# Western White Pine Bulletin

January 10, 1917

F. I. Rockwell

Photo Credit

Cover Photo: Old growth western white pine circa 1913, courtesy of the Latah County Historical Society. The photo, No. 25-03-072, is apparently one of a series taken by the *American Lumberman* on or about September 13, 1913 about 1/2 mile west of Collins (4 miles north of Bovill, ID).

# WESTERN WHITE PINE

# BULLETIN

January 10, 1917

U.S. Forest Service
Northern Region

# WESTERN WHITE PINE

## PART I

## THE TREE AND THE STAND

JANUARY 10, 1917

By

F. I. Rockwell

Transcribed by Daniel L. Miller
Precision Forestry LLC
2015

WESTERN WHITE PINE

PART I – THE TREE AND THE STAND


| | Page |
|---|---|
| INTRODUCTION | 1 |
| Purpose of Publication | 1 |
| Nomenclature | 1 |
| Habit | 1 |
| THE WOOD | 2 |
| Quality | 2 |
| Physical and Mechanical Properties | 2 |
| Lumber Grades | 3 |
| Utilization | 3 |
| Annual Cut | 3 |
| Markets and Uses | 4 |
| DISTRIBUTION AND INFLUENCES AFFECTING IT | 4 |
| Range | 4 |
| Merchantable Stand | 5 |
| Factors Controlling Distribution | 5 |
| Precipitation | 9 |
| Humidity | 9 |
| Soil | 10 |
| Relative Moisture Requirements | 13 |
| Temperature | 13 |
| Aspect | 14 |
| Altitude | 14 |
| Light Requirements | 18 |
| FOREST TYPES | 20 |
| The Western White pine Type | 20 |
| General Description | 20 |
| Proportion of Western White Pine | 21 |
| Composition of the Stands | 21 |
| Codominant Associates | 21 |
| Subordinate Associates | 24 |
| The Climax Type | 24 |
| Weed Species | 25 |
| Density and Number of Trees per Acre | 25 |
| Other Interior Types | 25 |
| Northern Coast Types | 26 |
| General Description | 26 |
| Douglas Fir Type | 26 |
| Mixed Fir Type | 26 |
| Southern Coast Types | 27 |

Page


SUSCEPTIBILITY TO INJURIES 28
- Fire 28
- Insects 29
  - The Mountain Pine Beetle 29
  - Other Insects 30
  - Control of Depredations 30
- Fungus Diseases 31
  - *Armillaria mellea* 32
  - *Echinodontiun tinctorium* 33
  - *Trametes pini* 33
  - *Polyporus schweinitzii* 34
  - *Fomes annosus* 35
  - White pine Blister Rust (*Peridermium strobi*) 35
  - Needle Disease (*Lophodermiun pinastri*) 36
- Windfall 36
- Deterioration of Dead White pine 36
  - Fire-killed Timber 36
  - Insect-killed Timber 38

REPRODUCTION 38
- Seed Production 38
- Seed Dissemination 39
- Germination of Seed 42
- Seedling Development 47

GROWTH 51
- Height 52
  - Under Full Light 52
  - Under Influenced of Overhead Shade 55
  - Recovery from Suppression 59
- Diameter 59
  - Recovery from Suppression 59

YIELDS PER ACRE OF WESTERN WHITE PINE 61
- Average Yields of the Type 61
- Maximum Yields 62
  - Pure Fully-stocked Stands 65
  - Pure Stands over Large Areas 68
  - Mixtures with Important Species 71
  - White pine – Western Larch Mixtures 71
  - Mixtures with Red Cedar 71
  - Mixtures with Balsam Firs and Hemlocks 73
  - White Pine – Douglas Fir Mixtures 73
  - Spruce and Other Mixtures on Lolo Forest 76
  - Pacific Coast Types 77
  - Summary Maximum Yields and Annual Growth 77

Page


Gross Yields vs. Utilization 77
Prediction of Yields 83
In Established Immature Stands 83
In Stands to be Established 84


PART II – MANAGEMENT


ADVISABILITY OF MANAGEMENT 86
Gross Returns 86
Costs of Growing the Timber 87
Land Values 87
Formation 88
Protection and Administration 88
Taxation 88
Net Returns 89
Federal and State Forestry 89
Private Forestry 93

OBJECT AND ROTATION 94

CHOICE OF SPECIES 97

[Improvement] THINNINGS 99

FINAL CUTTING AND REFORESTATION 100
Scientific Facts Affecting the Choice and Application of Silvicultural Systems 100
The Selection System 101
Clear-cutting Systems 103
Blocks or Alternate Strips 103
Groups of Seed trees 104
Scattered Seed Trees and Reserved Standards 105
System of Reserved Standards 105
System of Scattered Seed Trees 106
Clear-cutting the Whole Stand 106
The Shelterwood System 107
Two-story Shelterwood 107
Primitive Shelterwood 107
Practical Application of Cutting Systems 108
Marking Rules in Use on National Forests 109

| | Page |
|---|---|
| BRUSH DISPOSAL | 112 |
| Broadcast burning | 112 |
| Windrow Burning | 113 |
| Piling and Burning | 113 |
| Time of Burning | 114 |
| Leaving Slash Unburned | 115 |
| ARTIFICIAL REFORESTATION | 115 |
| Seed Collection and Extraction | 116 |
| Collection | 116 |
| Storing the Cones | 116 |
| Drying the Cones | 116 |
| Extraction, Storage and Cost | 117 |
| Nursery Practice | 118 |
| Time of Sowing | 118 |
| Growing the Stock | 118 |
| Damping Off | 119 |
| Cutworms | 119 |
| Cost | 119 |
| Sowing and Planting | 119 |
| APPENDIX | 121 |

LIST OF ILLUSTRATIONS AND TABLES
[Note: plates and figures that are photos have not been included]


| No. | Subject | Page |
|---|---|---|
| Figure 2 | Range of Western White Pine (Map) | 6 |
| Figure 3 | Interior Belt of Western White Pine Distribution Within the United States (Map) | 7 |
| Table I | Estimate of Total Stand of Western White Pine | 8 |
| Table II | Climatic and Site Conditions Favorable and Unfavorable to Western White Pine | 11 |
| Table III | Complementary Relation of Humidity and Soil Moisture with Respect to Influence of Distribution of Western White Pine | 13 |
| Figure 4 | Decrease in Soil Moisture during Dry Season | 15 |
| Figure 5 | Distribution of Western White Pine with Respect to Altitude and Aspect | 16 |
| Table IV | Relative Moisture Requirements of Western White Pine and Associates in Idaho | 17 |
| Table V | Scale of Tolerance of Western White Pine and Associates | 19 |
| Table VI | Estimate and Relative Importance of Standing Western White Pine in National Forests of Idaho White Pine Belt | 22 |
| Table VII | Estimated Stand of Western White Pine in National Forests of Western Washington and Oregon | 27 |
| Table VIII | Seed Dissemination on Average Rolling Lands and Flats | 40 |
| Table IX | Seed Dissemination of Western White Pine and Associates on Rolling Valleys Exposed to Constant Winds | 41 |
| Table X | Rate of Germination of Western White Pine Seed | 42 |
| Table XI | Comparative Rate of Reforestation of Various Surface Conditions Based Upon Two Representative Cut-over Areas on the Kaniksu National Forest | 44 |
| Table XII | Comparison of Germination and Survival of Western White Pine and Associates Under Important Conditions of Site, Light, and Surface | 49 |

| No. | Subject | Page |
|---|---|---|
| Table XIII | Best Site, Light and Surface Conditions for Germination and Survival of Western White Pine and Associates | 51 |
| Table XIV | Relative Height Growth of Associated Species on Areas Approximately Representative of Each Site Quality for White Pine Within the Western White Pine Type, Idaho | 53 |
| Table XV | Height Growth of Western White Pine and Douglas Fir Seedlings in Full Overhead Light, Western Washington | 56 |
| Table XVI | Height Growth of Dominant and Codominant Western White Pine in Western White Pine Type | 57 |
| Table XVII | Relative Height of Dominant Seedlings Under Shade on Representative Plots Within Western White Pine Type | 58 |
| Table XVIII | Increase in Diameter and Volume Growth of Scattered Western White Pines 130 Years Old | 60 |
| Table XIX | Average Yields of Western White Pine Type for Entire Watersheds | 62 |
| Table XX | Average Yields of Selected Good Stands in Western White Pine Type | 63 |
| Table XXI | Yield Per Acre of Western White Pine in Pure Fully-stocked Stands (Normal Yield) Idaho and Montana | 66 |
| Table XXII | Effect of Spacing on Growth and Yield in 47-year-old Stands Of Pure Western White Pine | 69 |
| Table XXIII | Yield of Maximum Western White Pine Stands Prevailing Over Large Areas All Sites – Idaho and Montana | 70 |
| Table XXIV | Yield of Fully-stocked White Pine – Western Larch Mixtures On Deep Moist Soils Lower Slopes and Flats – Kaniksu Forest, Idaho | 72 |
| Table XXV | Yield per Acre of White Pine and Larch Over Cedar | 74 |
| Table XXVI | Maximum Yield of Cedar in Mixture With White Pine | 75 |
| Table XXVII | Yields of Best-stocked White Pine – Douglas Fir Mixtures | 76 |
| Table XXVIII | Relative Yield of Fully-stocked White Pine, Engelmann Spruce and Douglas Fir Mixtures | 78 |
| Table XXIX | Annual Growth in Board Feet per Acre Mean and Periodic Western White Pine in Pure Stands | 79 |

| No. | Subject | Page |
|---|---|---|
| Table XXX | Percent Culled in Logging Western White Pine Stands | 80 |
| Figure VII | Comparison of Yields in Board Feet, Best stands and Mixtures of Western White Pine | 81 |
| Figure VIII | Mean Annual Growth and Periodic Annual Growth Compared, Western White Pine in Pure Stands | 82 |
| | PART II | |
| Table XXXI | Gross Returns per Acre From Pure Fully-stocked Western White Pine | 87 |
| Table XXXII | Rate of Compound Interest Accumulations on Items of Cost in Raising Western White Pine | 90 |
| Table XXXIII | Accumulation of Compound Interest on the Costs and Additional Premiums Earned in Federal or State Forests | 91 |
| Table XXXIV | Percent Profit Earned in Federal or State Forestry at Different Rotations and on $6, $3, & $1 Investment Information | 92 |
| Table XXXV | Per Cent Profit Earned in Federal or State Forestry at Different Rotations, Costs of Land & Formation, Not Taxed, & .05 Annual Expense | 93 |
| Table 36 | Rate of Accumulation of Land and Timber Taxes at Compound Interest | 94 |
| Table 37 | Per Cent Profit Earned in Federal or State Forestry in Fifty Years from $1 to $16 Initial Investment and with $4, $8 & $12 Stumpage by Western White Pine, Fully Stocked, on Site II | 95 |
| Table 38 | Scattered Seed Trees Left After Cutting | 102 |
| Plate XXII | A Substantial and Satisfactory Type of Crib for Storing Cones | 117 |

LIST OF TABLES IN APPENDIX


| No. | Subject | Page |
|---|---|---|
| Table A | Average Physical and Mechanical Properties of Western White Pine and Competing or Associate Species, Based on Tests of Small Green Clear Specimens 2” x 2” in Cross Section, Bending 28” Span | 122 |
| Table B | Average Percentage of Grades and Overrun of Lumber Cut From Western White Pine Logs Separately For Sound and Defective Timber | 124 |
| Table C | Percentage of Grades and Overrun by Size in 14’ & 16’ Western White Pine Logs for Sound Logs and for Various Degrees of Defect Based Upon Gross Log Scale | 125 |
| Figure 9. | Percent of Grades and Overrun in Lumber Cut from Sound Western White Pine Logs of Various Common Sizes | 127 |
| Figure 10. | Percent of Select Grades in Lumber Cut from Sound Western White Pine Logs of Various Common Sizes | 128 |
| Figure 11. | Percent of the Shop Grades in Lumber Cut from Sound Western White Pine Logs of Various Common Sizes | 129 |
| Figure 12. | Average Percent of Grades and Overrun in Lumber Cut from Defective Western White Pine Logs Consisting of 10% or Less Cull | 131 |
| Figure 13. | Average Percent of Grades and Overrun in Lumber Cut from Defective Western White Pine Logs Consisting of 11% to 20% cull. | 132 |
| Figure 14. | Percentage of Overrun in Lumber Over Gross Scale or Logs for the Various Common Sizes When Scaled by Scribner Decimal C Rule | 133 |
| Table C-1 | Overrun in an Entire Western White Pine Tree Whose Logs Average 10 per 1000 Board Feet | 134 |
| Table D | Percentage of Grades of Lumber Cut from Largest Western White Pine Ever Felled | 134 |
| Table D-1 | Prices of Western White Pine Lumber Average for 1913 | 135 |
| Table E | Value of Western White Pine Lumber as It is Affected by Size and Condition of Logs | 136 |
| Figure 15. | Value of Western White Pine Lumber as it is Affected by Size of Logs for (1)1000 Bd. Ft. of Lumber, Lumber Scale, (2) The Lumber from 1000 ft. of Logs. Scaled by Scribner Decimal C Rule. | 137 |

| No. | Subject | Page |
|---|---|---|
| Table F | Amount and Relative Importance of Western White Pine Lumber Cut in 1913 | 138 |
| Table G | Distribution of “Idaho” White Pine Lumber Shipments by States Reported to Western Pine Mfgrs. Assn. | 140 |
| Table H | Climatology of Western White Pine Range 1914 Data | 141 |
| Table I | Humidity under Climatic Conditions Favorable and Unfavorable to Growth of White Pine | 144 |
| Table J | Number of Trees per Acre by Diameter Class and Age, in Natural Unthinned Little Crowded Maximum Stands of Nearly Pure Western White Pine | 145 |
| Table K | Number of Trees per Acre by Diameter Class and Age, in Natural Unthinned Little Crowded Maximum Stands of Cedar in Mixture with Western White Pine | 147 |
| Table L | Number of Trees per Acre by Diameter Class and Age, in Natural Unthinned Little Crowded Maximum Stands of Western White Pine and Western Larch | 148 |
| Table M | Number of Trees per Acre by Diameter Class and Age, in Natural Unthinned Little Crowded Maximum Stands of Western White Pine and Douglas Fir | 149 |
| Table N | [Not found] | |
| Table O | Multiple Volume Tables for Western White Pine | 150 |

## Introduction and Comments on the Transcription of Western White Pine Bulletin

I first became aware of the *Western White Pine Bulletin* by F. I. Rockwell when I was assigned the task of developing descriptions of the pre-1900 forests of northern Idaho. I contacted Dr. Art Zack, Forest Ecologist on the Panhandle National Forest, looking for information. He gave me a photocopy of Rockwell's document. He had obtained the photocopies from Cort Sims, an archaeologist for the Idaho Panhandle National Forest (since retired). The bulletin provides one of the earliest comprehensive descriptions of the white pine forests of the west, especially the white pine type of northern Idaho and adjacent Montana. Written between 1912 and 1917, it describes the early white pine forests and management activities prior to the time when white pine blister rust became the dominant factor in white pine management.

This draft of the *Western White Pine Bulletin* was completed by Frank Irvin Rockwell in January, 1917. It possibly was intended to be published as one of a series of bulletins prepared by the Forest Service that described various timber species. According to the National Academy of Sciences (Anon. 1920), the project to prepare a monograph bulletin on western white pine was begun in 1912. It stated that field work on the project was practically completed in 1913 and a preliminary draft of the bulletin was submitted by Rockwell in 1914. A second draft of the bulletin was submitted in 1917 following supplemental field work and data compilation in 1914-15. Publication of the bulletin was withheld "until studies of other phases of the management of western white pine are made."

Copies of the bulletin that are currently available are photocopies of a photocopy of a carbon copy of the original draft. Because of the quality of the carbon copy and subsequent photo copies, the text of the available 241-page documents is often very light, fuzzy, and hard to read. The quality of the photographs is poor but suggests that somewhere in its history original pictures were photocopied. To date, a copy containing pictures of reproducible quality has not been located.

Because of the overall poor legibility of the copies, I decided to retype the bulletin so that it could be easily read and also to provide a digital copy that could be easily reproduced and accessed. Also, single spacing the text reduced the size by about 100 pages. It is my hope that it can be posted on a web site where it will be accessible to those who are interested in learning what the white pine forests were like prior to logging, fire suppression, and the ravages of blister rust.

### F. I. Rockwell

Charles Wellner (1976) stated in his history of the Forest Service's Priest River Experimental Forest:

> "F. I. Rockwell was in charge of Silvics in District 1 at the time the Station was established and had much to do with selection of the site and development of the research program. He personally was responsible for yield studies. Although not assigned to the Station, he stayed there frequently… He apparently left District 1 during World War I."

Wellner continued:

> “As Rockwell was working on growth and yield, little was done by the people at Priest River on mensurational studies except to give some assistance to Rockwell and establish a few permanent yield plots on the experimental forest. During this period, Rockwell prepared a comprehensive manuscript on western white pine and its management. Although he revised it several times, it was never published.”

Most of the following information on F. I. Rockwell was collected by Brennan A. Ferguson, Ferguson Forest Pathology Consulting, Inc., Missoula, MT.

According to information located by Ferguson, Rockwell worked for the Northern Region of the Forest Service as a forest examiner. He left the Forest Service in 1917 and worked as an agricultural agent for Benewah County, Idaho from February, 1918 until December, 1920.

Steve DeBoer of Rochester, Minnesota wrote a summary of Frank Rockwell's life for a family genealogy that was recently published. Ken Rockwell provided the following text which reads in part:

> "Frank Irvin Rockwell was born Dec. 28, 1882 in Minneapolis, Hennepin Cty., MN. ... [genealogical summary deleted] ... Frank was an Epsilon Sigma Phi graduate of the first class in forestry (1905) at the University of Minnesota. For the next decade he was with the U.S. Forest Service in the west. During World War I with the U.S. Department of Agriculture as an Emergency Demonstration Agent to increase food production in the United States. Following the war he spent four years in extension work in Idaho, followed by six years with a lumber company in Oregon and six years as a farm supervisor in North Dakota. From 1936 to 1945 he was an Extension Specialist Forester and Horticulturist at South Dakota State College, Brookings and from 1945 to 1948 State Forester, South Dakota Department of Game, Fish and Parks, Pierre. From that time until his death he was a landscape architect with Northwestern Nurseries, Valley City, ND and Minnesota Nurseries. He was also a consultant forester for Wisconsin and Minnesota timber owners. He was the author of many Extension Circulars and wrote many free lance articles for professional journals. He was a member of the Society of American Foresters, South Dakota Horticulture Society, and the Society of Advancement of Horticulture Science. ... He was killed in an auto accident when he swerved to avoid a small boy on a bicycle who cut into traffic from a side street. ..."

References:


Anonymous. 1920. Western white pine (project TS-1, D-1), p. 196. *In*: R. Cobb (compiler). Bull. of the National Research Council Vol.1, Part 3, No. 3. National Academy of Sciences, Washington, D.C.

Wellner, C. 1976. Frontiers of forestry research: Priest River Experimental Forest 1911-1976. Ogden UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 148 p.

**Comments on the Transcription**

Text enclosed in these brackets { } indicates notations hand-written on the typed copy. The author of the hand written comments and changes is unknown but probably was Rockwell himself. A formal reviewer would have noted the several typographical errors also present in the text.

Text enclosed in brackets [ ] has been inserted during transcription for clarity.
Tree names are the same as used in the report. Scientific names have been italicized. The currently used scientific names of fungi have been added in brackets following the names used in the report.

Many of the tables were recreated as spreadsheets. If errors in the original document were detected, they were identified with an * and bold font. If space permitted, the corrected numbers were inserted in brackets. If space for corrections was not available, the corrections were included in a following table with the changes similarly identified. [n.l.] was inserted in tables where words or numbers were not legible in available copies.

Some tables have been slightly reformatted to fit letter sized paper.
The following tables require legal paper for printing:

| Table | Page |
|---|---|
| XII | 49, 50 |
| XXV | 74 |
| J | 144, 145 |
| K | 146 |

When page numbers were referred to in the bulletin, they were transcribed as typed and followed in brackets [ ] by the page number in the transcribed document.
The bulletin also contained many photographs. These were reproduced in the photocopies but the image quality was too poor for further reproduction. Therefore, they have not been included in this transcription. Hopefully, the photos can be added at a later date if a copy of the bulletin containing original photos is found.

Special thanks are due to Marc Rust, Director of the Inland Empire Tree Improvement Cooperative at the University of Idaho College of Natural Resources, for his encouragement on this project and his thorough review of this document.

Daniel L. Miller Ph. D
Precision Forestry LLC
Moscow, Idaho
May, 2015

# WESTERN WHITE PINE

## INTRODUCTION

As the lumber manufacturers of the Great Lake region began to exhaust their white pine holdings, they turned their attention westward and found among the mountains of Northern Idaho and adjacent territory another white pine with the superior qualities of the eastern species. With the growing shortage of the eastern white pine the western or Idaho white pine has to some extent taken its place in the world's markets. The available supply of merchantable timber is limited, but large areas within the mountain regions of northwestern United States and Canada are adapted to its growth. Its exceptional qualities of rapid growth, heavy yield and response to management combine with its wide usefulness in making it by far the most valuable tree for forest management in the region in which it is abundant, and indicate that the species should receive increased attention in other parts of its range where its growth is equally good and its presence in commercial quantities would make exploitation practicable.

### Purpose of Publication

The purpose of this publication is to show the importance of the western white pine, describe the present condition of the stands, the necessity of and possibility for improvement, the returns to be derived from systematic management, and the best methods by which this can be accomplished. Although deduced mainly from data gathered in Idaho and adjacent territory, if the general principles governing the distribution of the species are kept in mind, the main conclusions will be found susceptible of general application.

### Nomenclature

The western white pine (*Pinus monticola* Dougl.) is by the woodsman commonly called "white pine" and by the lumber trade "Idaho white pine". Occasionally, also, it is known as "silver pine". The so-called "California white pine" and "New Mexico white pine" are for the most part not true white pines, but trade varieties of the western yellow pine (*Pinus ponderosa* Lawson),* whose lumber largely resembles white pine in its more important commercial properties.

### Habit

Readily recognized by its characteristic crown and bark and its soft silvery green needles, with its symmetrical appearance in youth and its clean, stately trunk at maturity, western white pine at once strikes the observer as one of the most beautiful trees of the forest. The crown of the forest grown tree is long, narrow and from conical to cylindrical in shape, with small branches grouped in symmetrically spaced whorls on a very straight stem (Plate I, Fig. I, and Plate VII). The bark, always relatively thin, is smooth in early

---

* See American Lumberman, Whole No.-2089-P45 "Uses of White & Sugar Pine["]; also Bull. No.232 U.S. Dept. of Agr. P14 "Western Pine".

youth but later becomes broken into peculiar small rectangular blocks, which in old age are joined together in longitudinal ridges, presenting an appearance quite unlike its associates. (Plate I, Fig. 2, Plate IV, Fig. 3 and Plate VI). This bark and crown afford a ready means of distinguishing the partly or fully grown trees from the eastern white pine, which as it matures developes [sic] a thick, deeply-fissured bark and broad, more rounded and shorter crown.

The bole of western white pine is quite cylindrical, and of very little taper, yielding more lumber from trees of given diameter and height than any of its associates, with the possible exception of some of the true firs (viz., *Abies grandis* and *Abies nobilis*). Trees grown in well-stocked, well-developed stands are taller and have less taper than those grown in thinner, more open stands.

Good clear length is found in western white pine only in mature trees grown under heavy side shade, as will be more fully explained later under the discussion of "Light Requirements". The lateral branches persist for many years after suppression, so that they are usually present on trees under 100 years old, and on open grown stands to a much greater age.

In size within its optimum range mature white pine commonly varies from 130 to 180 feet in height, and from 18 to 42 inches in diameter at breast height. But larger trees are not uncommon. The largest tree of record measured 9 feet in diameter and over 200 feet high when cut. It was found to be 425 years old and yielded 29,800 feet of sawed lumber.*

## THE WOOD**

### Quality

#### Physical and Mechanical Properties

The wood of the western white pine grade for grade is practically identical for commercial purposes with the eastern species. It is light but strong for its weight, straight and close grained and very soft, surpassing nearly all other woods in the ease with which it is worked. It is fairly durable. It takes paint quickly and evenly and holds its shape well. All these characteristics make it, equally with eastern white pine, the superior wood for all purposes requiring such qualities.

A series of tests on small, clear specimens from five trees of each species which was made at the United States Forest Products Laboratory, affords some comparison of the physical and mechanical properties of western white pine from Montana with other species, and especially with those of somewhat similar characteristics. In contrast with

---

* This tree grew near Collins, Latah County, Idaho, and was sawed into lumber by the Potlatch Lumber Company, January 5, 1912. See record of grades produced in Table D of the Appendix.

** See Bull No. 426 U.S. Dept. of Agr. "Sugar Pine" page 39, for "Key for the Identification of Sugar Pine, Western White Pine and White Pine Woods".

Wisconsin white pine, California sugar pine, Engelmann spruce from Colorado and western yellow pine from Montana, the western white pine which has a slightly greater specific gravity, was found to excel in elasticity, in bending strength, in crushing strength when used for upright support, and if air-dry also when used for longitudinal support. Not withstanding its strength, the seasoned specimens were found to be softer than all but the Colorado spruce. In the green state, on the other hand, the western white pine tested slightly harder and tougher than the others. It shrank more in drying and when, as cross-beams either green or dry, it was subjected to bending by sudden impact, it gave way the most quickly.

The detailed results of the tests on green specimens of each of the above mentioned species and on the other associates of western white pine, are given in Table A of the appendix.

Lumber Grades

The merchantable quality of a wood is largely determined by the grades of lumber it will yield. In this report, although differing in the yield of individual grades, the eastern and western white pines on the whole will average about the same value, according to lumbermen familiar with both species. The Idaho white pine yields less of the select grades, but this is compensated by a greater yield of the valuable No.1 Common and less of the poorer Nos. 3 and 4 Common. These differences are undoubtedly due to the smaller but more widely distributed knots of the western white pine, a result of the differences in forms of crown. * The average percentage of grades which the western white pine yields, as determined by mill scale studies averaged for five widely separated localities in the Idaho white pine belt, are given in Table B of the Appendix.

There is a decided variation in the yield of respective grades of western white pine, just as with other species, from logs of different age and size. The percentage of "select" grades cut from sound western white pine, increases decidedly [in] the older and larger logs, while that of the best grades of Common, No.1 and No. 2, decreases in a similar proportion. The relatively poor No. 3 Common makes up about the same percentage of the cut from sound logs in all the more common sizes and ages now logged, but this also diminishes rapidly when the logs become so large that it takes less than three to make a thousand board feet. The percentage of grades cut from logs of different size, separately for sound logs and for logs of different degrees of defect, is illustrated by Table C and by curves, Figs. 9 to 14 inclusive, in the appendix. The maximum quality attainable may be considered to be that cut from the big tree heretofore mentioned, which yielded the grades shown in Table D.

## Utilization

Annual Cut

The annual cut of western white pine in 1913 {1915} formed 34% {38.8%} of the total lumber production for Idaho, while the two species ranking next in importance, western yellow pine and western larch, formed 27% {26.6%} and 18% {14.5%} respectively. White pine is an important product also in the adjacent portions of

* See discussion of "Habit" on page 1 [2].

Montana and Washington, though the larger part of the present Washington cut was grown in Idaho. The proportion of the cut was much greater than the proportion of standing timber, due not so much to its abundance and accessibility as to its market value, which in 1912, was 12% {1915 was 24%} higher than the most valuable of the other northwestern species (western yellow pine). (See Table E and Fig. 15 for value in 1913) Over 13% {15%} of all the white pine lumber manufactures in 1913 {1915} was western white pine, and nearly all of this was produced in or adjoining the Idaho Panhandle. Idaho is now exceeded in white pine production only by the states of Minnesota and Wisconsin {in 1915 only by Minnesota}. (For cut by states in 1913 {1915} and relative importance of the species see Table F of the Appendix).

Markets and Uses

Most western white pine lumber goes to markets long accustomed to the white pine from the Lake Region or the Northeastern States. Over 60% is distributed in the Upper Mississippi Valley, and 25% east of Lake Michigan, to as far as New England. (For detailed distribution see Table G in the Appendix). Shipments to the latter region are increasing. Not less than 90% of the output consists of one inch boards. The grade in most demand is No. 2 Common. The use of western white pine is still chiefly for general construction, although an increasingly large proportion is being used for the special purposes to which its qualities peculiarly adapt it, such as matches, patterns, sash, doors, blinds, casings, mouldings, interior finish and fixtures, tanks, silos, boxes and baskets, and numerous kinds of woodenware. Occasionally, squared timbers of extra fine quality are shipped abroad to Great Britain to be resawed and used for ship decking; and boards and plank of a uniform size, 12” wide and 16’ long, have had some demand for South America. Very little western white pine is consumed in the region where it is manufactured, only 1/10 of 1 percent being distributed in Washington. The wood is considered too expensive for general construction. Some is used for special mining purposes, but much more, chiefly of the No. 3 Common Grade, is consumed in the manufacture of fruit boxes and crates.

## DISTRUBUTION AND INFLUENCES AFFECTING IT

### Range

Western white pine occurs mainly in two distinct belts on the Pacific slopes on North America. The coast belt, which is quite broken toward the south end, extends from the north part of Vancouver Island and the adjoining mainland of British Columbia 51° N. Latitude, southward between constantly rising altitudinal limits over the east slopes of the Olympics and both slopes of the Cascade, Siskiyou, Sierra Nevada and some minor mountain ranges to the high summits of the San Bernardino Mountains in southern California. The interior belt, embracing the more moist parts of the “Inland Empire”, spreads over the western slopes of the Continental Divide and over the more prominent ranges immediately to the westward, from 30 miles north of Quesnel Lake, about 53° N. Lat., in British Columbia, southeastward to and including the Flathead River watershed in Montana and well into the South Fork of the Clearwater River in Idaho. It is also found among the higher mountains of Eastern Oregon and Washington.

Throughout these regions the distribution of white pine is more or less diminished by competition with other species, or interrupted by inhospitable climatic or site conditions.

A better understanding of its importance throughout its range may be had by a glance at the accompanying maps (Figs. 2 and 3). From the standpoint of commercial possibilities the range outlined thereon is separated into three parts, which are distinguished as follows:

A. "Range of No Commercial Importance" – in which the species is so limited by climatic and site requirements that it attains relatively poor development or is confined to inaccessible areas or small isolated spots (Plate IV) and in which therefore it will never be of great commercial value. This region lies just within the range limits caused by cold, or by heat or drought.
B. "Region of limited occurrence but excellent development and promise for future extension" – in which the climatic conditions over wide areas are favorable for good development and the trees produced are of excellent quality, but in which the species at present is relatively unimportant because [it is] very limited in quantity, due chiefly to intense competition. An especially important part of this region is that portion of the coast belt to the north of California, since climatic conditions there are optimum for western white pine. (See Report on Western White Pine in District VI., by E. J. Hanzlik, December 3. 1912, pages 24 and 25, and succeeding pages of this bulletin).
C. "Region of present great commercial importance" – (Plate V.) in which the species attains equally good development and is both widely distributed and abundant, frequently dominating the stand. The climate of this region, which embraces Northern Idaho and adjacent portions of Washington, Montana and British Columbia, appears quite as favorable to white pine but less favorable to its competitors than the coast belt is.

## Merchantable Stand

While the distribution of western white pine is fairly extensive, the present stand of merchantable timber is rather limited. From the most reliable estimate obtainable, Table I has been prepared. This shows the total estimate of standing western white pine to be about 24 billion feet, 57 times the annual cut of this species in 1915 but only 9 times the total consumption of all white pine in the United States.

Of the total stand of western white pine 77 per cent is in Idaho and 16 per cent is scattered thru the dense forests of British Columbia, western Washington and Oregon. Of that within the United States, 62.5 per cent has been deeded to individuals or corporations, while 37.5 per cent has been granted to the states or retained by the Federal Government.

## Factors Controlling Distribution

Moisture, heat and light are the chief factors which control the distribution of white pine. The various requirements of soil, aspect and altitude are in the main important only as they affect these primary factors.

Figure 2. Range of Western White Pine

Figure 3. Interior Belt of Western White Pine Distribution Within the United States.

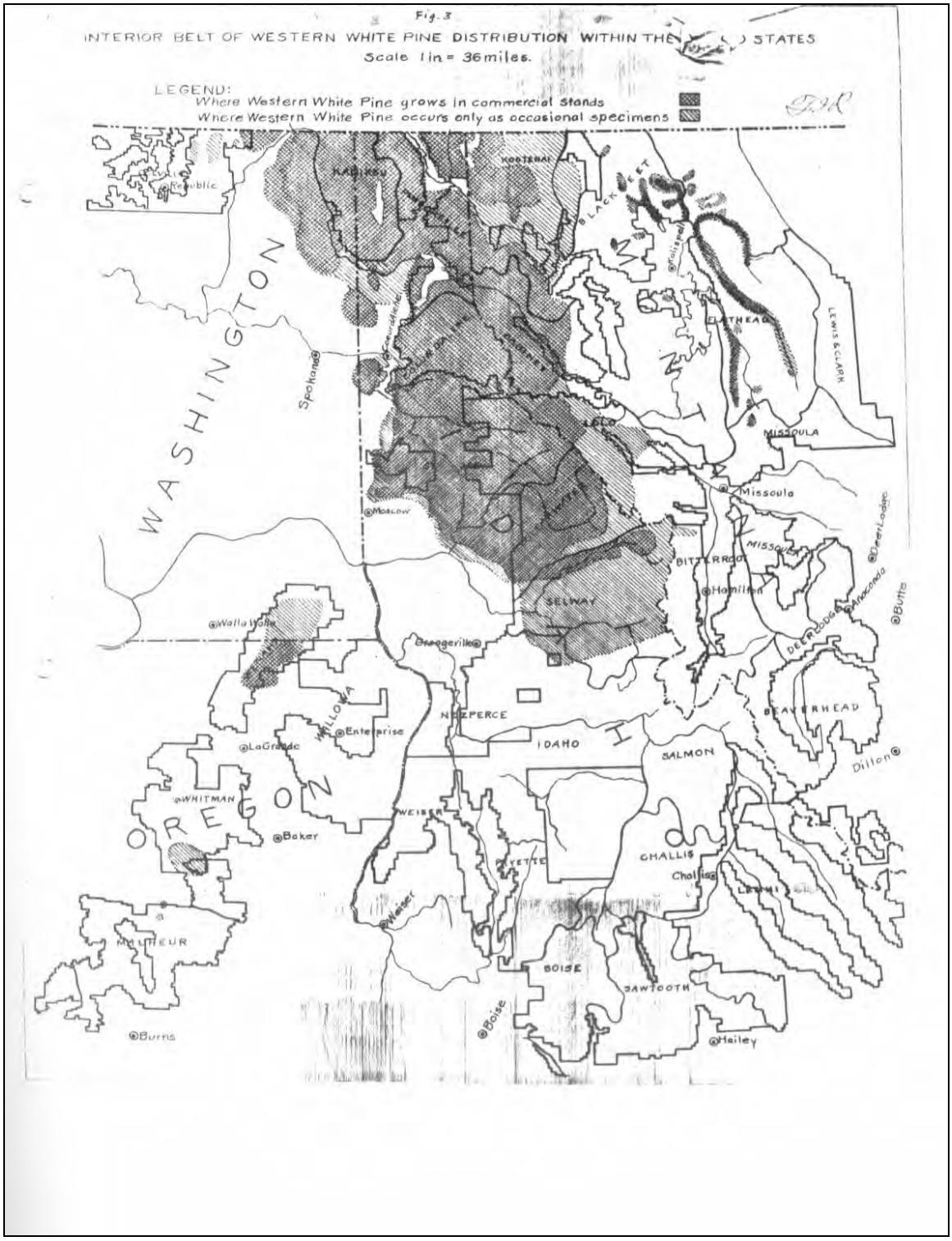


Table I.

ESTIMATE OF TOTAL STAND OF WESTERN WHITE PINE

By States and Ownership

(In millions of board feet)

| State or Province | State & National # Timber | Privately * Owned | Total |
|---|---|---|---|
| Montana | 620 | 190 | 810 |
| Idaho | 6,100 | 12,330 | 18,430 |
| Washington, extreme eastern | 200 | 460 | 660 |
| Washington, central and western | 340 | 120 | 460 |
| Oregon | 625 | 50 | 675 |
| Total in United States | 7,885 | 13,150 | 21,035 |
| British Columbia, Total | | | 2,650 |
| Interior 1,615 | | | |
| Coast 1,035 | | | |
| Total | | | 23,685 |

# 1916 estimates by the Forest Supervisor (See Tables V & VII) that of Eastern Washington comprising 145 million State and Federal timber for the Kaniksu National Forest; 10 for the Weneha and 5 for the Colville. To this Federal timber is added for Montana 36 million State timber, for Idaho 2,310 million and for eastern Washington 40 million.

* Figures for the Interior from the Lumber Industry study by D. T. Mason; for the coast belt from study of distribution and comparison with National Forest estimates.

The most obvious in its effect on distribution is moisture. Both atmospheric and soil moisture are essential. A deficiency, of one form or the other, is the principal cause of the lower altitudinal and latitudinal limits of the species, and of its further restriction to certain sites within its range.

The influence of heat is much less apparent. Yet low temperatures undoubtedly restrict the range at the upper altitudinal and latitudinal limits. At the same time the climate is noticeably cool wherever western white pine grows, perhaps because cool temperatures usually accompany high humidity.

Light affects the general range only to a minor extent. In cold climates, where the supply of heat is somewhat deficient, trees are able to utilize instead a certain amount of light.*

## Precipitation

The moisture supply varies with the precipitation. An annual precipitation of 20 inches is the least on record in localities where white pine grows, and there the species is rare, poorly developed and grows only on the most favorable sites. With greater precipitation, especially above 30 inches, it is often abundant, frequently dominating the stand on the more moist sites, though still rare in dry places. With 40 inches or more the species is far less exacting as to site and with other conditions favorable may occur anywhere. The heaviest precipitation recorded within its range is on the western slopes of the Olympics and Cascades, and on the British Columbia coast, where in many places it is from 100 to 150 inches.

The bulk of the precipitation throughout the western white pine range falls during autumn, winter and spring, while the summer is relatively dry. In some places, especially toward the south end of the range, the summer drought is very prolonged and severe, almost the only precipitation being in the form of snow.

## Humidity

A high degree of atmospheric moisture is characteristic of the region where western white pine grows. At the most humid part of the day, the early morning, the humidity per cent usually averages above 80, even during the dry summer season. The driest part of the day is in the late afternoon, and it is probably the lowness of the humidity at this time, and the frequency of these dry days, which is important in limiting the distribution of white pine. Within the western white pine belt the days when the humidity is less than 20% are very few, the average evening humidity for the dry summer season usually ranging from 30% in the drier regions to 60% or more in the more moist **

---

* See “Light in Relation to Tree Growth” by Zon & Graves, Bulletin 92. U.S. Forest Service, page 15.

** See Table I of Appendix for humidity at various points within white pine range. Further discussion of humidity in connection with “Soil”.

## Soil

The soil is primarily important as a reservoir of soil moisture. Soil moisture and atmospheric humidity are complementary factors in supporting the growth of white pine. Where one is low, the other must be relatively high; a deficiency of both excludes the species. As a result in localities of a high humidity, like most of the Puget Sound region, white pine will grow on the drier, more sterile soils, thriving there better than any of its competitors. But where the summer atmosphere is itself relatively dry, as on the lower more exposed sites in the interior belt, this species succeeds only on moist soils, deep and fertile, or those whose character or situation otherwise permits the retention of considerable moisture through the dry season.

That there is such a complimentary relation between soil moisture and atmospheric humidity is apparently substantiated by the meteorological records, and experiments of the Priest River Experiment Station. Table II compares the conditions of climate and soil moisture for three contrasting sites during 1914, the driest year of record, and for the site of least moisture during 1913, a relatively humid year. Of the several meteorological factors recorded, it appears from inspection of the table that at this point, humidity and soil moisture are the only ones sufficiently diverse to have caused the great effects on white pine seedlings indicated. (Temperature and wind velocity not differing greatly on the SW slope during the favorable year 1913 and the unfavorable year 1914 and evaporation being dependent upon the other factors.) And the same influences which so vitally affect the seedlings are undoubtedly responsible for the natural forest conditions on each site. The effect of these chief factors and their complementary relation, is shown more clearly in Table III. Condition No. 1 shows favorable humidity combined with a very favorable soil moisture. No. 2 shows probably the minimum combination of humidity and soil moisture that can be depended upon to permit the establishment of white pine. No. 3 had very dry soil conditions, but the humidity was so favorable that some seedlings still survived; but No. 4, with soil but a little less dry, had such a dry atmosphere that no freshly germinated seedlings could persist. Thus is plainly shown not only the complimentary relation between humidity and soil moisture, but also the approximate minimum requirements for the two.

This demand of white pine for soil of great moisture holding capacity in regions of low relative humidity is an important factor in limiting the distribution of the species in the rugged mountain country of the interior. For example, through much of the Rocky Mountains and of the east slopes of the Cascades, the slopes are very precipitous and the soil thin and rocky, and there white pine is scarce, being confined to the deep soils of the valley floors.

Aside from its soil moisture requirements, white pine is not exacting as to soil. Within the natural optimum range* of the species, as in the northern part of the Pacific Coast belt or in the more humid parts of the interior, it will thrive on shallow rocky soils or coarse gravel, but the preference of the species is always for good soil, deep and fertile, permeable and well drained, and there it makes the most rapid growth and reaches the largest size.

---

* See Dr. Henry Mayr quoted by Dr. C. A. Schenck " Biltmore Lectures on Silviculture" Page 39.

TABLE II

CLIMATIC and SITE CONDITIONS FAVORABLE and UNFAVORABLE TO WESTERN WHITE PINE

As Shown on Different Aspects at Priest River Experiment Station

| Aspect | | 35° NE Slope | Flat Sandy Bench | 30° SW Slope |
|---|---|---|---|---|
| AVERAGE CLIMATIC CONDITIONS | | | | |
| Total Annual Precipitation, inches | | 41.4 | 40.7 | 38.1 |
| Mean Relative Humidity 5 to 6 PM | Annual | 70% | 68% | 65% |
| | July | 55% | 48% | 47% |
| Mean Temperature, Fahr. | Annual | 43.3° | 42.8° | 45.2° |
| | July | 62.2° | 61.7° | 64.2° |
| Mean Wind Velocity mi. per 24 hrs. | | 19 | 38 | 70 |

CLIMATE AND SOIL DURING DRY PERIOD (JULY 15 TO AUG. 30) CONTRASTED FOR FAVORABLE AND UNFAVORABLE SEASONS.

| Year of Observation | 1914 Dry | 1914 Dry | 1913 Moist | 1914 Dry |
|---|---|---|---|---|
| Total Precipitation, inches | 0.19 | 0.17 | 0.77 | 0.19 |
| Mean Relative Humidity 5 to 6 PM | 35% | 29% | 40% | 25% |
| Minimum Relative Humidity 5 to 6 PM | 18% | 15% | 19% | 11% |
| No. Days with humidity less than 20% | 2 | 6 | 1 | 14 |
| Soil moisture at 1" to 6" depth, beginning of dry period | 60% | 22% | 19% | 23% |
| Soil moisture at 1" to 6" depth, avg. of dry period | 39% | 9.7% | 6.1% | 6.4% |
| Soil moisture at 1" to 6" depth, end of dry period | 31% | 6.5% | 2.1% | 3.7% |
| Mean soil temperature at 6" depth | 58° | 68° | 79° | 72° |
| Air temperature, Absolute maximum | 90.5° | 95° | 96° | 99° |
| Air temperature, Av. maximum | 78° | 84° | 84° | 85° |
| Air temperature, mean | 62.5° | 61.5° | 65.5° | 65.5° |
| Air temperature, Av. minimum | 47° | 39° | 47° | 46° |
| Air temperature, Absolute minimum | 34° | 24° | 34° | 34° |
| Mean wind velocity, mi. per 24 hrs. | 15 | 43 | 63 | 73 |
| Max. wind velocity, mi. per 24 hrs. | 31 | 81 | 134 | 184 |
| Total evaporation, inches | 3.4 | 9.2 | no record | 10.4 |

Table II continued on following page.

TABLE II
Continued

EFFECT ON WESTERN WHITE PINE

| Aspect | 35° NE Slope | Flat Sandy Bench | 30° SW Slope | |
|---|---|---|---|---|
| Year of Observation | 1914 Dry | 1914 Dry | 1913 Moist | 1914 Dry |
| (a) Mortality of unsheltered seedlings from Drought | | | | |
| Seedlings dying during dry period | | | | |
| Newly germinated | 1 | 1 | 3 * | 318 |
| 1 year old | 0 | 0 | - | 2 |
| Seedlings surviving dry period | | | | |
| Newly germinated | 68 | 249 | 3 | 0 |
| 1 year old | 199 | 180 | - | 1 |
| (b) Natural Forest Conditions | | | | |
| Predominating Species | Doug. Fir | W. Larch | W. Yellow Pine | |
| Associates, Other than White Pine | W. Larch<br>Cedar<br>Hemlock | Spruce<br>Cedar<br>Hemlock, Thrifty on good soil but stunted here on sandy soil | Douglas Fir | |
| Western White Pine, Occurrence | Common | Common | None, mature rare | |
| Western White Pine, Thrift | Excellent | Same as spruce, cedar, etc. | One sapling in a more favorable spot. | |

* Seedlings were killed during this season by fungus parasites.

TABLE III

COMPLEMENTARY RELATION OF HUMIDITY AND SOIL MOISTURE
WITH RESPECT TO
INFLUENCE OF DISTRIBUTION OF WESTERN WHITE
PINE

FROM RECORDS OF DRY SEASONS AT PRIEST RIVER EXPERIMENT STATION

| | Suitability of Conditions to Western White Pine | | Humidity 5-6 PM During Dry Season | | | Soil Moisture Percent at Depth of 1" to 6" During Dry Season | | |
|---|---|---|---|---|---|---|---|---|
| | For Survival of Seedlings | For Thrifty Growth (as indicated by natural stand) | Mean (%) | Minimum (%) | No. Days less than 20% | Beginning | Average | End |
| 1 | Very Favor-able 1914 | Favorable | 35 | 18 | 2 | 60 | 39 | 31 |
| 2 | Favorable | Rather Un-favorable | 29 | 15 | 6 | 22 | 97 | 6.1 |
| 3 | Moderate 1913 | Probably Un-favorable | 40 | 19 | 1 | 19 | 6.1 | 2.1 |
| 4 | Unfavorable | Unfavorable | 25 | 11 | 14 | 23 | 6.4 | 3.7 |

Note. No. 1 represents the 35° NE Slope in 1914. N0. 2 the Flat Sandy Bench in 1914. No.3 the 30° SW Slope in 1913, and No. 4 the 30° SW Slope in 1914.

## Relative Moisture Requirements

The prevalence of western white pine depends to a large extent upon its behavior with respect to moisture conditions in comparison with its competitors. Table IV, based on extensive observations of the relative distribution of white pine and its common Idaho associates, shows that the former is comparatively exacting with respect to either lack of or excess of soil moisture, and required atmospheric moisture more strongly than any other species save the hemlock.

## Temperature

The temperatures which prevent the growth of white pine are indefinitely known, although the species withstands quite a variety of conditions. In various parts of its

range, the mean annual temperature varies from 41° to 51° F. and the mean July and August temperatures from 59° to 68° F. Near the Pacific the climate is very equable, with little daily or seasonal variation and with no frosts for six or eight months of the year. On the other hand in the higher mountain altitudes of the interior, the temperature may range from 100° F. in summer to less than -25° F. in winter, with a diurnal range of 70° F. and with frequent frosts during the two or three months growing season.

## Aspect

The influence of aspect on distribution is well illustrated by the records of Priest River Experiment Station for 1913, which are given in Table II. These show that during the dry summer period, the shaded northeastern aspects are somewhat cooler, decidedly more moist, and evaporate much less moisture than the flats on southwestern aspects. They also have slightly more annual precipitation and relatively little wind. The southwest slopes on the other hand, are the most exposed to the wind as well as to the sun, have the least annual precipitation; the highest summer temperature, the least moisture in soil and air, and the greatest evaporation. The flats are intermediate. (See Fig. 4)

Such differences in climate of course cause considerable difference in the forest growth elsewhere as well as here. At this elevation (2400 ft.) in Northern Idaho, the moisture loving white pine is wont to predominate on northeasterly (north, northeast and east) aspects, and on moist soiled flats, but is rare on southwesterly exposures. Where the climate is drier, as at lower elevations, or further east in Montana, or in the southern part of the Coast Belt, the distribution becomes further restricted until it occupies only the better soils of northeasterly slopes. On the other hand, where the climate is more humid, as at higher altitudes, more northerly latitudes, or on the Pacific slopes of the northern Cascades, all aspects are favorable and the species occurs everywhere; and, where the climate, still humid, becomes rather cold for white pine, the seasons rather short, or the light rather deficient, as near the upper altitudinal or latitudinal limits, the species becomes restricted to the ridges or southerly aspects where the light and heat are more abundant and the seasons longest.

The distribution of western white pine on opposite aspects is illustrated diagrammatically for various latitudes and altitudes in Fig. 5.

## Altitude

Altitude influences each of the controlling factors. The higher the altitude is in a given locality, the more humid is the climate, the cooler the temperature, and up to certain limits, the lower the light intensity.*

The lower latitudinal limit, since it is determined chiefly by lack of moisture, gradually rises from north to south, and from west to east. It is found at sea-level in the more humid part of the coast belt, i.e. western British Columbia and Washington. Thence it gradually rises to 2000 feet in southwestern Oregon and to 8600 feet in southern California.

---

* See “Light in Relation to Tree Growth – Forest Service Bull. No. 92, page 14.

Figure 4. Decrease in Soil Moisture during Dry Season.

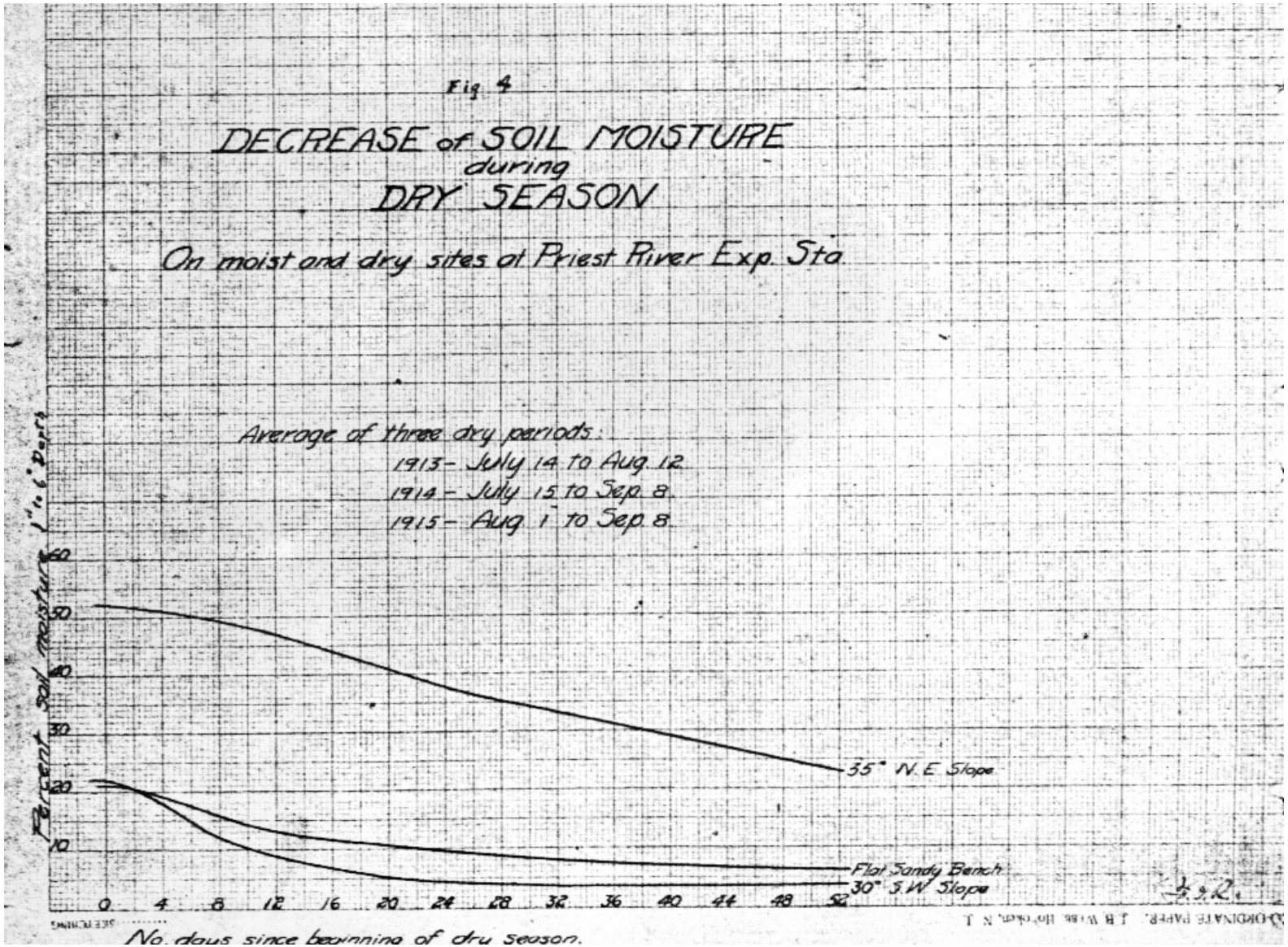


Figure 5. Distribution of Western White Pine with Respect to Altitude and Aspect.

