Side-cut (pithless).** The term used when the pith is not present in a piece.
- Softwood.** One of the group of trees which has needle-like or scale-like leaves, often referred to as conifers. The term softwood has no reference to the softness of the wood.
- Specific gravity.** The ratio of the weight of a body to the weight of an equal volume of water at some standard temperature.
- Spiral grain.** (See Grain)
- Split (through check).** A lengthwise separation of the wood which occurs usually across the rings of annual growth, extending from one surface through the piece to the opposite surface, or to an adjoining surface.
- Springwood.** The more or less open and porous tissue marking the inner part of each annual ring, formed early in the period

- of growth. It is usually less dense and weaker mechanically than summerwood.
- Stain, blue.** A bluish or grayish discoloration of the sapwood caused by the growth of certain mold-like fungi on the surface and in the interior of the piece.
- Strength.** The properties of wood which enable it to resist different forces or loads. Strength may apply to any one of the mechanical properties, such as strength in bending, hardness, strength in compression, etc.
- Strips.** (See Lumber)
- Structural lumber.** Lumber that is 2 or more inches thick and 4 or more inches wide, intended for use where working is based on the strength of the piece and the use of the entire piece.
- Summerwood.** The dense, fibrous outer portion of each annual ring, usually without conspicuous pores, formed late in the growing period, not necessarily in summer. It is usually more dense and stronger mechanically than springwood.
- Tangential.** Strictly, coincident with a tangent at the circumference of a tree or log, or parallel to such a tangent. In practice, however, it often means roughly coincident with a growth ring.
- Texture.** A term often used interchangeably with grain.
- Timber.** A broad term including standing trees, and certain products thereof.
- Round timber.** Timber used in the original round form, such as poles, piling, and mine timbers.
- Standing timber.** Timber still on the stump.
- Timber connectors.** Rings and dowels of metal or wood in adjoining members, placed in precut grooves or holes in timber framing, and the timber members then drawn and held tightly together by bolts. These devices provide an efficient means of transferring load at the joints of structural members.
- Timbers.** Lumber 5 inches or larger in least dimension.
- Twist.** A form of warp resulting in distortion caused by the turning or winding of the edges of a board.
- Veneer.** Thin sheets of wood.
- Vertical grain.** (See Grain)
- Vessels.** Wood cells of comparatively large diameter which have open ends and are set one above the other forming continuous tubes. The openings of the vessels on the surface of a piece of wood are usually referred to as pores.
- Virgin growth.** The original growth of mature trees.
- Wane.** Bark, or lack of wood or bark, from any cause, on edge or corner of a piece.
- Warp.** Any variation from a true or plane surface. It includes bow, crook, cup or any combination thereof.
- Wavy grain.** (See Grain)
- Weathering.** The mechanical and chemical disintegration and discoloration of the surface of wood that is caused by exposure

to light and by the alternate shrinking and swelling of the surface fibers with continual changes in moisture content due to weather changes. Weathering does not include decay.

Workability. The degree of ease and smoothness of cut obtainable with hand or machine tools.

Working of wood. Change in the dimensions of a piece of wood with change in moisture content.

Yard lumber. (See Lumber)

TRACTOR PRODUCTION AND COST ESTIMATION ¹

Today, the logger is becoming more and more interested in costs. With labor and other costs increasing, it is imperative that cost control in the logging industry be continually emphasized.

Ever since yarding with tractors and arches became common in the Redwood Region, the demand for production estimation has increased. The use of tractor and arch production tables can be very valuable to loggers and estimators who want a quick answer to possible pay loads and production per hour.

The conditions modifying production on the tables should be read carefully before any estimation is attempted. Of particular interest is the fact that ideal tractive conditions on level ground was assumed. In other words, the tables endeavor to show the maximum production possible with the intent of allowing the logging estimator to deduct for unfavorable conditions.

Log weight per board foot should also be checked. (See Table 32.) Eleven pounds per board foot (Scribner scale) was taken as average. If a logger knows his timber weighs more or less, then allowances should be made accordingly.

For example, assume on operation in timber that averages 14 pounds per board foot. A correction must then be made:

$$\frac{11 \# / \text{b.f.}}{14 \# / \text{b.f.}} = 79\% \text{ of the original load}$$

¹ The production tables and an explanation of their use were supplied by the Caterpillar Tractor Company of Peoria, Illinois. Estimated hourly production tables were prepared by the Hyster Company, Portland, Oregon.

If logs with an average diameter of 20' are being yarded by a tractor having a 113 drawbar horsepower, it becomes necessary to reduce the pay load from 5,600 b.f. to (5,600 x 0.79) 4,430 b.f. Production per hour on any length haul is reduced accordingly.

Note that six minutes per load has been allowed for hooking and unhooking. Also observe that second-gear hauling travel is assumed, with a return at fourth-gear speed.

Other factors to be considered are grades, adverse or favorable, bad tractive conditions, undergrowth or natural obstacle efficiency, weather conditions, effect of altitude on engine performance, mechanical efficiency (condition of equipment), scattered timber stands, and labor efficiency.

Ideal tractive conditions and resultant pounds of drawbar pull in low gear are usually rated at 90 percent of the tractor weight in pounds. This percentage is reduced to 60 percent for loose earth and to 30 percent for loose sand.

The tables are based on a log sliding resistance of 38 percent and a rolling resistance per ton of weight on the arch of 140 pounds. Sample problem:

Assumptions:

Equipment.....	80 drawbar horsepower tractor with towing winch and logging arch
Scale.....	Scribner
Log length.....	32' @ 11#/b.f.
Average log diameter.....	28"
Average haul length.....	3,000 ft. one way
Ground conditions.....	Ideal and level
Other assumptions.....	Similar to table
Tractor owning and operating cost (no operator).....	\$2.88 per hour
Winch owning and operating cost.....	1.04 per hour
Arch owning and operating cost.....	.68 per hour
Total equipment hourly cost.....	<u>\$4.60</u>

Solution (See Table 11)

Average number of logs per load 3.8

Average board foot per load-----4,400 b.f.

Production on 3,000' haul-----7,600 b.f./50 min. hour

Corrected production of fairly

good logging operation-----70% of 7,600 b.f. = 5,330 b.f.

Equipment and cable cost for yarding each M.b.f. is therefore :

$$\frac{\$4.60}{5.33 \text{ M.b.f.}} = \$0.87$$

To find a complete cost for yarding each M.b.f., it is necessary to know the hourly cost of the tractor operator, choker setters, unhook man, supervision and assigned overhead.

Correct equipment hourly costs should be secured from the local tractor dealer as these costs vary according to severity of operation, freight charge, taxes, etc. The hourly costs given here are to be used only as an aid in illustrating cost finding procedure.

TABLE 10—ESTIMATED HOURLY LOG PRODUCTION, 113 DRAWBAR H. P. TRACTOR

WITH TOWING WINCH AND LOGGING ARCH
(In Board Feet per Hour—Scribner Scale)

32' Logs

Average speeds: Loaded, second-gear—194 feet per minute
Unloaded, fourth-gear—317 feet per minute

Av. dia. of logs	Av. logs per load	Av. bd. ft., per load	AVERAGE LENGTHS HAUL IN FEET—ONE WAY							
			1,000'	1,500'	2,000'	2,500'	3,000'	3,500'	4,000'	4,500'
			16"	13,300	10,300	8,400	7,200	6,300	5,400	4,800
20"	10,000	15,000	12,200	10,300	8,900	7,900	7,000	6,400		
24"	7,500	16,100	13,100	11,100	9,600	8,500	7,600	6,800		
28"	5,000	20,200	15,600	12,700	10,700	9,300	8,200	7,300		
32"	4,000	20,500	15,900	12,900	10,900	9,400	8,300	7,400		
36"	3,200	20,500	15,900	12,900	10,900	9,400	8,300	7,400		
40"	2,500	20,500	16,100	13,100	11,100	9,600	8,500	7,600		
44"	2,000	20,500	15,900	12,900	10,900	9,400	8,300	7,400		

**TABLE 11—ESTIMATED HOURLY LOG PRODUCTION, 80 DRAWBAR H. P. TRACTOR
WITH TOWING WINCH AND LOGGING ARCH
(In Board Feet Per Hour—Scribner Scale)**

32' Logs
Average travel speeds: Loaded—second gear—194 feet per minute
Unloaded—fourth gear—405 feet per minute

Av. dia. of logs	Av. logs per load	Av. bd. ft. per load	AVERAGE LENGTH HAUL IN FEET—ONE WAY							
			1,000'	1,500'	2,000'	2,500'	3,000'	3,500'	4,000'	4,500'
16"	9.0	2,880	10,300	8,500	6,900	5,750	5,000	4,370	3,940	3,570
20"	8.0	4,480	15,800	12,800	10,500	8,900	7,800	6,860	6,150	5,560
24"	5.6	4,480	15,800	12,800	10,500	8,900	7,800	6,860	6,150	5,560
28"	3.8	4,400	15,800	12,600	10,300	8,750	7,600	6,750	6,040	5,460
32"	3.0	4,400	15,800	12,600	10,300	8,750	7,600	6,750	6,040	5,460
36"	2.4	4,480	15,800	12,700	10,400	8,850	7,750	6,810	6,100	5,530
40"	1.8	4,340	15,400	12,400	10,200	8,600	7,500	6,640	5,950	5,380
44"	1.5	4,440	15,600	12,650	10,350	8,800	7,700	6,740	6,080	5,500

**TABLE 12—ESTIMATED HOURLY LOG PRODUCTION, 55 DRAWBAR H. P. TRACTOR
WITH TOWING WINCH AND LOGGING ARCH
(In Board Feet Per Hour—Scribner Scale)**

32' Logs

Average travel speeds: Loaded—second gear—202 feet per minute
Unloaded—fourth gear—387 feet per minute

Av. dia. of logs	Av. logs per load	Av. bd. ft. per load	AVERAGE LENGTH HAUL IN FEET—ONE WAY							
			1,000'	1,500'	2,000'	2,500'	3,000'	3,500'	4,000'	4,500'
16"	9.0	2,880	10,600	8,320	6,820	5,790	5,040	4,430	3,840	3,600
20"	5.3	2,970	10,950	8,600	7,050	5,970	5,200	4,570	3,960	3,710
24"	3.7	2,960	10,900	8,560	7,000	5,950	5,170	4,550	3,940	3,700
28"	2.5	2,900	10,700	8,390	6,870	5,830	5,070	4,460	3,860	3,620
32"	2.0	2,940	10,850	8,500	6,960	5,900	5,140	4,530	3,920	3,680
36"	1.6	2,960	10,900	8,560	7,000	5,950	5,170	4,550	3,940	3,700
40"	1.2	2,900	10,700	8,390	6,870	5,830	5,070	4,460	3,860	3,620
44"	1.0	2,960	10,900	8,560	7,000	5,950	5,170	4,550	3,940	3,700

NOTE: The estimated production figures in Tables 10, 11 and 12 are calculated and are based entirely upon ideal conditions of level ground, a balanced operation, 100 percent operating efficiency, and logs weighing approximately 11 pounds per board foot Scribner Scale. Fifty minute hours are used, six minutes per load for hooking and unhooking and for loads of more than four logs to be bunched for the arch tractor.

Factors to be considered when using these figures:

1. Difficulty in maintaining average board feet per load.
2. Variable conditions of terrain, i.e., adverse grades, soil conditions, etc.

3. Undergrowth.

4. Weather conditions.

5. Altitude.

6. Mechanical condition of equipment.

7. Scattered timber stands.

8. Variable weight of logs in mixed stands of timber.

9. Efficiency of over-all operation.

Seventy percent of the above figures should be used as an estimate for a fairly good logging operation with no adverse grades for the loaded haul to the landing. For difficult operations, 40 percent of the above figures may be used.

**TABLE 13—ESTIMATED HOURLY PULPWOOD PRODUCTION, 43 DRAWBAR H.P. TRACTOR
USING TOWING WINCH AND LOGGING SULKY WITH PNEUMATIC TIRES**

(Cords per Hour)

Tree Length Logs

Average travel speeds: Loaded—second gear—211 feet per minute

Unloaded—fourth gear—475 feet per minute

Number of trees per cord	Cords, per load	AVERAGE LENGTH HAUL IN FEET—ONE WAY							
		1,000'	1,500'	2,000'	2,500'	3,000'	3,500'	4,000'	4,500'
18.....	3.3	12.8	10.7	8.4	7.1	6.2	5.4	4.9	4.5
14.....	4.0	15.6	13.0	10.1	8.6	7.5	6.5	6.0	5.4
11.....	4.3	16.7	14.0	10.9	9.3	8.0	7.0	6.4	5.8

A cord, 4' x 4' x 8', 128 cubic feet. To convert to a "unit," 4' x 5' x 8', 160 cubic feet, multiply by .8.

NOTE: These estimated production figures are calculated and are based entirely upon ideal conditions of level ground, a balanced operation, 100 percent operating efficiency, and logs weighing approximately 43 pounds per cubic foot. Fifty minute hours are used, six minutes per load for hooking and unhooking and loads are bunched for the sulky.

Factors to be considered when using these figures:

1. Difficulty in maintaining average cords per load.
2. Variable conditions of terrain, i.e., adverse grades, soil conditions, etc.
3. Undergrowth.

4. Weather conditions.

5. Altitude.

6. Mechanical condition of equipment.

7. Scattered timber stands.

8. Variable weight of logs in mixed stands of timber.

9. Efficiency of over-all operation.

Sixty percent of the above figures should be used as an estimate for a fairly good pulpwood operation with no adverse grades for the loaded haul to the landing. For difficult operations, 35 percent of the above figures may be used.

