# Annual Report

1958

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

COVER: Research entomologist releasing a colony of insect predators for control of the balsam woolly aphid. Predators have been imported from Europe and Asia in an attempt to halt the depredations of this highly destructive forest pest.

# ANNUAL REPORT

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

FOREST SERVICE U. S. DEPARTMENT OF AGRICULTURE

# What happened?

"What happened?" is a basic expression in the working vocabulary of the scientist. He asks himself and his colleagues this question often and, having an inquiring mind, proceeds to ask "Why does it happen?" and "How?" The observing forest manager, timber plant operator, or logging superintendent asks the same questions when he observes some unusual characteristic of the forest or any of its products. If we know precisely why and how certain natural phenomena occur, we may take advantage of this knowledge by encouraging desirable characteristics or discouraging undesirable ones.

We have by no means mastered the task of describing and classifying the natural biological processes in the forest community, and we have barely begun to learn the why and how of forest biology.

For example, many foresters have wondered why an adequate crop of Douglas-fir seed happens only once in every 6 or 7 years. Others ask why many tree seedlings fail to break dormancy after field planting and what mechanisms trigger their readiness and ability to grow.

We know that insect epidemics begin and end abruptly--but why? We also know that insects attack some trees in the forests and not others, but we don't know why. We know that some Douglas-fir trees escape Fomes pini infection under the same environmental conditions as infected trees--why? We know that some soils are susceptible to erosion and others are not, but we don't know all the reasons. We know that a deteriorated range may remain practically stagnant for 10 or 20 years, even under good management, and then suddenly improve as much in 1 or 2 years as in the previous 10 or 20, but again we don't know why.

Answers to these and similar questions are essential to the best management of our forest, range, and water resources. Answers are obtained through determining and defining in scientific terms the natural laws and principles that govern the specific behavior observed. Once these are learned we can anticipate and duplicate desirable characteristics and develop ways of more economically managing our resource heritage.

Sounds reasonably simple and highly desirable, you say, so why aren't we using these procedures more often? The principal reason is that the basic physiological, chemical or genetic principles involved are complex and cannot be determined efficiently or exactly through empirical studies in forest, field, or stream. They must be determined under conditions where

the pertinent factors may be positively controlled, precisely measured, and correctly recorded. This usually requires specially designed laboratories equipped with modern, precision, scientific equipment and staffed with highly trained specialists. After laboratory studies are made and findings confirmed beyond reasonable doubt, the principles usually must be tested under natural conditions by means of pilot studies. Often this stage must be followed by large-scale tests for demonstration purposes. Finally, principles may be placed in actual practice through applied management.

When these steps are compounded by the infinite variations in nature, the task seems monumental--and it is--but we know it can be done. More important, each new basic principle discovered may save many tedious hours of applied research and many costly trials of unproved practices in forest resource management that may result in partial or complete failure.

Encouraging progress in supplying or improving facilities for basic forest research is being made. Laboratories for basic research on problems in forest fire, forest genetics, and forest biology are being constructed in several other parts of the country. When these institutions are constructed, equipped and staffed, a start will have been made on a big job. However, more laboratories of this type are needed to solve basic problems in the other major forest regions. For example, the Pacific Northwest needs facilities designed to solve problems important and peculiar to this region. These facilities should consist not only of a central laboratory but improved field facilities as well. More scientists should be put to work in both laboratory and field to solve fundamental problems through basic studies and to define application of the results.

The current research program in the Pacific Northwest has been largely directed toward solution of immediate pressing problems through applied research. Considerable and encouraging progress has been made in this way, but much remains to be learned. Programs in applied research must be stepped up as well as those in basic research. Forestry has become much more intensive, and multiple-use management of forest resources is creating many complex problems, accenting the need for basic research to determine fundamental principles. We must attain a balanced program of basic and applied research with the strength to meet the many urgent problems confronting us now and in the future.

This report reviews Station accomplishments during 1958 and plans for 1959. Progress in 1958 was accelerated greatly through the fine cooperation of many public and private agencies. The cooperative approach has proved successful in the Pacific Northwest in forest research as it has in other forestry activities. We believe that continuing cooperative efforts will enable us to make greater progress in applied research programs and in initiating a comprehensive program of basic research designed to meet the needs of this great forest region.

R. W. Cowlin

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# Forest Insect Research

Good progress was made on the three principal activities of the Station's entomologists--research, surveys, and technical supervision of control.

In research, main efforts were devoted to the balsam woolly aphid, spruce budworm, black-headed budworm, and Douglas-fir beetle, and to development of survey techniques. Major accomplishments included the importation and colonization of six species of foreign insect predators of the balsam woolly aphid, and evaluation of the effects of native parasites and predators on natural control of the spruce budworm.

Forest insect surveys disclosed epidemic insect activity on some 2 million acres in Oregon and Washington, about the same as in 1957. The insects causing the bulk of the damage were the spruce budworm, balsam woolly aphid, Douglas-fir beetle, mountain pine beetle, and western pine beetle. In terms of timber volume killed, an outbreak of the Douglas-fir beetle in southwestern Oregon was the most destructive. Biological assessment of insect populations for predicting infestation trends was intensified over that of previous years.

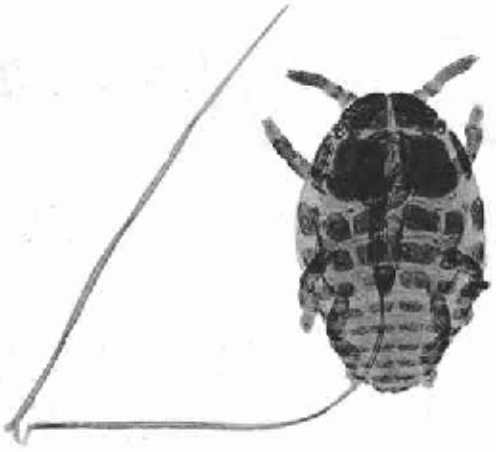
The Station provided technical guidance for spraying 818,000 acres of budworm infestation in the Blue Mountains of northeastern Oregon. This brings to 4.7 million acres the area sprayed since 1949 in a program that has prevented the budworm from causing serious loss of timber. Effects of natural control make spraying unnecessary in 1959, and probably longer. Present infested acreage is the least since 1946.

## RESEARCH

### Balsam Woolly Aphid

Forest insect research in the Douglas-fir region continued to center on the balsam woolly aphid. Investigations were coordinated with those of Weyerhaeuser Timber Co. and Oregon State College.

Major emphasis by the Station was placed on importing and colonizing foreign predators of the aphid. Six species of predators, totaling some 13,000 specimens, were received during the early summer from Sweden, Czechoslovakia, and Japan. Three of the predator species were flies, and 3 were beetles. The shipments from Europe were provided by the Canadian Department of Agriculture; those from Japan were collected



A balsam woolly aphid. The long feeding tube is also used by the insect to attach itself to the host tree. (x100)

and shipped by P. B. Dowden of the Northeastern Forest and Range Experiment Station, who was assigned to the project for the season.

The foreign predators were released in the Willamette Pass, Black Rock, and Corvallis areas in Oregon and in the Mount St. Helens and Wind River areas in Washington. By fall, at least two of the species had produced progeny. One was a beetle, Laricobius erichsonii (Rosenh.), which was recovered at several release points in both Oregon and Washington. The other was a fly, Aphidoletes thompsoni Möhn (also colonized in 1957), which was recovered near Corvallis, Oreg., and in the Mount St. Helens area of Washington. Although these early recoveries of the foreign predators are encouraging, it will be several years before it will be known whether the insects will (1) become permanently established and (2) accomplish significant control of the balsam woolly aphid.

A number of native predators of the aphid were found. Chief among these were 5 species of flies, 3 species of lacewings and at least 1 species of mite. Several of these predators are providing some control, but they vary greatly in abundance from area to area and between trees within areas. Most of them appear to be effective only when the aphid population is high. The effectiveness of some is hampered by poor synchronization of their life cycles with that of the balsam woolly aphid.

Fourteen species of true firs (Abies) are known to be infested with the balsam woolly aphid in Oregon and Washington. Many of these are exotic species in the Wind River Arboretum near Carson, Wash., and in the Hoyt Arboretum in Portland. Some are seriously damaged or dead, whereas others appear to have suffered little if any permanent damage. The species

of Abies on which infestations of varying degree of damage have been observed in the Pacific Northwest are as follows:

| Scientific name | Common name | Degree of damage |
|---|---|---|
| Abies amabilis | Pacific silver fir | Heavy |
| A. grandis | grand fir | Heavy |
| A. lasiocarpa | subalpine fir | Heavy |
| A. procera | noble fir | Light |
| A. lasiocarpa var. arizonica | corkbark fir | Light |
| A. fraseri | Fraser fir | Heavy |
| A. concolor | white fir | Light |
| A. balsamea | balsam fir | Moderate |
| A. alba | silver fir | Light |
| A. pinsapo | Spanish fir | Light |
| A. sachalinensis | Sakhalin fir | Light |
| A. sibirica | Siberian fir | Light |
| A. cephalonica | Greek fir | Light |
| A. firma | Momi fir | Light |

## Spruce Budworm

Long-term studies on population trends and the effects of natural control factors were largely terminated when the study areas were sprayed in 1958. However, measurement of population levels and parasitism in plots scattered over the region, chiefly in previously sprayed areas, was continued. And studies on the identity of natural control factors affecting hibernating larvae were intensified. Short-term studies of the effects of the 1958 spraying upon the budworm, its parasites, and associated insects were started.

For light to moderate populations, it was proved practicable to use egg counts made in late summer for predicting the number of larvae that will do damage the following spring. Predictions in 1957 that populations would be reduced on three study areas in 1958 were accurate. This prediction technique is based on data, accumulated since 1955, that show that the density of egg masses per 1,000 square inches of foliated branch surface can be used to forecast number of larvae per 100 15-inch twigs attacking buds the following spring. However, for high populations, the success with which larvae establish themselves in the buds varies considerably from stand to stand--due to heavy competition for food--and larval estimates based on egg mass density are likely to be high.

Nonepidemic populations in plots scattered over the region either remained at the same level or declined during 1958. The amount of decline

was in direct proportion to the parasitism recorded during early larval stages of the budworm at these plots in 1957. On the average, other defoliators of Douglas-fir on the plots were six times as numerous as the spruce budworm.

Several insect and mite species suspected of attacking overwintering spruce budworm have been tested in the laboratory to see if they are predaceous. Larvae of a number of beetles and lacewings attacked the budworm under laboratory conditions, but mites did not. The exact role and importance of these predators, which are sometimes very abundant, has not yet been determined.

Studies on a 1958 spray area to determine detailed effects of DDT on the budworm and its parasites revealed the following:

1. Mortality of spruce budworm larvae on dominant and codominant Douglas-firs and true firs was no different than that on smaller trees of the same species.

2. Many of the larvae that survived for as long as 10 days after the spraying eventually died from delayed effects of the insecticide, or from parasitism.

3. Comparisons of surviving budworm on 6- to 9-foot fir and ponderosa pine showed much higher survival on the pine, indicating that a significant reservoir of budworm population may remain on this host species after spraying.

4. Surviving adults of the group of parasite species that attack the budworm in the early larval stages greatly outnumbered surviving budworm adults.

5. Parasites of full-grown budworm larvae were hit hard by the spraying.

6. Pupal parasites survived the spraying in near-normal numbers.

Black-Headed Budworm

Comparison was made of the effects of natural control factors on the black-headed budworm in two widely separated infestations: one in hemlock stands in the Snoqualmie National Forest—Mount Rainier area in western Washington, and the other in subalpine fir stands in the Umatilla National Forest in eastern Oregon.

In western Washington, the new brood was reduced about 30 percent by sterility of eggs. Subsequently, populations of nearly full-grown larvae were reduced 85 percent by insect parasitism and by what appeared

to be disease. Of the two factors, parasitism was more important. A positive identification of disease, caused by a microsporidian, was obtained for one lot of killed larvae.

In the eastern Oregon infestation, insect parasitism caused a similar reduction in larval numbers, but little indication of disease was found. Two spot infestations observed since 1956 subsided in 1958 without causing noticeable damage. However, observations of pupal populations elsewhere in eastern Oregon indicate that other flareups may be expected.

Generally, different species of insect parasites were attacking the black-headed budworm in eastern Oregon and western Washington. However, one parasite was important in both areas. Two species exerting significant control in western Washington were not found in eastern Oregon plots, and the most important species in the eastern Oregon plots was not recovered in western Washington. It was learned from repeat collections in both areas that two collections about 3 weeks apart, the first timed with the end of the fourth larval stage, are necessary to show the degree of control inflicted by all parasite species on larvae of the black-headed budworm.