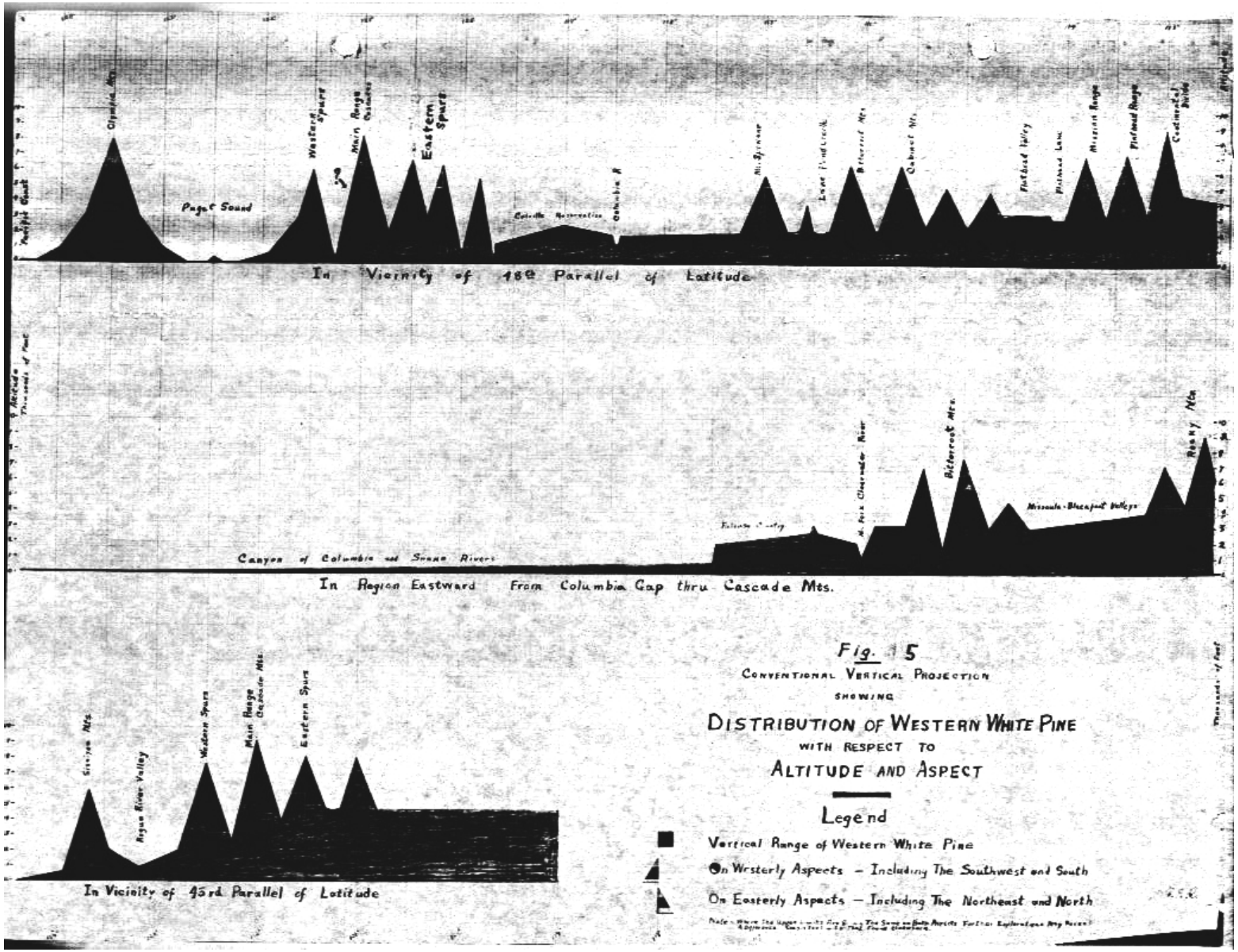


TABLE IV

RELATIVE MOISTURE REQUIREMENTS OF WESTERN WHITE PINE AND ASSOCIATES IN IDAHO

---

Rated in Accordance with Ability to Withstand

| Lack of Soil Moisture | Lack of Atmospheric Moisture | Poor Drainage |
|---|---|---|
| Western Yellow Pine | Western Yellow Pine | Alpine Fir |
| Douglas Fir | Douglas Fir | Engelmann Spruce |
| Lodgepole Pine | Lodgepole Pine | Western Red Cedar |
| Western Larch | Alpine Fir | Lodgepole Pine |
| Grand or White Fir | Engelmann Spruce | Western Hemlock |
| Alpine Fir | Grand or White Fir | Grand or White Fir |
| Western White Pine | Western Larch | Western White Pine |
| Engelmann Spruce | Western Red Cedar | Douglas Fir |
| Western Red Cedar | Western White Pine | Western Larch |
| Western Hemlock | Western Hemlock | Western Yellow Pine |

To the eastward the extraction of moisture from the westerly winds by each succeedingly higher mountain range causes increasing dryness, and the lower limit rises.

Close to and under the influence of these higher mountains on the east side of the main range of the Cascades in Washington and of the Bitterroots in the Inland Empire, the species occurs variously down to 2000, 1500 and even 1100 feet; while on the lower mountains and plateaus to the leeward, even though they rise much higher than these lower limits, it does not occur at all. (See Fig. 5).

The upper altitudinal limit, being determined chiefly by lack of heat, also rises from north to south. Starting at 2400 ft. at the north end of the range in British Columbia, it gradually increases to 6500 feet in Washington and Idaho, and to 10,000 feet in the Sierra Nevada and San Bernardino Mountains of California. Latitudinally, this limit remains stationary or varies with local climate conditions. #

# The upper limit has been reported at 3000 feet in the Olympic Mts., 4500 in the Cascades near Puget Sound and 4500 ft. in Montana, at the same latitude in which the species go[s] to 6000 ft. or more in the eastern Cascades and in Idaho. Further explorations may place some of these limits higher up.

The above described limits are the extremes and apply only on optimum sites. On poorer or otherwise unfavorable sites the limits are much contracted.

## Light Requirements

The capacity of trees for utilizing light in place of heat where the supply of heat is low, is, as previously intimated, at least partly responsible for white pine occupying the sunnier slopes and ridges in cold, cloudy or dark localities. Hence it is, that at its upper limits, the species is found only on these sites. It is chiefly for this reason perhaps that the upper altitudinal limits are reported higher in the drier, better-lighted localities of the interior (such as the eastern spurs of the Cascades), than nearer the coast. Another fact attributable to the same cause is the scarcity of white pine in localities within its range where there is such a deficiency of light or heat as to retard its growth. For white pine is largely crowded out and frequently replaced by species requiring less light, whether near its northern limits on the cloudy northwest coast, near the higher elevations of its range, or on the shaded sites elsewhere.

The relative requirements of the species for light, or their relative tolerance of shade, are therefore very important. Western white pine, like eastern white pine, is practically intermediate in its demands. It needs less light than the yellow pines and the larches, and more than the hemlocks, cedars, spruces and most true firs. The requirements of western white pine and Douglas fir are nearly the same, with the white pine appearing the more tolerant in Idaho, but the less so, according to reports in California. The indications of greater intolerance on the part of western white pine are its narrower, thinner crown, its greater height, its better self pruning, and its frequently lower growth in shade. The better pruning of the white pine may however be due to its smaller branches, and its slower growth in shade to its greater sensitiveness to lack of soil moisture. At any rate, in a crowded mixture of the two species in the Idaho Belt, beyond the sapling stages, at least, there is always greater mortality of overtopped trees among the Douglas fir.

A scale of tolerance for western white pine and its associates in each important region is given in Table V.

The tolerance of white pine, like that of other species varies. It requires more light in cold climates than in warm, and hence more in high altitudes and latitudes than in low. It requires more light in old age than in youth. Often a seedling will germinate and grow for a few years in considerable shade, and will survive under partial shade for many more. But it will not make its best growth after the first year or two without full overhead light. It follows that the less the light intensity of a locality or situation the earlier full light is required. Accordingly, while some shade for the earlier years is not objectionable or [is] even desirable near the lower, warmer, drier limits of western white pine, or on sunny slopes, on the other hand, near upper altitudinal or latitudinal limits, in a cloudy or foggy region, or on shaded slopes, full overhead light is needed from the start.

TABLE V

SCALE OF TOLERANCE OF WESTERN WHITE PINE AND ASSOCIATES

| IDAHO | CASCADE MTS. | CALIFORNIA * |
|---|---|---|
| | TOLERANT | |
| Western Yew (*Taxus brevifolia*) | Western Yew (*Taxus brevifolia*) | Western Yew (*Taxus brevifolia*) |
| Western Hemlock (*Tsuga heterophylla*) | Western Hemlock (*Tsuga heterophylla*) | |
| Mountain Hemlock (*Tsuga mertensiana*) | Mountain Hemlock (*Tsuga mertensiana*) | Mountain Hemlock (*Tsuga mertensiana*) |
| Western Red Cedar (*Thuja plicata*) | Western Red Cedar (*Thuja plicata*) | Incense Cedar (*Libocedrus decurrens*) |
| | Yellow Cypress or cedar (*Chamaecyparis nootkatensis*) | |
| Alpine Fir (*Abies lasiocarpa*) | Amabilis Fir (*Abies amabilis*) | |
| Grand Fir (*Abies grandis*) | Grand Fir (*Abies grandis*) | White Fir (*Abies concolor*) |
| | INTERMEDIATE | |
| Engelmann Spruce (Picea engelmannii) | Engelmann Spruce (Picea engelmannii) | Sugar Pine (*Pinus lambertiana*) |
| Western White Pine (*Pinus monticola*) | Western White Pine (*Pinus monticola*) | Red Fir (*Abies magnifica*) |
| Douglas Fir (*Pseudotsuga taxifolia*) | Douglas Fir (*Pseudotsuga taxifolia*) | Douglas Fir (*Pseudotsuga taxifolia*) |
| | Noble Fir (*Abies nobilis*) | Western White Pine (*Pinus monticola*) |
| | INTOLERANT | |
| Lodgepole Pine (*Pinus contorta*) | Lodgepole Pine (*Pinus contorta*) | Lodgepole Pine (*Pinus contorta*) |
| Western Larch (*Larix occidentalis*) | Western Yellow Pine (*Pinus ponderosa*) | Jeffrey Pine (*Pinus jeffreyi*) |
| Western Yellow Pine (*Pinus ponderosa*) | Western Larch (*Larix occidentalis*) | Western Yellow Pine (*Pinus ponderosa*) |

* Authority – Bulletin No. 426, U.S. Dept. Agr. “Sugar Pine” by Louis F. Larsen & T. D. Woodbury, except that Larsen & Woodbury place Lodgepole pine below western yellow pine in tolerance.

The amount of shade which will allow white pine to survive is approximately that cast by the intolerant class of trees. The overhead shade from equally or more tolerant species will prevent growth, and ultimately cause its death. Therefore, with similar rates of growth a greater proportion of white pine survives from competition with light-demanding species than with those that are shade-enduring.

The effect of shade on individual branches is the same as that on the tree. Therefore, light shading retards their growth and heavy shading kills them. The more the growth is retarded and the earlier they are killed the sooner the branches are broken off and the tree self-pruned. Accordingly, although the lateral branches remain small when in close competition with intolerant species, they are only killed and pruned by the shade of the intermediate or intolerant species. The more tolerant the associated trees the heavier the shade and the earlier and more complete the pruning. (Plate VI, XV and XVII.)

It, of course, also follows that pruning is more readily accomplished on aspects and in localities where the light intensity is low than where it is high. Well stocked nearly pure white pine stands in Idaho are quite well pruned on north slopes at 100 years, but on south slopes, or well lighted flats many strong dead branches persist at 150 years.

## FOREST TYPES

Trees which thrive under similar climates and site conditions are frequently associated as distinct tree societies or forest types. Some species, however, are more susceptible to certain climatic or site conditions than others, so that in different portions of a range the associates are apt to change and a new type be distinguished. In other words, changes in climate or site within the range of a species may give rise to different associates and therefore to distinct types.

### The Western White Pine Type

#### General Description

In the interior belt, the region in which western white pine is most abundant, the climatic and site conditions of all white pine sites vary within such narrow limits that with minor exceptions the same associates are at home in each; therefore only one type occurs in which white pine is of importance. For purposes of management this is called the western white pine type. The sites best adapted to white pine are the most suitable for all tree growth. Inasmuch as the climate in most of the region is only moderately humid, the soils as a rule are deep and of fair fertility.

In the most favorable parts of the interior belt, i.e. the Coeur d'Alene Mts., the Cabinet Mts., the western spurs of the Bitterroots, and the south end of the Selkirks, in Idaho, extreme western Montana, and extreme northeastern Washington, the white pine type is the predominating type. In the outlying portion of the belt, especially further east in Montana and north in British Columbia, a great restriction of suitable soils or climatic condition confines the type within much narrower limits, such as valley floors or gentle

slopes. Normally the stands are of great density and even-aged, with several species in mixture, but with western white pine predominant, either in amount or importance. Such diverse influences as fires, forest enemies, seed years, weather conditions, elevation, aspect, soil and age, however cause wide fluctuations both in density and in the proportion of each species, that if not considered in their broad relation to the surrounding stand are likely to disguise the true nature of the type.

Proportion of Western White Pine

The average proportion which white pine forms of the total stand on each Forest, and of the western white pine type, on those National Forests of Montana, Idaho and Washington in which the type occurs is shown in Table VI. On the more important white pine Forests, this species makes up 30% to 45% of the merchantable volume of the type and from 20% to 36% of all the timber on the Forest.

Composition of the Stands

Pure stands are not common. Occasionally as a result of the accident of seeding or because it is an especially favorable site for white pine, this species will form 80% to 95% of the stand. (See Plate XV). Such stands, practically pure, may be from an acre to a section in size. The soil is apt to be of the better quality, deep, well drained and fertile, since these conditions favor dominance of the white pine over other species. Nevertheless, mixtures are very common on such soils.

The associates naturally group themselves into two classes, in accordance with the way they behave in the stand. (Plate VII). The intolerant species, western larch, western yellow pine, and lodgepole pine, and the intermediate species, Douglas fir and Engelmann spruce, are codominant with the white pine. The most tolerant species, western hemlock and western red cedar, are subordinate, forming a lower story, except when they are survivors of some previous generation. The true or balsam firs, grand firs (*Abies grandis* Lindl.) and alpine fir (*Abies lasiocarpa* (Hook) Nutt) less tolerant but still very shade enduring, are sometimes codominant and sometimes subordinate.

Codominant Associates

Of the codominant associates in the western white pine type, Douglas fir, larch, grand fir and Engelmann spruce are quite important both commercially and silviculturally. This is because all are very abundant, all but the spruce being nearly always present. Spruce is apt to be found anywhere, but is abundant only in certain zones. The remaining species are less common and less important. In general each species prefers certain sites, though all but yellow pine may occur anywhere in the type.

Douglas fir (*Pseudotsuga taxifolia* (Poir) Britt.) usually makes up a heavy percentage of the stand in the more rugged localities, especially on the sunnier south and west exposures (Plate VI, Fig. 2), or the more shallow, rocky soils. On dry sites white pine gives way wholly to the Douglas fir type. On the heavily shaded, moist, deep soils of north slopes and bottomlands, due perhaps to a peculiar susceptibility to certain very destructive diseases, Douglas fir, in mature stands, is not common.

TABLE VI

ESTIMATE AND RELATIVE IMPORTANCE OF STANDING
WESTERN WHITE PINE, IN NATIONAL FORESTS
OF IDAHO WHITE PINE BELT*

1916

| State | National Forests | Total stand of white pine (millions B.F) | Proportion of white pine to total merch. stand on Forest (%) | Proportion of white pine to all timber within white pine belt (%) |
|---|---|---|---|---|
| Idaho & Wash. | Kaniksu | 508 | 33 | 40 |
| Idaho | Pend Oreille | 255 | 21 | 35 |
| | Coeur d'Alene | 1,500 | 36 | 45 |
| | St. Joe | 650 | 30 | 35 |
| | Clearwater | 1,000 | 20 | 35 |
| | Selway | 165 | 1 | 10 |
| Montana | Kootenai | 175 | 5 | 25 |
| | Blackfoot | 113 | 5 | 15 |
| | Flathead | 129 | 2 | 8 to 30 |
| | Cabinet | 102 | 12 | 25 |
| | Lolo | 68 | 3.5 | 35 |
| | All Forests | 4665 | 12 | 32 |

* In addition to the stand indicated in the table which comprises the white pine forests of District No. 1, there are 5 million on the Colville Forest in NE Wash. And 10 million on the Wenaha on the Ore-Wash. Border which are in reality, but detached fragments of the interior white pine belt. See Fig. 2.

Western larch (*Larix occidentalis*, Nuttall) is abundant in most young stands; when mature it dominates in second quality soils on ridges, benches, or other well lighted sites (Plate XVI); and where such situations are too dry for white pine it may occupy them in pure stands or in mixture with Douglas-fir or yellow pine. Unlike these species, however, it does not frequent very dry or steep south slopes, being considerably less common there than the white pine.

Engelmann spruce (*Picea engelmannii* Engelmann) always shorter than the associated white pine, but still more properly classed among the codominant species, occurs frequently in wet places, along streams or the borders of meadow or alder openings. In the colder parts of the type also (on north aspects above 4,000 feet and sometimes above 3000 feet), it frequently forms 1/3 or more of the stand, and in cold valleys and slopes around 4500 to 5500 feet elevation it may wholly replace the white

pine, forming an Engelmann spruce type. The grand fir (*Abies grandis* Lindl) commonly called white fir, (the principal one of the balsam fir group in the Interior), may occur anywhere in the western white pine type, since its range overlaps that of the white pine and extends considerably into warmer drier sites and climates. However, as previously intimated, it is not codominant everywhere, but is most frequently so above elevations of 2500 or 3000 feet. Higher up on the moist shaded sites, under the lee of the North Idaho ridges and mountain summits, the grand fir often predominates at the expense of the white pine, due perhaps to its greater tolerance and the lower intensity of light.

On mountain slopes, grand fir frequently remains sound until quite mature, and here occupies an important place in forest economy. But at lower levels, whether on wet flats on dry bench lands, the species is very commonly diseased. Often indeed, it becomes defective at such an early age as to be quite worthless.

The alpine fir (*Abies lasiocarpa* (Hook) Nuttall) range also overlaps that of the white pine. At the lower elevations of the white pine type, alpine fir is found chiefly along streams, because in dense stands there it is apt to be overtopped and suppressed by associates. But towards the upper limits, when it is less affected by the cold, it occurs more and more frequently and often joins the grand fir in competing successfully for the site. Above [,] it is the most common tree, occurring frequently in pure stands. At the lower elevations, alpine fir is even more defective and worthless than grand fir, but like the grand fir, higher up it is more often sound.

Western yellow pine (*Pinus ponderosa* Lawson) is a large valuable tree, and a very desirable associate at the lower altitudes where the soil is too dry to permit white pine to be uniformly successful. On very dry sites it occurs in pure stands or mixed with Douglas fir or western larch. It is not very common on the more moist white pine soils, and especially on the shaded sites, since owing to its intolerance and slower growth, it is crowded out at an early age.

Lodgepole pine (*Pinus contorta* Loudon) is of widespread occurrence, but usually of small size and inferior form at maturity in comparison with its associates. The species grows very rapidly in youth and often dominates the stand for the first 50 to 75 years. Later, however, if associated with white pine and other species in dense stand, the lodgepole is almost sure to be overtopped and become subordinate, soon dying of suppression. This suppression is often hastened by the work of beetles, so that lodgepole is quite scarce in heavy white pine or mixed stands more than 100 years old. Nevertheless, on the poor or shallow soil of ridges or dry benchlands or near the upper latitudinal limits of white pine, where the latter grows more slowly, the lodgepole once established is quite able to hold its own for a generation and not infrequently forms pure stands.

The species which are commonly codominant in the white pine type are as a rule of very even age, with five years or less variation in the larger trees and with not more than 20 or 30 years difference in extremes. Some stands, however, contain relics of the previous generation. These are generally the thick-barked yellow pine or larch, but sometimes, on moist sites, some cedar, hemlock or white pine itself may have managed to survive.

## Subordinate Associates

In those localities in which grand (white) fir is usually diseased, it may be almost wholly a subordinate species. On the other hand, where it is healthy and vigorous, it is coordinate if of the same or greater age than the rest of the stand, or subordinate if it comes in later. It has the ability to germinate and grow in dense shade and in drier soil than white pine requires. It tends to reproduce almost universally after light ground fires which have not been severe enough to kill the overhead stand, while white pine and other light-demanding species are kept out by their intolerance. We therefore find a fairly dense understory of fir under a large portion of the white pine forests, which when released by removal of the overhead stand grows rapidly and occupies the ground to the exclusion of other species.

Alpine fir is very similar in its habits to the other member of the balsam fir group and is subordinate under about the same conditions. It is, however, less rapid and persistent in growth and hence less abundant.

Western red cedar (*Thuja plicata* Don) and western hemlock (*Tsuga heterophylla* (Raf.) Sargent) demand about the same conditions of climate and soil that western white pine does, and the three species are therefore common associates. As a rule where one occurs either of the others may be expected. Both cedar and hemlock are very sensitive to lack of soil moisture, however, and on the drier white pine sites often do not appear until after other species have established a forest cover. Their great tolerance then permits them to reproduce in the shade and make fair growth.

Western red cedar is the most valuable of the subordinate associates. Its durable wood has many special uses, and cedar stumpage for poles and pilings brings even higher prices than white pine. The species is also relatively sound and free from pests. Western hemlock on the other hand, is subject to the same diseases as white fir, and is if anything, more defective. In many localities, especially on the lowlands, the hemlock is wholly worthless. Like the white fir, it is more apt to be sound on the slopes.

Black or mountain hemlock (*Tsuga mertensiana* (Bong) Sargent) is a sub-alpine tree, which mingles with western white pine only along its upper limits. Its wood is usually sound, and when accessible has considerable commercial value.

The subordinate species, as previously intimated, may be fairly even-aged and about as old as the dominant stand, or they may be of irregular younger ages.

## The Climax Type

Owing to the ability of the more tolerant species, especially the western red cedar, the western and the mountain hemlocks, and the balsam firs, to grow and reproduce in the shade, most western white pine stands usually contain more or less of an undergrowth of these species, cedar or hemlock commonly predominating on the more moist sites, grand and alpine firs on the drier. Reproduction of white pine and other light demanding species may come in sparsely and live for a few years but unless soon released to the light it finally dies. The tolerant species, however, persist and grow slowly for a long period, and as the overhead crown this [thins?] out, either by cutting or by natural causes, fill in the places thus made vacant, ultimately occupying the ground.

In this way the forest finally becomes entirely composed of the tolerant species, so that they form the final or climax type (Plate VIII).

In some forests, especially in parts of Montana, the hemlocks, balsam firs and cedar are scarce or absent and Engelmann spruce forms the climax type.

Weed Species

Because of their inferiority or utter unmerchantability in so many localities and because they occupy ground which might otherwise be supporting valuable species of timber, hemlock, alpine fir and lodgepole pine must in general be classed as weed trees, grand fir and even Douglas fir (as will be shown later) are frequently so. However, the tolerant species do perform an important function as lower story in protecting the soil, and in assisting in the natural pruning of the dominant stand as explained in the discussion of Light Requirements. Grand or white fir and hemlock where sound are also fairly merchantable, though less so than cedar. Therefore, when not defective and when not crowding out other more valuable species, an understory of one of these two species is desirable. In that case only those trees are weeds which interfere with the reproduction of the necessary proportion of more valuable and important species.

Density and Number of Trees per Acre

The density and number of trees per acre is usually greater in the white pine type than in other types of the region, due to the abundant moisture and fertility of the soil. Both density and number of trees varies widely, however, with the age, composition and degree of stocking of the stand. When only a single story of white pine and its associate co-ordinate species is present, there may be from 100 to 500 trees per acre. Still the crown is not dense enough to prevent growth of small shrubs and herbs. With a lower story of 100 or more shade-enduring trees present, however, the shade is so dense that little or no vegetation grows. Mixtures with the very tolerant cedar or hemlock afford the greatest density and permit the largest number of trees. The same qualities cause these species to be of the greatest service in pruning the trees which require more light.

The number of trees per acre, and its relation to age, yield and quality is illustrated in the tables and discussion on yield. The range in size of trees and the proportionate number of each diameter class in unthinned but little crowded maximum stands of representative age and composition is illustrated in Tables J, K, L and M in the Appendix.

## Other Interior Types

The occurrence of western white pine in the interior belt outside the white pine type is of little commercial importance. It occurs in places in the western larch, Douglas fir type, where the climatic conditions closely approach those indicated for the white pine range, often only as occasional seedlings, or more or less stunted trees. (Note non-commercial distribution in Fig. 3). Towards the borders of the white pine type it becomes more common, occurring in groups and spots in gulch bottoms and other especially moist places. These are in reality, however, outlying patches of the white pine type.

## Northern Coast Types

In the coast belt, distributed as it is through a wide latitude, white pine occurs under a considerably broader range of climatic conditions and under more diversified sites, several types being recognized.

### General Description

The northern and greater portion of the coast belt including those parts in British Columbia, Washington and Northern Oregon, forms a considerable part of that described as the "Region of Limited Occurrence but Excellent development and promise for future extensions" (Fig. 2). This region partakes largely of the general characteristics of the interior belt. On the east slope of the Cascades, the sites occupied are quite similar to those of Montana, but west of the Cascade summits the moisture and climatic conditions are considerably more favorable, even than that of Idaho, so that western white pine is not restricted as to site but grows on all aspects and on both moist and dry, both fertile and poor soils.

Most of the associates of the interior thrive on their favorite sites here also, and in addition other moisture loving and shade enduring species are found. Growth is rapid and the stands are very dense so that the light demanding slow growing species are crowded onto unfavorable sites or wholly eliminated. The slow growth of western white pine in early youth (See chapter on growth) and its demand for full overhead light therefore results in relative scarcity of the species, and while it grows rapidly in later stages, it thrives everywhere and becomes one of the largest trees of the forest, it is nowhere abundant, and forms only from1% to a maximum of 10% of the total stand. It, however, has the ability in this region to maintain itself thriftily on poor soils better than any of its associates. This valuable quality has undoubtedly greatly assisted in preventing the elimination of the species from the region.

Although the proportion of white pine in the Coast Forests is low, the aggregate amount of the species on some of the National Forests surpasses that on some of the Inland Empire Forests, as shown by comparison of Tables VI and VII.

### Douglas Fir Type

This type occupies the bottomlands and lower slopes of the northern coast belt. Douglas fir, less subject to disease than on the better sites of the interior, is the predominating species, with western white pine co-dominant. Amabilis fir (*Abies amabilis* (Loud.) Forbes), quite similar to grand fir in tolerance and habit, is the chief associate not found in the interior belt. These species with western red cedar and western hemlock form the understory and the climax type.

### Mixed Fir Type

This type occurs higher up the slopes. It is distinguished from the Douglas fir type by the replacement of 50% or more of the Douglas fir by noble fir (*Abies nobilis* Lindley) or by one of the other true firs, and by the occasional addition of yellow cypress (*Chamaecyparia nootkatensis* (Lamb.) Spach.) or mountain hemlock to the understory.

On the eastern slopes of the Cascades the codominant stand may also include western larch or western yellow pine.

Table VII

ESTIMATED STAND OF WESTERN WHITE PINE IN
NATIONAL FORESTS OF WESTERN WASHINGTON AND OREGON

| 1916 | | |
|---|---|---|
| State | National Forests | Stand of White Pine (Millions Bd.Ft.) |
| Washington | Chelan | 20 |
| | Columbia | 104 |
| | Olympia | 64 |
| | Rainier | 17 |
| | Snoqualmie | 40 |
| | Washington | 10 |
| | Wenatchee | 85 |
| Oregon | Cascade | 168 |
| | Crater | 316 |
| | Deschutes | 13 |
| | Fremont | 5 |
| | Siskiyou | 20 |
| | Santiam | 32 |
| | Umpqua | 70 |
| Total in the National Forests of Ore-Wash. Coast Belt | | 964 |

## Southern Coast Types

From central Oregon southward, the increasingly warmer and drier climate restricts white pine more and more to the higher, more moist, cooler altitudes; and because of the increasingly inaccessible and more exposed situations the species diminishes more and more in importance. The true balsam firs of the north, the cedars and western hemlock, gradually disappear from the sites where white pine grows. Their places are taken by other true firs, white fir (*Abies concolor* (Gord) Parry) in the lower portion of the white pine range, and the red fir (*Abies magnifica* Murray) in the upper, both of which dominate their respective sites to such an extent as to give their names to the type. The subalpine portion of the range, with lodgepole pine and mountain hemlock, becomes of greater prominence towards the south. Douglas fir still makes up an important portion of the codominant stand in Southern Oregon, but gradually diminishes to an insignificant proportion in southern California. Throughout, along the lower limits of altitude, the

sugar and Jeffrey pines intermingle to some extent. Western white pine, itself, as it becomes limited to the subalpine localities, is found only with the poor stunted development it attains in all the subalpine portions of its range, and is of value chiefly for watershed protection. (Plate IV, and Range of No Commercial Importance, Fig. 2).

## SUSCEPTIBILITY TO INJURIES

Destruction so great as to be scarcely conceivable has been the rule within the western white pine type. This has been inflicted chiefly by three groups of natural agencies, fire, insects and fungus disease. Aside from the wholesale desolation of stands wrought by destructive crown fires, the loss in other stands that have reached the age of merchantability, 100 years, through these agencies, amounts to not less than 50% of the total growth.* At later ages, the damage has become far greater than that.

### Fire

Enormous desolation in this type has been wrought by fire alone, greater probably than in any other western forest type. From time immemorial the interior belt has occasionally been the scene of terrific holocausts which swept over and destroyed the timber in entire watersheds. (Plate IX). Hardly a spot can be found even in the finest or oldest stands where ancient charred stumps are not visible, or where cinders or ashes are not readily found under the decaying litter of the forest floor. In 1910 alone, nearly 2 million acres or 24% of the 8 principal western white pine forests on Idaho and Western Montana were burned over, and nearly five billion feet or 20% of the total stand of timber destroyed. The uniformly even age of the white pine stands over large areas, found from the examination of hundreds of sample plots, is due to those wide-spread though occasional burns, upon which white pine has regenerated itself. Small fires also have been destructive but much more numerous and frequent, so much so that in the aggregate they have perhaps caused quite as much damage as the great fires.

The origin of a fire in this type is most frequently traceable to one of four causes. The mountainous region inhabited by western white pine is subject occasionally to electrical storms, accompanied by little rain, and 54% of the fires in 1914 were set in this way. These fires, however, are generally along ridge tops where conditions are unfavorable for rapid spreading. The other causes are chiefly preventable, 7% from railroads, 6% from campers, fishermen, etc., 6% by settlers and others burning brush.

The excessive destruction which fire has caused in the white pine type is due to several factors. The warmest part of the summer season is often very dry. The density of the stands is so great, that in addition to the live trees or reproduction, the debris from fallen trees and branches is exceptionally abundant; or in open stands, the underbrush is often very thick and of large size. Fires during the drier summer seasons therefore catch easily and burn furiously. The bark of white pine and of all the associate species, except larch, Douglas fir and yellow pine is very thin, so that not only crown fires but also severe ground fires usually cause their death outright. Even a light ground or surface fire will kill the tree when it scorches the bark on all sides, thus overheating the tender growing tissues. But even if it does not die, the wound thus formed affords a suitable point of

---

* See Discussion of ‘Yields” page 146 [83]. Compare Table XIX and those subsequent.

attack for fungi, and the weakened tree is less able to resist the attacks of leaf disease and of beetles which its injuries have attracted to it. If mature, and especially if on or near a very extensive burn, the tree is apt therefore to die within a few years. Young and very thrifty trees often successfully resist invasion and recover their vigor, but still the injuries leave "cat-faces" which as a rule allow fungi to enter the heart of the tree, causing decay and liability to windfall.

In addition to the damage sustained from the destruction of timber, the loss occasioned by the burning of the soil cover is also serious. The destruction of the humus greatly lessens the moisture holding capacity of the soil, removes much fertility and destroys many plant organisms, such as My corhiza [mycorrhizae] – which are of value to the trees roots in the absorption of food. It also permits the growth of many plants which are likely to be the alternate hosts of virulent twig and needle diseases. In each of these ways the thrift of the trees is lessened and their rate of growth decreased.

Fire causes a minimum of damage to the western white pine type when a considerable proportion is made up of the more fire-resistant species, western larch, yellow pine and Douglas fir. Western larch is especially valuable in this regard, since its thin relatively non-resinous crown is not very flammable and aids largely in diminishing the severity of crown fires; while its bark, comparatively thick at all ages, protects the sensitive cambium from the heat and enables the tree to survive when other species are killed. The bark of yellow pine is also very fire-resistant and answers a similar purpose. Douglas fir ranks considerably below the other two in this regard, both bark and crown being more flammable, but the species is able to withstand moderately heavy surface fires.

Of still greater importance in minimizing damage from fire is the rapidly increasing efficiency of organized fire protection service. By this means the number of fires due to preventable causes is being continuously decreased, and the damage resulting from fire is being lessened to such an extent that the danger of loss even to the most susceptible species promises to be insignificant.

## Insects

The Mountain Pine Beetle (*Dendroctonus monticolae*, Hopk)*.

The devastation wrought to western white pine by this insect is but little less than that wrought by fire. It is so widespread within the white pine type that it is difficult to find even an acre containing white pine over 100 years of age on which more or less timber has not been killed. As a rule this insect-killed white pine may be found in scattered patches, usually of just a few trees, but frequently of several acres in size. While the ordinary infestation may not grow to large proportions in any one year, it often persists in the same locality for long periods, in time killing out most of the white pine of the stand. Or the entire colony may migrate to a considerable distance, perhaps a mile or more, forming an entirely new infestation.

---

* See Bureau of Entomology Bull. No. 83, Part I – "Bark Beetles of the Genus *Dendroctonus*."

Occasionally, due to peculiarly favorable conditions, the beetle may multiply in vast numbers and kill large areas of sound thrifty timber. Sometimes these sudden increases may be traced to burned areas upon which the pine has been weakened but not killed by fire, thereby rendering the trees easy victims. This happened in the region visited by the fires of 1910. But in the case of many of these sudden increases, the stimulus is unknown. Usually, after reaching a certain climax, these large infestations subside as suddenly as they arose.

The mountain pine beetle breeds and feeds on the cambium or growing tissue between the bark and wood of western white pine and its principal associates [associated?] pines, the lodgepole, western yellow and sugar pines. The destruction of the cambium results in the death of the tree. In a mixed stand of lodgepole and white pine the former seems to be preferred for attack. White pine, as a rule, is not infested until the bark becomes thick enough to afford protection to the sensitive young broods (about 100 years old), but where a few smaller trees occur in the midst of an infested patch of mature timber they may be killed at the same time. Trees injured by fire or of otherwise lowered vitality appear to be more readily attacked than those that are perfectly thrifty. Healthy trees resist the invasion of the beetles by a flow of pitch, and when attacked by a small number (under 300) the latter are usually drowned out and the tree saved. But usually the beetles concentrate their attack, the invasion thereby occurring in such overwhelming numbers that the tree's pitch supply is soon exhausted and it begins to dry out and die.

Other Insects

In addition to the beetles attacking the bark, several insects also injure the crown, although the seriousness of the injuries is as yet undetermined. The leading shoots of young stands are very frequently destroyed by weevils (Genus *Pissodes*) thereby retarding growth. In the summer of 1913 enormous numbers of the white pine butterfly (*Neophasia menapia* Feld.) were fluttering about the foliage of mature stands. The larvae of this butterfly feed on the pine needles.

Control of Depredations

The insect plagues to which western white pine are subject, like most others, multiply to a certain maximum point and then nearly disappear to increase again at a later date. This decrease is attributed to the multiplication of the natural enemies of the insects. The mountain pine beetle, for example, is preyed upon by predaceous beetles, by insect and fungus parasites, and by woodpeckers, especially the Rocky Mountain hairy woodpecker. The extensive depredations of this beetle which followed the great 1910 fires has been rapidly subsiding since 1914, the decrease amounting, on the Coeur d'Alene Forest, in 1915 to approximately 80%. After the plague subsides, the natural enemies deprived of their food, diminish, when the depredating insects again begin to multiply.

Such an increase of insect depredation can be minimized, in the case of *Dendroctonus monticolae* infestations, by judicious logging operations. If infested trees are cut, the logs immersed or the bark removed between the laying of the eggs in summer or early fall and the emergence of the brood the following May or June, the new brood is destroyed. After a destruction of 75% of the broods the natural enemies of the

beetle will usually destroy the rest. If green pine logs are cut and decked during the period of flight – through May and June – the fresh pitch exuded by the logs attracts the beetles for a considerable radius, probably two miles or more, and the beetles lay their eggs therein in preference to standing timber. The immersion of the logs before the following spring will then destroy the young. Logging operations at 4 or 5 mile intervals through an infested district should therefore aid materially in controlling depredations of this beetle.

Insect damage is materially less in mixtures with western larch, cedar and Douglas fir, since these trees are, as a rule, not subject to attack by the same insects, and the infestation therefore cannot spread as readily.

## Fungus Disease*

Enormous as has been the waste in the western white pine type through fire and insects, that caused by fungus disease is scarcely of less importance. In the future, indeed, loss from this source will undoubtedly turn out to be the most serious, because the methods of combating fungi are less understood, and less readily applied. Damage to white pine itself, though serious enough, has been much less than that to some of the associated species. But that to Douglas fir, grand fir and western hemlock, because of their unusual susceptibility to certain fungi, is so great as to require special consideration in the management of the type.

A fungus may cause the death of a tree outright, and its subsequent total loss to the stand through decay, or it may merely produce rot in the living tree and a corresponding diminution of its merchantable contents. The extent to which trees are killed off and stands thinned by fungi is but little known, and can only be determined by keeping the stands under continuous observation. Death by this means will very likely be found to be quite as serious as that caused by beetles. On the other hand, the extent to which decay is present in the living tree, or the percent of cull as it is commonly called, is more readily determined. Douglas fir is more seriously affected in the first way, hemlock and the balsam firs in the second. As examples of the percent of cull in existing stands, an examination of 22 representative logged-off areas in the valley lands of the Idaho white pine belt showed the following percentages of each species too far decayed to be profitably removed from the area: -- Douglas fir 1.3%, Engelmann spruce 3.7%, western larch 8.1%, western white pine 5.4%, western red cedar 18.1%, grand fir 65.7%, and hemlock 100%. (See Table XXX). These percentages are rather too conservative for some of the species, especially white pine, since many of the logs removed, although merchantable, undoubtedly contained some decay. A more intensive examination of a sample plot of nearly pure white pine, 140 years old, made during the cutting revealed 11.5% of the gross log scale, or 11.85% of the total cubic contents worthless because of decay.

Only the more serious of the diseases infesting the white pine type are discussed below.

---

* The larger part of this information and the illustrations on Fungus Disease was supplied by the Missoula Laboratory of Forest Pathology, Dr. Jas. E. Weir, pathologist, U.S. Dept. of Agriculture.

*Armillaria mellea* (Vahl) Quel

This is perhaps the most deadly and destructive of all disease producing fungi. It seems to be universally prevalent, and probably kills as much if not more timber than the mountain pine beetle. It carries on its insidious work in timber of all ages, from the seedling to the veteran stage, but the younger age classes seem to have least resistance. Douglas fir is so extremely susceptible to its ravages that 95% or more of the species on the better white pine sites is estimated to be killed off by the time maturity is reached. Even on the drier sites, on shallow soiled south and west exposures where white pine does not thrive, the Douglas fir is frequently destroyed. Other trees, especially grand fir and white pine are also attacked. The latter, towards maturity, at least, is quite resistant, however, often being able to stop the advance of the disease by an excessive flow of pitch. Yet a great many of the white pine windfalls upon examination show roots attacked by *Armillaria* and either rotted completely off or so badly decayed as to be easily broken.

*Armillaria mellea* is easily recognized from its appearance and habit. It first attacks the roots and base of the trees. The fruiting bodies (Plate X, Fig. 1.) appear in clumps about the base. The pilei are conspicuously honey-colored when young, turning yellowish brown with age. Infection takes place in three ways. Perhaps the most common and effective way, quite distinct from the other fungi mentioned here, is through rhizomorphia (Plate X, Fig. 3), cylindrical or ribbon-like strands which ramify in all directions between the bark and wood of living trees and, extending into the earth, spread to the roots and base of neighboring trees. Infection may also occur through spores, or by the extension of the mycelium (vegetative part of the fungus) directly from one tree to another through contiguous roots. After gaining entrance, the mycelium develops as a white felt-like fan (Plate X, Fig. 2) which spreads around through the growing tissue of the tree just beneath the bark. As soon as the tree is surrounded, it is in effect girdled, but dies much more quickly than when girdled by mechanical means. The rapidity with which previously healthy trees turn yellow and die, even following a season of very vigorous growth, is a decided contrast to the long period of sickly growth following injury by insect or drought. The cambium destroyed, the mycelium attacks the wood, particularly the parenchyma of the resin cells, producing an abnormal resin flow which cements the soil about the base of the tree in a characteristic manner. After the death of the host, *Armillaria mellea* continues to grow and fruit about the stump as long as there is sound wood remaining, although other species of fungi also enter and assist in the rapid decay of the wood.

The rhizomorphs have the ability to remain viable under the bark for some time and then develop a new mycelium. In the roots under the soil therefore it may survive pretty severe surface fires; but will usually be killed by a ground fire since the rhizomorphs seldom develop more than two to six inches below the surface. As in the case of *Polyporus schweinitzii*, the fungus is more active and the destruction is accordingly greater in stands of Douglas fir, and most severe when the stands are overstocked. The most effective means of combating the disease therefore is the elimination of Douglas fir from the infected areas and the burning of slash in large piles about infected stumps.

*Echinodontium tinctorium* E & S. (Indian Paint Fungus)

This is the familiar fungus disease of western hemlock, grand fir and alpine fir. While it does not kill the trees, it produces the peculiar heart rot which causes these species to be worthless through such large stretches of country. Even though wholly worthless, from a merchantable standpoint, the sapwood and crown of these species will continue to grow vigorously, casting such heavy shade as to prevent the ingress and competition of other species not liable to infection.

More damage is done to the hemlock and alpine fir than to the grand fir, the last species often yielding much merchantable timber in localities where the other two are quite valueless. Site seems to be [a] very important influence on the prevalence of this disease, it being relatively infrequent on sunny exposures and on upper slopes and ridges, but so nearly universal on flats and shaded lower slopes that, as previously indicated, little or no merchantable timber of value can be produced by these species.

The fungus is easily recognized from the numerous conchs on the more severely infected trees, which are bright red under the weathered surfaces. Infection takes place through the dead branches, branch scars and other injuries, so that damage is much less in the younger and more vigorous stands, which have suffered little in this regard. Fortunately, this fungus rarely attacks white pine or other of the more valuable species. It can very likely be eradicated by destroying infected trees, reducing the occurrence of the host species, especially in infected districts, and harvesting future stands as soon as the trees are of merchantable size.

*Trametes* [*Fomes, Phellinus*] *pini* (Brot.)Fries "Ring Rot"

This species (See Plate XI) is undoubtedly the chief fungus disease of the western white pine. While it does not kill the tree outright, it is responsible for by far the largest part of the cull in green logs and a great deal of windfall and breakage. The disease generally occurs in the merchantable part of the trees at any height above ground. In old stands decay from this cause frequently exceeds the annual growth. Any of the western species in the western white pine type are subject to attack: white pine the most, then larch, spruce, Douglas fir, lodgepole pine, cedar, hemlock and grand fir in the order named. The prevalence of the disease in larch is in some places almost as great as in white pine; in the tolerant species, on the other hand, it is rare.

Infection always takes place by means of the small dust-like spores, and penetration to the heartwood is accomplished usually through the heart of dead or broken branches, or through other wounds such as fire scars which are not quickly covered with resin. Very rarely does a fire injury ("cat-face") in white pine become healed before infection from Trametes takes place. An abundance of resin in the sap and in the outer heartwood prevents the growth of the fungus there, except when the tree is in the last stages of decay, and causes its activities to be at first confined to certain annual rings, thus giving rise to the familiar "ring-rot". The sporophores or fruiting bodies are usually not produced until a luxuriant mycelium has developed and the decay is well advanced; they then continue to grow and bear spores for long periods, fifty years or more. The number, location and size of the sporophores are therefore good indications of the extent of the decay.

Since the chief method of infection in uninjured trees is through dead branches, trees under 80 years of age are but rarely attacked, and then usually only at the lower part of the trunk. After that age susceptibility gradually increases as more and more of the lower branches die and decay, as the vigor of the tree abates, and as the ability to cover wounds with a heavy flow of resin diminishes. Veteran trees are particularly susceptible. When the branches are small, easily pruned and quickly overgrown with sapwood, as is the case in crowded or two-story stands, infection does not readily take place; it is favored on the other hand by trees widely spaced with large limbs which remain in the trunk for many decades after being suppressed, and which leave large wounds after they fall. Circumstances favoring pruning therefore tend to hinder infection; so that conditions of moisture, light, etc., being equal, widely-spaced stands tend to be infected far more severely than those more heavily stocked and pure stands or mixtures with light-demanding species more than mixtures with tolerant trees. Sporophores high on tree trunks distribute the spores more widely and therefore are more serious sources of infection than those on the ground. And infection from dead timber is much less common than from green. Frequently the disease seems to occur in zones or localities, but that is due to the prevalence of such favorable conditions as those heretofore mentioned, combined with the survival of an infection from a previous stand in the vicinity. It is undoubtedly most abundant in the purer white pine stands. The production of mixed stands, and the cutting of white pine stands on a relatively early rotation, from 100 to 120 years, before fruiting bodies are extensively developed, with particular pains to see that each infected tree is cut, will tend largely to eliminate this disease from the stand.

*Polyporus* [*Phaeolus*] *schweinitzii* Fr. "Red Rot". "Butt Rot" (Plate XII).

Inhabiting the roots and heartwood of the butt, this fungus is less destructive to the merchantable contents of the tree than *Trametes pini*, but is even more deleterious to its vitality. When working in cooperation as the two fungi often do, their progress is really rapid and the destruction very complete. Although the disease does not kill the tree outright, the latter is rendered especially susceptible to windfall. White pine is infected frequently but Douglas fir is the most common host and is so readily attacked that in many localities few trees escape. Isolated cases of the disease seldom occur, all trees within reach usually being infected.

The sporophores of *Polyporus schweinitzii* are not very abundant, occasionally being found protruding upwards through the soil from the diseased roots, or still less frequently, growing directly on decayed logs or stumps. Because of their scarcity and their occurrence only on the ground, infection does not usually take place by means of spores, but rather by the mycelium of the fungus traveling through the roots from a tree already infected to another whose roots are in contact. In a crowded stand of either Douglas fir or white pine therefore, whether it is pure or a mixture, the fungus is able to enter many trees within a relatively short time. From the roots the mycelium enters the heartwood of the trunk causing a "red" or "butt" rot (Plate XII, Fig. 1) which extends upward on the average from five to eight feet; but seldom more than the first log length.

Young as well as old trees are attacked by this fungus, but if not windthrown, the merchantability of Douglas fir is often not seriously diminished under 100 years and that of white pine under 150. Although the presence of the fungus in the stand is hard to detect until the cutting of the trees reveals its rot in the stumps, in order to diminish its prevalence, infected trees should be cut as closely as possible. But it is of still greater

importance to diminish the percentage of Douglas fir in the next stand and increase that of other associates of white pine.

*Fomes annosus* [*Heterobasidion annosum*] Fries (*Trametes radiciperda* Hartig)

This parasite root-fungus is more destructive than was formerly supposed; in some localities causing as much damage as *Armillaria mellea* or *Polyporus schweinitzii*. It attacks practically all species, both conifers and broad leaved trees, but is more active against white pine than against its associates. It occurs frequently in stands 30 years old or more, and occasionally in those much younger.

Like *Armillaria mellea*, *Fomes annosus* attacks the tree in its most vital parts, sometimes causing its death in a very short time. The fungus spreads from one host to another through contiguous roots; much more rarely does infection take place through the spores. A white mycelium more delicate and shiny than that of *Armillaria mellea* is developed under the bark of the roots. This destroys the inner bark and the cambium and later attacks the wood. The wood in the first stages of the rot may show streaks of pinkish or lilac color, later becoming brown or slightly red with black spots surrounded by areas of white. The sporophores (Fig. 6) which differ in appearance from the other fungi, usually grow from root spurs, well below the surface, and so are frequently covered with forest debris and difficult to detect.

Because *Fomes annosus* prefers white pine to other species, the disease is more abundant and works greater injury in the purer stands and especially when the stand is overstocked, the closer inter-relation of the root-system enabling the fungus to spread the more easily. On the other hand, it is less abundant in mixed stands of white pine with cedar, larch or hardwoods, and in stands growing on the more exposed mineral soils. Thorough intermixing with these less susceptible species, and care against overstocking, will therefore greatly assist in controlling this disease. The transmission of infection from one generation to another can be largely prevented by cutting all infected trees and burning the slash on the stumps infected.

The White Pine Blister Rust* (*Cronartium ribicola* or *Peridermium strobi*)

Although not yet known to occur in the western United States, this dangerous disease, very destructive to all species of white pine, has secured a firm foothold throughout the white pine belt of the east, and must be strenuously guarded against to prevent its introduction into the range of the western species. Inasmuch as it propagates not only on white pines but on currants and gooseberries, there is danger of the disease being introduced through interstate shipment of nursery stock, of any of these forms. Once introduced into any of the forest regions of the west, the universal occurrence of wild currants and gooseberries and of some one of the five needle pines would permit its spread to all parts of the western white pine and sugar pine ranges, and ultimately result in the extinction of these valuable species as commercial woods.

---

* See Farmers Bulletin No. 742 for full description of the disease and danger of introducing it.

Needle Disease

*Lophodermium pinastri* (Schad.) Chev causes a needle disease which has always played a part in hastening the suppression of overtopped western white pine. Of late years it seems to be taking the form of an epidemic and is attacking the needles of trees of any age. The fungus is most active in shaded sites and especially in deep ravines. The needles turn brown, so that they appear at a distance as if scorched by fire. The disease has not yet appeared in the forest nursery but is a very common cause of the death of young seedlings in the forest.

## Windfall

Contrary to prevailing opinion, western white pine is a fairly windfirm species. Its root-system is moderately deep and from general observations it is apparent that the trees stand about as well as do those of the associate species. As an example of the ability of scattered trees to stand after the cutting of the main crop, an area fairly representative of the varied severity of conditions on the Coeur d'Alene Forest, and indeed of North Idaho, was examined intensively four years after the logging (Plate VIII). The area embraced ridges and southwest aspects well exposed to the strongest winds of the region, and northeastern aspects fairly protected (Results given in Table {38?}). {"Scattered seed trees left after cutting"} The windfall in the catfaced and butt rotten or otherwise decayed trees of course is not an indication of lack of windfirmness and hence need not be considered. Of the sound white pine trees, on the exposed ridges the uprooting amounted to 10%, on the exposed south and west slopes to less than 6%, and on the relatively protected north and east slopes to nothing at all. The Douglas fir apparently did not make quite as good a record, 8% of the sound trees on the ridge tops and 20% of those on the southwest slopes having been uprooted. The poor showing of the Douglas fir on the southwest slope, however, was very likely due to the shallower soil occupied by the Douglas-fir, and consequently to a shallower root system. The larger part of the wind-throw took place immediately after the cutting, -- so soon indeed that the overthrown trees were utilized by the loggers. A cursory examination two years later showed little change, indicating that after a few years have elapsed since the opening up of the stand, little windthrow need be anticipated. Other cutover areas, in similar mountainous localities, though somewhat more protected, showed less windfall than the one cited.

The reputation that white pine is easily overthrown by the wind has been derived from observations of windfall in regions subject to occasional violent winds on soils which were set [wet?] and soggy or very shallow, not permitting the development of deep root systems, or on areas infected with fungus parasites which have caused the roots to decay. It is highly probable that much the larger percentage of overthrown trees on deep well drained soils are the result primarily of fungus diseases in the base or roots.

## Deterioration of Dead White Pine

Fire-Killed Timber

After death from fire, western white pine deteriorates rapidly. The blue-stain fungi (*Ceratostomella* species) enter and stain the sapwood almost immediately. The checks and wounds which are often present largely assist this penetration. Staining continues more deeply and thoroughly throughout the summer season as long as enough moisture

is present. Later, if the moisture is still retained, decay sets in, in two or three years completely breaking down the sapwood. The heartwood however, does not stain, and there decay also is considerably retarded.

Where the fire is of great severity, burning the crown and outer bark, the wood in standing trees does not long remain moist. The unburned bark soon dries and scales from the trunk and the sapwood rapidly seasons. If the tree is killed but not badly burned, insects which follow the fire work under the bark and cause the same result in time, though much more gradually. This loss of bark and consequent drying of the wood in standing fire-killed trees stops the progress of the fungi in the sapwood but causes season checking, which proceeds year after year through both sap and heart. Seasoning and resultant checking progresses the more rapidly the drier the year is, the smaller the trees are, and the more exposed they are to the desiccating influences of sun and wind.

For example, trees standing on sunny south or west slopes which have lost their bark, especially if of small size, check so severely as to be practically valueless at the end of the summer following the death of the tree. The checks may then be 6 to20 feet long, 2 inches or more deep and occurring 6 or 8 inches apart around the tree. Two years after being killed such timber has been noticed to have checks 3 to5 inches deep.

On the other hand, retention of the bark, while it facilitates the staining and final decay of the sapwood, very largely prevents checking; and the shade and moisture of northerly slopes and gulches favors similar results. Large timber on such moist sites, from which the bark does not fall for two or three years, may therefore remain merchantable in the heartwood for as much as six years. In down timber, checking is further reduced.

The extent to which fire-killed white pine depreciates in value for lumber manufacture is of course very variable because of the many factors involved. Serious blue stain will depreciate even the select grades to No. 3 or No. 4 common. Those portions which become seriously checked are a total loss. As the checking increases, the amount of timber which can be profitably harvested of course decreases.

For example* a representative fire-killed area of 60 acres was accurately measured while being logged. Two years after the fire it showed a loss of 67% in timber too badly deteriorated to remove. Of the 33% logged additional cull due to defects caused by the fire brought the total loss up to 73% of the total original stand. This area was a portion of a very large burn, so severe that much of the timber was overthrown in the gale, and the bark shed very soon afterwards. The logs cut averaged 8.3 logs per M. feet and were largely from the down timber, that which was standing being too severely checked to utilize.

Much fire-killed timber could be salvaged if attended to in season. If the timber can be cut and stored in water immediately after the death of the trees, or before a prolonged spell of warm weather ensues, there will be little or no loss either from stain or check. But even when a hot dry period follows the same season as the burn, if cut and stored by the following spring, although there will be some deterioration from sap stain, the

* See Report by Pernot in 1912.

wood will be checked but little. If no water storage is available for the logs, felling to the ground, although it will hasten decay of the sapwood, will still retard the more serious trouble, checking.

Insect Killed Timber

Insect killed timber deteriorates in a manner similar to that killed by ground fires. The blue stain fungi are afforded ready entrance into the wood through the galleries of insects, so that the sapwood becomes stained even before the leaves begin to turn from green to red. Various secondary insects assist the *Dendroctonus* in undermining the bark, causing it sooner or later to loosen and fall. Then as the sapwood dries out checking occurs. The value of the wood is often further depreciated by the work of boring insects. Ordinarily insect-killed white pine is checked so badly as to be unmerchantable by the time the bark is partly off, unless the bark happens to be prematurely torn off by woodpeckers in their search for the beetles. For insect-killed white pine to remain merchantable longer than three years is exceptional, tho this may happen when the number killed is very few and they remain shaded by the surrounding stand.

## REPRODUCTION

A thorough knowledge of the different stages by which western white pine reproduces itself is essential if the natural abilities of the species are to be successfully taken advantage of in the renewal of the stands after harvesting; given this, by intelligent care it should even be possible for a man to assist nature, thus producing better stands than those that now exist.