TABLE 14—AREA OF CIRCLES IN SQUARE FEET

Diameter, inches	TENTHS OF INCHES									
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	Area—Square feet									
1	0.006	0.007	0.008	0.009	0.011	0.012	0.014	0.016	0.018	0.020
2	.022	.024	.026	.029	.031	.034	.037	.040	.043	.046
3	.049	.052	.056	.059	.063	.067	.071	.075	.079	.083
4	.096	.092	.096	.101	.106	.111	.115	.121	.126	.131
5	.136	.142	.147	.153	.159	.165	.171	.177	.184	.190
6	.196	.203	.210	.216	.223	.230	.238	.245	.252	.260
7	.267	.275	.283	.291	.299	.307	.315	.323	.332	.340
8	.349	.358	.367	.376	.385	.394	.403	.413	.422	.432
9	.442	.452	.462	.472	.482	.492	.503	.513	.524	.535
10	.545	.556	.568	.579	.590	.601	.613	.625	.636	.648
11	.660	.672	.684	.697	.709	.721	.734	.747	.760	.772
12	.785	.799	.812	.825	.839	.853	.866	.880	.894	.908
13	.922	.936	.950	.965	.979	.994	1.009	1.024	1.039	1.054
14	1.069	1.084	1.100	1.115	1.131	1.147	1.163	1.179	1.195	1.211
15	1.227	1.244	1.260	1.277	1.294	1.310	1.327	1.344	1.362	1.379
16	1.396	1.414	1.431	1.449	1.467	1.485	1.503	1.521	1.539	1.558
17	1.576	1.595	1.614	1.632	1.651	1.670	1.689	1.709	1.728	1.748
18	1.767	1.787	1.807	1.827	1.847	1.867	1.887	1.907	1.928	1.948
19	1.969	1.990	2.011	2.032	2.053	2.074	2.095	2.117	2.138	2.160
20	2.181	2.204	2.226	2.248	2.270	2.292	2.315	2.337	2.360	2.383
21	2.405	2.428	2.451	2.475	2.498	2.521	2.545	2.568	2.592	2.616
22	2.640	2.664	2.688	2.712	2.737	2.761	2.786	2.810	2.835	2.860
23	2.885	2.910	2.936	2.961	2.986	3.012	3.038	3.064	3.089	3.115
24	3.142	3.168	3.194	3.221	3.247	3.275	3.301	3.328	3.355	3.382

Diameter, inches	Area, sq. ft.	Diameter, inches	Area, sq. ft.	Diameter, inches	Area, sq. ft.	Diameter, inches	Area, sq. ft.	Diameter, inches	Area, sq. ft.
25	3.41	32	5.59	39	8.30	46	11.54	53	15.32
26	3.69	33	5.94	40	8.73	47	12.05	54	15.90
27	3.98	34	6.30	41	9.17	48	12.57	55	16.50
28	4.28	35	6.68	42	9.62	49	13.10	56	17.10
29	4.59	36	7.07	43	10.08	50	13.64	57	17.72
30	4.91	37	7.47	44	10.56	51	14.19	58	18.35
31	5.24	38	7.88	45	11.04	52	14.75	59	18.99

This table is used to calculate volume in cubic feet. Multiply value in table by length in feet and tenths of feet to get volume in cubic feet. Pieces over 4 feet in length must be figured as two or more pieces to allow for taper. A piece 8 feet long, 6 inches at small end and 8 inches at large end, figure as one piece 6 inches by 4 feet and one piece 7 inches by 4 feet.

TABLE 15—UNITS OF LENGTH AND AREA, CONVERSION FACTORS

LINEAL MEASURE

- 1 rod = 25 links = 16½ feet = 5½ yards
- 1 link = 7.92 inches
- 1 chain = 66 feet = 4 rods = 100 links
- 1 mile = 5,280 feet = 1,760 yards = 320 rods

SQUARE MEASURE

- 1 square link = 62.7 square inches = .436 square feet
- 1 square foot = 144 square inches
- 1 square yard = 9 square feet
- 1 square rod = 272½ square feet = 30½ square yards
- 1 acre = 43,560 square feet = 4,840 square yards = 160 square rods
- 1 section = 1 square mile = 640 acres
- 1 township = 36 square miles = 36 sections

CONVERSION FACTORS

- Feet x .00019 = miles
- Yards x .0006 = miles
- Square inches x .007 = square yards
- Square feet x .111 = square yards
- Square yards x .000207 = acres
- Acres x 4,840 = square yards
- Cubic inches x .00058 = cubic feet
- Cubic feet x .03704 = cubic yards
- Links x .22 = yard
- Links x .66 = feet
- Feet x 1.5 = links

**TABLE 16—SOLID CUBIC CONTENTS OF LOGS
AVERAGE MIDDLE DIAMETER, IN INCHES**

Length, feet	CONTENTS IN CUBIC FEET																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	20																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
4	.25	.25	.5	1	1	1	2	2	3	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
5	.25	.5	.5	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22	23	23	24	24	25	25	26	26	27	27	28	28	29	29	30	30	31	31	32	32	33	33	34	34	35	35	36	36	37	37	38	38	39	39	40	40	41	41	42	42	43	43	44	44	45	45	46	46	47	47	48	48	49	49	50	50	51	51	52	52	53	53	54	54	55	55	56	56	57	57	58	58	59	59	60	60	61	61	62	62	63	63	64	64	65	65	66	66	67	67	68	68	69	69	70	70	71	71	72	72	73	73	74	74	75	75	76	76	77	77	78	78	79	79	80	80	81	81	82	82	83	83	84	84	85	85	86	86	87	87	88	88	89	89	90	90	91	91	92	92	93	93	94	94	95	95	96	96	97	97	98	98	99	99	100	100	101	101	102	102	103	103	104	104	105	105	106	106	107	107	108	108	109	109	110	110	111	111	112	112	113	113	114	114	115	115	116	116	117	117	118	118	119	119	120	120	121	121	122	122	123	123	124	124	125	125	126	126	127	127	128	128	129	129	130	130	131	131	132	132	133	133	134	134	135	135	136	136	137	137	138	138	139	139	140	140	141	141	142	142	143	143	144	144	145	145	146	146	147	147	148	148	149	149	150	150	151	151	152	152	153	153	154	154	155	155	156	156	157	157	158	158	159	159	160	160	161	161	162	162	163	163	164	164	165	165	166	166	167	167	168	168	169	169	170	170	171	171	172	172	173	173	174	174	175	175	176	176	177	177	178	178	179	179	180	180	181	181	182	182	183	183	184	184	185	185	186	186	187	187	188	188	189	189	190	190	191	191	192	192	193	193	194	194	195	195	196	196	197	197	198	198	199	199	200	200	201	201	202	202	203	203	204	204	205	205	206	206	207	207	208	208	209	209	210	210	211	211	212	212	213	213	214	214	215	215	216	216	217	217	218	218	219	219	220	220	221	221	222	222	223	223	224	224	225	225	226	226	227	227	228	228	229	229	230	230	231	231	232	232	233	233	234	234	235	235	236	236	237	237	238	238	239	239	240	240	241	241	242	242	243	243	244	244	245	245	246	246	247	247	248	248	249	249	250	250	251	251	252	252	253	253	254	254	255	255	256	256	257	257	258	258	259	259	260	260	261	261	262	262	263	263	264	264	265	265	266	266	267	267	268	268	269	269	270	270	271	271	272	272	273	273	274	274	275	275	276	276	277	277	278	278	279	279	280	280	281	281	282	282	283	283	284	284	285	285	286	286	287	287	288	288	289	289	290	290	291	291	292	292	293	293	294	294	295	295	296	296	297	297	298	298	299	299	300	300	301	301	302	302	303	303	304	304	305	305	306	306	307	307	308	308	309	309	310	310	311	311	312	312	313	313	314	314	315	315	316	316	317	317	318	318	319	319	320	320	321	321	322	322	323	323	324	324	325	325	326	326	327	327	328	328	329	329	330	330	331	331	332	332	333	333	334	334	335	335	336	336	337	337	338	338	339	339	340	340	341	341	342	342	343	343	344	344	345	345	346	346	347	347	348	348	349	349	350	350	351	351	352	352	353	353	354	354	355	355	356	356	357	357	358	358	359	359	360	360	361	361	362	362	363	363	364	364	365	365	366	366	367	367	368	368	369	369	370	370	371	371	372	372	373	373	374	374	375	375	376	376	377	377	378	378	379	379	380	380	381	381	382	382	383	383	384	384	385	385	386	386	387	387	388	388	389	389	390	390	391	391	392	392	393	393	394	394	395	395	396	396	397	397	398	398	399	399	400	400	401	401	402	402	403	403	404	404	405	405	406	406	407	407	408	408	409	409	410	410	411	411	412	412	413	413	414	414	415	415	416	416	417	417	418	418	419	419	420	420	421	421	422	422	423	423	424	424	425	425	426	426	427	427	428	428	429	429	430	430	431	431	432	432	433	433	434	434	435	435	436	436	437	437	438	438	439	439	440	440	441	441	442	442	443	443	444	444	445	445	446	446	447	447	448	448	449	449	450	450	451	451	452	452	453	453	454	454	455	455	456	456	457	457	458	458	459	459	460	460	461	461	462	462	463	463	464	464	465	465	466	466	467	467	468	468	469	469	470	470	471	471	472	472	473	473	474	474	475	475	476	476	477	477	478	478	479	479	480	480	481	481	482	482	483	483	484	484	485	485	486	486	487	487	488	488	489	489	490	490	491	491	492	492	493	493	494	494	495	495	496	496	497	497	498	498	499	499	500	500	501	501	502	502	503	503	504	504	505	505	506	506	507	507	508	508	509	509	510	510	511	511	512	512	513	513	514	514	515	515	516	516	517	517	518	518	519	519	520	520	521	521	522	522	523	523	524	524	525	525	526	526	527	527	528	528	529	529	530	530	531	531	532	532	533	533	534	534	535	535	536	536	537	537	538	538	539	539	540	540	541	541	542	542	543	543	544	544	545	545	546	546	547	547	548	548	549	549	550	550	551	551	552	552	553	553	554	554	555	555	556	556	557	557	558	558	559	559	560	560	561	561	562	562	563	563	564	564	565	565	566	566	567	567	568	568	569	569	570	570	571	571	572	572	573	573	574	574	575	575	576	576	577	577	578	578	579	579	580	580	581	581	582	582	583	583	584	584	585	585	586	586	587	587	588	588	589	589	590	590	591	591	592	592	593	593	594	594	595	595	596	596	597	597	598	598	599	599	600	600	601	601	602	602	603	603	604	604	605	605	606	606	607	607	608	608	609	609	610	610	611	611	612	612	613	613	614	614	615	615	616	616	617	617	618	618	619	619	620	620	621	621	622	622	623	623	624	624	625	625	626	626	627	627	628	628	629	629	630	630	631	631	632	632	633	633	634	634	635	635	636	636	637	637	638	638	639	639	640	640	641	641	642	642	643	643	644	644	645	645	646	646	647	647	648	648	649	649	650	650	651	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26	11	14	17	20	24	28	32	36	41	46	51	57
27	9	15	18	21	25	29	33	38	43	48	53	59
28	10	15	18	22	26	30	34	39	44	49	55	61
29	10	16	19	23	27	31	36	40	46	51	57	63
30	10	16	20	24	28	32	37	42	47	53	59	65
31	11	17	20	24	29	33	38	43	49	55	61	68
32	11	17	21	25	29	34	39	45	50	57	63	70
33	12	18	22	26	30	35	40	46	52	58	64	72
34	12	19	22	27	31	36	42	47	54	60	67	74
35	12	19	23	27	32	37	43	49	55	62	69	76
36	13	20	24	28	33	38	44	50	57	64	71	79
37	13	20	24	29	34	40	45	52	58	65	73	81
38	13	21	25	30	35	41	47	53	60	67	75	83
39	14	21	26	31	36	42	48	54	61	69	77	85
40	14	22	26	31	37	43	49	56	63	71	79	87

U. S. FOREST SERVICE

TABLE 17—PULPWOOD MEASUREMENT
8-FOOT WOOD FOR TRUCKS, FLAT AND GONDOLA CARS

Length of load in feet	Height in feet					
	1	2	3	4	5	6
	Number of cords					
6.....	.37	.75	1.12	1.50	1.87	2.25
6¼.....	.39	.78	1.17	1.56	1.95	2.34
6½.....	.41	.81	1.22	1.62	2.03	2.44
6¾.....	.42	.84	1.27	1.69	2.11	2.53
7.....	.44	.87	1.31	1.75	2.19	2.62
7¼.....	.45	.91	1.36	1.81	2.27	2.72
7½.....	.47	.94	1.41	1.87	2.34	2.81
7¾.....	.48	.97	1.45	1.94	2.42	2.91
8.....	.50	1.00	1.50	2.00	2.50	3.00
8¼.....	.52	1.03	1.55	2.06	2.58	3.09
8½.....	.53	1.06	1.59	2.12	2.66	3.19
8¾.....	.55	1.09	1.64	2.19	2.73	3.28
9.....	.56	1.12	1.69	2.25	2.81	3.37
9¼.....	.58	1.16	1.73	2.31	2.89	3.47
9½.....	.59	1.19	1.78	2.37	2.97	3.56
9¾.....	.61	1.22	1.83	2.44	3.05	3.66
10.....	.62	1.25	1.87	2.50	3.12	3.75
10¼.....	.64	1.28	1.92	2.56	3.20	3.84
10½.....	.66	1.31	1.97	2.62	3.28	3.94
10¾.....	.67	1.34	2.02	2.69	3.36	4.03
11.....	.69	1.37	2.06	2.75	3.44	4.12
11¼.....	.70	1.41	2.11	2.81	3.52	4.22
11½.....	.72	1.44	2.16	2.87	3.59	4.31
11¾.....	.73	1.47	2.20	2.94	3.67	4.41
12.....	.75	1.50	2.25	3.00	3.75	4.50
12¼.....	.77	1.53	2.30	3.06	3.83	4.59
12½.....	.78	1.56	2.34	3.12	3.91	4.69
12¾.....	.80	1.59	2.39	3.19	3.98	4.78
13.....	.81	1.62	2.44	3.25	4.06	4.87
13¼.....	.83	1.66	2.48	3.31	4.14	4.97
13½.....	.84	1.69	2.53	3.37	4.22	5.06
13¾.....	.86	1.72	2.58	3.44	4.30	5.16
14.....	.87	1.75	2.62	3.50	4.37	5.25
14¼.....	.89	1.78	2.67	3.56	4.45	5.34
14½.....	.91	1.81	2.72	3.62	4.53	5.44
14¾.....	.92	1.84	2.77	3.69	4.61	5.53

Compiled by M&O Paper Company.

TABLE 18—STANDARD SPECIFICATIONS FOR TIMBER PILES

Species: Douglas fir, redwood and cedar.

Requirements: Sound, green, free from injurious ring shakes, rot; loose, unsound or large knots or other defects materially impairing their strength or durability. Of uniform taper from butt to tip; diameter 3' from butt no more than 1" less than butt diameter. Straight line from center of butt to center of tip shall not deviate more than 1" for each 10'. Short or reverse bends or kinks, spiral grain making a complete turn in 40' or less, not allowed. Piling to be peeled and limbs trimmed flush with surface. Butts and tips to be cut square and clean. Must average at least Douglas Fir 6, Redwood and Cedar 7 annual rings for average of third, fourth and fifth inch along any radial line from the center of the end of the pile.

Dimensions:

Length, feet	Douglas Fir			Redwood and Cedar		
	Maximum diameter, butt, inches	Minimum diameter, butt, inches	Minimum diameter, tip, inches	Maximum diameter, butt, inches	Minimum diameter, butt, inches	Minimum diameter, tip, inches
85 or more.....	20	16	7½	22	16	7½
75 to 84.....	20	15½	8	21	15½	8
65 to 74.....	20	15	8	20	15	8
55 to 64.....	19	14	8	20	14½	8
45 to 54.....	19	14	8	19	14	8
35 to 44.....	18	13	8	18	13½	8
25 to 34.....	18	13	8	18	13½	8
15 to 24.....	16	13	8	17	13½	8

Average diameter of heartwood for untreated Douglas fir 75 percent and redwood and cedar over 12", 80 percent of the average butt diameter. For piles 12" and less sapwood not to exceed 1½". When heartwood diameter is greater than minimum required, average thickness of sapwood may be increased one-third of the increased diameter of heartwood over that required, maximum 2¼".