Pandora Moth

A moth flight near Sisters, Oreg., in August furnished the first opportunity in a quarter century to obtain data on the biology and natural control of this periodic defoliator of ponderosa pine. Egg masses deposited in August hatched early in September and the larvae fed in colonies near the hatching site until the middle of October. Larvae then dispersed to feed as individuals or occasionally in groups of 2 to 4.

Reductions in population from egg deposition until the end of October approximated 20-26 percent, of which 5-6 percent was due to nonhatch of eggs. So far, there has been little evidence of parasitism, disease, or predation by birds. The amount of damage caused to the end of October was small; on the average, each larva had consumed two needle clusters. Greatly increased feeding is expected next spring.

Newly-hatched larvae and abandoned egg shells of the pandora moth on a ponderosa pine needle. (x4)

## Douglas-Fir Beetle

A 10-year study made cooperatively with Weyerhaeuser Timber Co. showed that mortality in a 180-year-old Douglas-fir stand in Coos County, Oreg., varied from 4,990 board-feet per acre in 1951 to only 60 board-feet in 1955. Mortality during the study period 1946-55 exceeded growth by more than 5 to 1.

The Douglas-fir beetle was the most important agent, causing 59 percent of the total tree killing. Windthrow and windbreak were next in importance, amounting to 38 percent. Disease, particularly root rot, also was important. Other lesser causes were suppression, mechanical injury, and lightning.

As a result of the study, it is recommended that landowners and managers of forests of this general type and age adopt the following practices:

1. Make annual surveys to detect and evaluate mortality.

2. Develop logging plans for salvage of killed trees so that valuable wood will be utilized and insect control benefits obtained.

3. Provide good access road systems to allow prompt pickup of killed trees.

4. Increase cutting budgets when abnormal mortality occurs.

Studies of Douglas-fir sawtimber-size trees killed in 1951 in western Oregon by the beetle showed that after 7 years considerable merchantable volume is still present, particularly in the butt logs of large trees. The tops of most trees are still intact, except for the fine branches. In most trees, wood-boring insects have penetrated at about the same rate as the rot, although some deep penetration into otherwise sound heartwood has occurred. These studies are continuing to (1) determine how long beetle-killed Douglas-firs in western Oregon and Washington remain merchantable, and (2) develop guides, based on exterior appearance, that field foresters can use for estimating how long a tree has been dead and therefore how much sound volume remains.

## Sitka Spruce Weevil

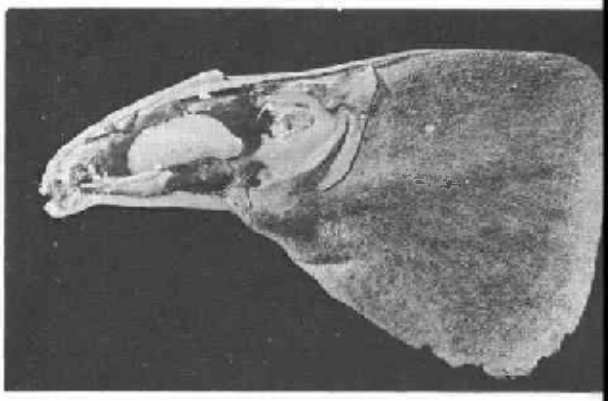
Young spruce on permanent plots in Clatsop and Tillamook Counties in Oregon showed a slight increase in number of attacks in 1958. At Cascade Head Experimental Forest, 4 percent of the study trees--which are 6 to 9 years old and therefore just reaching susceptible age--were weeviled. This compares to 2 percent in 1957 and less than 1 percent in 1956.

Weeviling of 30-year-old planted spruce in the Youngs River drainage in Clatsop County increased in 1958 to 9 percent, after declining steadily from a high of 35 percent in 1953 to only 5 percent in 1957. Effects of the catastrophic western Oregon and western Washington "deep freeze" of November 1955 are still very evident on these plots, and are making study of the weevil difficult. Terminals of many trees were frost-killed for 2 to 10 feet of their length, causing multiple leaders to develop. Now some of these are being weeviled. Defoliation by the freeze has reduced annual leader growth on some trees to as little as 3 inches, compared to 3 or 4 feet before 1955. Some of these frost-damaged leaders are dying and closely resemble those damaged by the Sitka spruce weevil. Studies at Youngs River and Tillamook Head are maintained in cooperation with Crown Zellerbach Corp.

In cooperation with the Industrial Forestry Association and Weyerhaeuser Timber Co., a study was started to test weevil susceptibility of a number of spruce species and hybrids. A total of 10 species and hybrids eventually will be represented in the study, which is replicated on 3 areas in the general vicinity of Raymond, Wash. So far, plantings have been made of Norway spruce (Picea abies), white spruce (Picea glauca), and the natural hybrid of Sitka and white spruce (Picea X lutzii). Other species and hybrids are being grown in the forest industry nursery at Nisqually, Wash., and will be outplanted soon.

## Cone and Seed Insects

Needs for research on control of these insects were evaluated during the year at meetings of private, State, and Federal foresters. At these meetings, forest managers and researchers stressed the increasing importance of controlling seed and cone insects in order to: (1) increase natural regeneration on cutting areas, (2) increase seed collection from wild trees and seed orchards, and (3) protect tree seed where hybridization, fertilization, and other research studies are in progress. Protection of ponderosa pine and Douglas-fir seed was judged highest in priority.



Insects, such as the larva of this small wasp feeding in a noble fir seed, are seriously hindering both natural and artificial regeneration. (x4)

Studies of the life histories and habits of cone and seed insects will be necessary before reliable control methods can be developed. A start was made in 1958, with rearing and identification of a number of the important seed and cone insects found in

cones collected by field foresters. These small-scale studies to identify the important insects will be continued, but no extensive research is possible with the present small staff.

### Improvement of Survey Methods

Developing aerial visual and photographic methods for detecting and evaluating damage by forest insects is a major activity of the Station. Results of the work carried on in 1958 are reported in the section on Aerial Survey Techniques.

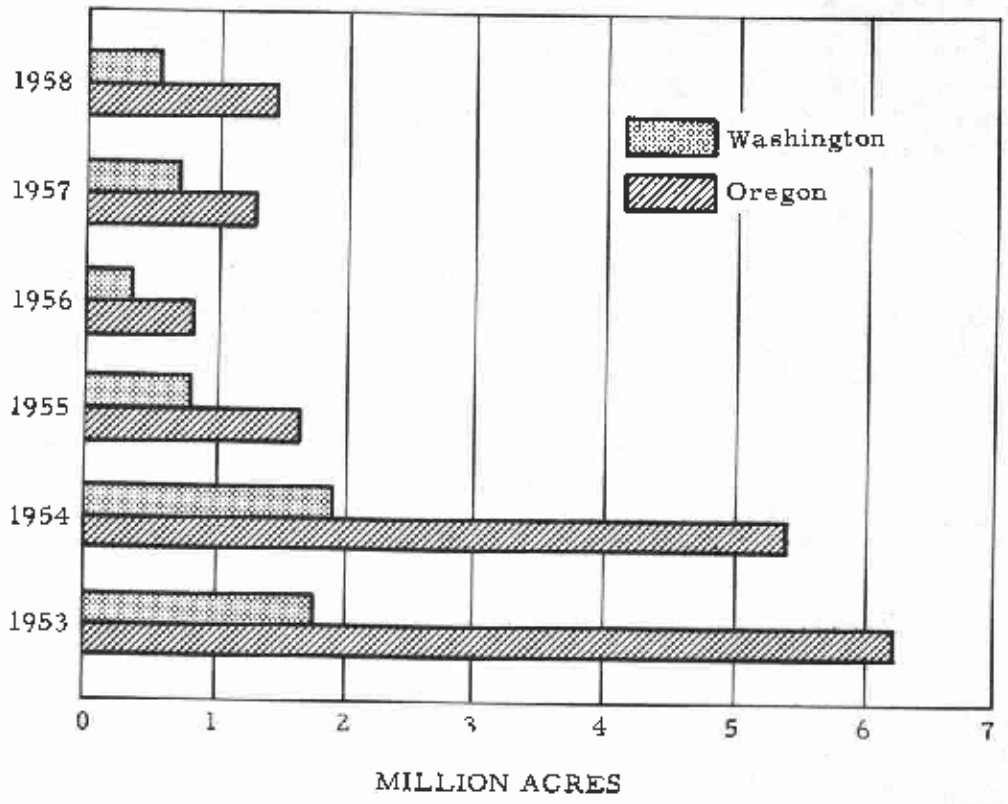
Methods for improving biological evaluations of the status of insect damage and populations were also investigated. (See discussion of spruce budworm and black-headed budworm, pp. 3 and 4.) A special study dealt with annual estimates of spruce budworm damage on individual trees. It was found that damage resulting from low and moderate populations was adequately expressed by estimates of percentage loss of current foliage, obtained by trained observers with field glasses. However, damage resulting from high populations was reflected by a rapid increase in bud killing, as well as an increase in defoliation, as population density increased. This incidence of bud killing cannot be accurately assessed with field glasses, but must be measured by examining foliage samples. Use of damage estimates to indicate past feeding populations is therefore not valid unless bud killing and percentage defoliation are both measured.

## SURVEYS AND CONTROL

### Status of Infestations

Epidemic outbreaks of forest insects were found on slightly more than 2 million acres in the Pacific Northwest in 1958, approximately the same total as in 1957. Infestations of the spruce budworm, balsam woolly aphid, Douglas-fir beetle, mountain pine beetle, and western pine beetle caused damage on the bulk of the area--1.9 million acres. The acreages of infestation for the past 6 years are shown in the accompanying graph.

Aerial spraying and natural control have reduced spruce budworm infestations to the lowest point since 1946, when detailed records were begun. However, residual infestations exist in the Blue Mountains of Oregon, on or near the Ochoco, Malheur, and Wallowa-Whitman National Forests; and two new outbreaks were discovered in the eastern Oregon Cascades on the Deschutes and Fremont National Forests. The severity and area of defoliation increased in 1958 on the Wallowa-Whitman Forests, but elsewhere defoliation was light. Egg population surveys in late summer in all major infestation centers indicated a general downward trend of the budworm in 1959. Because of this favorable trend and generally high natural control, no spraying is anticipated in 1959.




Acreages of epidemic insect outbreaks in the Pacific Northwest, 1953-58.

As forecast, the black-headed budworm outbreak in Washington declined sharply. Only 3,000 acres were infested in epidemic number, compared with more than 250,000 acres in 1957. Because of the effectiveness of natural control, only minor damage to foliage occurred in 1958, and trees showed striking recovery from the 1957 feeding.

Tree killing by the balsam woolly aphid declined, but an increase of aphid populations in the fall indicated damage might increase in 1959, particularly in subalpine fir stands.

Douglas-fir beetle losses increased regionwide and were particularly severe in southern Oregon and on the Colville Indian Reservation. Salvage programs are being planned in these areas. Ground surveys in southern Oregon showed that blowdown caused the outbreak in that area. Reduced beetle populations in 1958, coupled with increasing natural control, indicate a downward trend in 1959. Regionally, the decline may be short lived, for extensive blowdown late in 1958 is expected to cause a beetle buildup that will become evident in 1960.

Mountain pine beetle damage increased about 20 percent over that of last year but is still about average for this insect. Damage caused by the western pine beetle increased rather generally throughout the region after several years of extremely light losses. Infestations are mostly of a low epidemic nature, although there are a few local problem areas.

## Spruce Budworm Control

Control operations, suspended in 1956 and 1957, were resumed in 1958 with the spraying of 818,000 acres of severe epidemic infestations in the central Blue Mountains of Oregon. Spraying was undertaken upon recommendation of the Northwest Forest Pest Action Council.

The Station's Division of Forest Insect Research was responsible for technical supervision of the project. This responsibility included delineating infestation boundaries, sampling the overwintering population, supervising field counts before and after treatment, and computing mortality due to spraying.

Spruce budworm populations are carefully measured before and after spraying to determine the effectiveness of control.

Results of the 1958 control project showed good kill (96.2 percent) of the budworm larvae. For the eight projects that have been undertaken during the budworm control program, mortality has averaged 98.0 percent (table 1).

