

Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.



1.9622
P2R31

Duplicate

RESEARCH PAPER 33

OCTOBER 1959

S

The WIND RIVER ARBORETUM

by
ROY R. SIEN
and
LEONARD R. WOIKE

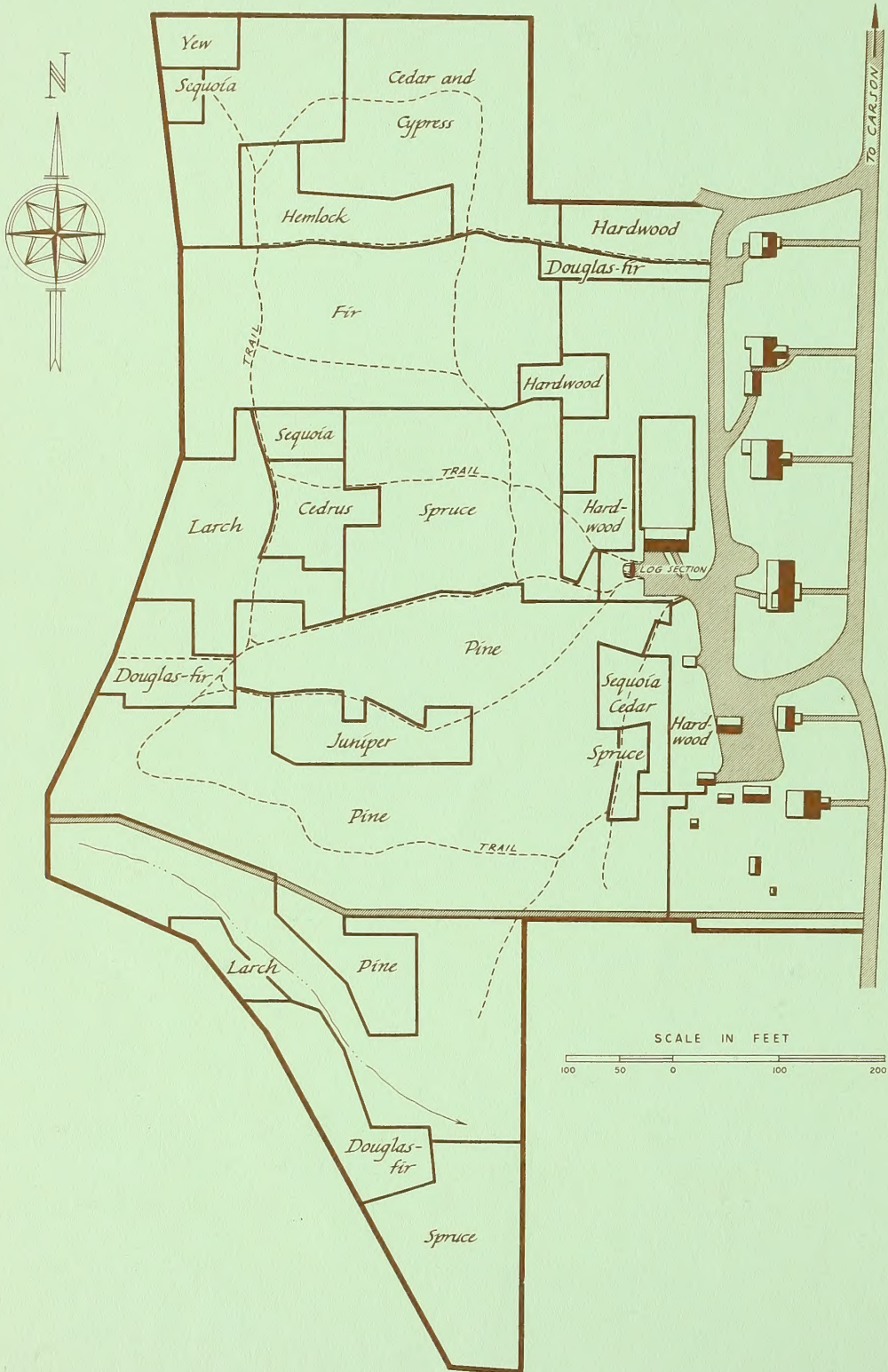
USDA LIBRARY
HAT'L AGRIC LIBRARY
1999 SEP 21 8:06
CURRENT SERIAL RECORDS
ACC. SERIAL BRANCH

FROM 1912 TO 1956



PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
U. S. DEPT. OF AGRICULTURE · FOREST SERVICE

The WIND RIVER ARBORETUM



THE WIND RIVER ARBORETUM

1912—1956

by

Roy R. Silen

and

Leonard R. Woike

October 1959

PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
R. W. Cowlin, Director Portland, Oregon

FOREST SERVICE

U. S. DEPARTMENT OF AGRICULTURE

CONTENTS

| | <u>Page</u> |
|--|-------------|
| INTRODUCTION | 1 |
| LOCATION | 2 |
| SITE | 2 |
| CLIMATE | 3 |
| HISTORY | 4 |
| Arrangement and Treatment of Arboretum Trees | 4 |
| Source of Seed and Planting Stock | 6 |
| Acquisition of Seed or Stock, 1947-56 | 7 |
| Disease and Pest Control | 7 |
| Damaging Factors | 10 |
| PERFORMANCE OF CONIFERS | 12 |
| The Pines (<u>Pinus</u>) | 24 |
| The Larches (<u>Larix</u>) | 26 |
| The Spruces (<u>Picea</u>) | 27 |
| The Hemlocks (<u>Tsuga</u>) | 27 |
| The Douglas-Firs (<u>Pseudotsuga</u>) | 28 |
| The Firs (<u>Abies</u>) | 29 |
| The Cedars (<u>Cedrus</u>) | 30 |
| The Sequoias (<u>Sequoia</u>) | 30 |
| Incense-Cedar (<u>Libocedrus</u>) | 30 |
| Thujopsis (<u>Thujopsis</u>) | 30 |
| The Thujas (<u>Thuja</u>) | 31 |
| The White-Cedars (<u>Chamaecyparis</u>) | 31 |
| The Cypresses (<u>Cupressus</u>) | 31 |
| The Junipers (<u>Juniperus</u>) | 31 |
| The Yews (<u>Taxus</u>) | 32 |
| The Araucarias (<u>Araucaria</u>) | 32 |
| PERFORMANCE OF BROAD-LEAVED TREES | 32 |
| CONIFERS FOUND UNSUITED TO THE WIND RIVER SITE | 35 |
| GENERAL COMMENTS ON PERFORMANCE | 40 |
| LITERATURE CITED | 49 |

INTRODUCTION

Wind River Arboretum, located in the Wind River valley near Carson, Wash., was established in 1912 with the planting of a few species of introduced trees on stump land adjacent to the Wind River Nursery. It is the oldest arboretum in the Northwest and ranks among the earliest forestry projects of an experimental nature still in existence in the region.^{1/} The initial objective was to test the suitability of trees from all parts of the world for forest planting under conditions generally prevailing west of the Cascade Range in Oregon and Washington. This objective was later broadened to include establishment of as many forest-tree species as possible to serve for dendrological study and exhibition purposes. In more recent years, the objective has been broadened still further to provide for planting different races of species in an attempt to determine racial variation within certain species and hybrid strains.

The arboretum is best known as an area for testing suitability of introduced species for forest plantings. The study may be broadened

^{1/} Human persistence and vision have been major factors in sustaining the 44 years of effort at the Wind River Arboretum. Names of many prominent foresters of the Northwest are recorded in the files. Thornton T. Munger had overall supervision from 1912 to 1919 and from 1924 to 1946. J. V. Hofmann was in immediate charge from 1913 to 1924. Leo A. Isaac and Ernest L. Kolbe had immediate charge from 1924 to 1930 and from 1930 to 1938, respectively. A. Gael Simson was resident officer from 1920 to 1940. Charles J. Kraebel helped in early establishment and R. H. Westveld made the first systematic plan in 1925. Large contributions in effort were made by R. W. Steele, G. S. Meagher, E. G. Dunford, L. Bransford, R. N. Young, W. Peterson, W. Allyn, E. Lofgren, T. Kachin, and E. Elm. James Hutchins and George Lopez assisted in the field work in 1956.

The authors are indebted to T. T. Munger, L. A. Isaac, and E. L. Kolbe for critical technical review of this report.

eventually to include every species in the world that has reasonable promise for this climate. To date, the study covers 621 lots of seed or planting stock, and is well along toward attaining this goal.

The arboretum occupies 11 acres and is arranged systematically to include space for species from most genera of conifers. A few hardwood species still remain from early plantings; but, because of very poor results with almost all hardwoods, no attempt has been made since 1928 to establish additional species.

Previously published reports (Munger and Kolbe, 1932; Munger and Kolbe, 1937; Munger, 1947) give a detailed description of the locality and history of the Wind River Arboretum. A brief summary of the most pertinent information from these previous reports is included in the present report.

LOCATION

Wind River Arboretum is situated at an elevation of 1,150 feet at the western edge of Wind River valley, which extends in a north-south direction in the Cascade Range in western Washington. It is surrounded by forested hills that rise 1,000 to 3,000 feet above the valley floor. Located 10 miles northwest of Carson, Wash., the arboretum may be reached by way of the Wind River road, which junctions with U. S. Highway 830 a few miles east of Stevenson, Wash. Wind River Forest Nursery, Hemlock Ranger Station, and Wind River Experimental Forest--all U. S. Forest Service installations--are immediately adjacent.

SITE

The site now occupied by the arboretum was originally a Douglas-fir forest. It was logged in 1908 or 1909, and the slash was broadcast burned. In 1934 and 1935, CCC workers cut the stumps and removed much of the debris from the area.

The soil is a deep, coarse, sandy loam that is stony in places. It was deposited as an alluvial bench or fan on an approximate 10-percent slope along the edge of the valley, bordering the steep hills. The soil is fairly porous, appears to have no hardpan subsoil, and dries out very rapidly. It has a Douglas-fir site index of 130.

Annual dense growth of bracken, a fern, has covered the floor of the arboretum since its establishment. No attempt has been made

to remove the bracken except around very small trees when it might cause damage by shading or by lodging upon and weighting down young trees. Other competing vegetation includes vine maple, hazel, whortleberry, huckleberry, alder, chinkapin, blueberry elder, and volunteer native and introduced conifer seedlings. These have been cut down periodically since the arboretum was established and have never been allowed to become serious competitors of arboretum trees.

CLIMATE

The climate is typical of much of the area along the west slopes of the Cascade Range in Oregon and Washington. It is characterized by heavy precipitation occurring mostly between October and May; acute summer drought with hot, dry days; absence of excessively cold winters; accumulation of 6 to 10 inches of heavy, wet snow; a rather short frost-free period; and cool nights, even in summer. Because the valley is surrounded by mountains, precipitation is somewhat heavier than would be expected at this altitude and the frost-free period is shorter because of cold-air drainage common to these valleys. Climatological data from the Wind River weather station for 1911 to 1950 are summarized as follows:

| | |
|--|--------------|
| Mean annual precipitation | 89.89 inches |
| Maximum annual precipitation | 142.60 " |
| Minimum annual precipitation | 54.15 " |
| Mean annual temperature | 48.1° F. |
| Mean maximum annual temperature | 59.7 " |
| Mean minimum annual temperature | 36.5 " |
| Highest recorded temperature | 107° F. |
| Lowest recorded temperature | -18 " |
| Average July temperature | 63.8° F. |
| Average January temperature | 31.5 " |
| Average length of season without frost | 131 days |
| Shortest season without frost | 73 " |
| Longest season without frost | 193 " |
| Clear days per year | 34 percent |
| Partly cloudy days per year | 22 " |
| Cloudy days per year | 44 " |

It should be pointed out that similar conditions are common at this elevation from southern Oregon to northern Washington in narrow valleys along the west slopes of the Cascades. For instance, climatological records at Prospect and McKenzie Bridge in Oregon and Darrington and Kosmos in Washington show similar temperature minimums and frost-free periods. Wide-valley locations, such as Albany and Corvallis in Oregon and Centralia in Washington, have recorded lower minimum temperatures, even at elevations under 500 feet. Apparently the location of the arboretum, within 12 miles of the Columbia Gorge, has had little effect on extremes of weather as reflected in climatological data.

HISTORY

ARRANGEMENT AND TREATMENT OF ARBORETUM TREES

As mentioned earlier, a few species of introduced trees were planted in 1912. Additions were made every year until 1925, with little regard to uniformity of treatment or systematic arrangement. During these early trials, plantings of hardwoods were made in at least equal proportion to the conifers. Their almost universal early failure strongly indicated that introduced hardwoods are poor risks in the long summer droughts and short growing season of the Cascade Range.

In 1920, a considerable number of species were moved to an area adjacent to the arboretum with the expectation of spreading the plantations over more area. Because the trees moved were quite large, many died. The trees were moved back to the original arboretum in 1924 with more loss resulting. The double transplanting seriously reduced growth rate of survivors for many years.

The plan for planting by a taxonomic arrangement of species was completed in 1925, with a section of the area allocated to each coniferous genus. Most subsequent plantings have followed this plan so that now most species in each genus are found in blocks an acre or more in size (fig. 1). Later plantings provided about 2,500 to 3,000 square feet for each species: 16 to 25 trees (if that many were available) were set 12 to 15 feet apart, avoiding regular rows where possible.

The trees have usually been set out when about 1 foot high. Care given to new lots is usually limited to removing competition and



Figure 1. --Interior view of the arboretum.
An acre or more is devoted to each of
the more important genera. The pine
block shown here contains 38 surviving
species and varieties of the 63 tested
at Wind River.

spading the ground well to give the trees adequate opportunity to become established. Some groups have been shaded during establishment. Snowbent or broken trees have been guyed or braced with splints.