CALIFORNIA DIVISION OF HIGHWAYS

TABLE 19—FUEL VALUE OF WOODS

Species	Lbs./cu. ft., air dry	Million B.T.U's/90 cu. ft., cord	Percent one ton of coal
Canyon live oak.....	54	36	137
Blue gum.....	52	35	135
Madrone.....	46	30	115
Tanbark oak.....	40	27	104
California black oak.....	40	27	104
California laurel.....	39	26	100
Black willow.....	31	20	77
Douglas fir.....	31	20	77
Redwood.....	28	18	69

TABLE 21—REDWOOD SPLIT PRODUCTS

BOARD FOOT VOLUME, NUMBER OF PIECES PER 1,000 BOARD FEET, AND
NUMBER OF PIECES PER TON, GREEN AND AIR DRY

Item	Size	Board ft. per piece	Number per M. bd. ft.	Number per ton	
				Green	Air dry*
Posts.....	5" x 5" x 8'	16.66	60	29	53
Posts.....	4" x 5" x 8'	13.33	75.0	36	64
Posts.....	4" x 5" x 7'	11.66	86	41	73
Posts.....	4" x 5" x 6'	10.00	100	48	86
Posts.....	4" x 4" x 7'	9.33	107	52	93
Posts.....	3" x 4" x 7'	7.00	143	68	121
Posts.....	3" x 4" x 6½'	6.50	154	74	132
Stakes.....	2" x 2" x 8'	2.66	375	180	321
Stakes.....	2" x 2" x 7'	2.33	429	206	368
Stakes.....	2" x 2" x 6'	2.00	500	240	429
Stakes.....	2" x 2" x 5'	1.66	600	287	512
Stakes.....	2" x 2" x 4'	1.33	750	361	645
Ties, R.R.....	6" x 8" x 8'	32.00	31.3	15	27
Ties, R.R.....	7" x 8" x 8'	37.33	27	13	23

* Twelve percent moisture content.

NOTE: Green weights may vary 20 percent and dry weights 5 percent above and below table figures.

TABLE 22—LOGS PER 1,000 BOARD FEET

SCRIBNER DECIMAL C. LOG SCALE

Log diameter, inches	Number of logs per M. bd. ft., Scribner C.					
	Length in feet					
	8	10	12	14	16	18
6.....	200	100	100	100	50	50
8.....	100	50	50	25	34	33
10.....	33.3	33.3	33.0	25	16.6	16.6
12.....	25	20	16.6	14.3	12.5	11.1
14.....	16.6	14.3	11.1	10.0	9.0	7.7
16.....	12.5	10	8.3	7.1	6.3	5.6
18.....	9.0	7.7	6.3	5.3	4.8	4.2
20.....	7.1	5.9	4.8	4.2	3.6	3.2
22.....	5.9	4.8	4.0	3.4	3.0	2.7
24.....	4.8	4.0	3.3	2.8	2.5	2.2
26.....	4.0	3.2	2.7	2.3	2.0	1.8
28.....	3.4	2.8	2.3	2.0	1.7	1.5
30.....	3.0	2.4	2.0	1.7	1.5	1.3

TABLE 23—FOREST PRODUCTS OF THE REDWOOD REGION

Saw Logs and Veneer Logs	Pulpwood
Redwood, old growth	Redwood
Redwood, second growth	Douglas fir
Douglas fir	Hardwood, various species
California laurel	Poles, Rustic
Madrone	Redwood
Golden chinquapin	Douglas fir
Tanbark oak	Cabin Logs
Alder	Douglas fir
Maple	True firs
Sugar pine	Redwood, second growth
Bishop pine	Burls
Monterey pine	Living redwood
Sitka spruce	Burls
Lowland white fir	Veneer burls of redwood and laurel
Western hemlock	Burls
Port Orford cedar	Manzanita
Western red cedar	Redwood Bark
Piling	Shredded
Douglas fir	Bark in slabs, for rustic
Redwood	Dust for soil conditioner, insecticides
White fir	Christmas Trees
Tanbark	Douglas fir
Poles, Peeled	White fir
Douglas fir	Beach pine
Redwood	Fern Roots
Red cedar	Various species
Hewn Timbers	Tree Moss
Redwood	Greenery
Cribbing	Ferns
Redwood	Redwood wreaths, garlands and sprays
Fence Posts	Christmas berries
Split redwood	Huckleberry greens
Round second growth redwood—treated	Salal
Round Douglas fir—treated	Leafmould
Other conifers and hardwoods treated	Hardwood
with wood preservatives	Woodrat Fertilizer
Pickets	Cascara Bark
Split redwood	Hop Poles
Grape Stakes	Redwood
Split redwood	Douglas fir
Shakes	Hop Sticks
Split redwood	Split redwood
Sawn redwood	Stepping Blocks
Shingles	Redwood rounds
Redwood	Bumper Logs
Railroad Ties	Douglas fir
Hewn redwood	Azalea and Rhododendron
Sawn redwood	Blossoms and plants
Sawn Douglas fir	Decorative Materials for window display
Mine Timbers	purposes
Round Douglas fir	Fuelwood
Sawn Douglas fir	Hardwood and softwood

TABLE 24—SIMPLIFIED SOFTWOOD LUMBER GRADES FOR SMALL MILLS

KIND		GRADES
Yard Lumber Lumber less than 5" thick intended for general purposes; grading based on use of entire piece.	Finish (less than 3" thick and 12" and under in width)	{ B or better D or better
	Boards (less than 2" thick and 8" wide or over in width)	{ No. 1 common No. 2 common No. 3 common Cull
	Dimension (2" and under 5" thick and of any width)	{ No. 1 Dimension No. 2 Dimension No. 3 Dimension
	Strips under 8" in width	{ No. 1 Dimension No. 2 Dimension No. 3 Dimension
Structural Lumber over 5" in thickness and width except joists and planks. Grading based on strength and use of entire piece.	Planks 2" and under 4" thick and 8" wide and over	{ No. 1 Dimension No. 2 Dimension No. 3 Dimension
	Scantling 2" and under 5" thick; under 8" wide	{ No. 1 Dimension No. 2 Dimension No. 3 Dimension
	Heavy Joists 4" thick; 8" or over wide	{ No. 1 Dimension No. 2 Dimension No. 3 Dimension
Structural Lumber over 5" in thickness and width except joists and planks. Grading based on strength and use of entire piece.	Joist and Plank (2" to 4" thick and over wide)	{ Select grade Common grade
	Beams and Stringers (5" and over thick; 8" and over wide)	{ Select grade Common grade
	Posts and Timbers (6" by 6" and larger)	{ Select grade Common grade

GRADE STANDARDS

A. Yard Lumber

Finish—Grade B and Better. Suitable for natural finish; practically clear with a few small imperfections; no sapwood in redwood or Douglas fir; small checks, pin knots allowed. For high-class trim and flooring.

Finish—Grade D and Better. Allows any number of surface imperfections that do not distract from the surface when painted; no sapwood in redwood; one- or two-faced; knots small and tight but may be rough and soft. For high-class painted trim, interior and exterior.

Boards—No. 1 Common. Sound, tight-knotted stock, all defects of small size; for use without waste; no sapwood in redwood; water-tight. Used for exterior trim, coverage for farm buildings and for interior trim in cheaper construction. Difficult to conceal knots with paint.

Boards—No. 2 Common. Allows large coarse defects which may be considered grain-tight; small amount of through-checks, pitch pockets and a small amount of decay permitted; 10% of knots may be loose, unround or partially open; no sapwood in redwood. For use in rough flooring, coverage where wood is not painted, vertical barn boards, etc. Boards for use without waste, but better adapted for recutting and use in shorter pieces.

Boards—No. 3 Common. Larger and coarser knots than in No. 2 Common with occasional knot holes; larger portion of knots than No. 2; used for form lumber, sheathing, subfloors, etc. Some waste in use.

Boards—Cull. Defects such as large, coarse knots, sapwood, rot, knotholes; for use generally as scrap lumber, short boards for repair, etc.

Dimension Lumber No. 1. Sound, straight and stiff; free from defects that affect strength; pitch streaks, torn grain and checks permitted; wane is limited to permit good nailing on one side and two edges. No sapwood in redwood. For use without waste.

Dimension—No. 2. Admits large, coarse, unround knots, some sapwood in redwood, fair nailing edges. No defect, however, is permitted that will limit the use of the piece as a whole.

Dimension—No. 3. All pieces falling below No. 2 suitable for use with some waste in cheap building. Waste no greater than 25% in one-third of the pieces.

B. Structural Lumber

Select. Straight, stiff pieces, heavy, straight grained; narrow growth rings with distinct lines of summerwood in Douglas fir; summerwood narrow; limited number of knots; no knot clusters; limited wane.

Common. Pieces falling below Select grades; light wide-ringed pieces, cross-grained, larger, coarse knots, deep checks or shake.

**TABLE 25—NUMBER OF TREES PER ACRE
(SQUARE AND RECTANGULAR SPACING)**

Spacing, feet	Number trees, per acre	Spacing, feet	Number trees, per acre
2 x 2.....	10,890	8 x 10.....	544
3 x 3.....	4,840	8 x 12.....	454
4 x 4.....	2,722	8 x 25.....	218
4 x 5.....	2,178	9 x 9.....	538
4 x 6.....	1,815	9 x 12.....	403
4 x 8.....	1,362	10 x 10.....	436
4 x 10.....	1,089	10 x 12.....	363
5 x 5.....	1,742	11 x 11.....	360
5 x 6.....	1,452	12 x 12.....	302
5 x 8.....	1,089	12 x 18.....	202
5 x 10.....	871	13 x 13.....	258
6 x 6.....	1,210	14 x 14.....	222
6 x 8.....	908	15 x 15.....	194
6 x 10.....	726	16 x 16.....	170
6 x 12.....	605	18 x 18.....	134
7 x 7.....	889	18 x 20.....	121
7 x 10.....	622	20 x 20.....	109
8 x 8.....	681	25 x 25.....	70

**TABLE 26—SECOND-GROWTH TANBARK OAK DIAMETER GROWTH PER DECADE
AVERAGE GROWTH BY DIAMETER CLASSES**

D.B.H., inches	Diameter growth per decade, inches
4.....	3.5
6.....	3.4
8.....	3.1
10.....	3.1
12.....	3.0
14.....	2.9
16.....	2.8
18.....	2.6
20.....	2.5
22.....	2.4

Mendocino County and south.

TABLE 27—SECOND-GROWTH REDWOOD, AVERAGE DIAMETER GROWTH PER DECADE

D.B.H., inches	Diameter growth per decade, inches	D.B.H., inches	Diameter growth per decade, inches
6.....	4.1	22.....	2.1
8.....	3.8	24.....	2.0
10.....	3.5	26.....	1.9
12.....	3.2	28.....	1.8
14.....	3.0	30.....	1.7
16.....	2.7	32.....	1.6
18.....	2.5	34.....	1.5
20.....	2.3	36.....	1.4

The above table gives average growth in d.b.h. for second growth redwood on average sites. A tree now 20 inches d.b.h. is predicted to grow 2.3 inches in the next decade. Individual trees will vary widely from these averages.

TABLE 28—DOUBLE BARK THICKNESS OF OLD-GROWTH REDWOOD BY TREE DIAMETER AT 20-FOOT HEIGHT

¹ D.O.B. at 20 feet, inches	² Mendocino county, inches	³ Humboldt county, inches
20.....	4.1	3.2
30.....	5.3	4.3
40.....	6.6	5.6
50.....	7.8	6.7
60.....	9.0	7.9
70.....	10.2	9.1
80.....	11.5	10.3
90.....	12.7	11.5
100.....	13.9	12.7
110.....	15.2	13.9

¹ Diameter outside bark 20 feet above ground.

² For southern redwood counties.

³ For northern redwood counties.

This table is helpful in estimating the diameter inside the bark of old growth redwood. The average 50-inch redwood in Mendocino County has about 8 inches of bark—i.e., 4 inches thick on each side of the diameter. Therefore the 50-inch tree would measure 42 inches inside bark.

WM. HALLIN, 1941

U. S. FOREST SERVICE

**TABLE 29—OLD-GROWTH REDWOOD, MERCHANTABLE LENGTH
AND UTILIZED TOP**

DOB ¹ 20 ft., inches	Average merch. height, feet	Average top diameter inside bark, inches	DOB 20 ft., inches	Average merch. height, feet	Average top diameter inside bark, inches
24.....	63	12.9	48.....	96	27.6
26.....	67	14.3	50.....	98	28.6
28.....	71	15.7	52.....	100	29.6
30.....	74	17.0	54.....	102	30.6
32.....	77	18.3	56.....	104	31.6
34.....	79	19.6	58.....	106	32.6
36.....	82	20.0	60.....	108	33.6
38.....	85	22.0	62.....	110	34.6
40.....	87	23.2	64.....	112	35.6
42.....	89	24.3	66.....	113	36.6
44.....	92	25.4	68.....	115	37.6
46.....	94	26.5	70.....	116	38.6

¹ Diameter outside bark 20 feet above ground.

R. G. WAGNER

U. S. FOREST SERVICE

TABLE 30—SIZE OF CIRCULAR AND SQUARE PLOTS

Acres	Radius of circle	Feet on each side	Area in square feet
1/40.....	18.6	33.0	1,089
1/10.....	37.2	66.0	4,356
1/5.....	52.7	93.3	8,712
1/4.....	58.8	104.4	10,890
1/3.....	68.0	120.5	14,520
1/2.....	83.2	147.6	21,780
1.....	117.75	208.7	43,560
5.....	263.2	466.7	217,800

TABLE 31—NOTES ON WATER MEASUREMENT

To measure watershed production at a specific time:

- (1) Estimate width and average depth of stream in feet.
- (2) Toss a twig in stream and estimate the distance it moves per second, in feet.
- (3) Calculate volume of stream flow per second by multiplying the three values determined above.
- (4) From a map, estimate area of watershed in square miles.
- (5) Divide volume of stream flow per second by number of miles of watershed to get cubic feet per second per square mile (c.s.m.).

A flow of 1 cu. ft. per second = 448.83 gallons per minute = 646,323 gallons per day.
= 86,400 cubic feet per day = 1.9835 acre feet per day.

A flow of 1 gallon per minute = 1,440 gallons per day = 192.5 cubic feet per day.
= 0.00442 acre feet per day

A flow of 1 c.s.m. = 0.7013 gallons per minute from one acre.

A flow of 1 gallon per minute per acre = 1.4259 c.s.m. 1 cubic foot = 7.48 gallons

1 acre foot of water = 325,851 gallons = 43,560 cubic feet.