Table 1.--Mortality and cost of spraying on spruce budworm control projects in Oregon and Washington, 1949-1958

| Year | Area treated | Cost | | Average mortality |
|---|---|---|---|---|
| | | Total | Per Acre | |
| | Acres | Dollars | Dollars | Percent |
| 1949 | 266,000 | 320,000 | 1.20 | 97.6 |
| 1950 | 934,000 | 990,000 | 1.06 | 99.2 |
| 1951 | 927,000 | 983,000 | 1.06 | 98.8 |
| 1952 | 655,000 | 681,000 | 1.04 | 98.2 |
| 1953 | 369,000 | 350,000 | .95 | 99.1 |
| 1954 | 68,000 | 63,000 | .93 | 99.0 |
| 1955 | 621,000 | 658,000 | 1.06 | 96.9 |
| 1958 | 818,000 | 537,000 | .70 | 96.2 |
| All years | 4,658,000 | 4,582,000 | -- | -- |
| Average (wtd.) | -- | -- | 0.99 | 98.0 |

## PLANS FOR 1959

Balsam woolly aphid: Continue (1) importing foreign insect predators, (2) rearing and cataloging native predators, and (3) assessing the effectiveness of natural control. Studies to evaluate the effect of the aphid on its host trees will be expanded.

Douglas-fir beetle: Continue to (1) measure and evaluate tree mortality on long-term study plots, (2) record trends of the beetle population and its natural controls in the current outbreak in southwestern Oregon, and (3) analyze deterioration of beetle-killed Douglas-fir.

Sitka spruce weevil: Complete plantings on the susceptibility study plots in western Washington, and continue cooperative studies to evaluate weevil damage in coastal stands.

Spruce budworm: Continue studies of population trend on plots scattered through the region; continue studies initiated in 1958 of the effect of spraying upon the budworm, its parasites, and associated insects; initiate studies on natural control of the budworm in the Fremont National Forest infestation.

Surveys: Conduct and report upon (1) the regional cooperative forest insect survey and (2) special surveys, such as those for Douglas-fir beetle, western pine beetle, balsam woolly aphid, and spruce budworm. Establish field and laboratory procedures for biological assessment of forest insect epidemics in Oregon and Washington.

Technical supervision of control: Provide, as required, necessary technical information and guidance for control projects in Oregon and Washington.

# Forest Management Research

An increase in funds starting July 1 enabled the Station to undertake two new projects on a modest scale and to strengthen work on a third.

Of the new projects, one entails focusing the full-time efforts of one man on studies of the silvicultural effects of spruce budworm defoliation on selected stands in northeastern Oregon.

The second new project marks the beginning of much needed research in management of the upper-slope fir-hemlock forests of western Washington. As a first step, private and public land managers were consulted to help determine high-priority research needs. A problem analysis and proposed action program will be prepared early in 1959.

Research in forest genetics, although still a one-man project, was strengthened through a small increase in funds that will be used for improvement of three progeny testing areas and employment of additional seasonal and part-time assistants.

Major accomplishments during 1958 included:

1. Release of papers on the silvical characteristics of 12 important native trees. Each paper provides a compilation of existing knowledge on the range, habitat conditions, and life history of one species.

2. Completion of a manuscript on the theory, practice, and economic aspects of commercial thinning in Douglas-fir. The manuscript has been submitted to the Forest Service Washington, D. C., office for consideration as a Department of Agriculture publication.

3. Revision of an important publication, Isaac's "Reproductive Habits of Douglas-Fir." After local review, the manuscript will be submitted for publication as a Department of Agriculture bulletin. The original bulletin, published in 1943 by the Charles Lathrop Pack Forestry Foundation, has been out of print for more than 10 years.

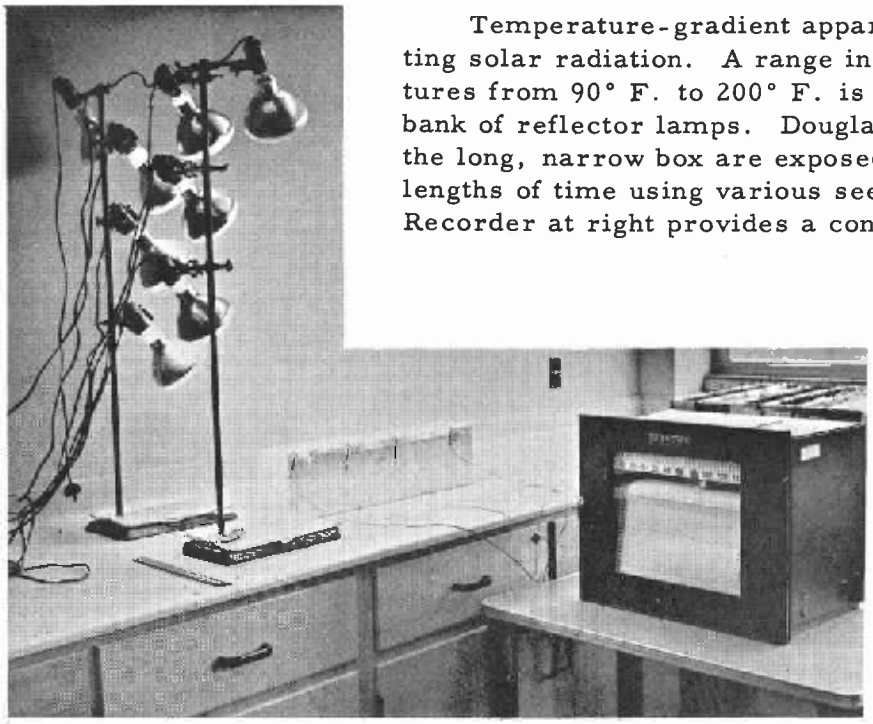
Progress in a number of other forest management and fire research projects and studies is reported in the pages that follow.

## Heat Damage to Douglas-Fir Seedlings

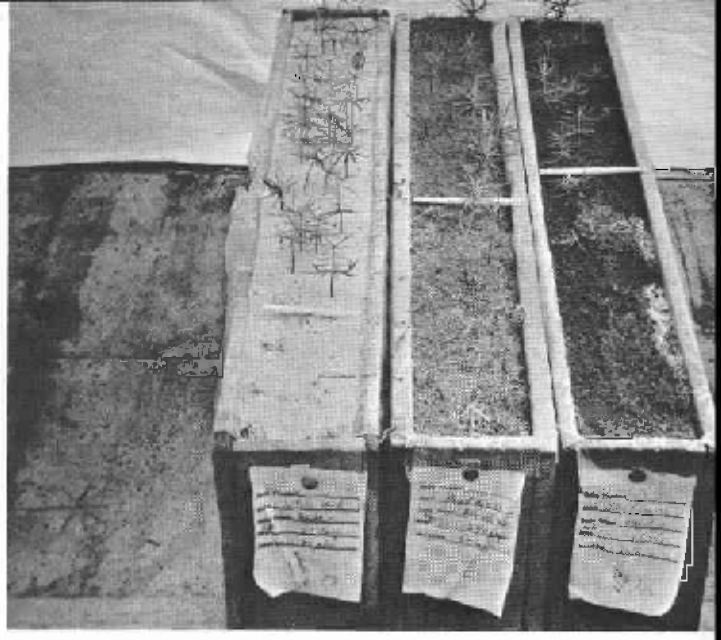
Laboratory tests are helping to provide a more precise measure of the conditions under which Douglas-fir seedlings are damaged by heat. Apparatus were developed and used for maintaining a temperature gradient and for a "dry" water bath. The latter is used for maintaining seedling stems at a desired temperature.

Results thus far indicate that heat kill depends upon both temperature and duration of exposure. Different surface seedbed materials, moreover, were found to exert distinct effects on the time-temperature relationship.

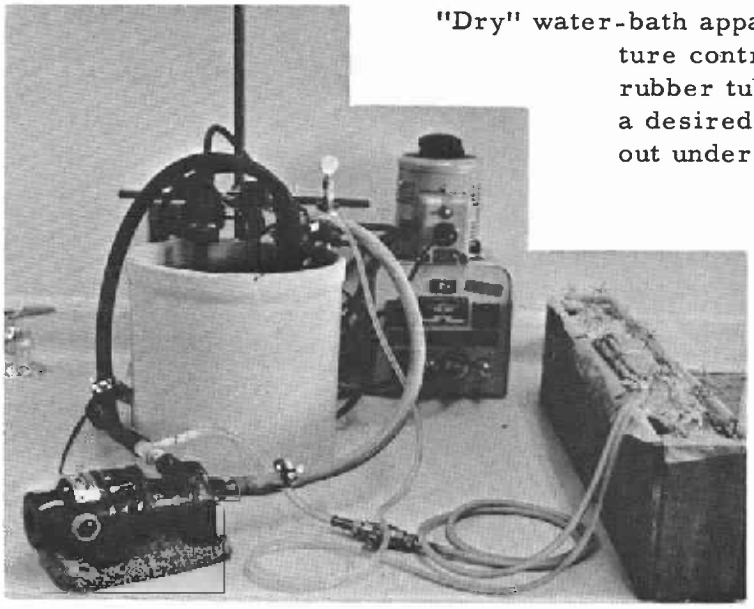
Previously, Douglas-fir seedlings were thought to develop tissues fairly resistant to heat damage within a few weeks following germination. These laboratory tests indicate, however, that an increase in age of seedling, at least up to 3 months, is accompanied by only a minor increase in heat resistance.



Temperature-gradient apparatus for simulating solar radiation. A range in surface tempertures from 90° F. to 200° F. is provided by a bank of reflector lamps. Douglas-fir seedlings in the long, narrow box are exposed for different lengths of time using various seedbed materials. Recorder at right provides a continuous record of surface temperature.



Boxes containing 3-weeks-old seedlings of Douglas-fir were each exposed in the temperature-gradient apparatus for 60 minutes. Seedbed material (left to right) is river sand with a 1/4-inch surface of white quartz sand, yellow mineral soil, and peat moss. Highest surface temperatures were reached at ends of boxes closest to camera. White lines indicate extent of damage to seedlings.

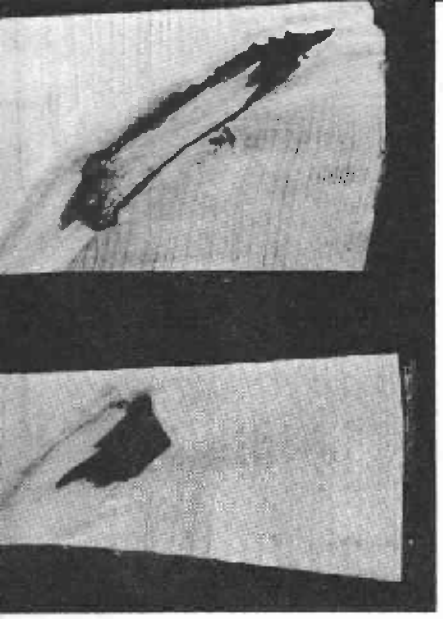


"Dry" water-bath apparatus used for temperature control. An extremely thin rubber tube, containing water at a desired temperature, blisters out under pressure through slits in an outer nylon tube (next to box) to provide close contact with stems of three seedlings. The seedling stem can be maintained at an exact temperature, with little effect on other physiological factors.

Information from the heat-damage study is expected to provide a more basic understanding of the physical conditions that favor survival of Douglas-fir seedlings after harvest cutting.

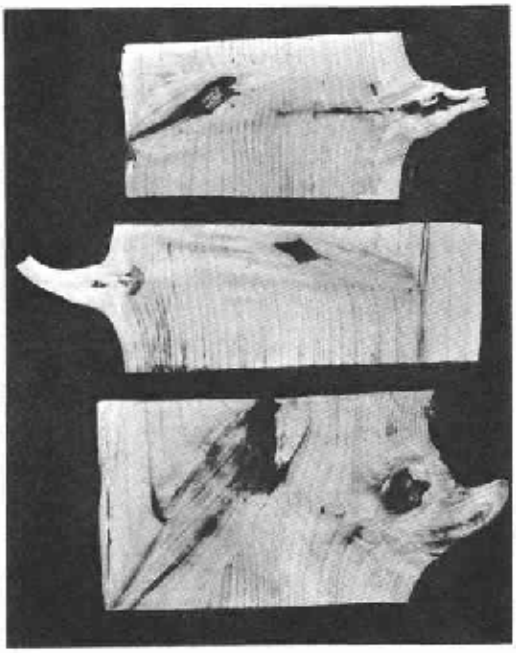
## Pruning and Epicormic Branching in Red Alder

In 1937, a 21-year-old stand of red alder was pruned at Cascade Head Experimental Forest. Study of dissected trunk sections 20 years later showed that although pruning scars healed very rapidly, formation of clear wood was limited by development of epicormic branches.