Once established, trees are usually given very limited care in order to test their suitability for planting in this locality (fig. 2). This is especially true for species vigorous enough to show promise as forest trees. Poorer lots that might be lost from representation in the arboretum are given great care, however. Water pipes were

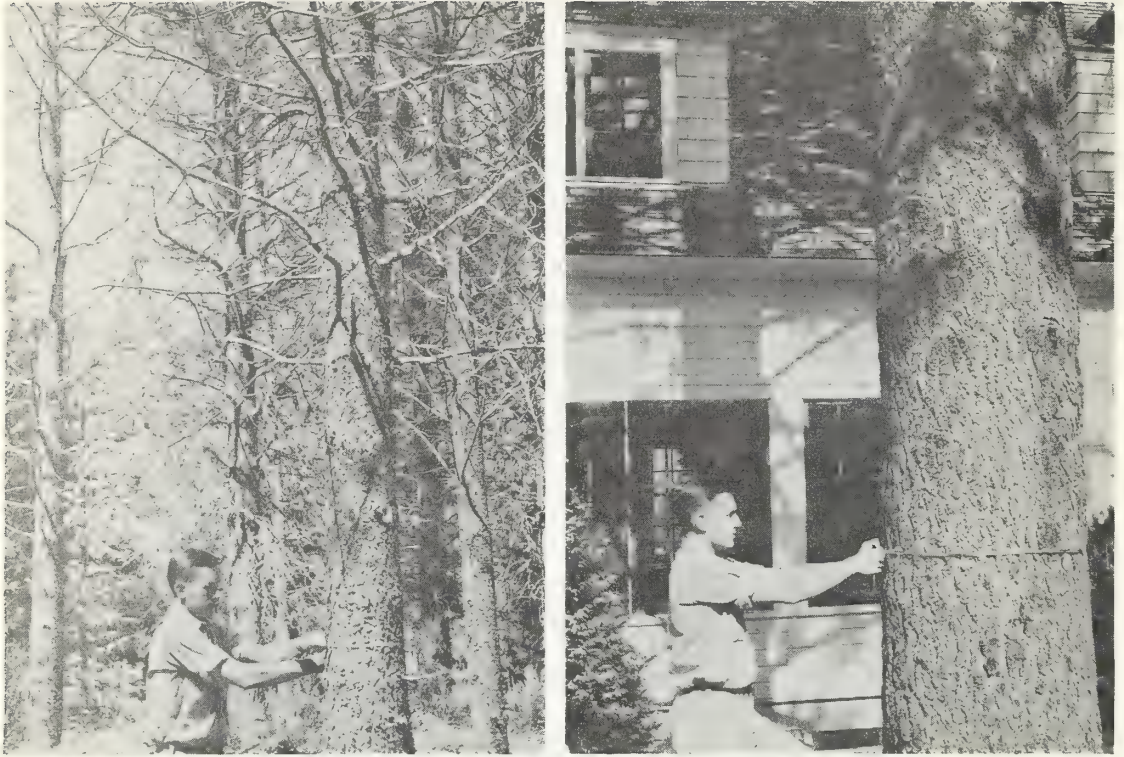


Figure 2. -- Two 44-year-old Jeffrey pines from the same seed lot show marked differences in growth rate under stand conditions of the arboretum (left) and on a watered lawn (right). Tallest tree in the arboretum group is 54 feet in height and 12.1 inches d. b. h. The individual specimen on the lawn is 73 feet tall and 30.2 inches d. b. h. Comparative volumes are 17 and 138 cubic feet.

laid over most of the area in the 1930's as a CCC project, largely for fire protection. Some sprinkling was done to assist in the establishment of new lots, but most of the plantings have received no artificial watering. The water system has not been used in recent years.

SOURCE OF SEED AND PLANTING STOCK

Most of the planting stock used in the arboretum has been grown from seed in nearby nursery beds. Some stock, however, has been shipped from as far as the East Coast States. Some of the earlier lots of seed were purchased from commercial seed houses, but almost all of the later lots have come from original collections

of forest experiment stations, agricultural explorers, or arboreta. Many organizations and individuals have contributed seed and seedlings for the Wind River Arboretum, and gratitude is due them for their cooperation.

Of 621 lots of seeds and plants acquired for the arboretum since 1912, 192 were never adequately tested. Fifty lots, obviously unsuited for the climate, were sent elsewhere for trial. The remaining 142 lots either failed to germinate, were destroyed as seedlings by frost heaving or rodents, or arrived in poor condition.

ACQUISITION OF SEED OR STOCK, 1947-56

Only 66 new lots were tried during the past 10 years because emphasis has been placed on acquiring rare species and those which might do well in the Northwest. A number of species from milder climates have been sent to locations having a less severe climate than that of the Wind River valley so they will have a better chance of becoming established. Acquisitions of the past 10 years are numbered 540 to 604. Table 1 gives the present location and condition of the new lots.

DISEASE AND PEST CONTROL

In 1928, in an attempt to safeguard the nursery and arboretum from white pine blister rust, crews began removing native Ribes species abundant in the locality. Eradication was continued through 1931 and repeated in 1939 and 1941. In spite of these efforts, blister rust has appeared on several species of five-needled pines and new infections continue to appear.

For a number of years between 1939 and 1946, a program of excising stem cankers and removing infected limbs was carried out. This has been discontinued in more recent years because the disease is too well established in the infected trees.

Aside from the work on blister rust, little has been done to control diseases or other pests. The firs were sprayed in 1956 to control the balsam woolly aphid (Chermes piceae), and minor effort was made earlier to control the Cooley spruce gall aphid (Chermes cooleyi) on Sitka spruce (Picea sitchensis).

Except for sporadic hunting, little attempt has been made to control the red-bellied sapsucker--a bird which has damaged many

Table 1. -- Acquisitions to Wind River Arboretum, 1947-56

| Lot No. : | Species | Range | Present location or condition |
|-----------|---|--------------|-------------------------------|
| 540 | <i>Larix lyallii</i> Parl. | Pac. NW. | No germination |
| 541 | <i>Larix lyallii</i> Parl. | Pac. NW. | No germination |
| 542 | <i>Juniperus formosana</i> Hayata | Formosa | Cascade Head, 1947? |
| 543 | <i>Chamaecyparis obtusa</i> var. <i>formosana</i> Hayata | Japan | Cascade Head, 1947? |
| 544 | <i>Taxus cuspidata</i> Sieb. & Zucc. | E. Asia | No germination |
| 545 | <i>Juniperus rigida</i> Sieb. & Zucc. | E. Asia | No germination |
| 546 | <i>Taxus cuspidata</i> Sieb. & Zucc. | E. Asia | No germination |
| 547 | <i>Fitzroya cupressoides</i> (Molina) Johnston | Chile | Destroyed |
| 548 | <i>Libocedrus chilensis</i> Endl. | Chile | Destroyed |
| 549 | <i>Nothofagus dombeyi</i> (Mirb.) Oerst. | Chile | Destroyed |
| 550 | <i>Laurelia aromatica</i> Fuss. ex Pair. | Chile | Destroyed |
| 551 | <i>Persea lingue</i> Nees | Chile | No germination |
| 552 | <i>Nothofagus obliqua</i> (Mirb.) Oerst. | Chile | Destroyed |
| 553 | <i>Metasequoia glyptostroboides</i> Hu and Cheng | Cen. China | Cascade Head, 1949 |
| 554 | <i>Taxus cuspidata</i> Sieb. & Zucc. | E. Asia | No germination |
| 555 | <i>Juniperus formosana</i> Hayata | Formosa | No germination |
| 556 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | N. U. S. | Arboretum, 1952 |
| 557 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | N. U. S. | Arboretum, 1952 |
| 558 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | N. U. S. | Arboretum, 1952 |
| 559 | <i>Tsuga chinensis</i> (Franch.) Pritz. | W. China | No germination |
| 560 | <i>Cunninghamia konishii</i> Hayata | Formosa | No germination |
| 561 | <i>Libocedrus formosana</i> Florin | Formosa | Frost killed in nursery |
| 562 | <i>Pseudotsuga wilsoniana</i> Hayata | Formosa | Not known |
| 563 | <i>Pinus gerardiana</i> Wall. | Himalayas | No germination |
| 564 | <i>Chamaecyparis pisifera</i> (Sieb. & Zucc.) Endl. | Japan | Arboretum, 1952 |
| 565 | <i>Podocarpus salignus</i> Don | Chile | No germination |
| 566 | <i>Nothofagus obliqua</i> (Mirb.) Oerst. | Chile | Not known |
| 567 | <i>Araucaria araucana</i> (Molina) K. Koch (?) | Chile | No germination |
| 568 | <i>Nothofagus dombeyi</i> (Mirb.) Oerst. | Chile | Not known |
| 569 | <i>Persea lingue</i> Nees | Chile | No germination |
| 570 | <i>Pinus cembra</i> L. | Alps | Mice ate seed |
| 571 | <i>Taiwania flousiana</i> Gaussen | China | Not known |
| 572 | <i>Abies firma</i> Sieb. & Zucc. | Japan | Not known |
| 573 | <i>Thuja orientalis</i> L. | N., W. China | Not known |
| 574 | <i>Metasequoia glyptostroboides</i> Hu & Cheng | Cen. China | Distributed |
| 575 | <i>Larix lyallii</i> Parl. | Rocky Mt. | Mice ate seed |

Table 1.--Acquisitions to Wind River Arboretum, 1947-56 (Continued)

| Lot No.: | Species | Range | Present location or condition |
|----------|--|--------------|-------------------------------|
| 576 | <i>Cupressus lusitanica</i> Mill (?) | Mexico | Not known |
| 577 | <i>Cryptomeria japonica</i> (L.f.) D. Don | Jap., China | Sent to Cascade Head |
| 578 | <i>Thuja occidentalis</i> L. | E., N. Amer. | Not known |
| 579 | <i>Picea maximowiczii</i> Reg. | Japan | Not known |
| 580 | <i>Abies homolepis</i> Sieb. & Zucc. | Japan | No germination |
| 581 | <i>Juniperus conferta</i> Parl. | Japan | Not known |
| 582 | <i>Juniperus rigida</i> Sieb. & Zucc. | E. Asia | Not known |
| 583 | <i>Picea glehnii</i> (Fr. Schmidt) Mast. | Japan | Not known |
| 584 | <i>Pseudotsuga japonica</i> (Shiras.) Beiss. | Japan | Not known |
| 585 | <i>Tsuga diversifolia</i> (Maxim.) Mast. | Japan | Not known |
| 586 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Arboretum, 1952 |
| 587 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Arboretum, 1952 |
| 588 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Arboretum, 1952 |
| 589 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Arboretum, 1952 |
| 590 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Not known |
| 591 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Died in nursery |
| 592 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Not known |
| 593 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Arboretum, 1952 |
| 594 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Arboretum, 1952 |
| 595 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Not known |
| 596 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Not known |
| 597 | <i>Pseudotsuga menziesii</i> (Mirb.) Franco | W. U.S. | Arboretum, 1952 |
| 598 | <i>Juniperus occidentalis</i> Hook. | W. U.S. | Arboretum, 1952 |
| 599 | <i>Pinus ponderosa</i> Laws. (Hybrid) | W. U.S. | Arboretum, 1953 |
| 600 | <i>Pinus ponderosa</i> Laws. (Hybrid) | W. U.S. | Arboretum, 1953 |
| 601 | <i>Pinus ponderosa</i> Laws. (Hybrid) | W. U.S. | Arboretum, 1953 |
| 602 | <i>Pinus ponderosa</i> Laws. (Hybrid) | W. U.S. | Arboretum, 1953 |
| 603 | <i>Pinus ponderosa</i> Laws. (Hybrid) | W. U.S. | Arboretum, 1953 |
| 604 | <i>Pinus contorta</i> Dougl. | W., N. Amer. | Arboretum, 1954 |

species by pecking rings of holes around the trunk, in some cases killing trees by girdling (fig. 3).



Figure 3. --Scotch pine damaged by the red-bellied sapsucker. Partial girdling by this bird has seriously deformed several introduced species.

Some trapping was done in earlier years to control root-gnawing rodents.

DAMAGING FACTORS

At the end of the 1956 growing season, all trees in the arboretum were remeasured and checked for general vigor, disease or insect infestations, and damage by other agencies.

The 10-year period 1947-1956 probably provided the most severe test of suitability for introduced species since the establishment of the arboretum. During this period, many species that had shown considerable promise as forest trees were severely damaged--and some killed--by the very severe winter of 1949-50 and by the exceptionally early and extremely low subfreezing temperatures in November 1955.

A severe drought in the spring and summer of 1951, during which no appreciable amount of rain fell from April to early September, provided a severe test for drought resistance.

Snowbreak continues to be a problem in some species, especially the larches. Some smaller trees below snow level have suffered severely from freezing of hard-packed snow to limbs and subsequent tearing of limbs from the trunk.

The balsam woolly aphid has appeared within the last 10 years as a killer of Abies (fig. 4). Blister rust has continued as a major

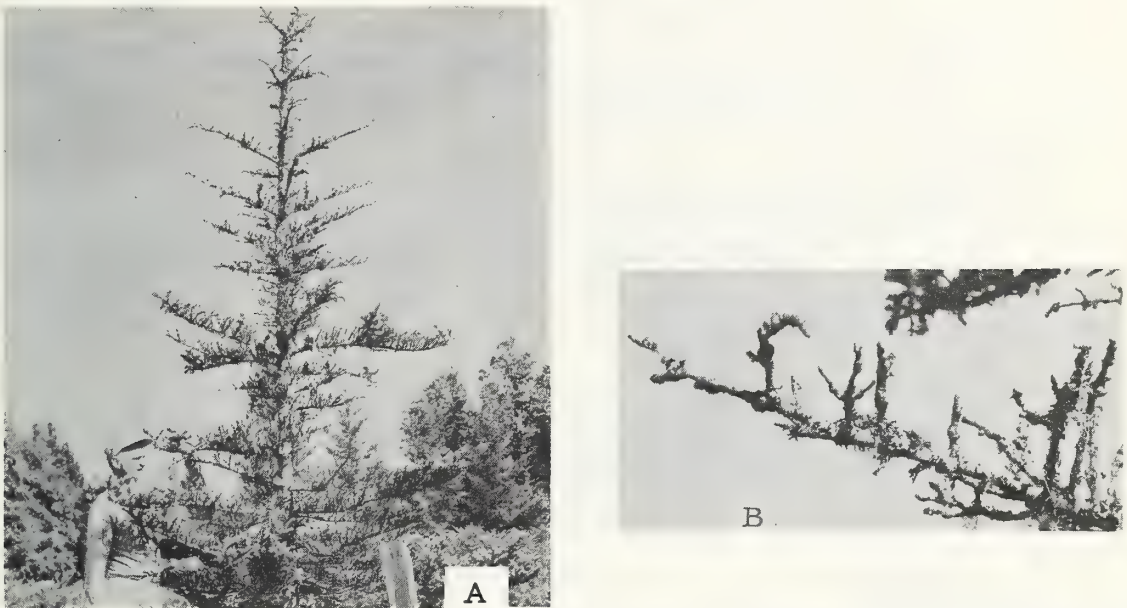


Figure 4. -- The arboretum serves to test relative susceptibility to disease and insects. A, Balsam woolly aphid infestation of Fraser fir, shown here, has almost destroyed the arboretum group. Of 24 species of Abies, 6 have been attacked by this insect, with Fraser fir the most susceptible. B, Closeup of a gouted branch.

source of mortality among susceptible white pines, and root rot has become established in several promising species of pines since 1946. Deer browsing has been a problem in the establishment of yew species.