One inch of rainfall means 100 tons of water per acre.

A gallon of water = 231 cubic inches = 8 1/3 pounds.

A cubic foot of water = 7.48 gallons = 62.4 pounds.

A ton of paper requires 50,000 to 170,000 gallons of water in its manufacture.

A large paper plant will use about 25,000,000 gallons of water per day.

The capacity of cylindrical tanks in gallons = .0034 × D² × H.

(D = diameter in inches, H = height in inches)

If the diameter of a pipe or cylinder is doubled, the capacity is quadrupled.

TABLE 32—APPROXIMATE AVERAGE WEIGHTS OF LOGS AND CORDWOOD

Species	Weights ¹ of green logs by diameter ² in lbs. per 1,000 b.f. log scale, Spaulding			Weight of green and dry cordwood in lbs. per cord ²	
	18'' diameter	24'' diameter	36'' diameter	Green ¹	Air dry ⁴
Redwood.....	7,200	6,600	6,300	4,500	2,520
Douglas Fir.....	5,500	5,000	4,800	3,400	3,060
Sitka Spruce.....	4,800	4,400	4,100	3,000	2,520
Western Hemlock.....	6,000	5,400	5,100	3,700	2,610
White Fir.....	6,600	6,100	5,800	4,100	2,430
Point Orford Cedar.....	8,100	7,400	7,000	5,000	2,610
Western Red Cedar.....	3,900	3,600	3,400	2,400	2,070
Red Alder.....	6,700	6,100	5,800	4,100	2,520
Bigleaf Maple.....	6,800	6,200	5,900	4,200	3,060

Prepared by G. A. Craig from U. S. Forest Service data, 1947.

¹ Average weights of green wood may vary as much as 20 percent.

² Diameter inside bark at small end of 20-foot log.

³ Calculated on basis of 1 cord = 90 cubic feet of wood.

⁴ Twelve percent moisture content.

TABLE 33—NATIVE TREES OF THE REDWOOD REGION AND ADJACENT AREA

This list of common and scientific names of trees, found within the area covered by this Handbook, has been included for reference purposes.

Scientific names are used for trees to avoid confusion. Students of trees the world over know which tree is being discussed if the technical name is used. Common names vary in different forest regions. For example the Douglas fir is known as red fir, yellow fir, Oregon pine, etc. An effort has been made to list the common name most generally used in the Redwood Region.

CONIFERS

<i>Sequoia sempervirens</i>	Redwood
<i>Pseudotsuga taxifolia</i>	Douglas fir
<i>Abies grandis</i>	Grand fir
<i>Abies concolor</i>	White fir
<i>Picea sitchensis</i>	Sitka spruce
<i>Tsuga heterophylla</i>	Western hemlock
<i>Pinus monticola</i>	Western white pine
<i>Pinus lambertiana</i>	Sugar pine
<i>Pinus contorta</i>	Shore pine
<i>Pinus sabiniana</i>	Digger pine
<i>Pinus ponderosa</i>	Ponderosa pine
<i>Pinus radiata</i>	Monterey pine
<i>Pinus attenuata</i>	Knobcone pine
<i>Pinus muricata</i>	Bishop pine
<i>Libocedrus decurrens</i>	Incense cedar
<i>Thuja plicata</i>	Western red cedar
<i>Cupressus macnabiana</i>	McNab cypress
<i>Cupressus pygmaea</i>	Pygmy cypress
<i>Cupressus sargentii</i>	Sargent's cypress
<i>Cupressus macrocarpa</i>	Monterey cypress
<i>Chamaecyparis lawsoniana</i>	Port Orford cedar
<i>Tumion californicum</i>	Nutmeg
<i>Taxus brevifolia</i>	Yew

HARDWOODS

<i>Myrica californica</i>	California myrtle
<i>Alnus rubra</i>	Red alder
<i>Populus trichocarpa</i>	Black cottonwood
<i>Castanopsis chrysophylla</i>	Western chinquapin
<i>Quercus lobata</i>	Valley oak
<i>Quercus garryana</i>	Garry oak
<i>Quercus douglasii</i>	Blue oak
<i>Quercus chrysolepis</i>	Canyon live oak
<i>Quercus agrifolia</i>	California live oak
<i>Quercus icislizenii</i>	Interior live oak
<i>Quercus kelloggii</i>	Black oak
<i>Lithocarpus densiflora</i>	Tanbark oak, tanoak
<i>Umbellularia californica</i>	California laurel
<i>Acer macrophyllum</i>	Broadleaf maple
<i>Acer negundo</i>	California boxelder
<i>Aesculus californica</i>	California buckeye
<i>Rhamnus purshiana</i>	Cascara
<i>Cornus nuttallii</i>	Western dogwood
<i>Arbutus menziesii</i>	Madrone
<i>Fraxinus oregona</i>	Oregon ash
<i>Platanus racemosa</i>	Sycamore

VOLUME TABLES AND THEIR USE

The volume table to be used for each species must be selected before beginning a cruise. Tallying and estimating must conform to the selected table's requirement for minimum top diameter, log length and unit for estimating height.

Refer to the Redwood volume table on page 126. Note that this table requires an estimate of the diameter at 20 feet above ground; that heights are given in 20-foot logs; and that top diameter inside bark is variable.

Refer to the volume table for second-growth redwood on page 130. This table requires diameter be measured at breast-height and heights be estimated in 16-foot logs to an eight-inch top inside bark.

Certain other tables have like differences which influence estimating and tallying.

To find the volume of a tree, find its diameter in the left-hand column and read off its volume in the proper log column. For example, in the old-growth redwood volume table, a 30-inch five-log tree has a volume of 1,790 board feet; a 52-inch seven-log tree has a volume of 7,640 board feet.

Volume tables also may be used to estimate volume growth in the following manner: Assume a 20-inch, six-log Douglas fir has been felled. On the stump, count growth rings back 10 years and mark the annual ring which was the outside layer of wood 10 years ago. Measure the width of this 10 years' growth and double the figure to get diameter growth. Subtract diameter growth from the present diameter to find the diameter of the tree 10 years ago. Look up in a volume table the volume of the present tree and the volume of the tree 10 years back. The difference is growth per decade, which, divided by 10 gives a measure of the trees recent annual growth rate in board feet. Example:

Using volume Table 39 for second-growth Douglas fir.

20-inch 6-log tree volume	= 543 bd. ft.
Measured radius growth, last 10 years	= 1.6 inches
Diameter growth = 2 x 1.6	= 3 inches

20 inches — 3 inches = diameter 10 years ago = 17 inches
 Volume 10 years ago (17-inch 5½ log) = 388 bd. ft.
 Difference in volume 543 — 388 = 155 bd. ft.
 Tree's growth per decade, an increase of 30% = 155 bd. ft.
 Average annual growth during last 10 years = 15½ bd. ft.

The assumption was made that the tree grew one-half log in height in last decade. The volume for the five and one-half log tree is the average volume of a five- and a six-log tree.

TABLE 34—OLD-GROWTH REDWOOD SIMPLIFIED VOLUME TABLE

D.B.H., inches	D.O.B. 20 ft., inches	Average merch. height feet	Volume Spaulding rule, board feet
34.....	26	70	750
38.....	28	75	1,010
40.....	30	79	1,300
42.....	32	83	1,590
46.....	34	87	2,010
48.....	36	90	2,270
50.....	38	94	2,640
54.....	40	97	3,050
56.....	42	100	3,450
58.....	44	103	3,930
62.....	46	105	4,440
64.....	48	107	4,950
66.....	50	109	5,460
70.....	52	111	6,030
72.....	54	113	6,630
74.....	56	115	7,270
78.....	58	116	7,890
80.....	60	117	8,520
82.....	62	119	9,170
84.....	64	120	9,940
86.....	66	121	10,680
88.....	68	122	11,440
90.....	70	123	12,230
92.....	72	124	13,050
94.....	74	125	13,770

The above table, based on average merchantable heights, can be used for rough estimates of standing redwood in Mendocino, Sonoma and other southern redwood counties. The table can be used either by measuring the D. B. H. of the tree or by measuring the D. O. B. at 20 feet. The merchantable length of trees estimated should approximate the heights given in the table.

FROM DATA BY WM. HALLIN, 1941

C. F. R. E. S.

TABLE 35—OLD-GROWTH REDWOOD VOLUME

D. O. B.* 20 Ft.	NUMBER OF 20-FOOT LOGS										Top D. I. B.†	
	1	2	3	4	5	6	7	8	9	10		
16	120	230	310	470	600							12
18		240	370	570	740							12
20		280	430	710	910							12
22		330	530	860	1,100							12
24			670									12
26			810	1,060	1,300							12
28			950	1,270	1,530							14
30			1,100	1,470	1,790	2,180						15
32			1,300	1,660	2,060	2,490	2,900					16
34			1,450	1,910	2,300	2,800	3,290	3,790				17
36			1,750	2,150	2,590	3,180	3,680	4,230				18
38			1,840	2,400	2,900	3,500	4,100	4,680				19
40			2,080	2,660	3,220	3,860	4,500	5,200				20
44			2,500	3,260	3,980	4,850	5,800	6,210				22
48				3,810	4,700	5,680	6,680	7,430				24
52				4,570	5,600	6,470	7,640	8,900				26
56				5,300	6,500	7,960	8,960	10,460				28
60					7,430	9,120	10,330	12,060	13,350			30
64					8,450	10,390	11,730	13,690	15,150			32
68					9,600	11,570	13,770	15,360	17,560			34

GROSS VOLUME IN BOARD FEET

SCRIBNER LOG RULE

72	10,900	12,990	15,450	17,130	19,640	36
76	12,200	14,360	17,100	19,100	21,770	38
80	13,800	15,870	17,960	21,060	23,990	40
86	15,900	18,890	21,740	24,230	27,640	43
92	18,100	20,890	24,790	28,650	31,830	46
98	20,750	23,660	28,070	31,300	35,670	49
104	23,260	26,620	31,610	35,240	40,160	52
110	25,750	29,720	35,240	39,270	44,780	55

FROM DATA BY WM. HALLIN

Top utilization diameter = 50 percent of diameter outside bark at 20 feet.

* D. O. B. = Diameter outside bark.

† D. I. B. = Diameter inside bark.

U. S. F. S.

TABLE 36—SECOND-GROWTH REDWOOD CUBIC FOOT VOLUME

DEL NORTE, HUMBOLDT, AND MENDOCINO COUNTIES

Diameter at breast high, inches	TOTAL HEIGHT OF TREE—FEET																Cubic Feet
	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160		
3	0.49	0.74	0.99	1.23	1.48												
4	1.80	1.20	1.60	2.05	2.55	3.07	3.52										
5	1.15	1.70	2.27	2.84	3.42	4.00	4.60										
6	1.49	2.26	3.02	3.79	4.55	5.31	6.11										
7	1.94	2.93	3.94	4.94	5.94	6.95	7.96										
8	2.47	3.74	5.02	6.30	7.60	8.86	10.2										
9	3.05	4.60	6.18	7.80	9.40	11.0	12.6	14.2									
10		5.58	7.50	9.47	11.4	13.3	15.3	17.2									
11		6.64	8.92	11.3	13.5	15.8	18.2	20.5	26.8								
12			10.5	13.2	15.9	18.5	21.3	24.0	28.8								
13			12.2	15.3	18.4	21.5	24.7	27.9	31.2								
14			13.7	17.3	21.0	24.6	28.2	31.8	35.4	39.2	42.8						
15			15.6	19.6	23.8	27.8	32.0	36.0	40.2	44.5	48.7	52.8					
16			17.5	22.1	26.8	31.3	35.9	40.7	45.2	50.0	54.7	59.4	64.2				
17			19.1	24.4	29.6	34.8	39.9	45.0	50.1	55.3	60.8	66.0	71.3				
18			21.1	26.9	32.6	38.4	44.1	49.8	55.5	61.2	67.2	73.1	78.9				
19			29.8	29.8	36.1	42.5	48.8	55.0	61.4	67.8	74.4	80.5	87.1	93.6			
20					39.2	46.2	53.3	60.1	67.0	74.0	81.0	88.4	95.3	102			

21	42.6	50.2	58.0	65.4	73.0	80.5	86.0	96.0	103	111	---
22	45.3	54.0	62.3	70.8	79.0	87.2	95.4	104	112	121	---
23	49.0	58.4	67.4	76.6	85.4	94.3	103	112	122	131	---
24	53.0	63.1	73.0	82.8	92.5	102	111	121	131	141	---
25	---	66.7	77.8	88.4	99.3	110	120	130	141	152	---
26	---	71.8	83.8	95.5	107	118	129	141	152	164	---
27	---	76.9	90.0	102	115	127	139	151	163	176	---
28	---	81.0	95.0	109	122	136	149	162	175	188	202
29	---	86.8	102	117	131	146	160	174	188	202	217
30	---	91.3	106	123	139	155	170	185	200	215	231
31	---	97.2	112	131	149	165	182	198	214	230	246
32	---	---	121	140	158	176	194	210	227	244	262
33	---	---	128	149	168	187	206	224	242	260	279
34	---	---	136	158	178	198	218	237	256	276	296
35	---	---	144	168	189	210	232	252	272	292	314
36	---	---	152	177	200	222	245	266	288	309	332
37	---	---	161	187	211	235	259	282	304	327	351
38	---	---	170	197	223	248	273	297	321	345	370
39	---	---	179	207	235	261	286	313	338	363	390
40	---	---	185	212	242	272	299	328	354	381	408

BRUCE AND SCHUMACHER, 1924.

TABLE 37—SECOND-GROWTH REDWOOD BOARD FOOT VOLUME

GROSS VOLUME IN BOARD FEET **SPAULDING LOG RULE**

D. B. H., inches*	NUMBER OF 16' LOGS TO 8" TOP INSIDE BARK									
	1	2	3	4	5	6	7	8	9	10
12	32	64	86	129						
14	45	89	135	181						
16	54	112	173	234						
18	70	145	223	301	292	350				
20		174	288	369	455	651				
22		213	319	433	547	656				
24		245	378	513	645	788				
26		285	438	588	745	921				
28		328	503	674	872	1,046	1,233	1,442		
30		372	571	779	972	1,197	1,402	1,606		
32		645	877	877	1,106	1,344	1,571	1,809		
34		723	982	982	1,290	1,508	1,785	2,028	2,300	
36		800	1,089	1,386	1,686	1,980	2,263	2,550	2,840	
38		893	1,210	1,545	1,886	2,225	2,510	2,840	3,120	
40		979	1,332	1,686	2,032	2,383	2,664	2,940	3,220	
42			1,450	1,830	2,235	2,630	2,920	3,200	3,480	
44			1,575	1,975	2,495	2,840	3,060	3,260	3,460	3,815
46			1,700	2,120	2,615	2,960	3,180	3,360	3,540	4,380
48			1,830	2,365	2,965	3,270	3,460	3,640	3,820	4,700
50			1,960	2,410	2,985	3,290	3,480	3,660	3,840	4,600

Prepared from table by Bruce & Schumacher by A. F. Wallen and J. L. Reveal, 1947.