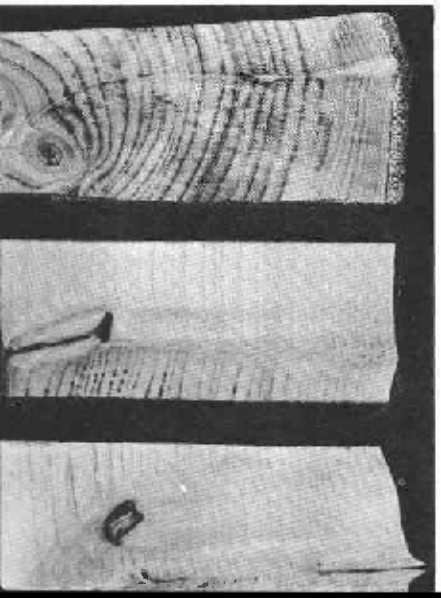


Although red alder pruning scars heal rapidly, development of epicormic branches may limit formation of clear wood.

A, Stub of an unpruned dead limb disfigured 20 years of growth (top), but clear wood formed over a pruned branch stub within 2 years (bottom).



B, Development of epicormic branches seriously hinders the formation of clear wood after pruning.



C, Bud strands grow outward radially from old leaf axils and may develop into epicormic branches in response to physiological release.

Careful examination of the wood formed after pruning disclosed that bud strands, originating in the leaf axil, elongate radially as each annual layer of wood is formed. These bud-producing tissues are believed to be held in check by substances produced by the leaves and buds of nearby live limbs. When adjacent limbs are pruned, the source of these inhibiting substances is apparently removed and buds are released to grow into epicormic branches. When light is increased, as through pruning or thinning, these substances are believed to move to the shaded side of the bole, so that dormant buds on parts of the stem subjected to increased light are released.

## Release of Sugar Pine Seedlings

Internode measurements on 49 sugar pine seedlings in southwestern Oregon indicate this species responds markedly to release following partial cutting. Seedlings studied had been suppressed for many years, averaging only 3 feet tall at time of release. Average annual height growths before and after release were:

| Period | Height growth (inches) |
|---|---|
| 1st and 2nd years before release | 2.7 |
| 1st and 2nd years after release | 3.3 |
| 3rd and 4th " " " | 5.2 |
| 5th and 6th " " " | 6.7 |
| 7th and 8th " " " | 6.9 |
| 9th and 10th " " " | 7.6 |

Whether the retention and protection of sugar pine seedlings during harvest cutting and slash disposal is a desirable forest practice remains to be determined.

## Juvenile Growth of Five Conifers

Seed sowing and installation of soil-moisture blocks late in the year marked the first phase of a detailed study on juvenile growth of five conifers native to southwestern Oregon— Douglas-fir, ponderosa pine, sugar pine, incense-cedar, and grand fir. Characteristics of both root and top growth will be compared during the first 2 years after germination for seedlings growing on light-, medium-, and heavy-textured soils. Interest will center on possible correlations between soil texture and root penetration and between soil and foliage nutrient content. The study is expected to provide basic silvical information on each species and a better understanding of species distribution in mixed-conifer stands.

## Effect of Spruce Budworm Defoliation on Species Composition

Although control of spruce budworm through aerial spraying has become a common forest protection measure, the impact of defoliation on

tree growth, mortality, and stand composition has remained a matter of conjecture. A project plan to help plug this gap was prepared during mid-summer, and field work for an exploratory study in mixed-conifer stands of the Wallowa-Whitman National Forests was completed during September through the assistance of national-forest administration.

Preliminary information indicates that severe infestations tend to greatly lower the competitive status of white fir, to only slightly change the competitive status of Douglas-fir and Engelmann spruce, and to improve the competitive status of ponderosa pine and western larch. This suggests that budworm attack can be expected to reduce the proportion of white fir in infested stands.

## Crown and Stem Development of Douglas-Fir

An intensive study of six Douglas-firs in the 35- to 70-year age range showed that branch characteristics and rate at which branch whorls die are fairly uniform within a tree but vary widely between trees. Generally, trees with highest ratio of live crown to bole length made greatest diameter growth, but the relationship was not consistent. Nor were fast or slow growth rates in youth necessarily maintained at later ages. Although crown development exerted little or no effect on stem form, the upward shift in position of maximum ring width tended to maintain a fairly constant stem diameter at base of the live crown.

In a study of crown and stem development of Douglas-fir, branches were removed from 3 live trees and from 3 felled trees. This sample tree on the McCleary Experimental Forest was pruned from a sectional aluminum ladder, using a short-handled pruning saw.

Height growth was apparently unrelated to crown development in this study.

During the study, a striking discrepancy was noted between number of annual rings at the base of a live branch and in the tree stem at their point of intersection. On one branch, the difference was as much as 15 years, and differences of 9 or 10 rings were common. Apparently, many branches do not form distinguishable growth rings during the latter part of their life, even though foliage is plentiful and healthy in appearance.

## GENETICS

### New Findings From Old Studies

A recent pooling of information from provenance tests started many years ago by both the Intermountain and Pacific Northwest Forest & Range Experiment Stations strengthens understanding of genetic differences in ponderosa pine.

Growth rates of the progeny were found to be consistently related to seed source, with seed from the northern and western parts of the tree's range displaying best growth. High April-May temperatures and dry summers characterized the source climate of the faster growing progenies.

Stem taper, in terms of height in feet per inch of d.b.h., varied widely but consistently between the individual seed sources, even though planting sites differed markedly in site quality. Stem taper, however, was apparently not related to origin in terms of broad geographic zones.

Survival was much higher from some seed sources than others and was related directly to progeny height growth.

Frost damage proved to be related to the difference between average July and January temperatures at the seed source. Progeny from geographic sources with large differences in temperature were most resistant to frost damage.

Browsing damage by wild animals differed widely. Progenies from some sources were browsed at all planting sites, but others were scarcely damaged.

The cooperative analysis by the two experiment stations also provides new information supporting the reliability of juvenile height measurements in ponderosa pine as a basis for selecting trees with above-average

inherent growth rates. Correlation coefficients between height at 30 years and height attained at earlier ages are as follows:

| Age | Correlation coefficient |
|---|---|
| In nursery: | |
| 2 | 0.85 |
| After field planting: | |
| 4 | .48 |
| 6 | .69 |
| 11 | .86 |
| 20 | .86 |

## Hybrid Poplars

Lots of 25 different poplar hybrids were planted 20 years ago at Lady Island near Camas, Wash., in cooperation with Crown Zellerbach Corporation and the Northeastern Forest Experiment Station. Only 9 of the 25 hybrid lots now have 5 or more surviving trees. Some hybrids failed because of sod competition before they had an opportunity to demonstrate their potential performance. Others were severely bent or broken by ice storms characteristic of areas adjacent to the Columbia River Gorge. Species that appear most promising for future breeding, particularly in crosses with Populus trichocarpa, include P. maximowiczii, P. 'Caudina,' P. angulata, and P. charkowiensis.

## Estimates of Genetic Variation

Genetic variation expressed as a percentage of total variation provides a useful index for predicting the rate of improvement that can be expected, per generation, through controlled breeding. Since most genetics studies on western trees are still in the exploratory stage, however, there have been few opportunities to make quantitative estimates. First estimates for 3 traits of ponderosa pine and 1 trait of Douglas-fir are as follows:

| Species | Trait | Genetic variation[1] (percent) |
|---|---|---|
| Ponderosa pine | Height at 30 years[2] | 36 |
| Ponderosa pine | Survival at 30 years (percentage of trees planted) | 51 |
| Ponderosa pine | Stem taper[3] at 30 years | 56 |
| Douglas-fir | Date of bud bursting 2 years after grafting[4] | 97 |

1/ Variation due to seed or clonal source as a percentage of total variation.

2/ Height of tallest one-third of trees planted.

3/ Height in feet per inch of d.b.h.

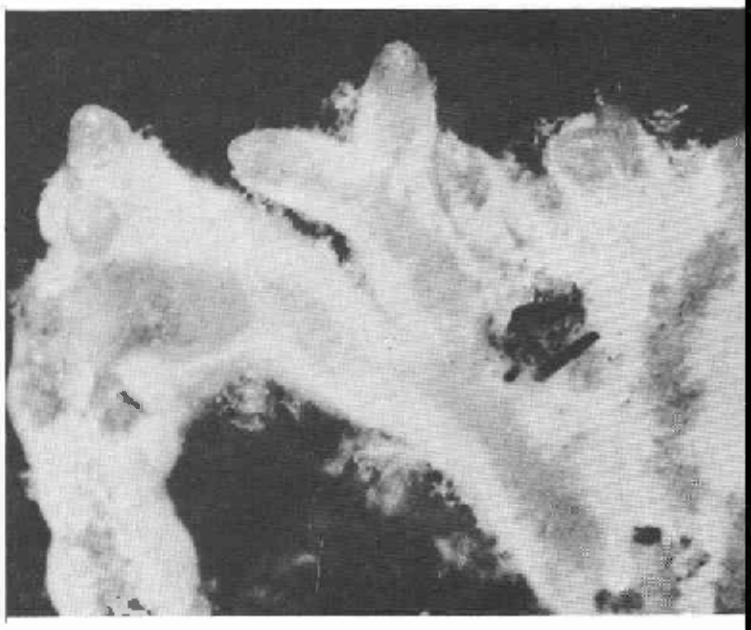
4/ Number of days after first graft burst its buds.

These heritability estimates can be expected to vary as experimental conditions and material change in each experiment. High or low estimates should, accordingly, not be considered firm figures but as an indication of the relative ease with which a given trait may be improved through intensive selection and breeding.

## REGENERATION

### Mycorrhizal Development on Tree Seedlings

Two recent studies provide new leads on environmental requirements for mycorrhiza formation. One, a pure culture test with ponderosa pine, indicates that many fungi are unable to form mycorrhizae when soil temperatures are as high as 30° C. Of several fungi tested, only Amanita pantherina formed mycorrhizae at this temperature.



Mycorrhizae formed by ponderosa pine and Amanita pantherina (x10). This fungus, unlike many, is able to form mycorrhizae at high soil temperatures.

In another study, seedlings of ponderosa pine, Douglas-fir, and Monterey pine were grown in jars immersed in controlled temperature baths. Soil was inoculated with mycorrhizae gathered from a Douglas-fir stand on a relatively cool, moist site. Mycorrhiza development was markedly inhibited by a high soil temperature (30° C.).

Because Amanita pantherina forms mycorrhizae with many tree species over a wide environmental range, it may be a suitable fungus to establish on nursery stock. Another likely fungus is Cenococcum graniforme,

which occurs from the coastal rain forests to ponderosa pine-desert transition zones, and upward into alpine shrub stands 1,500 feet above timberline.

## Use of Fertilizers on Planted Seedlings

Exploratory tests during 1958, using nitrogen and nitrogen-phosphorus fertilizers on newly planted seedlings of Douglas-fir and noble fir, showed surprisingly consistent first-year results. In all trials, the application of fertilizer--even the relatively mild nitrogen-phosphorus pellets--caused a sharp reduction in survival. Of the Douglas-fir seedlings that survived, however, those fertilized grew more rapidly than those not fertilized. For noble fir, the growth response of surviving seedlings was less positive.

Browsing by rabbits and deer varied from severe on some test areas to negligible on others, but animal damage was unrelated to the fertilizer treatment.

These empirical trials emphasize the need for more fundamental information on nutrient relationships--more adequate information on the nutrient requirements of tree seedlings, on the pattern and time of nutrient uptake, and on the best form of nutrient application.