PERFORMANCE OF CONIFERS

Table 2 shows the condition of all living groups of conifers in the Wind River Arboretum at the end of the 1956 growing season. Explanations of the column headings are:

Species. Approved names listed in the U. S. Forest Service's "Check List of Native and Naturalized Trees of the United States (including Alaska)" (Little, 1953) have been used for species native to the United States. 2/

Additional references, consulted for introduced species, are:

Dallimore, W., and Jackson, A. Bruce.

1948. A handbook of coniferae. Ed. 3, 682 pp., illus.
London.

Kelsey, Harlan P., and Dayton, William A.

1942. Standardized plant names. Ed. 2, 675 pp.
Harrisburg, Pa.

Rehder, Alfred

1940. Manual of cultivated trees and shrubs hardy in
North America exclusive of the subtropical and
warmer temperate regions. Ed. 2, 996 pp., illus.
New York.

Rehder, Alfred

1949. Bibliography of cultivated trees and shrubs hardy
in the cooler temperate regions of the northern
hemisphere. 825 pp. Jamaica Plain, Mass.

Lot number. The serial number given each acquisition, beginning with number 1 in 1912.

2/ The authors are grateful for the assistance of Dr. Elbert L. Little, Jr., who visited the arboretum to check identification of species and who verified nomenclature used in this report.

Table 2. --Status of living conifer species, Wind River Arboretum

| Species | Scientific name | Common name | Lot number | Year alive | Year sown | Number planted | Average height in 1956 | Tallest tree in 1956 | Index of growth | Condition |
|---|--------------------|-------------|------------|------------|-----------|----------------|------------------------|----------------------|-----------------|---|
| Abies (the firs): alba Mill. | silver fir | | 288 | 1927 | 20/20 | 11.5 | 22.0 | .40 | N | Fair; yellowish needles, snow-break, heavy Chermes without apparent damage. |
| amabilis (Dougl.) Forbes | Pacific silver fir | | 190 | 1922 | 19/16 | 18.9 | 27.0 | .41 | N | Good; aphid (probably <u>Mindarus</u>) |
| " | " | | 484 | -- | 5/4 | 11.7 | 14.0 | | N | Good |
| balsamea (L.) Mill. | balsam fir | | 295 | 1924 | 11/10 | 24.4 | 35.0 | .57 | N | Fair; moderate Chermes infestation |
| bracteata D. Don | bristlecone fir | | 511 | 1938 | 16/7 | 4.6 | 7.0 | .29 | N | Poor; bent; many almost dead; repeatedly frozen back |
| cephalonica Loud. | Greek fir | | 491 | 1935? | 20/15 | 4.9 | 8.0 | .24 | N | Fair; repeated freezeback, snow-break |
| fabri (Mast.) Craib | Faber fir | | 365 | -- | 7/1 | 4.0 | 4.0 | | N | Poor; snowbreak, repeated freeze-back |
| fraseri (Pursh) Poir. | Fraser fir | | 286 | 1927 | 21/11 | 8.0 | 16.0 | .29 | L | Poor; tops of most trees killed by Chermes |
| grandis (Dougl.) Lindl. | grand fir | | 236 | 1926 | 20/7 | 15.1 | 21.0 | .37 | N | Good |
| " | " | | 280 | (1/) | 20/4 | 14.7 | 26.0 | .40 | M | Excellent |
| " | " | | 300 | 1925? | 7/7 | 43.8 | 53.0 | .89 | M | Excellent |
| " | " | | 356 | (1/) | 6/5 | 43.4 | 50.0 | .81 | M | Excellent |
| " | " | | 473 | 1931 | 7/5 | 13.8 | 22.0 | .49 | N | Good |
| " | " | | 529 | 1942 | 4/4 | 5.7 | 14.0 | .97 | N | Good |
| grandis (hybrid) | grand fir (hybrid) | | 529A | 1950 | 1/1 | 2.0 | 2.0 | .91 | N | Good |
| holophylla Maxim. | Manchurian fir | | 124 | 1925 | 4/3 | 4.3 | 6.0 | .10 | N | Poor; snowbreak, repeatedly frozen back |
| " | " | | 272 | 1926 | 2/1 | 4.0 | 4.0 | .07 | N | Poor; snowbreak, repeatedly frozen back |
| " | " | | 425 | 1931 | 20/5 | 2.8 | 4.0 | .09 | N | Poor; snowbreak, repeatedly frozen back |
| homolepis Sieb. & Zucc. | Nikko fir | | 359 | 1926 | 20/1 | 19.0 | 19.0 | .33 | L | Good; snowbreak |
| koreana Wils. | Korean fir | | 412 | 1931 | 21/14 | 7.4 | 12.5 | .28 | M | Fair; many snowbroken |
| lasiocarpa (Hook.) Nutt. | subalpine fir | | 276 | (1/) | 10/7 | 20.5 | 28.0 | .43 | N | Good; many badly damaged by Chermes |
| " | " | | 485 | 1933? | 5/5 | 9.8 | 12.0 | .31 | N | Good; many badly damaged by Chermes |
| lasiocarpa var. arizonica (Merriam) Lemm. | corkbark fir | | 294 | 1927 | 21/18 | 12.0 | 19.0 | .35 | N | Fair; 4 of 18 have snowbreak, light Chermes infestation |

See footnote at end of table.

Table 2. --Status of living conifer species, Wind River Arboretum (Continued)

| Species | Scientific name | Common name | Lot number | Year sown | Year alive | Number planted | Average height in 1956 | Tallest tree in 1956 | Index of production | Condition |
|---|--------------------|-------------|------------|-----------|------------|----------------|------------------------|----------------------|---------------------|---|
| <i>Abies (the firs)</i> --Continued | | | | | | | | | | |
| <i>magnifica</i> A. Murr. | California red fir | | 291 | 1927 | 20/20 | 10.3 | 24.0 | .44 | N | Excellent |
| <i>magnifica</i> var. <i>shastensis</i> Lemm. | Shasta red fir | | 277 | (1/) | 6/5 | 20.0 | 26.0 | .40 | N | Good |
| " | " | | 406 | 1927 | 20/19 | 12.2 | 29.0 | .53 | N | Good |
| <i>mariesii</i> Mast. | Maries fir | | 464 | 1931 | 20/5 | 10.3 | 14.0 | .31 | N | Good; snowbroken but recovering |
| <i>nephrolepis</i> (Trautv.) Maxim. | Khingan fir | | 411 | 1931 | 20/5 | 6.8 | 11.0 | .25 | N | Good; doing well after repeated snowbreak |
| <i>pinseapo</i> Boiss. | Spanish fir | | 492 | 1935? | 21/19 | 4.3 | 9.0 | .27 | S | Poor to good; snowbreak and repeated freezeback, light <i>Chermes</i> infestation |
| <i>procera</i> Rehd. | noble fir | | 34 | 1913 | 15/10 | 36.4 | 49.0 | .59 | N | Good |
| " | " | | 189 | 1922 | 8/8 | 29.9 | 46.0 | .70 | N | Good |
| <i>sachalinensis</i> (Fr. Schmidt.) Mast. | Sakhalin fir | | 125 | 1925 | 20/5 | 21.2 | 39.0 | .66 | N | Good; crooked stems |
| <i>sibirica</i> Ledeb. | Siberian fir | | 463 | 1931 | 20/8 | 2.6 | 5.0 | .11 | N | Poor; snowbent |
| <i>veitchii</i> Lindl. | Veitch fir | | 462 | 1931 | 25/9 | 12.8 | 16.5 | .37 | M | Fair |
| <i>Araucaria (the araucarias)</i> : | | | | | | | | | | |
| <i>arucana</i> (Molina) K. Koch | monkey-puzzle | | 102 | 1913 | 2/2 | 7.5 | 7.5 | .09 | N | Good; doing well after repeated freezeback |
| <i>Cedrus (the cedars)</i> : | | | | | | | | | | |
| <i>atlantica</i> Manetti | Atlas cedar | | 47 | 1913 | 8/5 | 34.8 | 46.5 | .55 | N | Good |
| <i>deodara</i> (Roxb.) Loud. | deodar cedar | | 244 | 1926 | 13/4 | 16.9 | 22.0 | .38 | N | Fair; some crooked boles |
| <i>libani</i> A. Rich. | cedar-of-Lebanon | | 48 | 1913 | 19/7 | 27.3 | 35.5 | .42 | N | Good |
| " | " | | 528 | 1938 | 3/2 | 5.2 | 5.5 | .23 | N | Poor |
| <i>Chamaecyparis (the white-cedars)</i> : | | | | | | | | | | |
| <i>lawsoniana</i> (A. Murr.) Parl. | Port-Orford-cedar | | 39 | 1912 | 13/5 | 42.6 | 51.5 | .60 | L | Good |
| " | " | | 440 | 1929 | 20/16 | 21.4 | 30.0 | .60 | H | Excellent |
| <i>nootkatensis</i> (D. Don) Spach | Alaska-cedar | | 404 | 1927 | 23/20 | 13.7 | 24.0 | .44 | L | Excellent |

See footnote at end of table.

Table 2.--Status of living conifer species, Wind River Arboretum (Continued)

| Species | Scientific name | Common name | Lot number | Year sown | Number planted | Average height in 1956 | Tallest tree in 1956 | Index of growth | Condition |
|--|-----------------|-------------|------------|-----------|----------------|------------------------|----------------------|-----------------|---|
| Chamaecyparis (the white-cedars)--Continued | | | | | | | | | |
| pisifera (Sieb. & Zucc.) Endl. | | | 564 | 1947 | 27/19 | 2.0 | 3.0 | .59 | M Fair; some freezeback |
| thyoides (L.) B.S.P. | | | 480 | 1931 | 25/12 | 2.9 | 5.0 | .11 | S Poor; repeated freezeback |
| Cupressus (the cypresses): | | | | | | | | | |
| bakeri Jeps. | | | 117 | 1925 | 18/17 | 22.7 | 33.0 | .54 | S Good; 1 tree frost killed |
| " " | | | 242 | 1926 | 3/2 | 24.0 | 24.0 | .42 | M Good; 1 tree frost killed |
| macnabiana A. Murr. | | | 42 | 1913 | 2/1 | 15.0 | 15.0 | .18 | H Fair; some needles yellowing gradually; being shaded out by neighboring pines |
| Juniperus (the junipers): | | | | | | | | | |
| chinensis L. | | | 472 | 1931 | 20/17 | 5.8 | 12.0 | .27 | VL Poor; repeated snowbreak |
| occidentalis Hook. | | | 269 | (1/) | 6/4 | 3.3 | 5.0 | .07 | N Fair; snowbreak & twisted stems |
| " " | | | 279 | (1/) | 12/11 | 3.6/ | 6.0 | .09 | N Fair; snowbreak & twisted stems |
| " " | | | 598 | 1950 | 12/8 | 2.0 | 2.5 | 1.14 | N Fair |
| scopulorum Sarg. | | | 228 | (1/) | 14/14 | 9/2 | 15.0 | .22 | L Good; some snowbreak; best looking of all junipers in arboretum |
| virginiana L. | | | 40 | 1912 | 13/1 | 7.0 | 7.0 | .08 | N Fair to good; snowbreak |
| " " | | | 301 | 1925? | 8/7 | 6.7 | 10.0 | .17 | N Fair to good; snowbreak |
| " " | | | 317 | 1926? | 3/3 | 6.3 | 7.0 | .12 | VL Fair to good; snowbreak |
| " " | | | 481 | ? | 6/6 | 8.0 | 11.0 | | N Fair to good; snowbreak |
| Larix (the larches): | | | | | | | | | |
| decidua Mill. | | | 183 | 1923? | 3/2 | 56.5 | 58.0 | .91 | H Excellent; some snowbreak, sap-sucker injury |
| " " | | | 302 | 1925? | 6/6 | 50.3 | 57.0 | .96 | H Excellent; some snowbreak, sap-sucker injury |
| " " | | | 308 | 1925 | 10/10 | 40.0 | 51.0 | .86 | H Excellent; some snowbreak, sap-sucker injury |
| decidua X leptolepis (X eurolepis Henry) | | | 422 | 1931 | 19/13 | 34.2 | 45.0 | 1.00 | H Excellent; some crooked trees |
| decidua var. polonica (Racib.) Ostenfeld & Syrach-Larsen | | | 451 | 1932 | 20/18 | 30.6 | 46.0 | 1.18 | M Excellent; 7 of 17 snowbroken |

See footnote at end of table.

Table 2.--Status of living conifer species, Wind River Arboretum (Continued)

| Species | Scientific name | Common name | Lot number | Year sown | Year alive | Number planted | Average height in 1956 | Tallest tree in 1956 | Index of growth | Condition |
|--|------------------------|------------------------|------------|-----------|------------|----------------|------------------------|----------------------|-----------------|--|
| | | | num-ber | Year sown | Year alive | Number planted | Average height in 1956 | Tallest tree in 1956 | Index of growth | Condition |
| <i>Larix</i> (the larches)--Continued | | | | | | | | | | |
| <i>decidua</i> var. <i>polonica</i> (Racib.) Ostenfeld & Syrach-Larsen | Polish larch | Polish larch | 451A | 1933 | 2/2 | 29.0 | 34.0 | .87 | H | Good; both snowbroken |
| <i>gmelinii</i> (Rupr.) Litvin. | Dahurian larch | Dahurian larch | 459 | 1933 | 20/13 | 22.1 | 33.0 | .84 | H | Good; snowbreak, sapsucker injury, epicormic branches common |
| " | " | " | 459A | 1934 | 15/5 | 24.5 | 27.0 | .75 | N | Fair; some snowbend |
| <i>gmelinii</i> var. <i>japonica</i> (Reg.) Pilger | Kurile larch | Kurile larch | 112 | 1924 | 19/18 | 26.0 | 51.0 | .83 | H | Good; some snowbreak, sapsucker injury |
| " | " | " | 265 | 1926 | 1/1 | 30.0 | 30.0 | .52 | H | Good; some snowbreak, sapsucker injury |
| <i>gmelinii</i> var. <i>principis-rupprechtii</i> (Mayr) Pilger | Prince Rupprecht larch | Prince Rupprecht larch | 128 | 1925 | 6/2 | 27.5 | 28.0 | .47 | L | Fair; extreme snowbreak |
| " | " | " | 241 | 1926 | 14/4 | 23.8 | 29.0 | .51 | L | Fair; extreme snowbreak |
| <i>laricina</i> (Du Roi) K. Koch | tamarack | tamarack | 184 | 1923? | 1/1 | 25.0 | 25.0 | .39 | VL | Fair; spike top |
| " | " | " | 530 | 1939? | 13/13 | 12.9 | 18.0 | .84 | VL | Good; some snowbend |
| <i>leptolepis</i> (Sieb. & Zucc.) Gord. | Japanese larch | Japanese larch | 30 | 1913 | 10/6 | 33.3 | 41.0 | .49 | M | Fair; snowbend, heavy sapsucker injury |
| <i>occidentalis</i> Nutt. | western larch | western larch | 192 | 1922 | 10/2 | 17.0 | 18.0 | .27 | N | Poor; severe snowbreak |
| " | " | " | 229 | (1/) | 11/4 | 22.2 | 36.0 | | N | Poor; severe snowbreak |
| <i>sibirica</i> Ledeb. | Siberian larch | Siberian larch | 32 | 1913 | 12/7 | 49.5 | 66.0 | .79 | M | Good; severe snowbreak, sapsucker injury |
| <i>Libocedrus</i> (<i>incense-cedar</i>): <i>decurrens</i> Torr. | incense-cedar | incense-cedar | 36 | 1912 | 13/5 | 44.6 | 49.5 | .58 | N | Good; tendency to lean |
| " | " | " | 318 | 1926 | 24/23 | 17.5 | 25.0 | .44 | N | Good |
| <i>Picea</i> (the spruces): <i>abies</i> (L.) Karst. | Norway spruce | Norway spruce | 26 | 1912 | 10/6 | 42.0 | 55.0 | .64 | M | Good; severe sapsucker injury |
| " | " | " | 478A | 1936 | 8/7 | 22.8 | 40.0 | 1.33 | N | Excellent; 1 tree snowbroken |
| <i>bicolor</i> (Maxim.) Mayr | Alcock spruce | Alcock spruce | 247 | 1926 | 11/4 | 4.6 | 7.0 | .12 | L | Poor; yellowish needles, snowbreak |
| <i>breweriana</i> S. Wats. | Brewer spruce | Brewer spruce | 360 | 1925? | 8/6 | 11.4 | 16.0 | .27 | L | Fair; crooked stems |
| " | " | " | 469 | 1931 | 16/15 | 6.0 | 9.0 | .20 | N | Good; many double tops |

See footnote at end of table.