* Diameter breast high.

36	882	1,175	1,494	1,753	2,095	2,410	2,731	3,025	3,318	3,630
37	930	1,238	1,545	1,873	2,205	2,530	2,960	3,166	3,478	3,810
38	978	1,300	1,614	1,965	2,308	2,660	2,985	3,315	3,642	3,990
39	1,020	1,354	1,680	2,049	2,415	2,790	3,137	3,487	3,835	4,190
40	---	1,410	1,778	2,150	2,523	2,892	3,266	3,634	3,995	4,390
41	---	1,478	1,861	2,250	2,633	3,015	3,390	3,768	4,135	4,530
42	---	1,541	1,937	2,340	2,735	3,138	3,528	3,920	4,301	4,717
43	---	1,609	2,020	2,440	2,850	3,258	3,672	4,086	4,490	4,917
44	---	1,663	2,090	2,520	2,949	3,386	3,812	4,241	4,651	5,100
45	---	1,730	2,171	2,625	3,065	3,508	3,950	4,391	4,822	5,290
46	---	1,790	2,255	2,724	3,180	3,638	4,094	4,550	5,008	5,495
47	---	1,854	2,330	2,810	3,225	3,770	4,247	4,720	5,197	5,709
48	---	1,920	2,420	2,927	3,414	3,906	4,400	4,890	5,400	5,936
49	---	1,985	2,511	3,020	3,534	4,051	4,572	5,075	5,583	6,120
50	---	---	2,606	3,130	3,660	4,190	4,725	5,259	5,774	6,330
51	---	---	2,690	3,237	3,775	4,328	4,878	5,440	5,976	6,555
52	---	---	2,775	3,350	3,908	4,480	5,055	5,620	6,168	6,758
53	---	---	2,864	3,440	4,034	4,616	5,230	5,830	6,366	7,000
54	---	---	2,944	3,550	4,153	4,760	5,389	6,010	6,610	7,240

Stump height 2.0 feet.

Trees scaled in 16-foot logs with 0.3-foot trimming allowance to 8 inches d.i.b. in top. No allowance made for defect.

MUNGER AND McARDLE, 1926

U. S. FOREST SERVICE

TABLE 40—SECOND-GROWTH DOUGLAS FIR CUBIC FOOT VOLUME

To 8-Inch Top

Gross Volume

D. B. H., inches	TOTAL HEIGHT IN FEET																					
	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	
10	6.7	7.7	8.7	9.7	10.8	11.8	12.8	13.9	15.0	16.1												
12	8.4	10.9	13.4	16.0	18.6	21.2	23.8	26.4	29.0	31.6	34.2	36.8										
14	10.9	14.8	18.8	22.8	26.8	30.8	34.8	38.8	42.8	46.8	50.8	54.8	58.8	62.8								
16	16.3	21.1	26.0	30.9	35.8	40.7	45.6	50.5	55.4	60.4	65.5	70.6	75.7	81.9	88.1							
18	28.0	34.0	40.0	46.0	52.0	58.0	64.0	70.0	76.0	82.2	89.0	97.0	105	113	122	132						
20	35.9	42.7	49.7	56.7	63.7	70.7	77.9	85.3	93.0	101	109	118	128	138	148	158	168	178	188	201	215	230
22	43.9	50.7	58.0	66.0	74.0	82.0	90.4	99.1	108	117	127	137	147	158	172	187	202	218	234	250	266	283
24		59.3	67.9	76.6	85.4	94.2	103	112	122	133	145	158	170	185	202	220	239	249	268	287	306	325
26				89.1	98.0	107	117	127	138	150	165	180	196	213	230	249	268	287	306	325	347	369
28					109	122	132	143	155	168	185	202	220	240	261	282	303	325	347	369		
30					125	136	147	158	172	187	206	225	245	268	292	314	340	365	389	417		
32						149	160	174	188	205	226	248	270	294	320	349	379	411	443	477	513	
34						175	188	205	224	245	268	291	318	348	378	412	447	485	523	561		
36							203	221	242	265	291	318	348	378	412	447	485	523	561			
38							218	238	260	284	312	341	374	408	446	484	524	567	610			
40								278	303	333	364	401	438	480	522	566	613	660				
42										354	388	426	468	513	559	609	659	710				
44											375	411	453	499	548	598	651	705	760			
46											395	435	479	527	581	636	692	751	811			
48											415	458	504	557	613	672	733	796	859			
50											435	481	530	587	648	710	774	841	908			
52											456	505	555	617	683	749	817	887	957			
54											476	528	581	646	715	784	856	931	1,006			

Volume of peeled stem, exclusive of bark and limbs, between stump and 8-inch top d.i.b. Stump height equals d.b.h. for trees to 24 inches, 2-foot stump for trees 24 or more inches in d.b.h.

J. R. DILWORTH, 1947, FROM DATA BY P. A. BRIEGLER

U. S. FOREST SERVICE

TABLE 41—SECOND-GROWTH DOUGLAS FIR CUBIC FOOT VOLUME

Gross Volume

To 4-Inch Top

D. B. H., inches	TOTAL HEIGHT OF TREE IN FEET																							
	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	
6	1.2	1.04	2.7	3.4	4.1	4.8	5.6	12.1	13.2	14.6	16	17.3	18.7	20.1	21.5	22.9	24.3	25.7	27.1	28.5	29.9	31.3	32.7	34.1
8	2.7	4.13	5.4	6.8	8.0	9.5	11.1	12.1	13.2	14.6	16	17.3	18.7	20.1	21.5	22.9	24.3	25.7	27.1	28.5	29.9	31.3	32.7	34.1
10	4.5	6.57	8.7	10.6	12.9	15.1	17.2	18.8	20.7	22.9	24.8	27.3	29.7	32.1	34.5	36.9	39.3	41.7	44.1	46.5	48.9	51.3	53.7	56.1
12	9.72	12.6	15.5	18.6	21.3	24.3	26.6	29.4	32.9	36.4	39.7	42.2	46.0	49.8	53.6	57.4	61.2	65.0	68.8	72.6	76.4	80.2	84.0	87.8
14	12.78	16.8	20.6	24.8	28.6	32.8	36.3	40	43.6	48	51.8	56.4	61.2	65.8	70.0	74.6	79.4	84.2	89.0	93.8	98.6	103.4	108.2	113
16	21.6	26.5	31.5	36.8	41.9	46.7	51.2	55.2	61	63.3	67.7	74	80	87.7	96	102	110	118	126	136	144	153	164	174
18	32.8	39.2	45.2	51.2	57.2	61.2	67.9	75.1	80.6	88	96	105	114	123	133	143	153	164	174	187	199	211	224	234
20	47.0	54.8	63.5	73.2	81.9	91.0	98.2	107	117	126	137	144	153	163	177	191	206	222	238	254	269	287	308	329
22	63.5	73.2	81.9	91.0	98.2	107	117	126	137	144	153	163	177	191	206	222	238	254	269	287	308	329	349	374
24	81.9	91.0	98.2	107	117	126	137	144	153	163	177	191	206	222	238	254	269	287	308	329	349	374	408	436
26	103.4	113	126	136	147	159	172	189	206	224	244	265	286	307	331	349	374	408	436	469	506	546	589	636
28	126	136	147	159	172	189	206	224	244	265	286	307	331	349	374	408	436	469	506	546	589	636	687	742
30	152	163	177	191	208	229	251	273	296	317	343	370	392	423	456	491	528	568	610	654	700	748	798	851
32	178	191	208	227	250	276	297	325	352	382	414	447	481	516	553	592	633	676	721	768	817	868	920	974
34	206	224	245	271	296	321	351	381	415	450	488	526	565	605	647	691	736	783	831	880	930	981	1,033	1,086
36	221	241	263	291	316	344	377	411	449	486	529	570	613	658	704	751	799	848	898	948	999	1,050	1,102	1,155
38	241	261	280	307	335	366	403	440	482	524	561	601	643	687	732	778	825	873	921	969	1,017	1,065	1,114	1,163
40	261	280	307	335	366	403	440	482	524	561	601	643	687	732	778	825	873	921	969	1,017	1,065	1,114	1,163	1,212
42	280	307	335	366	403	440	482	524	561	601	643	687	732	778	825	873	921	969	1,017	1,065	1,114	1,163	1,212	1,261
44	307	335	366	403	440	482	524	561	601	643	687	732	778	825	873	921	969	1,017	1,065	1,114	1,163	1,212	1,261	1,310
46	335	366	403	440	482	524	561	601	643	687	732	778	825	873	921	969	1,017	1,065	1,114	1,163	1,212	1,261	1,310	1,359
48	366	403	440	482	524	561	601	643	687	732	778	825	873	921	969	1,017	1,065	1,114	1,163	1,212	1,261	1,310	1,359	1,408
50	403	440	482	524	561	601	643	687	732	778	825	873	921	969	1,017	1,065	1,114	1,163	1,212	1,261	1,310	1,359	1,408	1,457
52	440	482	524	561	601	643	687	732	778	825	873	921	969	1,017	1,065	1,114	1,163	1,212	1,261	1,310	1,359	1,408	1,457	1,506
54	482	524	561	601	643	687	732	778	825	873	921	969	1,017	1,065	1,114	1,163	1,212	1,261	1,310	1,359	1,408	1,457	1,506	1,555

Volume of stem, exclusive of bark and limbs between stump and 4-inch top d.i.b. Stump height—d.b.h. for trees to 24 inches, 2-foot stump for trees 24 or more inches in d.b.h.

P. A BRIEGLEB

U. S. FOREST SERVICE

TABLE 42.—SITKA SPRUCE CUBIC FOOT VOLUME

D. B. H., inches	TOTAL HEIGHT IN FEET											To 4-inch Top					
	VOLUME IN CUBIC FEET																
	20	40	60	80	100	120	140	160	180	200	220		240	260			
6	1.3	2.9	4.6	11.5	22.2												
8		6.0	9.1	18.0													
10		9.9	13.7														
12		13.1	19.6	26.6	32.6												
14		17	25	34	42												
16			30	41	50	60											
18			37	50	62	75											
20			44	60	75	90	107	120									
22			51	70	87	107	125	140									
24			59	82	103	124	144	162	179								
26			68	95	119	142	164	185	203	230							
28			78	108	136	159	184	209	235	264							
30			90	121	151	179	207	237	268	296							
32			103	134	168	200	233	267	301	331	366						
34				147	183	220	255	293	331	364	404						
36				160	200	241	280	322	361	401	441						
38				173	219	264	307	352	395	439	481	524					
40				187	241	287	335	381	430	476	523	568					

42	258	308	360	409	462	511	565	612	714
44	277	329	387	439	495	548	610	661	
46	294	360	414	468	537	596	650	704	
48	314	375	443	502	564	631	694	753	830
50	332	399	469	534	599	674	734	799	874
52	370	447	530	600	680	754	833	901	981
54	501	583	676	763	850	931	1,013	1,095	1,177
56	610	701	803	903	1,003	1,103	1,203	1,303	1,401
58	641	732	832	932	1,032	1,132	1,232	1,332	1,431
60	663	763	864	965	1,065	1,165	1,265	1,365	1,464
62	693	804	906	1,006	1,106	1,206	1,306	1,406	1,504
64	739	848	956	1,060	1,163	1,263	1,363	1,463	1,562
66	672	788	904	1,013	1,121	1,224	1,324	1,424	1,521
68	848	970	1,083	1,197	1,311	1,421	1,531	1,641	1,749
70	909	1,039	1,166	1,293	1,420	1,547	1,674	1,801	1,924
72	980	1,114	1,252	1,391	1,530	1,669	1,808	1,947	2,086
74	1,063	1,209	1,379	1,539	1,709	1,866	2,024	2,181	2,330
76	1,156	1,331	1,521	1,711	1,901	2,091	2,280	2,470	2,660
78	1,471	1,671	1,871	2,071	2,271	2,471	2,671	2,871	3,070
80	1,632	1,840	2,053	2,265	2,477	2,689	2,901	3,113	3,325
82	1,827	2,053	2,285	2,517	2,749	2,981	3,213	3,445	3,677
84	2,295	2,535	2,780	3,025	3,270	3,515	3,760	4,005	4,250
86	2,571	2,821	3,071	3,321	3,571	3,821	4,071	4,321	4,570
88	2,882	3,142	3,402	3,662	3,922	4,182	4,442	4,702	4,960

Volume of stem, exclusive of bark and limbs, between stump and 4-inch top d.i.b. Stump height equals d.b.h. for trees to 24 inches, 2-foot stump for trees 24 or more inches in d.b.h.

J. R. DILWORTH, 1947

U. S. FOREST SERVICE

TABLE 43—SITKA SPRUCE BOARD FOOT VOLUME

Gross Volume		Scribner Decimal C										
Diameter above swell, inches	Number of 32-foot logs											
	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½
	Total height in feet											
	112	128	142	158	173	188	202	217	231	241		
Volume—board feet, in tens												
12	26											
14	28											
16	30	41										
18	34	46	59									
20	39	53	69	83								
22	45	60	79	96	111							
24	51	69	90	109	129							
26	56	78	102	123	147	170	194					
28		88	115	139	167	195	226	255				
30		98	130	158	188	220	254	287				
32		110	144	175	210	246	283	321	358			
34		123	158	195	234	273	314	355	406			
36			174	215	258	302	346	382	437			
38			191	237	283	330	379	430	479			
40			208	259	310	362	415	469	523			
42			224	283	338	394	452	511	570			
44			239	309	369	429	491	554	619	686		
46			255	335	400	464	532	601	671	742		
48				364	433	502	576	650	726	802	881	
50				395	466	542	622	702	783	866	951	
52					503	584	668	755	842	932	1,022	
54					538	626	718	810	904	999	1,096	
56						673	769	868	968	1,069	1,173	1,278
58						718	821	926	1,034	1,147	1,253	1,366
60						764	875	988	1,102	1,220	1,334	1,455
62						811	930	1,051	1,172	1,295	1,418	1,545
64						860	987	1,115	1,246	1,373	1,505	1,638
66						911	1,045	1,182	1,320	1,454	1,597	1,734
68							1,107	1,252	1,397	1,539	1,690	1,833
70							1,168	1,323	1,474	1,630	1,786	1,933
75								1,509	1,680	1,862	2,037	2,199
80								1,707	1,904	2,102	2,301	2,495
85									2,148	2,374	2,586	2,814
90									2,424	2,656	2,891	3,139

Top diameter of 10 inches inside bark; height of stump averaged 8 feet; logs were scaled in 32-foot lengths and less, plus an allowance of 0.4 foot for trimming. Trees are classified according to their diameter outside bark at 1 foot above pronounced basal swell, which was found to average 8 feet above ground. No allowance is made for defect or breakage.