## Ripening Douglas-Fir Seed Artificially

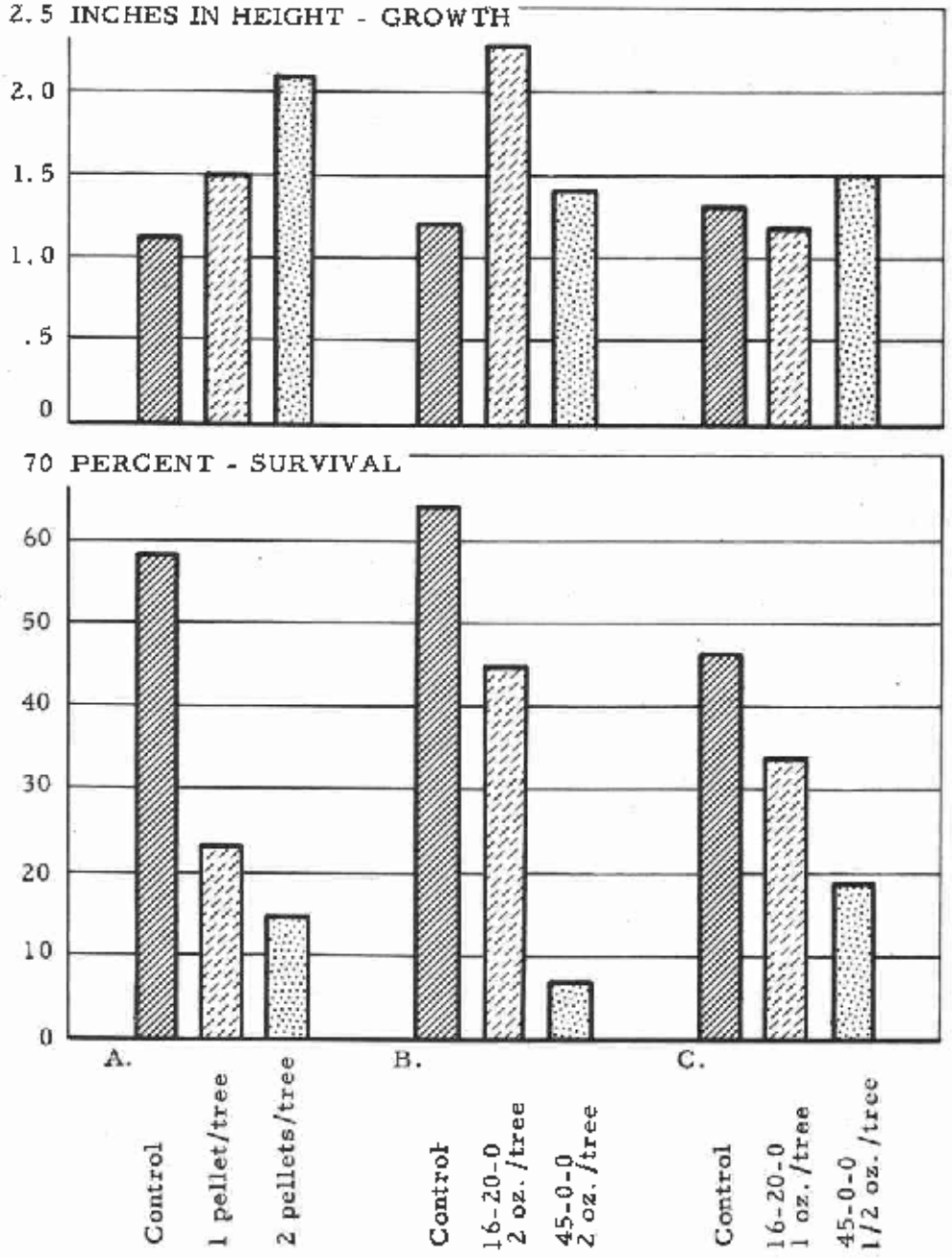
A small-scale test in 1956 demonstrated that seed in early picked cones can be ripened artificially under favorable storage conditions. A followup study begun in 1957 at Wind River Nursery tested several storage treatments that could be adapted to commercial practice.

Beginning August 1, cones were collected from 3 sites at 10-day intervals and stored on shaded racks under 4 storage conditions:

1. Dry storage in burlap bags.
2. Continuous sprinkling in burlap bags.
3. Continuous mist spray in burlap bags.
4. Dry storage in polyethylene-lined kraft paper bags.

Results were less conclusive than hoped for because the 1957 cone crop had a high proportion of wormy cones and produced extremely low yields of sound seed.

All cone collections, even the earliest, provided some germination under all storage treatments. Continuous-sprinkling storage increased germination in all early picked lots, whereas polyethylene-lined-bag storage reduced germination because of cone fermentation. Germination of early picked cones either stored dry or subjected to continuous mist spray was intermediate between the other two treatments.




Survival and first-year height growth of fertilized conifer seedlings. A, 2-0 Douglas-fir seedlings fertilized with nitrogen-phosphorus pellets (Snoqualmie National Forest). B, 2-0 Douglas-fir seedlings heavily fertilized with nitrogen (45-0-0) and nitrogen-phosphorus (16-20-0) (average of 3 tests--2 on Siuslaw National Forest, 1 on H. J. Andrews Experimental Forest). C, 3-0 noble fir seedlings heavily fertilized with nitrogen (45-0-0) and nitrogen-phosphorus (16-20-0) (Gifford Pinchot National Forest).

Seed from August 1 collections produced seedlings with cotyledons and epicotyls slightly shorter than normal--evidence of a small reduction in vigor. Seed from later collections, however, produced seedlings of normal size.

For all collections after August 1, the continuous-sprinkling treatment provided germination on a par with that of tree-ripened seed.

## Douglas-Fir Planting Stock: 2-0 vs. 3-0

High mortality of 2-0 Douglas-fir planted on south slopes prompted a comparison of survival between 2-0 and 3-0 stock on the H. J. Andrews Experimental Forest. The test was carried out to determine if larger trees might better withstand summer heat and drought. Survival (in percent) was:

| Age of planting stock | Survival | |
|---|---|---|
| | (First season) | (Second season) |
| 2-0 | 37 | 33 |
| 3-0 | 60 | 51 |

Most mortality resulted when soil and other debris moved down the steep slope and either dislodged or buried seedlings. Better survival of 3-0 trees was due mainly to their larger size, which provided more resistance to mechanical disturbance.

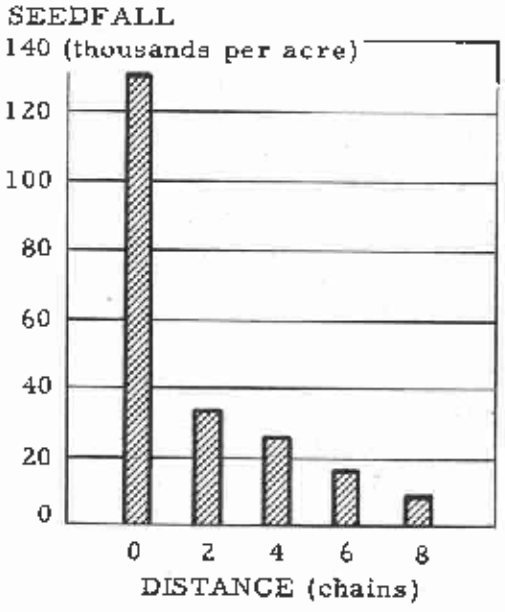
Survival of the planted stock was not greatly influenced by shade from other vegetation although there was some indication that heavy shade was better than no shade on this south exposure. Height growth, which averaged about 1 inch per year, was the same for both classes of planting stock.

## Dispersal of Ponderosa Pine Seed

A heavy crop of ponderosa pine seed at Pringle Falls Experimental Forest provided an opportunity to observe seed dispersal into a 65-acre clearcut located within a virgin pine stand. By November 6, an average of 130,000 seeds per acre fell under trees at the edge of the clearcut. Seedfall dropped off sharply to 33,500 per acre 2 chains from the edge, then tapered off uniformly out to 8 chains (the clearcut center), where 7,300 seeds per acre were caught. Seedfall within the adjacent uncut forest was much greater than at the clearcut edge--about 338,000 seeds per acre.

Heavy winds during the cone-opening period increased distance of seed dispersal in the direction of prevailing winds. Thus, average seedfall at 2 chains in this direction was about 47,000 per acre, compared to 20,000 in the opposing direction.

Aerial view of 65-acre clearcut that provided the setting for a study of ponderosa pine seed dispersal.




Relation of seedfall to distance from timber edge--ponderosa pine.

In another study of seedfall of Douglas-fir, at Voight Creek Experimental Forest, deer mice were found to invade seed traps covered with 1/2-inch-mesh hardware cloth. The use of 1/3-inch-mesh hardware cloth, successfully prevented this disturbance.

## BRUSH DEVELOPMENT AND CONTROL

### Plant Succession After Logging in Douglas-Fir

On the H. J. Andrews Experimental Forest, 14 units of old-growth Douglas-fir that were cut clear and broadcast-burned 5 or more years ago have been examined periodically to determine density and composition of plant cover. Altogether, 104 plant species or species groups were found after logging. Of these, 101 were found on north slopes but only 65 on south slopes.

Herbaceous species quickly invaded logged areas. Annuals maintained a high frequency of occurrence the first two years, and then declined in an obvious trend from annuals to perennials. Number of perennials increased rapidly the first 4 or 5 years, after which the increase slowed.

Woody species that survived logging and slash burning increased slowly in frequency. New woody species invaded the cutover area but increased at a slower rate than woody survivors. There was little difference in species frequency from elevations of 1,850 to 3,800 feet. After 5 years, there was likewise little difference in species composition or plant density between burned and unburned areas.

## Aerial Application of Herbicides in Southwestern Oregon

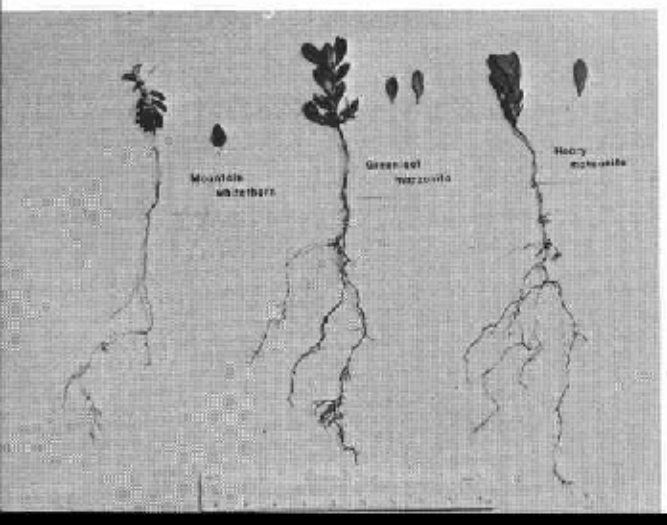
Promising results of small-plot tests have led to project-scale trials on the Rogue River and Siskiyou National Forests.

On the Rogue River, a foliage spray of a low-volatile ester of 2,4-D was applied by plane to 200 acres of Howell manzanita during mid-June at a dosage of 4 ahg (pounds acid equivalent per 100 gallons of spray solution). By early fall the herbicide treatment was judged highly effective, and plans were made for followup planting and seeding trials. The nonsprouting character of Howell manzanita was a deciding factor in the success of this operation.

In contrast, pilot-scale tests on the Siskiyou National Forest indicate two or more aerial spray treatments will be needed to obtain satisfactory control in a brushfield composed of sprouting species of ceanothus, manzanita, and live oak.

## Effect of Burning on Germination of Brush Seeds

Several brushfields on the Siskiyou National Forest in southwestern Oregon were aerially sprayed with herbicides in 1955. Major species were greenleaf manzanita, canyon live oak, mountain whitethorn ceanothus, and golden evergreenchinkapin. A year after chemical treatment, some of the dead brush was burned in early fall.



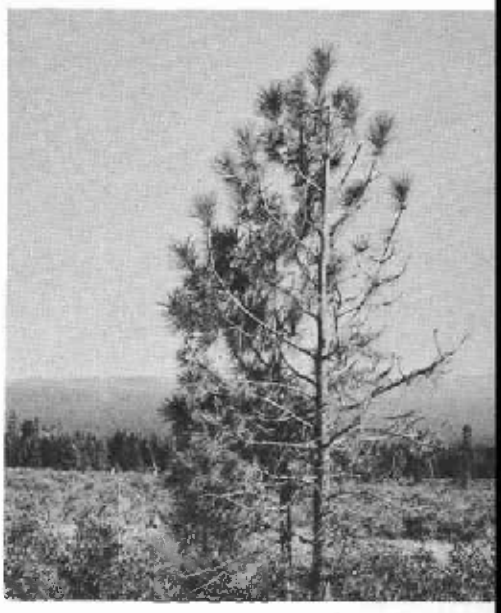
New brush seedlings that followed a test burning on the Siskiyou National Forest were not only numerous but extremely vigorous. These 1-year-old seedlings of ceanothus and manzanita have a well-developed root system 8 to 10 inches long.