Table 2.--Status of living conifer species, Wind River Arboretum (Continued)

| Species | Scientific name | Common name | Lot num-ber | Year: sown: | (1956) | Number planted: | Average height: | Tallest tree in: | Year: alive in 1956: | Year: produced in: | Index of growth: | Condition |
|---|----------------------|-------------|-------------|-------------|--------|-----------------|-----------------|------------------|----------------------|--------------------|------------------|--|
| | | | | | | | (feet) | (feet) | (1955) | | | |
| <i>Picea</i> (the spruces) | | | | | | | | | | | | |
| engelmannii Parry | Engelmann spruce | | 25 | 1913 | 13/10 | 33.9 | 42.0 | .50 | H | | | Good; many spruce galls (<u>Chermes cooleyi</u>), sapsucker injury |
| " | " | | 405 | 1926 | 7/4 | 23.2 | 29.0 | .51 | H | | | Good; spruce gall (<u>Chermes cooleyi</u>) and sapsucker injury |
| glauca (Moench) Voss | white spruce | | 24 | 1914 | 15/13 | 33.7 | 40.0 | .49 | M | L | | Good; many spruce galls (<u>Chermes cooleyi</u>) |
| glauca var. albertiana (S. Brown) Sarg. | western white spruce | | 495 | 1937 | 20/20 | 7.7 | 15.0 | .55 | L | | | Good; many spruce galls (<u>Chermes cooleyi</u>), 1 tree snowbent |
| jezoensis (Sieb. & Zucc.) Carr. | Yeddo spruce | | 470 | 1931 | 14/11 | 4.1 | 10.0 | .56 | N | | | Fair; snowbent |
| koyamai Shiras. | Koyama spruce | | 249 | 1926 | 20/16 | 9.8 | 19.0 | .52 | L | | | Fair; some snowbreak |
| mariana (Mill.) B.S.P. | black spruce | | 27 | 1913 | 4/1 | 26.5 | 26.5 | .32 | L | | | Fair |
| " | " | | 467 | 1931 | 20/16 | 12.1 | 20.0 | .45 | M | | | Fair; snowbreak and snowbent |
| " | " | | 532 | -- | 7/6 | 4.7 | 7.0 | | N | | | Good |
| omorika (Panic) Purkyne | Serbian spruce | | 474 | 1929 | 20/19 | 23.1 | 30.0 | .60 | L | | | Excellent |
| orientalis (L.) Link | Oriental spruce | | 266 | 1919 | 21/21 | 22.5 | 31.0 | .43 | M | | | Good; many double trunks |
| polita (Sieb. & Zucc.) Carr. | tigertail spruce | | 478 | 1928? | 18/3 | 2.0 | 3.0 | .06 | N | L | | Poor; repeatedly snowbroken |
| pungens Engelm. | blue spruce | | 28 | 1915 | 14/6 | 24.3 | 51.0 | .64 | N | | | Excellent |
| " | " | | 243 | 1920 | 12/4 | 15.5 | 23.0 | .33 | N | | | Good; 1 tree snowbroken |
| rubens Sarg. | red spruce | | 312 | 1928 | 5/4 | 7.5 | 10.0 | .19 | L | | | Good; some snowbreak |
| " | " | | 468 | 1931 | 19/15 | 10.0 | 18.0 | .40 | L | | | Good; some snowbreak |
| sitchensis (Bong.) Carr. | Sitka spruce | | 29 | 1913 | 10/5 | 29.6 | 45.0 | .54 | L | | | Fair; many spruce galls (<u>Chermes cooleyi</u>) |
| " | " | | 358 | 1927 | 18/12 | 24.8 | 36.0 | .66 | L | | | Good; many spruce galls (<u>Chermes cooleyi</u>) |
| smithiana (Wall.) Boiss. | Himalayan spruce | | 448A | 1933 | 12/2 | 3.5 | 4.0 | .10 | N | L | | Poor; repeated snow damage |
| " | " | | 523 | -- | 20/1 | 1.0 | 1.0 | .05 | N | | | Poor; repeatedly snowbroken |
| <i>Pinus</i> (the pines); | | | | | | | | | | | | |
| albicaulis Engelm. | whitebark pine | | 1 | 1917 | 10/5 | 27.0 | 40.0 | .53 | M | | | Fair, but all have blister rust |
| aristata Engelm. | bristlecone pine | | 2 | 1913 | 12/1 | 12.5 | 12.5 | .15 | N | | | Poor; snowbent |
| " | " | | 9 | 1912 | 7/6 | 4.2 | 5.9 | .07 | N | | | Fair; slow growth; heavy scale on needles |
| " | " | | 466 | 1931 | 20/12 | 4.2 | 7.0 | .14 | MF | | | Poor; severely snowbent |
| balfouriana Grev. & Balf. | foxtail pine | | 498 | 1938 | 28/27 | 2.6 | 4.0 | .16 | N | | | Good; 1 killed by blister rust |

Table 2.--Status of living conifer species, Wind River Arboretum (Continued)

| Scientific name | Common name | Lot : num-ber | Year: alive :(1956) | Number planted | Average height | Tallest tree in | Cone :Growth: index | Condition |
|---|---------------------|------------------|------------------------|-------------------|-------------------|--------------------|------------------------|--|
| <i>Pinus (the pines)</i> --Continued | | | | | | | | |
| <i>banksiana</i> Lamb. | jack pine | 8 | 1914 | 11/2 | 51.2 | 54.0 | .66 | L Good; crooked boles, some branches girdled by animal gnawing |
| <i>bungeana</i> Zucc. | lacebark pine | 209 | ? | 9/1 | 1.5 | 1.5 | | S Almost dead; repeatedly frozen back |
| " | " | 296 | 1924 | 2/1 | 4.0 | 4.0 | .06 | N Almost dead; repeatedly frozen back |
| <i>contorta</i> Dougl. var. | shore pine | 539 | 1947 | 20/20 | 6.5 | 8.5 | 1.67 | N Excellent |
| <i>contorta</i> var. <i>latifolia</i> Engelm. | lodgepole pine | 6 | 1913 | 11/4 | 48.4 | 56.0 | .67 | H S Poor; diseased foliage, damaged by dry, east winds |
| " | " | 604 | 1/1951 | 20/19 | 1.5 | 2.7 | 1.22 | N Good |
| <i>densiflora</i> Sieb. & Zucc. | Japanese red pine | 130 | 1925 | 8/1 | 30.0 | 30.0 | .50 | H L Poor; considerable snowbreak |
| " | " | 175 | 1925? | 21/7 | 27.0 | 37.0 | .58 | H L Poor; considerable snowbreak |
| <i>echinata</i> Mill. | shortleaf pine | 178 | 1923 | 18/2 | 24.5 | 26.0 | .41 | N M Fair; yellow foliage |
| " | " | 270 | (1/) | 13/3 | 14.7 | 20.0 | | N S Poor; yellow foliage, snowbreak |
| <i>echinata</i> X <i>rigida</i> | hybrid pine | 389 | 1929 | 9/8 | 22.1 | 27.0 | .57 | N N Good |
| <i>engelmannii</i> Carr. | Apache pine | 16 | 1912 | 11/2 | 44.5 | 48.6 | .57 | N Good; tendency to snowbreak |
| " | " | 409 | 1930 | 30/14 | 18.5 | 30.0 | .63 | N Poor; tendency to snowbreak |
| <i>flexilis</i> James | limber pine | 299 | 1925 | 9/9 | 27.9 | 32.5 | .55 | L Good; light blister rust, some snowbreak |
| " | " | 407 | 1927 | 10/10 | 28.4 | 38.5 | .70 | L Good; light blister rust, some snowbreak |
| <i>flexilis</i> James var. <i>reflexa</i> Engelm. | Mexican white pine | 408 | 1930 | 42/38 | 27.0 | 39.0 | .82 | L Good; many have blister rust, some crooked and forked |
| <i>griffithii</i> McClelland (?) heldreichii Christ var. <i>leucodermis</i> (Ant.) Markgraf | Himalayan pine | 534 | 1945 | 1/1 | 11.0 | 11.0 | 1.10 | N Excellent; possible drought damage |
| <i>jeffreyi</i> Grev. & Balf. | Bosnian pine | 339 | 1928 | 18/18 | 7.0 | 12.0 | .23 | L Fair; occasional snowbreak |
| <i>koraiensis</i> Sieb. & Zucc. | Jeffrey pine | 13 | 1912 | 11/9 | 43.5 | 54.0 | .63 | L Fair; 1 tree damaged by frost |
| <i>lambertiana</i> Dougl. | Korean pine | 131 | 1925 | 23/20 | 19.3 | 25.0 | .42 | N Good; evidence of root rot |
| " | sugar pine | 14 | 1911 | 10/2 | 52.5 | 56.0 | .64 | N M Good; blister rust on all trees |
| " | " | 230 | 1924 | 10/2 | 49.0 | 59.0 | .96 | N Good; blister rust on all trees |
| <i>massoniana</i> Lamb. | Masson pine | 392 | 1929 | 22/17 | 19.2 | 25.0 | .42 | H Good; heavy snowbreak |
| <i>monticola</i> Dougl. | western white pine | 17 | 1912 | 21/12 | 61.2 | 70.0 | .82 | L Excellent, except for blister rust |
| <i>mugo</i> Turra | Swiss mountain pine | 476 | 1929 | 20/20 | 22.8 | 26.0 | .44 | H Good; many trees well formed, some multiple stems |

See footnote at end of table.

Table 2.--Status of living conifer species, Wind River Arboretum (Continued)

| Scientific name | Common name | Number | Planted | Average height in 1956 | Tallest tree in 1956 | Year alive in 1956 | Year sown (1956) | Index | Condition |
|--|---------------------------|---------|---------|------------------------|----------------------|--------------------|------------------|-------|---|
| Pinus (the pines)--Continued | | | | | | | | | |
| mugo var. mugo | mugho Swiss mountain pine | 282 | 1925? | 3/3 | 16.0 | 18.0 | .30 | M | Excellent |
| " | " | 352 | 1928 | 21/21 | 13.5 | 19.0 | .36 | H | Excellent; 1 tree snowbroken |
| mugo var. rostrata (Ant.) Hoopes | tree Swiss mountain pine | 341 | 1928 | 20/20 | 18.2 | 24.0 | .46 | H | Excellent; shrubby form |
| nigra var. caramanica (Loud.) Rehd. | Crimean pine | 180 | 1923? | 15/11 | 46.8 | 58.0 | .91 | N | Excellent; some forked trees |
| nigra Arnold var. nigra | Austrian pine | 4 | 1912 | 7/7 | 45.1 | 60.0 | .71 | M | Good; rapid taper, slight frost damage to foliage |
| " | " | 4A | 1914 | 5/3 | 56.7 | 60.0 | .73 | M | Good; some sapsucker injury |
| nigra Arnold var. poiretiana (Ant.) Schneid. | Corsican pine | 15 | 1912 | 12/3 | 33.3 | 40.0 | .47 | N | Excellent; slight sapsucker injury |
| " | " | 398 | 1929 | 21/20 | 27.7 | 36.0 | .60 | L | Good; some sapsucker injury |
| " | " | 503 | 1936 | 20/19 | 20.1 | 26.0 | .87 | N | Fair; several trees dying, probably root rot |
| parviflora Sieb. & Zucc. | Japanese white pine | 252 | 1926 | 22/18 | 18.1 | 27.0 | .47 | H | Fair; stem cankers, evidence of root rot, heavy sunscald |
| peuce Griseb. | Balkan pine | 351 | 1928 | 3/3 | 23.3 | 24.0 | .46 | N | Excellent; good ornamental qualities |
| " | " | 505 | 1936? | 17/17 | 7.8 | 14.0 | .47 | N | Excellent |
| ponderosa Laws. | ponderosa pine | 18 | 1912 | 18/15 | 57.8 | 76.0 | .89 | N | Excellent; 4 best trees are forked, probably from snow |
| ponderosa (hybrid) | ponderosa pine (hybrid) | 599-603 | 1950 | 60/55 | 2.2 | 4.0 | 1.82 | N | Excellent |
| ponderosa var. scopulorum Engelm. | ponderosa pine | 330 | 1928 | 20/14 | 22.0 | 33.0 | .63 | H | Fair to excellent; some snowbreak, unidentified top disease |
| pungens Lamb. | Table-Mountain pine | 177 | 1923? | 18/11 | 24.5 | 39.0 | .61 | H | Good; some snowbreak, twisted stems, some yellow foliage |
| resinosa Ait. | red pine | 19 | 1914 | 8/3 | 48.3 | 51.5 | .63 | MF | Excellent |
| " | " | 111 | 1924 | 20/18 | 38.4 | 43.0 | .70 | MF | Excellent |
| rigida Mill. | pitch pine | 20 | 1914 | 15/12 | 23.1 | 38.0 | .46 | VL | Good; badly snowbent |
| " | " | 475 | 1929 | 15/11 | 13.2 | 21.0 | .42 | VL | Good; considerable snowbreak and snowbent |
| sabiniana Dougl. | Digger pine | 274 | 1926 | 18/3 | 29.3 | 30.0 | .52 | N | Poor; snowbreak, needle blight |
| strobus L. | eastern white pine | 21 | 1912 | 8/8 | 55.7 | 62.0 | .73 | M | Good, except for blister rust |
| sylvestris L. | Scotch pine | 22 | 1912 | 14/6 | 36.5 | 39.0 | .46 | L | Fair; heavy sapsucker injury, acute branch angle |