### Seed Production

For the production of seed as well as that of wood a trees depends on the food manufactured in the leaves by the agency of light. For that reason the larger the crown which a tree develops and the more fully exposed it is to the light the earlier and more abundantly it will bear cones. Western white pine in the open has been known to produce cones at 14 years of age; in well-stocked stands the dominant trees bear considerable at 20 to 30 years. But abundant seed production does not begin until the trees are 50 to 75 years old, while those heavily shaded may not bear at all. Productiveness increases with the development of the crown for a long time, and may continue heavy at least up to 250 years of age.

Production of seed varies also from year to year, in some years being abundant, in others altogether lacking. Such variation is due undoubtedly to some climatic influence as yet undetermined. The same influence may be responsible for local variation in seed crops, causing a fair crop to occur in one locality simultaneously with no crop in another. Heavy crops occur at irregular intervals of several years. When the crop is light, only the thrifty vigorous trees and stands of good seed producing age bear cones. When it is heavy, cones may also be found on those relatively young and relatively aged. When the crop is light, only the topmost branches of the large, more dominant trees have cones. On the other hand, when there is a heavy crop additional cones are found on the lateral branches of dominant trees and also on the intermediate and partly overtopped trees. The amount and distribution of cones in the several age classes and crown

classes therefore is a good index of the relative abundance of the seed crop. And in light seed years those areas which have the largest number of dominant and mature but vigorously growing trees may be expected to have the heaviest seed production.

A uniformly heavy crop in which nearly all classes of thrifty trees bore cones occurred throughout the western white pine belt of Idaho and western Montana in1909. Following this almost no seed was borne in 1910. In 1911 there was a medium crop: four sample plots showed a yield of 2 ½ to 5 pounds per acre in vigorous, well-stocked stands ranging from 70 to 250 years of age. Irregular light to medium crops were also borne in 1912 and 1913, while a second fairly heavy crop was produced in 1914.

Western white pine cones require two seasons to mature. At the end of the first season they are one or two inches long, so that the size of the following season's crop can be predicted a year in advance. The seed ripens in late August or early September of the second summer and the cones open to shed the seed during the warm sunny days of September.

There is a very wide variation in the size and quality of the seed and of the cones, depending on the age and condition of the trees and of the seed crop. Cones vary from 3 to 12 inches in length. They may yield anywhere from ¼ pound to 5 pounds of seed to each bushel of cones. A pound may contain from 21,000 to 57,000 clean seeds, but averages about 30,000. In quality, the seed ranges from10% to 90% germinable. Investigations so far made indicate that the larger the seed is the better in quality, and that such seed is produced by the larger cones. The largest cones and the largest and best quality of seed appear to be borne during the period of most vigorous growth, from 70 years on. The smallest cones and the poorest yield of seed come from crowded and slow-growing trees, crowding having a far more deleterious effect than age in lessening the yield. In good seed years also the cones are of larger size. In poor years the small quantity is disproportionately reduced by rodents and birds, and the poor quality further impaired by the ravages of insects and fungi.

The seed production of western white pine is much smaller even in a good seed year, and these are more infrequent, than in the case of the principal associate species. A good illustration of this fact is afforded by Tables VIII and IX in which the total amount of seedlings still surviving on the areas examined was proportionately much less in the case of white pine than its associates, although the white pine was the predominant species in the stand from which the seed was disseminated. This handicap is largely offset in competition with western hemlock, western red cedar and western larch, however, by the fact that white pine seed is of better quality; moreover it is much longer lived and can remain dormant for years awaiting an opportunity to germinate.

## Seed Dissemination

The bulk of western white pine seed undoubtedly falls from the cones immediately after the opening of the cones in the fall. The cones frequently hang on the tree however for a year after opening, and some seed very likely remains therein to be blown out by the strong winds. Wind is the chief agent in dissemination. Some of the main facts concerning white pine seed distribution are shown in Tables 8 and IX, which give the results of observations on a number of different burnt and cutover areas. Although the seed is several times heavier than that of the principal associate species, the wing is proportionately large, being more than 1 inch long, while the seed is about ¼ inch long,

so that, as the per cent columns show, the seed travels approximately as far as that of the associates. But as a rule this is not far. Because the air is apt to be fairly still on the warm September days when the cones open, on average or protected sites such as illustrated in table 9, about 70% of all species fall within 200 feet of the parent tree, and 80% to 88% within the first five chains. During a reasonable reproduction period of 3 to 5 years, only within the first three chains from the parent trees have enough white pine seedlings been produced to form a stand by themselves. At the fifth chain on the areas examined, with 310 white pine, 190 larch and fir, and 420 cedar per acre, enough seedlings are present if they all continue to grow to produce a fully stocked stand of the mixture; at a greater distance the stocking is hardly sufficient. On protected sites, therefore, complete and prompt reforestation further than 3 to 5 chains from the parent tree cannot be depended on. Within heavy stands dissemination is much less than this distance since the seeds are obstructed in their flight by the crowns of adjoining trees.

Table VIII

SEED DISSEMINATION ON AVERAGE ROLLING LANDS AND FLATS

As Shown by Number of Seedlings Present 3 to 5 Years
After Complete Burn

| Chain Length From Timber (66 Ft.) | White Pine | | W. Hemlock | | W. Red Cedar | | W. Larch | | Douglas Fir | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. per Acre | % of Total White Pine | No. per Acre | % of Total Hemlock | No. per Acre | % of Total W. Red Cedar | No. per Acre | % of Total W. Larch | No. per Acre | % of Total Douglas Fir |
| 1 | 820 | 40.3 | 1800 | 41.7 | 1820 | 31.4 | 640 | 36.3 | 500 | 36.2 |
| 2 | 360 | 17.8 | 765 | 17.7 | 1300 | 22.4 | 320 | 18.1 | 265 | 19.2 |
| 3 | 240 | 11.8 | 490 | 11.4 | 920 | 15.9 | 230 | 13.0 | 160 | 11.5 |
| 4 | 170 | 8.4 | 345 | 8.0 | 630 | 10.8 | 155 | 8.7 | 100 | 7.2 |
| 5 | 120 | 5.9 | 250 | 5.8 | 420 | 7.2 | 110 | 6.2 | 80 | 5.8 |
| 6 | 85 | 4.2 | 190 | 4.4 | 250 | 4.2 | 75 | 4.3 | 70 | 5.0 |
| 7 | 60 | 3.0 | 140 | 3.2 | 145 | 2.5 | 55 | 3.1 | 60 | 4.3 |
| 8 | 45 | 2.2 | 105 | 2.4 | 90 | 1.6 | 40 | 2.3 | 50 | 3.6 |
| 9 | 37 | 1.8 | 75 | 1.7 | 60 | 1.4 | 35 | 2.0 | 40 | 2.9 |
| 10 | 30 | 1.5 | 55 | 1.3 | 50 | 0.9 | 30 | 1.7 | 30 | 2.2 |
| 11 | 25 | 1.2 | 40 | 0.9 | 40 | 0.7 | 25 | 1.4 | 20 | 1.4 |
| 12 | 20 | 1.0 | 30 | 0.7 | 30 | 0.5 | 20 | 1.1 | 10 | 0.7 |
| 13 | 13 | 0.6 | 20 | 0.5 | 20 | 0.3 | 15 | 0.9 | 0 | 0.0 |
| 14 | 6 | 0.3 | 10 | 0.2 | 10 | 0.2 | 10 | 0.6 | 0 | 0.0 |
| 15 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 5 | 0.3 | 0 | 0.0 |
| Total on 15 chains | 2031 | 100% | 4315 | 100% | 5785 | 100% | 1765 | 100% | 1385 | 100% |

Table IX

SEED DISSEMINATION OF WESTERN WHITE PINE AND ASSOCIATES
ON ROLLING VALLEYS EXPOSED TO CONSTANT WINDS

As Shown by
Number of Seedlings Present 8 Years after Complete Burn

| Chain Length From Timber (66 Ft.) | White Pine | | W. Hemlock | | W. Red Cedar | | W. Larch | | Douglas Fir | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No. per Acre | % of Total White Pine | No. Per Acre | % of Total Hemlock | No. per Acre | % of Total W. Red Cedar | No. per Acre | % of Total W. Larch | No. Per Acre | % of Total Douglas Fir |
| 1 | 670 | 15.7 | 1800 | 30.0 | 4700 | 31.5 | 800 | 27.2 | 800 | 19.2 |
| 2 | 555 | 13.0 | 1050 | 17.5 | 3400 | 22.8 | 400 | 13.6 | 580 | 14.0 |
| 3 | 465 | 11.0 | 600 | 10.0 | 2000 | 13.5 | 280 | 9.5 | 470 | 11.2 |
| 4 | 390 | 9.2 | 460 | 7.6 | 1170 | 7.8 | 220 | 7.5 | 385 | 9.2 |
| 5 | 330 | 7.8 | 365 | 6.1 | 900 | 6.0 | 170 | 5.8 | 320 | 7.7 |
| 6 | 285 | 6.7 | 295 | 4.9 | 700 | 4.7 | 145 | 4.9 | 265 | 6.4 |
| 7 | 240 | 5.7 | 240 | 4.0 | 535 | 3.6 | 125 | 4.2 | 220 | 5.3 |
| 8 | 210 | 5.0 | 200 | 3.3 | 380 | 2.5 | 114 | 3.9 | 185 | 4.4 |
| 9 | 180 | 4.2 | 170 | 2.8 | 270 | 1.8 | 100 | 3.3 | 155 | 3.7 |
| 10 | 155 | 3.7 | 145 | 2.4 | 195 | 1.3 | 88 | 3.0 | 130 | 3.1 |
| 11 | 135 | 3.2 | 125 | 2.1 | 140 | 0.9 | 80 | 2.7 | 115 | 2.8 |
| 12 | 120 | 2.8 | 112 | 1.9 | 100 | 0.7 | 74 | 2.5 | 100 | 2.4 |
| 13 | 107 | 2.5 | 100 | 1.7 | 90 | 0.6 | 67 | 2.3 | 90 | 2.2 |
| 14 | 95 | 2.2 | 87 | 1.5 | 80 | 0.5 | 60 | 2.0 | 80 | 1.9 |
| 15 | 82 | 1.9 | 74 | 1.2 | 70 | 0.5 | 53 | 1.8 | 70 | 1.7 |
| 16 | 70 | 1.7 | 60 | 1.0 | 60 | 0.4 | 47 | 1.6 | 60 | 1.4 |
| 17 | 57 | 1.3 | 48 | 0.8 | 50 | 0.3 | 40 | 1.4 | 50 | 1.2 |
| 18 | 45 | 1.1 | 36 | 0.6 | 40 | 0.3 | 34 | 1.2 | 40 | 1.0 |
| 19 | 32 | 0.8 | 24 | 0.4 | 30 | 0.2 | 27 | 0.9 | 30 | 0.7 |
| 20 | 20 | 0.5 | 12 | 0.2 | 20 | 0.1 | 20 | 0.7 | 20 | 0.5 |
| Total | 4,243 | 100% | 6,003 | 100% | 14,930 | 100% | 2,944 | 100% | 4,165 | 100% |

Table X

RATE OF GERMINATION OF WESTERN WHITE PINE SEED

Sown in Nurseries and in the Field

| Location, Forest Experiment State | Time of Sowing | Germination Percents | | |
|---|---|---|---|---|
| | | First Year | Second Year | Both Years |
| A. In Nursery beds, as indicated by exact weekly counts | | | | |
| Savanac Nursery, Lolo F., Mont. | May I, 1912 | 7.3% | 28.3% | 35.6% |
| Boulder Nursery, Helena F., Mont. | June 5, " | 3.2 | 15.8 | 19.0 |
| Priest River Exp. Sta. Kaniksu F., Id. | May 15, " | 4.4 | 23.2 | 27.6 |
| All Nurseries | Spring, " | 5.0 | 22.4 | 27.4 |
| B. In Seedspots in field, as indicated by seasonal counts | | | | |
| Priest River Exp. Sta. Kaniksu F., Id. | | | | |
| Exp. 4-C-111 1100 good seed | Nov. 1911 | 3.22% | 1.38% | 4.6% |
| Exp. 9-C-111 1100 good seed | May, 1912 | 0.62% | 8.18% | 8.8% |
| Average | Fall & Spring | 1.92% | 4.78% | 6.7% |

On lands exposed to severe winds, satisfactory dissemination takes place to a greater distance. The conditions on one such area unusually well exposed to constant lake breezes are illustrated in Table IX. In this case the decrease in number of seedlings on portions of the area more removed from the seed producing timber is much more gradual, particularly in the case of white pine. The first three chains contain only 40% of all white pine and the first five chains only 57%. Of the small-seeded species, hemlock, cedar and larch, on the other hand, 70% to 80% was found within the first five chains. White pine seedlings were numerous enough by themselves in the sixth chain to form a well-stocked stand; and even in the twelfth the 294 white pine, larch and fir and the 100 cedar were still sufficient to form an excellent two-story forest. This table shows that on sites exposed to heavy and constant winds, dissemination can be expected for from two to three times the distance to which seed will travel on protected slopes, a distance of 10 chains being easily possible.

## Germination of Seed

Western white pine seed which is fresh and has not been injured in extracting is usually of excellent quality and has a high germination, ranging from 70 to 90 per cent. The seed is very sluggish in germinating, however, even when fresh and of the best quality. A small proportion, from 1 to 10 per cent, will sprout at once, as shown by

greenhouse, nursery and field tests, under a wide range of temperature, of moisture, and of light. This portion will germinate whether it happens to be on the cool forest floor in the shade of a mature stand, or in the open on a warm soil exposed directly to the sun's heat. But the balance and larger portion of fertile seed, even under the excellent conditions in nursery and greenhouse, will remain dormant for one, two and often three years. No satisfactory method of stimulating the seed to prompt activity has yet been found, altho some increase has been obtained. In greenhouse tests, a noticeable increase was secured by raising the temperature from 60° to 90° F. This was further increased by decreasing the cover of sand from 1 inch to 1/8 inch. Heat was obviously the important factor, altho light also has a noticeable effect in stimulating the seed to germinate. The conclusions, from above experiments and from general observations, are that this sluggish portion of the seed is apt to remain dormant for years, even until it finally loses its vitality, altho plenty of moisture may be present, and that it will germinate only when exposed to a considerable amount of light and to the greater heat found on surfaces open to the sun's rays.

The cost of nursery management is considerably increased because of this characteristic sluggishness. In attempting to shorten the prolonged germination period, both fall and spring sowing have been tried. The results of a two year record of the germination of seed sown outdoors in the spring at each of the three nurseries growing western white pine seedlings, and in both spring and fall in seed spots in the field, are given in Table X. The average of the nursery tests for spring sowing are quite representative, showing 5% germinating the first season and 22.4% the second. Fall sowing gives a larger stand at the end of the first season but is still so incomplete as to necessitate carrying a second season, just as with the spring sown seed. At the end of the second season the total stand resulting from spring sowing is uniformly larger than that secured from fall sowing. The seed spot sowing in the field shows the larger germination of fall sown seed the first year and of spring sown seed the second, the final stand from spring sowing being the greater. The total results of both years germination in the seed spots, however, is so low as to make it seem probable that many of the seeds and seedlings were destroyed by rodents and other causes.

Germination of white pine seed is good on soil having either a mineral surface or a covering layer of duff, which is a partially decomposed litter consisting in the western white pine belt of twigs, needles, rotten wood, and other organic material, usually from ½ to 3 inches thick. The seed has sufficient stored food to enable the root tip to penetrate through several inches of this loose coniferous duff in search of soil in which it can become rooted and grow, so that the presence of such litter on the ground is ordinarily small hindrance to the establishment of the seedlings. On the other hand, the duff is sponge-like and contains somewhat more moisture than does the exposed mineral surface. On the whole, therefore, germination is better on duff than on mineral soil. This advantage is slight, however, since the mineral soil generally has enough surface moisture in the spring to supply all that is needed by germinating seedlings.

In order to determine which sort of soil cover was most favorable to white pine germination, the relative number of seedlings present on various kinds of surfaces has been investigated on a number of different cutover areas and burns. The findings of this study averaged for two typical areas are shown in Table XI. Therein are given the average number of seedlings per acre which were present as advance growth or which germinated each year since the denudation of the areas, for each species, and separately for the various surfaces, severe burns, light burns, unburned mineral soil,

## Table XI

Comparative Rate of Reforestation of Various Surface Conditions
Based Upon Two Representative Cut-over Areas on the Kaniksu National Forest

| Species | Season after cutting that seedlings germinated | Severe Burn | | Light Burn | | Unburned Mineral | | Unburned Duff | | Rotten Wood | | All Surfaces | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1.352 acres examined or 51.5 % of total area examined | | 9.498 acres examined or 19.0 % of total area examined | | 0.065 acres examined or 2.5 % of total area examined | | 0.66 acres examined or 25.3 % of total area examined | | 0.044 acres examined or 1.7 % of total area examined | | 2.82 acres examined or 100 % of total area examined | |
| | | Number per acre of severe burn | Proportion of this species & age on this surface | Number per acre of light burns | Proportion of this species & age on this surface | Number per acre of unburned mineral | Proportion of this species & age on this surface | Number per acre of unburned duff | Proportion of this species & age on this surface | Number per acre of rotten wood | Proportion of this species & age on this surface | Number per acre of all surfaces | Proportion of this species & age on this surface |
| Western | Advance gr.. | - | - | 4 | 1.9% | 15 | 1.0% | 151 | 96.1% | 23 | 1.0% | 40 | 100.0% |
| White | 1 st 1910 | 5 | 8.0% | 6 | 3.4% | - | - | 109 | 81.8% | 136 | 6.8% | 34 | 100.0% |
| Pine | 2 nd 1911 | 7 | 3.0% | 20 | 3.3% | 62 | 1.3% | 398 | 86.8% | 386 | 5.6% | 115 | 100.0% |
| | 3 rd 1912 | 144 | 27.4% | 160 | 11.2% | 539 | 4.9% | 548 | 50.7% | 932 | 5.8% | 272 | 100.0% |
| | 4 th 1913 | 26 | 12.2% | 58 | 10.0% | 246 | 5.6% | 300 | 68.7% | 227 | 3.5% | 110 | 100.0% |
| | Total | 182 | 16.4% | 248 | 8.3% | 852 | 3.8% | 1506 | 66.5% | 1704 | 5.0% | 571 | 100.0% |
| Western | Advance gr. | 1 | 0.8% | - | - | - | - | 257 | 96.6% | 114 | 2.8% | 67 | 100.0% |
| Hemlock | 1 st 1910 | 5 | 46.7% | - | - | - | - | 11 | 46.7% | 23 | 6.6% | 6 | 100.0% |
| | 2 nd 1911 | 1 | 4.7% | 6 | 14.3% | - | - | 26 | 81.0% | - | - | 8 | 100.0% |
| | 3 rd 1912 | 24 | 17.7% | 18 | 5.0% | 354 | 12.7% | 174 | 63.5% | 46 | 1.1% | 69 | 100.0% |
| | 4 th 1913 | 29 | 11.5% | 2 | 0.3% | 246 | 4.7% | 379 | 73.7% | 750 | 9.8% | 129 | 100.0% |
| | Total | 60 | 10.9% | 26 | 1.8% | 600 | 5.3% | 847 | 76.4% | 933 | 5.6% | 279 | 100.0% |
| Western | Advance gr. | - | - | - | - | 62 | 2.2% | 244 | 87.5% | 432 | 10.3% | 70 | 100.0% |
| Red | 1 st 1910 | - | - | - | - | - | - | 15 | 66.7% | 114 | 33.3% | 6 | 100.0% |
| Cedar | 2 nd 1911 | 1 | 4.0% | - | - | - | - | 35 | 92.0% | 23 | 4.0% | 10 | 100.0% |
| | 3 rd 1912 | 53 | 17.1% | 90 | 10.7% | 539 | 8.3% | 373 | 58.7% | 500 | 5.2% | 160 | 100.0% |
| | 4 th 1913 | 65 | 24.0% | 66 | 9.0% | 277 | 4.9% | 332 | 59.9% | 182 | 2.2% | 140 | 100.0% |
| | Total | 119 | 15.9% | 156 | 7.7% | 878 | 5.6% | 999 | 65.4% | 1251 | 5.4% | 385 | 100.0% |

Table XI continued on following page.

Table XI continued

| Species | Season after cutting that seedlings germinated | Severe Burn: 1.352 acres examined Or 51.5 % of total area examined | | Light Burn: 9.498 acres examined Or 19.0 % of total area examined | | Unburned Mineral: 0.065 acres examined Or 2.5 % of total area examined | | Unburned Duff: 0.66 acres examined Or 25.3 % of total area examined | | Rotten Wood: 0.044 acres examined Or 1.7 % of total area examined | | All Surfaces: 2.82 acres examined Or 100 % of total area examined | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number per acre of severe burn | Proportion of this species & age on this surface | Number per acre of light burns | Proportion of this species & age on this surface | Number per acre of unburned mineral | Proportion of this species & age on this surface | Number per acre of unburned duff | Proportion of this species & age on this surface | Number per acre of rotten wood | Proportion of this species & age on this surface | Number per acre of all surfaces | Proportion of this species & age on this surface |
| White or Grand Fir | Advance gr. | - | - | - | - | 123 | 3.2% | 355 | 96.4% | 23 | 0.4% | 93 | 100.0% |
| | 1 st 1910 | 1 | 9.0% | - | - | - | - | 15 | 91.0% | - | - | 4 | 100.0% |
| | 2 nd 1911 | - | - | - | - | 46 | 3.9% | 90 | 76.6% | 341 | 19.5% | 29 | 100.0% |
| | 3 rd 1912 | 20 | 4.8% | - | - | 447 | 5.2% | 648 | 76.4% | 1727 | 13.6% | 213 | 100.0% |
| | 4 th 1913 | - | - | - | - | - | - | 53 | 94.6% | 46 | 5.4% | 14 | 100.0% |
| | Total | 21 | 3.0% | - | - | 616 | 4.3% | 1161 | 82.6% | 2137 | 10.1% | 353 | 100.0% |
| Western Larch | Advance gr. | 14 | 10.0% | -n | - | - | - | 12 | 80.0% | 23 | 10.0% | 4 | 100.0% |
| | 1 st 1910 | 3 | 80.0% | - | - | - | -b | 2 | 20.0% | - | - | 2 | 100.0% |
| | 2 nd 1911 | 7 | 58.9% | 6 | 17.6% | - | - | 6 | 23.5% | - | - | 6 | 100.0% |
| | 3 rd 1912 | 7 | 52.6% | - | - | 31 | 10.5% | 9 | 31.6% | 23 | 5.3% | 7 | 100.0% |
| | 4 th 1913 | 3 | 16.6% | - | - | 77 | 20.9% | 18 | 50.0% | 69 | 12.5% | 9 | 100.0% |
| | Total | 21 | 38.7% | 6 | 4.0% | 108 | 9.3% | 47 | 41.3% | 115 | 6.7% | 28 | 100.0% |
| Douglas Fir | Advance gr. | - | - | - | - | - | - | 5 | 75.0% | 23 | 25.0% | 2 | 100.0% |
| | 1 st 1910 | - | - | - | - | - | - | 9 | 100.0% | - | - | 2 | 100.0% |
| | 2 nd 1911 | - | - | - | - | - | - | 5 | 100.0% | - | - | 1 | 100.0% |
| | 3 rd 1912 | - | - | - | - | - | - | 6 | 100.0% | - | - | 2 | 100.0% |
| | 4 th 1913 | - | - | - | - | - | - | B - | - | - | - | - | 100.0% |
| | Total | - | - | - | - | - | - | 25 | 94.2% | 23 | 5.2% | 7 | 100.0% |
| All Species | Total | 403 | 12.8% | 436 | 5.1% | 3054 | 4.7% | 4585 | 71.0% | 6163 | 6.4% | 1623 | 100.0% |

Occasional seedlings of lodgepole pine and Engelmann spruce were found on the areas studied but are considered too few to tabulate.

Percentage of the different surfaces are the result of an ocular estimate made by observer in walking along the strip and are only approximate and useful for comparative purposes.

The two areas included in this table are Jurgens Brothers sale, Sec.20,T.[5?] 7 N., R.4W, B.M., cut in the winter of 1909-10 and Fidelity Lumber Co. sale, Sec.26, T. 57 N., R.5 W., B.M. also cut in winter of 1909-10. Both areas are on similar sites and were cut and handled in a like manner.

unburned duff, rotten wood, and for all surfaces, or the area examined taken as a whole. For the seedlings of each species germinating in any one year and for the total number of seedlings of all species the percentage occurring on each kind of surface is shown. The proportion which each kind of surface made up of the total area examined is also given.

The most obvious facts indicated are the small number of seedlings per acre on the burned surfaces, compared with the unburned. While the severe burn comprised 51.5% of the area examined, upon it was found no advance growth, only16.4% of all the white pine seedlings, and only 12.8% of all seedlings of all species. Light burn, on which the duff still remains but partly consumed, or lightly scorched, showed a slightly larger number of trees per acre for white pine and cedar, and less for the other species. But each of the unburned surfaces, including mineral, duff, and rotten wood, showed for each species and each age class except larch during the first three years, a decided increase in number of trees per acre. The unburned duff alone, tho comprising only 25.3% of the area examined contained 96% of the white pine advance growth, from 50% to 86% of the white pine seedlings, and 71% of all seedlings. The presence or absence of fire therefore has had more influence in determining the position of seedlings than has the presence or absence of duff.

The seed from which the seedlings originated must have come from one of two sources; it was either dropped from the trees overhead previous to or at the time of cutting {winter of 1909-1910}, or was disseminated from the seedblocks which had been left standing in different portions of the cutting area. In the case of white pine, the fact that seed was produced during 1911 and 1912 makes it possible for the seed germinating in 1912 and 1913 to have come from the seedblocks. But since there was practically no white pine seed produced in the seedblocks in 1910, it is concluded that the 1911 germination must have been almost entirely from seed dropped from the trees previous to their cutting, probably at the maturity of the heavy seed crop in 1909, which had since lain dormant on the ground. The seedlings germinating in 1910 also were probably from this seed stored in the soil. The shade from the overhead stand had produced cool storage conditions, and exposure of the surface to greater light and heat was necessary to stimulate germination. This is quite consistent with the characteristic long life and sluggishness of western white pine seed.

Additional evidence that white pine seed lies dormant on the ground surface several years awaiting favorable conditions to germinate was obtained from other studies. A ten year old clean cutting, one-half mile wide, on which the slash had never been burned, had a good stand of white pine seedlings, eight, nine and ten years old, uniformly distributed over the area, while seedlings of the younger ages were almost entirely absent, except within a few chains of the standing timber on the borders of the cutting. These seedlings undoubtedly came from stored seed. Again, examinations of the duff beneath mature white pine stands revealed the presence of approximately 50,000 seed distributed over each acre, of which several thousand per acre were white pine and firm and apparently good. This 50,000 seed tested 7%germination in fourteen months, or sufficient viable seed per acre to make a stand of 3,500 seedlings.

Such seed storage is undoubtedly of great advantage in regeneration of western white pine. At least part of it will probably remain viable from one good seed year to another. Hence, the stored seed is the produce of from two to five years of seed bearing by a complete stand of timber immediately overhead. Naturally this body of seed is

much greater in numbers and more evenly distributed than that which might be produced by scattered seed trees or disseminated from timber outside the area. Such scattered trees or bordering timber would have to bear a number of crops to produce an amount equal to the stored seed and the distribution would always be more uneven, - too dense close to seed bearing trees and not dense enough at other points. In addition, reproduction from stored seed occurs much more promptly. From the standpoint of stored seed alone, then, regeneration is much more satisfactory on unburned than on burned surfaces.

Germination of dormant stored seed may be induced by any opening large enough to materially increase the amount of light and increase the temperature of the surface soil. It is therefore not necessary that the previous stand be entirely cut, a removal of 70% or more of the volume ordinarily being sufficient.

## Seedling Development

The presence of a layer of duff and litter on the surface is not only favorable to germination but also encourages the most thrifty growth after seedlings have become established. Investigations which are still incomplete indicate that seedlings growing on duff are more subject to attack from soil fungi during the first few weeks of their life than are those growing on burned mineral surfaces. This disadvantage is more than offset, however, by the better development of the seedlings on duff surfaces when once thoroughly established and past the danger of “damping off”. This difference in growth and vigor is plainly evident on average sites when seedlings two or three years old are compared. Those found on severely burned mineral soil are generally small and have short yellowish-green needles and thin wiry stems, while those on adjoining ground, covered with ½ to 1 inch of rotted needles and duff are usually much larger and have thick vigorous stems and long blue-green needles. The duff mulch preserves moisture in the under-lying soil and hence helps the seedlings over periods of drought which might kill or severely affect those which are without this protection. The store of available plant food in the humus beneath the duff is also conserved for the use of the plant and aids materially in producing vigorous growth.

If soil is moist and fertile, as is the case with most duff-covered forest soils, western white pine seedlings will become established and survive on a wide variety of soils, ranging from hot, rather dry and well drained southerly slopes having a thin, rocky soil, to river flats and bottoms having a wet, poorly drained, heavy clay or silt soil. Establishment is easiest and development best, however, on benches or rolling valley land or northerly slopes which have a deep, finely-divided silt or loam soil, moist, well-drained and relatively cool.

Protection from direct sunlight is not essential to the survival and growth of western white pine seedlings except when the quantity of soil moisture required will not otherwise be conserved. In examinations of some thirty cut-over areas and burns, fully as many if not more seedlings were found growing vigorously entirely in the open as were found partially or wholly shaded by surrounding objects and vegetation. In nursery practice, quarter or half shade on seedlings during July and August of the first year has been found to have a distinct value and it undoubtedly has about the same value as a help to natural grown seedlings in the first year of life, particularly on hot flats and southerly exposures which are apt to dry out in dry seasons.

Therefore, the partial shade afforded by standing dead trees, down trees and logs, slash which has been lopped and scattered, and possibly by thin surface vegetation, is desirable on those sites which are not constantly moist. Its presence will encourage the germination, survival and best development of a larger number of seedlings than would be the case if it were absent. It is of special value in protecting those seedlings which start in exceptionally dry years, and which without the protection could not then survive. Except under the latter circumstances, however, protection is not necessary and many excellent stands of white pine have undoubtedly developed without it. Indeed north slopes where the topography itself obstructs the direct rays of the sun, the soil nearly always remains moist, so that direct shading is decidedly of no value and it might easily be a check instead. For full overhead light is essential after the roots are well established if the seedlings are to make the most vigorous growth.

Under almost all stands the careful inspection of the ground reveals many puny white pine seedlings from one to eight or ten years old which have persisted in spite of the shade. They are absent usually only when the shade is extremely heavy. Most of these persist for a few years and finally die unless light is admitted to them by the removal of the overhead trees. In such a contingency many of these seedlings, not too exhausted will revive and take thrifty growth.

A comparison of the germination and survival of western white pine and its associates when protected and when unprotected by shade, on burned mineral soil and on soil covered with duff and the natural vegetation of the site, in extremely moist, extremely dry, and intermediate situations, is the subject of a series of experiments started at the Priest River Experiment Station in 1913. This first year was unusually moist so that the results are neither average nor complete; but the figures give some interesting indications. The shaded plots having a mineral surface were surrounded by ditches to prevent the roots of the overhead trees from absorbing the moisture. Readings of soil moisture, soil temperature, light, wind, humidity and precipitation gave a complete record of the conditions present on each site and plots were protected from birds and rodents by wire screens. Seed was sown broadcast on the surface in the latter part of April and a close record kept of germination, survival, death and cause of death. A digest of the season's results is shown in Table XII.

In this experiment germination of larch and yellow pine averaged much the best, western white pine was fair, and cedar was very poor. The moist northeast slope had relatively good germination for all species, while the dry southwest slope was the poorest. Survival, however, was best on the northeast slope only for hemlock and cedar. Of the other species, the larger percentage survived on the sandy flat. The light and surface conditions affected each species differently. The best conditions for germination and survival are summarized in Table XIII.

In the case of white pine it will be noticed that survival was best on mineral soil in each case except on the shaded northeast slope. This loss was due almost entirely, as far as could be determined by cultures and detailed study, to the greater activity of "damping off fungi" on the natural surfaces and in the shade. These fungi also caused the largest part of the death of the other species and were by far the most important single factor present. As a check on the field observations, the particular fungus in question was isolated in pure culture and eight out of 16 healthy seedlings in the greenhouse were inoculated by touching the stems lightly with a needle containing the

Table XII

COMPARISON OF GERMINATION AND SURVIVAL OF WHITE PINE AND ASSOCIATES UNDER IMPORTANT CONDITIONS OF SITE, LIGHT, AND SURFACE

| Site Conditions | | | Plot | Light or | Surface | Seedlings germinating and surviving from 1000 seed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | W. White Pine | | | W. Yellow Pine | | | Douglas Fir | | | Western Larch | | | W. Hemlock | | | W. Red Cedar | | |
| | | | | | | Germin- | Surviving | | Germin- | Surviving | | Germin- | Surviving | | Germin- | Surviving | | Germin- | Surviving | | Germin- | Surviving | |
| Site | Climate | Type | No. | Shade | Conditions | ating No. | No. | % of Germ. | ating No. | No. | % of Germ. | ating No. | No. | % of Germ. | ating No. | No. | % of Germ. | ating No. | No. | % of Germ. | ating No. | No. | % of Germ. |
| N.E. Slope | Cool, Moist | White Pine | 1 | Open | Natural vegetation (duff) | 228 | 192 | 84% | 234 | 119 | 51% | 50 | 19 | 36% | 130 | 29 | 22% | 101 | 36 | 37% | 13 | 6 | 46% |
| | | Species W. Pine D,Fir W, Larch R.Cedar W. Hemlock | 2 | Open | Burned | 218 | 202 | 93% | 416 | 351 | 79% | 155 | 123 | 79% | 279 | 187 | 67% | 87 | 73 | 84% | 30 | 21 | 70% |
| | | | 3 | Full shade young timber | Natural vegetation (duff) | 323 | 106 | 33% | 286 | 21 | 7% | 120 | 70 | 58% | 473 | 29 | 6% | 288 | 189 | 66 | 51 | 26 | 51% |
| | | | 4 | Full shade young timber | Ditched and denuded | 289 | 53 | 18% | 395 | 20 | 5% | 147 | 57 | 39% | 684 | 74 | 11% | 261 | 107 | 41% | 61 | 32 | 52% |
| | | | Average | | | | | 57% | | | 35% | | | 54% | | | 27% | | | 57% | | | 55% |
| S.W. Slope | Hot, Dry | Yellow Pine | 1 | Open | Natural vegetation (duff) | 23 | 1 | 4% | 184 | 112 | 61% | 39 | 5 | 13% | 192 | 10 | 5 | 90 | 0 | 0% | 8 | 0 | 0% |
| | | Species Y. Pine | 2 | Open | Burned | 14 | 3 | 21% | 153 | 130 | 85% | 43 | 0 | 0% | 145 | 59 | 46 | 1 | 0 | 0% | 2 | 2 | 100% |
| | | | 3 | Half shade of willows | Natural vegetation | Figures omitted as | | | rodent injury makes | | | comparisons valueless | | | | | | | | | | | |
| | | | 4 | Half shade of willows | Ditched and denuded | | | | | | | | | | | | | | | | | | |
| | | | Average | | | | | 12% | | | 73% | | | 6% | | | 23% | | | 0% | | | 50% |

Table XII continued on following page.

Table XII Continued

COMPARISON OF GERMINATION AND SURVIVAL OF WHITE PINE AND ASSOCIATES UNDER IMPORTANT CONDITIONS OF SITE, LIGHT, AND SURFACE

| Site Conditions | | | Plot | Light or | Surface | Seedlings germinating and surviving from 1000 seed | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | W. White Pine | | | W. Yellow Pine | | | Douglas Fir | | | Western Larch | | | W. Hemlock | | | W. Red Cedar | | |
| | | | | | | Germin- | Surviving | | Germin- | Surviving | | Germin- | Surviving | | Germin- | Surviving | | Germin- | Surviving | | Germin- | Surviving | |
| Site | Climate | Type | No. | Shade | Conditions | ating No. | No. | % of Germ. | ating No. | No. | % of Germ. | ating No. | No. | % of Germ. | ating No. | No. | % of Germ. | ating No. | No. | % of Germ. | ating No. | No. | % of Germ. |
| Sandy Flat | Intermediate but more nearly approximating SW slope | | 1 | Open | Natural vegetation | 64 | 46 | 72% | 176 | 148 | 84% | 155 | 132 | 85% | 205 | 106 | 52% | 29 | 6 | 21% | 15 | 9 | 60% |
| | | | 2 | Open | Burned | 146 | 133 | 91% | 455 | 389 | 85% | 226 | 179 | 79% | 627 | 542 | 86% | 121 | 50 | 41% | 20 | 15 | 65% |
| | | Larch-D. Fir | 3 | Half shade serviceberry | Natural vegetation | None sown | | | 105 | 30 | 29% | 49 | 17 | 35% | 73 | 16 | 22% | None sown | | | None sown | | |
| | | Species W. Larch D. Fir W. Pine Lodgepole Pine | 4 | Half shade serviceberry | Ditched and denuded | * 16 | 16 | 100% | 714 | 641 | 90% | 358 | 304 | 85% | 814 | 661 | 81% | * 10 | 6 | 60% | * 1 | 0 | 0% |
| | | | Average | | | | | 88% | | | 72% | | | 71% | | | 60% | | | 40% | | | 42% |
| Average for all sites | | | | | | | | 52% | | | 60% | | | 44% | | | 37% | | | 39% | | | 49% |

* Plot sown four weeks later than others, hence comparisons are not exact.

Table XIII

BEST SITE, LIGHT AND SURFACE CONDITIONS FOR GERMINATION AND SURVIVAL OF WESTERN WHITE PINE AND ASSOCIATES

| Species | Factor | Best Site | Best Surface | Best Light |
|---|---|---|---|---|
| White pine | Germination | N.E. Slope | Duff | Shade Timber |
| | Survival | do | Mineral | Open |
| W. Hemlock | Germination | N.E. Slope | Duff | Shade Timber |
| | Survival | do | Duff | Shade Timber |
| W. Red Cedar | Germination | N.E. Slope | Mineral | Shade Timber |
| | Survival | do | Mineral | Shade Timber |
| W. Larch | Germination | Larch Flat | Mineral | Shade Shrubs |
| | Survival | do | Mineral | Open |
| W. Yellow pine | Germination | Larch Flat | Mineral | Little Difference |
| | Survival | do | Mineral | Open |
| Douglas fir | Germination | Larch Flat | Mineral | Open |
| | Survival | do | Mineral | Open |

material from culture. Within twelve days after inoculation, six out of the eight treated seedlings were either dead or dying while none of the other ten showed signs of disease, even tho left more than a month longer. The fungus used in the inoculation was found only in the cultures of the six which died so promptly, no sign of it being present in the other ten cultures of healthy seedlings. This is considered excellent evidence in connection with numerous cultures and other evidence from the field work that this fungus, a species of *Rhizoctonia*, is distinctly parasitic and was a major factor in causing the death of seedlings on these plots.

## GROWTH

The remarkably long duration of its period of rapid growth is largely responsible for the supremacy of western white pine in North Idaho forests. This rapid growth, however, does not start at once. As with all trees, the rate varies with the age of the tree, the amount of light received, and the quality of the site. In the early seedling stage it is quite slow. This slow growth is often considerably prolonged by shade or by poor soil conditions, but is relatively short on first quality sites. The quality of site depends not only upon soil fertility, but also upon soil depth, moisture, drainage, altitude and aspect, the best conditions, as shown heretofore, being a soil deep, fertile and porous, and a topography such as to afford good drainage, abundant light and soil moisture, and protection from drying or constantly severe winds. Growth is slower on shallow or rocky soils, poorly drained flats, or on deeply shaded slopes and gulches, even though the soil be good. It is poorest on very dry or shallow soils, and on cold shaded slopes or wind-swept ridges at the upper altitudinal limits of the species.

## Growth in Height

### Under Full Light

Height growth of western white pine, in contrast to that of lodgepole pine or larch, but in common with other associated conifers of the interior, is very slow for the first few years, until the root system has opportunity to become well established. Gradually it is accelerated becoming quite rapid in open situations somewhere between the third and tenth year. From the time the tree reaches a height of 5 feet or more up to the age of about 60 years, height growth is at a maximum. Thereafter a slackening occurs, but very gradually. This degree of persistence in rapid height growth is unusual and enables the white pine on most sites to pass its associates, even tho the latter have a long lead at the start. The growth of white pine and associated species in competition, under full light, as found on representative areas in Northern Idaho, is shown in Table XIV. Part 1 compares the height of the dominant seedlings at the end of each year, and their current annual growth during the 5$^{th}$, 10$^{th}$, and 15$^{th}$ years. Part 2 compares the growth of those dominant and codominant trees which have reached maturity, by showing the height at the end of each decade, and the current annual growth during the 10$^{th}$, 50th and 100$^{th}$ years. As will be noticed, western larch and lodgepole pine always grow rapidly after the first or second year, leaving the white pine far behind. Yellow pine, Douglas fir, white fir, Engelmann spruce , cedar and even hemlock make quite as fast growth or often even take the lead over white pine at the start, but given an equal opportunity and full overhead light, they are almost sure to be passed by the latter within 50 or 60 years. Larch and lodgepole pine, having a greater lead, hold their own for a longer period. Lodgepole is usually overtopped at 100 years. Larch in general makes more persistent height growth than lodgepole does; altho, on the best white pine sites, even under full light conditions the larch is usually overtopped by white pine, (such as ridge tops, knolls, benches, or open flats) it requires much longer for the white pine to pass the larch, if indeed it does so at all. On areas F and G for example, the white pine has not passed the larch at 140 and 100 years respectively, altho the difference in heights is being constantly narrowed. On area C, a relatively much better site for larch than for white pine (compare with area B), it is doubtful if the latter can ever catch up with the other.

The above example also shows that the best site quality for white pine is not necessarily the best for its associate species. Other comparisons tend to prove the same thing. Area D for example, illustrates the best growth for white pine and larch, but Douglas fir and cedar are better on the steep slopes illustrated by area E.

On the Pacific Slope of the Cascade Mountains, western white pine grows faster than in the interior. But in the early seedling stage its growth here also is relatively slow, lagging behind the Douglas fir, western hemlock and red cedar, its more important competitors. Later, however, where it has not been suppressed by the shade, it forges ahead of the others, just as in Idaho. On poor sandy or gravelly soils, near the coast, white pine, as previously explained, has the advantage. It is therefore able to overtop the other species more quickly on those sites, and there it is found more abundant than elsewhere. The average growth of white pine seedlings on good soil in one locality of western Washington with the average for Douglas fir throughout the coast belt, compared in Table XV, shows the decided superiority of Douglas fir growth during the earlier years.

Table XIV

RELATIVE HEIGHT GROWTH OF ASSOCIATED SPECIES ON AREAS APPROXIMATELY
REPRESENTATIVE OF EACH SITE QUALITY FOR WHITE PINE WITHIN THE WESTERN WHITE PINE TYPE, IDAHO

(1) Dominant Seedlings Grown in Full Light

| | Palouse Division of St. Joe Forest, Idaho 3000 feet elevation | | | | | | | | Priest River Valley, Kaniksu Forest, Idaho 2400 feet elevation | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area A Deep-Soiled Hilltops Site 1 | | | | | Area B Foothill Slopes Site II | | | Area C Sandy Benchlands (Benton Flat) Site III | | | | | | | | |
| Age Years | White Pine | West. Larch | Yellow Pine | Douglas Fir | Red Cedar | White Pine | West. Larch | Red Cedar | White Pine | West. Larch | Lodge-pole Pine | Yellow Pine | Douglas Fir | White & Alpine Fir | Engelmann Spruce | West. Hemlock | Red Cedar |
| | Total Height in Feet | | | | | | | | | | | | | | | | |
| 1 | 0.16 | 0.6 | 0.18 | 0.17 | 0.35 | 0.1 | 0.4 | 0.2 | 0.07 | 0.4 | 0.5 | 0.1 | 0.1 | 0.05 | 0.05 | 0.1 | 0.15 |
| 2 | 0.3 | 1.2 | 0.5 | 0.4 | 0.7 | 0.2 | 1.0 | 0.4 | 0.12 | 0.9 | 1.0 | 0.26 | 0.2 | 0.1 | 0.12 | 0.26 | 0.35 |
| 3 | 0.8 | 2.1 | 1.0 | 0.7 | 1.1 | 0.5 | 1.6 | 0.6 | 0.2 | 1.5 | 1.7 | 0.46 | 0.35 | 0.2 | 0.25 | 0.4 | 0.55 |
| 4 | 1.3 | 3.4 | 1.6 | 1.0 | 1.6 | 0.9 | 2.2 | 0.9 | 0.4 | 2.1 | 2.7 | 0.7 | 0.55 | 0.3 | 0.45 | 0.65 | 0.80 |
| 5 | 1.9 | 4.9 | 2.5 | 1.5 | 2.1 | 1.2 | 3.0 | 1.2 | 0.6 | 2.8 | 3.8 | 1.0 | 0.8 | 0.5 | 0.65 | 0.9 | 1.0 |
| 6 | 2.6 | 6.7 | 3.4 | 2.1 | 2.8 | 1.8 | 3.8 | 1.6 | 0.8 | 3.6 | 5.1 | 1.4 | 1.0 | 0.7 | 0.9 | 1.15 | 1.3 |
| 7 | 3.6 | 8.7 | 4.5 | 2.9 | 3.3 | 2.4 | 4.7 | 2.0 | 1.0 | 4.5 | 6.5 | 1.9 | 1.3 | 0.9 | 1.2 | 1.5 | 1.8 |
| 8 | 4.6 | 10.8 | 5.6 | 3.9 | 4.2 | 3.1 | 5.8 | 2.4 | 1.3 | 5.7 | 8.0 | 2.5 | 1.7 | 1.1 | 1.5 | 1.9 | 2.0 |
| 9 | 5.8 | 12.9 | 6.9 | 5.0 | 5.1 | 3.9 | 7.0 | 2.9 | 1.7 | 7.2 | 9.4 | 3.2 | 2.1 | 1.4 | 1.8 | 2.3 | 2.4 |
| 10 | 7.0 | 15.0 | 8.0 | 6.2 | 6.0 | 4.9 | 8.4 | 3.4 | 2.0 | 9.2 | 10.9 | 3.9 | 2.5 | 1.8 | 2.2 | 2.8 | 2.8 |
| 11 | 8.2 | 17.1 | 9.5 | 7.4 | 6.9 | 6.0 | 9.9 | 4.0 | 2.4 | 11.3 | 12.5 | 4.7 | 3.0 | 2.1 | 2.6 | 3.3 | 3.2 |
| 12 | 9.5 | 19.2 | 10.7 | 8.7 | 7.9 | 7.3 | 11.3 | 4.6 | 2.9 | 13.3 | 14.2 | 5.7 | 3.6 | 2.5 | 3.0 | 3.9 | 3.7 |
| 13 | | | | 10.1 | 8.8 | 8.7 | 12.8 | 5.2 | 3.4 | 15.4 | 15.9 | 6.8 | 4.3 | 3.0 | 3.4 | 4.5 | 4.2 |
| 14 | | | | 11.6 | 9.8 | 10.1 | 14.2 | 5.9 | 4.0 | 17.5 | 17.7 | 8.0 | 5.2 | 3.6 | 3.8 | 5.3 | 4.8 |
| 15 | | | | 13.0 | 10.7 | 11.5 | 16.7 | 6.6 | 4.7 | 19.5 | 19.5 | 9.3 | 6.2 | 4.2 | 4.3 | 6.1 | 5.4 |
| | Current Annual Height Growth in Feet at 5, 10, and 15 Years | | | | | | | | | | | | | | | | |
| 5 | 0.6 | 1.5 | 0.9 | 0.5 | 0.5 | 0.3 | 0.8 | 0.3 | 0.2 | 0.7 | 1.1 | 0.3 | 0.25 | 0.2 | 0.2 | 0.25 | 0.2 |
| 10 | 1.2 | 2.1 | 1.3 | 1.2 | 0.9 | 1.0 | 1.4 | 0.5 | 0.3 | 2.0 | 1.5 | 0.7 | 0.4 | 0.4 | 0.4 | 0.5 | 0.4 |
| 15 | | | | 1.4 | 0.9 | 1.4 | 1.5 | 0.7 | 0.7 | 2.0 | 1.8 | 1.3 | 1.0 | 0.6 | 0.5 | 0.8 | 0.6 |

The figures underlined emphasize the approximate height at which white pine passed the other species likewise marked.

Table XIV continued on following page.

Table XIV Continued

(2) Dominant & Co-dominant Trees in Fully-stocked Mature Stands

| | Area D<br>Deep Soiled Gentle Slopes<br>2,200 ft. elevation<br>Priest River Valley<br>Kaniksu Forest, Idaho<br>Site ( I ) | | | | Area E<br>Deep Soiled Steep Slopes<br>2,600 to 3,600 ft. elevation<br>St Joe River<br>St Joe Forest, Idaho<br>Site ( I ) | | | | Area F<br>* Alluvial Flats<br>2,200 ft. elevation<br>Priest River Valley<br>Idaho<br>Site ( II ) | | Area G<br>Ridge tops, 4,000 ft. elev.<br>E. Fork St. Joe River Val.<br>Site Between II and III | | | Area H<br>Steep Slopes<br>4,500 ft. to 5,000 ft. elev.<br>St. Regis Valley, Lolo Forest, Mont.<br>Site Between II and III | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Years | White Pine | West. Larch | Douglas Fir | Red Cedar | White Pine | West. Larch | Douglas Fir | Red Cedar | White Pine | West. Larch | White Pine | West. Larch | Douglas Fir | White Pine | Douglas Fir | White Fir | Engelmann Spruce |
| | | | | | | | | Total | Height | In | Feet | | | | | | |
| 10 | 10 | 18 | 12 | 2 | 8 | 15 | 10 | 3 | 4 | 9 | 3 | 8 | 5 | 2.5 | 4 | 3.5 | 3 |
| 20 | 31 | 43 | 26 | 7 | 23 | 35 | 28 | 10 | 16 | 25 | 15 | 24 | 16 | 11 | 14 | 13 | 10 |
| 30 | 62 | 62 | 41 | 14 | 41 | 53 | 45 | 20 | 30 | 43 | 29 | 41 | 30 | 24 | 28 | 25 | 20 |
| 40 | 73 | 78 | 58 | 20 | 58 | 69 | 60 | 32 | 48 | 61 | 43 | 56 | 44 | 39 | 43 | 40 | 34 |
| 50 | 93 | 92 | only | 27 | 75 | 84 | 75 | 43 | 65 | 78 | 58 | 70 | 57 | 55 | 57 | 55 | 47 |
| 60 | 108 | 106 | young | 34 | 91 | 97 | 87 | 54 | 80 | 91 | 72 | 81 | 69 | 70 | 70 | 66 | 60 |
| 70 | 122 | 116 | Douglas | 41 | 105 | 108 | 97 | 65 | 93 | 103 | 83 | 91 | 79 | 83 | 80 | 76 | 72 |
| 80 | 132 | 125 | fir | 50 | 118 | 118 | 106 | 75 | 105 | 113 | 93 | 98 | 87 | 94 | 89 | 84 | 82 |
| 90 | 141 | 132 | trees | 59 | 129 | 126 | 114 | 83 | 115 | 122 | 100 | 105 | 94 | 105 | 95 | 91 | 92 |
| 100 | 148 | 139 | measured | 68 | 138 | 131 | 121 | 90 | 126 | 129 | 107 | 110 | 99 | 114 | 103 | 97 | 100 |
| 110 | 154 | 144 | on this | 77 | | | | | 131 | 136 | | | | | | | |
| 120 | 159 | 149 | site | 84 | | | | | 137 | 141 | | | | | | | |
| 130 | 163 | 153 | | 90 | | | | | 143 | 146 | | | | | | | |
| 140 | 167 | 156 | | 95 | | | | | 148 | 150 | | | | | | | |
| | | | | | | | | Current Annual Height Growth in Feet at 10, 50, 100 Years ( from curves) | | | | | | | | | |
| 10 | 1.5 | 2.5 | 1.5 | 0.3 | 1.3 | 2.0 | 1.7 | .05 | 0.8 | 1.7 | 0.7 | 1.6 | 0.8 | 0.7 | 0.8 | 0.8 | 0.7 |
| 50 | 2.0 | 1.4 | 0.8 | 0.7 | 1.7 | 1.5 | 1.5 | 1.1 | 1.7 | 1.7 | 1.5 | 1.4 | 1.3 | 1.6 | 1.4 | 1.5 | 1.3 |
| 100 | 0.7 | 0.6 | | 0.9 | 0.9 | 0.5 | 0.7 | 0.7 | 0.8 | 0.7 | 0.7 | 0.5 | 0.8 | 0.9 | 0.7 | 0.8 | 0.8 |

The figures underlined emphasize the approximate height at which white pine passed the other species likewise marked.

* Area F is representative only for those sites in the valley which were of Site II quality and in which the larch was equally dominant with the white pine. Areas of Site I quality occur on these flats also, where the larch over 50 years of age is gradually suppressed by the white pine, just as happens on Area D

The average height growth of western white pine on each quality of site within the white pine type, as exhibited by dominant and codominant trees which have reached maturity, is given in Table XVI. The quality of site is rated in accordance with the relative growth. Site I including those situations which permit the most rapid growth, Site III the slowest, and Site II the intermediate. By comparing the total heights of the dominant and codominant trees of any given stand with that of the same age shown in the table, the relative quality of site can be approximately determined.

The gradual slackening which is shown for the latter decades continues for many years, until at 200 to 300 years height growth is almost negligible.

Under Influence of Shade

Any diminution of the full amount of direct light is responsible for more or less change in relative growth. An open grown tree grows uniformly in all directions, in the lower as well as the upper parts. Where the base of the tree is shaded by trees on all sides, preventing or suppressing the development of the lower branches, more wood is formed in the upper part of the tree and height growth is stimulated. So trees in a fully-stocked stand grow taller than in one more open. If overcrowded, however, so much of the crown is shaded from the side that the necessary nourishment cannot be supplied, and even height growth is retarded. The more intolerant species respond most quickly to the shading of the base, and on the other hand suffer most quickly as the shading reaches too high up the sides. In other words, for best height growth the intolerant trees in a stand must have a thinner forest canopy and more space between the crowns than do the tolerant associates.

Inasmuch as the intolerant species require more light than the tolerant for their leaves to function, their relative growth in the shade differs greatly from that in the open. This relative growth is therefore of very great importance as affecting the future composition of the stand. Table XVII shows the growth of seedlings of associated species on three sample areas under certain common conditions of shade, all on sites of the second quality for white pine. By comparing the total height and current annual growth in this table with that of the corresponding site in Table XV, it will be noticed that whereas the retardation of growth is very pronounced among the more intolerant species, larch, white pine and Douglas fir, the tolerant species such as cedar, hemlock, white fir and spruce are retarded very little and in some cases not at all. The latter are therefore favored by shade because it assists them to overtop the more intolerant trees.