One year after the fire, burned areas were found to contain more than 10,000 new brush seedlings per acre in contrast to only a few seedlings in either the sprayed-unburned area or a control area of untreated green brush. The majority of new brush seedlings on the burned area were mountain whitethorn ceanothus.

Although carried out primarily to clean up dead standing brush and to kill back sprouts preparatory to planting or seeding, burning has resulted in a vigorous new crop of brush seedlings that seriously endanger reforestation efforts.

## Effects of Herbicides on Conifers

When foliage sprays are used in brush-control operations, effects of the herbicide on intermixed young trees are of immediate concern to the land manager. Several recent tests indicate that some common herbicides are sufficiently selective to provide control of certain woody shrubs without permanent injury to associated conifers.



Although the top and one side of this ponderosa pine were killed by aerially sprayed herbicides, it is making rapid recovery. Diameter and height growth in the 2 years since treatment almost equalled growth rates during the 2 years before treatment.

Observations of ponderosa pine poles that were severely damaged in an aerial spraying project in the Deschutes Basin indicate this species has remarkable ability to recover promptly from what appeared to be heavy damage.

Concentrations of chemicals used in this early trial were heavier than those now recommended to control manzanita, chinkapin, and snowbrush ceanothus in the Deschutes area.

Screening trials at Cascade Head on seedlings of western hemlock and Sitka spruce demonstrate that both tree species can tolerate moderate concentrations of several commonly used herbicides. In recent trials, the propylene glycol butyl ether (PGBE) ester formulation of 2, 4, 5-T caused less damage to seedlings than other herbicides tested. Since this chemical is also one of the best for salmonberry control, it appears to have real promise for controlling brush in coastal areas.

## Salmonberry Control

Six chemicals have been screened for salmonberry control at Cascade Head. These trials indicate that four commercial herbicides can be used to release tree seedlings from salmonberry competition, even though salmonberry plants sprout following defoliation and may eventually recover. PGBE ester of 2-(2, 4, 5-TP) provided the most complete defoliation (90-100 percent) but was closely followed by three formulations of 2, 4, 5-T. All four chemicals provide freedom from severe salmonberry competition for a period of 2 to 3 years, believed adequate in coastal forests for effective release of established conifers.

Treatment during wet weather, when special effort was made to wet the undersides of leaves and the stem, was found to be equally as effective as dry weather treatment, when only the upper sides of leaves were wetted in normal fashion. June application provided slightly better defoliation than September treatment but the differences were small.



One year after foliage treatment with PGBE ester of 2-(2, 4, 5-TP), the salmonberry clump in A was completely defoliated (B).

## GROWTH AND YIELD

### Site Curves for Red Alder

Site curves resulting from stem analysis of 43 felled and sectioned trees from 9 western Washington counties were made available late in the year. Based on total height at 50 years of age, the site indices range from 60 to 120 feet.

In using the curves, at least 3 trees should be measured. Also, measured trees should not range more than 5 feet above or below the average height of the sample, nor more than 2 years above or below the average age.

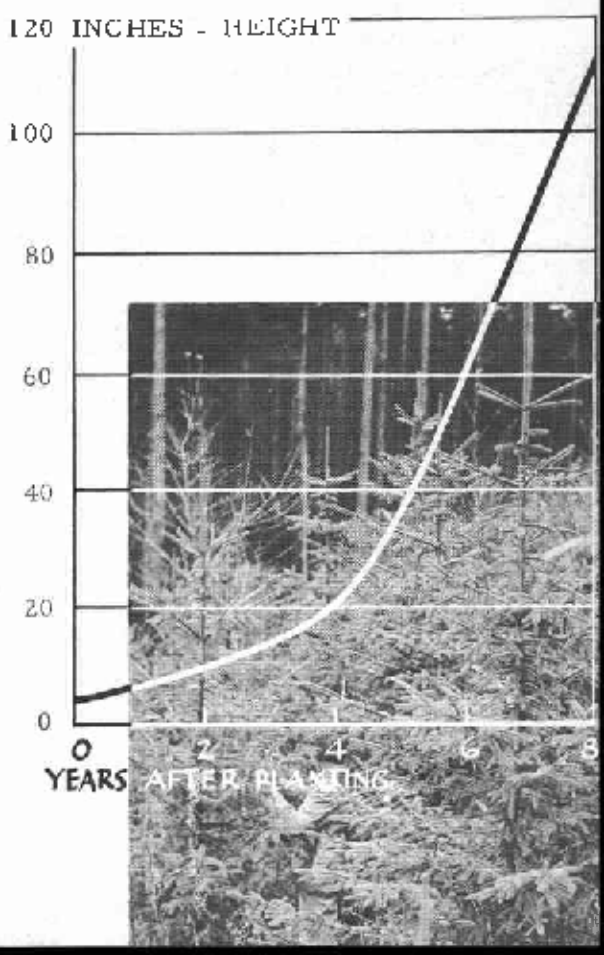
The curves were constructed by means of a new analysis technique that may be applicable to other species.

Red alder yield tables--expressed in number of trees, basal area, cubic feet, and board-feet (Scribner)--are being prepared for publication. Analyses required for these tables were performed with electronic data-processing equipment. The project is sponsored by the Puget Sound Research Center Advisory Committee, with many private and public agencies cooperating.

### Initial Height Growth of Planted Sitka Spruce

Measurements during the first 8 years after planting at Cascade Head show that Sitka spruce accelerates rapidly in height growth following initial establishment. Seedlings about doubled in total height every 2 years.

Seedlings would have been even taller had not the terminal leaders on one-fifth of the trees been killed by the Sitka spruce weevil or by whipping of intermixed hardwoods.




Sitka spruce seedlings free of brush competition reached a height of more than 9 feet 8 years after planting at Cascade Head Experimental Forest. Seedlings growing in direct competition with brush averaged less than half as tall.

### Yields of Planted Douglas-Fir

Recent studies of a Douglas-fir plantation on the Olympic National Forest in western Washington provide additional evidence that plantations furnish much higher yields at an early age than fully stocked natural stands of comparable age and site. At 25 years of age (from seed) the plantation was found to contain a volume of 3,850 cubic feet, or 12,260 board-feet (International rule). Comparison with yield-table values for the indicated site index--158--show that although the plantation contains only 81 percent of the normal number of stems, its cubic-foot yield is 214 percent of normal. The ability of the plantation to produce more than twice as much cubic volume at age 25 is attributed to wider and more uniform initial spacing (8x8 feet), which favors the full and unhibited development of the individual tree.

## SALVAGE CUTTING, THINNING, AND SPACING

### High-Lead Salvage

A time and production study at the H. J. Andrews Experimental Forest shows that cable yarding with a mobile logger provides a practical method for periodic salvage of leave settings in old-growth Douglas-fir.

Prediction equations were developed for each step in the yarding sequence. These equations can be used for predicting yarding time per turn for various log sizes and yarding distances, where conditions of stand and topography are similar to those of the study area. Then, yarding costs can be estimated by applying a machine rate to yarding time. Such information is useful both in appraising the feasibility of proposed salvage and in planning more efficient salvage operations.

### Initial Spacing of Ponderosa Pine

A long-term study to investigate the best spacings for young ponderosa pine was extended from the drawing board into the woods at Pringle Falls during 1958.

The study is designed to fulfill two main objectives: (1) determine influence of early spacing on stand development and commercial yields, and (2) determine age and size when stands of various spacings fully occupy the site and first begin to produce maximum cubic-foot growth. Also, brush and herbaceous vegetation are being removed from half the plots to provide a measure of the impact of understory vegetation on growth.

### Thinning in Century-Old Douglas-Fir

A site III Douglas-fir stand at Wind River, now 115 years old, was first thinned at age 96 (12 percent removal, by volume) and again at age 110 (19 percent removal). Periodic remeasurements show that mean

Following removal of the overstory, this sapling stand of ponderosa pine was thinned to a 13.2-foot spacing. This is one of 30 plots installed to measure growth under five degrees of stocking.

annual net increments have declined steadily in both thinned and unthinned parts of the stand. Current level of mean annual net increment per acre is almost identical under both stand conditions--about 120 cubic feet, or 930 board-feet (International rule). In contrast, periodic net increment for the 18 years since thinning has been highest in the thinned stand, and periodic gross increment highest in the unthinned stand, as shown below:

| | Thinned | Unthinned |
|---|---|---|
| Periodic net increment (per acre annually) | | |
| Cubic feet | 90 | 41 |
| Board-feet (International rule) | 727 | 456 |
| Periodic gross increment (per acre annually) | | |
| Cubic feet | 128 | 177 |
| Board-feet (International rule) | 1,013 | 1,475 |

These figures indicate that although the thinnings succeeded in reducing mortality losses and in increasing periodic net increment, they lowered periodic gross increment and failed to halt the downward trend of mean annual net increment. Apparently trees as old as 100 years on site III do not have the ability to respond to release and rapidly appropriate growing space made available through the removal of competing stems.

## FIRE RESEARCH

During 1958, substantial effort was devoted by the Station meteorologist to two projects of national import. Early in the year, he was detailed to Washington, D. C., to assist with the organization and technical editing of a fire-weather handbook for foresters. This is a joint undertaking of the Forest Service, Weather Bureau, and forest fire control agencies of the Department of Interior. The principal objective is to assemble in convenient and usable form, essential meteorological information needed by fire-control men.

In late spring, he presented a number of lectures on meteorology at a national fire-behavior training school that the Forest Service conducted at Missoula, Mont. The school is part of a nationwide effort to prevent forest fire disasters that take human lives.

## Fuel Moisture as a Guide to Slash Burning

Records collected by five national forests covering 171 slash fires in the Douglas-fir region show that fuel moisture indicator sticks are very helpful in choosing a favorable day for burning--when fire will burn well in slash but will not spot and spread in adjoining green timber. These records indicate that clear-cut logging units can be burned satisfactorily under average conditions of fuel, slope, and wind when fuel moisture sticks record 14 percent in the slash and 20 percent or more in adjacent green timber. The use of these guidelines is limited to typical fall burning conditions when fair weather follows a rain that thoroughly wets the duff.

Under the most favorable fuel moisture conditions, a slash fire will burn readily but will not spot outside the slash area.

## Trends in Fire Occurrence in the Douglas-Fir Region

Trends in fire occurrence are usually dominated so much by fire-weather conditions that it is extremely difficult to appraise year-to-year progress in fire-prevention and fire-control efforts.

Analyses during 1957, however, had shown that the yearly number of man-caused fires is closely correlated with one or more of the fire-season weather indexes that are calculated annually by the Station. During 1958 the resulting regressions were used to help determine if there was a time trend in occurrence and size of man-caused fires after the influence of fire weather had been eliminated.

For western Washington, this analysis disclosed a definite increase in number of man-caused fires during the period 1944-56. For lands in State and private protection districts, the increase averaged 37 fires per year, or 4 percent of the average annual number during the 13-year period. On national-forest lands, number of man-caused fires increased at a rate of about 5 per year during the same period, representing a 9-percent increase yearly. Although number of fires was on the increase, the size of the average fire on State and private lands showed a downward trend.

For western Oregon, no trends in either number or size of man-caused fires were apparent after the effects of fire weather had been accounted for.