N. L. CARY, 1920

TABLE 44—WESTERN HEMLOCK BOARD FOOT VOLUME

Gross Volume

Scribner Decimal C

Diameter breast high, inches	Number of 16-foot logs									
	2	3	4	5	6	7	8	9	10	11
	Volume—board feet, in tens									
12.....	9	16	21	28	32	44	78	96		
13.....	10	17	23	31	37	49	87	104		
14.....	12	18	26	35	42	55	91	112	140	
15.....		19	29	39	47	61	100	122	148	
16.....		21	32	43	52	68	108	130	156	
17.....		23	35	47	58	76	116	148	184	
18.....		26	39	52	64	84	124	165	204	237
19.....			42	57	71	91	139	186	248	
20.....			46	62	77	104	148	204	276	
21.....				54	67	84	112	158	214	248
22.....				57	73	90	122	167	228	288
23.....					80	96	130	177	250	288
24.....					86	104	139	186	263	305
25.....									214	248
26.....				92	112	133	148	174		
27.....				100	120	141	158	184		
28.....				106	128	149	167	193	228	
29.....				113	139	158	177	204	237	
30.....				121	147	168	186	214	248	
31.....					156	177	197	226	260	
32.....					165	186	208	238	274	
33.....					173	195	219	250	288	
34.....					181	204	229	263	305	353
35.....					190	213	242	278	323	376
36.....						222	253	293	343	404
37.....						231	266	310	366	436
38.....						240	280	330	393	477
39.....						250	294	351	424	519
40.....						259	308	378	460	561

Stump height equals diameter breast high. Diameter inside bark of top 8 inches. Logs cut 16 feet or less with 0.2 foot allowed for trimming on each log. No allowance was made for defects or breakage.

HANZLIK, 1912

TABLE 45—WESTERN HEMLOCK CUBIC FOOT VOLUME

D. B. H., inches	TOTAL HEIGHT IN FEET																				To 4-Inch Top			
	Gross Volume																							
	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230		240	250	260
6	2.3	3.3	4.4	5.4	6.7	6.9																		
8	4.3	6.1	7.9	9.6	11.5	13.1	15	17																
10		10	12	15	17	20	22	25	28	30	33													
12			18	22	24	28	32	35	39	42	46	49	52	56										
14				24	29	34	39	43	48	52	57	62	66	71	76									
16					32	38	44	50	56	62	68	74	80	86	90	99	105	112	118					
18						40	47	54	62	70	77	84	92	100	107	114	122	129	136	143				
20								57	66	76	85	94	103	113	122	129	138	147	155	163	171	179	187	
22										90	101	112	123	133	143	153	163	173	183	192	201	210	220	
24											103	117	131	143	155	166	177	188	200	212	222	233	244	254
26												117	136	150	164	177	190	202	215	229	242	254	267	280
28													136	155	171	186	201	216	230	245	261	275	289	303
30														155	175	192	209	226	242	258	275	293	310	325
32															175	197	227	234	252	270	288	308	327	345
34																197	218	238	257	278	299	319	340	362
36																	218	238	257	278	299	319	340	362
38																		238	257	278	299	319	340	362
40																			257	278	299	319	340	362
																				278	299	319	340	362
																				299	319	340	362	380
																				319	340	362	380	399
																				340	362	380	399	414
																				362	380	399	414	439
																				380	399	414	439	466
																				399	414	439	466	496
																				414	439	466	496	531
																				439	466	496	531	566
																				466	496	531	566	600
																				496	531	566	600	632
																				531	566	600	632	667
																				566	600	632	667	707

TABLE 46—WHITE FIR VOLUME

Gross Volume

Scribner Decimal C

Diameter breast high, inches	Number of 16-foot logs											
	1	2	3	4	5	6	7	8	9	10	11	12
	Volume—board feet, in tens											
10.....	3	5	9	12								
12.....	4	7	11	15								
14.....	4	8	13	19								
16.....	4	10	16	23	30							
18.....	5	11	19	28	37	48						
20.....		13	23	34	45	57	68					
22.....		15	28	42	56	70	83	97				
24.....		17	32	49	66	82	98	114				
26.....		19	38	58	78	97	117	136	156			
28.....			44	67	90	113	136	159	182			
30.....			49	75	101	128	154	181	207	234		
32.....			56	85	114	144	174	204	233	263	292	
34.....			63	95	128	161	194	227	260	294	327	
36.....			69	106	142	179	216	253	290	327	364	
38.....				117	157	198	238	279	320	360	401	441
40.....				128	172	217	262	307	352	397	442	487
42.....				139	188	237	286	335	384	432	481	528
44.....				151	204	258	311	364	418	471	524	577
46.....					221	279	336	394	452	509	567	625
48.....					239	301	364	426	489	551	613	676
50.....					257	324	391	458	525	592	659	726
52.....						347	418	489	561	632	703	774
54.....						367	443	520	596	672	748	824
56.....							469	549	630	710	791	871
58.....								549	666	751	836	921
60.....									702	794	885	936

Table applies to stands where tallest 10 percent merchantable trees are 9.6 logs and over.

Stump height, 1.5 feet; diameter inside bark at top, 8 inches.

Trees scaled in 16-foot logs with 0.3-foot trimming allowance.

DONALD BRUCE

U. S. FOREST SERVICE

TABLE 47—OLD-GROWTH PORT ORFORD CEDAR VOLUME

Gross Volume

Scribner Decimal C

Diameter breast high, inches	Number of 16-foot logs												
	1	2	3	4	5	6	7	8	9	10	11	12	
	Volume—board feet, in tens												
14	6	13	19	27									
16	6	14	21	31	37								
18	6	14	24	32	42	50							
20		16	25	38	46	56	66						
22			30	41	54	64	72	90					
24			32	48	57	72	82	101					
26			35	51	65	78	93	110					
28			41	56	72	86	106	124					
30			44	63	81	100	116	138	157				
32			50	68	89	111	133	147	171				
34			52	77	96	124	143	168	189				
36			57	82	106	132	154	175	209				
38				90	117	142	170	198	225				
40				98	123	156	186	225	253				
42				107	138	172	205	240	267				
44				117	147	181	216	258	287	327			
46				123	159	197	233	276	310	354			
48				128	173	211	257	287	337	374			
50					188	227	271	318	360	407	446		
52					194	240	287	330	375	414	472		
54					206	251	307	351	406	448	504		
56						268	321	375	431	485	536	595	
58						282	341	406	450	505	568	627	
60						298	361	420	482	546	604	651	
62							317	386	437	507	564	641	691
64							339	398	466	543	609	677	734
66							359	426	493	566	641	712	782
68							373	447	523	590	682	750	818
70							400	479	545	632	707	787	866
72							417	500	574	660	743	832	907
74							432	525	606	691	785	872	956
76							455	547	639	737	824	912	1,004
78							475	570	669	763	866	955	1,057
80							505	594	691	793	904	1,012	1,096

TABLE 48—SUGAR PINE VOLUME

SITE II

Gross Volume

Scribner Decimal C

Diameter breast high, inches	Number of 16-foot logs											
	1	2	3	4	5	6	7	8	9	10	11	12
	Volume—board feet, in tens											
12	3	8	13									
14	3	10	15	22								
16	5	11	17	26	33							
18	5	12	20	29	39	48						
20	6	13	23	33	43	55	65					
22	8	15	26	38	52	65	77	88				
24	10	17	30	44	61	75	90	104				
26		18	24	51	70	89	106	122				
28		20	40	59	81	102	122	142	162			
30			46	68	92	116	139	163	187			
32			51	78	105	131	159	186	214			
34				89	118	148	179	211	242			
36				100	134	166	202	237	272	308		
38				111	148	185	225	264	303	342		
40				122	165	205	249	292	336	379	423	
42					182	227	275	323	371	417	466	
44					201	251	304	357	410	464	517	
46					222	278	337	395	454	513	572	
48					244	306	371	435	501	565	629	694
50					269	337	408	478	550	621	693	763
52					294	370	448	525	603	680	758	835
54					323	406	489	574	658	742	827	911
56					354	443	534	627	718	810	902	994
58					382	482	582	682	782	882	982	1082
60						517	622	729	836	942	1048	1156
62						551	657	768	880	993	1107	1235
64						576	690	805	918	1041	1165	1288
66						594	711	832	950	1075	1207	1333
68							732	854	976	1110	1242	1370
70							753	878	1007	1146	1277	1410
72							785	914	1054	1191	1331	1468
74							822	966	1100	1246	1392	1532
76							858	1007	1149	1302	1454	1598
78							898	1053	1202	1362	1522	1671

DUNNING

U. S. FOREST SERVICE

TABLE 49—PONDEROSA PINE VOLUME

Gross Volume

Scribner Decimal C

Di- ame- ter breast high, inches	Number of 16-foot logs												Diam- eter inside bark of top inches		
	1	2	3	4	5	6	7	8	9	10	11	12			
	Volume—board feet, in tens														
10	4	7											7		
12	4	8	15										8		
14	5	10	17										8		
16	6	12	19	27									8		
18	7	14	23	32	41								8		
20	9	18	29	38	48	58							9		
22	11	24	35	46	58	71	84						9		
24	15	30	44	57	71	86	102						9		
26	20	39	55	70	87	104	123	143					10		
28	26	48	68	86	106	126	146	169					10		
30	35	60	83	105	128	150	172	196	230				10		
32		72	100	125	152	176	201	230	260				10		
34		86	119	148	176	200	230	260	290	330			11		
36		110	140	170	200	230	260	290	330	360			11		
38			170	200	230	260	290	330	360	400	450		11		
40			200	230	260	290	330	370	400	450	500		11		
42			240	270	300	330	370	410	450	500	550		11		
44				300	330	370	410	450	500	550	600	660	12		
46				330	370	420	460	500	560	610	660	710	12		
48				360	420	470	510	560	610	660	720	770	12		
50					470	520	570	610	670	720	780	830	12		
52					520	570	630	670	730	780	840	890	12		
54					570	630	690	730	790	850	910	960	12		
56						690	750	790	850	920	980	1040	12		
58						750	790	860	920	990	1060	1130	12		
60						790	860	920	990	1070	1150	1230	13		
62							920	980	1060	1150	1240	1340	13		
64							980	1060	1130	1230	1340	1450	13		
66								1060	1130	1210	1320	1440	1570	13	
68									1200	1300	1410	1550	1690	13	
70										1280	1390	1500	1660	1820	14
72									1360	1480	1600	1770	1950		
74										1580	1700	1880	2090		
76										1680	1800	1990	2230		

Average stump height, 2.2 to 2.8 feet. Logs scaled in commercial lengths as cut.

U. S. FOREST SERVICE

TABLE 50—RED ALDER VOLUME

Gross Volume		Scribner Decimal C									
D.B.H. inches	Number of 8-foot logs										
	1	2	3	4	5	6	7	8	9	10	
	Volume—board feet, in tens										
10.....	3										
11.....	3	6	9								
12.....	3	6	9	11	14	16					
13.....		7	10	13	16	18					
14.....		8	10	14	17	21	25	30			
15.....		9	11	16	19	23	27	32			
16.....		10	12	18	22	26	30	36	43	49	
17.....			14	20	25	29	33	40	46	53	
18.....			16	22	27	32	37	44	50	58	
19.....			18	25	30	36	42	48	54	62	
20.....			20	28	33	40	45	52	59	67	
21.....				31	37	44	50	56	64	72	
22.....				35	41	48	55	62	69	77	
23.....					46	54	60	66	74	83	
24.....					51	59	65	72	79	89	
25.....					57	64	70	77	84	94	
26.....						70	76	82	90	100	
27.....						76	82	88	96	106	
28.....						82	88	94	101	111	

Top d.l.b. 10"

W. H. MEYER, 1931

TABLE 51—TANBARK OAK, WEIGHT OF BARK ON TREES OF DIFFERENT SIZES

Diameter inches	Height, feet	Length peeled, trunk	Diameter peeled, top	Age, years	Green weight, pounds	Est. dry weight, pounds
4- 9.....	30- 50	4- 8	3- 6	20- 40	15- 80	10- 70
10-12.....	40- 80	16- 32	5- 8	40-100	80-350	70-250
13-18.....	80-100	32- 65	7- 12	70-125	350-900	250-650
19-24.....	90-120	65- 80	7- 11	100-159	900-1,700	650-1,200
24-36.....	115-140	80- 95	9- 11	125-180	1,700-2,500	1,200-1,800
36-48.....	100-120	80- 90	9- 18	150-210	2,500-4,000	1,800-2,800
49-60.....	100-120	80- 90	9- 18	170-250	3,500-8,000	2,500-5,700

Tanbark is sold by weight. A standard cord weighs 2,400 pounds. On the average it takes 800 board feet of tanbark oak to yield a cord of bark.

DR. W. L. JEPSON

UNIVERSITY OF CALIFORNIA

TABLE 52—TANBARK OAK—NUMBER OF TREES TO YIELD ONE CORD OF BARK

Average D.B.H. of trees	Trees per cord of tanbark ¹	Trees per cord of tanbark ²
inches	Average number	Average number
12.....	16	10
14.....	12	7.5
16.....	9	5.5
18.....	7	4.5
20.....	6	3.5
22.....	5	3.0
24.....	4	2.5
26.....	3.5	2.2
28.....	3.0	1.9
30.....	2.5	1.6

¹ Mendocino County and south.
² Humboldt County old growth bark.