Table 2.--Status of living conifer species, Wind River Arboretum (Continued)

| Scientific name | Common name | Lot number | Year alive | Year sown | Number planted | Average height in 1956 | Tallest tree in 1956 | Index of growth | Condition |
|---|-----------------------------------|------------|------------|-----------|----------------|------------------------|----------------------|-----------------|---|
| | | num-ber | num-ber | num-ber | num-ber | :(feet) | :(feet) | :(feet) | |
| <i>Pinus (the pines)</i> --Continued | | | | | | | | | |
| <i>sylvestris</i> L. | Scotch pine | 179 | 1923? | 18/12 | 40.1 | 49.0 | .77 | H | Good; some snowbreak, severe sapsucker injury |
| <i>sylvestris</i> var. <i>mongolica</i> Litw. | Scotch pine | 361 | 1929 | 20/20 | 26.8 | 31.0 | .62 | H | Good; light sapsucker injury |
| <i>tabulaeformis</i> Carr. | Chinese pine | 253 | 1926 | 18/13 | 21.0 | 32.0 | .56 | H | Fair; half show snowbreak or snowbend |
| " | " | 264 | 1926 | 18/17 | 29.5 | 43.0 | .75 | H | Good; some snowbreak, sapsucker injury |
| <i>tabulaeformis</i> Carr. (?) thunbergii Parl. | Chinese pine (?) | 314 | 1928 | 20/1 | 14.0 | 14.0 | .27 | N | Fair; snowbreak and snowbend |
| <i>virginiana</i> Mill. | Japanese black pine | 132 | 1925 | 18/4 | 22.5 | 26.0 | .44 | N | Poor; crooked and snowbroken |
| " | Virginia pine | 176 | 1923? | 16/2 | 18.5 | 20.0 | .31 | N | Poor; severe snowbreak |
| " | " | 488 | (1/) | 20/2 | 18.0 | 22.0 | | N | S Poor; severe snowbreak |
| <i>Pseudotsuga (the Douglas-firs)</i> : | | | | | | | | | |
| <i>macrocarpa</i> (Vasey) Mayr | bigcone Douglas-fir | 285 | 1927 | 24/1 | 5.0 | 5.0 | .09 | N | Poor; barely above fern |
| <i>menziesii</i> (Mirb.) Franco | Douglas-fir (Rocky Mountain form) | 33 | 1914 | 20/2 | 23.0 | 27.0 | .33 | N | Poor; severe snowbreak, thin foliage, <u>Rhabdocline</u> infected |
| " | " (N. Mex., 9,000') | 556 | 1948 | 14/11 | 2.81 | 4.5 | .70 | N | Good |
| " | " (Mont., 3,100') | 557 | 1948 | 12/11 | 2.76 | 4.1 | .64 | N | Good |
| " | " (Idaho, 2,200') | 558 | 1948 | 12/11 | 3.32 | 6.7 | 1.04 | N | Good |
| " | " (Calif., Sierra N.F.) | 586 | 1948 | 12/4 | 1.20 | 1.9 | .30 | N | Good |
| " | " (Wash., Olympic N.F.) | 587 | 1948 | 11/11 | 3.85 | 6.2 | .97 | N | Good |
| " | " (Oreg., Siuslaw N.F.) | 588 | 1948 | 7/6 | 2.80 | 3.7 | .58 | N | Good |
| " | " (Wash., Fidalgo Island) | 589 | 1948 | 11/10 | 2.5 | 4.1 | .64 | N | Good |
| " | " (Mont., Flat-head N.F.) | 593 | 1948 | 12/11 | 1.95 | 3.3 | .52 | N | Good |
| " | " (Idaho, Nez Perce N.F.) | 594 | 1948 | 12/11 | 1.50 | 2.0 | .31 | N | Good |
| " | " (Ariz., Tucson) | 597 | 1948 | 10/10 | 1.26 | 1.9 | .30 | N | Good |

See footnote at end of table.

Table 2.--Status of living conifer species, Wind River Arboretum (Continued)

| Scientific name | Common name | Lot number | Year sown | Year alive | Number planted | Average height in 1956 | Tallest tree in 1956 | Index of growth | Condition in 1955 | Condition |
|---|----------------------|------------|-------------------|------------|----------------|------------------------|----------------------|-----------------|---|-----------|
| <i>Sequoia (the sequoias): gigantea</i> (Lindl.) Decne. | giant sequoia | 35 | 1912 | 14/9 | 70.1 | 76.0 | .89 | N | Excellent; leader dead in 1 tree, frost in 1955 | |
| " | " | 461 | 1932 | 2/2 | 4.5 | 6.0 | .13 | N | Excellent; 1 previously cankered tree killed by frost, few others damaged | S |
| " | " | 479 | 1928 [?] | 16/15 | 18.7 | 39.0 | .75 | N | Excellent | S |
| <i>sempervirens</i> (D. Don) Endl. | redwood | 233 | 1926 | 21/5 | 4.5 | 5.5 | .09 | N | Poor; repeatedly frozen back | S |
| <i>Taxus (the yews): baccata</i> L. | English yew | 421 & 432 | 1931 | 29/19 | 1.3 | 1.5 | .03 | N | Poor; repeated freezeback | S |
| <i>brevifolia</i> Nutt. | Pacific yew | 357 | (1/) | 21/5 | 1.3 | 1.5 | .02 | N | Poor; repeated freezeback | S |
| <i>Thuja (the thujas): occidentalis</i> L. | northern white-cedar | 182 | 1923 [?] | 20/5 | 9.2 | 17.0 | .27 | H | Good | L |
| <i>plicata</i> Donn | western redcedar | 37 | 1912 | 10/9 | 46.5 | 58.0 | .68 | H | Excellent | L |
| " | " | 497 | (1/) | 17/3 | 3.3 | 4.0 | .09 | N | Poor; repeated freezeback, browsed | S |
| <i>Thujaopsis (thujopsis): dolabrata</i> (L.f.) Sieb. & Zucc. | Hiba arborvitae | 256 | 1926 | 5/5 | 14.6 | 25.0 | .44 | L | Excellent; planted in lawn | |
| <i>Tsuga (the hemlocks): canadensis</i> (L.) Carr. | eastern hemlock | 181 | 1923 [?] | 18/12 | 19.7 | 26.0 | .41 | H | Good | |
| <i>caroliniana</i> Engelm. | Carolina hemlock | 506 | 1938 | 8/8 | 11.4 | 18.0 | .74 | N | Good; snowbreak | |
| <i>heterophylla</i> (Raf.) Sarg. | western hemlock | 353 | (1/) | 16/10 | 41.1 | 51.0 | .83 | H | Excellent | |
| <i>mertensiana</i> (Bong.) Carr. | mountain hemlock | 278 & 354 | (1/) | 19/13 | 20.7 | 26.0 | .41 | L | Excellent | |
| <i>sieboldii</i> Carr. | Siebold hemlock | 414 | 1931 | 12/4 | 5.2 | 8.0 | .18 | N | Fair | M |

1/ Wild seedlings of unknown age.

Year sown. In the case of fall-sown seed, this is the year of germination. A question mark indicates that stock was of indeterminate age or grown elsewhere, and that the date of sowing is approximate.

Number planted; number alive (1956). Number planted does not include first-year replacements of trees that probably died from transplanting. Replacements were not made in many instances. The ratio of trees alive to trees planted is not a good measure of the suitability of a species since early lots were moved when the trees were too large for successful transplanting. Some other lots were also mechanically injured or killed by rodents.

Average height in 1956. Average height in feet of all living trees in each group at the end of the 1956 growing season.

Tallest tree in 1956. Height of tallest tree at the end of the 1956 growing season.

Growth index. Ratio of height of tallest tree in each lot to height of average dominant Douglas-firs on the same site at the same age (table 3).

Cone production. Noted as "N" for none, "L" for light, "M" for moderate, and "H" for heavy if cones have been produced. Where male flowers were being produced and no visible evidence of cones was present, the symbol "MF" was noted under "Cone production."

Frost damage in 1955. This column was included mainly to show the relative damage caused by the severe, early, regionwide freeze in November 1955. Following unusually mild weather, temperatures dropped rapidly to -1° F. and remained below 32° F. for 6 days (Duffield, 1956). Several lots were completely killed. In most cases, the injured species had previously shown susceptibility to damage by freezing, as noted in the "Condition" column. Damage is listed as light (L), medium (M), or severe (S).

Condition. Taken from field records to indicate the general condition of each group with regard to (1) vigor and (2) damage by insects, diseases, or other agencies.

Table 3.--Height-age relationships for dominant Douglas-firs
native to the Wind River Arboretum^{1/}

| Age (years) | Height | Age (years) | Height |
|-------------|-------------|-------------|-------------|
| | <u>Feet</u> | | <u>Feet</u> |
| 1 | 0.2 | 24 | 42.0 |
| 2 | 0.4 | 25 | 44.8 |
| 3 | 0.6 | 26 | 47.4 |
| 4 | 1.0 | 27 | 49.8 |
| 5 | 1.6 | 28 | 52.3 |
| 6 | 2.2 | 29 | 54.8 |
| 7 | 2.8 | 30 | 57.3 |
| 8 | 3.9 | 31 | 59.5 |
| 9 | 5.1 | 32 | 61.6 |
| 10 | 6.4 | 33 | 63.5 |
| 11 | 8.2 | 34 | 65.7 |
| 12 | 10.0 | 35 | 67.8 |
| 13 | 11.9 | 36 | 69.8 |
| 14 | 14.4 | 37 | 71.9 |
| 15 | 16.7 | 38 | 74.0 |
| 16 | 19.0 | 39 | 75.9 |
| 17 | 21.5 | 40 | 77.8 |
| 18 | 24.3 | 41 | 80.0 |
| 19 | 27.2 | 42 | 81.9 |
| 20 | 30.0 | 43 | 83.7 |
| 21 | 33.0 | 44 | 85.4 |
| 22 | 36.0 | 45 | 87.2 |
| 23 | 39.1 | | |

^{1/} These height-age relationships were determined by averaging measurements from 11 dominant Douglas-firs, all volunteers within the arboretum.

Exact age of each tree was determined by boring to tree center at ground line. Heights at ages beyond 10 years were found by measuring to the appropriate whorl. Heights were averaged at 5-year intervals, and a smooth curve was drawn through these points. Data for the lower end of the curve, from 1 to 10 years, were determined from four saplings less than 12 years old.

THE PINES (PINUS)

Sixty-two species and varieties of pines have been tried at the Wind River Arboretum. Of this number, 38 are living and doing reasonably well, and 4 are living but doing very poorly.

Many pines have shown rapid initial growth, but none tested for more than 20 years have shown a growth rate equal to that of the native Douglas-fir. Many lots of white pines tested have shown excellent thrift and form but hold no eventual promise, because of susceptibility to white pine blister rust. The white pines have shown greater resistance than the hard pines to frost and snow damage and are not attacked by sapsuckers.

The white pines (P. monticola, P. lambertiana, and P. strobus) continue to grow very well and are of excellent form and vigor. However, they are rather heavily infected with blister rust.

P. peuce is in excellent condition though it is slow growing. The older group displays a very symmetrical pyramidal crown that reaches to the ground, and the younger group is beginning to assume the same form. This species would be a most attractive ornamental or windbreak tree.

The high-altitude white pines (P. aristata, P. flexilis, P. balfouriana, P. albicaulis, and P. flexilis var. reflexa) are doing reasonably well. They are typically slow growing, and most have suffered some snowbreak and snowbend.

P. griffithii, P. koraiensis, P. peuce, and P. aristata have shown immunity to blister rust. P. flexilis var. reflexa, P. balfouriana, P. flexilis, and P. strobus have shown some susceptibility; P. monticola is very susceptible; P. lambertiana is extremely susceptible; and P. albicaulis is the most susceptible of all the white pines in the arboretum. This substantiates the pattern of resistance to blister rust found by Childs and Bedwell (1948).

With the exception of the faster growing P. ponderosa and P. contorta, hard pines from both eastern and western United States do equally well in this climate. Those from the more southern latitudes have done poorly in general, and those from the Northeast and Northwest, including northern California, have done well.

P. ponderosa, P. banksiana, and P. resinosa continue to do relatively well and, along with the mugho pines, are the best of the hard pines. However, they are not doing well enough to recommend them for planting as timber species in this climate. The mugho pines are among the hardiest of all species in the arboretum. Though they are slow growing and cannot be recommended as a timber species, they do well as ornamentals and may prove acceptable for use in watershed work. Some young lots of P. contorta show excellent growth rates.

With few exceptions, none of the Asiatic or European pines have done well enough to recommend them for planting as timber trees in this climate. The mugho pines and P. peuce have been mentioned. P. griffithii, though doing quite well, is still fairly young and no accurate statement can be made as to its suitability to the Wind River site. Most European pines are susceptible to sapsucker damage, and some groups have suffered from snowbreak. The Asiatic pines are damaged by snow and suffer occasional frost damage.

Of the 23 species of pine that have failed or are doing poorly, 7 are native to the Orient, 12 are from eastern or western North America below the 42nd parallel, 3 are from maritime climates, and 1 is believed to be European. Cold temperature has caused death in almost every case where the cause of failure has been recorded. Some species had done relatively well for 30 to 40 years before being killed by severe low temperatures (fig. 5).

Figure 5. -- Adequate tests of introduced species require many years. Coulter and knobcone pine were promising species but were completely killed by frost in November 1955, after growing well for 39 and 43 years, respectively. Dead trees of the knobcone pine group are shown at right.



THE LARCHES (LARIX)

As a group the larches are one of the most successful of all genera in the arboretum. Eleven species have been tried at Wind River and only one may be listed as a failure. With the exception of L. leptolepis and L. occidentalis, the larches are resistant to frost damage. However, since 1946 the larches have suffered considerable snowbreak. Because of this tendency and their susceptibility to sap-sucker damage, they are not regarded suitable for introduction into this climate.