## Discovery of Fires From Aircraft

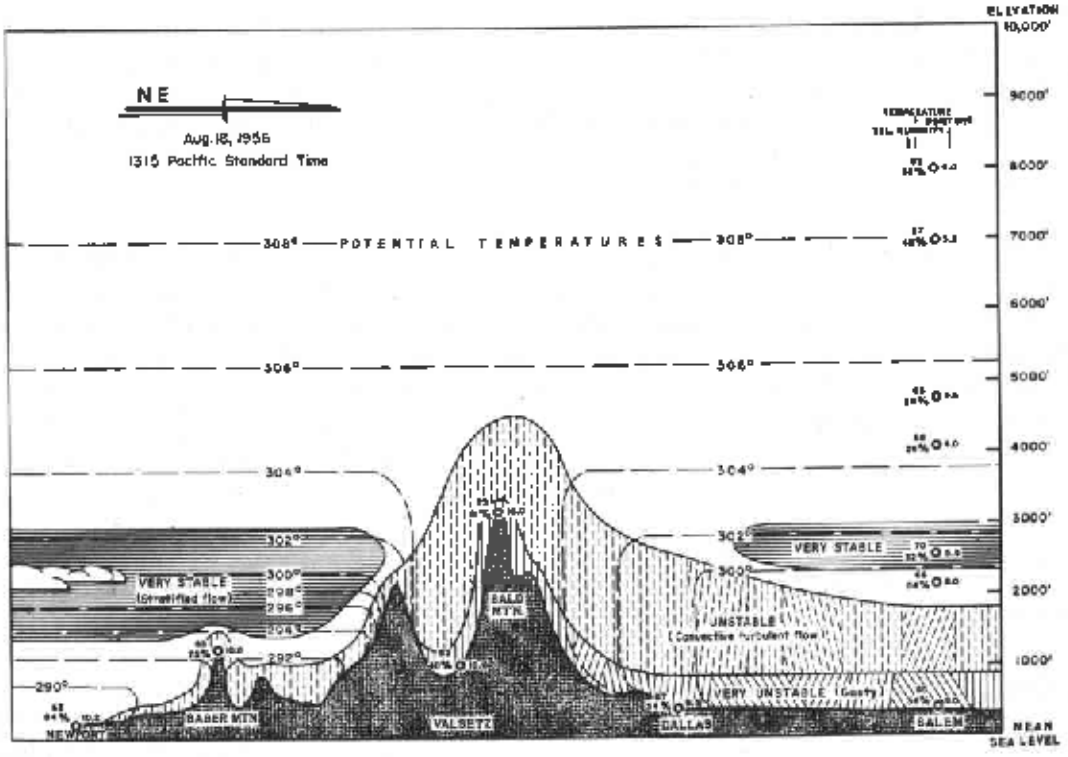
In planning use of aircraft to supplement or replace ground methods of detection, fire-control men need information on discovery time, distance from observer, and size of fire at time of detection.

Reports on discovery of 250 fires by national-forest aerial observers show an average elapsed time from origin to discovery of 15 hours for those discovered within 3 days. Only 15 percent of aerial discoveries were made during the second or later flights after ignition. Distance from observer to fire at time of discovery averaged 1.3 miles. Additional fires missed by aerial searchers and later discovered by others averaged 2.3 miles from the flight path. And, in 93 percent of aerial discoveries, observers estimated the size as a small spot.

## Atmospheric Cross Sections and Local Winds

Fifty-mile-long atmospheric cross sections between Newport and Salem were used successfully to show how local heating during the day and cooling at night affect not only local winds but also humidity and air pressure in the Oregon Coast Range. Similar application of large-scale atmospheric

cross sections based mostly on surface observations should provide a valuable tool for analyzing the three-dimensional structure of surface wind in mountainous terrain.




Simplified atmospheric cross section through the Oregon Coast Range, showing effect of topography on air stability and motion.

## 1958 Fire Weather in the Douglas-Fir Region

The entire fire season (April 1-October 31) was more severe than normal in western Washington and of about normal severity in western Oregon according to seasonal indexes calculated at the Station. The summer--probably the hottest of record in the Douglas-fir region--brought fire weather of average severity to western Oregon and the most severe fire weather of record to western Washington. During the fall, fire weather neared record-high severity in western Oregon, but reached only slightly above normal severity in western Washington. Summer lightning storms were more numerous than usual in southwestern Oregon and in the Mount Baker area of northwestern Washington, but were near normal frequency in other parts of the region west of the Cascade Range.

## PLANS FOR 1959

No major changes in scope and direction of forest management investigations are anticipated during 1959. The forest management research staff will continue to work toward more thorough program and study planning, prompter publication of findings, more adequate laboratory and greenhouse facilities, and increased opportunities for graduate study by staff members. A few examples of specific tasks to be undertaken include:

1. Compilation by the Deschutes Research Center of gross growth data for lodgepole pine. This information will provide the first estimate of potential growth of lodgepole pine under management.

2. Preparation by the Puget Sound Research Center of a problem analysis and proposed action program for research in upper-slope fir-hemlock forest types.

3. Installation by the Siskiyou-Cascade Research Center of an initial-spacing study for ponderosa pine on the South Umpqua Experimental Forest.

4. Development by the Willamette Research Center of new plans for thinning and harvesting trials in spruce-hemlock stands at Cascade Head. Continuation of this cooperative harvesting program has been assured through the recent signing of a new 5-year memorandum of understanding with Publishers' Paper Co. of Oregon City, Oreg.

5. Initiation of new studies on the physiology of nursery-grown tree seedlings. This project will aim to disclose why seedlings often fail to resume active growth following planting.

6. Completion of field planting for a study of reciprocal transplanting of Douglas-fir clones from various altitudinal sources, in cooperation with the School of Forestry at Oregon State College.

7. Preparation of a project analysis and proposed program of studies in the field of fire-weather research.

The Station's special project on silvicultural effects of spruce budworm defoliation will be accelerated in cooperation with the Portland regional office of the Forest Service.

# Forest Utilization Research

Order files for wood products improved in the Pacific Northwest in 1958. Although general price levels were slightly better than the previous year's, they were somewhat lower than those of 2 years ago. The trend toward closer utilization of raw material continued, due to competition for stumpage and rising production costs. Improved mechanization, plant expansions, and more integrated operations have made closer utilization economically feasible.

Present and planned expansion in production of pulp and composite panel board will utilize primary manufacturing residues in greater amounts. Early in the year a large, new pulp mill began production in western Oregon, and another is being constructed in southeastern Washington. At least two more pulp mills are being considered for the region in 1959 but definite plans and locations have not been announced. A large plant began manufacturing a low-density composition board from lodgepole pine roundwood in south central Oregon. Another plant--in northwestern Washington--started making flakeboard from alder roundwood and cedar slabs. Increased utilization of roundwood on a large scale would consume thinnings and make sustained-yield forest management more attractive.

Need for information on the properties and uses of species from upper-elevation forest types has increased. During the year, a large timber sale was made at Windigo Pass in the Umpqua National Forest in Oregon. The sale involves 75 million board-feet, 40 percent of which is mountain hemlock. Limited previous utilization experience with this species has not afforded an opportunity to evaluate all its properties or the problems peculiar to its manufacture and marketing. Also, between 3 and 4 billion board-feet of Pacific silver fir are affected by the balsam woolly aphid, and the only counteraction to this insect attack is to rapidly harvest the dead and dying trees. Widespread volume consumption of the species in the building industry is limited because it is presently graded by Sitka spruce rules, which have no stress grades. Although silver fir may be stronger in some properties than other true firs, the inability to distinguish between true fir species once they are sawed into boards further complicates the marketing problem. The U. S. Forest Products Laboratory at Madison, Wis., has nearly completed a report on the strength and related properties of this species.

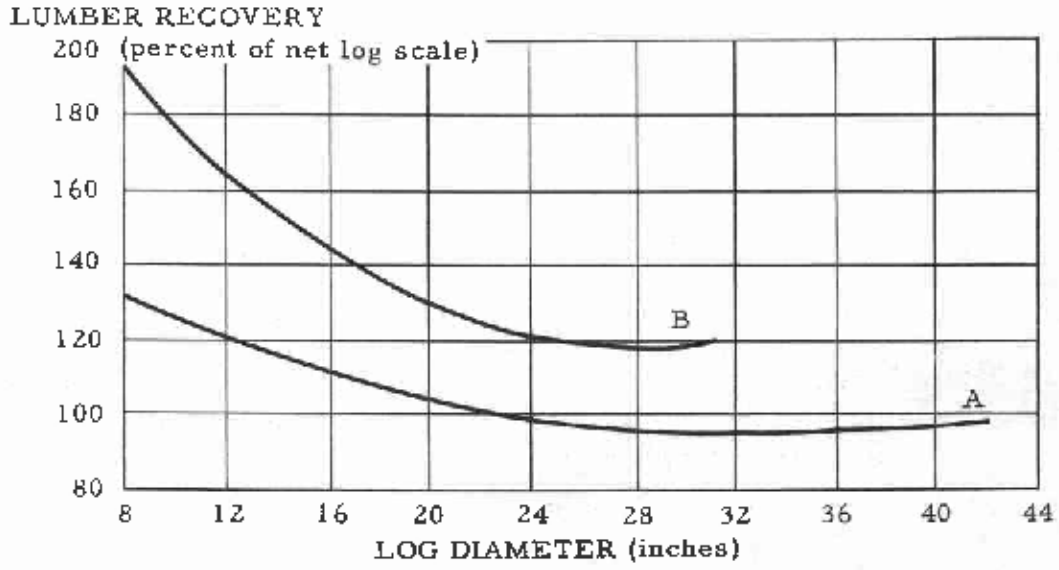
During the year, the scope of the Station's forest utilization research work was broadened to include the new State of Alaska.

## APPRAISAL BASE STUDY

In 1955, the Station and the Portland regional office of the Forest Service initiated a 3-year project to develop end-product recovery data for logs of various species, sizes, and grades. Other Federal agencies have cooperated. Since initiation of the project, lumber recovery studies have been made for western redcedar, old-growth and young-growth Douglas-fir, western hemlock, white fir, and ponderosa pine and associated species. In addition, six veneer recovery studies in Douglas-fir plywood plants and one western redcedar shingle recovery study have been made. A start has been made in the Pacific Northwest to use end-product recovery data for timber appraisals, and it is now anticipated that the development of these data will continue to keep abreast of changing utilization practices.

During 1958 two Douglas-fir lumber recovery studies were made at sawmills west of the Cascades in Oregon: one on old-growth logs at Roseburg, and the other on second-growth logs at Mapleton. Each study involved approximately 200 logs. In both studies, grade recovery was determined at the green chain.

Results of two 1957 lumber recovery studies--on ponderosa pine at a mill in Washington and on old-growth Douglas-fir at a mill in Oregon--were written up and are undergoing prepublication review. The accompanying graph shows total lumber recovery by log diameters for sound logs for each study. Curve "A" for sound ponderosa pine logs compares well with the curve from a study conducted 25 years ago by this Station, involving more than 10,000 sound 16-foot pine logs.




Total lumber recovery from sound saw logs. A, Based on 239 ponderosa pine logs (dry-surfaced lumber tally). B, Based on 215 Douglas-fir logs (green-chain lumber tally).

The physical task of obtaining lumber grade recovery on a dry-surfaced basis is not always easy due to the complicated flow of materials at some mills. However, for appraisal purposes, manufacturing costs for many lumber items are tied to dry-shipping tally base, and the recovery information must be adjusted to that base. To facilitate this adjustment, the Station conducts seasoning degrade studies on the species in question and applies the data to rough-green recovery. Such a study was conducted on hemlock lumber in 1958 at a large mill at Foster, Oreg.

The current electronic-computing program used for analyzing mill scale studies has been greatly improved over the past 2 years. A major transition in technique, which is now developing, will allow faster analyses and better application in appraisals: in lieu of determining grade-yield recovery as a percentage of net log scale or of total lumber tally for each log diameter within a log grade, end-product values by diameters are established. This new technique should be as accurate as the previous technique, and it is simpler. Great variations exist in the grade-yield recovery percentages from logs of like diameters and grades. These variations are greatly reduced when recovery is put on a value basis.

## BUILDING CONSTRUCTION

### Moisture Content Changes

Late in 1957 the U. S. Forest Products Laboratory started a nationwide study to measure moisture-content and dimensional changes in wooden framing members of houses during construction and while occupied.

Test houses at Chelatchie Prairie Ranger Station in Washington are identical except for original moisture content of the framing lumber. Information is sought on the amount of distortion developed in house framing as it stabilizes in use.

In this region, three identically designed houses being built at a Forest Service ranger station were selected for the study. For each house, framing material of a different moisture content was used: unseasoned, kiln dried to 19 percent, and kiln dried to 12 percent. Results of this study will permit a comparison of the condition of the houses after the framing has reached its equilibrium moisture content. Moisture content and dimension data will be taken until the spring of 1960.

This Station and the West Coast Lumbermen's Association cooperated in selecting the test houses and are obtaining field data during the life of the study.

Maximum Temperatures in House Framing

The lumber industry is seeking to develop methods for gluing small pieces of lumber into sizes and quality suitable for house framing. Studs and rafters offer a good market for such glued products. Proper glues must be chosen, however, as some that might be used would not be durable if they were subjected to excessive temperatures in service.

In 1958, the Forest Products Laboratory initiated a nationwide study to measure maximum temperatures developed in studs and rafters on the south side of houses directly exposed to the sun. The Station and the Western Pine Association installed thermocouples in the studs, rafters, and sheathing of two houses in Portland, Oreg., and are periodically measuring temperatures during the hottest months of the year. This study will be continued through 1959.