Steep mountain slopes which are little or not at all exposed to the direct light of the sun may act somewhat like an overhead stand in retarding the growth of the light demanding species. This undoubtedly accounts for the prevailing scarcity of yellow pine and larch on steep north and northeast slopes whenever a good stand of more tolerant species is found there also. The strong light demanding trees when in competition are quickly suppressed except on the well-lighted points and ridges, or with the exception of an occasional individual which starts well in advance of the rest and is able to maintain its lead by exceptionally rapid growth.

Complete suppression and death, like retardation of growth, takes place more rapidly under a given condition of shade the more intolerant the species is. Larch and yellow pine are quickly killed either by overhead or heavy side shade, and therefore, as soon as

outstripped by other species, they are doomed. Lodgepole, Douglas fir and white pine, however, will make considerable growth under intense suppression from the side. As a consequence, the white pine when growing in mixture, is often able to persist until it overtops its associates, while lodgepole or Douglas fir survive until completely shaded out from above, or as frequently happens are killed by insects or fungi. Very often neither happens until after the hundredth year. Engelmann spruce and white fir, being tolerant, survive for a still longer period, and are wholly suppressed only when the crown density is as great as that of a complete canopy of white pine or Douglas fir. Hemlock or red cedar cannot usually be suppressed even by a shade as heavy as this, but require the still heavier shade which is cast by a complete crown cover of white fir, Engelmann spruce or even more tolerant species.

TABLE XV

HEIGHT GROWTH OF
WESTERN WHITE PINE AND DOUGLAS FIR SEEDLINGS
IN FULL OVERHEAD LIGHT
WESTERN WASHINGTON

| | Western White Pine | | Douglas Fir | |
|---|---|---|---|---|
| | Average for one area; 72 trees on good soil | | Average for western Washington and Oregon - 2608 trees | |
| Age Years | Total Height (feet) | Current Annual Growth (feet) | Total Height (feet) | Current Annual Growth (feet) |
| 1 | 0.45 | 0.45 | 0.20 | 0.20 |
| 2 | 0.85 | 0.40 | 0.50 | 0.30 |
| 3 | 1.35 | 0.50 | 1.00 | 0.50 |
| 4 | 1.85 | 0.50 | 1.80 | 0.80 |
| 5 | 2.40 | 0.55 | 2.95 | 1.15 |
| 6 | 3.15 | 0.65 | 4.50 | 1.55 |
| 7 | 4.00 | 0.85 | 6.25 | 1.75 |
| 8 | 4.90 | 0.90 | 8.50 | 2.25 |
| 9 | 6.00 | 1.10 | | |
| 10 | 7.50 | 1.50 | | |
| 11 | 9.50 | 2.00 | | |
| 12 | 12.00 | 2.50 | | |

Table XVI

HEIGHT GROWTH OF DOMINANT AND CODOMINANT WESTERN WHITE PINE IN WESTERN WHITE PINE TYPE

| Age Years | Total Height in Feet | | | Current Annual Height Growth - Ft. | | |
|---|---|---|---|---|---|---|
| | Site I | Site II | Site III | Site I | Site II | Site III |
| 10 | 9 | 5 | 2 | 1.5 | 0.8 | 0.4 |
| 20 | 26 | 17 | 11 | 1.7 | 1.2 | 1.0 |
| 30 | 43 | 30 | 22 | 1.7 | 1.3 | 1.1 |
| 40 | 60 | 45 | 34 | 1.7 | 1.5 | 1.2 |
| 50 | 78 | 61 | 46 | 1.8 | 1.6 | 1.2 |
| 60 | 94 | 77 | 59 | 1.6 | 1.6 | 1.3 |
| 70 | 109 | 91 | 70 | 1.5 | 1.4 | 1.1 |
| 80 | 121 | 102 | 80 | 1.2 | 1.1 | 1.0 |
| 90 | 131 | 110 | 89 | 1.0 | 0.8 | 0.9 |
| 100 | 138 | 117 | 97 | 0.7 | 0.7 | 0.7 |
| 110 | 143 | 124 | 104 | 0.5 | 0.7 | 0.7 |
| 120 | 148 | 130 | 111 | 0.5 | 0.6 | 0.7 |
| 130 | 153 | 136 | 117 | 0.5 | 0.6 | 0.6 |
| 140 | 157 | 141 | 123 | 0.4 | 0.5 | 0.6 |
| 150 | 161 | 146 | 128 | 0.4 | 0.5 | 0.5 |
| 160 | 165 | 150 | 133 | 0.4 | 0.4 | 0.5 |

| | Basis | | |
|---|---|---|---|
| No. Trees | 90 | 119 | 52 |
| No. Plots | 20 | 29 | 17 |

Note: The plots were so selected as to supply, as nearly as could be estimated, an equal number of trees above and below the average for the site. Judgment as to site being based upon the experience gained in preparing yield tables.

Table XVII

RELATIVE HEIGHT OF DOMINANT SEEDLINGS UNDER SHADE
ON REPRESENTATIVE PLOTS WITHIN THE WESTERN WHITE PINE TYPE.
SITE II FOR WHITE PINE

| | Area I. Cleared 50 Feet Strips on N. Slopes Coeur d'Alene Forest | | | | Area J. 90 Feet Opening in Mature Timber Clearwater County, Idaho. | | | | | | Area K. Under Shade of 120 Larch per acre - 140 years old Priest River Valley, Kaniksu Forest. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Age Years | White Pine | Douglas Fir | White Fir | Western Hemlock | White Pine | Western Larch | Douglas Fir | White Fir | Engelmann Spruce | Red Cedar | White Pine | Douglas Fir | White Fir | Engelmann Spruce | Western Hemlock | Red Cedar |
| HEIGHT IN PART | | | | | | | | | | | | | | | | |
| 1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.1 | 0.4 | 0.1 | 0.1 | 0.1 | 0.3 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 |
| 2 | 0.3 | 0.2 | 0.3 | 0.4 | 0.3 | 0.8 | 0.2 | 0.2 | 0.3 | 0.6 | 0.2 | 0.2 | 0.3 | 0.2 | 0.2 | 0.5 |
| 3 | 0.5 | 0.4 | 0.6 | 0.6 | 0.5 | 1.2 | 0.4 | 0.4 | 0.4 | 0.9 | 0.3 | 0.4 | 0.5 | 0.3 | 0.3 | 0.8 |
| 4 | 1.0 | 0.7 | 1.0 | 0.9 | 0.7 | 1.6 | 0.7 | 0.6 | 0.6 | 1.2 | 0.4 | 0.6 | 0.8 | 0.5 | 0.5 | 1.2 |
| 5 | 1.5 | 1.0 | 1.6 | 1.2 | 1.0 | 2.0 | 1.0 | 0.9 | 0.8 | 1.6 | 0.6 | 0.9 | 1.1 | 0.7 | 0.8 | 1.7 |
| 6 | 2.0 | 1.3 | 2.3 | 1.5 | 1.4 | 2.5 | 1.4 | 1.2 | 1.0 | 2.0 | 0.8 | 1.3 | 1.5 | 1.0 | 1.1 | 2.2 |
| 7 | 2.4 | 1.7 | 3.0 | 1.9 | 1.8 | 3.0 | 1.9 | 1.6 | 1.3 | 2.3 | 1.1 | 1.7 | 2.1 | 1.4 | 1.5 | 2.8 |
| 8 | 2.9 | 2.2 | 3.9 | 2.2 | 2.2 | 3.5 | 2.5 | 2.1 | 1.6 | 2.7 | 1.5 | 2.1 | 2.7 | 1.8 | 1.9 | 3.4 |
| 9 | 3.5 | 2.7 | 4.8 | 2.5 | 2.7 | 4.0 | 3.2 | 2.6 | 1.9 | 3.2 | 1.9 | 2.6 | 3.5 | 2.2 | 2.4 | 4.1 |
| 10 | 4.0 | 3.2 | 5.7 | 2.9 | 3.2 | 4.5 | 4.0 | 3.2 | 2.2 | 3.7 | 2.3 | 3.2 | 4.3 | 2.7 | 2.9 | 4.8 |
| 11 | 4.6 | 3.7 | 6.7 | 3.3 | 3.7 | 5.0 | 4.9 | 3.8 | 2.6 | 4.2 | 2.8 | 3.8 | 5.2 | 3.3 | 3.5 | 5.5 |
| 12 | 5.1 | 4.2 | 7.7 | 3.7 | 4.2 | 5.4 | 5.8 | 4.5 | 3.1 | 4.7 | 3.4 | 4.4 | 6.1 | 3.9 | 4.1 | 6.3 |
| 13 | 5.6 | 4.8 | 8.7 | 4.1 | 4.8 | 5.8 | 6.7 | 5.2 | 3.5 | 5.3 | 4.0 | 5.0 | 7.0 | 4.6 | 4.7 | 7.2 |
| 14 | 6.1 | 5.3 | 9.7 | 4.5 | 5.3 | 6.2 | 7.6 | 6.0 | 4.0 | 5.7 | 4.7 | 5.7 | 7.9 | 5.4 | 5.3 | 8.0 |
| 15 | 6.5 | 5.8 | 10.7 | 4.9 | 5.9 | 6.6 | 8.5 | 6.8 | 4.5 | 6.2 | 5.4 | 6.4 | 8.8 | 6.4 | 6.0 | 9.0 |
| 16 | 6.9 | 6.3 | 11.7 | 5.4 | 6.3 | 6.9 | 9.3 | 7.5 | 4.9 | 6.7 | | | | | | |
| Current Annual Growth at 5, 10 and 50 Years | | | | | | | | | | | | | | | | |
| 5 | 0.5 | 0.3 | 0.6 | 0.3 | 0.3 | 0.4 | 0.3 | 0.3 | 0.2 | 0.4 | 0.2 | 0.3 | 0.3 | 0.2 | 0.3 | 0.5 |
| 10 | 0.5 | 0.5 | 0.9 | 0.4 | 0.5 | 0.5 | 0.8 | 0.6 | 0.3 | 0.5 | 0.4 | 0.6 | 0.8 | 0.5 | 0.5 | 0.7 |
| 50 | 0.4 | 0.5 | 1.0 | 0.4 | 0.6 | 0.4 | 0.9 | 0.8 | 0.5 | 0.5 | 0.7 | 0.7 | 0.9 | 1.0 | 0.7 | 1.0 |

Recovery from Suppression

The degree to which a white pine which has been suppressed can recover normal growth after exposure to full light varies largely with the age of the tree and the degree to which it has been suppressed. Seedlings, or even saplings or poles, in which stages of growth the vitality is strong, have been observed to make good recovery after taking several years for re-adjustment, altho they usually fall off in growth at first. It has been observed, however, that 130 year old trees, ten years after being released in this way had not yet recovered even the height growth which was being made while under suppression. No evidence has been obtained to show whether any recovery of height growth can be made after the period of fairly rapid height growth and especially after the century mark is past.

## Growth in Diameter

Growth in diameter is determined by the width of the annual ring formed each year. It responds to site quality and light conditions a good deal as height growth does. The better the soil or the more abundant the light, the faster the growth. Like height growth also it is more rapid in youth and falls off later in life. It is more persistent, however, and continues at a moderate rate long after the other has practically ceased. When the crown is supplied with an abundance of light, white pine will continue to grow fairly rapidly in diameter up to 150 or more years of age.

Diameter growth is not uniform throughout the length of the trunk, but varies with the distribution of light and the corresponding development of the crown. Open-grown trees are more uniform in the thickness of their annual layers of rings than are forest-grown trees, and the boles are therefore more conical. The butts of white pine trees grown in dense stands usually have wider rings in youth and narrower rings towards maturity than do the upper portions of the trunks; in badly crowded stands or in deep mountain canyons where almost the only light is directly overhead, the rings at the butt are often almost invisible.

In comparison with other species, western white pine holds about the same relative position in diameter growth that it does in height growth. On the best sites for white pine it ultimately passes all other species, with the possible exception of grand or white fir (*Abies grandis*). On the drier sites of the interior better suited as they are to Douglas fir or western larch, these species make better diameter growth than the white pine. On the poorer soils in the northern coast belt, however, white pine surpasses all associates.*

Recovery {from} Suppression

Trees which have been considerably crowded but are released by the cutting of their oppressing neighbors will recover their diameter growth to some degree, provided the crowns have not been too much reduced. Table XVIII shows the results of the examination of 22 western white pines of this description 130 years old, on the

---

* See Hazliks report “Western White Pine in Dist. VI”, Dec. 3, 1912, page 4.

Coeur d'Alene Forest. While the results are somewhat irregular, they show after 3 years an increase of 125% to 400% in diameter growth for the trees measured. They were all codominant, intermediate or overtopped trees with fairly good crowns. The dominant and suppressed trees examined are not shown, since the former were maintaining the same uniform growth as before the cutting, while the smaller trees with badly suppressed or broken crowns had not improved in ten years time.

Table XVIII

INCREASE IN DIAMETER AND VOLUME GROWTH OF
SCATTERED WESTERN WHITE PINES 130 YEARS OLD

- thrifty, codominant, intermediate, and overtopped
seed trees released by logging –

| Average D.B.H. at Cutting (inches) | Annual Diameter Growth - Inches | | | | *Volume Growth Percent Average annual increase in years after cutting | | | | | | No. of Trees Measured |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 yrs before cutting | Each Year Following Cutting | | | | | | | | | |
| | | 1 | 2 | 3 to 10 | 1 | 2 | 3 | 4 | 5 | 10 | |
| 7.4 | 0.05 | 0.06 | 0.12 | 0.24 | 1.6 | 2.4 | 3.7 | 4.3 | 4.6 | 4.9 | 3 |
| 10 | 0.04 | 0.07 | 0.08 | 0.10 | 1.4 | 1.6 | 1.7 | 1.8 | 1.8 | 1.9 | 5 |
| 13.5 | 0.07 | 0.08 | 0.10 | 0.12 | 1.2 | 1.3 | 1.4 | 1.5 | 1.5 | 1.6 | 11 |
| 18 | 0.16 | 0.16 | 0.25 | 0.25 | 2.0 | 2.3 | 2.3 | 2.5 | | | 3 |

*Formula

$$p = \frac{V - v}{V - v} \times \frac{200}{n}$$

[formula incorrect ?]

When:

V = Volume at time of cutting
v = Volume at end of N years after cutting
n = Number of years elapsed since cutting
p = Volume growth percent

## YIELDS PER ACRE OF THE WESTERN WHITE PINE TYPE

Because of the many influences which affect their regeneration and growth, virgin white pine stands vary extremely in yield. Reproduction may originally have been sparse, due to an insufficient seed supply, or to the encroachment of a dense cover of brush or grass; even tho plentiful, as it usually is on good white pine sites, it is frequently very unevenly distributed and in many places so abundant as to stagnate growth. The soil has usually been denuded and impoverished by repeated fires, thus bringing about decreased vigor and contributing to premature death of the seedlings. Inferior species of very low productiveness, such as the relatively unmerchantable lodgepole, the commonly defective hemlock and white fir, or the disease-smitten Douglas fir, often occupy the ground in such density as to keep out white pine. The ravages of the several injurious influences hinder growth, cause a large amount of cull and, most serious of all, cut down the stands. All this tends greatly to lower the yield. These factors, however, by continued good management, may largely be eliminated. Only age, site and quality then will remain to cause variations in yield.

In addition to the quantity of the yield, many of these factors affect the quality also, and the two are best discussed in connection.

### Average Yields of the Type

The present extreme variability in yield is naturally more marked in the case of average stands than in those chosen as maximum. Two examples of average yields for entire watersheds, which show this tendency, are given in Table XIX. From this table few other conclusions can be drawn because of the disparity in area of the several age classes. An undoubted tendency to increase in yield as the stand grows older is apparent. The mean annual growth, however, falls off after 80 or 90 years, just as it will later be shown to do in better stocked stands.

In stands which have been more fortunate in the circumstances surrounding their reproduction, the percentage of white pine being relatively large, and which have escaped the more serious injuries, (altho few, if any were wholly free from some losses through insects and disease), average yields are much higher. Such stands are illustrated in Table XX.

By comparing the yield in board feet which these areas show with the yield produced by fully-stocked pure white pine stands of the same age and site quality, (Table XXI), the percentage ratio between the two shown in the eleventh column of Table XX was secured. This indicates that the average stands of these selected localities, which have succeeded in largely maintaining the original degree of stocking, and which contain so much higher proportion of white pine than ordinary (from 32% to 87%), yield from 50% to 90%, or an average of 2/3 as much in board feet as do pure fully-stocked white pine stands on the same site. If this proportion over such large areas can be attained by nature, with her haphazard methods of regeneration, it will undoubtedly be very largely increased in the stands reproduced and protected by man, even where reliance is placed chiefly on natural reproduction.

The absence or low proportion of hemlock, in the stands illustrated, will be noted. This is essential for high yields.

## Maximum Yields

A fully-stocked or normal stand is one which yields for its site and age the maximum quantity of timber possible. This ideal is brought about by such a distribution of trees as will utilize all the growing space and yet maintain excellent growth. If the trees are too closely spaced, the crowding retards growth and results in slender trees and a relatively low yield, especially in board feet. If the stands are too open, trees grow less tall and more limby. Incidentally the lumber therefrom is more knotty and of lower grade.

A careful study and comparison of three hundred sample areas in the most fully stocked stands to be found throughout the Idaho white pine belt, show that only those stands with a complete crown canopy are fully stocked. Breaks in the canopy result in a reduction of the yield in proportion to the area of opening. The proportion of the crown space occupied, therefore, serves as a guide in determining the degree to which a stand is stocked.

TABLE XIX

AVERAGE YIELDS OF WESTERN WHITE PINE TYPE FOR ENTIRE WATERSHEDS

(After deducting for cull)

| Age Years | Yield *Board Feet Per Acre | Mean Annual Growth Bd.Ft. | Species in Mixture Percentage | | | | | | Area Represented (acres) |
|---|---|---|---|---|---|---|---|---|---|
| | | | White Pine | Western Larch | Douglas Fir | White Fir | Red cedar | # Misc. | |
| **Coeur d'Alene National Forest - Steamboat Creek | | | | | | | | | |
| 70 | 16,700 | 239 | 28 | | 55 | 15 | | 2 | 80 |
| 90 | 24,200 | 269 | 45 | 6 | 25 | 22 | | 2 | 1,050 |
| 110 | 27,300 | 248 | 33 | 4 | 21 | 33 | | 9 | 860 |
| 130 | 23,600 | 220 | 34 | 17 | 14 | 34 | | 1 | 64 |
| ***Clearwater National Forest - Lolo Creek | | | | | | | | | |
| 80 | 15,240 | 190 | 37 | 6 | 19 | 4 | 22 | 12 | 440 |
| 100 | 17,575 | 176 | 10 | 14 | 18 | 22 | 31 | 5 | 520 |
| 120 | 16,630 | 139 | 40 | 9 | 23 | 6 | 10 | 12 | 320 |
| 160 | 13,650 | 85 | 27 | 15 | 12 | 10 | 23 | 13 | 440 |
| 200 | 20,415 | 102 | 54 | 5 | 8 | 12 | 16 | 5 | 1,280 |
| Over 200 | 23,625 | 100 | 29 | 18 | 7 | 6 | 36 | 4 | 2,280 |

* Board feet calculated by Scribner Decimal C. Rule to 6" tops in W.P.; 8" in other species.
** From measured strips taken at mechanical intervals throughout watersheds.

*** From reconnaissance estimates by averaging those forties consisting of only one age class.
# Misc. includes lodgepole pine, Engelmann spruce, alpine fir, and yellow pine.

Table XX

AVERAGE YIELDS OF SELECTED GOOD STANDS IN WHITE PINE TYPE
(No Allowance For Cull)

| Age Years | Site Quality Approx. | Board Feet 6" D.I.B. Tops Yields Total | Board Feet 6" D.I.B. Tops Growth Mean Annual | Cubic Feet Entire Peel. Stems Yields Total | Cubic Feet Entire Peel. Stems Growth Mean Annual | Basal Area Sq. Ft. | No. of Trees | Average W. Pine Height Feet | Average W. Pine Dia. Breast High Inches | Ratio of Bd. Ft. Yield to Table XXI Site II % | Ratio of Bd. Ft. Yield to Table XXIII Avg. % | Composition by % White Pine % | Composition by % Other Species | Acres | Conditions and Locality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 75 | I - II | 37,300 | 497 | | | | 250 | | | 65 | 89 | 86 | 10% Fir | 22 | 5 areas on northerly slopes denuded in fluming earth for bridge-fills |
| 95 | I - II | 54,000 | 570 | | | | 200 | | | 70 | 90 | 80 | 14% Fir – 10% Larch | 45 | along East of North Fork of St. Joe River, Idaho. |
| 99 | I - II | 52,200 | 527 | 10,900 | 110 | 232 | 298 | 123 | 12.7 | 65 | 82 | 77 | 17% Fir & Larch | 31 | 7 representative plots, all on St Joe River, Idaho |
| 98 | II | 37,800 | 386 | 7,620 | 78 | 182 | 232 | 112 | 12.8 | 60 | 65 | 58 | 10% Fir – 25% Spruce | 60 | 3 average strips on Big and Dominion Creeks, Lolo Forest, Montana. |
| 98 | II | 42,000 | 429 | 9,000 | 92 | 218 | 308 | 113 | 12.2 | 70 | 66 | 48 | 9% Fir – 26% Spruce | 18 | 4 plots on Big, Dominion and Rainy Creeks, Lolo Forest, Mont. |
| 118 | I - II | 50,700 | 429 | 9,270 | 79 | 220 | 267 | 134 | 15.0 | 50 | 71 | 62 | 21% Fir – 10% Larch 6% Cedar | 26 | 6 representative plots on northerly slopes, Eagle Cr. Coeur d'Alene Forest, Id. |
| 124 | I | 102,500 | 827 | 19,670 | 159 | 365 | 276 | 143 | 16.2 | 90 | 140 | 83 | 13% Fir | 12 | Foothills, Elk Cr. Basin, Clearwater Co., St. Joe Forest, Idaho. |
| 128 | I | 81,400 | 656 | 15,560 | 122 | 302 | 243 | 140 | 15.2 | 70 | 109 | 82 | 18% Fir & Larch | 20 | Foothills, Elk Cr. Basin, Clearwater Co. ,St. Joe Forest, Idaho. |
| 142 | II - III | 45,330 | 319 | 9,060 | 64 | 230 | 480 | 125 | 13.0 | 55 | 60 | 79 | 8% hemlock 7% Cedar | 6 | 2 representative plots on Burnt Cabin Cr. Coeur d'Alene Forest, Idaho. |
| 142 | II | 54,350 | 272 | | | | 216 | | | 55 | 72 | 69 | 7% Fir - 12% Hemlock | 59 | 1 representative plot on Lavin Cr., Coeur d'Alene Forest , Id. |

Table XX continued on following page.

Table XX Continued

| Age Years | Site Quality Approx. | Board Feet 6" D.I.B. Tops Yields Total | Board Feet 6" D.I.B. Tops Growth Mean Annual | Cubic Feet Entire Peel. Stems Yields Total | Cubic Feet Entire Peel. Stems Growth Mean Annual | Basal Area Sq. Ft. | No. of Trees | Average W. Pine Height Feet | Average W. Pine Dia. Breast High Inches | Ratio of Bd. Ft. Yield to Table XXI Site II % | Ratio of Bd. Ft. Yield to Table XXIII Avg. % | Composition by % White Pine % | Composition by % Other Species | Acres | Conditions and Locality |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 146 | II - III | 62,500 | 428 | 12,500 | 86 | 248 | 265 | 130 | 12.8 | 75 | 83 | 83 | 17% Fir & Larch | 27 | Foothills, Moose Cr. Palouse Division of St.Joe.,St.Joe Forest, Idaho. |
| 140 | I | 62,220 | 445 | | | | | | | 50 | 83 | 63 | 16% Cedar 19% Larch | 62 | Actual cut on sale, Westbranch Valley-lower N. slope, Kaniksu Forest, Idaho. |
| 143 | II -III | 63,330 | 442 | 12,500 | 87 | 246 | 246 | 131 | 13.8 | 80 | 84 | 84 | 16% larch | 15 | Overstocked white pine flat on Pine Cr., Kaniksu Forest, Id. |
| 140 | | 66,700 | 476 | 12,560 | 90 | 257 | 160 | 122 | 17.3 | 85 | 89 | 87 | 9% Fir | 15 | White pine on south slopes of Big Cr., Kaniksu Forest, Idaho. |
| 137 | II | 67,700 | 494 | 13,900 | 101 | 336 | 303 | 136 | 15.4 | 70 | 89 | 32 | 42% Larch 15% Cedar | 6 | Westbranch Valley flat - white pine and larch over cedar |
| 138 | I | 86,000 | 623 | 15,850 | 115 | 325 | 208 | 153 | 19.8 | 65 | 115 | 64 | 18% Larch 16% Cedar | 110 | Westbranch Valley - typical lower north slopes, Kaniksu Forest, Idaho. |
| 140 | I | 98,000 | 700 | 18,000 | 129 | 340 | 230 | 147 | 18.0 | 75 | 180 | 81 | 9% Larch 6% Cedar | 42 | Westbranch Valley - nearly pure white pine, Kaniksu Forest, Idaho. |
| 220 | | 53,170 | 242 | | 92 | 180 | 73 | | 23.3 | ? | | 52 | 20% Larch 17% Spruce | 24 | 1 average strip thru age class St. Regis Cr., Lolo Forest, Mont. |
| 220 | | 82,760 | 376 | | | 268 | 164 | | 24.9 | ? | | 64 | 28% Spruce | 2 | Representative of spruce mixture Lolo Forest, Mont. |
| 235 | | 73,200 | 311 | 13,800 | 59 | 256 | 129 | 153 | 23.3 | ? | | 32 | 41% Larch 10% Spruce | 13 | 2 representative plots, southeast slopes, Rainy Cr., Lolo Forest, Mont. |
| 262 | I | 95,650 | 365 | 15735 | 60 | 320 | 125 | 182 | 27.7 | ? | | 65 | 8% Larch 15% Cedar | 14 | Westbranch Valley - typical veteran stand, tho better than average stocked, Kaniksu Forest, Idaho. |

Pure Fully-Stocked Stands

Stands containing 70% or more of white pine are found not to differ greatly in yield from pure white pine stands. Table XXI shows the maximum timber production which can be expected from such stands in their unthinned natural state. Because of the great irregularity in distribution of the trees, these fully-stocked stands are scarce and limited in size, usually comprising not over ½ acre to 1 acre in extent. Only one normally stocked area as large as four acres could be found, although several of larger size were very nearly normal, the largest, of 12 acres, having a crown cover 94% complete.

The yield per acre of fully-stocked stands, like the rate of growth, varies considerably with the quality of the site. In selecting data from which to construct a normal yield table, the sample areas were first classified into three site classes in accordance with their cubic volume. Those plots whose total basal areas deviated more than 15% from the average for the site were discarded as abnormal. 100 sample areas thus selected, half of which were fully stocked and the other half sufficiently so as to warrant placing on the same basis, are the basis of Table XXI.

After the site classification had been completed, the three qualities were found to correspond quite well to fairly distinct physical conditions, as follows:

Site Class I comprises those sites which are best for tree growth. The soils are mainly alluvial loam, always moist with enough slope to provide good drainage, always very deep, but not necessarily of the greatest fertility. Typical areas are the gentle lower slopes of the Kaniksu Forest, the deepest soiled slopes and creek bottoms of the Coeur d'Alene and St. Joe Forests, and the fertile rolling foothills of the North Fork of the Clearwater River valley. This site is not limited by aspect or degree of slope. It may be found on broad ridges or high south slopes as well as lower north slopes, provided soil and moisture conditions are of the right kind. (Plate XV).

Site Class II includes the great bulk of white pine soils. They are fairly moist and deep, but less favorable than those of Site I. Localities such as most of the steep mountain slopes of the St. Joe, Lolo, Coeur d'Alene and Kaniksu Forests, as well as the valley flats of the latter, fall within the limits of this class.

Site Class III includes the poorest white pine sites, such as shallow or rocky slopes, sandy or gravelly benchlands, high windswept ridges, areas at the upper limits of the type where growth is hindered by frequent frosts or shortness of the growing season, and areas near the lower limit where the moisture supply is too scanty. Stands of pure white pine are much less frequent on this site than on the other two, due perhaps to the fact that other species compete more strongly with the white pine. They are fairly common, however, on the shallow and rocky slopes of the Coeur d'Alene mountains.

The yield per acre, in Table XXI as in the other yield tables herein described, is expressed both in cubic and board feet. The cubic feet expresses the amount of solid wood in the entire peeled trunks from the ground to the tip. The board feet yield is based only on that portion of the trunk between the stump and the six-inch inside diameter point in the top, in accordance with the present standards of utilization in North

Table XXI

YIELD PER ACRE OF WESTERN WHITE PINE
IN PURE FULLY –STOCKED STANDS
(NORMAL YIELD)
IDAHO AND MONTANA

| Age Years | *Height of Tree of Average Cu. Vol. Feet | Ratio of Diameter To No. Trees: Most Open Stands Av. Diam Inches | Most Open Stands No. Trees | Most Open Stands Av. Diam Inches | Most Open Stands No. Trees | Basal Area Per Acre Sq. Ft. | Total Yield per Acre: Cubic Feet of Entire Peeled Stems | **Board Feet to 6" Top Diameters |
|---|---|---|---|---|---|---|---|---|
| | | | | SITE I | | | | |
| 20 | 30 | 5.0 | --- | 2.5 | --- | 105 | 1,500 | --- |
| 30 | 51 | 7.0 | 635 | 3.7 | 2600 | 167 | 3,700 | 8,000 |
| 40 | 69 | 9.0 | 545 | 5.0 | 1600 | 215 | 6,000 | 18,000 |
| 50 | 83 | 10.6 | 465 | 6.2 | 1200 | 255 | 8,400 | 30,000 |
| 60 | 95 | 12.2 | 390 | 7.3 | 960 | 290 | 10,700 | 43,000 |
| 70 | 105 | 13.5 | 330 | 8.5 | 780 | 317 | 13,000 | 58,000 |
| 80 | 113 | 14.8 | 280 | 9.6 | 660 | 342 | 15,100 | 71,000 |
| 90 | 121 | 16.0 | 245 | 10.6 | 575 | 362 | 17,200 | 84,000 |
| 100 | 128 | 17.2 | 220 | 11.6 | 510 | 380 | 19,200 | 94,000 |
| 110 | 135 | 18.3 | 200 | 12.4 | 465 | 395 | 20,600 | 104,000 |
| 120 | 140 | 19.3 | 185 | 13.2 | 430 | 410 | 21,600 | 112,000 |
| 130 | 145 | 20.2 | 175 | 13.9 | 375 | 422 | 22,400 | 120,000 |
| 140 | 149 | 21.0 | 165 | 14.5 | 265 | 432 | 23,000 | 128,000 |
| 150 | 153 | 21.8 | 155 | 15.2 | 335 | 442 | 23,500 | 135,000 |
| | | | | SITE II | | | | |
| 20 | 21 | 4.0 | --- | 1.6 | --- | 50 | 600 | --- |
| 30 | 40 | 6.0 | 770 | 2.8 | 4200 | 130 | 2,500 | --- |
| 40 | 57 | 7.5 | 650 | 4.0 | 3000 | 182 | 4,500 | 11,000 |
| 50 | 71 | 9.0 | 540 | 5.2 | 1850 | 215 | 6,500 | 22,000 |
| 60 | 83 | 10.5 | 450 | 6.4 | 1320 | 241 | 8,400 | 32,000 |
| 70 | 92 | 11.8 | 360 | 7.5 | 1030 | 261 | 10,300 | 43,000 |
| 80 | 100 | 13.0 | 320 | 8.6 | 850 | 277 | 12,000 | 53,000 |
| 90 | 107 | 14.2 | 270 | 9.5 | 720 | 290 | 13,600 | 63,000 |
| 100 | 113 | 15.3 | 240 | 10.3 | 625 | 300 | 15,000 | 71,000 |
| 110 | 119 | 16.3 | 215 | 11.0 | 550 | 310 | 16,000 | 78,000 |
| 120 | 124 | 17.2 | 200 | 11.7 | 490 | 319 | 16,900 | 84,000 |
| 130 | 128 | 18.0 | 190 | 12.2 | 440 | 327 | 17,500 | 90,000 |
| 140 | 132 | 18.8 | 180 | 12.7 | 400 | 335 | 18,000 | 96,000 |
| 150 | 135 | 19.6 | 170 | 13.2 | 370 | 341 | 18,500 | 101,000 |

Table XXI continued on following page.

Table XXI Continued

| Age Years | *Height of Tree of Average Cu. Vol. Feet | Ratio of Diameter To No. Trees: Most Open Stands Av. Diam. Inches | Most Open Stands No. Trees | Most Open Stands Av. Diam. Inches | Most Open Stands No. Trees | Basal Area Per Acre Sq. Ft. | Total Yield per Acre: Cubic Feet of Entire Peeled Stems | **Board Feet to 6" Top Diameters |
|---|---|---|---|---|---|---|---|---|
| | | | | SITE III | | | | |
| 30 | 30 | 4.3 | 1100 | 2.2 | --- | 97 | 1,200 | --- |
| 40 | 45 | 5.6 | 900 | 3.2 | --- | 148 | 2,800 | 5,000 |
| 50 | 58 | 7.0 | 730 | 4.2 | 2800 | 182 | 4,500 | 13,000 |
| 60 | 70 | 8.2 | 600 | 5.1 | 1950 | 205 | 6,100 | 21,000 |
| 70 | 79 | 9.4 | 490 | 6.0 | 1500 | 224 | 7,600 | 29,000 |
| 80 | 86 | 10.5 | 410 | 6.7 | 1240 | 238 | 9,000 | 36,000 |
| 90 | 93 | 11.6 | 345 | 7.4 | 1050 | 248 | 10,000 | 43,000 |
| 100 | 98 | 12.6 | 300 | 8.0 | 920 | 256 | 11,000 | 48,000 |
| 110 | 102 | 13.4 | 265 | 8.5 | 810 | 263 | 11,700 | 53,000 |
| 120 | 116 | 14.2 | 240 | 8.9 | 730 | 268 | 12,200 | 57,000 |
| 130 | 109 | 15.0 | 225 | 9.3 | 675 | 273 | 12,600 | 60,000 |
| 140 | 112 | 15.7 | 210 | 9.6 | 630 | 278 | 12,900 | 63,000 |
| 150 | 115 | 16.4 | 200 | 9.8 | 600 | 282 | 13,200 | 67,000 |

* Average height for each diameter class weighted in accordance with its cubic volume, in determining average height for the stand.
** Board foot volume scaled by Scribner Decimal C. Rule.

Idaho white pine, scaled by the Scribner Decimal C Rule as laid down in the Forest Service Scaling Manual.*

Since logs scaled by this rule give a very large overrun,** the figures applied to lumber scale are conservative especially in stands yielding the smaller sized logs. Because of the tendency to grouping and overcrowding which prevails in natural stands, the fully-stocked and well managed western white pine forests of the future should the more readily pass the yields here given, and future utilization to diameters of three or four inches will cause a still further increase.

The ratio, in Table XXI, of diameter to number of trees shows the wide variation which occurs in the number of trees growing in fully-stocked natural stands, and its effect on the average diameter of the trees. The largest average diameter attainable at a given

* "Instructions for Scaling and Measurement of National Forest Timber – 1916". pages 14 and 15.
** See Figs. 9 and 14, and Tables B, C, and C1 of Appendix.

age and on a given site occurs of course in the most widely spaced stands; the number of trees corresponding is approximately the minimum which is required in order to produce the full yield in cubic and board feet. On the other hand, the smallest average diameters found in stands which produce normal cubic yields are those indicated in the most crowded stands, and the number of trees is approximately the maximum which can grow to that age without a decided falling off in cubic yield, altho board foot yields do fall off perceptibly. (Compare the yields of 3 to 7 ft. spacing with those from wider spacings (Table XXII) and note how much more rapidly board foot yield falls off with closer spacing.)

While the two columns giving number of trees accordingly indicate the range in numbers which fully-stocked natural stands at any particular age have, they do not necessarily indicate the course of natural thinning which takes place in the stands. Those which are crowded undoubtedly do thin out rapidly, but it seems from the appearance of the stands showing high yields at maturity that many of these have experienced less than normal competition until comparatively late in life. The number of trees indicated for widely spaced stands shows therefore the minimum number which will yield the amount for any particular age but does not show what yield that number would give at an earlier or later period. On the other hand, the number of trees shown for the most crowded stands indicated the maximum number which can be permitted for any age with hope of securing full cubic volume, altho because of the stagnation in growth which results from such crowding the number must be cut down considerably to secure the full yield in board feet.

The effect of spacing on the growth and theoretically on the yield of pure white pine is shown in greater detail for one age class and site in Table XXII, which is prepared from a detailed study of individual trees. It will be noted that the table is comparable with the 50 year age class and Site II quality of Table XXI, the diameters and numbers of trees for the 5 foot and 9 foot spacings corresponding quite closely to those of the yield table. The board foot yields from the 5, 6 and 7 ft. spacings bear out the statement that the board foot yields fall off more rapidly than the cubic yields in the more crowded stands. With the ideal spacing of Table XXII it is seen that the yield in cubic and board feet indicated in Table XXII could also be secured with the numbers of trees and corresponding sizes shown for the 10 ft., 11 ft. and 12 ft. spacings. The 10 ft. spacing gives the highest yields, both in cubic feet and board feet at 50 years but the 9 ft. spacing yields nearly as much and results in better pruning. A 9 ft. or 10 ft. spacing at the beginning of the stand then will permit on an average site the most rapid growth and the highest yields for the beginning of merchantability, 50 years. At the same time such a stand without any thinning will grow to 110 or 120 years without overcrowding sufficiently serious to cut down the yield, (See Table XXII, Site II) while it also permits moderately good pruning and a natural thinning of 60% without danger of diminishing the yield.

Pure Stands Over Large Areas

Altho the majority of western white pine stands within the white pine type fall with Site II, still owing to the customary method (Baur's) of determining these figures the average maximum acre of the type even if fully stocked, may deviate considerably above or below the normal yield for the site. Moreover, as previously indicated, but few of the maximum plots of one acre or larger are fully stocked. Table XXIII is a mechanical average of the reasonably large areas representing maximum nearly pure white pine

stands on all sites as they usually occur. Altho called maximum, they are the result of an approximately average degree of stocking originally. They are exceptional, however, in that they contain unusually high percentages of white pine (over 70%) and escaped the more serious visitations of destructive influences. They are maximum because the present average stands do not meet these two conditions.

TABLE XXII

EFFECT OF SPACING ON GROWTH AND YIELD
IN 47-YEAR-OLD STANDS OF PURE WESTERN WHITE PINE

Northerly Slopes of Kaniksu Forest
Approximately Site II

| Spacing Feet | Diameter Breast High Inches | Description of the Tree | | | | | Number of Trees Per Acre | Theoretical Yield per Acre | |
|---|---|---|---|---|---|---|---|---|---|
| | | Height Feet | *Dead Length Feet | Crown Length Feet | Vol. per Tree Cubic Feet | Vol. per Tree **Board Feet | | Cubic Feet | **Board Feet |
| 3 | 3.5 | 36 | 16 | 18 | 1 | | 4,840 | 5,840 | |
| 4 | 4.3 | 40 | 21 | 19 | 2 | | 2,722 | 5,500 | |
| 5 | 5.3 | 45 | 24 | 21 | 3 | | 1,742 | 5,999 | |
| 6 | 6.3 | 49 | 25 | 24 | 5 | 4 | 1,210 | 6,400 | 4,840 |
| 7 | 7.1 | 54 | 26 | 28 | 7 | 16 | 889 | 6,600 | 12,220 |
| 8 | 8.0 | 58 | 25.5 | 32.5 | 10 | 31 | 680 | 6,880 | 21,080 |
| 9 | 8.9 | 62 | 25 | 37 | 13 | 46 | 538 | 7,200 | 24,750 |
| 10 | 9.7 | 65 | 24 | 41 | 17 | 60 | 435 | 7,250 | 26,100 |
| 11 | 10.3 | 66 | 23 | 43 | 19 | 71 | 360 | 6,880 | 25,560 |
| 12 | 10.7 | 66 | 22 | 44 | 21 | 78 | 302 | 6,230 | 23,560 |
| 13 | 11.0 | 66 | 21 | 45 | 22 | 84 | 258 | 5,620 | 21,670 |
| 14 | 11.2 | 66 | 20 | 46 | 23 | 88 | 222 | 5,010 | 19,540 |
| 15 | 11.4 | 65 | 19 | 46 | 23 | 92 | 194 | 4,470 | 17,850 |
| 16 | 11.5 | 64 | 18 | 46 | 23 | 94 | 170 | 3,920 | 15,980 |
| 17 | 11.6 | 62 | 16 | 46 | 23 | 94 | 150 | 3,410 | 13,100 |
| 18 | 11.6 | 59 | 13 | 46 | 22 | 93 | 134 | 2,900 | 12,460 |

* Dead length is the length of trunk upon which the branches have been suppressed by shade.

** Board feet is log scale by the Scribner Decimal C Rule to 6” diameter inside bark at top end. Volume per tree determined from volume curve of Benton Creek trees having same cubic volume.

TABLE XXIII

YIELD OF MAXIMUM WESTERN WHITE PINE STANDS
PREVAILING OVER LARGE AREAS
Well But Not Fully-Stocked

ALL SITES – IDAHO AND MONTANA

| Age Year | Average basal Area Sq. Feet | Total Yield per Acre | | | | Ratio of Av. To Normal Yield For Site II |
|---|---|---|---|---|---|---|
| | | Cu. Ft. in Entire Peeled Stems Average | *Board Feet to 6" Top Diameter | | | |
| | | | Average | Maximum | Minimum | |
| 20 | 70 | 900 | | | | |
| 30 | 135 | 2,500 | 2,000 | 8,000 | | |
| 40 | 175 | 4,300 | 8,500 | 22,000 | 3,000 | 77 |
| 50 | 205 | 6,100 | 18,000 | 38,000 | 10,000 | 84 |
| 60 | 225 | 7,800 | 27,500 | 53,000 | 16,000 | 87 |
| 70 | 242 | 9,400 | 37,500 | 68,000 | 22,000 | 87 |
| 80 | 255 | 10,700 | 47,000 | 82,000 | 27,000 | 88 |
| 90 | 263 | 11,800 | 56,000 | 95,000 | 31,000 | 89 |
| 100 | 267 | 12,700 | 63,500 | 107,000 | 33,500 | 89.5 |
| 110 | 269 | 13,400 | 68,500 | 117,000 | 35,500 | 88 |
| 120 | 268 | 13,900 | 72,000 | 126,000 | 36,000 | 85 |
| 130 | 267 | 14,000 | 74,500 | 134,000 | 36,500 | 83 |
| 140 | 266 | 14,100 | 75,000 | 140,500 | 37,000 | 79 |
| --- | --- | --- | --- | --- | --- | --- |
| 220 | 251 | 14,300 | 80,500 | 96,000 | 62,000 | |

Basis: 96 Plots, over 70% White Pine; Those over 50 years, varying from 1 to 59 acres, averaged 3.7 acres in size.

* Board feet scaled by Scribner Dec. C. Rule.

In comparison with the normal yield for Site II, Table XXIII shows that the maximum 100 year stands, prevailing over large areas, tho under stocked, yield nearly 90% of the normal. This ratio falls off in older stands, due in small part to the fact that the proportion of Site III plots used in construction of the Table was greater in 140-150 year stands, but chiefly to the fact that even the purer white pine stands are thinned at an accelerated rate after 100 years from the activities of insects and disease. The same thing is shown in the lack of increase in basal area after that age is reached.

It is quite impracticable to determine this yield by site qualities because most natural stands are under stocked to different degrees and consequently there is no constant relation between the various factors which go to make up volume (vis. no. of trees, basal

area and height) such as is the case with normal stands. From columns (Table XXXIII) showing maximum and minimum board foot yields it can be seen that the range of yields which are averaged in the table is very nearly the same as that of normal stands.

Mixtures With Important Species

As previously indicated, in the white pine type besides pure white pine the following mixtures occur: (1) white pine and larch, (2) white pine and larch over cedar, (3) white pine over cedar, (4) white pine and Douglas fir, (5) white pine and Engelmann spruce. Others are also found but are too infrequent to furnish enough data for yield tables.

White Pine - Western Larch Mixtures

Mixtures of white pine and western larch in approximately equal proportions are confined principally to situations such as the deep soiled alluvial flats and benches of the Kaniksu National Forest (Plate XVI). The quality of the site here is about medium (II) for white pine but is about as good as exists (site I) for larch. From eighteen fully stocked areas, nine of which ranged from twenty to fifty years of age while nine were about 140, Table XXIV was prepared, the data for intermediate ages being interpolated by the use of curves. Altho the number of plots is limited, their remarkable uniformity in growth warrants the acceptance of the table for that site and locality. The yield of the larch mixture at 40 years as will be noticed is only 50% of the board foot volume and 71% of the cubic volume of pure white pine on quality II. This difference is gradually diminished however, until at 120 years the mixture equals 93% of the pure white pine both in cubic and in board foot contents. (The disparity between the cubic and board foot ratios in the younger age class probably is due to the extreme height and slenderness of the young larch combined with the difference in the proportions of the trunk measured.)

The average height of the two species illustrates the dominance of the larch over the white pine on these soils up to an age of about 180 years, at about which time the relative order is changed. This long dominance of larch is due to the site quality of the areas measured being relatively better for larch than for white pine.

Some mixtures of white pine and larch with a cedar understory are illustrated in Table XXV. On these particular areas the sites are most favorable for white pine as well as for larch. The larch is generally exceeded by the white pine in both average diameter and average height, and since the larch is rapidly suppressed when overtopped, wherever the two species are in close competition, its proportion in the stand must rapidly decrease with age. Even where it persists an increase of 25% larch in a white pine – larch stand will only make 8% or 10% decrease in the final yield. (In Table XXV compare Plot No. 58 with 59, or 55A with 53.)

Mixtures with Red Cedar

Probably the most valuable white pine mixtures are those with western red cedar or with both larch and cedar, such as occur in the West Branch Valley, Kaniksu Forest. Several of these stands, all of one age and of fairly uniform site quality, and illustrating various degrees of completeness in upper and under story, are shown in Table XXV, (A story was called complete when all its crown space was occupied.)

TABLE XXIV

YIELD OF FULLY-STOCKED WHITE PINE – WESTERN LARCH MIXTURES ON DEEP MOIST SOILS

LOWER SLOPES AND FLATS – KANIKSU FOREST, IDAHO

SITE II FOR W.P.

| Age Years | Number Trees Per Acre | Basal Area Sq. Ft. | Average Size of Trees* Height - Ft. White Pine | Height - Ft. Western Larch | D.B.H. Inches White Pine | D.B.H. Inches Western Larch | Total Yield Per Acre Cubic Feet in Entire Peeled Stem | **Board Feet to 6" Top Diameters |
|---|---|---|---|---|---|---|---|---|
| 20 | 2,000 | 50 | 21 | 36 | 2.0 | 3.0 | 500 | ***** |
| 30 | 1,540 | 104 | 36 | 53 | 3.1 | 4.8 | 1,800 | 1,500 |
| 40 | 1,170 | 147 | 50 | 68 | 4.3 | 6.4 | 3,200 | 5,500 |
| 50 | 940 | 173 | 63 | 80 | 5.5 | 7.8 | 4,800 | 1,000 |
| 60 | 770 | 198 | 75 | 90 | 6.8 | 9.1 | 6,400 | 16,000 |
| 70 | 630 | 221 | 86 | 100 | 8.0 | 10.4 | 8,000 | 22,500 |
| 80 | 530 | 244 | 96 | 110 | 9.3 | 11.6 | 9,700 | 30,500 |
| 90 | 440 | 265 | 105 | 118 | 10.5 | 12.8 | 11,300 | 40,000 |
| 100 | 370 | 286 | 114 | 125 | 11.8 | 14.0 | 12,700 | 51,000 |
| 110 | 320 | 306 | 122 | 132 | 13.0 | 15.3 | 14,000 | 63,000 |
| 120 | 270 | 326 | 129 | 138 | 14.2 | 16.5 | 15,200 | 75,000 |
| 130 | 230 | 345 | 135 | 143 | 15.4 | 17.7 | 16,200 | 84,000 |
| 140 | 200 | 363 | 142 | 148 | 16.6 | 18.9 | 17,100 | 92,000 |
| 160 | *** | *** | 151 | 156 | 18.8 | 21.2 | ***** | ***** |
| 180 | *** | *** | 160 | 161 | 20.9 | 23.5 | ***** | ***** |
| 200 | *** | *** | 167 | 164 | 22.9 | 25.7 | ***** | ***** |
| 250 | *** | *** | 181 | 166 | 27.0 | 31.0 | ***** | ***** |

*Average size of the tree after 140 years determined from measurements in this locality of stands 250 yrs. old but not fully enough stocked to afford data on yield for this table.

** Board feet in logs scaled by Scribner Decimal C. Rule.

---

Stands having a heavy cedar understory, as illustrated by the first seven examples in Table XXV, give the best combination of high yield plus quality. The white pine is so widely spaced that its growth is unhampered by competition for light. The trees therefore are of very large diameter and have the greatest length between branches

possible for that age, the cedar understory which fills the interspaces has early suppressed and pruned the branches from the lower part of the white pine trunk, and, due to the early dropping of branches and closing of limb scars, disease is less destructive than in other stands on the same site. The cedar is just of the sizes most desirable for poles and pilings. The larch has been thinning out for the past ninety years, whenever closely pressed by more rapid growing pine; that which is left is largely of excellent tie size.

Stands with a complete upper story of pure white pine (Note Plots 55A and 53, under Table XXV) appear able to produce but a low yield of cedar in the understory. The yield of the white pine is as high as if there was no understory; but its quality is inferior to that in the stands containing more cedar, because of poorer pruning and some overcrowding. But even such stands are better pruned than the pure white pine without any cedar in mixture.

With the decrease in density of the upperstory, there occurs a corresponding increase in the volume of cedar in the understory. Understories of cedar up to 12,000 board feet per acre may be found under a complete tho relatively thin canopy containing as much or more larch than white pine and yielding as high as 100,000 board feet pre acre. (Plots 58 and 59). Under similar but slightly more open canopies, over 22,000 board feet of cedar may occur.

The maximum yields of which can be expected of each story in stands with a well distributed white pine upper story widely enough spaced to permit the maximum yield of a red cedar understory, are given for 80 to 260 year age classes in Table XXVI. (Plate XVII). While prepared from a small amount of data, the sites upon which such an excellent development of cedar can be secured (approximately Site I for white pine) are so uniform as to give a good idea of the yield of such maximum stands.

Mixtures with the Balsam Firs and Hemlocks

While the balsam or true firs and hemlocks, either separately, together or with cedar, exercise the same beneficial influences on the growth and quality of white pine trees that cedar does, their influence on the yield of white pine stands is diverse. When confined to the lower story, any of those species if sound will increase the total yield by the small quantity of additional wood they produce, just as cedar does. If unsound, this increase of course is of no value; but in either case the yields of the upper story is little, if at all affected. When hemlock invades the upper story or prevents the white pine from forming a complete canopy, high yields are in a measure debarred, and especially so if the hemlock is diseased. With sound grand fir in the upper story, the yield is as great as that of pure white pine; but with the grand fir decayed, yield is of course diminished to that extent. However, the decrease of yield in grand fir due to unsoundness is relatively little under one hundred years of age, except in severely infected localities.

White Pine - Douglas Fir Mixtures

Table XXVII is a mechanical average of stands 90 to 100% stocked in which both white pine and Douglas fir are about equally represented. (Plate VI, Fig.2) The extremes of yield in board feet show the limits of stands embraced. In comparing this with Table XXIII, it will be noticed that the average white pine – Douglas fir stands yield only from 85% to 90% as much as the nearly pure white pine, except in young stands under 50

TABLE XXV

YIELDS PER ACRE OF WHITE PINE AND LARCH OVER CEDAR
Representative Areas 138 Years Old
Lower Westbranch Valley - Kaniksu National Forest – Site Quality I

| | DOMINANT STORY | | | | | | | | RED CEDAR UNDERSTORY | | | | | | | TOTAL FOR BOTH STORIES | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Yield per Acre | | | | Average Tree | | | | Total Yield per Acre | | | | Average Tree | | | Total Yield per Acre | | | | | |
| Proportion of Species in Composition | No. of Trees | Basal Area Sq.Ft. | Cubic Ft. Entire Stem (peeled) | Board Ft.* [To 6"] D.I.B. in Tops | Height White Pine | Height W. Larch | D.B.H. White [Pine?] | D.B.H. W. Larch | No. of Trees | Basal Area Sq. Ft. | Cubic Ft. Entire Stem (peeled) | *Board Ft. To 6" D.I.B. in Tops | Poles or Pilings 30' or Longer | Total Height | D.B.H. | No. of Trees | Basal Area Sq.Ft. | Cubic Ft Entire Stem (peeled) | Board Ft. To 6" D.I.B. Tops | Area Repre-sented | Plot Nos. |
| (A) Forty Acre Tracts With Heaviest Cedar Understories | | | | | | | | | | | | | | | | | | | | | |
| White Pine 2/3, W. Larch 1/3 | 101 | 220 | 12,000 | 69,000 | 156 | 148 | 21.0 | 18.5 | 101 | 95 | 3,100 | 13,000 | 59 | 89 | 13.3 | 202 | 315 | 15,100 | 82,000 | 40 | 57-60*** |
| White Pine 5/6, W. Larch 1/6 | 164 | 285 | 15,800 | 87,900 | 148 | 145 | 18.4 | 16.0 | 255 | 90 | 2,900 | 11,300 | 70 | 89 | 18.4 | 419 | 375 | 18,700 | 99,200 | 40 | 19-57-6 |
| (B) Well Distributed Upper Story Over Complete Lower Story | | | | | | | | | | | | | | | | | | | | | |
| White Pine 1/2, W. Larch 1/2 | 90 | 206 | 10,750 | 61,300 | 158 | 145 | 23.4 | 19.2 | 164 | 165 | 5,200 | 23,500 | 126 | 95 | 13.9 | 254 | 371 | 15,950 | 84,800 | 0.5 | 61 |
| White Pine 4/5, W. Larch 1/5 | 172 | 320 | 17,500 | 98,600 | 151 | 148 | 18.7 | 17.8 | 183 | 163 | 5,000 | 21,000 | 127 | 90 | 12.7 | 355 | 483 | 22,500 | 119,600 | 8.0 | 64 |
| (C) Complete Upper Story Over Well Distributed Under Story | | | | | | | | | | | | | | | | | | | | | |
| White Pine 1/4, W. Larch 3/4 | 162 | 339 | 16,600 | 93,500 | 151 | 152 | 18.2 | 20.0 | 158 | 47 | 3,200 | 11,400 | 20 | 81 | 10.6 | 320 | 436 | 19,800 | 104,900 | 0.5 | 58 |
| White Pine 1/2, W. Larch 1/2 | 164 | 341 | 17,600 | 100,100 | 154 | 151 | 20.1 | 20.1 | 151 | 24 | 6,200 | 11,900 | 26 | 85 | 10.3 | 315 | 435 | 20,800 | 112,000 | 1.0 | 59 |
| White Pine 4/5, W. Larch 1/5 | *150 | 323 | 18,000 | 100,700 | 156 | 148 | 21.0 | 18.2 | 148 | 118 | 3,750 | 13,100 | 112 | 85 | 12.7 | 296 | 446 | 21,750 | 113,800 | 1.0 | 57 |
| White Pine 3/5, W. Larch 2/5 | **284 | 444 | 19,000 | 98,600 | 130 | 141 | 15.2 | 17.7 | 146 | 69 | 1,800 | 3,200 | 66 | 67 | 8.8 | 430 | 506 | 20,800 | 101,800 | 2.5 | **555 |
| White Pine 3/5, W. Larch 1/5 | 300 | 484 | 24,100 | 125,000 | 138 | 141 | 17.3 | 16.9 | 142 | 72 | 2,000 | 6,800 | 64 | 75 | 9.8 | 442 | 556 | 26,100 | 131,800 | 0.5 | 55A |
| White Pine Pure | 273 | 491 | 25,400 | 135,900 | 140 | *** | 18.1 | *** | 71 | 40 | 1,200 | 3,900 | 48 | 72 | 10.0 | 344 | 531 | 26,000 | 139,800 | 0.6 | 53 |

* Upper story incomplete, due to narrower crowns of white pine, the nearly equal in number of trees and basal area tp 58 and 59. This plot includes [sic] for comparison with 58 and 59.