TABLE 53—OLD-GROWTH REDWOOD OVERRUN WITH HUMBOLDT LOG SCALE

REPRESENTATIVE AVERAGES BY TREE SIZES

D.O.B. 20-feet	Overrun percent	D.O.B. 20-feet	Overrun percent
16.....	103	60.....	8.0
20.....	65	64.....	7.5
24.....	28	68.....	7.0
28.....	18	72.....	6.5
32.....	15	76.....	6.0
36.....	13	80.....	5.0
40.....	12	84.....	4.0
44.....	11	88.....	2.5
48.....	9.5	92.....	1.5
52.....	9.0	96.....
56.....	8.5	100.....	-1.5

$$\text{Overrun in percent} = \frac{\text{Rough green lumber tally}}{\text{Humboldt Log Scale}}$$

TABLE 54—SCRIBNER DECIMAL C LOG RULE
FOR LOGS FROM 6 TO 18 FEET LONG

Diameter inches	Length—feet						
	6	8	10	12	14	16	18
	Contents—board feet						
6.....	.5	.5	1	1	1	2	2
7.....	.5	1	1	2	2	3	3
8.....	1	1	2	2	2	3	3
9.....	1	2	3	3	3	4	4
10.....	2	3	3	3	4	6	6
11.....	2	3	4	4	5	7	8
12.....	3	4	5	6	7	8	9
13.....	4	5	6	7	8	10	11
14.....	4	6	7	9	10	11	13
15.....	5	7	9	11	12	14	16
16.....	6	8	10	12	14	16	18
17.....	7	9	12	14	16	18	21
18.....	8	11	13	16	19	21	24
19.....	9	12	15	18	21	24	27
20.....	11	14	17	21	24	28	31
21.....	12	15	19	23	27	30	34
22.....	13	17	21	25	29	33	38
23.....	14	19	23	28	33	38	42
24.....	15	21	25	30	35	40	45
25.....	17	23	29	34	40	46	52
26.....	19	25	31	37	44	50	56
27.....	21	27	34	41	48	55	62
28.....	22	29	36	44	51	58	65
29.....	23	31	38	46	53	61	68
30.....	25	33	41	49	57	66	74
31.....	27	36	44	53	62	71	80
32.....	28	37	46	55	64	74	83
33.....	29	39	49	59	69	78	88
34.....	30	40	50	60	70	80	90
35.....	33	44	55	66	77	88	98
36.....	35	46	58	69	81	92	104
37.....	39	51	64	77	90	103	116
38.....	40	54	67	80	93	107	120
39.....	42	56	70	84	98	112	126
40.....	45	60	75	90	105	120	135
41.....	48	64	79	95	111	127	143
42.....	50	67	84	101	117	134	151
43.....	52	70	87	105	122	140	157
44.....	56	74	93	111	129	148	166
45.....	57	76	95	114	133	152	171
46.....	59	79	99	119	139	159	178
47.....	62	83	104	124	145	166	186
48.....	65	86	108	130	151	173	194
49.....	67	90	112	135	157	180	202
50.....	70	94	117	140	164	187	211

TABLE 54—SCRIBNER DECIMAL C LOG RULE—Continued

FOR LOGS FROM 6 TO 18 FEET LONG

Diameter inches	Length—feet						
	6	8	10	12	14	16	18
	Contents—board feet						
51.....	73	97	122	146	170	195	219
52.....	76	101	127	152	177	202	228
53.....	79	105	132	158	184	210	237
54.....	82	109	137	164	191	218	246
55.....	85	113	142	170	198	227	255
56.....	88	118	147	176	206	235	264
57.....	91	122	152	183	213	244	274
58.....	95	126	158	189	221	252	284
59.....	98	131	163	196	229	261	294
60.....	101	135	169	203	237	270	304
61.....	105	140	175	210	245	280	315
62.....	108	145	181	217	253	289	325
63.....	112	149	187	224	261	299	336
64.....	116	154	193	232	270	309	348
65.....	119	159	199	239	279	319	358
66.....	123	164	206	247	288	329	370
67.....	127	170	212	254	297	339	381
68.....	131	175	219	262	306	350	393
69.....	135	180	226	271	316	361	406
70.....	139	186	232	279	325	372	419
71.....	144	192	240	287	335	383	430
72.....	148	197	247	296	345	395	444
73.....	152	203	254	305	356	406	457
74.....	157	209	261	314	366	418	471
75.....	161	215	269	323	377	430	484
76.....	166	221	277	332	387	443	498
77.....	171	228	285	341	398	455	511
78.....	176	234	293	351	410	468	527
79.....	180	240	301	361	421	481	541
80.....	185	247	309	371	432	494	556
81.....	190	254	317	381	444	508	572
82.....	196	261	326	391	456	521	586
83.....	201	268	335	401	468	535	601
84.....	206	275	343	412	481	549	618
85.....	210	281	351	421	491	561	631
86.....	215	287	359	431	503	575	646
87.....	221	295	368	442	516	589	663
88.....	226	301	377	452	527	603	678
89.....	231	308	385	462	539	616	693
90.....	236	315	393	472	551	629	708

**TABLE 55—SPAULDING LOG RULE
FOR LOGS FROM 12 TO 24 FEET LONG**

Diameter in inches	LENGTHS IN FEET											Diameter in inches	
	12	13	14	15	16	17	18	19	20	21	22		23
10	38	41	44	47	50	53	57	60	63	66	69	72	76
11	47	51	55	59	63	67	70	74	78	82	86	90	94
12	58	62	67	72	77	83	87	91	96	101	106	111	116
13	71	76	82	88	94	100	106	112	118	124	130	136	142
14	86	93	100	107	114	121	129	136	143	150	157	164	172
15	103	111	120	128	137	145	154	163	171	180	188	197	206
16	121	131	141	151	161	171	181	191	201	211	221	231	242
17	141	152	164	176	188	199	211	223	235	246	258	270	282
18	162	175	189	202	216	229	243	256	270	283	297	310	324
19	184	199	214	230	245	260	276	291	306	322	337	352	368
20	207	224	241	258	276	293	310	327	345	362	379	396	414
21	231	250	269	288	308	327	346	365	385	404	423	442	462
22	256	277	298	320	341	362	384	405	428	448	469	490	512
23	282	305	329	352	376	399	423	446	470	493	517	540	564
24	309	334	360	387	412	437	463	489	515	540	566	592	618
25	337	365	393	421	449	477	505	533	561	589	617	645	674
26	366	396	427	457	488	518	549	579	610	640	671	701	732
27	396	429	462	495	528	561	594	627	660	693	726	759	792
28	427	462	498	533	569	604	640	676	711	747	782	818	854
29	459	497	535	573	612	650	688	726	765	803	841	879	918
30	492	533	574	615	656	697	738	779	820	861	902	943	984
31	526	569	613	657	701	745	789	832	876	920	964	1,008	1,052
32	561	607	654	701	748	794	841	888	935	981	1,028	1,075	1,122
33	597	646	696	746	796	845	896	945	995	1,044	1,094	1,144	1,194
34	634	686	739	792	845	898	951	1,003	1,056	1,109	1,162	1,215	1,268
35	673	729	785	841	897	953	1,009	1,065	1,121	1,177	1,233	1,289	1,346
36	713	772	831	891	950	1,010	1,069	1,128	1,188	1,247	1,307	1,366	1,426

37	755	817	880	943	1,006	1,069	1,132	1,195	1,258	1,321	1,384	1,447	1,510
38	798	864	931	997	1,064	1,130	1,197	1,263	1,330	1,397	1,463	1,529	1,596
39	843	913	983	1,053	1,124	1,194	1,264	1,334	1,405	1,475	1,545	1,615	1,686
40	889	963	1,037	1,111	1,185	1,259	1,333	1,407	1,481	1,555	1,629	1,703	1,778
41	936	1,014	1,092	1,170	1,248	1,326	1,404	1,481	1,560	1,638	1,716	1,794	1,872
42	984	1,066	1,148	1,230	1,312	1,394	1,476	1,558	1,640	1,722	1,804	1,886	1,968
43	1,033	1,119	1,205	1,291	1,377	1,463	1,549	1,635	1,721	1,807	1,893	1,979	2,066
44	1,086	1,176	1,267	1,357	1,448	1,538	1,629	1,719	1,810	1,900	1,991	2,081	2,172
45	1,134	1,228	1,323	1,417	1,512	1,606	1,701	1,795	1,890	1,984	2,079	2,173	2,268
46	1,186	1,284	1,383	1,482	1,581	1,680	1,779	1,877	1,976	2,075	2,174	2,273	2,372
47	1,239	1,342	1,445	1,548	1,652	1,755	1,858	1,961	2,065	2,168	2,271	2,374	2,478
48	1,293	1,400	1,508	1,616	1,724	1,831	1,939	2,047	2,155	2,262	2,370	2,478	2,586
49	1,348	1,460	1,572	1,685	1,797	1,909	2,022	2,134	2,246	2,358	2,470	2,582	2,696
50	1,404	1,521	1,638	1,755	1,872	1,989	2,106	2,223	2,340	2,457	2,574	2,691	2,808
51	1,461	1,582	1,704	1,826	1,948	2,069	2,191	2,313	2,435	2,556	2,678	2,800	2,922
52	1,519	1,645	1,772	1,898	2,025	2,151	2,278	2,405	2,531	2,657	2,784	2,911	3,038
53	1,578	1,709	1,841	1,972	2,104	2,235	2,367	2,498	2,630	2,761	2,893	3,024	3,156
54	1,638	1,774	1,911	2,047	2,184	2,320	2,457	2,593	2,730	2,866	3,003	3,139	3,276
55	1,700	1,841	1,983	2,125	2,266	2,408	2,550	2,691	2,833	2,974	3,116	3,258	3,400
56	1,763	1,909	2,056	2,203	2,350	2,497	2,644	2,791	2,938	3,085	3,232	3,379	3,526
57	1,827	1,979	2,131	2,283	2,436	2,588	2,740	2,892	3,045	3,197	3,349	3,501	3,654
58	1,893	2,050	2,208	2,366	2,524	2,681	2,839	2,997	3,155	3,312	3,470	3,628	3,786
59	1,960	2,123	2,286	2,450	2,613	2,776	2,940	3,103	3,266	3,429	3,592	3,756	3,920
60	2,028	2,197	2,366	2,535	2,704	2,873	3,042	3,211	3,380	3,549	3,718	3,887	4,066
61	2,098	2,272	2,447	2,622	2,797	2,972	3,147	3,321	3,496	3,671	3,846	4,021	4,196
62	2,169	2,349	2,530	2,711	2,892	3,072	3,253	3,434	3,615	3,795	3,976	4,157	4,338
63	2,241	2,427	2,614	2,801	2,988	3,174	3,361	3,548	3,735	3,921	4,108	4,295	4,482
64	2,315	2,507	2,700	2,893	3,086	3,279	3,472	3,665	3,858	4,051	4,244	4,437	4,630
65	2,390	2,589	2,789	2,987	3,185	3,385	3,585	3,784	3,983	4,182	4,381	4,580	4,780
66	2,467	2,672	2,878	3,083	3,289	3,494	3,700	3,906	4,111	4,316	4,522	4,728	4,934
67	2,545	2,757	2,969	3,181	3,393	3,605	3,817	4,029	4,241	4,453	4,665	4,877	5,090
68	2,625	2,843	3,062	3,281	3,500	3,718	3,937	4,156	4,375	4,593	4,812	5,031	5,250
69	2,706	2,931	3,157	3,382	3,608	3,833	4,059	4,284	4,510	4,735	4,961	5,186	5,412
70	2,789	3,021	3,253	3,486	3,718	3,951	4,183	4,415	4,648	4,880	5,113	5,345	5,578
71	2,874	3,113	3,353	3,592	3,832	4,071	4,311	4,550	4,790	5,029	5,269	5,508	5,748
72	2,960	3,206	3,453	3,700	3,946	4,193	4,440	4,686	4,933	5,180	5,426	5,673	5,920
73	3,047	3,301	3,555	3,809	4,062	4,316	4,570	4,824	5,078	5,332	5,586	5,840	6,094
74	3,135	3,396	3,657	3,919	4,180	4,441	4,702	4,964	5,225	5,486	5,747	6,008	6,269

TABLE 55—SPAULDING LOG RULE—Continued
FOR LOGS FROM 12 TO 24 FEET LONG

Diameter in inches	LENGTH IN FEET											Diameter in inches		
	12	13	14	15	16	17	18	19	20	21	22		23	24
75	3,224	3,492	3,761	4,030	4,298	4,567	4,836	5,104	5,372					75
76	3,314	3,590	3,866	4,142	4,418	4,694	4,970	5,246	5,522					76
77	3,405	3,688	3,972	4,256	4,540	4,823	5,107	5,391	5,675					77
78	3,497	3,788	4,080	4,371	4,663	4,954	5,245	5,537	5,829					78
79	3,590	3,889	4,188	4,487	4,786	5,085	5,385	5,684	5,983					79
80	3,684	3,991	4,298	4,605	4,912	5,219	5,526	5,833	6,140					80
81	3,779	4,094	4,408	4,723	5,038	5,353	5,668	5,983	6,298					81
82	3,874	4,190	4,519	4,842	5,165	5,488	5,811	6,133	6,456					82
83	3,970	4,301	4,631	4,962	5,293	5,624	5,955	6,285	6,616					83
84	4,067	4,406	4,745	5,084	5,423	5,762	6,101	6,440	6,778					84
85	4,165	4,512	4,859	5,206	5,553	5,900	6,247	6,594	6,941					85
86	4,264	4,619	4,974	5,330	5,685	6,040	6,396	6,751	7,106					86
87	4,364	4,727	5,091	5,455	5,818	6,182	6,546	6,909	7,273					87
88	4,465	4,837	5,209	5,581	5,953	6,325	6,697	7,069	7,441					88
89	4,566	4,946	5,327	5,707	6,088	6,468	6,849	7,229	7,610					89
90	4,668	5,057	5,446	5,835	6,224	6,613	7,002	7,391	7,780					90
91	4,771	5,168	5,566	5,964	6,361	6,759	7,156	7,554	7,951					91
92	4,875	5,281	5,687	6,094	6,500	6,906	7,312	7,719	8,125					92
93	4,980	5,395	5,810	6,225	6,640	7,055	7,470	7,885	8,300					93
94	5,085	5,508	5,932	6,356	6,780	7,203	7,627	8,051	8,475					94
95	5,192	5,624	6,057	6,490	6,922	7,355	7,788	8,220	8,653					95
96	5,300	5,741	6,183	6,625	7,066	7,505	7,950	8,391	8,833					96
97	5,409	5,840	6,280	6,738	7,187	7,636	8,085	8,534	8,983					97
98	5,502	5,960	6,418	6,876	7,334	7,792	8,250	8,708	9,166					98
99	5,614	6,081	6,548	7,015	7,482	7,949	8,416	8,883	9,350					99
100	5,727	6,204	6,681	7,158	7,635	8,112	8,589	9,066	9,543					100
101	5,840	6,326	6,812	7,298	7,784	8,270	8,756	9,242	9,728					101