During its first 30 years, Larix is the only genus of all those tried at Wind River that equals the native Douglas-fir in height growth. The growth comparison becomes less favorable after 30 years, however. The lowest growth index of all the groups of larch under 30 years of age is 0.75. On the other hand, 7 of the 11 groups older than 30 years have a growth index of 0.59 or less.

In general, the larches from Europe are now doing better than those from Asia. L. decidua and L. decidua X leptolepis, both from Europe, are presently the best of all the larches and L. decidua var. polonica, another larch from Europe, is also doing very well. Many of the larches from Japan and continental Asia were once leading all arboretum groups in growth rate, but almost all have now proved very susceptible to snowbreak (fig. 6). L. leptolepis has also been damaged by frost.



Figure 6.--Siberian larch, which once outgrew Douglas-fir, has recently shown susceptibility to snow breakage.

The tamarack, or eastern larch, L. laricina, has done fairly well and has not suffered as much snow damage as other larches.

Both groups of western larch, L. occidentalis, are doing poorly. They have been damaged by snow and frost and earlier records indicate that they had a serious needle blight for many years. It should be pointed out that the seed for both groups in the arboretum came from east of the Cascade Range, where climate is more continental and humidities are therefore lower. In contrast to the poor showing of western larch groups in the arboretum, the western larch found native to the Wind River valley is a tree of excellent vigor.

L. lyallii has been the only failure of all species of larches. Only one group has done well enough in the nursery to warrant planting in the arboretum, and this group died over a period of 10 years.

THE SPRUCES (PICEA)

Although not generally rapid growing, most species of spruce have succeeded at Wind River. Of 20 species tried in the arboretum, 16 are doing fairly well, 3 are doing very poorly and may be classed as failures, and 1 has failed.

Though few of the spruces have done poorly, only P. abies has done well enough to warrant further trials in forest planting. So far this species has displayed excellent growth and vigor, though it shows evidence of light frost damage. To date it has not been attacked by Chermes cooleyi.

None of the other spruces show a growth index greater than 0.66, and P. glauca, P. engelmannii, and P. sitchensis are attacked by Chermes cooleyi. P. engelmannii is also damaged by sapsuckers.

The Asiatic spruces have not done well, and all of the failures are from the continent of Asia or from Japan. P. likiangensis gradually died out. P. bicolor, P. smithiana, and P. polita are also dying out, and P. smithiana and P. polita were repeatedly broken by snow.

THE HEMLOCKS (TSUGA)

All the hemlock species except two are thriving: T. sieboldii has suffered from frost damage, and occasional trees of the T. caroliniana group have been broken by snow. The two native species,

T. heterophylla and T. mertensiana are the best of all the Tsuga species. T. mertensiana, though slow growing, is the handsomest and hardiest. T. canadensis is doing fairly well but is growing considerably slower than the native T. heterophylla.

To date no species of hemlock may be listed as a failure at Wind River.

THE DOUGLAS-FIRS (PSEUDOTSUGA)

Only two species, P. menziesii and P. macrocarpa, have been tested at Wind River. P. macrocarpa has only one survivor after the low temperatures in 1955. This 30-year-old group has been of poor vigor and repeatedly broken by snow. The Rocky Mountain group of P. menziesii at 43 years of age had only three survivors. This group has been very severely and repeatedly attacked by needle diseases (Rhabdocline sp.) (fig. 7). Seed lots of the Asiatic species of Pseudotsuga have either failed to germinate or died in the nursery.



Figure 7. -- Strains of native species introduced from more continental climates have performed poorly at Wind River. Douglas-fir from a Rocky Mountain seed source was planted at the arboretum more than 40 years ago; today, most of the trees are dead from repeated attacks by needle diseases, and adjacent natural Douglas-firs of about the same age as the survivors reach far over them (left). Similar poor performance has been shown by introduced strains of ponderosa pine, western larch, and lodgepole pine.

Ten lots of Douglas-fir, sown in 1948, were added to the arboretum in 1952. These lots are from various locations throughout the West and will be used to demonstrate racial variation within the species. So far the only differences observed have been in height growth, as shown in table 2.

THE FIRS (ABIES)

In all, 28 species and subspecies of Abies have been tried at Wind River. Of these, 24 are living, but only 11 have done well. Eight are only fairly successful, and 5 have been found not suited to the Wind River site.

Balsam woolly aphid (Chermes piceae) has become a serious threat among the firs since the last remeasurement in 1946. There is conclusive evidence that it appeared before 1949 in Fraser fir (A. fraseri), for tops of the Fraser firs that died in 1949 are heavily gouted from Chermes attack. At that time, Chermes was not known to be a serious problem in the Northwest, and extreme frost was reported as the agent responsible for damage (Steele, 1954). Because of the heavily gouted condition of all dead tops, it is certain that Chermes had reached the arboretum before this date, and it is now doubtful that cold played any role in the damage reported. Climatological records show the native climate of this group of Fraser fir (Mount Mitchell, N. C.) to be more severe than that at Wind River, and no frost damage was observed after the 1955 freeze.

Because a large number of fir species and varieties are established in the arboretum, there has been a good opportunity to observe relative resistance to Chermes attack. Six species and varieties are attacked: A. lasiocarpa var. arizonica and A. pinsapo show light infestation; A. balsamea has moderate infestation; and A. fraseri, A. lasiocarpa, and A. alba are heavily infested. (A. alba, though heavily infested, shows no apparent damage.) The remaining groups, including A. grandis, show no Chermes infestation to date.

As might be expected, species native to the Northwest and northern California have proved most successful at Wind River. Of the 11 species that are doing well, 8 are native to the Northwest, 1 to the Northeast, 1 to the Southwest, and 1 to northern Japan. It should be noted that the species from northern Japan, A. sachalinensis, is the only fir from outside the United States that has done well at Wind River. Although A. sachalinensis grows more slowly than native Douglas-fir, only A. grandis and A. procera are more rapid growing among the Abies.

A. grandis is the most rapid growing of all the balsam firs in the arboretum. The native species A. procera, A. amabilis, A. lasiocarpa, and a variety of A. grandis are also growing well but

considerably slower than A. grandis. A. balsamea and A. lasiocarpa var. arizonica are doing well, but the recent attack by Chermes has reduced their vigor.

Perhaps the handsomest of all the firs are A. magnifica and A. magnifica var. shastensis.

The greatest single factor causing failure among the firs is repeated freezeback. Many Asiatic and European firs suffer almost annual freezeback because they burst their buds quite early and are damaged by late spring frost.

No species of balsam fir from south of 42° latitude has shown good growth at Wind River, and many are listed as failures.

THE CEDARS (CEDRUS)

Of three species of Cedrus, none has failed at Wind River. However, C. deodara is not doing well, and C. atlantica and C. libani, though fairly vigorous, are both slow growing.

THE SEQUOIAS (SEQUOIA)

S. sempervirens is doing very poorly and is definitely not suited to the Wind River site. It is frozen back repeatedly. S. gigantea is displaying an excellent growth rate and some cones have been produced. One volunteer S. gigantea has been observed in the arboretum. This species occasionally suffers minor frost damage.

INCENSE-CEDAR (LIBOCEDRUS)

Two groups of Libocedrus have been tried at Wind River. Though some individuals of L. decurrens have been seriously damaged by frost, most trees of the species are doing very well.

L. formosana is the only incense-cedar that may be called a failure. It was killed by frost in the nursery.

THUJOPSIS (THUJOPSIS)

Only a single representative of this genus, T. dolabrata, has been included in the arboretum. Specimens of this species are growing well on a watered lawn near the headquarters building.

THE THUJAS (THUJA)

Six species of Thuja have been tried at Wind River, two of which failed to germinate. Of the four that did germinate, two are now living. The native T. plicata is doing very well, though one group has suffered freezeback. T. occidentalis has suffered light frost damage but is doing well.

Both T. standishii and T. orientalis were killed by frost in the arboretum.

THE WHITE-CEDARS (CHAMAECYPARIS)

C. lawsoniana and C. nootkatensis are the only species doing well. Both show occasional but not serious frost damage.

Other Chamaecyparis species are doing poorly. C. obtusa and C. pisifera were killed by repeated frost and winter damage. C. thyoides is frozen back repeatedly and, though living, is not suited to the Wind River site.

THE CYPRESSES (CUPRESSUS)

Of the eight species and subspecies of Cupressus tried, only C. macnabiana and C. bakeri are living. Some individuals have been damaged by frost, but all groups are doing very well.

Of the six Cupressus species that failed at Wind River, five were killed by frost or winter damage (table 6) and one died out in the Wind River nursery from unknown causes.

THE JUNIPERS (JUNIPERUS)

J. scopulorum has survived best of all the junipers, but it does not display good vigor. All the junipers show a tendency to snow and frost damage.

Four junipers have failed at Wind River, three as a result of frost damage. One lot died out in the arboretum over a period of 10 years.

THE YEWS (TAXUS)

None of the yews have been successful at Wind River. Attempts to establish T. brevifolia and T. baccata have failed because both species are heavily browsed by deer.

THE ARAUCARIAS (ARAUCARIA)

The two specimens of A. araucana are doing well after having been repeatedly frozen back for more than 30 years. The trees showed no damage from the severe early frosts of November 1955.

PERFORMANCE OF BROAD-LEAVED TREES

As mentioned earlier, no attempt has been made to establish hardwoods in the arboretum since 1928.

Major eastern hardwood species have done very poorly; only Quercus rubra and Tilia americana approach the size and form attained in their native habitat (table 4).

Of the maples, only Acer platanoides (Norway maple) has done well. Though it grows slowly, the single specimen of this species has developed fairly well and is an attractive tree. Both Acer macrophyllum var. kimballiae and Acer saccharum continue to do poorly.

The American chestnut, Castanea dentata, is the only species of the genus still surviving in the arboretum. The five living trees appear to have good vigor despite relatively slow growth; and some trees bore a heavy crop of chestnuts.

Golden chinkapin, Castanopsis chrysophylla, is the best hardwood group in the arboretum (fig. 8). The trees are tall and straight, of excellent vigor, and regularly bear fruit. These have produced a large number of natural seedlings throughout the arboretum.

All the Fraxinus species have done poorly, though the trees continue to survive. Green ash, F. pennsylvanica, has suffered from snowbreak.

Of the poplars, Populus X berolinensis is in fair condition and Populus X petrowskyana has been frozen back repeatedly.

Table 4. --Status of living broad-leaved species, Wind River Arboretum

| Scientific name | Species | Lot | Year | Number | Height |
|---|----------------------------|---------|--------|-----------------|---------|
| | Common name | num-ber | sown | planted; number | in 1956 |
| | | | | alive (1956) | (feet) |
| <i>Acer platanoides</i> L. | Norway maple ^{1/} | 95 | 1913 | 87/1 | 37.5 |
| <i>Castanea dentata</i> (Marsh.) Borkh. | American chestnut | 191 | 1924 | 67/5 | 24.8 |
| <i>Castanopsis chrysohylla</i> (Dougl.) A. DC. | golden chinkapin | 54 | 1913 | 14/10 | 45.2 |
| <i>Fraxinus americana</i> L. | white ash | 72 | 1912 | 16/7 | 8.3 |
| " <i>latifolia</i> Benth. | Oregon ash | 74 | 1913 | 16/14 | 9.6 |
| " <i>pennsylvanica</i> Marsh. | green ash | 75 | 1912 | 157/4 | 13.2 |
| <i>Liriodendron tulipifera</i> L. | yellow-poplar | 63 | 1911 | 177/13 | 19.1 |
| <i>Lithocarpus densiflorus</i> (Hook. & Arn.) Rehd. | tanoak | 120 | 1925 | 9/2 | 2.5 |
| <i>Populus X berolinensis</i> Dipp. | Berlin poplar | 49 | 2/1916 | 37/1 | 25.0 |
| " <i>X petrowskyana</i> (Reg.) Schneid. | Petrowsky poplar | 273 | 1926 | 18/13 | 3.1 |
| <i>Prunus serotina</i> Ehrh. | black cherry | 64 | 1913 | 15/11 | 1.5 |
| " <i>sp.</i> ^{3/} | Patagonian cherry | 283 | 2/1927 | 11/2 | 3.5 |
| <i>Quercus alba</i> L. | white oak | 188 | 1923 | 16/4 | 6.5 |
| " <i>chrysolepis</i> Liebm. | canyon live oak | 119 | 1925 | 12/8 | 6.0 |
| " <i>garryana</i> Dougl. | Oregon white oak | 55 | 1913 | 7/4 | 20.2 |
| " <i>kelloggii</i> Newb. | California black oak | 121 | 1925 | 16/7 | 20.7 |
| " <i>prinus</i> L. | chestnut oak | 187 | 1923? | 14/7 | 14.0 |
| " <i>rubra</i> L. | northern red oak | 57 | 1912 | 167/13 | 35.6 |
| " <i>velutina</i> Lam. | black oak | 56 | 1914 | 11/3 | 15.7 |
| <i>Rhamnus purshiana</i> DC. | cascaara buckthorn | 239 | 1925 | 18/13 | 5.1 |
| <i>Tilia americana</i> L. | American basswood | 70 | 1912 | 6/4 | 28.2 |
| <i>Ulmus americana</i> L. | American elm | 62 | 1912 | 13/6 | 13.0 |

^{1/} Planted on watered lawn.

^{2/} Cuttings or plants set that year.

^{3/} Identified by common name only.



Figure 8.--Broad-leaved species in general failed so consistently that the arboretum was devoted exclusively to conifers after 1928. The most successful broad-leaved group has been chinkapin, a native of southern Oregon, which attained a height of 45 feet in 43 years. Douglas-fir would be expected to grow 84 feet in the same length of time.

Tulip poplar, Liriodendron tulipifera, has grown very poorly at Wind River in comparison with growth in its native environment.

Northern red oak, Quercus rubra, is growing well, but all other surviving oaks are doing poorly.

Apparently the broad-leaved species have been very adversely affected by the hot, dry summers and porous soil. In earlier reports, the almost universal failure of these trees was attributed to the long, rainless period during July and August; low humidity; and porous, gravelly soil. Many species that failed in the arboretum have done well on watered lawns. Very little evidence of freezeback has been noted, even following the cold winter of 1949-50 and the early freeze of November 1955.

CONIFERS FOUND UNSUITED TO THE WIND RIVER SITE

Of 165 coniferous species tested at Wind River, 42 have died and another 17--although living--are obviously unsuited to the habitat (table 5). Some of these unsuccessful species were tried several times.