** This plot also included for comparison with 55A which it adjoins and 53, altho size of white pine trees would seem to indicate poorer site.

*** SE1/4 – NE1/4

TABLE XXVI

MAXIMUM YIELD OF CEDAR IN MIXTURE WITH WHITE PINE

Clearwater and Kaniksu National Forests. Idaho, Site Quality I

| DOMINANT STORY | | | | | | | RED CEDAR UNDER STORY | | | | | | | TOTAL FOR BOTH STORIES | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Yield per Acre | | Avg White Pine | | | | Yield per Acre | | Average Tree | | | | | Yield per Acre | |
| Age Years | Number of Trees | Basal Area Sq. Ft. | Cu. Ft. Entire Stem (peeled) | Board Ft.* to 6" D.I.B. in Tops | Total Height Feet | D.B.H. Inches | Number of Trees | Basal Area Sq. Ft. | Cu. Ft. Entire Stem (peeled) | Board Ft.* to 6" D.I.B. in Tops | Poles or Pilings 30' or Longer | Total Height Feet | D.B.H. Inches | Number of Trees | Basal Area Sq. Ft. | Cu. Ft. Entire Stem (peeled) | Board Ft.* to 6" D.I.B. in Tops |
| 80 | 190 | 260 | 11,200 | 67,500 | 120 | 15.0 | 195 | 95 | 2,700 | 14,000 | 105 | 77 | 11.0 | 385 | 355 | 13,900 | 81,500 |
| 100 | 185 | 280 | 13,700 | 80,000 | 133 | 16.3 | 195 | 120 | 3,900 | 17,000 | 125 | 85 | 11.6 | 380 | 400 | 17,600 | 97,000 |
| 120 | 180 | 300 | 15,900 | 90,000 | 144 | 17.6 | 190 | 145 | 4,500 | 19,000 | 140 | 90 | 12.2 | 370 | 445 | 20,400 | 109,000 |
| 140 | 170 | 320 | 17,600 | 99,000 | 152 | 18.8 | 185 | 165 | 5,000 | 21,000 | 150 | 95 | 12.8 | 355 | 485 | 22,600 | 120,000 |
| 170 | 150 | 320 | 17,800 | 101,000 | 163 | 21.0 | 165 | 175 | 5,600 | 24,000 | 140 | 100 | 14.0 | 315 | 495 | 23,400 | 125,000 |
| 200 | 120 | 300 | 16,800 | 98,000 | 171 | 23.4 | 140 | 175 | 6,000 | 27,000 | 120 | 103 | 15.4 | 260 | 475 | 22,800 | 125,000 |
| 260 | 50 | 220 | 13,100 | 83,000 | 182 | 27.6 | 80 | 140 | 6,400 | 31,000 | 40 | 107 | 18.0 | 130 | 360 | 19,500 | 114,000 |

Basis: Curved from one 79 year 2-acre plot on the Clearwater Forest; twp 140 year plots containing 3.5 acres, and twp 260 year plots containing 15 acres on the Kaniksu Forest.

* Board feet scaled by Scribner Decimal C. Rule top 6 inch diameter inside bark (D.I.B.) in the tops.

years, when the mixture yields slightly more. The table undoubtedly falls off more than it should in the older age classes, because of the prevailing tendency of the Douglas fir as the stand approaches maturity, to disappear from these mixtures and especially from better sites.

TABLE XXVII

YIELD OF BEST-STOCKED WHITE PINE – DOUGLAS FIR MIXTURES

Mountain slopes of Idaho & Montana
(All Sites)

| Age Years | Average Number Trees Per Acre | Average Basal Area Sq. Ft. | Average Size Each Species | | | | Total Yield Per Acre | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Height - Ft. | | D.B.H. Inches | | *Cubic Feet in Entire Stems Avg. | **Board Ft. to 6" Top Diam. | | |
| | | | White Pine | Douglas Fir | White Pine | Douglas Fir | | Average | Maximum | Minimum |
| 20 | 2000 | 53 | 15 | 18 | 2.3 | 2.5 | 500 | *** | *** | *** |
| 30 | 1450 | 130 | 39 | 40 | 4.0 | 4.5 | 2,500 | 100 | 8,000 | *** |
| 40 | 1130 | 180 | 57 | 55 | 5.5 | 6.1 | 4,400 | 10,000 | 23,000 | *** |
| 50 | 910 | 208 | 70 | 66 | 6.6 | 7.5 | 6,000 | 19,000 | 36,000 | *** |
| 60 | 750 | 228 | 81 | 75 | 7.7 | 8.7 | 7,500 | 27,000 | 46,000 | *** |
| 70 | 620 | 242 | 91 | 83 | 8.8 | 9.8 | 8,800 | 35,000 | 55,500 | 16,000 |
| 80 | 510 | 254 | 100 | 90 | 9.8 | 10.9 | 10,000 | 42,000 | 63,500 | 25,000 |
| 90 | 420 | 264 | 107 | 96 | 10.9 | 12.0 | 10,900 | 48,000 | 70,000 | 32,000 |
| 100 | 360 | 272 | 114 | 102 | 12.0 | 13.1 | 11,600 | 54,000 | 75,500 | 39,000 |
| 110 | 300 | 280 | 120 | 107 | 13.0 | 14.1 | 12,200 | 58,000 | 80,000 | 44,000 |
| 120 | 265 | 287 | 126 | 111 | 14.0 | 15.0 | 12,800 | 62,000 | 85,000 | 48,000 |
| 130 | 230 | 295 | 131 | 114 | 15.0 | 15.9 | 13,200 | 65,000 | 88,500 | 52,000 |
| 140 | 200 | 302 | 136 | 118 | 16.0 | 16.8 | 13,600 | 67,000 | | 54,000 |
| 150 | 180 | 308 | 140 | 120 | 17.0 | 17.7 | 14,000 | 69,000 | | 57,000 |

* All cubic measurements taken of the entire trunk peeled or without bark, but including stump and top.
** Board feet scaled by Scribner Decimal C. Rule.
BASIS – Mechanical average of 36 sample areas on Kaniksu, St. Joe & Lolo Forests.

Spruce and Other Mixtures on Lolo Forest

As previously indicated, occurrence of this mixture is not frequent, though of appreciable importance in the higher altitudes of the type above 4000 ft. especially on the Lolo, Pend Oreille and St. Joe National Forests. On the Lolo present stands are

about 100 years old, of uniform age and site but varying in proportion of different species. The average height shows the site quality of the region to be between II and III. Table XXVIII gives comparative yields for representative mixtures. This table confirms previous statements that pure white pine gives higher yields than spruce or Douglas fir mixtures, although when compared in this one locality the difference was not great.

## Pacific Coast Types

In the Pacific Coast Types, except in the subalpine portions of the western white pine range, yields undoubtedly are nowhere less than in Idaho, and west of the Cascades they are much greater, because of the more vigorous and rapid growth of both white pine and its associates. The most common mixtures of white pine, with Douglas fir, is far more thrifty than in Idaho and yields are better in quality as well. The same is true of the mixtures with cedar, hemlock and the true firs.

## Summary Maximum Yields and Annual Growth

The important yields of each of the preceding tables are illustrated graphically in Fig. 7. This shows at a glance the relative yields which the different stands produce at any age up to 140 or 150 years.

The rate at which stands increase in volume, the annual growth, is of use in contrasting the growth of different stands or of the same stand at different ages. The mean annual growth or the average annual increase for the entire life of the stand up to the age under consideration, is obtained by dividing the yields at that age by the age. The periodic annual growth, or the average growth for any given decade, is obtained by dividing the increase of yield during that decade by 10 /. Table XXIX and Fig. VIII compare the mean annual growth and the periodic annual growth for the stands of pure white pine whose yields are given in Tables XXI and XXIII. It will be noticed that the mean annual growth of these stands reaches its maximum at about 110 years, while the periodic annual growth culminates at a much earlier age, from 50 to 70 years.

## Gross Yield vs. Utilization

The yields indicated for the preceding tables are based on the scale of the entire merchantable part of the stem, and make no allowance for cull or waste except the necessary three inches on each log for trim in the case of the board foot yields. The deduction required for cull and unavoidable waste varies between considerable margins, depending on the age and condition of the stand. The percent culled on 21 representative cutover areas of the valley lands in the Idaho white pine belt are summarized in Table XXX. The unavoidable waste, or the amount by which yields should be discounted, includes only cull butts, decay and breakage. Breakage is as a rule least in the younger and the very old timber, but seldom amounts to more than 2 or 3 percent. Cull butts range from 0 for white pine to nearly 5% for larch, but even in the latter is very low in the younger timber. And decay varied from nothing in the relatively young timber to 85% in the veteran grand fir. Only in the case of white fir and cedar, however, did the total cull amount to as much as 8% in stands 140 years old or less.

TABLE XXVIII

RELATIVE YIELD OF FULLY-STOCKED WHITE PINE, ENGELMANN SPRUCE AND DOUGLAS FIR MIXTURES

Comparison of 98 Year Old Stands on Lolo National Forest, Montana
(Elevation 4,400 to 5,000 feet)
Site between II and III for white pine

| Prevailing Species in Mixture | Number of Trees Per A. | Basal Area Per A. Sq. Ft. | Yield per Acre: Cubic Ft. Entire Stem (peeled) | Yield per Acre: Board Ft.* to 6" tops. Diameter | Dimensions of Average Tree: Height of White Pine | Dimensions of Average Tree: Diameter Breast Height: White Pine | Dimensions of Average Tree: Diameter Breast Height: Engel-mann Spruce | Dimensions of Average Tree: Diameter Breast Height: D. Fir | Composition Percentage of Cubic Volume: White Pine | Composition Percentage of Cubic Volume: Engel-mann Spruce | Composition Percentage of Cubic Volume: D. Fir | Composition Percentage of Cubic Volume: White Fir | Composition Percentage of Cubic Volume: Other Species | Basis Area Represented: No. Acres | Basis Area Represented: No. Plots |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chiefly White Pine | 400 | 265 | 11,000 | 50,000 | 106 | 11.2 | 9.8 | 12.9 | 68 | 15 | 6 | 5 | 6 | 3.0 | 4 |
| White Pine - Spruce-D. Fir | 442 | 279 | 11,040 | 49,000 | 104 | 10.3 | 10.6 | 11.5 | 30 | 30 | 34 | | 3 | 1.0 | 1 |
| White pine - Douglas. Fir | 440 | 251 | 10,640 | 46,600 | 100 | 10.4 | 9.4 | 10.0 | 55 | 11 | 27 | 5 | 1 | 3.6 | 3 |
| White Pine - Spruce | 359 | 237 | 9,830 | 45,500 | 105 | 11.5 | 10.0 | 13.3 | 52 | 32 | 5 | 3 | 8 | 14.5 | 7 |
| Miscellaneous Mixture | 448 | 250 | 11,200 | 45,000 | 100 | 9.8 | 9.1 | 12.8 | 55 | 12 | 4 | 16 | **13 | 5.0 | 1 |

* Board feet scaled by Scribner Decimal C. Rule.

** Chiefly lodgepole.

TABLE XXIX

ANNUAL GROWTH IN BOARD FEET PER ACRE
MEAN AND PERIODIC
WESTERN WHITE PINE IN PURE STANDS

(From Curves in Fig. VIII)

| Age Years | Fully Stocked Stands Site I | Site II | Site III | Large Areas Best Prevailing Stands Mechanical Avg. |
|---|---|---|---|---|
| Mean Annual Growth | | | | |
| 40 | 450 | 475 | 125 | 210 |
| 50 | 600 | 440 | 260 | 360 |
| 60 | 720 | 540 | 350 | 460 |
| 70 | 830 | 615 | 415 | 540 |
| 80 | 890 | 660 | 450 | 590 |
| 90 | 920 | 700 | 475 | 620 |
| 100 | 940 | 710 | 480 | 635 |
| 110 | 945 | 710 | 480 | 625 |
| 120 | 935 | 700 | 475 | 600 |
| 130 | 925 | 690 | 465 | 570 |
| 140 | 915 | 680 | 450 | 530 |
| 150 | 900 | 670 | 440 | *** |
| Periodic Annual Growth | | | | |
| 40 | 1000 | 950 | 500 | 650 |
| 50 | 1150 | 1100 | 750 | 900 |
| 60 | 1300 | 1100 | 800 | 1000 |
| 70 | 1500 | 1100 | 800 | 1000 |
| 80 | 1400 | 1000 | 750 | 950 |
| 90 | 1200 | 900 | 650 | 900 |
| 100 | 1050 | 800 | 550 | 750 |
| 110 | 950 | 700 | 500 | 500 |
| 120 | 850 | 650 | 450 | 350 |
| 130 | 800 | 600 | 400 | 200 |
| 140 | 750 | 550 | 350 | 100 |
| 150 | 700 | 500 | 300 | *** |

TABLE XXX

PERCENT CULLED IN LOGGING WESTERN WHITE PINE STANDS*

| Species | Age | Percentage | | | | Percent Merchantable | No. Plots |
|---|---|---|---|---|---|---|---|
| | | Cull Butts | Decay | Breakage | Total Culled | | |
| White Pine | 130 | | 0.0 | 0.0 | 0.0 | 100% | 1 |
| | 140 | | 5.3 | 2.3 | 7.6 | 92.4 | 7 |
| | 150 & 175 | | 3.3 | 1.8 | 5.1 | 94.9 | 4 |
| | 200 | | 6.3 | 1.0 | 7.3 | 92.7 | 8 |
| | 350 | | 14.1 | 2.3 | 16.4 | 83.6 | 1 |
| Average | | | 5.4 | 1.6 | 7.0 | 93.0 | 21 |
| Larch | 140 | 0.5 | 5.5 | 0.7 | 6.7 | 93.3 | 7 |
| | 150-175 | 3.9 | 13.9 | 2.0 | 19.8 | 80.2 | 4 |
| | 200 | 9.7 | 7.3 | 6.7 | 23.7 | 76.3 | 6 |
| Average | | 4.5 | 8.1 | 3.1 | 15.7 | 84.3 | 17 |
| Cedar | 140 | 0.8 | 15.4 | 0.05 | 16.3 | 83.7 | 6 |
| | 150-175 | 0.0 | 31.9 | 0.3 | 32.2 | 67.8 | 4 |
| | 200 | 2.1 | 14.8 | 0.4 | 17.2 | 82.8 | 8 |
| | 350 | 1.8 | 6.3 | 0.0 | 8.1 | 91.9 | 1 |
| Average | | 1.2 | 18.1 | 0.3 | 19.6 | 80.5 | 19 |
| Douglas Fir | 130 | 0.0 | 0.6 | 0.3 | 0.9 | 99.1 | 1 |
| | 140 | 0.0 | 1.8 | 0.9 | 2.7 | 97.3 | 6 |
| | 150-175 | 0.0 | 0.0 | 2.2 | 2.2 | 97.8 | 1 |
| | 200 | 0.4 | 1.8 | 0.8 | **2.6 [3.0]** | 97.4 | 4 |
| Average | | 0.1 | 1.3 | 0.8 | 2.2 | 97.8 | 12 |
| Grand or White Fir | 130 | 0.0 | 41.4 | 0.0 | 41.4 | 58.6 | 1 |
| | 150-175 | 8.8 | 32.4 | 2.4 | 43.6 | 56.4 | 1 |
| | 200 | 0.0 | 85.0 | 0.0 | 85.0 | 15.0 | 3 |
| Average | | 1.8 | 65.7 | 0.5 | 68.0 | 32.0 | 5 |
| Spruce | 140 | *** | **21.1[2.1?]** | 1.3 | 3.4 | 96.6 | 5 |
| | 150-175 | | 1.9 | 2.5 | 4.4 | 95.6 | 1 |
| | 200 | | 5.9 | 0.5 | 6.4 | 93.6 | 4 |
| | 350 | | 6.9 | 0.5 | 7.5 | 92.5 | 1 |
| Average | | | 3.7 | 1.1 | 4.8 | 95.2 | 11 |
| Yellow Pine | 130 | | 0.0 | 0.0 | 0.0 | 100.0 | 1 |
| | 200 | | 0.0 | 7.8 | 7.8 | 92.2 | 1 |
| Average | | | 0.0 | 3.9 | 3.9 | 96.1 | 2 |

* From 5 acre plots taken on 21 cutover areas representative of the more or less level valley lands, both National Forest and private, throughout the Idaho White Pine Belt.
**[ ]** = Number needed to produce the correct average.

Figure VII. Comparison of yields in board feet. Best stands and mixtures of western white pine type.

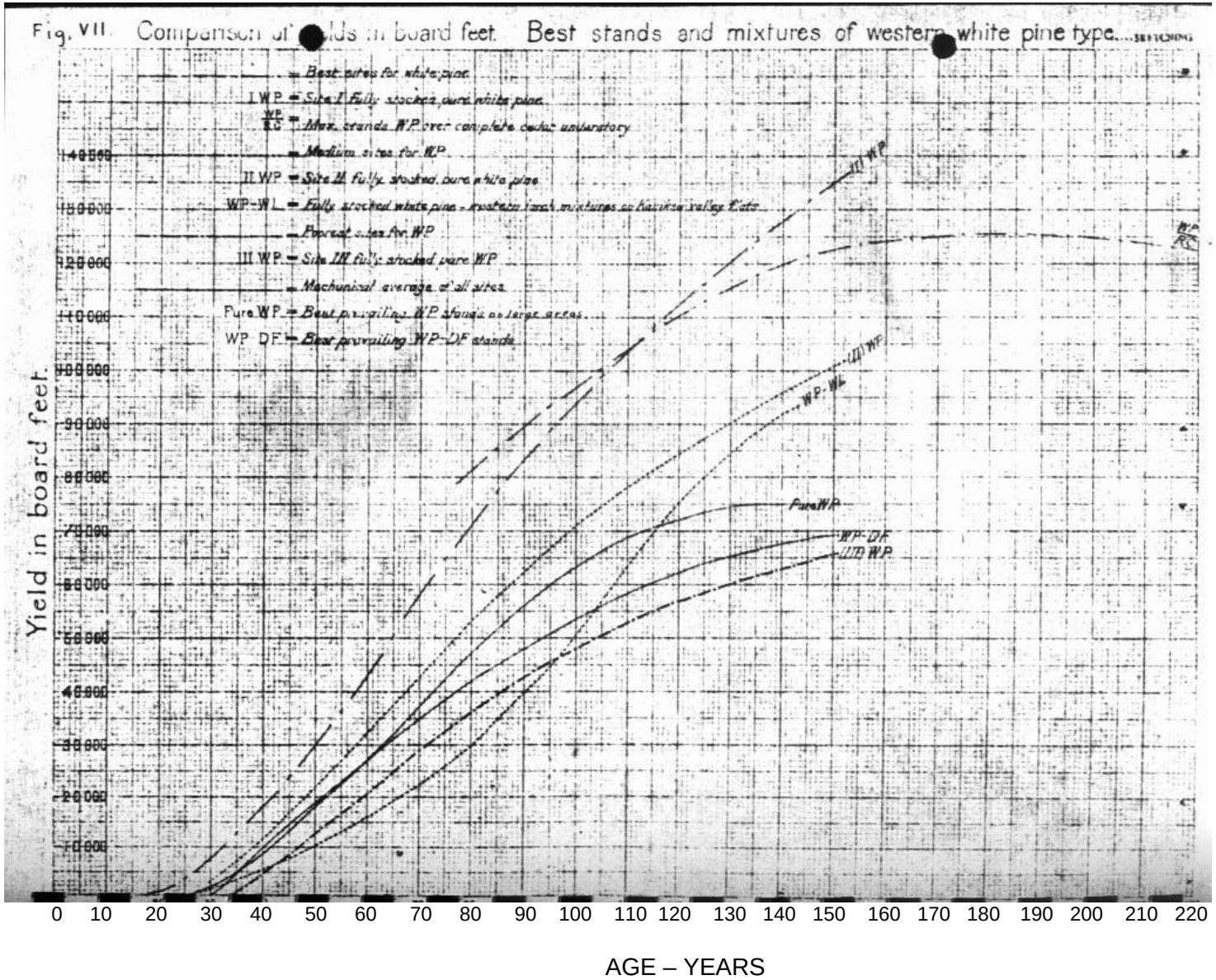
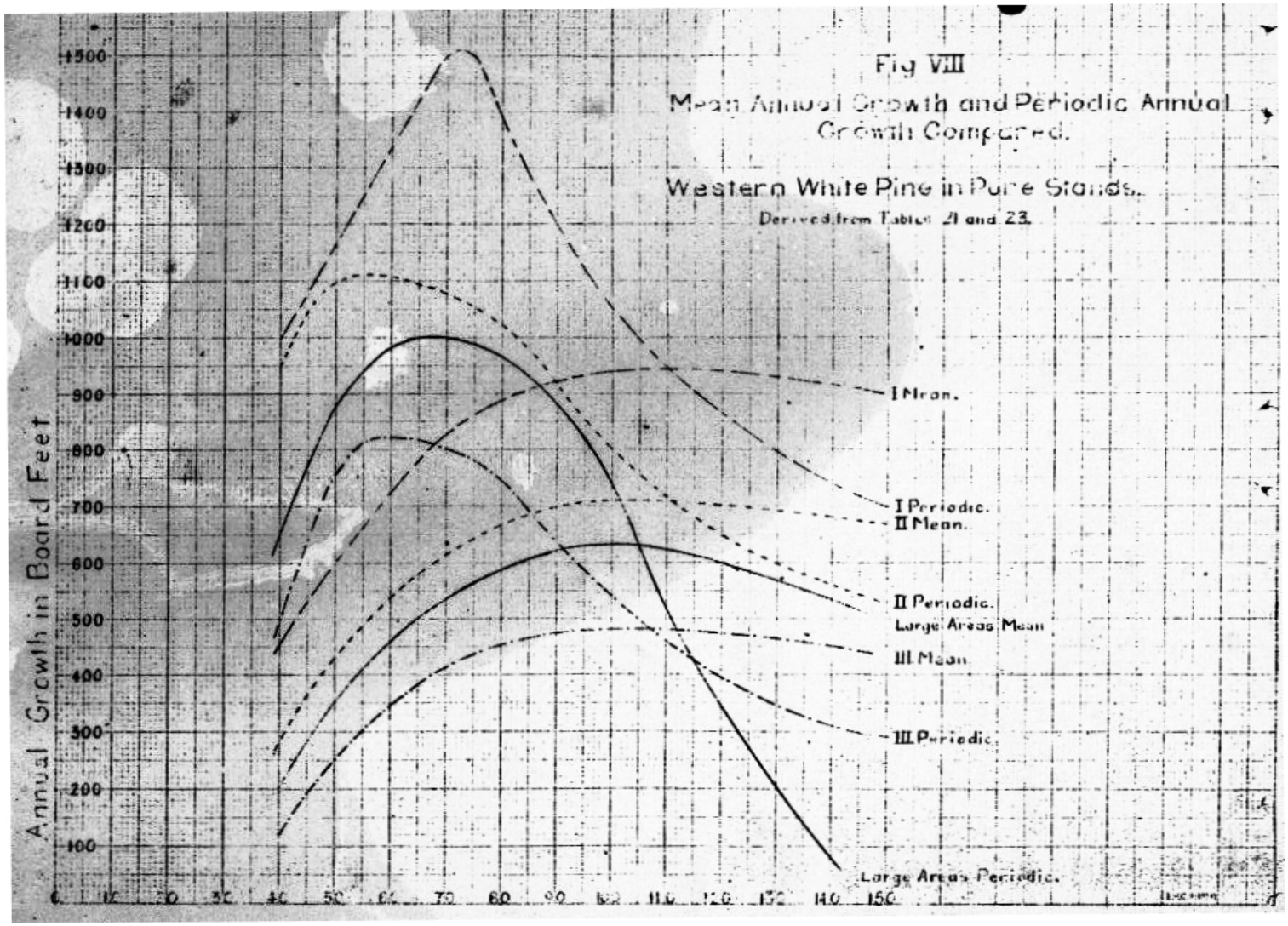


Figure V III. Mean Annual Growth and Periodic Annual Growth Compared. Western White Pine in Pure Stands Derived from Tables 21 and 23.




AGE – YEARS

In the stands measured for yield, practically the only timber culled in those 100 years of age or less was for breakage: but because of the small size of the trees, even this was less than 1%. The maximum cull was in a nearly pure fully-stocked white pine plot 140 years old and yielding 150,000 feet per acre. The entire area was measured while being logged. Because the stumps and logs were so thick on the ground, breakage was unusually large, 4.4%. And because the area had been visited by a fire years previously, decay was excessive, amounting to 11.5%.

In predicting future yields then, a discount of 2% for stands of 100 years or less, of 5% for 120 year stands, and of 10% for stands of 140 years or older, should be amply sufficient to cover the cull in living trees, except when a large percentage of hemlock, alpine fir or grand fir is present.

## Prediction of Yields

### In Established Immature Stands

Because the increasingly efficient methods of forest protection will in the future prevent the greater part of the devastation which destructive influences have wrought on the present merchantable stands, it is not justifiable to predict future yields from the average yields now secured, (Table XIX), even in the young stands already developing. Moreover, as previously intimated natural reproduction in the western white pine type is fairly complete on most burns, except those which have been burned over repeatedly, and even there becomes so after a more or less prolonged period of regeneration. The chief influences which tend to cause low yields, as already shown, are the presence of inferior species and the action of the several destructive agencies which enter the stand after its regeneration. Efficient fire protection and insect control combined with early cutting will eliminate the larger part of the destruction in the white pine itself, and greatly lower the losses from decay. Yields of nearly pure white pine stands then will closely approach those shown in Table XXIII, {at least double the yields of present average stands [author unknown]}. In mixed stands the associates are apt to be of those species which give low yields, become defective, or disappear from the stand, such as lodgepole pine, the hemlocks, the balsam firs or Douglas fir. It will be entirely conservative, however, to predict that the yield of mixtures, whether of individual stands or of the type as a whole, will bear fully as large ratio to the average of Table XXIII as white pine bears to the entire stand of trees in mixture. For example, the yield of each of the areas given in Table XX with one exception, forms a larger percentage of the average yield of the same age in Table XXIII than white pine forms of the composition of the stand on the area (Compare columns 12 and 13, Table XXIII). Practically the same comparison holds with respect to the yields on Steamboat Creek, Table XIX. It does not hold with the yields of Lolo Creek, Clearwater National Forest, because the stands there have been more seriously broken by fire, insects and disease.

Under this system the yield of immature stands for the type as a whole on any National Forest may be predicted with the use of the percentages in Table VI, in the column headed “Proportion of white pine to all timber within the white pine type”. Where the percentage of white pine is low, however, and that of the sounder species, larch, spruce and cedar is high, it is evident that the prediction will be too conservative, and these species may be credited with a proportional yield half as great as the white pine.

In Stands To Be Established

Future stands will be established either by planting or by natural reproduction under special previsions to assist in bringing it about. Where adequate provision is made for natural propagation of the valuable productive species as on timber sale areas, the yields will of course be higher than in those already established, very likely equal to those of Tables XXIII, XXIV, XXVII, etc. And on forest plantations of the proper composition, carefully spaced, they will undoubtedly equal the conservative yields indicated for fully stocked stands in Table XXI.

# WESTERN WHITE PINE

## PART II

## MANAGEMENT

----------O----------

February 7, 1917

By F. I. Rockwell
Forest Examiner

# PART II

## MANAGEMENT

The vast difference between the average yields of the western white pine type and the best yields which are occasionally found emphasizes the great desirability and need of taking whatever steps may be practicable to improve conditions and so produce higher returns. Fully stocked stands can be raised on any or all portions of the type (save on spots that are absolutely barren) and should be the aim wherever the land is to be devoted further to growing timber. All those measures which have this in view, including those which aim at the establishment or renewal, maintenance, and improvement of the forests, are to be considered in its management.

### ADVISABILITY OF MANAGEMENT

Whether or not the management of land for future timber crops is advisable depends on the returns in comparison with those to be secured by devoting the land and the capital used in defraying expenses to other purposes. A considerable proportion of the western white pine lands are fairly level and fertile, and have favorable climatic conditions; such lands are suitable for agriculture when cleared, but the greatly increased cost as a result of the added expense of clearing makes if doubtful whether it would not be more profitable to retain them in a forested state at least for another rotation. Many other lands are sufficiently level and fertile for agriculture, but will always be so inaccessible to market or are so subject to severe frosts during the growing season, that the agricultural value of the improved land would not warrant the cost of clearing. But by far the larger portion of western white pine lands are mountain slopes and ridges, uncultivable or inaccessible for agricultural purposes. On the whole they are not suitable for grazing either, because after removal of the timber they quickly spring up to brush or trees. Such lands are absolute forest lands and should always be devoted to growing timber.

The following paragraphs show the items in the cost of forest management of western white pine, and the returns to be expected under different conditions, thereby indicating under what circumstances forest management is advisable.

#### Gross Returns

Stumpage prices of western white pine at the present time range between $3 and $6 per M., with $4 a representative figure. As compared with that of eastern white pine, this price is very low. Table XXXI gives the average gross returns from pure fully stocked western white pine stands at this price. A good cedar-white pine mixture containing pole size cedar, though containing less volume, will yield as great or even greater money returns, due to the higher stumpage value of the cedar. With the eastern supply of the white pine diminishing and the demand for western species increasing, the price of stumpage seems certain to advance considerably.

TABLE XXXI

GROSS RETURNS PER ACRE FROM PURE
FULLY-STOCKED WESTERN WHITE PINE

At $4 per M. Board Feet for Stumpage

| Age | Gross Returns Per Acre | | |
|---|---|---|---|
| Years | Site I | Site II | Site III |
| 40 | 72 | 44 | 20 |
| 50 | 120 | 88 | 52 |
| 60 | 172 | 128 | 84 |
| 70 | 232 | 172 | 116 |
| 80 | 284 | 212 | 144 |
| 90 | 336 | 252 | 172 |
| 100 | 376 | 284 | 192 |
| 110 | 416 | 312 | 212 |
| 120 | 448 | 336 | 228 |
| 130 | 480 | 360 | 240 |
| 140 | 512 | 384 | 252 |
| 150 | 540 | 404 | 268 |

## Costs of Growing the Timber

### Land values

And land which is devoted to forest management must yield interest or rental on its value equivalent at least to the returns which could be received if given over to other uses, or its use for forestry cannot be considered financially warranted. The value of land may be considered from the standpoint of selling price, of cost, of assessed valuation for purposes of taxation, or of productive capacity (expectation value).

But the values of western white pine lands from any of these standpoints at the present time are either very diverse or not satisfactorily established. Absolute forest lands have practically no sale value. Even cutover stump lands suitable for agriculture are not much in demand at present. Those which are sold bring from almost nothing up to as high as $15.00 or more per acre.

The cost value of white pine lands is in general, as low or lower than the sale value. Most of those belonging to the federal and state governments were obtained without financial cost. The same is true of a large portion of the private lands, since they were purchased on the basis of the standing timber and no charge was made for title to the land itself.

The valuation placed upon the land for purposes of taxation is supposed to equal its sale value. Cutover and burned over timber lands in 1915 were assessed from $2 per acre in one county (Shoshone) to $8 per acre in another (Bonner), the average in the white pine belt of Idaho being $5.50. These figures are not representative for the white pine type as a whole, however, since the lands now cutover are for the most part the more accessible and fairly level valley lands, some of which are in pasture or otherwise partly improved. A liberal figure for the average valuation under the present system of taxation is $2.50 per acre for the absolute forest lands of the mountain slopes and $5.00 for the better quality lands of more or less agricultural value.

The soil expectation value or the value of the land on the basis of what timber it will produce cannot be definitely determined with the unstable market conditions prevailing at present. Before it can be computed it is necessary to know what the stumpage will bring at the maturity of the stand.

Formation

The cost of formation of the stand, or in other words, of stocking the land with its full quota of young trees, can be kept within fairly narrow limits. By most fully utilizing the advance growth and seed in the soil, and not leaving any investment in seed trees of merchantable value, it is often possible to restock a white pine stand for as little as $1 per acre. Nearly always the seed on the ground can be depended on to furnish a part of the stand. But even areas wholly denuded and upon which no natural reproduction can be secured can be completely planted up with thrifty nursery stock at a cost which need not exceed $6 per acre. The latter figure therefore may be considered the maximum cost required for formation of a complete new stand.

Protection and Administration

Under this head are embraced the annual expenses of caring for the forest. This factor of cost has varied much in the past due to unperfected protective systems. During a moderate Idaho season, such as that of 1913, efficient protection either by Government or private associations has cost but about 1½¢ per acre for the gross acres protected. Even during 1914, the driest season in North Idaho since forest protection has been attempted, the average cost of protection was not disproportionately large. It is true the assessments for fire-fighting amounted to 25¢ per acre for one or two associations on whose lands disastrous fires occurred, and on the Clearwater Forest the cost was as high as 13¢, nevertheless, for the twenty three million acres of National Forest which encompass the white pine belt in Montana and North Idaho expenditures averaged only 4½¢ per acre, and for the unalienated portion of the Coeur d'Alene Forest alone, where the fire hazard that year, as always, was particularly great, but where a fairly thorough protective system was in operation, the cost was less than 3¢ per acre. Five cents is therefore a conservative yet ample figure for this average annual expense, over a long term of years.

Taxation

Taxation is not a factor of cost in federal or state property except in so far as the Government is deprived of the revenue which the property would yield by taxation if in private hands; but it is a relatively heavy item in the expense of raising private forests. It

is separable into taxes on land and taxes on timber. In predicting taxation costs, below, the tax on timber is assumed to be applied only after the crop has a distinct merchantable value, and is based of course on its yield and stumpage value. The stumpage value assumed for each ten year period is based on the yield at the beginning of the decade. The tax rate* is assumed to be 10 mills.

## Net Returns

### Federal and State Forestry

Since returns on an investment in forests cannot be collected until after the lapse of many years, they represent compound rather than simple interest. There are several methods that can be used to estimate them. One way is to choose the rate of interest to be earned, (such as that at which the owner can borrow money) and compare the added returns or premium (above the amount of that rate) which can be obtained at different ages. Table XXXII shows the amounts to which each $1 invested in land or formation of stand, or to which each 1¢ expense for protection and administration, will accumulate at different ages, at 3%, 5%, and 6% compound interest. The total amount of all costs at 3% and 4% compound interest, from fully stocked western white pine stands, under conditions such as prevail in Federal and State forestry, at different ages and under different costs for formation, and corresponding premium or additional profit which can be earned by each site, when $4 is received for stumpage, is given in Table XXXIII. It will be noticed that the age which yields the maximum premium (underlined) occurs earlier the poorer the site or the greater the initial investment in formation. Higher receipts for stumpage will largely increase the premiums at each age and cause the maximum to come later. Some of the premiums, especially from older stands, are shown as minus quantities, indicating the profits to be that much less than the amount yielded by the rate of interest used in the calculation.

Another way of finding the profits of forestry is to determine the “forest per cent” which expresses the total profit earned on the investment. Table XXXIV shows this for the same conditions as are illustrated in Table XXXIII. Table XXXV shows the profits on average quality soils, when 5¢ per acre annually is allowed for protection and administration, and when land values are respectively 0, $2.50 and $5.00 per acre. The highest rate of interest it will be noticed can be obtained by cutting at a relatively early age – 40 to 60 years. But even for long rotations, the income to the government is much higher than would be secured if the land were privately owned and depended upon to yield an income to the state through taxation.

Tables XXXIII, XXXIV and XXXV, then, indicate the profits to be expected in State and Federal forestry should stumpage prices remain as at present. It is plain that an investment in forestry is bound to be remunerative even under present economic conditions, and since stumpage prices are almost sure to rise, for newly established stands still greater profits are promised.

---

* Present tax rates in N. Idaho vary widely in different counties from year to year. The state and county levy in 1915 ranged from 9.7 mills for Latah Co. to 25.32 mills in Clearwater Co. and averaged 13.5 mills for the several white pine counties. In addition each road or school district may levy special taxes to a maximum of 12½ mills.

TABLE XXXII

RATE OF COMPOUND INTEREST ACCUMULATIONS
ON
ITEMS OF COST IN RAISING WESTERN WHITE PINE
(Not Including Taxation)

| Age Years | Interest on Each $1.00 Land Value | Accumulated Cost of Formation for Each $1 Expended | Protection & Administration for Each 1¢ Annual Exp. | Interest on Each $1.00 Land Value | Accumulated Cost of Formation for Each $1 Expended | Protection & Administration for Each 1¢ Annual Exp. |
|---|---|---|---|---|---|---|
| | Compound Interest 3% | | | Compound Interest 4% | | |
| 40 | 2.26 | 3.26 | 0.75 | 3.80 | 4.80 | 0.95 |
| 50 | 3.38 | 4.38 | 1.13 | 6.11 | 7.11 | 1.53 |
| 60 | 4.89 | 5.89 | 1.63 | 9.52 | 10.52 | 2.38 |
| 70 | 6.92 | 7.92 | 2.31 | 14.57 | 15.57 | 3.64 |
| 80 | 9.64 | 10.64 | 3.21 | 22.05 | 23.05 | 5.51 |
| 90 | 13.30 | 14.30 | 4.43 | 33.12 | 34.12 | 8.28 |
| 100 | 18.22 | 19.22 | 6.07 | 49.50 | 50.50 | 12.38 |
| 110 | 24.83 | 25.83 | 8.28 | 73.76 | 74.76 | 18.44 |
| 120 | 33.71 | 34.71 | 11.24 | 109.66 | 110.66 | 27.41 |
| 130 | 45.65 | 46.65 | 15.22 | 162.81 | 163.81 | 40.70 |
| 140 | 61.69 | 62.69 | 20.56 | 241.47 | 242.47 | 60.37 |
| 150 | 83.25 | 84.25 | 27.75 | 357.92 | 358.92 | 189.48 |
| | Compound Interest 5% | | | Compound Interest 6% | | |
| 40 | 6.04 | 7.04 | 1.21 | 9.29 | 10.29 | 1.55 |
| 50 | 10.47 | 11.47 | 2.09 | 17.42 | 18.42 | 2.90 |
| 60 | 17.68 | 18.68 | 3.54 | 31.99 | 32.99 | 5.33 |
| 70 | 29.43 | 30.43 | 5.89 | 58.08 | 59.08 | 9.68 |
| 80 | 48.56 | 49.56 | 9.71 | 104.90 | 105.90 | 17.48 |
| 90 | 79.73 | 80.73 | 15.95 | 188.63 | 189.63 | 31.44 |
| 100 | 130.50 | 131.50 | 26.10 | 338.60 | 339.60 | 56.43 |

TABLE XXXIII

ACCUMULATION OF COMPOUND INTEREST ON THE COSTS AND ADDITIONAL PREMIUMS EARNED IN FEDERAL OR STATE FORESTS
By Fully Stocked Western White Pine at $4.00 per M. Stumpage
(Costs include 3¢ per acre annual for current expenses, and the amt.
indicated below for formation, but no cost for land and no taxes.)

| Length of Rotation Years | Formation $6 per Acre | | | | Formation $3 per Acre | | | | Formation $1 per Acre | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Costs Plus Interest | Premium | | | Costs Plus Interest | Premium | | | Costs Plus Interest | Premium | | |
| | | Site I | Site II | Site III | | Site I | Site II | Site III | | Site I | Site II | Site III |
| Computed as a 3% Investment | | | | | | | | | | | | |
| 40 | 21.81 | 50.19 | 22.19 | -1.81 | 12.03 | 59.97 | 31.97 | 7.97 | 5.51 | 66.49 | 38.49 | 14.49 |
| 50 | 29.67 | 90.33 | 58.33 | 22.33 | 16.53 | 103.47 | 71.47 | 35.47 | 7.77 | 112.23 | 80.23 | 44.23 |
| 60 | 40.23 | 131.77 | 87.77 | 43.77 | 22.56 | 149.44 | 105.44 | 61.44 | 10.78 | 161.22 | 117.22 | 73.22 |
| 70 | 54.45 | 177.55 | 117.55 | 61.55 | 30.69 | 201.31 | 141.31 | 85.31 | 14.85 | 217.15 | 157.15 | 101.15 |
| 80 | 73.47 | 210.53 | 138.53 | 70.53 | 41.55 | 242.45 | 170.45 | 102.45 | 20.27 | 263.73 | 191.73 | 123.73 |
| 90 | 99.09 | 236.91 | 152.91 | 72.91 | 56.19 | 279.81 | 195.81 | 115.81 | 27.60 | 308.40 | 224.40 | 144.40 |
| 100 | 133.53 | 242.47 | 150.47 | 58.47 | 75.87 | 300.13 | 208.13 | 116.13 | 37.43 | 338.57 | 246.57 | 154.57 |
| 110 | 179.82 | 236.08 | 132.18 | 32.18 | 102.33 | 313.82 | 209.67 | 109.67 | 50.67 | 365.33 | 261.33 | 161.33 |
| 120 | 241.98 | 206.02 | 94.02 | -13.98 | 137.85 | 310.15 | 198.85 | 90.15 | 68.43 | 379.57 | 267.57 | 159.57 |
| 130 | 325.56 | 154.44 | 34.44 | -85.56 | 185.61 | 294.39 | 144.39 | 54.39 | 92.30 | 387.70 | 267.70 | 147.70 |
| 140 | 457.82 | 74.18 | -51.82 | -185.82 | 249.75 | 262.25 | 136.75 | 2.25 | 124.37 | 387.63 | 261.63 | 127.63 |
| 150 | 588.75 | -48.75 | -184.75 | -324.75 | 366.00 | 204.00 | 68.00 | -72.00 | 167.50 | 372.50 | 237.50 | 96.50 |
| Computed as a 4% Investment | | | | | | | | | | | | |
| 40 | 31.65 | 40.35 | 12.35 | -11.65 | 17.25 | 54.75 | 26.75 | 2.75 | 7.65 | 64.35 | 36.35 | 12.35 |
| 50 | 47.25 | 72.75 | 40.75 | 4.75 | 25.92 | 94.08 | 62.08 | 26.08 | 11.70 | 108.30 | 76.30 | 40.30 |
| 60 | 70.26 | 101.74 | 57.74 | 13.74 | 38.70 | 133.30 | 89.30 | 45.30 | 17.66 | 154.34 | 110.36 | 66.36 |
| 70 | 104.34 | 127.66 | 67.66 | 11.66 | 57.63 | 174.37 | 114.37 | 58.37 | 26.49 | 205.51 | 145.51 | 89.51 |
| 80 | 154.83 | 129.17 | 57.17 | -10.83 | 85.68 | 198.32 | 126.32 | 58.32 | 39.58 | 244.42 | 172.42 | 104.42 |
| 90 | 229.56 | 106.44 | 22.44 | -57.56 | 127.20 | 208.80 | 124.80 | 44.80 | 58.96 | 277.04 | 193.04 | 113.04 |
| 100 | 340.14 | 35.86 | -56.14 | -148.14 | 188.64 | 187.36 | 95.36 | 3.36 | 87.64 | 288.36 | 196.36 | 104.36 |
| 110 | 503.88 | -87.88 | -191.88 | -391.88 | 280.50 | 135.40 | 31.40 | -88.60 | 130.08 | 285.92 | 181.92 | 81.92 |
| 120 | 746.19 | -298.19 | -410.19 | -518.19 | 414.21 | 33.79 | -102.21 | -202.21 | 192.89 | 255.11 | 143.11 | 35.11 |
| 130 | 1104.96 | -624.96 | -744.96 | -864.96 | 613.53 | -133.53 | -277.53 | -385.53 | 285.91 | 194.09 | 74.09 | -45.91 |

TABLE XXXIV

** PERCENT PROFIT EARNED IN FEDERAL OR STATE FORESTRY
AT DIFFERENT ROTATIONS AND ON $6, $3, & $1 INVESTMENT IN FORMATION

At $4.00 stumpage
by western white pine, fully-stocked on all sites
and not subject to taxation

| Length of Rotation Years | Compound Interest Earned when Investment per Acre is: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *$6.00 - Formation .03 - Annual Expense | | | *$3.00 - Formation .03 - Annual Expense | | | *$1.00 - Formation .03 - Annual Expense | | |
| | Site I | Site II | Site III | Site I | Site II | Site III | Site I | Site II | Site III |
| 40 | 6.3 | 4.9 | 2.8 | 8.0 | 6.6 | 4.4 | 10.7 | 9.2 | 6.8 |
| 50 | 6.0 | 5.3 | 4.2 | 7.5 | 6.8 | 5.5 | 9.45 | 8.6 | 7.5 |
| 60 | 5.6 | 5.1 | 4.3 | 6.8 | 6.2 | 5.4 | 8.5 | 7.8 | 7.0 |
| 70 | 5.2 | 4.8 | 4.2 | 6.2 | 5.8 | 5.1 | 7.35 | 7.1 | 6.4 |
| 80 | 4.8 | 4.4 | 3.9 | 5.7 | 5.3 | 4.7 | 6.8 | 6.4 | 5.9 |
| 90 | 4.5 | 4.1 | 3.6 | 5.2 | 4.9 | 4.4 | 6.3 | 5.8 | 5.4 |
| 100 | 4.1 | 3.7 | 3.4 | 4.8 | 4.5 | 4.0 | 5.5 | 5.2 | 4.9 |
| 110 | 3.8 | 3.5 | 3.2 | 4.5 | 4.1 | 3.6 | 5.1 | 4.9 | 4.5 |
| 120 | 3.5 | 3.2 | 2.9 | 4.2 | 3.7 | 3.4 | 4.8 | 4.6 | 4.2 |
| 130 | 3.2 | 3.0 | 2.6 | 3.7 | 3.5 | 3.2 | 4.6 | 4.3 | 3.8 |

** Rate of compound interest earned on both initial and current costs and determined graphically by curving the profits and losses found by computing initial and annual expenses at several fixed rates of interest, as described by Mr. W. B. Barrows in the Proceedings of the Society of American Foresters, Vol. 8, No. 3, p 362.

* With the same total investment, but with soil value substituted wholly or in part for the cost of formation, the interest earned will increase slightly, but usually less than 1/10 of 1%.

TABLE XXXV

PER CENT PROFIT EARNED IN FEDERAL OR STATE FORESTRY
AT DIFFERENT ROTATIONS, COSTS OF LAND & FORMATION,
NOT TAXED, & .05 ANNUAL EXPENSE

by Western white pine, fully-stocked, on Site II
$4.00 stumpage

| | Investment per Acre | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cost of Land | --- | --- | --- | 2.50 | 2.50 | 2.50 | 5.00 | 5.00 | 5.00 |
| Cost of Formation | 1.00 | 3.00 | 6.00 | 1.00 | 3.00 | 6.00 | 1.00 | 3.00 | 6.00 |
| Annual Expense | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| Rotation Years | Compound Interest Earned | | | | | | | | |
| 40 | 8.6 | 6.3 | 4.7 | 6.1 | 5.0 | 4.0 | 5.0 | 4.3 | 3.6 |
| 50 | 8.4 | 6.4 | 5.2 | 6.5 | 5.5 | 4.6 | 5.3 | 4.8 | 4.2 |
| 60 | 7.5 | 6.0 | 5.0 | 5.8 | 5.1 | 4.5 | 5.0 | 4.6 | 4.1 |
| 70 | 6.8 | 5.6 | 4.7 | 5.4 | 4.8 | 4.2 | 4.7 | 4.3 | 3.9 |
| 80 | 6.1 | 5.1 | 4.3 | 4.95 | 4.4 | 3.9 | 4.3 | 3.95 | 3.7 |
| 90 | 5.6 | 4.7 | 4.0 | 4.6 | 4.1 | 3.6 | 4.1 | 3.7 | 3.4 |
| 100 | 5.1 | 4.4 | 3.7 | 4.2 | 3.8 | 3.3 | 3.7 | 3.4 | 3.2 |
| 110 | 4.7 | 4.0 | 3.5 | 3.9 | 3.6 | 3.2 | 3.5 | 3.3 | 3.0 |
| 120 | 4.4 | 3.7 | 3.2 | 3.6 | 3.3 | 3.0 | 3.3 | 3.0 | 2.8 |
| 130 | 4.0 | 3.4 | 3.0 | 3.4 | 3.1 | 2.8 | 3.0 | 2.8 | 2.6 |

Note: Profit determined as explained in footnote to Table XXXIV.

## Private Forestry

In figuring returns from private forestry the additional cost of taxation must be considered. Private owners also usually demand a higher rate of interest on their money because it costs them more to borrow. The rate at which annual expenditures for taxes increase at compound interest is computed at 5% and 6% for ages 40 to 80 years, separately for the land and timber, in Table XXXVI. These increased costs decrease the length of rotation which is profitable. The rotation of greatest profit is in most cases approximately 50 years. Since the gross returns from a fully stocked stand remain the same no matter what the expense of establishing and caring for the stand, it follows that the greater the amount invested in costs the lower the rate of interest earned. Table XXXVII shows this profit from 50 year stands under private management, and how it is affected adversely by increasing the initial investment, or favorably by higher stumpage prices. It will be noticed that over 6% interest is earned when the investment is $3 or less, even at present stumpage prices. With the practical certainty of higher stumpage at maturity the investment in cost of formation or in land can be correspondingly increased and a fair profit assured.

TABLE 36

RATE OF ACCUMULATION
OF LAND AND TIMBER TAXES AT COMPOUND INTEREST

Rate of 1% on Full Valuation

| Age Years | Land taxes for each $1 valuation | *Taxes on full yield per acre of timber for each $4 per M. stumpage value | | |
|---|---|---|---|---|
| | | Site I | Site II | Site III |
| At 5% Compound Interest | | | | |
| 40 | 1.21 | 4.02 | 0.75 | 0.20 |
| 50 | 2.09 | 15.61 | 6.77 | 2.52 |
| 60 | 3.54 | 40.50 | 21.83 | 10.66 |
| 70 | 5.89 | 87.48 | 51.63 | 27.83 |
| 80 | 9.71 | 171.72 | 105.62 | 61.57 |
| At 6% Compound Interest | | | | |
| 40 | 1.55 | 4.22 | 0.79 | 0.20 |
| 50 | 2.91 | 17.05 | 7.22 | 2.64 |
| 60 | 5.33 | 46.37 | 24.25 | 11.58 |
| 70 | 9.68 | 105.75 | 58.30 | 31.85 |
| 80 | 17.48 | 219.65 | 124.40 | 72.40 |

* The yield at the beginning of each decade is used as the basis of the taxation for the succeeding ten years.

---

## OBJECT AND ROTATION

The length of rotation, or period during which a stand should be allowed to grow and occupy the ground before being cut and replaced by a new stand, depends on the object of management; the latter differs with ownership. The aim of Federal or State forestry should be primarily to produce timber for the needs of the community, in accordance with market demands, since the prosperity of the body politic is the ultimate aim of its government. To this the aim of highest financial returns to the soil owner is subordinate. Since the production of timber is the main object, the rotation should be that which supplies the largest increment provided the quality produced is what the market requires.

TABLE 37

*PER CENT PROFIT EARNED IN PRIVATE FORESTRY IN FIFTY YEARS

FROM $1 TO $16 INITIAL INVESTMENT AND WITH $4, $8 & $12 STUMPAGE

BY WESTERN WHITE PINE, FULLY STOCKED, ON SITE II

---

after deducting accumulated annual expense of 3¢ for protection
and taxes at 1% rate, plus 6% compound interest.

| **Initial Investment per Acre | Compound interest earned when stumpage brings | | |
|---|---|---|---|
| | $4.00 | $8.00 | $12.00 |
| 1 | 8.25% | 10.3% | 13.5% |
| 2 | 7.0 | 8.8 | 9.8 |
| 3 | 6.2 | 7.9 | 8.9 |
| 4 | 5.6 | 7.3 | 8.3 |
| 5 | 5.1 | 6.8 | 7.8 |
| 6 | 4.7 | 6.4 | 7.4 |
| 7 | 4.4 | 6.1 | 7.1 |
| 8 | 4.05 | 5.8 | 6.85 |
| 9 | 3.8 | 5.6 | 6.6 |
| 10 | 3.55 | 5.35 | 6.4 |
| 11 | 3.3 | 5.25 | 6.25 |
| 12 | 3.1 | 4.95 | 5.95 |
| 13 | 2.9 | 4.8 | 5.8 |
| 14 | 2.7 | 4.65 | 5.6 |
| 15 | 2.5 | 4.5 | 5.45 |
| 16 | 2.35 | 4.4 | 5.3 |

* Rate of compound interest earned on investment in formation and determined by formula described in Proceedings of Society of American Foresters, Vol.8. No.3, p 365.
P = 100((((S+L-A)/(L+F))^-n)-1)

**This investment is computed as the cost of formation of the stand. If a portion of this capital represents the cost of the land, the returns are slightly greater.

The highest mean annual volume production is shown by Table XXIX and Fig. VIII to be between 100 and 110 years.