102	5,957	6,453	6,949	7,445	7,941	8,437	8,933	9,429	9,925	102
103	6,067	6,572	7,177	7,682	8,187	8,692	9,197	9,702	10,207	103
104	6,190	6,705	7,220	7,735	8,250	8,765	9,280	9,795	10,310	104
105	6,309	6,834	7,359	7,884	8,411	8,944	9,469	9,994	10,519	105
106	6,467	7,005	7,543	8,081	8,619	9,157	9,695	10,233	10,771	106
107	6,549	7,094	7,639	8,184	8,729	9,274	9,819	10,364	10,909	107
108	6,689	7,224	7,779	8,334	8,889	9,444	9,999	10,554	11,109	108
109	6,782	7,355	7,928	8,501	9,074	9,647	10,220	10,793	11,366	109
110	6,909	7,484	8,059	8,634	9,209	9,784	10,359	10,934	11,509	110
111	7,035	7,622	8,209	8,796	9,385	9,970	10,557	11,144	11,731	111
112	7,133	7,727	8,321	8,915	9,509	10,103	10,697	11,291	11,885	112
113	7,273	7,879	8,485	9,091	9,697	10,303	10,909	11,515	12,121	113
114	7,400	8,016	8,632	9,248	9,864	10,480	11,096	11,712	12,328	114
115	7,532	8,159	8,786	9,413	10,040	10,667	11,294	11,921	12,548	115
116	7,661	8,299	8,937	9,575	10,213	10,851	11,489	12,127	12,765	116
117	7,792	8,441	9,090	9,739	10,388	11,037	11,686	12,335	12,984	117
118	7,922	8,582	9,242	9,902	10,562	11,222	11,882	12,542	13,202	118
119	8,058	8,729	9,400	10,071	10,742	11,413	12,084	12,755	13,426	119
120	8,204	8,887	9,570	10,253	10,936	11,619	12,302	12,985	13,668	120
121	8,338	9,032	9,726	10,420	11,114	11,808	12,502	13,196	13,890	121
122	8,432	9,134	9,838	10,538	11,240	11,942	12,644	13,346	14,048	122
123	8,614	9,331	10,048	10,765	11,482	12,199	12,916	13,633	14,350	123
124	8,801	9,534	10,267	11,000	11,733	12,466	13,199	13,932	14,665	124
125	8,888	9,628	10,368	11,108	11,848	12,588	13,328	14,068	14,808	125
126	9,034	9,786	10,538	11,280	12,042	12,794	13,546	14,298	15,050	126
127	9,172	9,936	10,700	11,464	12,228	12,992	13,756	14,520	15,284	127
128	9,320	10,096	10,872	11,648	12,424	13,200	13,976	14,752	15,528	128
129	9,465	10,253	11,041	11,829	12,617	13,405	14,193	14,981	15,769	129
130	9,615	10,416	11,217	12,018	12,819	13,620	14,421	15,221	16,022	130
131	9,761	10,574	11,387	12,200	13,013	13,826	14,639	15,452	16,265	131
132	9,904	10,729	11,554	12,379	13,204	14,029	14,854	15,679	16,504	132
133	10,059	10,897	11,735	12,573	13,411	14,249	15,087	15,925	16,763	133
134	10,207	11,057	11,907	12,757	13,607	14,457	15,307	16,157	17,007	134
135	10,361	11,232	12,103	12,974	13,845	14,716	15,587	16,458	17,329	135
136	10,504	11,379	12,254	13,129	14,004	14,879	15,754	16,629	17,504	136

TABLE 56—HUMBOLDT LOG SCALE
FOR LOGS 16 TO 60 FEET LONG

DIAMETER Ins.	LENGTH—FEET											DIAMETER Ins.	
	16	20	24	28	32	36	40	44	48	52	56		60
	CONTENTS—BOARD FEET												
14	80	100	120	140	160	180	200	220	240	260	280	300	14
15	97	121	145	169	193	217	241	270	289	313	337	361	15
16	113	141	169	197	225	253	281	309	337	365	393	421	16
17	132	165	198	231	264	297	330	363	396	429	462	495	17
18	151	189	227	265	303	341	379	417	455	493	531	569	18
19	172	215	258	301	344	387	430	473	516	559	602	645	19
20	193	241	289	337	385	433	481	529	577	625	673	721	20
21	216	270	324	378	432	486	540	594	648	702	756	810	21
22	239	299	359	419	479	539	599	659	719	779	839	899	22
23	264	330	396	462	528	594	660	726	792	858	924	990	23
24	288	360	432	504	576	648	720	792	864	936	1008	1080	24
25	315	394	473	552	631	710	789	868	947	1026	1105	1184	25
26	342	428	514	600	686	772	858	944	1030	1116	1202	1288	26
27	371	464	557	650	743	836	929	1022	1115	1208	1301	1394	27
28	399	499	599	699	799	899	999	1099	1199	1299	1399	1499	28
29	430	538	646	754	862	970	1078	1186	1294	1402	1510	1618	29
30	460	576	692	808	924	1040	1156	1272	1388	1504	1620	1736	30
31	492	615	738	861	984	1107	1230	1353	1476	1599	1722	1845	31
32	523	653	783	913	1043	1173	1303	1433	1563	1693	1823	1953	32
33	558	697	836	975	1114	1253	1392	1531	1670	1809	1948	2087	33
34	592	740	888	1036	1184	1332	1480	1628	1776	1924	2072	2220	34
35	629	786	943	1100	1257	1414	1571	1728	1885	2042	2199	2356	35
36	665	831	997	1163	1329	1495	1661	1827	1993	2159	2325	2491	36
37	705	881	1057	1233	1409	1585	1761	1937	2113	2289	2465	2641	37
38	745	931	1117	1303	1489	1675	1861	2047	2233	2419	2605	2791	38
39	788	985	1182	1379	1576	1773	1970	2167	2364	2561	2758	2955	39
40	830	1038	1246	1454	1662	1870	2078	2286	2494	2702	2910	3118	40
41	875	1094	1313	1532	1751	1970	2189	2408	2627	2846	3065	3284	41
42	919	1149	1379	1609	1839	2069	2299	2529	2759	2989	3219	3449	42
43	967	1209	1451	1693	1935	2177	2419	2661	2903	3145	3387	3629	43
44	1014	1268	1522	1776	2030	2284	2538	2792	3046	3300	3554	3808	44
45	1060	1325	1590	1855	2120	2385	2650	2915	3180	3445	3710	3975	45
46	1106	1382	1658	1934	2210	2486	2762	3038	3314	3590	3866	4142	46
47	1157	1446	1735	2024	2313	2602	2891	3180	3469	3758	4047	4336	47
48	1207	1509	1811	2113	2415	2717	3019	3321	3623	3925	4227	4529	48
49	1259	1574	1889	2204	2519	2834	3149	3464	3779	4094	4409	4724	49
50	1311	1639	1967	2295	2623	2951	3279	3607	3935	4263	4591	4919	50
51	1364	1705	2046	2387	2728	3069	3410	3751	4092	4433	4774	5115	51
52	1417	1771	2125	2479	2833	3187	3541	3895	4249	4603	4957	5311	52
53	1473	1841	2209	2577	2945	3313	3681	4049	4417	4785	5153	5521	53
54	1529	1911	2293	2675	3057	3439	3821	4203	4585	4967	5349	5731	54
55	1587	1983	2379	2775	3171	3567	3963	4359	4755	5151	5547	5943	55
56	1644	2054	2464	2874	3284	3694	4104	4514	4924	5334	5744	6154	56
57	1706	2132	2558	2984	3410	3836	4262	4688	5114	5540	5966	6391	57
58	1767	2209	2651	3093	3535	3977	4419	4861	5303	5745	6187	6629	58
59	1830	2287	2744	3201	3658	4115	4572	5029	5486	5943	6400	6857	59
60	1892	2364	2836	3308	3780	4252	4724	5196	5668	6140	6612	7084	60

TABLE 56—HUMBOLDT LOG SCALE—Continued
FOR LOGS 16 TO 60 FEET LONG

DIAMETER Ins.	LENGTH—FEET											DIAMETER Ins.	
	16	20	24	28	32	36	40	44	48	52	56		60
	CONTENTS—BOARD FEET												
61	1958	2447	2936	3425	3914	4403	4892	5381	5870	6359	6848	7337	61
62	2024	2530	3036	3542	4048	4554	5060	5566	6072	6578	7084	7590	62
63	2092	2615	3138	3661	4184	4707	5230	5753	6276	6799	7322	7845	63
64	2160	2700	3240	3780	4320	4860	5400	5940	6480	7020	7560	8100	64
65	2232	2790	3348	3906	4464	5022	5580	6138	6696	7254	7812	8370	65
66	2303	2879	3455	4031	4607	5183	5759	6335	6911	7487	8063	8639	66
67	2377	2971	3565	4159	4753	5347	5941	6535	7129	7723	8317	8911	67
68	2450	3062	3674	4286	4898	5510	6122	6734	7346	7958	8570	9182	68
69	2526	3157	3788	4419	5050	5681	6312	6943	7574	8205	8836	9467	69
70	2602	3252	3902	4552	5202	5852	6502	7152	7802	8452	9102	9752	70
71	2682	3352	4022	4692	5362	6032	6702	7372	8042	8712	9382	10052	71
72	2762	3452	4142	4832	5522	6212	6902	7592	8282	8972	9662	10352	72
73	2844	3555	4266	4977	5688	6399	7110	7821	8532	9243	9954	10665	73
74	2928	3658	4390	5122	5854	6586	7318	8050	8782	9514	10246	10978	74
75	3009	3761	4573	5265	6017	6769	7521	8273	9025	9777	10529	11281	75
76	3092	3864	4636	5408	6190	6952	7724	8496	9268	10040	10812	11584	76
77	3178	3972	4766	5560	6354	7148	7942	8736	9530	10324	11118	11912	77
78	3264	4080	4896	5712	6528	7344	8160	8976	9792	10608	11424	12240	78
79	3352	4190	5028	5866	6704	7542	8380	9218	10056	10894	11732	12570	79
80	3439	4299	5159	6019	6879	7739	8599	9459	10319	11179	12039	12899	80
81	3527	4409	5291	6173	7055	7937	8819	9701	10583	11465	12347	13229	81
82	3615	4519	5423	6327	7231	8135	9039	9943	10847	11751	12655	13559	82
83	3706	4633	5560	6487	7414	8341	9268	10195	11122	12049	12976	13903	83
84	3797	4747	5697	6647	7597	8547	9497	10447	11397	12347	13297	14247	84
85	3888	4860	5832	6804	7776	8748	9720	10692	11664	12636	13608	14580	85
86	3979	4973	5967	6961	7955	8949	9943	10937	11931	12925	13919	14913	86
87	4073	5091	6109	7127	8145	9163	10181	11199	12217	13235	14253	15271	87
88	4167	5209	6251	7293	8335	9377	10419	11461	12503	13545	14587	15629	88
89	4261	5327	6392	7457	8522	9587	10652	11717	12782	13847	14912	15977	89
90	4356	5444	6532	7620	8708	9796	10884	11972	13060	14148	15236	16324	90
91	4453	5566	6679	7792	8905	10018	11131	12244	13357	14470	15583	16696	91
92	4550	5688	6826	7964	9102	10240	11378	12516	13654	14792	15930	17068	92
93	4648	5810	6972	8134	9296	10458	11620	12782	13944	15106	16268	17430	93
94	4745	5931	7117	8303	9489	10675	11861	13047	14233	15419	16605	17791	94
95	4846	6057	7268	8479	9690	10901	12112	13323	14534	15745	16956	18167	95
96	4946	6182	7418	8654	9890	11126	12362	13598	14834	16070	17306	18542	96
97	5041	6301	7561	8821	10081	11341	12601	13861	15121	16381	17641	18901	97
98	5135	6419	7703	8987	10271	11555	12839	14123	15407	16691	17975	19259	98
99	5240	6550	7860	9170	10480	11790	13100	14410	15720	17030	18340	19650	99
100	5345	6681	8017	10021	10689	12025	13361	14697	16033	17369	18705	20041	100

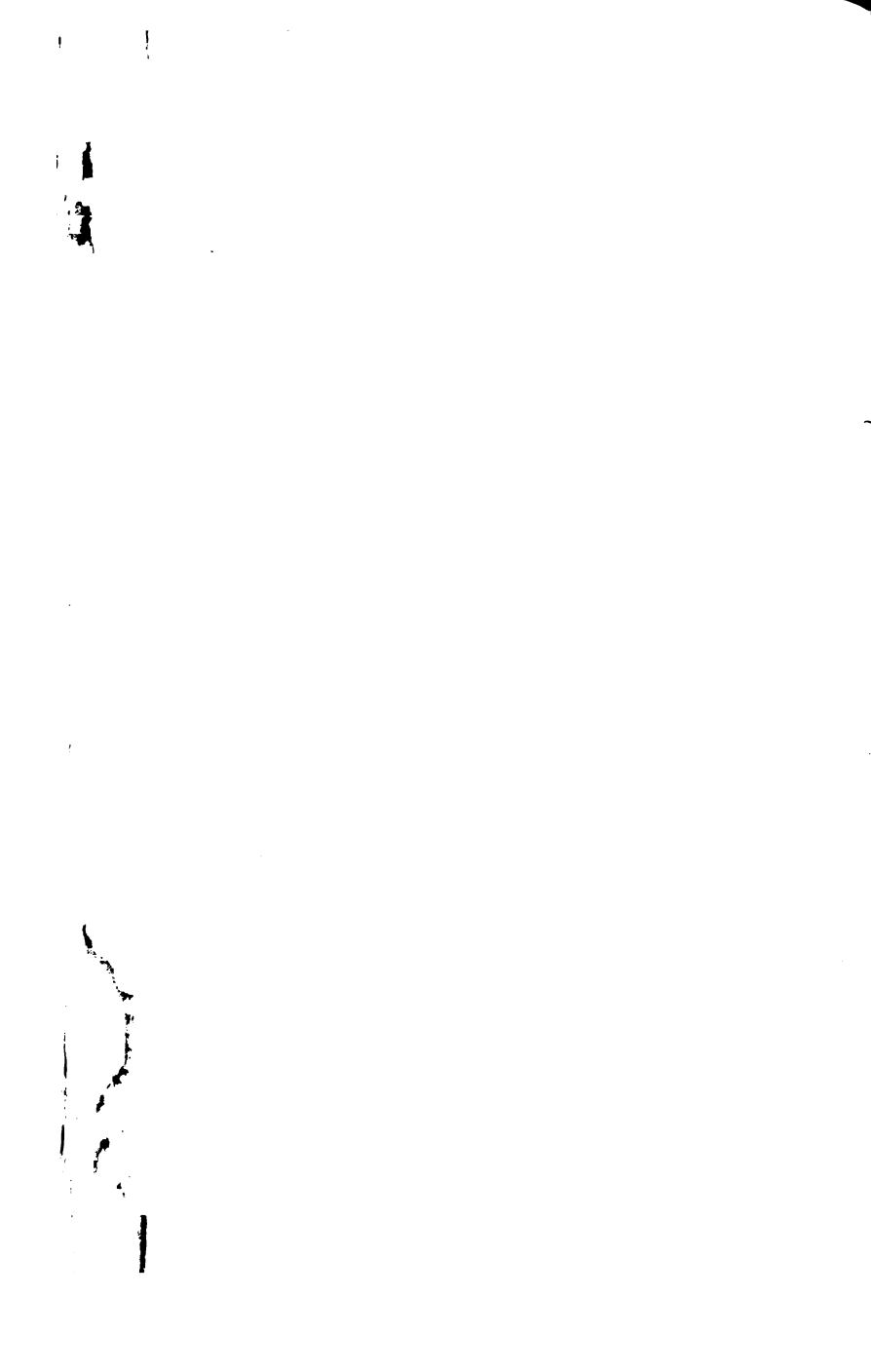
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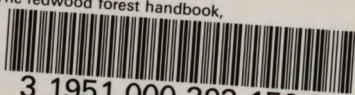
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Reveal, Jack.
The redwood forest handbook,



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