Cause of failure, though recorded, is difficult to evaluate; most lots died between examination dates, leaving questionable causal evidence. Winterkilling was listed for 29 percent of the lots, whereas a combination of causes was recorded for 57 percent--including winter damage, competition, drought, and disease. Often, several different causes were listed for individuals within the same lot. Fourteen percent had no cause of death listed.

Diseases or insects, though important killers of individual trees, have not yet been listed as causing the failure of any species. Although white pine blister rust has been present in the arboretum for several decades, it has not completely wiped out any white pine lot, even though all trees in some lots are infected. Likewise, the recent balsam woolly aphid attack on Abies has not completely killed any single species. In such outbreaks the arboretum has served to test the relative susceptibility of the species within a genus.

A number of species continue to live year after year, even though they are repeatedly damaged by frost, snow, or some other agency. These species also are considered unsuited to the Wind River site.

Table 5. --Conifers unsuited to Wind River

| Species | Range | Seed source ¹ | Reason for unsuitability | Age at death | Years |
|--|-----------------|--------------------------|--|--------------|-------|
| Dead: | | | | | |
| <i>Abies firma</i> Sieb. & Zucc. | Japan | Japan | Repeated winter damage | 20 | |
| <i>Abies veitchii</i> Lindl. | Japan | Japan | Repeated winter damage | 20 | |
| <i>Abies bracteata</i> D. Don | Calif. | S. Calif. | Repeated frost damage | ? | |
| <i>Chamaecyparis obtusa</i> (Sieb. & Zucc.) Endl. | Japan | Orient | Repeated winter damage | 17 | |
| <i>Chamaecyparis pisifera</i> (Sieb. & Zucc.) Endl. | Japan | Orient | Frost killed and winter killed | 30 | |
| <i>Cephalotaxus harringtonia</i> var. <i>drupacea</i> (Sieb. & Zucc.) Koidzumi | Japan | Austria | Frost killed | 18 | |
| <i>Cryptomeria japonica</i> (L.f.) D. Don | Japan | Japan | Died gradually | 15 | |
| <i>Cupressus arizonica</i> Greene | SW. U.S. | Arizona | Frost killed | 18 | |
| <i>Cupressus goveniana</i> Gord. | Calif. | S. Calif. | Frost killed | 18 | |
| <i>Cupressus lusitanica</i> Mill. | Mexico | Mexico | Stock died in nursery (see 1947 publication) | 3 | |
| <i>Cupressus macrocarpa</i> Hartw. | SW. U.S. | S. Calif. | Winter damage | 20 | |
| <i>Cupressus sempervirens</i> L. | S. Eur., W. As. | Medit. | Winter killed | 4 | |
| <i>Cupressus duclouxiana</i> Hickel | Himalayas | Austria | Winter killed | 2 | |
| <i>Ginkgo biloba</i> L. | E. China | Japan | Repeatedly killed back | 8 | |
| <i>Juniperus ashei</i> Buchholz | E. U.S., Mex. | Not given | Frost killed | 17 | |
| <i>Juniperus excelsa</i> Bieb. | Medit. | Austria | Frost killed | 19 | |
| <i>Juniperus monosperma</i> (Engelm.) Sarg. | SW. U.S. | SW. U.S. | Died gradually | 21 | |

See footnote at end of table.

Table 5.--Conifers unsuited to Wind River (Continued)

| Species | Range | Seed source ^{1/} | Reason for unsuitability | Age at death |
|--|----------------|---------------------------|--|--------------|
| Dead--Continued | | | | |
| <i>Juniperus semiglobosa</i> | As. Min. | Russia | Frost killed | 19 |
| <i>Larix lyallii</i> Parl. | Pac. NW. | E. Wash. | Died in nursery and arboretum | 13 |
| <i>Libocedrus formosana</i> Florin. | Formosa | Japan | Frost killed | 2 |
| <i>Picea likiangensis</i> (Franch.) Pritz. | W. China | China | Died out in arboretum; probably frost | 30 |
| <i>Pinus armandi</i> Franch. | Cen., W. China | China | Repeated freezeback | 31 |
| <i>Pinus attenuata</i> Lemm. | W. U.S. | Calif. | Frost killed | 43 |
| <i>Pinus canariensis</i> C. Smith | Canary I. | Canary I. | Winter killed, nursery | 4 |
| <i>Pinus elliottii</i> Engelm. | SE. U.S. | SE. U.S. | Winter killed, nursery | 39 |
| <i>Pinus coulteri</i> D. Don | Mex., Calif. | S. Calif. | Frost killed | 20 |
| <i>Pinus edulis</i> Engelm. | SW. U.S. | SW. U.S. | Frost and winter killed | |
| <i>Pinus gerardiana</i> Wall. | Himalayas | India | Did poorly for several years; killed by rust disease | 34 |
| <i>Pinus halepensis</i> Mill. | Medit. | S. Cen. Eur. | Died out in nursery & arboretum | 8 |
| <i>Pinus khasya</i> Royle | N. Burma | India | Winter killed, nursery | 1 |
| <i>Pinus leiophylla</i> Schlecht. & Cham. | SW. U.S., Mex. | Mexico? | Winter killed, nursery | 5 |
| <i>Pinus roxburghii</i> Sarg. | Himalayas | Himalayas | Winter killed, nursery | 3 |
| <i>Pinus montezumae</i> Lamb. | Mexico | Mexico | Winter killed, nursery | 6 |
| <i>Pinus palustris</i> Mill. | SE. U.S. | SE. U.S. | Winter killed, nursery | 5 |
| <i>Pinus patula</i> Schlecht. & Cham. | Mexico | Mexico | Killed in nursery | 5 |

See footnote at end of table.

Table 5. --Conifers unsuited to Wind River (Continued)

| Species | Range | Seed source ^{1/} | Reason for unsuitability | Age at death |
|---|--------------|---------------------------|---|--------------|
| Dead--Continued | | | | |
| <i>Pinus pinaster</i> Ait. | Medit. | Holland | Frost killed | 27 |
| <i>Pinus radiata</i> D. Don | Calif. | S. Calif. | Winter killed | 12 |
| <i>Pinus taeda</i> L. | SE. U.S. | SE. U.S. | Gradually died off; finally killed by frost | 43 |
| <i>Pinus torreyana</i> Parry | Calif. | S. Calif. | Winter killed, nursery | 5 |
| <i>Taxodium distichum</i> (L.) Rich. | S. U.S. | Louisiana | Died after few years | 10 |
| <i>Thuja standishii</i> (Cord.) Carr. | Japan | Japan | 1 small lot failed after 5 years in arboretum | 13 |
| <i>Thuja orientalis</i> L. | N., W. China | Japan | Frost and winter killed | 20 |
| Living, but in poor condition: | | | | |
| <i>Abies bracteata</i> D. Don | Calif. | S. Calif. | Repeatedly frozen | -- |
| <i>Abies fabri</i> (Mast.) Graib | W. China | China | Repeatedly frozen | -- |
| <i>Abies holophylla</i> Maxim. | Manch., Kor. | Japan | Repeatedly frozen | -- |
| <i>Abies sibirica</i> Ledeb. | U.S.S.R. | Not given | Repeatedly frozen | -- |
| <i>Chamaecyparis thyoides</i> (L.) B.S.P. | E. U.S. | N. J. | Repeatedly frozen | -- |
| <i>Picea bicolor</i> (Maxim.) Mayr | Japan | Japan | Gradually dying off | -- |
| <i>Picea polita</i> (Sieb. & Zucc.) Carr. | Japan | Japan | Repeatedly snowbroken | -- |
| <i>Picea smithiana</i> Boiss. | Himalayas | India | Repeatedly snowbroken | -- |

See footnote at end of table.

Table 5. -- Conifers unsuited to Wind River (Continued)

| Species | Range | Seed source ^{1/} | Reason for unsuitability | Age at death |
|--|----------------|---------------------------|--|--------------|
| Living, but in poor condition--Continued | | | | |
| <i>Pinus bungeana</i> Zucc. | NW. China | China | Repeatedly frozen back (2 alive but very poor) | -- |
| <i>Pinus densiflora</i> Sieb. & Zucc. | Japan | Japan | Gradually dying off (snow-break; frost) 8 of 29 left in 2 lots | -- |
| <i>Pinus griffithii</i> McClelland (?) | Himalayas | Himalayas | Frost--1 of 2 lots killed | -- |
| <i>Pinus sabiniana</i> Dougl. | Calif. | N. Calif. | Frost | -- |
| <i>Pinus thunbergii</i> Parl. | Japan | Japan | Frost; gradually dying off | -- |
| <i>Pinus virginiana</i> Mill. | E. U.S. | N.C. | Frost; gradually dying off | -- |
| <i>Pseudotsuga macrocarpa</i> (Vasey) Mayr | Calif. | S. Calif. | Gradually dying off (1 survivor) | -- |
| <i>Sequoia sempervirens</i> (D. Don) Endl. | Calif. | S. Calif. | Repeatedly frozen | -- |
| <i>Taxus baccata</i> L. | Euras., N. Af. | Austria | Repeatedly frozen | -- |

^{1/} Seed source as recorded in file record. Where source is outside species range, the seed may have come from arboreta, or may simply be the address of the collector.

GENERAL COMMENTS ON PERFORMANCE

Although tests of introduced trees at Wind River Arboretum are not statistically designed, it would be a disservice not to discuss those observations that seem to throw light on performance of introduced species in the Pacific Northwest. The Wind River area, being low site III, and at an elevation of 1,150 feet, certainly provides a conservative test of adaptability for plantings on forest land over much of the Pacific Northwest region. The risk of planting a species that does poorly at Wind River would be considerable, even in milder parts of the region.

With few exceptions, introduced trees have not attained growth rates equal to that of Douglas-fir native to the area. In this latest remeasurement, the average height of Douglas-fir dominants in the arboretum was determined for each year up to 45 years of age (table 3). These heights closely follow the curve for Douglas-fir site index 130. A growth index--the expression of performance of each lot--was provided by dividing the height of the tallest individual by the average height of Douglas-fir dominants of the same age. At first, this method for deriving the growth index seems overly favorable to the introduced tree. However, the tallest tree in a lot is probably a better expression than the average height in indicating how a species might perform if seed source were carefully selected to match the climate at Wind River. Even with such a favorable comparison, the growth index of almost all introduced trees falls below 1.00; hence it serves to focus attention on how few of the 215 living groups have possibilities for introduction as timber trees.

Practically all species that have grown at faster rates than Douglas-fir did so during early life and were eventually overtaken--mostly before reaching 20 years of age. This is particularly true of the pines. Several larches have continued to grow at high rates, but have been broken by snow. Even when comparisons are made within genera, instead of with native Douglas-fir, the Northwest representatives have usually shown the best growth rate.

Some introduced species seem to have promise, however. Better adapted strains of Sequoia gigantea, Picea excelsa, and several larches should be tested more exhaustively, for example, since the arboretum lots have shown good sustained performance.

Mention should also be made of patterns associated with growth and mortality. One of these patterns is the generally poor growth or

outright failure of introduced species and subspecies from the southern and southeastern United States, Mexico, southern Asia, China, Japan, and the southern hemisphere. Best performers in each genera have been native to the west slope of the Cascade Range and Sierra Nevada. Conifers from the northeastern United States have done fairly well, and those from western Europe have generally survived. This pattern is shown, species by species, for various climatic regions of the world (Heintzelman and Highsmith, 1955) in table 6. As shown in this table, the comparisons with height growth of native Douglas-fir (growth index) are fairly consistent by groups of species in each climatic region. In interpreting the table, however, the reader should recognize that the data used for evaluating any one species were very limited and that the classification is not a rigorous one.

The similar performance at Wind River of whole groups of species from climatic regions of the world supports the view long held by plant geographers (Gray, 1878; Gray and Hooker, 1881, p. 41) that climatic requirements of plant communities are highly restricted and probably have not changed much over millions of years.

Many tree species introduced at Wind River, now native to the Orient and southeastern United States, existed abundantly in the flora of the Pacific Northwest in the Miocene epoch (Beck, 1945; Chaney, 1948) but failed to survive as the climate became cooler and subject to more summer droughtiness. Their general unsuitability following reintroduction supports the idea of an inherently narrow ecological amplitude; these species have failed to develop a tolerance for the present climate of the Pacific Northwest, even after millions of years. This emphasizes the difficulty of finding species or strains from the Orient or southeastern United States that are adapted to Northwest conditions.

Another interesting pattern has been the poor performance of species native to the Northwest, but having origins from seed collected east of the Cascades. Growth rates are excellent for Douglas-fir, western larch, lodgepole pine, and ponderosa pine that are native to the Wind River valley, but strains of these species from areas having a more continental climate than at Wind River have usually done poorly at the arboretum. Likewise, better growth of trees from seed sources west of the Cascades is already apparent in the 10 lots of Douglas-fir sown in 1948 from various seed sources over its great range. Native needle diseases have undoubtedly played a major role in the poor performance of the Rocky Mountain form of Douglas-fir. Arboretum lots

Table 6. --Performance of species by climatic regions of the world

| Species | Range | Seed source | Performance | Growth index |
|--|---------------|------------------|------------------------------------|--------------|
| Dry-summer subtropics: | | | | |
| <i>Abies bracteata</i> D. Don | Calif. | S. Calif. | Repeated frost damage | -- |
| <i>Cupressus goveniana</i> Gord. | Calif. | S. Calif. | Frost killed | -- |
| <i>Cupressus lusitanica</i> Miller | Mexico | Mexico | Died in nursery | -- |
| <i>Cupressus sempervirens</i> L. | S.Eur., N.As. | Palestine | Winter killed | -- |
| <i>Picea smithiana</i> (Wall.) Boissier | Himalayas | Turkey | Repeated snow damage | -- |
| <i>Pinus coulteri</i> D. Don | Calif. | S. Calif. | Frost killed | -- |
| <i>Pinus halepensis</i> Mill. | Medit. | Italy and France | Died out in nursery & arboretum | -- |
| <i>Pinus muricata</i> D. Don | Calif. | S. Calif. | Died in arboretum | -- |
| <i>Pinus radiata</i> D. Don | Calif. | S. Calif. | Frost killed | -- |
| <i>Pinus torreyana</i> Parry | Calif. | S. Calif. | Frost killed in nursery | -- |
| Humid subtropics: | | | | |
| <i>Abies firma</i> Sieb. & Zucc. | Japan | Japan | Repeated winter damage | -- |
| <i>Abies holophylla</i> Maxim. | Manch., Kor. | Japan | Repeatedly frozen back | .10 |
| <i>Abies sachalinensis</i> Mast. | Japan | Japan | Good; light frost; crooked stems | .66 |
| <i>Araucaria araucana</i> (Molina) K. Koch | Chile | Argentina | Repeatedly killed back; now good | .09 |
| <i>Chamaecyparis obtusa</i> (Sieb. & Zucc.) Endl. | Japan | Japan | Repeated winter damage | .31 |
| <i>Larix gmelini</i> var. <i>principis-rupprechtii</i> (Mayr) Pilger | E. Asia | Japan | Fair; extreme snowbreak | .47 |
| <i>Picea bicolor</i> (Maxim.) Mayr | Japan | Japan | Poor; repeatedly snowbroken | .12 |
| <i>Picea polita</i> (Sieb. & Zucc.) Carr. | Japan | India | Poor; snowbroken | .06 |
| <i>Pinus echinata</i> Mill. | E. U.S. | N.C. | Suffers frost damage; poor to fair | .41 |