The present quality demand can be best determined by comparing average prices received for the mill-run produce from different aged timber. Table E and Fig. XV(2) (Appendix Part I) show that the mill-run value of lumber from 1000 feet of sound western white pine logs is considerably greater for the smaller logs scaling less than 100 board feet and especially for those scaling 50 feet or less than that from logs of an intermediate size. This is due in part to a relatively high mill-run value per 1000 board feet of lumber for those small sizes which contain the highest percent of No. 1 Common (Table E and Fig. XV(1)), but in greater part to the larger overrun, or yield of lumber above the scale which the log rule indicates, for the smaller logs (Table C, and Figs. 9 and 14). Logs of these smaller sizes come chiefly from stands 80 to 140 years old. Logs of the highest value, containing about 50 board feet are approximately the average size produced from 100 year stands. Stands whose logs average the intermediate sizes, between 100 to 300 feet, are as a rule over 140 years old, and logs of an average size great enough to exceed the value of the small logs, 350 feet or more, usually come from stands 250 to 400 years old. This is altogether too great an age to consume in growing a timber crop. Greater scarcity of high quality lumber will probably increase the demand for such large timber in the future, but even in that case the increased cost of growing it must greatly exceed the gain in value over that of the small sizes. Hence, in planning for the second cutting for this higher quality only a relatively small proportion of the trees of a forest; those, for example, which are of little value at the first cutting, or which can serve some other valuable purpose such as for seed trees.

Since it appears that greater value can be secured from the smaller 100 year old timber than from any stand of greater age which it is practicable to grow, even tho the logs are sound in both instances, it is manifest that the increasingly greater percentage of decay and other cull conditions present in the older stands still further increases the relative value of the smaller timber. For cull diminishes both quality and quantity. Furthermore, there is danger of the quantity being still further reduced, owing to the continually increasing danger from insects, fire or some other destructive influence.

The 100 to 110 year rotation therefore, is in general most desirable, both from a quality and quantity standpoint.

Private forestry necessarily aims for the greater financial returns and therefore will use the shortest rotation which can supply marketable products. Fifty year old white pine yields lumber suitable for the manufacture of matches and boxes, and with a uniform stumpage price for all ages and fifty year stands will yield highest returns. An increase in prices, or a relatively higher price for the larger size material may lengthen the rotation for which the most profitable returns can be secured, but in private management it will always be relatively short.

## CHOICE OF SPECIES

For long rotations or 100 years or more pure stands of western white pine are inadvisable, since judicious mixtures will decrease liability to injury and produce a higher quality of material without – if proper care is taken – any material lessening of yield.

The most valuable associate, as previously explained, is western red cedar, which should always be an important component of the stand on moist soils and at moderate elevations. How cedar reduces the damage from injurious influences, and how, thru its habit of forming a lower story, it not only assists in the pruning and therefore in the improvement of the quality of the white pine, but also produces an added yield of decided value, has been shown. More than this, by bringing about ideal forest conditions, cedar exercises a very beneficial influence on the rate of growth of the white pine.

Western larch is also important. It is of even greater value than cedar in reducing damage from injurious influences, for it is resistant to fire while cedar is not. Even in young stands 20 years old the larch will often survive a fire which has killed other species. It, therefore, should be present in every stand as an insurance against total loss in case of fire. The greatest usefulness of larch, however, is during the life of the stand. Since the presence of over 25% at maturity means a somewhat lessened yield, the aim should usually be to have any larch above that proportion suppressed by the white pine, if possible, or removed by the later thinnings, provided the white pine can utilize its crown space.

Larch and cedar, then, are the two associates to be encouraged on all white pine sites where they will grow, and that is throughout the larger part of the Idaho White Pine Belt.

On slopes too high or dry for cedar, grand fir (*Abies grandis*) is the best substitute to associate with white pine, provided it is not badly defective on that site. The chief enemies of each species (save fire) do not seriously both [bother?] the other, the yields of each species are high, and grand fir exercises the same beneficial influences on white pine that cedar does although to a less extent. The wood is useful for paper pulp and structural purposes and supplies a considerable market demand.

On cold wet sites, and especially above 4000 feet elevation Engelmann spruce is a desirable and effective substitute for the grand fir and cedar. The wood is valuable for lumber and for pulp. On the sites mentioned, it is more apt to be thrifty and make successful growth than either grand fir or cedar, or even than white pine itself. Hence, to insure successful stocking the spruce should always be provided for in the regeneration.

Western yellow pine is a desirable substitute for larch especially at the lower limits of the type, on south slopes or shallow soils where larch does not thrive. The hardy yellow pine will insure the stand against failure through drought, and with its excellent fire and disease-resisting qualities, against serious later injuries, practically as well as larch. The high intrinsic value of the yellow pine for lumber makes it even more valuable as insurance. If the white pine dies from any reason the yellow pine is there to take its place; on the other hand, if the white pine survives and makes vigorous growth, it will overtop and suppress the yellow pine, forming a pure white pine stand.

Douglas fir is a very strong durable wood. But, except for mining purposes, its market value in the Inland Empire is only fair, not exceeding that of western larch. In that region, too, it is not of very great value for fire insurance, nor is it ever perceptably [sic] better than white pine for improving silvicultural conditions. Hence, in view of its extraordinary susceptibility to diseases, which are injurious to its associates as well and in view of its consequent tendency to die before reaching merchantability, there is no good reason for encouraging this species as an associate of white pine. On the contrary it should be discouraged as much as possible. Either yellow pine, larch, grand fir, or spruce, in their several preferred sites, are effective and desirable substitutes. Because Douglas fir throughout this region tends to occur abundantly and frequently to form pure stands on sites adjoining the typical white pine sites, it will always be present in white pine stands to a greater or less extent. But pure white pine stands as a rule are preferable to mixtures with Douglas fir. Hence, the latter should be encouraged only on those sites on which it is doubtful if white pine will succeed, and on which it is impracticable to propagate the more desirable substitutes, as for example, on shallow-soiled south slopes where natural reproduction must be depended on and where there is insufficient yellow pine, grand fir and white pine for seed trees.

Of the undesirable associates, western hemlock is the most decidedly and universally so, because of its low yield and tendency to defectiveness, and because wherever it grows the valuable cedar can grow instead. White fir when customarily defective, as it frequently is at low elevations, is equally undesirable.

In the shorter rotations of 70 years or less, little gain in quality can be attained by propagating special mixtures with that end in view. Moreover, as a rule, the rotation is too short to produce merchantable cedar. Hence, since maximum volume is the only object, the main attempt should be to reproduce pure widely spaced white pine stands. However, mixtures with white fir or Engelmann spruce will still yield good returns on their respective favorite sites, and may be especially encouraged when a good market is promised for their products.

In order to attain the end for which the mixtures are designed, it is essential that the several species be thoroughly intermingled. For example, on a white pine, cedar and larch plantation the best protection from injurious influences, the ultimate complete suppression of the larch, and the best development of the two storied white pine – cedar forest can only be attained {theoretically} when each of the three species is surrounded equally by the other two and its roots or crown does not come in contact with other trees of its own kind. This is accomplished in this case by spacing in equilateral triangles, with one species at each apex. A distance of nine feet between the trees gives 620 trees per acre, or 207 of each species, less than would be required to secure similar results by any other method.

This ideal composition is more difficult of attainment where natural regeneration is practiced. However, if provision for reseeding does not include each species in its proper proportion the additional species required may of course be introduced by planting.

## IMPROVEMENT THINNING

Most of the cuttings in western white pine stands, below the rotation age, will fall in this class. Such a thinning consists in the removal of a portion of the trees with the object of improving the stand, without inviting reproduction. In general, thinnings are not warranted until returns from the sale of the material taken out is equivalent to or greater than the cost of the operation. This will at present confine the operations chiefly to stands nearly mature and principally to the larger trees of the stand. It is often possible to make thinnings in this class of material when the stand is included within or adjoins an area of older timber to be logged, or when the stand is accessible to a good market for some special product. Under such circumstances, for example, Douglas fir, larch or hemlock may be used for cross-tie or mine timbers, spruce and white fir and white pine for pulp wood, lumber and box boards, and all species for cord-wood.

The primary aim of a thinning should be to encourage maximum growth and best quality in the forest, just as far as the material which it is advisable to remove can be utilized. By the French method, which is the system of thinning most practicable of application, the dominant stand is thinned out in such a way as to favor the growth and development of just enough desirable individuals to form the final dominant stand at maturity. It should be the aim to reserve for this purpose from 200 to 300 trees per acre of the most valuable species and the best form, with straight and well pruned trunks and with thrifty, well-developed and well spaced crowns, whether of the intermediate, codominant or dominant classes. The remainder of the dominant stand, including especially all ill formed, defective trees, and all which threaten to crowd the upper crown of the selected trees, should as far as possible be cut. The subordinate stand, with the exception of dying trees, is preferably not cut, since its removal would not assist in the growth of the leaders, and the trees act as a soil cover, preventing excessive drying out, or the growth of grass, brush, or weed species, which is deleterious to the thrift of the stand. If an undergrowth of cedar or other desirable tolerant species is present, the stand may be thinned more heavily and large openings made without this danger, since these species make rapid growth with the increased light and quickly shade the soil. Promising young cedars may be especially favored so as to produce poles by opening the overhead canopy more than under ordinary circumstances. But should the tolerant species be undesirable for the next rotation care should be taken not to favor their regeneration and growth to such an extent as to endanger or diminish the reproduction of desirable species after the final cutting. In any thinning operation where practical logging requirements make it necessary to thin a stand so severely as to cause large openings, reproduction should be aimed for by one of the systems of final cutting.

In general, the earlier thinnings can be practiced, the better the results secured. To be very beneficial, they must be made before the crowns of the trees to be left become very small or very short; otherwise the trees cannot respond to the improved light conditions. In the very evenly developed and badly over-crowded stands which sometimes occur, if good yields are to be obtained, thinnings are required in order to overcome the retardation of growth. In such cases, thinnings are desirable even where no immediate returns from them can be secured.

## FINAL CUTTING AND REFORESTATION

Where forestry is practiced, any harvesting of timber crops must consider the effect on the future forest. If the cutting, even tho only partial, brings about the reproduction of a new growth, it is a reproduction cutting; if not it is in reality a thinning.

In former efforts at cutting western white pine so as to secure the best natural reproduction, the selection system and not less than four of the clear-cutting systems have been more or less roughly attempted. Much has been learned from this experience, one of the most important being that while many of the systems have some good points, no one is universally applicable to the numerous site and stand conditions of the western white pine type. Besides the points to be kept in mind in regard to choice of species, (Page 161 [97]), other salient facts brought out previously in the discussion of "The Tree & The Stand" have a decided influence upon the wise choice of a silvicultural system and its application to a specific stand.

## SCIENTIFIC FACTS AFFECTING CHOICE AND APPLICATION OF A SILVICULTURAL SYSTEM

(1) Seed of a quantity ample for good regeneration, the result of seed crops from one to five years previously, is nearly always present on the ground for some distance around each seed bearing white pine tree.

(2) About 10 percent of the white pine seed will sprout in a heavy shade, but the bulk of the seed requires considerable light before it will germinate.

(3) Heavy shade not only prevents the germination of the larger part of the seed, but prevents the growth and ultimately kills many of the seedlings which do germinate. The extent to which this occurs depends on the density of the shade, 50% to 100% unobstructed overhead light being necessary for even moderate growth. Whether the shade is cast by seedlings, underbrush or by mature trees, makes relatively little difference.

(4) Even scattered or solitary specimens, large seedlings or saplings, of the tolerant heavy crowned species, by developing into broad spreading and relatively worthless wolf trees, will interfere seriously with the growth of the new stand, and largely cut down the yield.

(5) Under good conditions of light and moisture, the heaviest germination takes place the second season after the seed ripens, altho some occurs the first, third and fourth seasons.

(6) The number of seedlings per acre resulting from stored seed depends upon:

   a. The quantity of seed stored (largely dependent upon the distribution of seed-bearing white pines in the original stand)
   b. The amount of light admitted to the ground.

(7) White pine regeneration from seed stored in the duff, supplemented by any advance growth which may happen to be present, is more certain, more

complete and two or more years earlier than that from seed maturing after the cutting of seed trees or adjoining stand.

(8) White pine must be given at least an equal start with other species, and full overhead light, if it is expected to form the major part of the dominant stand.

(9) Western white pine is quite as windfirm as its more windfirm associates. It stands particularly well on deep-soiled mountain slopes and ridges (Table XXXVIII) but on soft alluvial bottoms, and on exposed shallow slopes (which sites however are usually not occupied by white pine) considerable windfall may be expected.

(10) Size is no indication of age of white pine trees, especially in crowded stands.

(11) White pine under 150 years of age which has been long suppressed in crowded stands will make greatly increased growth in diameter and volume when the stand is opened up, provided the crown of the tree is still thrifty.

(12) Seed will be distributed in a sufficient amount for reproduction from 3 to 5 chains from a seed tree, depending primarily upon the size of the crown and the tree's strategic location.

(13) White pine is a comparatively light seed producer. One crop from seed trees, even tho a heavy one, cannot be expected to restock the ground.

(14) The presence of certain diseases in severe form make it advisable to eliminate usually the affected trees and frequently the affected species, thus possibly changing the plan which would otherwise be followed.

## The Selection System

Owing to the fact that shade is generally deleterious to the development of western white pine, better growth and higher yields are secured in even-aged stands. The selection system, therefore, should seldom be used. Selection cuttings as a rule, are applied to stands in which all or at least many ages are represented, the largest or most mature trees being picked out and harvested, leaving the balance to grow and seed up the openings.

Many-aged stands of three radically different kinds are found, however, on western white pine sites. They may be stands which have come in very gradually on severe and extensive burns; relatively young, thrifty stands, largely of the more valuable intolerant species. Or they may be examples of the climax type in its earlier or later stages, with white pine and intolerant associates present as aged or decadent veterans, the younger age classes consisting of shade-enduring species. Or they may be stands which have been badly broken by repeated fires, not all-aged but many-aged, with an irregular distribution of age classes and with composition varying anywhere between the extreme light-demanding and extreme shade-enduring species. In the latter kind, the intolerant thick-barked larch or yellow pine are apt to predominate in the older age classes, and the shade-enduring white fir and hemlock in the younger. Whatever the composition, injuries from disease, insects, etc. are apt to be excessive.

TABLE 38

SCATTERED SEED TREES LEFT AFTER CUTTING

Number reserved and Per Cent Surviving Four Years Later.
Per Cent Bearing and Not Bearing Cones in 1913.
Per Cent of Total Number Dying from Each Cause.

Kennedy Sale Area, Coeur d'Alene Forest, Idaho.

| Site | | N. & E. Slopes | | S. & W. Slopes | | Deep-soiled Ridges | | All Sites | |
|---|---|---|---|---|---|---|---|---|---|
| Species | | White Pine | Douglas Fir | White Pine | Douglas Fir** | White Pine | Douglas Fir | White Pine | Douglas Fir |
| | | TREES RESERVED PER ACRE - QUANTITY | | | | | | | |
| Number | | 18.0 | *** | 13.6 | 9.0 | 16.0 | 4.8 | 15.4 | 7.6 |
| Volume Bd. Ft. | | 8240 | *** | 4240 | 1410 | 6740 | 1260 | 5980 | 1360 |
| | | TREES SURVIVING - 1913 - PER CENT | | | | | | | |
| Total | | 92.6 | *** | 83.8 | 66.7 | 82.5 | 58.3 | 86.5 | 65.0 |
| Bearing Cones | | 59.3 | *** | 47.0 | 28.9 | 60.0 | 25.0 | 54.3 | 28.1 |
| Not Bearing | | 33.3 | *** | 36.8 | 37.8 | 22.5 | 33.3 | 32.2 | 36.9 |
| | | DEAD SEED TREES - PER CENT FROM EACH CAUSE | | | | | | | |
| Condition | Cause | | | | | | | | |
| Standing | Brush burning | *** | *** | 1.5 | 6.7 | *** | *** | 0.6 | 5.3 |
| " | Bugs or Fungi | *** | *** | 1.5 | 2.2 | 5.0 | 25.0 | 1.9 | 7.0 |
| Broken | Heart-rot | 1.8 | *** | *** | 2.2 | *** | *** | 0.6 | 1.7 |
| " | *Exposure | *** | *** | 1.5 | 2.2 | *** | *** | 0.6 | 1.7 |
| Uprooted | ***Rot | 5.6 | *** | 5.9 | *** | 2.5 | 8.3 | 4.9 | 1.7 |
| " | *Exposure | *** | *** | 5.9 | 20.0 | 10.0 | 8.3 | 4.9 | 17.5 |
| Total | Down | 7.4 | *** | 13.3 | 24.4 | 12.5 | 16.7 | 11.0 | 22.6 |
| Sound | Trees Down | *** | *** | 7.4 | 22.2 | 10.0 | 8.3 | 5.5 | 19.2 |
| Area of Strips Measured - Acres | | 3.0 | | 5.0 | | 2.5 | | 10.5 | |

*"Exposure" caused by removal of trees close by which largely protected or supported the ones overthrown; trees sound and no other cause apparent.

**"Douglas fir" on S. & W. slopes largely on very shallow soil, hence high per cent overthrown by wind. All white pine and other Douglas fir was on deep soil.

***"Rot" includes decay in either butt or roots, or both, nearly all that in white pine being traceable to catfaces caused by light fire about 50 years before.

In the first cutting made in uneven-aged stands of the western white pine type, the trees were cut to a diameter limit of 18 or 20 inches. This was really only a selection cutting, the bulk of the stand consisting of smaller trees below that size. The trees left were chiefly of the tolerant species, white fir and cedar, and therefore scattered white pine, larch and Douglas-fir of the dominant stand were reserved to encourage reproduction of those species. The leaving of the intolerant seed trees was of course quite ineffective in securing regeneration, because it could not take place in the shade. On the other hand, the result of such practice, in a mixture of tolerant and intolerant species is invariably the gradual elimination of the white pine and its intolerant associates.

Selection stands should ultimately be converted into even-aged stands. In some stands, where the bulk of the timber is merchantable, almost a complete conversion can be made with one heavy cutting. The relatively small material, if promising, can be treated as advance growth and form a part of the next rotation. Very often it will be practicable to remove just the larger, more mature and defective trees at the first cutting and leave the smaller trees to provide for another cutting when they have made sufficient growth, (Thinning or Shelterwood Cutting: q.v.)

## Clear-Cutting Systems

Western white pine stands are adapted to a number of the clear cutting systems. A wise choice depends on composition, site, age, merchantability, health, and general thrift of the stand, at the same time keeping in mind the object to be served, the species to be sought, and the scientific facts previously discussed. For reproduction, dependence is placed either on the seed in the duff, on that distributed from scattered seed trees, reserved standards, scattered groups, blocks or alternate strips; on a shelterwood; or on artificial planting.

Under any system it is obvious that in order to make the system a true clear cutting system and secure good and valuable yields, special pains must be taken to prevent advance growth of the non-productive weed species, such as hemlock, alpine fir, defective grand fir, and, on sites infected with its most destructive diseases, Douglas fir, from taking possession of the site to the exclusion of the productive species. Often it will be possible to eradicate these weeds in burning the slash. At other times special measures, such as cutting or mowing the seedlings or saplings, and girdling the larger trees, must be employed.

### Seed Blocks or Alternate Strips

Adopted originally in the belief that western white pine was {un}usually subject to windfall, that it required a bare mineral soil for germination, and that its seed readily carried to considerable distances, upon refutation these systems have fallen into disuse. The blocks were left on level or gently rolling valley lands. They occupied ¼ to 15 acres, located preferably on prominent points from 200 to 500 feet apart. (Plate XVIII, Fig. 1). The alternate strips were reserved at right angles to contours on steep mountain slopes, 150 feet wide and 300 to 450 feet apart. (Plate XVIII, Fig. 2).

The timber thus reserved comprised from 25 to 35% of the total volume, as far as practicable, of the youngest, thriftiest timber and best species. It was expected that

after regeneration was fully established, possibly not until it began to bear seed, the reserved timber would be taken out in a second cutting. On the areas cut over the weed species were felled and lopped, and the slash was burned broadcast, destroying all advanced growth, whether desirable or not, and the seed-containing duff as well.

While some results may be secured by this method, they are necessarily unsatisfactory because all reliance is placed on succeeding seed crops, the seed must be carried a long distance, and a long time is required for it to reach all portions of the area. Reproduction therefore is very slow and irregular, and in places may never reach the proper density. Moreover, the amount invested in regeneration is quite heavy, and in case it should not be expedient to return for the seed-blocks or seed-strips at a second cutting and they are wholly sacrificed to reproduction, the investment would be far greater than the cost of reforestation by planting. The application of this system is therefore as a rule undesirable.

Blocks or alternate strips may however be advisable occasionally on very exposed, shallow-soiled slopes or moist flats in localities where the danger from windfall is extreme, where seed in the soil cannot be relied upon, and where it is practicable to make two cuttings. When used, the system should be improved by making the clearings not over 150 to 200 feet wide, in order that the reproduction may be sufficiently dense and uniform. It will often be advisable to make an improvement cutting on the reserved areas to remove defective trees which would be apt to deteriorate greatly before the next cutting, or to take out hemlock or other weed species which should be kept from reproducing. The second cutting can be made from 30 to 50 years later, after the reproduction begins to bear seed.

Groups of Seed Trees

After discovering the undesirability of broadcast burning and the shortness of distance to which seed ordinarily is carried, the method of leaving frequent groups was substituted (Plate XIX). Because it has since become known that windfall need not be specially guarded against, groups are now discarded except on pronounced ridges and prominent points where the timber is shorter and smaller than the main body of the stand. Occasionally, however, there are other sites in exceptional danger of windfall, such as some of the highly exposed south and west slopes with shallow soils, or wet flats or draws, where groups are still desirable.

As originally used the groups contained 10 or more trees, placed so as to include clumps of the smaller less merchantable white pine, together with other species most desired in the new stand, and spaced between 3 and 6 chains apart. But in many stands it was difficult to apply because the desired combinations of correct spacing, proper number of trees, desirable species, suitable seed-producers, sanitation, and low market value could not be secured.

When used the groups should be made to include only sound trees of the desirable species. These are far more important factors than spacing or number of trees, since it is much better economy to plant up areas which do not properly reproduce than to eradicate worthless or diseased species, or even to permit them to grow.

Scattered Seed Trees and Reserved Standards

These systems were among the first employed in western white pine stands. They were discarded for a number of years, because on one area on soft alluvial bottom lands the seed trees were badly windthrown. But since such bad results did not follow on the more representative white pine sites (See Table 38), they have again come into use.

Scattered seed trees are left primarily for the purpose of producing seed. As a rule economic conditions will not permit them to be utilized later, so they are sacrificed for reproduction. Reserved standards on the other hand are selected to stand through the succeeding rotation. Their purpose is not only to produce seed, but to grow high quality wood for the next cutting (Plates XX & XXI).

The selection of the trees to be left, under either system, requires special care. To make good volume growth, they must have good crowns, fairly long and full, and thrifty, especially at the top. To produce seed abundantly they must also be fairly large, either open-grown, or chosen from the dominant or codominant classes. Suppressed trees, trees with long boles and dwarfed, misshapen crowns, or trees with dying crowns are useless for either seed production or growth. Neither should the crowns be unduly large and heavy, because such trees would yield timber of poor quality, as well as interfere with reproduction. To avoid windfall the trees selected should be standing upright, growing singly rather than in clumps, and perfectly sound, without catfaces, hollow butts, or conchs. To secure proper seed distribution, the seed producers should not be farther apart than the height of the trees.

With the different species, further requirements for good seed trees or reserves vary somewhat. Western larch or yellow pine should be either of the intermediate, or preferably, of the dominant or codominant classes, since it is doubtful if others can recover sufficiently to produce seed or make good growth. Rough barked or conical topped yellow pine or larch are usually younger and more vigorous than the smoother barked trees with irregular crowns, and hence preferable. Cedar just above pole size are more economical than larger or smaller sizes. Other tolerant species may be relatively small, since they recover quickly in growth and seed producing capacity.

The System of Reserved Standards is undoubtedly the system of widest application in the western white pine type. Most white pine stands are under 180 years of age and contain sound, vigorous, well formed and wind-firm trees capable of standing 100 years longer. Very often these trees are of relatively small size, of little present merchantable value. If dependence can be placed on the seed in the duff, the present seed producing capacity of the trees chosen for leaving need not be considered, and these small trees which will make the greatest increase in value may be left. But if additional seed is required, as is usually the case with at least some of the species desired, from two to six trees of that species should be good seed-producers, chosen from the larger, more vigorous crowned trees. More seed producers are required, of course, where they are of small size, where the percentage of trees of desirable species in the stand is relatively low, or where there is danger of the duff being destroyed by fire.

Just how many trees per acre may be reserved without interfering seriously with the growth of the young stand has not been determined. Too many seed trees will cast so much shade and produce so much seed that an extremely dense and badly overcrowded reproduction will be encouraged, growth will be retarded, and the tolerant species favored at the expense of the white pine. (See Table XVII, Part I). From 20 to 50 of all species, depending on size, may not interfere seriously.

The System of Scattered Seed Trees, leaving seed producers which cannot be expected to stand through the next rotation but which must therefore be sacrificed to the securing of reproduction, is more frequently applied to the mixed species than to the white pine.

In the case of the latter species, when the seed trees can not serve the additional purpose of reserves, the common prevalence of seed in the duff usually makes seed trees unnecessary. If sufficient reproduction can be expected from the duff, it is usually cheaper to cut clean and plant than sacrifice large valuable white pine. Large white pines, unmerchantable on account of defect, {and therefore representing no investment,} are sometimes left, but the uncertainty of the trees standing up long, and the increased danger of infecting new stands renders the wisdom of this step questionable. {The consensus of opinion however is that the advantage in seed production will more than offset the danger of infection.}

The desirable mixed species, however, have such low present value that two to six trees per acre may usually be sacrificed without incurring too much investment. Large veteran larch and cedar, especially, maybe of low merchantable value and yet good seed producers.

Clearcutting the Whole Stand

When there are no trees suitable for reserves because of their age, species, or defective condition, and when they are too valuable to be sacrificed as seed-trees; when there are large amounts of weeds, valueless or defective, which can be most economically eradicated by broadcast burning; or, when logging methods prevent leaving trees for seed, clear cutting the whole stand is often advisable. Regeneration then may be secured from advance growth, from seed in the duff, from an adjoining stand, or, natural methods failing, by planting.

Many white pine stands, visited by fire at some time in the past and now defective already have excellent reproduction of desirable species. By logging on the snow, and either burning the slash in piles or leaving it unburned, enough of this advance growth can be preserved to form a new stand.

In other stands with a similar history, or with trees too old and valuable for seed trees or reserves, or where donkey logging is practiced, the only advance growth may be worthless hemlock or other weeds. Still with 30 or 40 white pines per acre there will be enough seed in the duff to provide good regeneration, providing the duff is preserved, the weeds are eradicated and full light admitted. Part of the weeds may be eradicated by burning the piles of slash around or among them, part by slashing with a brush-hook or axe.

When it is impractical to destroy weeds in this way, they may be exterminated by burning the area broadcast with the slash lopped. On small areas within 5 or 6 chains of standing timber, regeneration may be obtained from the adjoining stand. At greater distances planting must be resorted to.

## Shelterwood System

This system contemplates the removal of the stand in two or more cuttings, reproduction being well-established under the shelter of the portion left standing before its final removal. The first cutting is called a partial cutting, the last a final cutting. Several of the conditions prevalent in western white pine stands are best handled under some form of the shelterwood system.

### Two Story Shelterwood

In many white pine stands above the rotation age, while the larger part by volume consists of large merchantable timber, there are yet many good, thrifty trees of relatively small size, between 6 inches and 14 inches or 16 inches diameter, which are of small merchantable value, and which will undoubtedly pay better to leave for future growth. If the number of these trees is less than about 50, they are too few to make a second logging operation profitable so they must be left to the end of the rotation. They are then classed as reserve standards. If they exceed that number they will likely yield enough to make another later cutting profitable. (Fifty trees averaging ten inches in diameter will yield approximately 15,000 board feet 50 years hence.) Unless the partial cutting is so light that it is in reality but an improvement thinning, regeneration will undoubtedly occur and the system is a modified form of the shelterwood – the so called two-story form.

The lower story thus resulting is very apt to be of such extreme density as to stagnate growth, and of the more tolerant and perhaps worthless species. But even should it prove of no market value, as a soil protection it is more or less beneficial to the upper story. At the next cutting it may be destroyed, utilized for minor products, or protected for a later crop as economic and stand conditions may warrant.

### Primitive Shelterwood

On some very dry sites, white pine seedlings in ordinary years stand little chance of survival, unless protected from sun and drought. Here is needed a shelterwood system in which the shelterwood is removed within a very few years after the white pine reproduction is established. Sometimes, where logging operations are carried on from the same camps for several years in succession, it is practicable to take out a stand in two cuttings, two or three years apart. The shelterwood left gives the seedlings which spring up after the first cutting the protection needed to permit them to become firmly established. The extra cost of logging which represents the investment in reproduction, it is estimated would in this case amount to 25¢ to 50¢ per thousand feet.

In this primitive form of the system, the shelterwood should be composed of sound thrifty trees and contain, in addition to white pine, good seed producers of the more drought-resistant species, yellow pine, larch, grand fir, and perhaps a small proportion of Douglas fir, to insure a proper representation of these species in the regeneration. They are especially necessary to fill any blanks in the new stand which might be caused by

failure of the white pine. When not well represented in the reproduction at the final cutting, scattered seed trees of these species should be reserved.

## Practical Application of Cutting Systems

In actual practice conditions on any cutting area are usually so diverse that more than one, perhaps several, of the silvicultural systems must be used. The method used may actually be a mixture, or compromise, of several systems. For example, the seed in the duff is usually the main dependence for regeneration of white pine, and often circumstances make advisable the clearcutting of that species, when, of other species, reserved standards, scattered seed trees, or groups, are provided. Often reserved standards merely supplement the main source of seed supply – the duff – to preclude possible failure. As previously indicated, reserves of the thick-barked larch or yellow pine are especially valuable as an insurance against fire.

In contemplating the adoption of any system, the best policy is always to consider relative cost as well as final results, and balance this against the estimated cost of artificial planting, a method which when properly carried out must give a more satisfactory stand than any natural system.

For the guidance of National Forest officers engaged in directing the application of silvicultural systems to the cutting areas on National Forests, the following marking rules have been adopted. Under the system of cutting previously described, A-1. stands are to be given improvement thinnings (Page 167 [99]); A.2. stands partial cuttings under the two-story shelterwood system (Page 185 [107]); [margin note:] {modified in District Office to accord with change in marking rules} B.1 and B.2 stands are to be clear-cut leaving standards reserved for seed and growth, or in exceptional instances, leaving seed groups. In B.3 stands the white pine is to be clear cut, with no seed trees except where the trees are defective (a provision of questionable safety); but desirable mixed species are to be provided for by seed trees or reserves.

(The chief criticism of the marking rules as they now stand is that the Douglas fir is favored more than it should be, in view of its very great susceptibility to dangerous diseases.)

MARKING RULES FOR STANDS OF THE WESTERN WHITE PINE TYPE
ON THE COEUR D'ALENE NATIONAL FOREST.

October 2, 1916

[Margin note:] {These marking rules changed in wording but not in spirit by the Forester, Dec. 20, 1916.}

Part I.

Classification of Western White Pine Stands.

A. Stands which contain a minimum of about fifty trees per acre, between 6" and 14" D.B.H., thrifty trees suitable to increase in growth after a cutting and excluding Hemlock and defective trees of other species.
    1. Stands which contain practically all trees below 14" D.B.H.
    2. Stands which contain sufficient trees over 14" D.B.H. to justify a logging operation.
B. Stands which contain less than about fifty trees per acre as described above.
    1. In which small trees of desirable species between 6" and 14" D.B.H. occur frequently.
    2. In which there are practically no small trees but in which there are thrifty trees including some White Pine, capable of living through a second rotation.
    3. In which there are no White Pine trees evidently capable of living through a second rotation.

Part II.

Objects of Marking.

A. To secure a second cut from trees already established.
    1. An improvement thinning.
    2. A partial cutting to harvest the merchantable timber and leave a sufficient stand to utilize the productive capacity of the site; and incidentally to secure reproduction in unavoidable openings.
B. To harvest the crop and establish a new stand of White Pine and other desirable species; and incidentally to secure the benefit of increased growth on any trees which may be left.

Part III.

Application to Classified Stands.

A. 1. Improvement thinnings will be made in these stands whenever practicable.
A. 2. In these stands a partial cutting will be made which will leave not less than 50 trees per acre and preferably more. These will include trees 6" D.B.H. and over, exclusive of Hemlock and defective trees. A flexible diameter limit of 14" to 16" will be used as a guide in leaving a sufficient basis for a second cut. Where this will result in leaving less than 6 White Pines per acre, the diameter limit will be raised to provide for at least this number.

B. 1. The merchantable trees will be cut with the primary object of securing reproduction. To supplement the supply of seed in the duff, two to six White Pine trees of seed-bearing size and condition will be left per acre. Also two to six trees per acre, preferably of Larch, or if Larch is not present, of Douglas Fir should be reserved as seed insurance against fire. The number of seed trees will vary inversely as their seed productive capabilities. Two trees 18" or over D.B.H. may be considered the equivalent in seed productive capacity of six trees 12" or 14" D.B.H. As far as possible seed trees should be selected with reference to their windfirmness.

In addition to the prescribed reservation of seed trees, any thrifty White Pines below 14" D.B.H. should be left.

Where it is possible to select groups of short full-crowned trees on ridges, the seed trees on adjoining slopes should be combined in these groups. If the ridges are not pronounced or if there is no marked difference in the timber no attempt should be made to leave the seed trees in groups.

Spruce, White Fir and Hemlock will be cut to the lowest merchantable size. Where cedar is desirable and should be favored, seed trees of this species may be left.

In general, reproduction openings must be at least ¼ acre in extent to be effective. This involves the cutting or killing of all Hemlock, all defective White Fir and trees of any species unmerchantable on account of defect, and the destruction of all thickets of White Fir and Hemlock reproduction which will interfere with White Pine reproduction.

B. 2. These stands will be clean-cut with the reservation of two to six seed trees each of White Pine and Larch or Douglas Fir per acre as specified under B.1.

B. 3. White Pine reproduction will be expected chiefly from seed in the duff. White Pines should be left as seed trees only when they are unmerchantable on account of defect. Further provision for seed production should be made by leaving seed trees of mixed species, giving preference to Larch, Cedar, Spruce and Douglas Fir in the order named.

The ground should be cleared as much as possible of all other trees.

If it proves necessary to plant such areas to secure a good proportion of White Pine in the reproduction, broadcast burning will be employed to dispose of the brush and only Larch seed trees need be left.

## Part IV.

### General Treatment of Associate Species of White Pine

Western Larch and Douglas Fir. On the best white pine sites, larch, because of its relatively higher resistance to diseases over long periods, should be considered more desirable than Douglas Fir, while on the more severe sites, Douglas Fir should be given the preference. These species will be depended upon for seed insurance, and

reservations are to be provided for this purpose. Veteran larch, free from disease but unmerchantable because of wind shake, may be used to fulfill the seed insurance function when other trees are not available.

Hemlock and White Fir. Hemlock and white fir are the least desirable species. It is desirable that they be cut to the lowest merchantable limit and this will be done in reproduction cuttings. All Hemlock and all defective White Fir trees and as much as possible of the reproduction of both species will be burned, slashed or girdled. In partial cuttings and as a rule in B 1 stands, sound, thrifty White Fir above 4" D.B.H. will not be slashed or girdled. In B 2, B 3 and where necessary in B 1 stands also, except where they occur in patches, such trees will be cut or killed when they will interfere with White Pine reproduction.

Western Red Cedar. Cedar should be favored wherever it occurs. Ordinarily all trees which will not make a 30 foot pole should be left and defective, over mature trees, which represent no investment, will frequently be desirable for seed production.

Engelmann Spruce. Spruce should be favored equally with cedar. Grouping of reserved trees is almost always essential for protection against wind, and in general no reservations should be made unless compact groups, of pure or mixed character, are possible. No reservations should be made on wet flats.

Lodgepole Pine. Merchantable lodgepole trees should be cut.

Western Yellow Pine. Where yellow pine occurs it should be favored equally with larch and Douglas Fir. It is particularly desirable on dry sites.

## Part V.

### Application to Specific Stands.

It is the intention of these marking rules to outline general principles and suggestions of broad application, for the guidance of marking officers. Field practice will be carried on under specific rules drawn up for each logging chance based on these type rules. On any logging unit, areas of different classification will usually occur, to each of which the proper marking principles as previously outlined, should be applied. The specific marking rules, and a marking map, showing the application of the rules will be submitted to the approving officer.

## BRUSH DISPOSAL

Both as a general protective measure, and in order to minimize the danger of the reproduction being destroyed by fire, the hazard which in the white pine type usually results from the slash must be reduced to comparative safety by some form of brush disposal. On lands devoted to forestry purposes, the system of brush disposal adopted depends on three considerations:

(1) The extent of fire hazard compatible with safety;
(2) The condition of the cutting area which will best favor the regeneration desired;
(3) The cost.

Ordinarily the fire danger should be reduced to the point where it is at least no greater than that which prevails in the uncut forest. This is usually accomplished by burning the inflammable debris. In some exceptional cases, however, as when the amount removed and consequently the slash to be left is small, it may be permissible to lop and scatter the brush so that it will decay quickly.

To leave a cutting in a condition favorable for regeneration it preferably should be burned over as little as possible, thus preserving the seed in the ground and retaining the humus and moisture conserving duff. However, when an area is covered with a dense seedling growth of weed species burning may be necessary to foster replacement by more desirable species.

The expense of brush disposal is secondary to safety from fire, but is to be considered in connection with the cost of the system chosen for securing reproduction. For instance if the factor of safety is not enhanced it will not pay to use a method of brush disposal which will save the seed in the duff when it would be cheaper to dispose of the brush another way and replant.

### Broadcast Burning

Broadcast burning is the most primitive way to burn brush. And from both the silvicultural and the economical standpoints, it is often the most unsatisfactory. If thoroughly done it burns nearly all the duff, impoverishes the soil, and kills the seed stored thereon. It as a rule cannot be satisfactorily carried on until the material is rather dry. But at such times the woods are apt to be dry also, so that there is danger of the fire escaping and doing much damage.

Burning by this method is generally planned either in the spring before, or in the fall immediately after the danger season, when the chances for escape from control are at a minimum. However, considerable difficulty is involved in selecting a proper time even within these limits. If practiced in early spring while the woods and soil are still damp the burning is merely superficial. The needles and smaller twigs are consumed or charred, but so much inflammable debris still remains on the ground that a second fire even the same season is quite possible. Furthermore this second burning is very apt to take place, since fire may smoulder in hollow or partially decayed stumps or logs for months, invisible until fanned into flame by a severe wind. Many of the most dangerous and destructive forest fires have been started in this way.

This serious result cannot of course happen after a timely fall burning. However, a time favorable to burn in the fall is usually very difficult to decide upon. Before the rainy season begins conditions are so dry that burning is dangerous. After the rains start they may continue so long that burning becomes impossible.

These many considerations make broadcast burning generally inadvisable, and especially where natural regeneration is desired. On forest lands from which undesirable species must be eradicated and on which any other method of eradication is impracticable, the method may have to be resorted to, but even then it should not be attempted unless it can be satisfactorily and safely done.

In burning broadcast thorough precautions are required to prevent a spread of the fire. These are much like the measures commonly used in stopping forest fires, except that because of the much greater hazard of slash over ordinary woods the measures must be intensified. The area to be burnt should be surrounded by a fire-lane cleared of inflammable debris, for a width sufficient to leave a reasonable safety against the spread of the fires: very seldom less than 50 feet wide and generally more, depending on direction of prevailing wind, slope, exposure, fire hazard of adjoining timber, etc. Since there is nearly always danger of fire crossing the fire-lane along roots or under the duff, a trench about two feet in width should be cut to the mineral soil along the outside edge of the fire lane. If the area is large and there is danger of the fire becoming intensely hot similar fire-lanes should be constructed to break the area into smaller units. Within a strip in the neighborhood of 200 feet wide along the exterior boundaries all dead snags over 20 feet or so in height should be felled so that sparks will not be scattered outside the fire-lane. Branches should be lopped from the tops of down trees as far as may be necessary to make them lie flat on the ground and so burn well.

## Windrow Burning

Windrow burning presents some advantages over the broadcast method and is not much more expensive. It is convenient to use in horse logging, for there the slash in swamping operations is generally thrown into rough windrows and it costs but little more to put them in shape to burn well. Good windrows burn more readily and generate more heat than slash scattered broadcast, and therefore can be burned in damper weather. At the same time, when thorough care is exercised the fires are more easily controlled and run over less of the ground.

Nevertheless the method has serious disadvantages. The large size of the individual fires demands special care in setting, to prevent their escape from control. The spots burned are usually too large to permit a good stocking of reproduction from the duff. It is difficult also to protect advance growth and seed trees, because they are most frequently left where the windrows would naturally be thrown.

## Piling and Burning

Piling and burning is in general the most satisfactory method of brush disposal, although its cost is usually higher than that in other methods. If properly piled the slash will be wholly consumed without rehandling; it will also shed considerable rain or snow and so burn readily when the first damp weather of the fall sets in. By the thorough control thus permitted, the fire can be confined to the smallest area, the seed-containing duff, the advance growth, and the seed trees can be well protected, weed trees and

undesirable reproduction can be largely killed, and infections of dangerous fungi can to some extent be combatted. Any further weed trees left may be destroyed by girdling, or by slashing and throwing on the brush piles.

Piling, to be most efficient and economical, requires that as a rule slash be handled but once and therefore that it be done in connection with the swamping. Good swampers can be trained to properly pile the slash they handle instead of tossing it indiscriminately to one side. The addition of but little more labor to the swamping crew will complete the piling. This system is practicable in nearly all instances except when the trees are felled in deep wet snow. In that case it can be most economically done in spring.

Brush piles of the best kind are roughly conical and compact with the smaller limbs upside down underneath and the larger material up to four inches in diameter stacked on the outside. The piles should be placed where they will not injure reserved trees or desirable advance growth; but should be stacked close about undesirable hemlock, white fir, or other trees, in patches of undesirable reproduction, or at the side of defective white pine stumps, provided any of those conditions are present and provided such procedure will not endanger the trees reserved. When advance growth or seed in the duff is largely relied upon for the future stand, the piles should not be over twelve or fifteen feet in diameter, since if larger the spots burned would give rise to blanks in the new crop too large to be made use of by the trees coming up on the unburned ground.

Burning by this method just as by the others is usually best done at a favorable season after the brush has dried out. But during the dry fall weather, which occasionally occurs, it may sometimes be practicable to burn the brush as piled, it being thrown on a fire already started. This method burns even less of the soil than the usual method, and since it often permits the removal of much of the brush before skidding, the cost of the latter may be considerably lessened.

There are some disadvantages to piling and burning. Sometimes the proportion of weed species which can be destroyed by this method is smaller than in broadcast burning. And its greater cost causes a smaller immediate revenue from stumpage.

The cost of piling and burning, however, is by no means excessive. In mature white pine stands on the Coeur d'Alene National Forest some good piling when carried on in connection with swamping in 1914 cost 18¢ to 22¢ per thousand feet of timber cut. Burning on these areas was 5¢ to 6¢. With efficient work the sum of the two costs can often be kept around 25¢ per thousand. When piling and swamping cannot be done at the same time, and where the slash is exceedingly heavy and abundant, as in over mature stands consisting largely of defective trees or of such limby species as hemlock and cedar, piling and burning will of course be more expensive, but at the most should not exceed 50¢. In spite of its cost, the more thorough control of the fire which this method allows, guaranteeing greater safety while leaving the cutover area in the most desirable shape silviculturally, usually warrants its use in preference to the other methods.

## Time of Burning

Burning by any method should preferably be done in the fall, because of the danger of summer fires from spring burns, and the cost of keeping them under close watch

throughout the following summer. Perhaps the best time is immediately after the fall rains begin, but before the brush has wet thru. There is often some clear weather of a few days or weeks, at this season, after the summer's drought is broken but before the long rainy periods begin. Fires at that time can usually be kept under control by beginning at the upper edge of a slope, and firing narrow strips, or single isolated windrows or brush piles, gradually progressing downwards. Extreme caution should be used in firing a slashing at the lower edge, since the intense heat generated by the draught even in damp weather may dry out the soil cover so as to permit the fire to spread and escape control.

### Leaving Slash Unburned

If burning can be avoided very decided savings are made in soil fertility, in seed lying dormant in the duff, in advance of reproduction, and in the injury to seed trees and adjoining stand which often occurs when brush is burned. Further, the presence of brush on exposed sunny slopes, especially if they are hot and dry, is of decided value in conserving the soil moisture and protecting the seedlings, particularly during their tenderest ages, the first year or two. The danger of fire catching on the area is decidedly greater for a time immediately succeeding the cutting but this begins to diminish after the second year when the needles have fallen off. Slash in contact with the ground soon decays, so that in five to seven years, if lopped and scattered, or left in small piles, the fire risk will probably have decreased to normal.

Extreme caution is required in leaving slash unburned since there is great danger of a serious fire starting before it has sufficiently decayed. Areas where fires are liable to originate, such as those near railroads or other routes of travel or those subject to lightning, should have the brush properly burned. Only where the amount of slash to be left is so light that the fire risk will be no greater than that which prevails in the uncut forest, and where the burning would be apt to cause serious damage, should the risk of not burning be incurred. Leaving the slash is desirable chiefly where its burning would destroy good reproduction already established, or where the survival of reproduction on burned areas would be questionable without the protection which the scattered slash would afford.

To reduce the fire hazard when slash is left unburned it should usually be either lopped and scattered so as to lie flat on the ground, or left in small piles. Lopping and scattering is practicable only on open sites, and is desirable chiefly where the sites are dry and the scattered slash would help to conserve soil moisture. In thick stands of young growth, or on very moist sites, small piles are preferable since they will become pressed down by the snow, and remain moist longer and decay more quickly.

To facilitate control of chance fires cuttings should be surrounded by broad fire-lines 50 to 100 feet in width, upon which all debris should be piled and burned. Large areas should be subdivided by other such fire-lines.

## ARTIFICIAL REGENERATION

Thruout [sic] its range a western white pine forest can always be established by sowing or planting even where natural methods of reforestation fail. And there are large areas of burned and denuded land both inside and outside the National Forests of the

Pacific Northwest suited to the growth of this tree which could be profitably reforested. When done on a large scale the cost can be reduced to a very reasonable figure.

## Seed Collection and Extraction

Western white pine seed may be purchased from dealers, but where large quantities are required, money may be saved and a better quality secured by collecting the cones in the woods.

### Collection

The seeds ripen and the cones begin to turn brown as a rule early {late} in September. This is the time for collection. It must be done promptly, for the cones open very quickly during the warm September days. The cones may be gathered from trees felled in logging or by picking them from trees; but squirrel hoards or "caches" afford the quickest and most economical method while permitting operations to be carried on for a long period, since cones thus stored away are kept moist and do not open up. {Collection from squirrel hoards usually not begun till Oct. 10th, as caches are not filled much before then.} In order that the squirrel's food supply be not too seriously depleted, other species collected by the squirrels should be left undisturbed. Caches are often made year after year in the same place. They may be found anywhere, but are usually most abundant or largest in damp places, such as creek bottoms, the cones frequently being placed in the water.

The average daily pick in a twenty thousand bushel job in 1911 was nearly eleven bushels (220 lbs.) of cones per man for each day actually at work, making the cost 21¢ per bushel. But including the hauling and overhead charges the average was only 5.5 bushels and the cost 56¢ per bushel. Over 20,000 acres were scoured in making the collection, so the yield was approximately one bushel per acre.

### Storing the Cones

As soon as collected the cones must be stored until such a time as they can be dried and the seed extracted. In storing it is very important that the cones be kept dry and admit a free circulation of air to permit evaporation of surplus moisture. In large operations they are stored in substantially built cribs with water-tight roofs, provision being made for a series of floors, one eighteen inches above another, the lower floor tight, the others composed of 6 inch boards one inch apart. (Plate XXI). The upper floors are not laid until the floor below has been covered with cones, in a layer not over 4 inches deep. When thoroughly ventilated in this way and thoroly [sic] protected from the rain and snow, during the winter season the cones open largely of themselves, and the seed is easily freed. Seed extracted thus at natural temperature is usually of much better vitality than when the cones are opened by artificial heat.

### Drying the Cones

If weather conditions will not dry the cones sufficiently to permit them to open, some artificial heat is necessary. Cones are often dried in wire-bottomed trays arranged in tiers around the sides of the building with a stove in the center. A better arrangement, however, is a car with screen floors, the car when loaded being wheeled into a dry room

heated by steam similar to a lumber dry kiln. When using artificial heat, two serious dangers must be avoided; vis., (1) In no case should the temperature of the dry room exceed 110° F. (2). too long drying resulting in excessive evaporation of moisture. Either will reduce the viability of the seed or entirely kill it. If, however, proper precautions are taken in storing, moderate heat (up to 100 degrees) and short periods of artificial heating are all that are necessary to open the cones sufficiently for extraction. The cones should be screened before heating, so as not to subject seed already extracted to further heat.

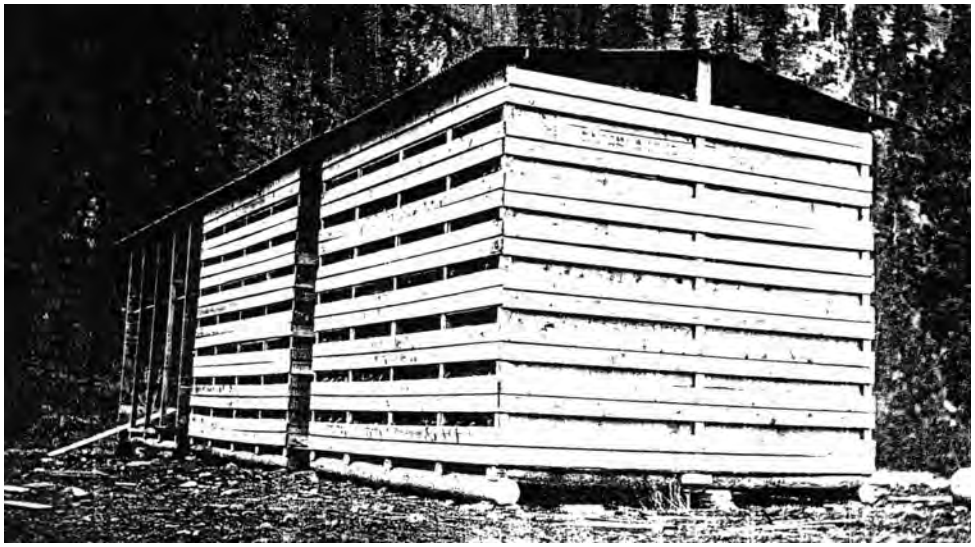
Extraction, Storage and Cost

After the opening of the cones, the seed is readily extracted by passing the cones through a large revolving square drum, having screen sides. The seed and trash falling through the screen, is then run through a fanning mill, and finally through a seed grader. The “Rumley Rainbow” hand or power grader does this work very efficiently, blowing out all light seed and chaff, and leaving only the good clean seed. One-fourth to one-third pounds of seed should be secured from each bushel of cones.

If thoroughly dry, seed may be stored until ready for use in an air-tight seed container, or suspended in cloth or paper bags in a cool dry room with free air circulation. If not sufficiently dried before storing, moulding may result.

The total cost of western white pine seed may vary from $1.00 to $2.50 per pound, depending upon the abundance of the seed crop, the size of the job, facilities for extraction, etc.

Plate XXII A Substantial and Satisfactory Type of Crib for Storing Cones.



## Nursery Practice*

If only small areas are to be planted, suitable stock can usually be secured from one of the commercial nurseries which make a business of growing seedlings in large quantities for forest planting; but if large areas are to be reforested each season, a considerable saving can be affected by establishing a nursery*. Wild seedlings are sometimes used, but as a rule their root systems are straggling, and the plants do not resist unfavorable conditions as well as nursery grown stock, and especially transplants.

### Time of Sowing

Because of the sluggish germination of western white pine seed, complete germination cannot be expected until the second season after the sowing, although fall sowing usually gives from 40% to 60% germination the next spring, and the few seedlings coming up the second season may be disregarded. Spring sown seed, however, requires two seasons for a full stand of seedlings. Besides an increased expense for culling, the younger seedlings are apt to be suppressed by the older. With spring sowing from 5% to 25% of the fertile seed germinates that year, and the remainder the following season.

### Growing the Stock

Transplant stock of western white pine is as a rule preferable to seedlings for field planting. The best transplants have been secured by transplanting the seedlings when one year old, and leaving two years in the transplant bed. If they are to be put into the transplant bed that early, the aim should be to secure from 12,000 to 15,000 seedlings on each 4' x 12' bed. This will ordinarily take one to three pounds of seed, depending on the germination percent.

On very favorable sites, seedlings which have not had the advantage of the root developing process of the transplant bed may still be used successfully in field planting. Such seedlings should be two or three years old, and produced in an uncrowded stand so that the plants will be strong and sturdy. To prevent crowding the number of seedlings per bed should be not over 6000 to 7000, and the amount of seed should be correspondingly less. When seedlings two or three years old can be planted directly from the seed bed into the field, the cost is lessened in the neighborhood of $1.00 per thousand.

The seed after sowing should be covered with a light layer of sand; one-half inch has been found to give best germination at the Savanac nursery, Haugen, Montana, altho at the Priest River Forest Experiment Station there was little difference between the one-fourth inch and the one-half inch coverings.

Western white pine seedlings may be raised without shelter, provided they are given plenty of water. However, they grow larger and are of better color if provided with half shade during the first summer. This is easily supplied by using a lath screen, the lath being separated by a space equivalent to their own width.

---

* Note: Bulletin 76 of the Forest Service and Yearbook Separate 376 of the Department of Agriculture give detailed information on nursery work.

Damping Off

The most destructive enemy of seedlings is the damping off fungus. This can be controlled quite thoroughly by the use of a sulphuric acid solution, applied at the rate of 3-16 fluid ounces of commercial sulphuric acid diluted in 3-16 gallons of water, to each square foot of bed. This solution is comparatively weak and will not injure the plants as a strong one would. It should be applied immediately after sowing the seed.
{District revision} [apparently pasted in]
pected, as in fall sown beds or those which have lain over one year, treatment should be given before germination commences and repeated later if needed.

Cut Worms

Cut worms, which are large, greenish larvae of a moth of the Noctuidae family, sometimes make serious inroads in white pine nursery beds. The cut worms feed only at night, and during the day may be found buried about one inch under ground. Digging the worms out by hand is perhaps the most effectual method of defense, tho bran of finely clipped alfalfa soaked in Paris green is used to destroy them in gardens. Paris green must be applied to the seedlings with caution, as too strong a solution will kill them.

Cost

The total cost of western white pine stock, age 1-2, (that is, one year in the seed bed and two years in the transplant bed), at the Savanac Nursery, including packing for shipment, in 1913 was $3.38 per thousand. With the benefit of previous experience it is expected that the cost will not be over $3.25 per M and it may be reduced to $2.75. Two-year seedling stock should be produced for about $2.00 per thousand.

## Sowing and Planting

Direct seeding of western white pine in the past experience of the Forest Service, has given much poorer results than the planting of nursery stock. Failures have been aided by several causes. The slow germination of white pine seed causes it to lie two years or more exposed to the ravages of birds and rodents. Severe droughts which frequently occur during the summer months are responsible for the death of many seedlings. Others are killed by “damping off” or other such diseases. Some methods of direct seedling gave poorer results than others, but all have been poor. Sowing in prepared seed spots at a cost of $14.13 per acre gave 13.3% success; seeding with a corn planter at a cost of $3.40 per acre gave 9% success; and scattering the seed broadcast at a cost of $10.28 per acre gave practically no results. Plantations of nursery stock, however, have been 97% successful.

On the whole, it is in the long run cheaper to plant healthy nursery stock. The cost of reforestation by the latter method has finally been reduced to $5.60 per acre.

Under usual conditions, western white pine is the most easily planted of any of the species commonly used for commercial reforestation. This is due largely to the soft soil characteristics of the western white pine type, the lesser amount of brush usually found on north exposures, and the small size of white pine nursery stock. The soil conditions

are so favorable to rapid work that instead of having one man to dig holes and another to set the trees, with the use of a specially constructed mattock it is possible for one man to perform both operations. The single handed mattocks thus used are made with a handle eighteen inches long, a blade nine inches long, two and one-half inches wide, and one-eighth inch thick, weight of head two pounds, and total weight of tool two pounds and seven ounces. With this tool holes deep enough for 1-2 transplants are dug with two or three movements, and the seedlings, carried in a bag suspended from the planter's shoulder, are set in place before the move is made to the site for the next tree. By this method the average day's work has been increased to {700 to} 1,000 trees per man.

The greatest single factor in the per acre cost of planting is the spacing used. In table 22 it was shown that a nine-foot spacing in the 47 year old class gives the highest yields {per individual tree, but a spacing of 8½ x 8½ will give greatest yield per acre because of the larger number of trees occupying the acre.} It is thought therefore that this is the best spacing to use. The method of spacing most desirable is explained in page [98].

APPENDIX

(Appendix)

Table A

Average Physical and Mechanical Properties of Western White Pine And Competing or Associate Species, Based on Tests of Small Green Clear Specimens 2” x 2” in Cross Section, Bending 28” Span.

| | Bending | Compression | | Hardness | | |
|---|---|---|---|---|---|---|
| Species | Maximum Fiber stress. Lbs. per sq. inch | Parallel to grain at Max. load. Lbs. per sq. inch | Perpend. To grain. Max. Lbs. per sq. inch | End | Side | Shear |
| Douglas Fir (Pacific Coast) | 8280 | 4030 | 528 | 511 | 474 | 909 |
| Western Larch (Montana) | 7630 | 3870 | 559 | 466 | 452 | 917 |
| Western Hemlock (Washington) | 7294 | 3392 | *** | *** | *** | *** |
| Western Larch (Washington) | 7251 | 3696 | *** | *** | *** | *** |
| Grand or White Fir (Montana) | 6090 | 3030 | 316 | 448 | 375 | 735 |
| Western Red Cedar (Washington) | 5730 | 3050 | 351 | 462 | 272 | 742 |
| Idaho White Pine | 5700 | 3070 | 303 | 334 | 333 | 712 |
| Lodgepole Pine (Montana) | 5663 | 2680 | 291 | 331 | 340 | 672 |
| Western Yellow Pine (East. Wash.) | 5659 | 2770 | *** | *** | *** | *** |
| Eastern White Pine | 5310 | 2720 | 314 | 304 | 296 | 644 |
| Sugar Pine | 5270 | 2600 | 353 | 334 | 324 | 708 |
| Norway Pine | 5173 | 2504 | 358 | 355 | 342 | 776 |
| W. Yellow Pine (Other States) | 5090 | 2403 | 348 | 312 | 320 | 685 |

Note: This material, as tested, was free from defects, such as shake, check, knots, cross grain, etc.

The overrun indicated in the following tables and curves is the excess of lumber yielded by the logs over and above the board feet contents indicated by the scale rule when the logs are scaled by the Scribner Decimal C Rule.

(Appendix)
Table B

Average Percentage of Grades and Overrun
of Lumber Cut From Western White Pine Logs
Separately
For Sound and Defective Timber
---
Logs Scaled by Scribner Decimal C Rule

| | Sound | Defective | Sound and Defective |
|---|---|---|---|
| Grades: | Percent of Lumber Cut | | |
| B Select | 3.7 | 2.8 | 3.2 |
| C Select | 5.5 | 4.1 | 4.6 |
| D Select | 7.1 | 7.2 | 7.1 |
| Factory C | 0.4 | 1.0 | 0.7 |
| #1 Shop | 2.5 | 2.5 | 2.5 |
| #2 Shop | 6.1 | 3.5 | 4.6 |
| #3 Shop | 1.7 | 0.9 | 1.2 |
| #1 Common | 27.7 | 8.7 | 17.2 |
| #2 Common | 19.5 | 16.1 | 17.5 |
| #3 Common | 22.1 | 31.6 | 27.3 |
| #4 Common | 3.6 | 19.6 | 12.3 |
| #5 Common | 0.1 | 2.0 | 1.8 |
| Overrun: | Percent of Log Scale | | |
| Net lumber tally over full log scale | 19.3 | 6.8 | 12.2 |
| Net lumber tally over net log scale | 19.3 | 42.0 | 30.8 |
| #3 Lumber and better over net log scale | 14.8 | 11.3 | 13.0 |
| Basis: | | | |
| Number butt logs | 173 | 357 | 530 |
| Number middle logs | 1492 | 1059 | 2551 |
| Number top logs | 523 | 80 | 603 |
| Total number logs | 2188 | 1496 | 3684 |
| Av. length of logs, ft. | 15.10 | 15.65 | 15.29 |
| Av. top diameter In. | 12.55 | 16.88 | 14.32 |
| Av. butt diameter In. | 14.48 | 19.72 | 16.60 |
| Av. full scale, B.F. | 101.2 | 210 | 148.00 |
| *Av. reduction B.F. (normal) | *** | 32.9 | 13.37 |
| **Av. reduction B.F. (fire) | *** | 19.4 | 7.85 |
| Total reduction B.F. | *** | 52.3 | 21.22 |
| Av. net scale B.F. | 101.2 | 157.7 | 126.78 |
| Percent of net full scale | 100% | 75% | 85.70% |
| Av. net lumber Tally B.F | 126.06 | 224.3 | 165.95 |
| No. logs per M net scale | 9.9 | 6.4 | 7.9 |

Data averaged for five mills scattered throughout western white pine belt.
* Rot, etc.
** Check and stain

(Appendix )  Table C

Percentage of Grades and Overrun by Size in 14' & 16' Western White Pine Logs
For Sound Logs and For Various Degrees of Defect
Based Upon Gross Log Scale, Scribner Decimal C Rule

| Size of Logs (Gross scale) | | Percentage of Gross | | | | | | | | | | | Over- | | Basis | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Selects | | | Shop | | | Common | | | | | | | Average | Average | Average | Average |
| Feet | Average No. per M. | B | C | D | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | run % | Number of Logs | Gross Log Scale (feet) | Net Log Scale (feet) | Lumber Tally (feet) | % of Defect |
| SOUND LOGS | | | | | | | | | | | | | | | | | | |
| 20-50 | 3.1 | *** | 0.44 | 2.08 | 0.02 | 0.05 | 0.03 | 40.48 | 28.24 | 25.11 | 3.49 | 0.06 | 35.10 | 613 | 32 | 32 | 44 | *** |
| 60-90 | 0.4 | *** | 1.24 | 5.34 | 0.20 | 0.38 | 0.02 | 48.47 | 21.19 | 19.52 | 3.63 | 0.01 | 26.20 | 409 | 71 | 71 | 89 | *** |
| 100-140 | 8.7 | 0.13 | 3.02 | 7.54 | 0.46 | 3.03 | 0.86 | 32.98 | 25.26 | 22.73 | 3.77 | 0.22 | 24.57 | 322 | 115 | 115 | 144 | *** |
| 150-190 | 6.0 | 0.77 | 4.53 | 8.08 | 1.07 | 6.70 | 2.45 | 21.06 | 23.43 | 25.15 | 4.76 | *** | 19.60 | 176 | 167 | 167 | 200 | *** |
| 200-290 | 4.2 | 2.86 | 6.94 | 7.95 | 2.55 | 11.90 | 4.40 | 16.84 | 16.38 | 26.58 | 3.60 | 0.01 | 15.00 | 136 | 239 | 239 | 274 | *** |
| 300-390 | 3.0 | 6.85 | 10.49 | 9.56 | 7.45 | 13.46 | 3.23 | 13.43 | 10.21 | 21.31 | 4.18 | *** | 10.40 | 67 | 325 | 336 | 370 | *** |
| 400-490 | 2.4 | 14.91 | 10.25 | 7.65 | 10.84 | 15.39 | 3.45 | 13.26 | 8.64 | 13.14 | 2.37 | 0.10 | 4.34 | 36 | 424 | 424 | 454 | *** |
| 500-1000 | 1.7 | 20.38 | 16.39 | 11.41 | 10.16 | 5.19 | 1.95 | 12.57 | 7.88 | 11.93 | 2.02 | 0.20 | 3.76 | 34 | 584 | 584 | 605 | *** |
| LOGS 0 - 10% DEFECTIVE | | | | | | | | | | | | | | | | | | |
| 20-50 | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** |
| 60-90 | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** | *** |
| 100-140 | 9.1 | *** | 0.54 | 3.80 | *** | *** | *** | 15.74 | 26.36 | 39.30 | 13.83 | 0.43 | 37.41 | 27 | 110 | 100 | 137 | 9.09 |
| 150-190 | 5.9 | 0.84 | 2.06 | 4.59 | 3.93 | 4.96 | *** | 23.77 | 15.54 | 38.74 | 5.57 | *** | 34.40 | 10 | 169 | 159 | 214 | 5.92 |
| 200-290 | 4.2 | 0.99 | 4.65 | 8.04 | 3.99 | 5.74 | 0.19 | 13.89 | 21.77 | 33.73 | 6.89 | 0.12 | 20.02 | 22 | 236 | 208 | 262 | 7.51 |
| 300-390 | 3.0 | 3.50 | 9.43 | 12.09 | 2.64 | 5.21 | 0.22 | 11.98 | 16.31 | 30.60 | 8.02 | *** | 16.41 | 20 | 336 | 313 | 364 | 7.13 |
| 400-490 | 2.4 | 1.26 | 8.47 | 9.58 | 6.71 | 10.50 | 5.22 | 6.95 | 12.70 | 22.98 | 13.47 | 2.16 | 14.58 | 14 | 419 | 390 | 446 | 7.31 |
| 500-1000 | 1.5 | 23.59 | 12.98 | 9.44 | 11.98 | 5.32 | 1.00 | 3.13 | 7.60 | 17.70 | 6.71 | 0.55 | 12.46 | 15 | 652 | 605 | 680 | 7.15 |
| LOGS 11 - 20% DEFECTIVE | | | | | | | | | | | | | | | | | | |
| 20-50 | 20.0 | *** | *** | 1.77 | *** | *** | *** | 25.75 | 31.04 | 33.44 | 8.02 | *** | 50.00 | 16 | 50 | 40 | 60 | 20.00 |
| 60-90 | 14.0 | 0.44 | 1.68 | 7.21 | *** | *** | *** | 42.40 | 22.40 | 21.24 | 4.63 | *** | 37.92 | 81 | 72 | 62 | 85 | 14.09 |
| 100-140 | 8.5 | *** | 2.27 | 6.85 | *** | *** | *** | 26.21 | 27.27 | 30.07 | 6.99 | 0.34 | 38.37 | 57 | 117 | 97 | 134 | 17.06 |
| 150-190 | 6.0 | 0.23 | 2.02 | 5.09 | 0.19 | 4.61 | *** | 13.36 | 24.74 | 38.57 | 10.15 | 1.04 | 32.66 | 46 | 167 | 147 | 195 | 11.96 |
| 200-290 | 4.1 | 1.28 | 4.22 | 6.49 | 1.21 | 1.97 | 0.42 | 7.88 | 19.07 | 47.93 | 9.45 | 0.08 | 32.83 | 40 | 246 | 211 | 281 | 13.93 |
| 300-390 | 2.9 | 4.37 | 6.19 | 13.92 | 1.34 | 2.94 | 1.65 | 9.31 | 19.11 | 32.89 | 6.28 | *** | 30.43 | 11 | 342 | 292 | 371 | 14.63 |
| 400-490 | 2.3 | 15.03 | 7.36 | 11.44 | 7.49 | 2.07 | 1.34 | 10.04 | 16.22 | 18.50 | 10.50 | *** | 22.81 | 7 | 443 | 370 | 469 | 13.22 |
| 500-1000 | 1.8 | 12.47 | 15.72 | 8.80 | 13.45 | 0.86 | 1.26 | 1.15 | 4.00 | 27.65 | 14.24 | 0.40 | 16.06 | 5 | 550 | 478 | 555 | 13.09 |

(Appendix) Table C Continued

Percentage of Grades and Overrun by Size in 14' & 16' Western White Pine Logs
For Sound Logs and For Various Degrees of Defect
Based Upon Gross Log Scale, Scribner Decimal C Rule

| Size of Logs (Gross scale) | | Percentage of Gross | | | | | | | | | | | Over- | Number | Basis | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Selects | | | Shop | | | Common | | | | | run | | Average Gross Log | Average Net Log | Average Lumber | Average % of |
| Feet | Average No. per M. | B | C | D | 1 | 2 | 3 | 1 | 2 | 3 | 4 | 5 | % | of Logs | Scale (feet) | Scale (feet) | Tally (feet) | Defect |
| LOGS 21 - 30% DEFECTIVE | | | | | | | | | | | | | | | | | | |
| 20-50 | 23.0 | *** | 2.83 | 7.93 | *** | *** | *** | 35.56 | 21.91 | 27.90 | 6.87 | *** | 58.80 | 31 | 43 | 32 | 51 | 25.37 |
| 60-90 | 13.0 | *** | 1.33 | 2.54 | *** | *** | *** | 22.83 | 26.84 | 36.18 | 9.20 | 1.08 | 50.12 | 44 | 75 | 44 | 80 | 28.05 |
| 100-140 | 8.2 | 0.35 | 2.14 | 6.72 | *** | *** | 0.12 | 14.58 | 13.69 | 40.15 | 19.49 | 2.78 | 52.65 | 53 | 122 | 90 | 138 | 26.00 |
| 150-190 | 5.9 | 0.76 | 3.89 | 9.86 | *** | *** | *** | 20.91 | 15.23 | 25.77 | 23.29 | 0.29 | 42.46 | 15 | 170 | 130 | 185 | 23.52 |
| 200-290 | 4.2 | 1.68 | 7.53 | 10.64 | 0.74 | 3.23 | 1.39 | 7.83 | 19.93 | 31.31 | 15.31 | 0.59 | 44.18 | 26 | 240 | 180 | 259 | 24.88 |
| 300-390 | 2.8 | *** | 4.55 | 10.37 | 2.93 | 3.67 | 1.66 | 6.53 | 16.31 | 38.13 | 15.63 | 0.22 | 39.57 | 16 | 351 | 262 | 366 | 25.13 |
| 400-490 | 2.3 | 9.50 | 8.25 | 8.81 | 4.19 | 5.10 | *** | 1.63 | 4.16 | 35.33 | 21.75 | 1.28 | 24.10 | 9 | 444 | 336 | 146 | 24.50 |
| 500-1000 | 1.8 | 6.65 | 14.01 | 9.25 | 0.91 | 1.02 | 2.34 | 4.68 | 16.16 | 26.66 | 17.52 | 0.80 | 29.80 | 5 | 546 | 408 | 530 | 25.27 |
| LOGS 31 - 40% DEFECTIVE | | | | | | | | | | | | | | | | | | |
| 20-50 | 28.0 | *** | *** | 9.03 | *** | *** | *** | 15.55 | 15.34 | 34.45 | 23.74 | 1.89 | 44.24 | 14 | 36 | 24 | 34 | 35.29 |
| 60-90 | 14.0 | *** | *** | 4.41 | *** | *** | *** | 20.50 | 16.87 | 33.30 | 24.92 | *** | 64.22 | 24 | 70 | 45 | 75 | 35.12 |
| 100-140 | 9.0 | *** | 1.65 | 5.46 | *** | *** | *** | 6.38 | 17.30 | 39.67 | 28.37 | 1.17 | 85.58 | 21 | 112 | 70 | 130 | 37.71 |
| 150-190 | 6.0 | | 3.07 | 7.61 | *** | *** | *** | 10.15 | 8.72 | 32.03 | 35.46 | 2.96 | 58.99 | 11 | 166 | 108 | 172 | 34.97 |
| 200-290 | 4.3 | 1.58 | 4.62 | 8.71 | *** | 0.64 | *** | 6.45 | 10.55 | 32.57 | 31.80 | 3.08 | 63.80 | 20 | 233 | 152 | 250 | 34.69 |
| 300-390 | 3.0 | 4.30 | 6.99 | 8.05 | *** | 0.54 | 0.75 | 1.54 | 4.26 | 39.29 | 29.93 | 4.35 | 52.71 | 13 | 338 | 215 | 329 | 36.22 |
| 400-490 | 2.3 | 0.37 | 4.53 | 13.58 | 0.89 | 8.68 | 1.78 | 2.23 | 6.79 | 35.14 | 25.23 | 0.78 | 54.88 | 6 | 433 | 290 | 449 | 33.07 |
| 500-1000 | 1.8 | 12.08 | 7.53 | 12.52 | 2.79 | 0.90 | 0.18 | 1.96 | 4.83 | 31.71 | 20.41 | 5.09 | 51.39 | 8 | 565 | 359 | 543 | 36.50 |

Figure 9. Percent of Grades and Overrun in Lumber Cut from Sound Western White Pine Logs of Various Common Sizes.

P
PROJECT U-24

FOREST SERVICE
MISSOULA, MONTANA
1914.

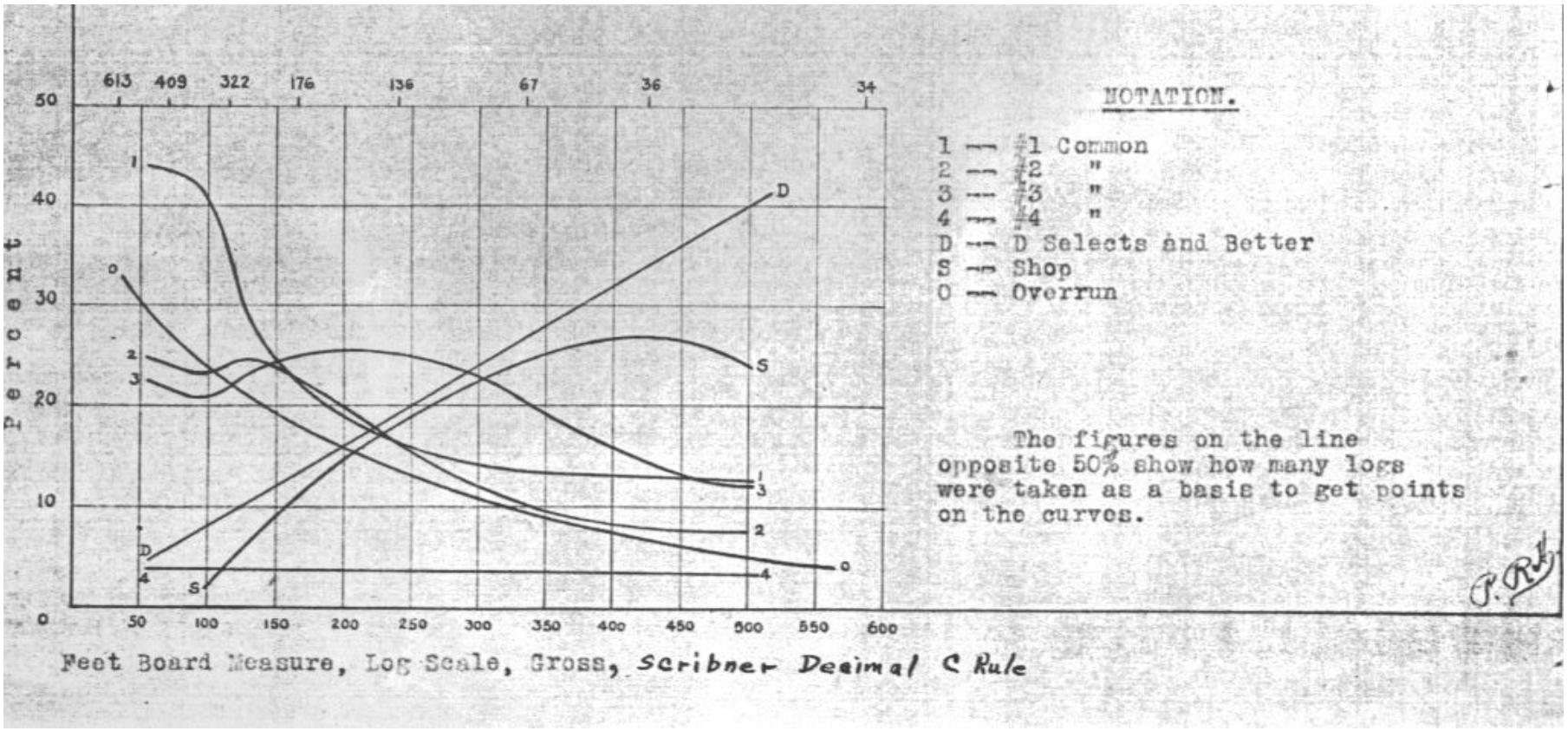


Figure 10. Percent of Select Grades in Lumber Cut from Sound Western White Pine Logs of Various Common Sizes.

P
PROJECT U-24

FOREST SERVICE
MISSOULA, MONTANA
1914.

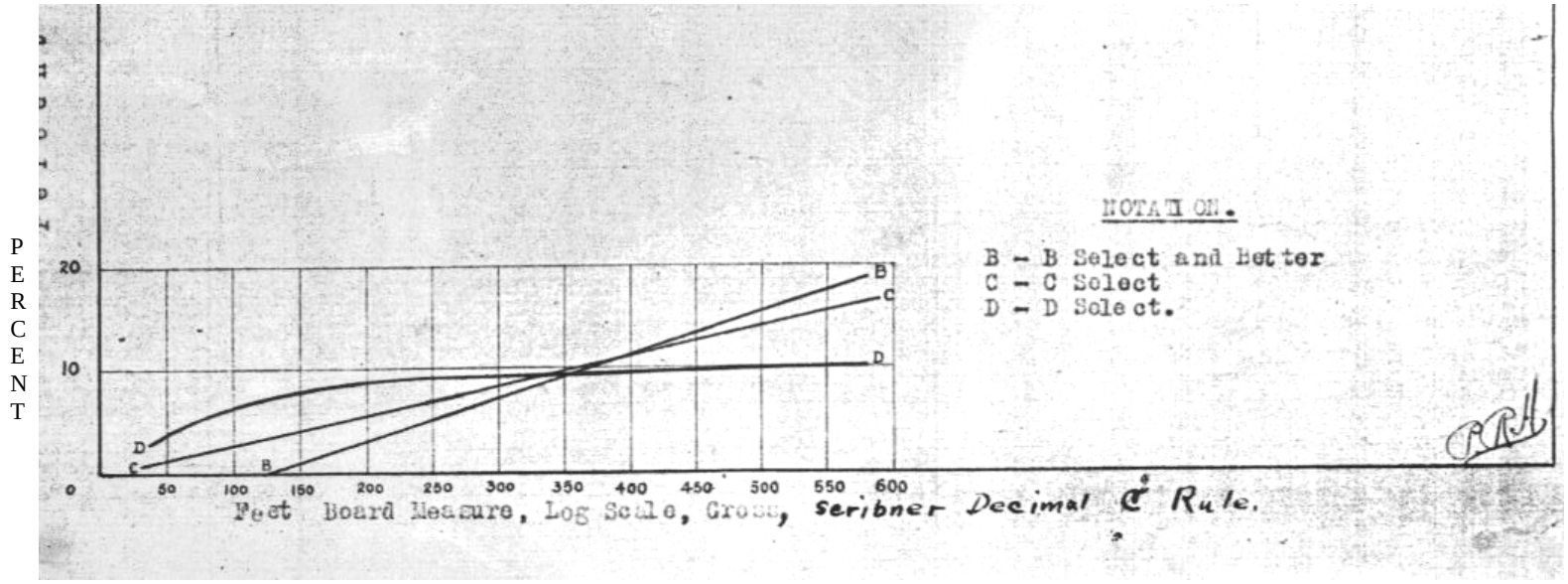
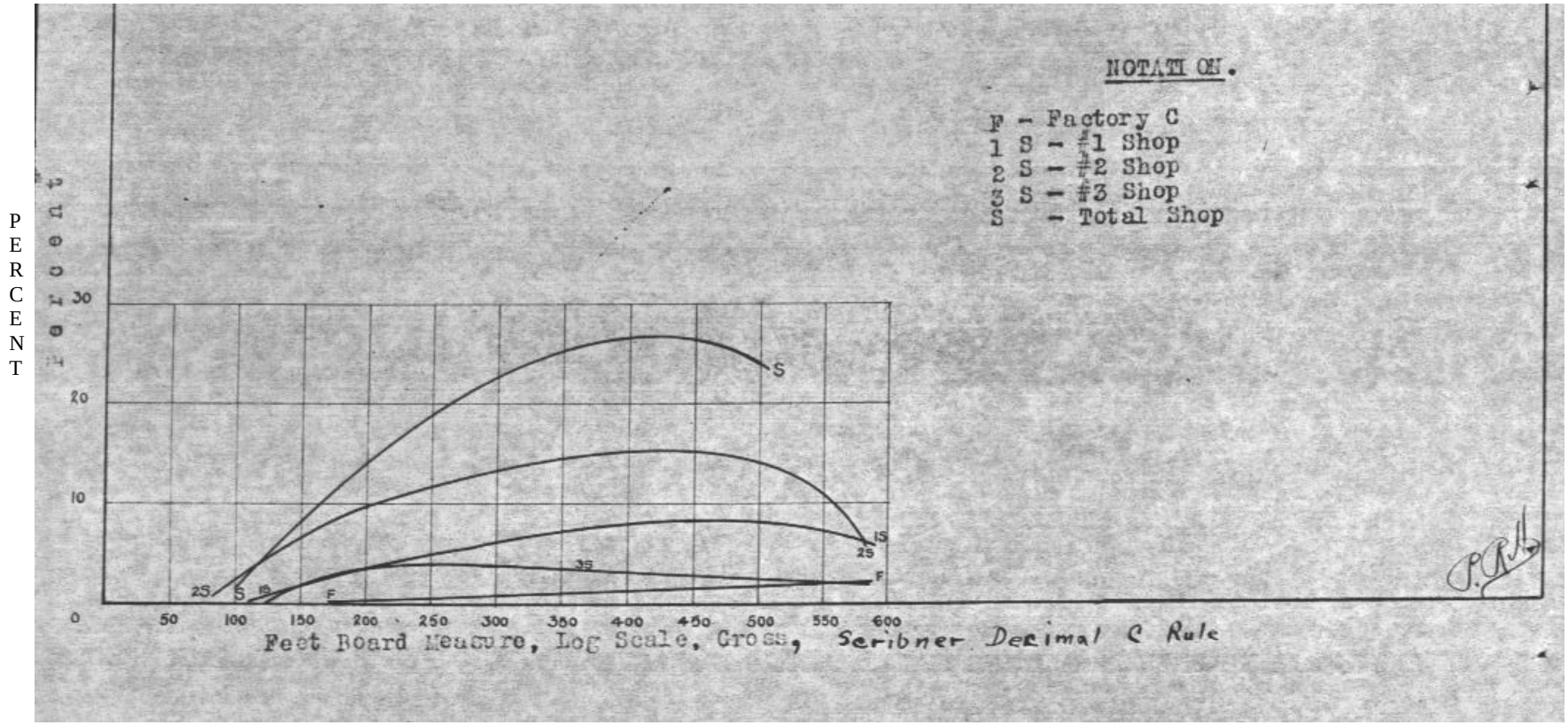


Figure 11. Percent of the Shop Grades in Lumber Cut from Sound Western White Pine Logs of Various Common Sizes.
.

P
PROJECT U-24

FOREST SERVICE
MISSOULA, MONTANA
1914.



The two following figures (Figs. 12 and 13) containing curves which show the cut from defective logs are included here merely to illustrate the erratic yields which defective logs give.  The curves do not afford a very safe basis upon which to estimate the yield of other defective logs.

Figure 12. Average Percent of Grades and Overrun in Lumber Cut from Defective Western White Pine Logs Consisting of 10% or Less Cull.

P
PROJECT U-24

FOREST SERVICE
MISSOULA, MONTANA
1914.

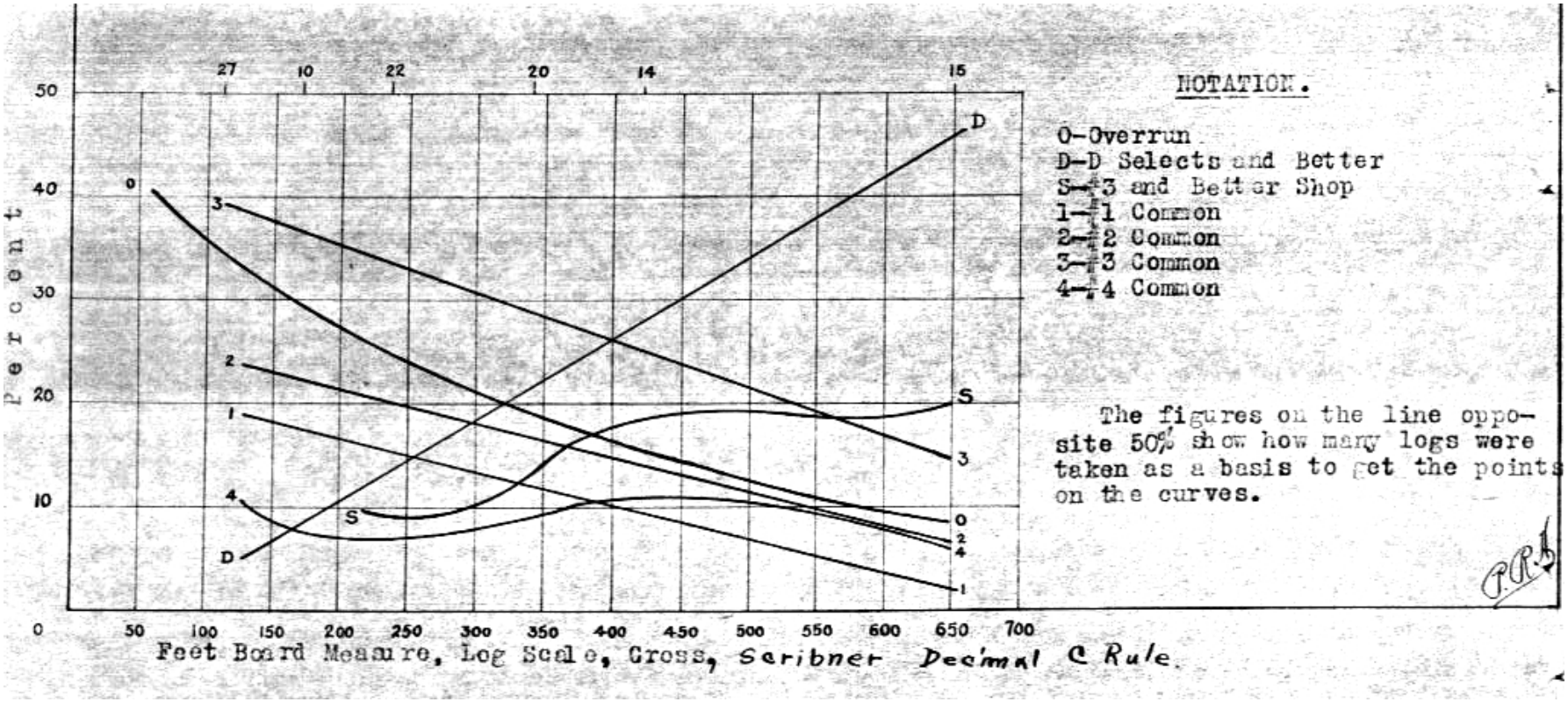


Figure 13. Average Percent of Grades and Overrun in Lumber Cut from Defective Western White Pine Logs Consisting of 11% to 20% cull.

P
PROJECT U-24

FOREST SERVICE
MISSOULA, MONTANA
1914.

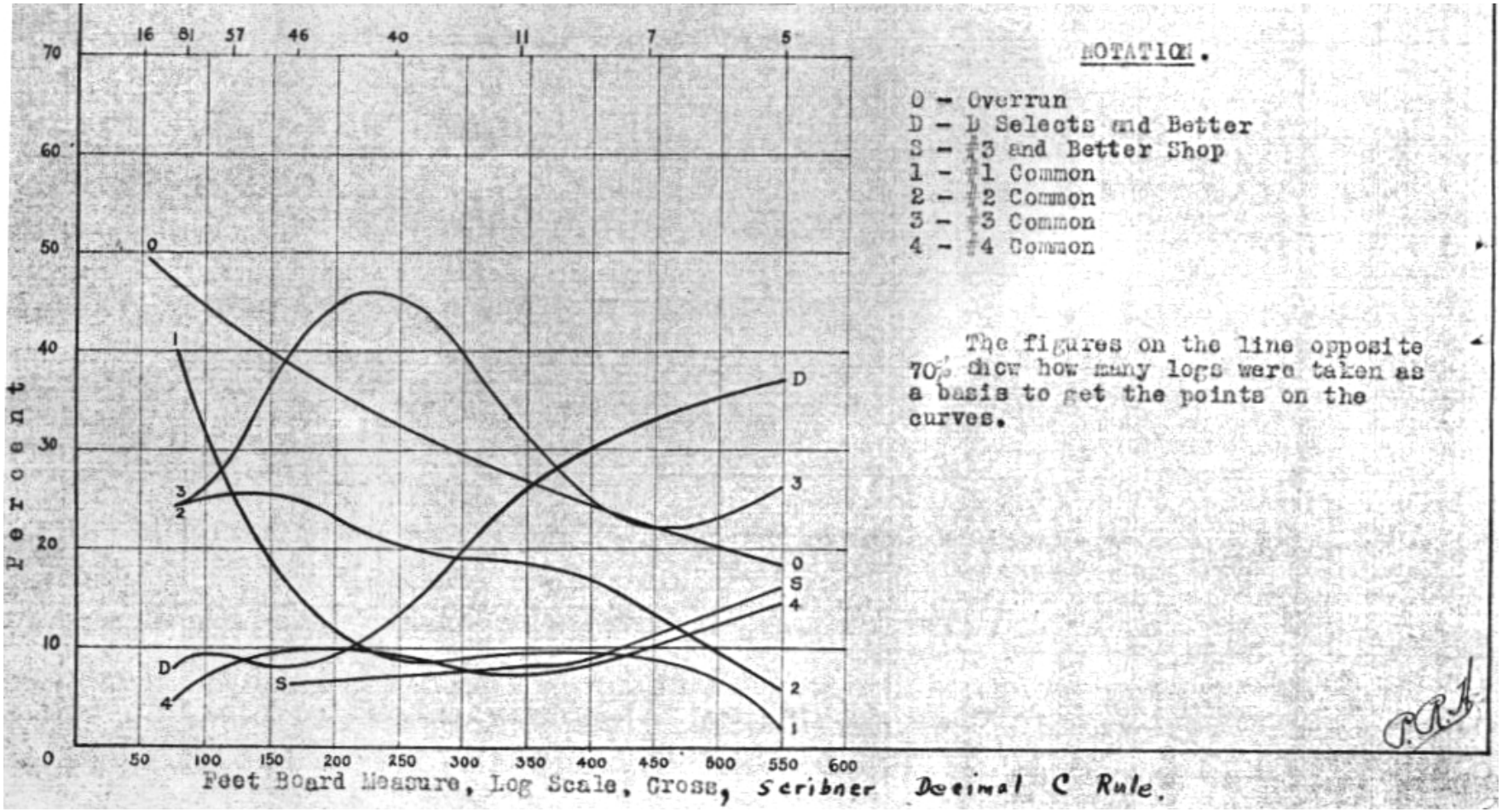
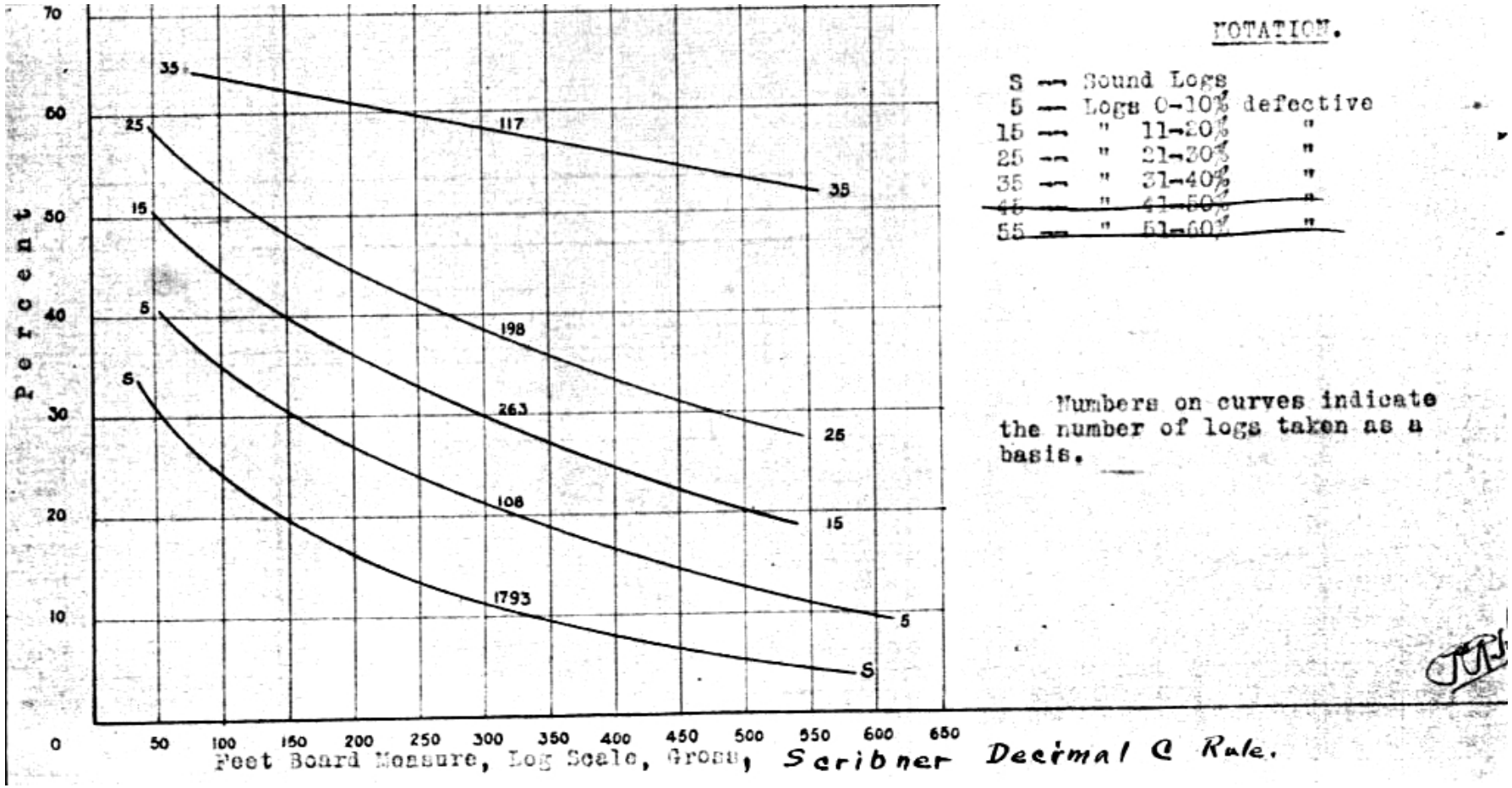


Figure 14. Percentage of Overrun in Lumber Over Gross Scale or Logs for the Various Common Sizes When Scaled by Scribner Decimal C Rule.

Separately for sound logs and for logs containing various degrees of defect.



(Appendix)

Table C-1

*OVERRUN IN AN ENTIRE WESTERN WHITE PINE TREE
WHOSE LOGS AVERAGE 10 PER 1000 FEET BOARD MEASURE

| Size of log diameter at small end (in.) | Scale Ft. B.M. | Approx. % overrun shown by mill scale study | Overrun in Ft. B.M. | % of total scale of tree in each log | Weighted overrun by % of total volume |
|---|---|---|---|---|---|
| 17 | 180 | 17 | 30.6 | 36 | 6.12 |
| 15 | 140 | 21 | 29.4 | 28 | 5.88 |
| 13 | 100 | 25 | 35.0 | 20 | 5.00 |
| 10 | 60 | 30 | 18.0 | 12 | 3.60 |
| 6 | 20 | 37 | 7.4 | 4 | 1.48 |
| Totals | 500 | | 110.4 [Total should be 120.4] | 100 | 22.08 |

* From report “Appraisal of Stumpage Values, Deception Creek, Coeur d’Alene National Forest.” By Lumberman Jas. G. Girard & Cruiser U.S. Schwartz. Page 17.

Table D

*PERCENTAGE OF GRADES OF LUMBER CUT FROM LARGEST
WESTERN WHITE PINE EVER FELLED.

9 ft. diameter, yielding 12 logs containing 29,800 Bd. Feet.

| Grade | Percent of Lumber Cut |
|---|---|
| C select & Better | 34.04 |
| D select | 36.93 |
| No. 1 common | 5.72 |
| No. 2 common | 4.70 |
| No. 3 common | 8.41 |
| No. 4 common | 10.20 |
| Total | 100 |

* From advertisement of the Potlatch Lumber Co. in the American Lumberman, Page 9. March 30, 1912.

(Appendix)

Table D-1

PRICES OF WESTERN WHITE PINE LUMBER
AVERAGE FOR 1913

F. O. B. Mill

| Grade | Price per M Feet |
|---|---|
| B Select | $45.00 |
| C Select | 38.00 |
| D Select | 27.00 |
| Shop (Average) | 20.50 |
| No. 1 Common | 25.00 |
| No. 2 Common | 21.00 |
| No. 3 Common | 15.00 |
| No. 4 Common | 11.00 |
| No. 5 Common | 6.00 |

Mill Run (See Table E).

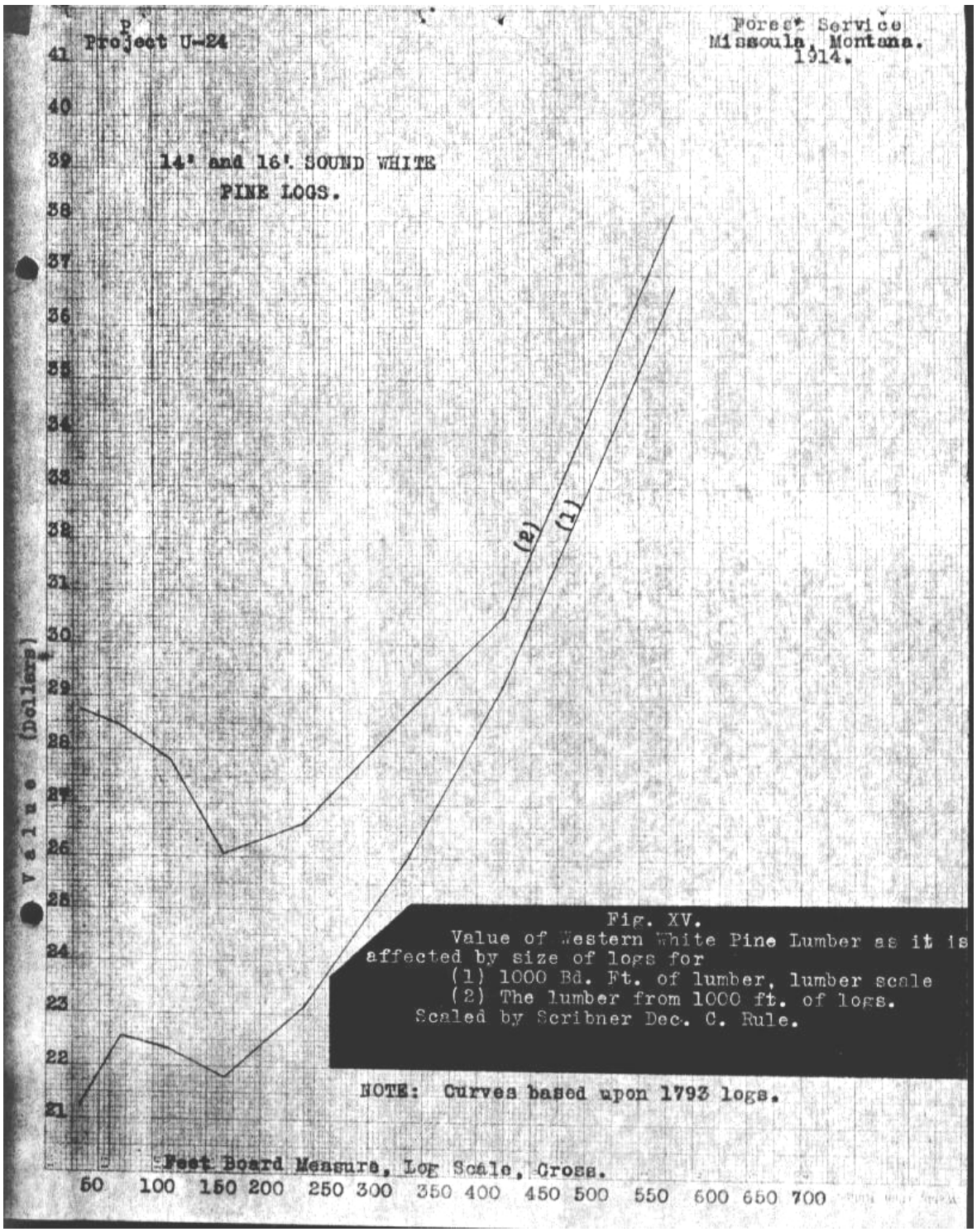
(Appendix) Table E

## VALUE OF WESTERN WHITE PINE LUMBER AS IT IS AFFECTED BY SIZE AND CONDITION OF LOGS

Based on Percentage of Grades in Table C and 1913 Average Mill Prices (Table D-1)

| Size of Logs (Gross Scale Ft. B.M.) | | | | Value of Lumber produced from | |
|---|---|---|---|---|---|
| Range | Average | Avg. No. per M. ft. | Value per M ft. of lumber | M. ft. net log scale | M. ft. gross log scale |
| | | | SOUND LOGS | | |
| 20-50 | 32 | 31.0 | 21.26 | 28.73 | 28.73 |
| 60-90 | 71 | 13.0 | 22.57 | 28.44 | 28.44 |
| 100-140 | 115 | 8.7 | 22.31 | 27.80 | 27.80 |
| 150-190 | 167 | 5.9 | 21.79 | 26.05 | 26.05 |
| 200-290 | 239 | 4.6 | 23.15 | 26.64 | 26.64 |
| 300-390 | 335 | 2.9 | 26.04 | 28.72 | 28.72 |
| 400-490 | 424 | 2.3 | 29.25 | 30.53 | 30.53 |
| 500-1000 | 584 | 1.7 | 36.78 | 38.15 | 38.15 |
| | | | LOGS 0 - 10% DEFECTIVE | | |
| 20-50 | *** | *** | *** | *** | *** |
| 60-90 | *** | *** | *** | *** | *** |
| 100-140 | 110 | 9.0 | 18.41 | 25.30 | 23.00 |
| 150-190 | 169 | 5.9 | 20.92 | 28.12 | 26.45 |
| 200-290 | 236 | 4.2 | 21.51 | 25.83 | 23.89 |
| 300-390 | 336 | 2.9 | 23.69 | 27.58 | 25.62 |
| 400-490 | 419 | 2.3 | 21.94 | 25.14 | 23.30 |
| 500-1000 | 652 | 1.5 | 31.73 | 35.68 | 33.12 |
| | | | LOGS 11 - 20% DEFECTIVE | | |
| 20-50 | 50 | 20.0 | 19.50 | 29.25 | 23.00 |
| 60-90 | 72 | 14.0 | 22.56 | 31.13 | 26.74 |
| 100-140 | 117 | 8.5 | 21.90 | 30.30 | 25.13 |
| 150-190 | 167 | 6.0 | 19.23 | 26.28 | 23.12 |
| 200-290 | 246 | 4.1 | 19.74 | 26.22 | 22.57 |
| 300-390 | 342 | 2.9 | 23.52 | 30.67 | 26.18 |
| 400-490 | 443 | 2.3 | 27.40 | 33.65 | 29.20 |
| 500-1000 | 550 | 1.8 | 27.59 | 32.01 | 27.82 |
| | | | LOGS 21 - 30% DEFECTIVE | | |
| 20-50 | 43 | 23.0 | 22.37 | 35.51 | 26.51 |
| 60-90 | 75 | 13.0 | 19.34 | 29.03 | 20.90 |
| 100-140 | 122 | 8.2 | 18.26 | 27.89 | 20.63 |
| 150-190 | 170 | 5.9 | 20.20 | 28.78 | 22.02 |
| 200-290 | 240 | 4.2 | 21.22 | 30.60 | 23.00 |
| 300-390 | 351 | 2.8 | 19.75 | 27.57 | 20.64 |
| 400-490 | 444 | 2.3 | 22.90 | 28.42 | 21.45 |
| 500-1000 | 546 | 1.8 | 23.90 | 31.03 | 23.20 |
| | | | LOGS 31 - 40% DEFECTIVE | | |
| 20-50 | 36 | 28.0 | 17.96 | 25.90 | 16.75 |
| 60-90 | 70 | 14.0 | 17.95 | 29.50 | 19.14 |
| 100-140 | 112 | 9.0 | 16.88 | 31.35 | 19.53 |
| 150-190 | 166 | 6.0 | 17.13 | 27.25 | 17.71 |
| 200-290 | 233 | 4.3 | 18.21 | 29.85 | 19.50 |
| 300-390 | 338 | 3.0 | 18.93 | 28.90 | 18.43 |
| 400-490 | 433 | 2.3 | 19.02 | 29.45 | 19.70 |
| 500-1000 | 565 | 1.8 | 23.49 | 35.66 | 22.58 |

Figure 15. Value of western white pine lumber as it is affected by size of logs for
(1) 1000 Bd. Ft. of lumber, lumber scale
(2) The lumber from 1000 ft. of logs.
Scaled by Scribner Decimal C Rule.



(Appendix)

Table F

AMOUNT AND RELATIVE IMPORTANCE

OF

WESTERN WHITE PINE LUMBER CUT IN 1913.
{1915 Figures Next sheet}

| State | Number of active mills reporting | Quantity M. ft. B.M. | Percent of western white pine cut in state | Percent which white pine made of all species cut In commonwealth | Percent which white pine made of all species cut in U.S. |
|---|---|---|---|---|---|
| Idaho | 38 | 227,845 | 67.2 | 34.2 | 8.87 |
| Washington | 19 | 83,974 | 24.8 | 1.8 | 3.26 |
| Montana | 16 | 24,606 | 7.3 | 6.9 | 0.96 |
| *Oregon | 7 | 2,352 | 0.7 | 0.1 | 0.09 |
| Total Western White Pine | 80 | 338,777 | 100.0 | 4.4 | 13.18 |
| Total White Pine Cut in U.S. | | 2,568,636 | | **6.7 | 100.00 |

* It is most probable that much of the cut reported from Oregon as western white pine is actually western yellow pine (*Pinus ponderosa*) since the true white pine there is scarce, grows at high altitudes and is at present relatively inaccessible. Indeed some firms which are operating in a part of the state where little if any white pine grows are advertising their major output as “western white pine”.

** This is the proportion which the total cut of all white pines formed to the total cut of all species in the United States. Western or Idaho white pine formed but .09 percent of the total cut of the country.

(Appendix)

Table F

AMOUNT AND RELATIVE IMPORTANCE

OF

WESTERN WHITE PINE LUMBER CUT IN 1915.

| State | Number of active mills reporting | Quantity M. Ft. B.M. | Per cent of total western white pine cut in each state | Percent which white pine made of all species cut by states | Percent which white pine made of all white pine cut in U.S. |
|---|---|---|---|---|---|
| Idaho | 36 | 301,600 | 71.9 | 38.6 | 11.17 |
| Washington | 38 | 90,240 | 21.5 | 1.6 | 3.34 |
| Montana | 9 | 27,330 | 6.5 | 8.3 | 1.01 |
| #Oregon | 8 | 622 | 0.1 | 0.4 | 0.02 |
| Total Western White Pine | 91 | 419,792 | 100.0 | *1.13 | 15.54 |
| Total White Pine Cut in U.S. | | 2,700,000 | | ## 7.3 | 100.00 |

# It is most probable that much of the cut reported from Oregon as western white pine is actually western yellow pine (*Pinus ponderosa*) since the true white pine there is scarce, grows at high altitudes and is at present relatively inaccessible. Indeed some firms which are operating in a part of the state where little if any white pine grows are advertising their major output as “western white pine”.

** This is the proportion which the total cut of all white pines formed to the total cut of all species in the United States.