Table 6. --Performance of species by climatic regions of the world (Continued)

| Species | Range | Seed source | Performance | Growth index |
|---|-------------|-------------|---|--------------|
| Humid subtropics--Continued | | | | |
| <i>Pinus eliottii</i> Engelm. | SE. U.S. | Louisiana | Winter killed in nursery | -- |
| <i>Pinus koraiensis</i> Sieb. & Zucc. | Jap., Kor. | Japan | Good; evidence of root rot | .42 |
| <i>Pinus palustris</i> Mill. | SE. U.S. | N.C. | Winter killed in nursery | -- |
| <i>Pinus rigida</i> Mill. | E., N.Amer. | Georgia | Good; badly snowbent | .46 |
| <i>Pinus rigida</i> var. <i>serotina</i> (Michx.) Loud. | SE. U.S. | Florida | Died in nursery | -- |
| <i>Pinus taeda</i> L. | SE. U.S. | Louisiana | Gradually died off; finally frost killed | -- |
| <i>Pinus thunbergii</i> Parl. | Japan | Japan | Frost; gradually dying off | -- |
| <i>Pinus virginiana</i> Mill. | E. U.S. | N.C. | Frost; gradually dying off | -- |
| <i>Sciadopitys verticillata</i> (Thumb.) Sieb. & Zucc. | Japan | Japan | Died in nursery | -- |
| <i>Taxodium distichum</i> (L.) Rich. | S. U.S. | Louisiana | Died after few years in arboretum | -- |
| <i>Thuja orientalis</i> L. | N., W.China | Japan | Frost and winter killed | -- |
| Dry continentals: | | | | |
| <i>Cupressus arizonica</i> Greene | SW. U.S. | Arizona | Frost killed | -- |
| <i>Juniperus monosperma</i> (Engelm.) Sarg. | SW. U.S. | N. Mex. | Died off gradually | -- |
| <i>Juniperus occidentalis</i> Hook. | W. U.S. | E. Oregon | Fair; snowbreak, twisted stems, extremely slow growth | .09 |
| <i>Juniperus scopulorum</i> Sarg. | W. N.Amer. | E. Oregon | Good; some snowbreak, slow growing | .22 |
| <i>Juniperus semiglobosa</i> Regel | As. Minor | U.S.S.R. | Frost killed | -- |
| <i>Pinus aristata</i> Engelm. | W. U.S. | Arizona | Poor; snowbent | .14 |

Table 6. Performance of species by climatic regions of the world (Continued)

| Species | Range | Seed source | Performance | Growth index |
|--|-------------------|-------------|--|--------------|
| Dry continentals--Continued | | | | |
| <i>Pinus contorta</i> var. <i>latifolia</i> S. Wats. | W. N. Amer. | Montana | Poor; diseased, foliage damaged by east wind | .67 |
| <i>Pinus edulis</i> Engelm. | SW. U.S. | N. Mex. | Frost and winter killed | -- |
| <i>Pinus engelmannii</i> Carr. | SW. U.S. | Arizona | Good; tendency to snowbreak | .63 |
| <i>Pinus flexilis</i> James | Mexico | N. Mex. | Good; blister rust; some crooked and forked | .82 |
| <i>Pinus leiophylla</i> Schiede & Deppe ex. Schlecht. & Cham. | SW. U.S., Mex. | Mexico | Winter killed in nursery | -- |
| <i>Pinus montezumae</i> Lamb. | Mexico | Mexico | Winter killed in nursery | -- |
| <i>Pinus patula</i> Schlecht. & Cham. | Mexico | Mexico | Killed in nursery | -- |
| <i>Pinus ponderosa</i> Laws. | W. U.S. | E. Wash. | Excellent; 4 best trees forked | .89 |
| <i>Pinus ponderosa</i> Laws. | W. U.S. | Arizona | Fair to excellent; unidentified top disease, snowbreak | .63 |
| Long-summer humid continentals: | | | | |
| <i>Chamaecyparis thyoides</i> (L.) B.S.P. | E. U.S. | N. J. | Poor; repeated freezeback; very slow growth | .11 |
| <i>Juniperus virginiana</i> L. | E. N. Amer. | Virginia | Fair to good; snowbreak; light frost; extremely slow growing | .17 |
| <i>Pinus echinata</i> X <i>rigida</i> | | Penn. | Good; fair growth | .57 |
| <i>Pinus nigra</i> var. <i>poiretiana</i> (Ant.) Schneider | Medit. | Yugoslav. | Good; fair growth; sapsucker injury | .60 |
| <i>Pinus rigida</i> Mill. | E. N. Amer. | N. J. | Good; snowbreak and snowbend | .42 |

Table 6. --Performance of species by climatic regions of the world (Continued)

| Species | Range | Seed source | Performance | Growth index |
|---|-------------------|---------------------|---|--------------|
| Short-summer humid continentals: | | | | |
| <i>Larix gmelinii</i> var. <i>japonica</i> (Reg.) Pilger | NE. As. | Kurile I. | Good; some snowbreak, sap-sucker damage | .83 |
| <i>Larix laricina</i> (Du Roi) K. Koch | Can., N. U.S. | | Good; some snowbend | .84 |
| <i>Picea glauca</i> (Moench) Voss | Can., N. U.S. | N. Minn. | Good; many galls | .49 |
| <i>Pinus banksiana</i> Lamb. | Can., N. U.S. | Minn. | Good; crooked boles | .66 |
| <i>Pinus strobus</i> L. | NE. U.S. | Minn. | Good except for blister rust | .73 |
| <i>Pinus sylvestris</i> L. | Eur., NW.As. | Manchuria | Good; light sapsucker damage | .62 |
| <i>Pinus tabulaeformis</i> Carr. | China, Kor. | Korea | Good; some snowbreak, sap-sucker injury | .75 |
| <i>Thuja occidentalis</i> L. | NE. U.S., Can. | | Good; slow growth | .68 |
| Marine west coasts: | | | | |
| <i>Abies nordmanniana</i> (Steven) Spach. | As. Minor | France | Died in arboretum | -- |
| <i>Cupressus macrocarpa</i> Hartw. | SW. U.S. | Oregon | Winter killed | -- |
| <i>Cupressus duclouxiana</i> Hickel | Himalaya | Austria | Frost killed in nursery | -- |
| <i>Larix eurolepis</i> Henry | (hybrid) | England | Excellent; some crooked trees | 1.00 |
| <i>Picea abies</i> (L.) Karst. | N.Gen.Eur. | Prussia, Germany | Excellent; 1 tree snowbroken | 1.33 |
| <i>Picea sitchensis</i> (Bong.) Carr. | NW. U.S., Can. | Wash. and Oreg. | Fair to good; many spruce galls | .66 |
| <i>Pinus pinaster</i> Ait. | Medit. | Holland | Frost killed | -- |
| <i>Sequoia sempervirens</i> (D. Don) Endl. | Calif., Oreg. | Calif. | Repeatedly frozen back; very poor | .09 |

Table 6. Performance of species by climatic regions of the world (Continued)

| Species | Range | Seed source | Performance | Growth index |
|---|---------------|-------------|------------------------------------|--------------|
| Middle-latitude highlands: | | | | |
| High elevations--Europe and Asia: | | | | |
| <i>Abies alba</i> Mill. | Europe | Switzerland | Fair | .40 |
| <i>Picea likiangensis</i> (Franch.) Pritz. | N. China | China | Frost killed | -- |
| <i>Pinus mugo</i> Turra. | Gen. & S.Eur. | Switzerland | Excellent | .36 |
| High elevations--western America: | | | | |
| <i>Abies amabilis</i> (Dougl.) Forbes | Pac. NW. | Wash. | Good; slow growth | .41 |
| <i>Abies lasiocarpa</i> (Hook.) Nutt. | Pac. NW. | Wash. | Fair | .43 |
| <i>Abies magnifica</i> A. Murr. | Calif., Oreg. | Calif. | Excellent | .44 |
| <i>Abies magnifica</i> var. <i>shastensis</i> Lemm. | Calif., Oreg. | Oregon | Good | .40 |
| <i>Abies procera</i> Rehd. | Oreg., Wash. | Wash. | Good | .70 |
| <i>Cupressus macnabiana</i> A. Murr. | Calif. | SW. Oreg. | Good; severe frost injury | .18 |
| <i>Larix lyallii</i> Parl. | Pac. NW. | Wash. | Died out in arboretum | -- |
| <i>Larix occidentalis</i> Nutt. | Pac. NW. | E. Wash. | Poor; severe snowbreak | .27 |
| <i>Picea engelmannii</i> Parry | Pac. NW. | N. Idaho | Good; many galls, sapsucker injury | .51 |
| <i>Picea pungens</i> Engelm. | W. U.S. | Utah | Excellent | .61 |
| <i>Pinus albicaulis</i> Engelm. | W. N.Amer. | E. Oreg. | Fair; all have blister rust | .53 |
| <i>Pinus balfouriana</i> Grev. & Balf. | Calif. | Calif. | Good; one killed by blister rust | .16 |

Table 6.--Performance of species by climatic regions of the world (Continued)

| Species | Range | Seed source | Performance | Growth index |
|--|---------------|-------------|---------------------------------------|--------------|
| Middle-latitude highlands--Continued | | | | |
| High elevations--western America--Continued | | | | |
| <i>Pinus flexilis</i> James | SW. U.S. | Montana | Good; some snowbreak and blister rust | .70 |
| <i>Tsuga mertensiana</i> (Bong.) Carr. | Pac. NW. | Wash. | Excellent | .41 |
| Middle elevations west of Cascade Range and Sierra Nevada: | | | | |
| <i>Abies grandis</i> (Dougl.) Lindl. | Pac. NW. | Wash. | Excellent | .81 |
| <i>Pinus jeffreyi</i> Grev. & Balf. | Calif., Oreg. | Calif. | Fair; 1 tree damaged | .63 |
| <i>Pinus lambertiana</i> Dougl. | NW. U.S. | Calif. | Excellent; 1 tree damaged by frost | .96 |
| <i>Sequoia gigantea</i> (Lindl.) Decne. | Calif. | Calif. | Excellent | .89 |
| <i>Taxus brevifolia</i> Nutt. | Pac. NW. | Wash. | Poor; repeated deer damage | .02 |
| <i>Thuja plicata</i> Donn. | Pac. NW. | Wash. | Excellent | .68 |
| <i>Tsuga heterophylla</i> (Raf.) Sarg. | Pac. NW. | Wash. | Excellent | .83 |

of western larch, ponderosa pine, and lodgepole pine have also suffered from disease as well as breakage from heavy, wet snows.

As previously mentioned, the known causes of mortality have been mostly climatic extremes--cold, heavy snows, and drought. Many species survived severe winters for 20 to 40 years until finally killed by some more extreme weather condition than previously encountered. Within the last 10 years, several lots--notably those of knobcone, cluster, and Coulter pine--were killed after growing well



Figure 9.--The major conclusion from testing introduced trees over a 44-year period is that native trees seem to be superior in both growth and vigor. At left, the bordering natural Douglas-fir stand towers above all lots in the arboretum. The area was logged about 1909, hence the Douglas-fir stand is about the same age as the oldest plantings.

in the Wind River climate for 41 years. Thus, the value of the arboretum as a test of adaptability increases with time.

The major conclusion from the arboretum testing is that no species has been found that seems presently suitable for introduction as a timber tree in the Pacific Northwest (fig. 9). Perhaps more careful choice of races better adapted to the Northwest climate will change the picture eventually.

Obviously, growth rate and mortality are only two of many criteria by which the performance of lots might be judged. The usefulness of some trees for watershed and ornamental plantings has been mentioned.

LITERATURE CITED

Beck, George F.

1945. Ancient forest trees of the sagebrush area in central Washington. Jour. Forestry 43: 334-338, illus.

Chaney, Ralph Works

1948. The ancient forests of Oregon. Oreg. State System Higher Ed. Condon Lectures. 55 pp., illus. Eugene, Oreg.

Childs, Thomas W., and Bedwell, J. L.

1948. Susceptibility of some white pine species to *Cronartium ribicola* in the Pacific Northwest. Jour. Forestry 46: 595-599.

Duffield, John W.

1956. Damage to western Washington forests from November 1955 cold wave. U.S. Forest Serv. Pac. NW. Forest and Range Expt. Sta. Res. Note 129, 8 pp., illus. (Processed.)

Gray, Asa

1878. Forest geography and archeology. Amer. Jour. Sci. and Arts 16(92): 85-94.

_____ and Hooker, Joseph D.

1881. The vegetation of the Rocky Mountain region and a comparison with that of other parts of the world. U.S. Geol. & Geog. Survey of the Ter., v. 6, Bul. 1, pp. 1-77. Washington, D. C.

Heintzelman, Oliver Harry, and Highsmith, R. M.

1955. World regional geography. 357 pp., illus. Englewood Cliffs, N. J.

Little, Elbert L., Jr.

1953. Check list of native and naturalized trees of the United States (including Alaska). U.S. Dept. Agr. Handb. 41, 472 pp.

Munger, Thornton T.

1947. The Wind River Arboretum from 1937 to 1946. U.S. Forest Serv. Pac. NW. Forest and Range Expt. Sta., 21 pp., illus. (Processed.)

and Kolbe, Ernest L.

1932. The Wind River Arboretum from 1912 to 1932. U.S. Forest Serv. Pac. NW. Forest and Range Expt. Sta., 22 pp., illus. (Processed.)

and Kolbe, Ernest L.

1937. The Wind River Arboretum from 1932 to 1937. U.S. Forest Serv. Pac. NW. Forest and Range Expt. Sta., 15 pp. (Processed.)

Steele, R. W.

1954. Cold weather damages promising species in the Wind River Arboretum. U.S. Forest Serv. Pac. NW. Forest and Range Expt. Sta. Res. Note 95, 7 pp., illus. (Processed.)