*** Western or Idaho white pine formed but 1.13 percent of the total cut of the country [in 1915].

(Appendix)

Table G

DISTRIBUTION OF “IDAHO” WHITE PINE

Lumber Shipments by States Reported to Western Pine Mfgrs. Assn.

| States | % of Total Consumed | |
|---|---|---|
| | 1913 | 1st Half of 1916 |
| N. Dak. | 22 | 15.5 |
| S. Dak. | 11 | 9.8 |
| Minnesota | 11 | 11.7 |
| Iowa | 11 | 9.8 |
| Illinois | 9 | 10.4 |
| Nebraska | 8 | 7.0 |
| Wisconsin | 6 | 4.1 |
| | | |
| Michigan | 2 | 3.5 |
| Ohio | 2 | 3.8 |
| Indiana | - | 0.5 |
| | | |
| Pa. and Del. | 3 | 7.0 |
| N. Y. and New Jersey | 6 | 7.0 |
| N. Eng. | 2 | 3.5 |
| | | |
| Montana | 3 | 3.3 |
| Colo. and Wyo. | 1 | 1.7 |
| Kan. and Mo. | 2 | 1.5 |
| Others | 1 | 0.2 |
| | 100 | 100 |

(Appendix ) TABLE H

CLIMATOLOGY OF WESTERN WHITE PINE RANGE
1914 data

| Station | Elevation Feet | Temperature °F Average Highest | Temperature °F Average Lowest | Temperature °F Mean | Precipitation Total Average Inches | Precipitation Unmelted Snow Inches | No. days between heavy frosts | Number of Days Clear | Number of Days Partly Cloudy | Number of Days Cloudy | Prevailing Wind Direction | Duration of Record |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A. Within Region of Excellent Development | | | | | | | | | | | | |
| Montana Stations | | | | | | | | | | | | |
| Saltese | 3600 | | | | 34.3 | 153 | | 230 | 12 | 123 | W. | 9 |
| Idaho Stations | | | | | | | | | | | | |
| Clarks Fork | | 92 | -6 | 44.0 | 32.3 | 77 | 165 | 132 | 133 | 100 | -- | 2 |
| Dent | 1350 | 104 | -7 | 48.8 | 29.1 | 49 | 162 | 126 | 140 | 99 | -- | 7 |
| Deary | 2854 | 98 | -6 | --.- | 31.1 | 129 | 130 | --- | --- | -- | S.W. | 2 |
| Grand Forks | 3000 | 94 | -19 | 41.9 | 52.0 | 159 | 68 | --- | --- | -- | -- | 3 |
| Kellogg | 2305 | 98 | -11 | 45.3 | 30.4 | 53 | 122 | 151 | 31 | 183 | S.W. | 10 |
| Lakeview | 2250 | 92 | -1 | 46.0 | 28.0 | 54 | 157 | 130 | 82 | 153 | S.W. | 16 |
| Murray | 2750 | 95 | -12 | 43.3 | 37.7 | 129 | 107 | 116 | 98 | 151 | W. | 15 |
| Priest River #-1 | 2500 | 92 | -16 | 42.1 | 33.3 | 88 | 139 | 108 | 108 | 149 | S.W. | 2 |
| Exp. Sta. #-2 | 2400 | 98 | -13 | 43.9 | 31.3 | 81 | 139 | 109 | 109 | 147 | S.E.-S.W. | 2 |
| St. Maries | 2263 | 99 | -8 | 47.4 | 28.2 | 56 | 135 | 150 | 86 | 129 | S.W.-N.W. | 15 |
| Sandpoint | 2086 | 94 | -10 | 44.2 | 27.2 | 81 | 117 | 143 | 63 | 159 | S. | 3 |
| Wallace | 2728 | 96 | -9 | 44.2 | 39.8 | -- | 143 | --- | --- | --- | N. [?] | 6 |
| Eastern B. C. | | | | | | | | | | | | |
| Nelson | 1771 | (97) | (-7) | 46.4 | 29.0 | 84 | --- | --- | --- | --- | -- | -- |
| Revelstoke | 1503 | (100) | (-25) | 42.8 | 43.0 | 120 | --- | --- | --- | --- | -- | -- |
| Rossland | 3461 | (88) | (-11) | 42.5 | 31.0 | 123 | --- | --- | --- | --- | -- | -- |
| Western B. C. | | | | | | | | | | | | |
| Alberni | 300 | (106) | (3) | 48.3 | 62.0 | 53 | --- | --- | --- | --- | -- | -- |
| Premberton Meadows | 700 | (95) | (-22) | --- | 34.9 | 112 | --- | --- | --- | --- | -- | -- |
| Quantaino | 0 | (86) | (11) | 46.6 | 112.3 | 22 | --- | --- | --- | --- | -- | -- |
| Vancouver | 136 | (92) | (2) | 48.6 | 58.0 | 27 | --- | --- | --- | --- | -- | -- |
| Victoria | 85 | (90) | (6) | 50.7 | 29.2 | 9 | --- | --- | --- | --- | -- | -- |

Table H Continued.

| Station | Elevation Feet | Temperature °F Average Highest | Temperature °F Average Lowest | Temperature °F Mean | Precipitation Total Average Inches | Precipitation Unmelted Snow Inches | No. days between heavy frosts | Number of Days Clear | Number of Days Partly Cloudy | Number of Days Cloudy | Prevailing Wind Direction | Duration of Record |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [A. Within Region of Excellent Development Continued] | | | | | | | | | | | | |
| Western Washington | | | | | | | | | | | | |
| Baker | 390 | 96 | 9 | 50 | 66.3 | 48 | 180 | 130 | 54 | 181 | -- | 7 |
| Lake Keechalus | 2479 | -- | - | -- | 63.9 | 264 | --- | 105 | 70 | 190 | -- | 6 |
| Skagit Power Dam | 510 | 101 | 8 | 48.4 | 69.0 | 60 | 187 | 162 | 40 | 163 | W. | 4 |
| Washougal | 650 | 95 | 16 | 51.4 | 54.6 | 8 | 219 | 164 | 59 | 141 | W. | 13 |
| Wind River | 1300 | 99 | 8 | 47.4 | 75.0 | 134 | --- | 126 | 89 | 150 | W. | 2 |
| B. Within Usual Range or at Lower Limits of Altitude | | | | | | | | | | | | |
| California | | | | | | | | | | | | |
| Sumit | 7017 | -- | - | 42.1 | 48.3 | 447 | 242 | 222 | 48 | 75 | S.W. | 30 |
| C. Just Within or at Lower Limits of Altitude | | | | | | | | | | | | |
| California | | | | | | | | | | | | |
| Cisco | 5939 | -- | - | 46.6 | 51.2 | 578 | --- | 248 | 10 | 107 | W. | 25 |
| Truckee | 5818 | -- | - | 43.9 | 27.2 | 194 | --- | 140 | 83 | 122 | S W. | 30 |
| Montana | | | | | | | | | | | | |
| Columbia Falls | 3100 | 96 | -12 | 42.4 | 22.9 | 56 | 71 | 138 | 75 | 152 | S W. | 18 |
| Haugan | 3150 | 99 | -25 | 43.0 | 24.3 | 157 | 63 | --- | --- | --- | N.E. | 5 |
| Libby | 2075 | 100 | -19 | 44.9 | 25.6 | 65 | 78 | 120 | 99 | 146 | S W. | 18 |
| Thompson Falls | 2424 | 97 | -13 | 44.2 | 20 | 56 | --- | 158 | 88 | 119 | W. | 2 |
| Idaho & East. Wash. | | | | | | | | | | | | |
| Bonner's Ferry | 1850 | 96 | -14 | 44.3 | 21.0 | 64 | 128 | 149 | 128 | 88 | S W. | 7 |
| Coeur d'Alene | 2157 | 98 | -12 | 46.8 | 25.1 | 57 | 156 | 142 | 92 | 131 | S W. | 10 |
| Porthill | 1685 | 93 | -13 | 44.5 | 22.5 | 71 | 143 | 152 | 71 | 142 | S W. | 24 |
| Newport, Wn. | 2400 | 97 | -21 | 43.3 | 23.2 | 69 | 94 | 131 | 122 | 112 | S W. | 7 |

Table H Continued

| Station | Elevation Feet | Temperature °F Average Highest | Temperature °F Average Lowest | Temperature °F Mean | Precipitation Total Average Inches | Precipitation Unmelted Snow Inches | No. days between heavy frosts | Number of Days Clear | Number of Days Partly Cloudy | Number of Days Cloudy | Prevailing Wind Direction | Duration of Record |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| D. Shortly Below or Outside Lower Limits of Altitude | | | | | | | | | | | | |
| Kalispell, Mont. | 2965 | 92 | -16 | 42.9 | 15.2 | 42 | 148 | 119 | 120 | 127 | W. | 14 |
| Missoula, " | 3225 | 97 | -15 | 44.2 | 15.7 | 24 | 114 | | | | W. | 34 |
| Ovardo, " | 4050 | 94 | -50 | 30.0 | 19.8 | 81 | 41 | 100 | 157 | 99 | W. | 14 |
| Pleasant Valley, " | 3500 | 93 | -40 | 38.9 | 18.2 | 73 | 42 | | | | W. | 6 |
| *Kooskia, Id. | 1961 | 104 | -11 | 49.1 | 25.1 | 27 | 147 | 124 | 105 | 136 | S W. | 5 |
| Spokane, Wash. | 1943 | 99 | -7 | 48.1 | 18.9 | 38 | 181 | 97 | 111 | 157 | S W. | 31 |
| Klamath Agency, Ore. | 5000 | 93 | -39 | 43.1 | 21.5 | 69 | -30 | 200 | 75 | 90 | W. | 4-15 |
| E. Considerably Below Lower Limits | | | | | | | | | | | | |
| **California | | | | | | | | | | | | |
| Blue Canyon | 4695 | -- | -- | 49.2 | 73.8 | 189 | 122 | 242 | 18 | 105 | S W. | 10 |
| La Porte | 5000 | -- | -- | 45.4 | 86.0 | 299 | 102 | 193 | 112 | 60 | [n. l.] | 15 |
| Lake Elenor | 4700 | -- | -- | 47.9 | 42.5 | 175 | --- | 217 | 67 | 81 | S.E. | -- |
| F. Shortly Above Upper Limits of Altitude | | | | | | | | | | | | |
| California | | | | | | | | | | | | |
| Tamarack | 8000 | -- | -- | 37.1 | 66.1 | 353 | --- | 187 | 49 | 129 | S.W. | 6 |

* Absence of white pine here possibly due to its newness from ecologic standpoint and the consequent youth of forest conditions; but more likely to low atmospheric humidity on summer days.

** Absence of white pine here undoubtedly due to long summer drought and low atmospheric humidity.

(Appendix)

Table I

HUMIDITY
UNDER CLIMATIC CONDITIONS FAVORABLE AND UNFAVORABLE
TO GROWTH OF WHITE PINE

| | Climate of Entire Avg. Yr. | | | | | Humidity During Dry Seasons* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Precip-itation | Temper-ature | Humidity | | | | | | | |
| Station | Total | Mean | AM | Mean | PM | Mean AM | Mean PM | Max. PM | Max. PM | Days Less Than 20% |
| With Conditions Favorable for White Pine | | | | | | | | | | |
| Seattle | 34.6 | 51.4 | 87 | 77 | 68 | 87 | 54 | 87 | 22 | 0 |
| Tacoma | 45.4 | 50.7 | 90 | 79 | 65 | 85 | 46 | 91 | 22 | 0 |
| Priest River | | | | | | | | | | |
| Exp. Sta. I | 41.4 | 43.3 | *** | *** | 70 | *** | 35 | 100 | 18 | 2 |
| " III | 40.7 | 40.7 | *** | *** | 68 | *** | 29 | 94 | 15 | 6 |
| " II(A) | 38.1 | 45.2 | *** | *** | 65 | *** | 40 | 91 | 19 | 1 |
| Portland | 43.8 | 53.0 | 83 | 72 | 47 | 80 | 45 | 90 | 17 | 1 |
| With Conditions Unfavorable for White Pine# | | | | | | | | | | |
| Kalispell | 15.2 | 42.9 | 83 | 70 | 58 | 72 | 29 | 76 | 16 | 4 |
| Priest River | | | | | | | | | | |
| Exp. Sta. II(B) | 38.1 | 45.2 | *** | *** | 65 | *** | 25 | 94 | 11 | 14 |
| Spokane | 17.2 | 48.1 | 78 | 65 | 50 | 55 | 19 | 66 | 9 | 19 |
| Red Bluff Calif. | 25.6 | 62.5 | 71 | 56 | 44 | 56 | 21 | 44 | 7 | 50 |

* Data given here is that for dry period of 1914 (taken as representative of a dry year) at all stations except Priest River Experiment Station II (A); at the latter the data is for 1913, a season in which seedling white pine grew thriftily, to be contrasted with the same station under (B) for 1914, when seedlings died.

# From a general familiarity of the climatic conditions at these points and of requirements of white pine, it is concluded that the particular conditions which do not favor white pine at the several points are: At Kalispell, -- low precipitation and consequent low soil moisture; at Priest River Exp. Sta. II (B), -- low soil moisture due to aspect combined with low afternoon humidity; at Spokane. – low soil moisture due to low precipitation combined with low afternoon humidity; at Red Bluff, -- low humidity either by itself or combined with high temperature.

(Appendix) TABLE J

NUMBER OF TREES PER ACRE BY DIAMETER CLASS AND AGE IN NATURAL UNTHINNED LITTLE-CROWDED MAXIMUM STANDS OF NEARLY PURE WESTERN WHITE PINE

| | NUMBER | | | | | OF | | | | TREES | | | | | PER | | | | | ACRE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 35 Years Old | | | | | 80 Years Old | | | | | 125 Years Old | | | | | | 140 Years Old | | | |
| Diameter | Kaniksu Forest, Idaho | | | | | Clearwater Forest, Idaho | | | | | Near Elk River, Clearwater County, Idaho | | | | | | Kaniksu Forest, Idaho | | | |
| at Breast Height | White Pine | Dougl. Fir | West. Larch | Red Cedar | Total | White Pine | White Fir | Dougl. Fir | Misc. | Total | White Pine | White Fir | Dougl. Fir | West. Larch | Red Cedar | Total | White Pine | West. Larch | Red Cedar | Misc. | Total |
| 1 & 2 | 88 | 20 | | 260 | 368 | | | | | | | 6.2 | | | 26.2 | 32.4 | | | | | |
| 3 & 4 | 36 | 64 | 12 | 8 | 120 | | | | | | 0.9 | 7.4 | | | 28.2 | 36.5 | | | | | |
| 5 & 6 | 52 | 48 | 32 | | 132 | 10.0 | 0.6 | | 0.3 | 10.9 | 4.3 | 7.7 | 0.8 | 0.4 | 12.6 | 25.8 | 2.5 | | 7.5 | 0.5 | 10.5 |
| 7 & 8 | 64 | 20 | 36 | 4 | 124 | 22.4 | 1.5 | | 1.2 | 25.1 | 9.8 | 9.2 | 1.2 | | 3.2 | 23.4 | 16.0 | | 16.0 | 1.5 | 33.5 |
| 9 & 10 | 56 | 8 | 16 | | 80 | 27.6 | 2.8 | 0.6 | 1.2 | 32.2 | 16.2 | 8.7 | 0.8 | 0.3 | 1.9 | 27.9 | 26.0 | 0.7 | 6.8 | 2.2 | 35.7 |
| 11 & 12 | 48 | 8 | 12 | | 68 | 31.0 | 3.1 | 0.3 | 1.2 | **8.6*** | 26.0 | 9.6 | 2.1 | 1.1 | 0.7 | 39.5 | 23.3 | 3.3 | 5.7 | 1.0 | 33.3 |
| 13 & 14 | 16 | | | | 16 | 33.5 | 1.5 | 0.9 | 0.3 | 36.2 | 38.2 | 9.3 | 2.1 | 1.4 | | **46.0*** | 24.5 | 4.2 | 1.5 | | 30.2 |
| 15 & 16 | | | | | | 32.9 | 1.5 | 1.5 | 0.3 | 36.2 | 48.6 | 6.2 | 1.8 | 0.3 | | 56.9 | 27.5 | 4.8 | 0.8 | 0.3 | 33.4 |
| 17 & 18 | | | | | | 23.6 | 3.1 | 2.1 | | 28.8 | 34.0 | 5.3 | 1.8 | 0.5 | | 41.6 | 25.2 | 3.5 | | 0.2 | 28.9 |
| 19 & 20 | | | | | | 17.5 | 1.2 | 0.9 | 0.3 | 19.9 | 31.0 | 3.0 | 1.3 | 0.2 | 0.1 | 35.6 | 27.3 | 2.2 | 0.5 | 0.7 | 30.7 |
| 21 & 22 | | | | | | 9.8 | 0.6 | 0.9 | | 11.3 | 15.5 | 1.2 | 0.3 | | 0.1 | 17.1 | 24.0 | 3.5 | | | 27.5 |
| 23 & 24 | | | | | | 4.3 | 0.9 | 0.6 | 0.3 | 6.1 | 8.7 | 0.9 | 0.2 | 0.1 | | 9.9 | 10.5 | 0.5 | | 0.2 | 11.2 |
| 25 & 26 | | | | | | 1.2 | | 0.6 | | 1.8 | 3.3 | 0.1 | 0.1 | | | 3.5 | 8.5 | | | | 8.5 |
| 27 & 28 | | | | | | 1.2 | | 0.6 | | 1.8 | 0.4 | | | | | 0.4 | 3.7 | | | | 3.7 |
| 29 & 30 | | | | | | 0.6 | | 0.6 | 0.3 | 1.5 | 0.2 | | | | | 0.2 | 2.5 | | | | 2.5 |
| 31 & 32 | | | | | | | | | | | | | | | | | 0.5 | | | | 0.5 |
| 33 & 34 | | | | | | | | | | | | | | | | | 0.7 | | | | 0.7 |
| 37 | | | | | | | | | | | | | | | | | 0.3 | | | | 0.3 |
| Tot 1" up | 360 | 168 | 108 | 272 | 908 | | | | | | **232.1*** | 74.8 | 12.5 | 4.3 | 73.0 | **396.7*** | | | | | |
| Tot 3" up | 272 | 148 | 108 | 12 | 540 | | | | | | **232.1*** | 68.6 | **11.2*** | 4.3 | 46.8 | **363.0*** | | | | | |
| Tot 5" up | 236 | 84 | 96 | 4 | 420 | 215.6 | 16.8 | 9.6 | 5.4 | 247.4 | **231.2*** | 61.2 | **11.2*** | 4.3 | 18.6 | **326.5*** | 223.0 | 22.7 | 38.8 | 6.6 | 291.1 |
| Avg. D.B.H. | 7.9 | 5.7 | 8.0 | 1.8 | 7.4 | 14.4 | 14.6 | 19.7 | 17.1 | 14.7 | 16.2 | 13.2 | 14.4 | 13.7 | 4.2 | 15.6 | 17.0 | 16.7 | 9.1 | 9.8 | 17.0 |
| Cu.Ft. Volume | 3,350 | 520 | 780 | 30 | 4,680 | 11,000 | 875 | 750 | 240 | 12,865 | 18,000 | 2,760 | 625 | 195 | 120 | 21,700 | [n. l.] | 1,570 | 580 | * | 22,150 |
| Bd. Ft. Vol. Log Scale | 1,460 | 1,920 | 880 | 20 | 14,280 | 57,000 | 5,000 | 4,000 | 1,300 | 67,300 | 95,300 | 12,700 | 3,100 | 740 | 210 | 112,050 | 131,300 | 8,100 | 1,600 | * | 141,000 |
| % of all trees 5" up | 56.2 | 20.0 | 22.8 | 1.0 | 100.0 | 87.1 | 6.8 | 3.9 | 2.2 | 100.0 | 70.8 | 18.7 | 3.4 | 1.3 | 5.7 | 100.0 | 76.6 | 7.8 | 13.3 | 2.3 | 100.0 |
| % of Cu. Volume | 71.5 | 11.1 | 16.8 | 0.6 | 100.0 | 85.5 | 6.8 | 5.8 | 1.9 | 100.0 | 83.0 | 12.7 | 2.9 | 0.9 | 0.6 | 100.0 | 90.2 | 7.1 | 2.6 | | 100.0 |
| Basis Notes | 1/4 A. on Westbranch Foothill Slope | | | | | 3 1/4 A. on Orogrande Hilltops | | | | | 12 A. on Elk Creek Hill Slopes | | | | | | 4 A. on Westbranch Flats, Chiefly white fir vol. computed cedar | | | | |

[* Totals found to be incorrect in a spreadsheet during transcription. See following table for corrections.]

TABLE J [Corrected*]

NUMBER OF TREES PER ACRE BY DIAMETER CLASS AND AGE IN NATURAL UNTHINNED LITTLE-CROWDED MAXIMUM STANDS OF NEARLY PURE WESTERN WHITE PINE

| | NUMBER | | | | | OF | | | | TREES | | | | | PER | | | | | ACRE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 35 Years Old | | | | | 80 Years Old | | | | | 125 Years Old | | | | | | 140 Years Old | | | |
| Diameter | Kaniksu Forest, Idaho | | | | | Clearwater Forest, Idaho | | | | | Near Elk River, Clearwater County, Idaho | | | | | | Kaniksu Forest, Idaho | | | |
| at Breast | White | Dougl. | West. | Red | | White | White | Dougl. | | | White | White | Dougl. | West. | Red | | White | West. | Red | |
| Height | Pine | Fir | Larch | Cedar | Total | Pine | Fir | Fir | Misc. | Total | Pine | Fir | Fir | Larch | Cedar | Total | Pine | Larch | Cedar | Misc. | Total |
| 1 & 2 | 88 | 20 | | 260 | 368 | | | | | | | 6.2 | | | 26.2 | 32.4 | | | | | |
| 3 & 4 | 36 | 64 | 12 | 8 | 120 | | | | | | 0.9 | 7.4 | | | 28.2 | 36.5 | | | | | |
| 5 & 6 | 52 | 48 | 32 | | 132 | 10.0 | 0.6 | | 0.3 | 10.9 | 4.3 | 7.7 | 0.8 | 0.4 | 12.6 | 25.8 | 2.5 | | 7.5 | 0.5 | 10.5 |
| 7 & 8 | 64 | 20 | 36 | 4 | 124 | 22.4 | 1.5 | | 1.2 | 25.1 | 9.8 | 9.2 | 1.2 | | 3.2 | 23.4 | 16.0 | | 16.0 | 1.5 | 33.5 |
| 9 & 10 | 56 | 8 | 16 | | 80 | 27.6 | 2.8 | 0.6 | 1.2 | 32.2 | 16.2 | 8.7 | 0.8 | 0.3 | 1.9 | 27.9 | 26.0 | 0.7 | 6.8 | 2.2 | 35.7 |
| 11 & 12 | 48 | 8 | 12 | | 68 | 31.0 | 3.1 | 0.3 | 1.2 | **35.6*** | 26.0 | 9.6 | 2.1 | 1.1 | 0.7 | 39.5 | 23.3 | 3.3 | 5.7 | 1.0 | 33.3 |
| 13 & 14 | 16 | | | | 16 | 33.5 | 1.5 | 0.9 | 0.3 | 36.2 | 38.2 | 9.3 | 2.1 | 1.4 | | **51.0*** | 24.5 | 4.2 | 1.5 | | 30.2 |
| 15 & 16 | | | | | | 32.9 | 1.5 | 1.5 | 0.3 | 36.2 | 48.6 | 6.2 | 1.8 | 0.3 | | 56.9 | 27.5 | 4.8 | 0.8 | 0.3 | 33.4 |
| 17 & 18 | | | | | | 23.6 | 3.1 | 2.1 | | 28.8 | 34.0 | 5.3 | 1.8 | 0.5 | | 41.6 | 25.2 | 3.5 | | 0.2 | 28.9 |
| 19 & 20 | | | | | | 17.5 | 1.2 | 0.9 | 0.3 | 19.9 | 31.0 | 3.0 | 1.3 | 0.2 | 0.1 | 35.6 | 27.3 | 2.2 | 0.5 | 0.7 | 30.7 |
| 21 & 22 | | | | | | 9.8 | 0.6 | 0.9 | | 11.3 | 15.5 | 1.2 | 0.3 | | 0.1 | 17.1 | 24.0 | 3.5 | | | 27.5 |
| 23 & 24 | | | | | | 4.3 | 0.9 | 0.6 | 0.3 | 6.1 | 8.7 | 0.9 | 0.2 | 0.1 | | 9.9 | 10.5 | 0.5 | | 0.2 | 11.2 |
| 25 & 26 | | | | | | 1.2 | | 0.6 | | 1.8 | 3.3 | 0.1 | 0.1 | | | 3.5 | 8.5 | | | | 8.5 |
| 27 & 28 | | | | | | 1.2 | | 0.6 | | 1.8 | 0.4 | | | | | 0.4 | 3.7 | | | | 3.7 |
| 29 & 30 | | | | | | 0.6 | | 0.6 | 0.3 | 1.5 | 0.2 | | | | | 0.2 | 2.5 | | | | 2.5 |
| 31 & 32 | | | | | | | | | | | | | | | | | 0.5 | | | | 0.5 |
| 33 & 34 | | | | | | | | | | | | | | | | | 0.7 | | | | 0.7 |
| 37 | | | | | | | | | | | | | | | | | 0.3 | | | | 0.3 |
| Tot 1" up | 360 | 168 | 108 | 272 | 908 | | | | | | **237.1*** | 74.8 | 12.5 | 4.3 | 73.0 | **401.7*** | | | | | |
| Tot 3" up | 272 | 148 | 108 | 12 | 540 | | | | | | **237.1*** | 68.6 | **12.5*** | 4.3 | 46.8 | **369.3*** | | | | | |
| Tot 5" up | 236 | 84 | 96 | 4 | 420 | 215.6 | 16.8 | 9.6 | 5.4 | 247.4 | **236.2*** | 61.2 | **12.5*** | 4.3 | 18.6 | **332.8*** | 223.0 | 22.7 | 38.8 | 6.6 | 291.1 |
| Avg. D.B.H. | 7.9 | 5.7 | 8.0 | 1.8 | 7.4 | 14.4 | 14.6 | 19.7 | 17.1 | 14.7 | 16.2 | 13.2 | 14.4 | 13.7 | 4.2 | 15.6 | 17.0 | 16.7 | 9.1 | 9.8 | 17.0 |
| Cu.Ft. Volume | 3,350 | 520 | 780 | 30 | 4,680 | 11,000 | 875 | 750 | 240 | 12,865 | 18,000 | 2,760 | 625 | 195 | 120 | 21,700 | [n. l.] | 1,570 | 580 | * | 22,150 |
| Bd. Ft. Vol. Log Scale | 1,460 | 1,920 | 880 | 20 | 14,280 | 57,000 | 5,000 | 4,000 | 1,300 | 67,300 | 95,300 | 12,700 | 3,100 | 740 | 210 | 112,050 | 131,300 | 8,100 | 1,600 | * | 141,000 |
| % of all trees 5" up | 56.2 | 20.0 | 22.8 | 1.0 | 100.0 | 87.1 | 6.8 | 3.9 | 2.2 | 100.0 | 70.8 | 18.7 | 3.4 | 1.3 | 5.7 | 100.0 | 76.6 | 7.8 | 13.3 | 2.3 | 100.0 |
| % of Cu. Volume | 71.5 | 11.1 | 16.8 | 0.6 | 100.0 | 85.5 | 6.8 | 5.8 | 1.9 | 100.0 | 83.0 | 12.7 | 2.9 | 0.9 | 0.6 | 100.0 | 90.2 | 7.1 | 2.6 | | 100.0 |
| Basis Notes | 1/4 A. on Westbranch Foothill Slope | | | | | 3 1/4 A. on Orogrande Hilltops | | | | | 12 A. on Elk Creek Hill Slopes | | | | | | 4 A. on Westbranch Flats, Chiefly white fir vol. computed cedar | | | | |

[* Data or totals corrected in a spreadsheet during transcription.]

(Appendix)

TABLE K

NUMBER OF TREES PER ACRE BY DIAMETER CLASS AND AGE, IN NATURAL UNTHINNED LITTLE-CROWDED MAXIMUM STANDS OF CEDAR IN MIXTURE WITH WESTERN WHITE PINE

| Diameter at Breast Height | NUMBER OF TREES PER ACRE | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 60 Years Old - Clearwater Forest | | | | | 140 Years Old - Kaniksu Forest | | | | | 250 Years Old - Kaniksu Forest | | | | | |
| | White Pine | Red Cedar | White Fir | *Others | Total | White Pine | Red Cedar | Western Hemlock | **West. Larch | Total | White Pine | Red Cedar | Western Hemlock | White Fir | West. Larch | Total |
| 5 & 6 | 7.0 | 9.0 | 1.0 | | 17.0 | | 17.7 | 1.3 | | 19.0 | | 0.9 | 0.1 | | | 1.0 |
| 7 & 8 | 10.5 | 21.5 | 3.0 | | 35.0 | 8.0 | 36.3 | 2.7 | | 47.0 | 0.1 | 6.3 | 7.1 | 2.1 | | 15.6 |
| 9 & 10 | 13.0 | 27.0 | 1.0 | 0.5 | 41.5 | 9.7 | 37.7 | 3.7 | 1.0 | 52.1 | 0.4 | 6.4 | 7.4 | 2.5 | | 16.7 |
| 11 & 12 | 17.5 | 18.5 | 3.0 | 2.5 | 41.5 | 11.0 | 25.0 | 1.7 | 4.3 | 42.0 | 0.4 | 4.6 | 4.6 | 1.9 | | 11.5 |
| 13 & 14 | 15.0 | 13.5 | 3.0 | 2.0 | 33.5 | 11.3 | 15.0 | 2.7 | 8.7 | 37.7 | 0.7 | 4.3 | 2.9 | 1.1 | | 9.0 |
| 15 & 16 | 17.5 | 8.0 | 3.5 | 2.0 | 31.0 | 13.7 | 11.3 | 0.7 | 7.0 | 32.7 | 1.9 | 2.7 | 1.3 | 0.6 | 0.1 | 6.6 |
| 17 & 18 | 16.5 | 8.5 | 3.5 | 1.0 | 29.5 | 14.7 | 7.0 | 2.0 | 9.7 | 33.4 | 2.5 | 2.6 | 0.7 | 0.9 | 0.1 | 6.8 |
| 19 & 20 | 8.0 | 3.5 | 1.5 | 0.5 | 13.5 | 12.0 | 7.7 | 1.0 | 9.3 | 30.0 | 3.2 | 2.3 | 0.4 | 0.4 | 0.1 | 6.4 |
| 21 & 22 | 7.0 | 1.5 | 5.0 | 3.5 | 17.0 | 12.7 | 2.7 | 1.3 | 6.0 | 22.7 | 2.6 | 2.0 | 0.6 | 0.5 | 0.6 | 6.3 |
| 23 & 24 | 8.0 | 0.5 | 2.5 | 0.5 | 11.5 | 7.7 | 0.7 | 1.0 | 3.7 | 13.1 | 3.3 | 1.4 | 0.4 | 0.1 | 0.3 | 5.5 |
| 25 & 26 | 3.5 | | 4.0 | 0.5 | 8.0 | 10.7 | 1.0 | 1.0 | 1.0 | 13.7 | 4.2 | 0.9 | 0.1 | | 0.6 | 5.8 |
| 27 & 28 | 1.5 | | 1.0 | | 2.5 | 4.3 | 0.3 | 0.3 | 0.3 | 5.2 | 5.1 | 1.6 | 0.6 | 0.1 | 0.8 | 8.2 |
| 29 & 30 | 0.5 | | 1.0 | | 1.5 | 1.0 | 1.0 | | | 2.0 | 3.3 | 1.2 | 0.5 | | 1.1 | 6.1 |
| 31 & 32 | | | | | | 0.7 | 1.3 | | | 2.0 | 3.1 | 1.5 | 0.1 | 0.1 | 0.6 | 5.4 |
| 33 & 34 | 0.5 | | | | 0.5 | 0.7 | | | | 0.7 | 2.8 | 0.5 | 0.2 | 0.1 | 0.5 | 4.1 |
| 35 & 36 | | | | | | | | | | | 2.4 | 0.6 | | | 0.6 | 3.6 |
| 37 & 38 | | | | | | | 0.3 | | | 0.3 | 1.3 | 0.6 | 0.1 | | 0.5 | 2.5 |
| 39 & 40 | | | | | | | | | | | 0.6 | 0.4 | 0.1 | | 0.1 | 1.2 |
| 41 & 42 | | | | | | | | | | | 1.1 | 0.4 | | | | 1.5 |
| 43 & 44 | | | | | | | | | | | 0.4 | 0.5 | | | 0.1 | 1.0 |
| 45 & 46 | | | | | | | | | | | 0.2 | 0.1 | | | | 0.3 |
| 47 & 48 | | | | | | | | | | | 0.1 | 0.2 | | | | 0.3 |
| 49 & 50 | | | | | | | | | | | | | | | 0.1 | 0.1 |
| 51 & 52 | | | | | | | | | | | 0.1 | | | | | 0.1 |
| 53 & 54 | | | | | | | | | | | 0.1 | | | | | 0.1 |
| Total No. | 126.0 | 111.5 | 33.0 | 13.0 | 283.5 | 118.2 | 165.0 | 19.4 | 51.0 | 353.6 | 39.0 | 42.0 | 27.2 | 10.4 | 6.2 | 125.7 |
| Avr. D.B.H. | 15.7 | 11.8 | 18.7 | 17.5 | 12.9 | 18.7 | 12.7 | 15.0 | 17.8 | 15.8 | 27.7 | 19.2 | 13.6 | 13.8 | 30.3 | 21.7 |
| Cu. Ft. Vol. | 7,530 | 3,150 | 2,530 | 950 | 14,140 | 13,000 | 5,000 | | 4,500 | 22,600 | 10,240 | 2,440 | 1,270 | 500 | 1,280 | 15,740 |
| B. F. Vol. | 41,570 | 13,960 | 19,600 | 5,270 | 80,400 | 77,000 | *21000 | | 21,600 | 119,600 | 63,600 | 14,400 | 6,600 | 2,800 | 8,200 | 95,600 |
| Basis Notes | 2 Acres in Orogrande Foothills spruce, Doug.fir, larch & alpine fir | | | | *Eng. | 3 Acres in Westbranch Foothills ** Including Douglas Fir * Including the hemlock | | | | | 14 Acres on Westbranch Flats | | | | | |

(Appendix) TABLE L

NUMBER OF TREES PER ACRE BY DIAMETER CLASS AND AGE, IN NATURAL UNTHINNED LITTLE-CROWDED MAXIMUM STANDS OF WESTERN WHITE PINE AND WESTERN LARCH

| Diameter at Breast Height | NUMBER OF TREES PER ACRE | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 38 Years Old | | | | | | | 52 Years Old | | | | | *137 Years Old | | | | |
| | Kaniksu Forest, Idaho | | | | | | | Kaniksu Forest | | | | | Kaniksu Forest | | | | |
| | White Pine | West. Larch | Lodge-pole | Dougl. Fir | Engelm Spruce | Red Cedar | Total | White Pine | West. Larch | Spruce & D.Fir | Cedar & Hemlock | Total | White Pine | West. Larch | Engelm Spruce | Red Cedar | Total |
| 1 & 2 | 114 | 6 | | 6 | 38 | 400 | 564 | 92 | 4 | 4 | 780 | 880 | | | | | |
| 3 & 4 | 170 | 32 | 2 | 24 | 44 | | 272 | 214 | 68 | 6 | 190 | 478 | | | | | |
| 5 & 6 | 98 | 32 | 6 | 26 | 20 | | 182 | 108 | 74 | 4 | 28 | 214 | 4.6 | | 0.2 | 30.2 | 35.0 |
| 7 & 8 | 70 | 40 | 2 | 6 | 2 | | 120 | 58 | 56 | | 14 | 128 | 11.7 | 0.8 | 1.1 | 34.0 | 47.6 |
| 9 & 10 | 18 | 26 | 10 | | 2 | | 56 | 24 | 42 | | 2 | 68 | 22.6 | 3.4 | 1.1 | 26.8 | 53.9 |
| 11 & 12 | 4 | 20 | | | | | 24 | 14 | 22 | | 2 | 38 | 15.8 | 8.6 | 2.9 | 16.9 | 44.2 |
| 13 & 14 | | | | | | | | 2 | 12 | | | 14 | 16.3 | 10.3 | 1.7 | 6.5 | 34.8 |
| 15 & 16 | | | | | | | | | 6 | | | 6 | 15.0 | 15.4 | 2.0 | 4.2 | 36.6 |
| 17 & 18 | | | | | | | | | | | | | 13.7 | 16.3 | 1.5 | 0.8 | 32.3 |
| 19 & 20 | | | | | | | | | | | | | 11.2 | 14.6 | 0.5 | 1.1 | 27.4 |
| 21 & 22 | | | | | | | | | | | | | 10.6 | 12.5 | 0.6 | | 23.7 |
| 23 & 24 | | | | | | | | | | | | | 5.4 | 8.6 | | 0.2 | 14.2 |
| 25 & 26 | | | | | | | | | | | | | 2.6 | 4.5 | | 0.1 | 7.2 |
| 27 & 28 | | | | | | | | | | | | | 1.2 | 1.7 | | | 2.9 |
| 29 & 30 | | | | | | | | | | | | | 0.8 | 0.2 | | | 1.0 |
| 31 & 32 | | | | | | | | | | | | | 0.2 | | | | 0.2 |
| 33 & 34 | | | | | | | | | | | | | 0.1 | 0.3 | | | 0.4 |
| Tot 1" up | 474 | 156 | 20 | 62 | 106 | 400 | 1218 | 512 | 284 | 14 | 1016 | 1826 | | | | | |
| Tot 3" up | 360 | 150 | 20 | 56 | 68 | | 654 | 420 | 280 | 10 | 236 | 946 | | | | | |
| Tot 5" up | 190 | 118 | 18 | 32 | 24 | | 382 | 206 | 212 | 4 | 46 | 468 | 131.8 | 97.2 | 11.6 | 120.6 | 361.2 |
| Aver. D.B.H. | 5.3 | 7.5 | 7.8 | 5.0 | 4.5 | 1.0 | | 5.3 | 7.5 | 3.8 | 1.7 | | 15.5 | 18.2 | 17.7 | 9.3 | |
| Cu. Ft. Vol. | 1,400 | 1,060 | 180 | 165 | 180 | | 2,985 | 2,150 | 2,660 | 20 | 230 | 5,040 | 9,500 | 8,000 | 700 | 1,650 | 19,850 |
| Bd. Ft. Vol. | 2,580 | 2,520 | 530 | 130 | 170 | | 5,930 | 3,980 | 7,650 | | 420 | 12,050 | 48,000 | 42,300 | 3,400 | 5,300 | 99,000 |
| Basis | 1/2 A. on Lower Westbranch Flats | | | | | | | 1/2 A. on Benton Flat | | | | | 6.5 A. in Lower Westbranch Valley | | | | |
| Notes | | | | | | | | | | | | | * Average of four normal stands. | | | | |

(Appendix)

TABLE M

NUMBER OF TREES PER ACRE BY DIAMETER CLASS AND AGE IN NATURAL UNTHINNED LITTLE-CROWDED MAXIMUM STANDS OF WESTERN WHITE PINE AND DOUGLAS FIR

| Diameter at Breast Height | NUMBER OF TREES PER ACRE | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 35 Years Old | | | | | | 90 Years Old | | | | 125 Years Old | | | |
| | Kaniksu Forest, Idaho | | | | | | St. Joe Forest | | | | Kaniksu Forest | | | |
| | White Pine | Dougl. Fir | West. Larch | Lodge-pole | Hemlock & W. Fir | Total | White Pine | Dougl. Fir | *Others | Total | White Pine | Dougl. Fir | White Fir | Total |
| 1 & 2 | 51 | 38 | | | 27 | 116.0 | | | | | | | | |
| 3 & 4 | 83 | 80 | 1 | 3 | 2 | 169.0 | | | | | | | | |
| 5 & 6 | 73 | 75 | 6 | 4 | 1 | 159.0 | 1.8 | 3.4 | 2.7 | 7.9 | | | | |
| 7 & 8 | 58 | 83 | 5 | 6 | | 152.0 | 1.4 | 6.8 | 0.5 | 8.7 | | | 1.3 | 1.3 |
| 9 & 10 | 35 | 51 | 6 | 4 | | 96.0 | 5.9 | 7.3 | | 13.2 | 2.7 | 1.3 | | 4.0 |
| 11 & 12 | 20 | 21 | 2 | 1 | | 44.0 | 8.6 | 13.6 | 2.7 | 24.9 | 4.0 | 1.3 | | 5.3 |
| 13 & 14 | 3 | 5 | 1 | | | 9.0 | 11.8 | 15.9 | 2.3 | 30.0 | 8.0 | 6.7 | | 14.7 |
| 15 & 16 | | | | | | | 16.8 | 14.5 | 1.4 | 32.7 | 13.3 | 8.0 | 1.3 | 22.6 |
| 17 & 18 | | | | | | | 27.8 | 15.5 | 0.9 | 44.2 | 14.7 | 14.7 | 2.7 | 32.1 |
| 19 & 20 | | | | | | | 15.4 | 15.0 | 0.9 | 31.3 | 20.0 | 16.0 | 6.7 | 42.7 |
| 21 & 22 | | | | | | | 9.6 | 5.5 | 0.9 | 16.0 | 9.3 | 5.3 | 4.0 | 18.6 |
| 23 & 24 | | | | | | | 4.5 | 2.7 | | 7.2 | 5.3 | 6.7 | 4.0 | 16.0 |
| 25 & 26 | | | | | | | 2.3 | 0.5 | | 2.8 | 2.7 | 2.7 | 4.0 | 9.4 |
| 27 & 28 | | | | | | | 0.4 | 0.4 | | 0.8 | 1.3 | 4.0 | | 5.3 |
| 29 & 30 | | | | | | | | | | | | | | |
| 31 & 32 | | | | | | | | | | | | 1.3 | 1.3 | 2.6 |
| Tot 1" up | 323 | 353 | 21 | 18 | 30 | 745 | | | | | | | | |
| Tot 3" up | 272 | 315 | 21 | 18 | 3 | 629 | | | | | | | | |
| Tot 5" up | 189 | 235 | 20 | 15 | 1 | 460 | 106.3 | 101.1 | 12.3 | 219.7 | 81.3 | 68 | 25.3 | 174.6 |
| Aver. D.B.H. | 6.5 | 7.0 | 8.5 | 7.6 | 1.6 | | 17.1 | 15.7 | 13.6 | | 18.3 | 19.7 | 21.5 | |
| Cu. Ft. Vol. | 1800 | 1960 | 230 | 130 | | 4120 | 8250 | 4570 | 500 | 13320 | 7070 | 5950 | 3160 | 16,180 |
| Bd. Ft. Vol. | 5,070 | 5,100 | 685 | 415 | | 11270 | 45,000 | 22,100 | 2,400 | 69500 | 37,800 | 30,200 | 17,550 | 85,550 |
| Basis | 1 Acre N.W. slope, on Lower West Branch | | | | | | 2.2 A. on Upper S. slope St. Joe River | | | | 3/4 A. on Upper S. slope Big Creek | | | |
| Notes | | | | | | | * W. Fir, Larch & Lodgepole | | | | | | | |

[No Table N found in existing copies]

(Appendix)

TABLE O

MULTIPLE VOLUME TABLE FOR WESTERN WHITE PINE

Based on Millar's Kaniksu Table of 1908.

| Diameter Breast High In. | No. Logs Per Tree | Number of trees | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | Volume to nearest 100 Bd. Ft. Scribner Rule | | | | | | | | | |
| 8 | 2 | 0 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 4 | 4 |
| | 3 | 1 | 1 | 2 | 2 | 3 | 4 | 4 | 5 | 6 | 6 |
| | 4 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 7 | 8 | 9 |
| | 5 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 10 | 2 | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 | 5 |
| | 3 | 1 | 2 | 3 | 4 | 5 | 5 | 6 | 7 | 8 | 9 |
| | 4 | 1 | 2 | 4 | 4 | 5 | 6 | 7 | 8 | 9 | 11 |
| | 5 | 1 | 3 | 4 | 6 | 7 | 8 | 10 | 11 | 13 | 14 |
| | 6 | 2 | 3 | 5 | 6 | 8 | 10 | 11 | 13 | 14 | 15 |
| 12 | 2 | 1 | 2 | 2 | 3 | 4 | 5 | 6 | 6 | 7 | 8 |
| | 3 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 11 |
| | 4 | 2 | 3 | 5 | 6 | 8 | 9 | 10 | 12 | 14 | 15 |
| | 5 | 2 | 4 | 5 | 7 | 9 | 11 | 13 | 14 | 16 | 18 |
| | 6 | 2 | 4 | 7 | 9 | 11 | 13 | 15 | 18 | 20 | 22 |
| | 7 | 3 | 5 | 7 | 10 | 1 | 15 | 17 | 20 | 23 | 25 |
| 14 | 3 | 2 | 3 | 4 | 6 | 8 | 9 | 11 | 12 | 14 | 15 |
| | 4 | 2 | 4 | 6 | 8 | 10 | 11 | 13 | 15 | 17 | 19 |
| | 5 | 2 | 5 | 7 | 9 | 11 | 14 | 16 | 18 | 21 | 23 |
| | 6 | 3 | 5 | 8 | 11 | 14 | 16 | 19 | 22 | 24 | 27 |
| | 7 | 3 | 6 | 10 | 13 | 16 | 19 | 22 | 26 | 29 | 32 |
| | 8 | 4 | 7 | 11 | 14 | 18 | 22 | 25 | 29 | 32 | 36 |
| 16 | 3 | 2 | 4 | 5 | 7 | 9 | 11 | 13 | 14 | 19 | 18 |
| | 4 | 2 | 5 | 7 | 9 | 11 | 14 | 16 | 18 | 21 | 23 |
| | 5 | 3 | 6 | 9 | 12 | 14 | 17 | 20 | 23 | 26 | 29 |
| | 6 | 3 | 7 | 10 | 14 | 17 | 20 | 24 | 27 | 31 | 34 |
| | 7 | 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 |
| | 8 | 5 | 9 | 14 | 18 | 23 | 27 | 32 | 36 | 41 | 45 |
| 18 | 4 | 3 | 7 | 8 | 11 | 14 | 17 | 20 | 22 | 25 | 28 |
| | 5 | 4 | 7 | 11 | 14 | 18 | 21 | 25 | 28 | 32 | 35 |
| | 6 | 4 | 8 | 15 | 17 | 21 | 25 | 29 | 34 | 38 | 42 |
| | 7 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | 8 | 6 | 11 | 17 | 23 | 28 | 34 | 40 | 46 | 51 | 57 |
| | 9 | 6 | 13 | 19 | 26 | 32 | 38 | 45 | 51 | 58 | 64 |

TABLE O Continued.

| Diameter Breast High In. | No. Logs Per Tree | Number of trees 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Volume to nearest 100 Bd. Ft. Scribner Rule | | | | | | | | | |
| 20 | 4 | 3 | 6 | 10 | 13 | 16 | 19 | 22 | 26 | 29 | 32 |
| | 5 | 4 | 8 | 12 | 16 | 20 | 25 | 29 | 33 | 37 | 41 |
| | 6 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | 7 | 6 | 12 | 10 | 24 | 30 | 36 | 42 | 48 | 54 | 60 |
| | 8 | 7 | 14 | 21 | 28 | 35 | 41 | 48 | 55 | 62 | 69 |
| | 9 | 8 | 16 | 24 | 32 | 40 | 47 | 55 | 63 | 71 | 79 |
| | 10 | 9 | 18 | 26 | 35 | 44 | 53 | 62 | 70 | 79 | 88 |
| 22 | 5 | 5 | 9 | 14 | 18 | 23 | | 32 | 37 | 41 | 46 |
| | 6 | 6 | 12 | 17 | 23 | 29 | 35 | 41 | 46 | 52 | 58 |
| | 7 | 7 | 14 | 21 | 28 | 36 | 43 | 50 | 57 | 64 | 71 |
| | 8 | 8 | 17 | 25 | 33 | 42 | 50 | 58 | 66 | 75 | 83 |
| | 9 | 10 | 19 | 29 | 38 | 48 | 58 | 67 | 77 | 86 | 96 |
| | 10 | 11 | 22 | 32 | 43 | 54 | 65 | 76 | 86 | 97 | 108 |
| 24 | 5 | 5 | 10 | 15 | 20 | 25 | 31 | 36 | 41 | 46 | 51 |
| | 6 | 7 | 13 | 20 | 26 | 33 | 40 | 47 | 53 | 59 | 66 |
| | 7 | 8 | 16 | 24 | 33 | 42 | 50 | 58 | 66 | 75 | 82 |
| | 8 | 10 | 20 | 29 | 39 | 49 | 59 | 68 | 78 | 88 | 98 |
| | 9 | 11 | 23 | 34 | 46 | 57 | 68 | 80 | 91 | 103 | 114 |
| | 10 | 13 | 26 | 39 | 52 | 65 | 78 | 91 | 104 | 117 | 130 |
| 26 | 6 | 8 | 15 | 23 | 30 | 38 | 46 | 53 | 61 | 68 | 76 |
| | 7 | 9 | 19 | 28 | 38 | 47 | 57 | 66 | 76 | 85 | 95 |
| | 8 | 11 | 23 | 34 | 46 | 57 | 68 | 80 | 91 | 103 | 114 |
| | 9 | 13 | 27 | 40 | 53 | 67 | 80 | 93 | 106 | 120 | 133 |
| | 10 | 15 | 30 | 46 | 61 | 76 | 91 | 106 | 122 | 137 | 152 |
| 28 | 6 | 9 | 17 | 26 | 34 | 43 | 52 | 60 | 69 | 77 | 86 |
| | 7 | 11 | 22 | 32 | 43 | 54 | 65 | 76 | 86 | 97 | 108 |
| | 8 | 13 | 26 | 39 | 52 | 65 | 78 | 91 | 104 | 117 | 130 |
| | 9 | 15 | 31 | 46 | 61 | 77 | 92 | 107 | 122 | 138 | 153 |
| | 10 | 18 | 35 | 53 | 61 | 88 | 105 | 123 | 140 | 168 | 175 |
| 30 | 6 | 11 | 21 | 32 | 42 | 53 | 63 | 74 | 84 | 95 | 105 |
| | 7 | 12 | 24 | 37 | 49 | 61 | 73 | 85 | 98 | 110 | 122 |
| | 8 | 15 | 29 | 44 | 59 | 74 | 88 | 103 | 118 | 132 | 147 |
| | 9 | 17 | 35 | 52 | 69 | 87 | 104 | 212 | 138 | 156 | 173 |
| | 10 | 20 | 40 | 60 | 80 | 100 | 119 | 139 | 159 | 179 | 199 |
| 32 | 6 | 11 | 22 | 34 | 45 | 56 | 67 | 78 | 90 | 101 | 112 |
| | 7 | 14 | 27 | 41 | 54 | 68 | 82 | 95 | 109 | 122 | 136 |
| | 8 | 16 | 33 | 49 | 65 | 82 | 98 | 114 | 130 | 147 | 163 |
| | 9 | 19 | 39 | 58 | 77 | 97 | 116 | 135 | 154 | 174 | 193 |
| | 10 | 22 | 45 | 67 | 89 | 112 | 134 | 156 | 178 | 201 | 223 |

TABLE O Continued.

| Diameter Breast High In. | No. Logs Per Tree | Number of trees 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Volume to nearest 100 Bd. Ft. Scribner Rule | | | | | | | | | |
| 34 | 6 | 12 | 24 | 36 | 48 | 60 | 72 | 84 | 96 | 108 | 120 |
| | 7 | 15 | 30 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | 150 |
| | 8 | 18 | 36 | 54 | 72 | 90 | 107 | 125 | 143 | 161 | 179 |
| | 9 | 21 | 43 | 64 | 86 | 107 | 128 | 150 | 171 | 193 | 214 |
| | 10 | 25 | 50 | 75 | 100 | 125 | 149 | 174 | 199 | 224 | 249 |
| 36 | 6 | 13 | 26 | 39 | 52 | 66 | 79 | 92 | 105 | 118 | 131 |
| | 7 | 16 | 33 | 49 | 66 | 82 | 98 | 115 | 131 | 148 | 164 |
| | 8 | 20 | 40 | 59 | 79 | 99 | 119 | 139 | 158 | 178 | 198 |
| | 9 | 24 | 47 | 71 | 94 | 118 | 142 | 165 | 189 | 212 | 236 |
| | 10 | 28 | 55 | 83 | 111 | 139 | 166 | 194 | 222 | 249 | 277 |
| 38 | 6 | 14 | 28 | 42 | 56 | 70 | 84 | 98 | 112 | 126 | 140 |
| | 7 | 18 | 36 | 54 | 72 | 90 | 108 | 126 | 144 | 162 | 180 |
| | 8 | 21 | 42 | 63 | 84 | 105 | 126 | 147 | 168 | 189 | 210 |
| | 9 | 25 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 |
| | 10 | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 | 270 | 300 |
| 40 | 6 | 15 | 30 | 45 | 60 | 75 | 90 | 105 | 120 | 135 | 150 |
| | 7 | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 |
| | 8 | 23 | 46 | 69 | 92 | 115 | 138 | 161 | 184 | 207 | 230 |
| | 9 | 28 | 56 | 84 | 112 | 140 | 168 | 196 | 224 | 252 | 280 |
| | 10 | 33 | 66 | 99 | 132 | 165 | 198 | 231 | 264 | 297 | 330 |
| 42 | 6 | 17 | 34 | 51 | 68 | 85 | 102 | 119 | 136 | 153 | 170 |
| | 7 | 21 | 42 | 63 | 84 | 105 | 126 | 147 | 168 | 189 | 210 |
| | 8 | 25 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 |
| | 9 | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 | 270 | 300 |
| | 10 | 36 | 72 | 108 | 144 | 180 | 216 | 252 | 288 | 324 | 360 |
| 44 | 6 | 19 | 38 | 57 | 76 | 95 | 114 | 133 | 152 | 171 | 190 |
| | 7 | 23 | 46 | 69 | 92 | 115 | 138 | 161 | 184 | 207 | 230 |
| | 8 | 27 | 54 | 81 | 108 | 135 | 162 | 189 | 216 | 243 | 270 |
| | 9 | 33 | 66 | 99 | 132 | 165 | 198 | 231 | 264 | 297 | 330 |
| | 10 | 39 | 78 | 117 | 156 | 195 | 234 | 273 | 312 | 351 | 390 |
| 46 | 6 | 21 | 42 | 63 | 84 | 105 | 126 | 147 | 168 | 189 | 210 |
| | 7 | 25 | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 225 | 250 |
| | 8 | 29 | 58 | 87 | 116 | 145 | 174 | 203 | 232 | 261 | 290 |
| | 9 | 35 | 70 | 105 | 140 | 175 | 210 | 245 | 280 | 315 | 350 |
| | 10 | 43 | 86 | 129 | 172 | 215 | 258 | 301 | 344 | 387 | 430 |

TABLE O Continued.

| Diameter Breast High In. | No. Logs Per Tree | Number of trees | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | | Volume to nearest 100 Bd. Ft. Scribner Rule | | | | | | | | | |
| 48 | 6 | 22 | 44 | 66 | 88 | 110 | 132 | 154 | 176 | 198 | 220 |
| | 7 | 27 | 54 | 81 | 108 | 135 | 162 | 189 | 216 | 343 | 270 |
| | 8 | 31 | 62 | 93 | 124 | 155 | 186 | 217 | 248 | 279 | 310 |
| | 9 | 37 | 74 | 111 | 148 | 185 | 222 | 259 | 296 | 333 | 370 |
| | 10 | 46 | 92 | 138 | 184 | 230 | 276 | 322 | 368 | 414 | 460 |
| 50 | 6 | 26 | 48 | 72 | 96 | 120 | 144 | 168 | 192 | 216 | 240 |
| | 7 | 29 | 58 | 87 | 116 | 145 | 174 | 205 | 232 | 261 | 290 |
| | 8 | 34 | 68 | 102 | 136 | 170 | 204 | 238 | 272 | 3060 | 340 |
| | 9 | 40 | 80 | 120 | 160 | 200 | 240 | 280 | 320 | 360 | 400 |
| | 10 | 49 | 98 | 147 | 196 | 245 | 294 | 343 | 392 | 441 | 490 |