## LAMINATING

The program of inspecting bridges constructed with glued-laminated Douglas-fir beams and arches was continued during the year. Bridge members bonded with a resorcinol glue and pressure treated with creosote (1949) show satisfactory glue bonds, and the surface creosote deposit has given satisfactory protection against weather checking. Members in which the lumber was pressure treated with water-borne salts before gluing with resorcinol glue (1948) show some delamination at the glue joints and some weather checking.

The Station is cooperating with the laminating industry in its efforts to develop a shorter end joint for producing long laminations. The aim is to reduce the amount of wood lost in making the conventional scarf joint and still retain a high allowable design-stress value for the joint. Also, to enable architects to design laminated members of western hemlock, the West Coast Lumbermen's Association has developed standards for the design and fabrication of structural glued-laminated members of this species. These standards are based on a knot frequency survey made on stress-graded material.

The need for special lumber grades for use by the laminating industry continues. For the sake of appearance, the present rules for grading lumber limit the size of loose knots and knotholes to one-half to two-thirds the size of allowable tight knots. However, these characteristics are hidden from view in the laminated member. On the other hand, laminating requires full strength throughout the length of the lumber. The Station is cooperating with the laminating industry in development of grading rules that will meet these requirements.

## VENEER AND PLYWOOD

The Douglas Fir Plywood Association and the Forest Products Laboratory continued work on a cooperative project of major importance to determine the suitability of "white pocket" Douglas-fir veneer for plywood. White pocket is caused by a fungus (Fomes pini) that attacks growing trees.

It is estimated that between 65 and 100 billion board-feet of Douglas-fir timber in western Oregon contains some stage of white pocket. The Station helped select and grade dry veneer containing various degrees of white pocket, as well as D-grade veneer used for a control. This material was shipped to the Forest Products Laboratory where it was made into panels and subjected to several controlled tests to determine its physical properties.

## SKYLINE LOGGING

Results of a 3-year project on the Okanogan National Forest have demonstrated that logging by skyline cable methods is feasible on areas considered inoperable under conventional logging methods. The project was carried out with a Swiss machine operated by Swiss technicians.

The Station was instrumental in establishing this demonstration in the hope that it would encourage American manufacturers to develop similar equipment. Two firms in the Seattle area did become interested in the project and as a result have developed machines designed to do a comparable job. These machines are currently in use near Twisp, Wash., on a timber sale involving the removal of 8 million board-feet. The second has been completed for use on a 22 million board-foot sale on the Mount Baker National Forest. This machine costs approximately $60,000 and employs a 2-1/2-inch-diameter skyline and a radio-operated diesel engine within the carriage.

The 260-acre area of the Mount Baker sale is divided into various clear-cut units, one of which will be a 1,000-foot-wide strip extending from the bottom to the top of the ridge. Another 1,000-foot-wide strip will be cut into 20-acre cut-and-leave units. A third strip will be triangular in shape, with the base at the ridgetop. These cutting patterns were designed

to enable study of the effects of snow slides, soil erosion, slash disposal, and logging costs.

## HEMLOCK DEGRADE STUDY

A study to evaluate drying and manufacturing degrade in producing kiln-dried hemlock lumber was made at a large mill at Foster, Oreg. This study involved finish items, ladder stock, and 2-inch dimension. Approximately 100,000 board-feet of lumber was graded in the rough-green, sorted, and kiln dried. The firm's regular commercial drying schedules were used.

After kiln drying, the material was surfaced on all four sides and regraded, and the amount of change in grade from the original rough-green condition was established. The reasons for this change in grade and for cull and trim losses were also recorded. Degrade, as expected, was highest in the upper grades of lumber. For example, about 80 percent of the C and Better flat-grain finish remained on grade. Degrade was considerably less in the dimension lumber: about 98 percent of the Utility remained on grade.

## WOOD PRESERVATION

A number of coast-type Douglas-fir and western hemlock posts, supplied to the Forest Products Laboratory by a Portland treating plant, were impregnated with Boliden salts by means of an oscillating pressure method. This relatively new process, developed in Sweden, involves alternately raising and lowering the pressure of the preservative fluid above and below the air pressure within the wood. Its chief advantage is the elimination of predrying the wood; a disadvantage is the longer treating time required.

After treatment, the material was installed in a Forest Service test plot in Mississippi. Periodic inspections will be made by Laboratory personnel to compare durability of these posts with others treated differently.

## PACKAGING DEVELOPMENTS

### Bulk Handling of Fruit

In 1958, approximately 50 apple growers used 125,000 bin pallets (25- to 30-bushel capacity) to move their crops from the orchard to the warehouse for repacking or storage. This compares with use of approximately 30,000 bin pallets by 7 growers in 1957. Initial use was made in 1956, when 1 grower experimented with 50 bulk bins. About 10 percent of this year's apple crop was harvested into bin pallets. One pear grower began using the technique in 1958.

This development has been brought about by the increased use of corrugated fiberboard cartons for shipping fruit to market. It is estimated that approximately one-third of this year's crop will be shipped in fiberboard cartons. These cartons are lightweight and lower in cost and possess excellent printing surfaces. In addition, they serve as carryout containers in supermarkets. Formerly, when nailed, wooden boxes were used for shipping, they first served as picking containers and then were repacked for shipment. Since fiberboard cartons cannot be used as picking containers, due to low moisture resistance, the problem arose of either carrying a large inventory of wooden picking lugs or developing a suitable alternate. The bin pallet for bulk-handling the fruit has served this need well.

The Station and the Forest Products Laboratory cooperated with the fruit industry in developing minimum design specifications, and a report entitled "Bin Pallets for Agriculture Products" has been published by the Laboratory. Apparently a bin pallet of good utility can be fabricated from relatively low-grade lumber from little-used species. This new concept in fruit handling is expected to spread rapidly.

### Paper-Overlaid Veneers

Paper-overlaid veneers have found widespread application in the domestic and export packaging field in recent years. One manufacturer in this region tripled production capacity in 1958 by acquiring an 8-foot laminating machine to supplement a 4-foot machine. The product manufactured by the firm utilizes white-pocket Douglas-fir veneer between two heavy kraft laminates. Under the present commercial standard for Douglas-fir plywood, veneer of this quality is not used, resulting in high volume losses to plants operating on white-pocket timber. Therefore, use of white-pocket veneer in paper-overlaid products reduces the amount of raw material formerly wasted.

## PLANS FOR 1959

Most projects are of a continuing nature. Emphasis will be placed on maintaining cooperative relations with industry, trade associations, the Oregon Forest Products Research Center, the Washington Institute of Forest Products, and the U. S. Forest Products Laboratory. Major projects for 1959 are:

1. Continue, in both the Douglas-fir and ponderosa pine subregions, end-product grade-recovery studies for the timber appraisal-base project.

2. Initiate a Douglas-fir (and associated species) log and tree grading project to establish adequate standards for measuring quality of timber in standing trees. The project will involve studies throughout the range of Douglas-fir.

3. Continue to develop seasoning and manufacturing degrade data for the improvement of kiln-drying methods.

4. Initiate plans for studying deterioration of alder pulpwood and chips during outdoor storage, to improve utilization of western hardwoods.

5. Cooperate with industry and the Portland regional office of the Forest Service to develop logging methods suitable for areas now considered inoperable.

6. Continue cooperation with industry on improvement of laminating techniques and development of new uses for laminated products.

7. Plan for initiation of utilization research projects in Alaska.

8. Continue collection of moisture-content and dimension data on framing members in test houses. Complete schedule of measurements of maximum temperatures reached in house walls and roof members.

9. Assist in revising the manuscript "Cost of Hauling Logs by Motor Truck and Trailer" for Department of Agriculture publication.

# Range Management Research

In 1958, increased emphasis was given to game-habitat research in Washington and Oregon. Continued study has shown the increasing impact of game management problems, especially those dealing with interrelations between deer, elk, livestock, and timber production. A highlight of the year's program was the establishment of a comprehensive vegetation-game management study of the South Silver Lake Deer Herd in cooperation with the Oregon State Game Commission.

## MANAGEMENT OF BIG-GAME RANGES

### Game Habitat Problems

A preliminary analysis of big-game habitat problems was completed for central Washington. Three general categories of problems were encountered: (1) how to improve big-game habitat management, (2) how to restore the productive capacity of deteriorated ranges and increase the productivity of marginal or low-quality habitat types, and (3) how to integrate the habitat needs of big game with other important land uses.

Improving habitat management. --Range depletion through excessive stocking is a primary habitat management problem in central Washington. Lack of clear-cut management goals and guidelines has been the major deterrent to proper use of available administrative procedures in correcting this situation. Since present conditions can be greatly improved with better use of existing knowledge, recommended research activities are centered around problems of a more fundamental nature.

Ecological studies of important game-habitat types and game-forage species are needed. Studies of key plants, such as bitterbrush, should emphasize growth requirements, reproduction, food synthesis, and how these processes are affected by varying intensities and periods of use. Studies of important game range types should consider the successional relationships of key browse and forage plants to dominant or climax species, and how grazing, browsing, or other environmental factors affect normal successional sequences. Low-elevation ponderosa pine-bitterbrush types in north central Washington should receive early attention. Studies next in order should include high-elevation herblands in the northern Cascade Range; low-elevation sagebrush-bitterbrush-grass types throughout the region; and cutover, transitory timbered ranges at various elevations.

If program expansion permits, an appropriate big-game herd should be selected for intensive investigation of (1) foraging patterns and food preferences, by habitat types, in relation to seasonal and year-round forage cycles, and (2) relations between various phases of herd population ecology, trends in range conditions, and major land-use practices.

A useful prerequisite to both management and research efforts would be an intensive interagency survey of the big-game resource, with attention to (1) subdividing the region into natural herd or management units, and (2) determining the status of deer herds and the habitat problems in each unit. Such a survey would facilitate coordination of game use with other uses of the land.

Restoring deteriorated ranges.--There are two principal approaches to the problem of game-range rehabilitation--natural recovery through improved management, and artificial revegetation. Of the two, improved management is considered the first and most practical solution. In some instances, however, the amount of time and degree of protection needed for natural recovery is prohibitive, and reseeding or other cultural improvements may be the only recourse.

The ponderosa pine-bitterbrush type constitutes a major part of winter game range in central Washington. Many bitterbrush stands have declined through prolonged and excessive use and are in need of rehabilitation. Fall plantings of rodent-repellent-treated seed normally yield satisfactory germination and emergence, but additional investigation is needed so that seedling survival can be increased. In numerous other situations, dense stands of ponderosa pine reproduction have greatly suppressed bitterbrush understories. Investigations are needed to determine the response of bitterbrush and other browse and forage species to tree thinning and other stand-improvement practices.

Wet meadows and high-elevation grasslands furnish approximately 80 percent of the summer forage for large herds of elk in the Yakima area. Much of the grassland type has been severely depleted by previous livestock use and attempts to revegetate for game forage and watershed protection have consistently failed. Investigation of site factors as well as methods and species for reseeding is needed for these areas.

The search for improved methods and most suitable species for revegetating the many different sites in the province should be a continuous although minor part of the research program.

Integrating big game with other land uses.--Increasing numbers of people and the resulting heightened demand for various wild-land products in the central Washington area has created trends toward more intensive management of individual resources. Thus, the need for considering the problems of obtaining optimum returns from overlapping and sometimes

conflicting land uses is increasing in importance. Broad, long-term game habitat objectives concern (1) possible relations between big-game ecology and the habitat changes that may result from different land-use programs, and (2) how to reconcile the detrimental effects of one resource use upon another.

Some important habitat-research areas in need of investigation concern guidelines for managing dual-use game-livestock ranges; integration of soil and watershed protection needs and range utilization standards; and the relation between logging, stand improvement practices, and game forage production on ponderosa pine and upper-slope mixed-conifer types.

## Deer-Range Relationships

A study has been started on the South Silver Lake Deer Herd Range in central Oregon to learn the relations between mule deer and their ranges. Purpose of this study, in cooperation with the Oregon State Game Commission, is to learn about seasonal use of various forage plants, the amount of forage available for use, and the relations between range condition and deer health and fecundity. The study also is designed to measure direct and indirect competition for forage plants used commonly by deer and livestock (cattle and sheep).

Initial work has dealt with classification of seasonal ranges according to type. The following tabulation indicates the diversity of the summer range part of the study area:

| Type number | Type name | Acreage |
|---|---|---|
| 1 | Grassland | 370 |
| 2 | Meadow | 10,782 |
| 4 | Sagebrush | 44,626 |
| 5 | Mountain browse (primarily mountain-mahogany) | 2,008 |
| 6 | Conifer | |
| | Ponderosa pine | 66,222 |
| | Other | 55,856 |
| 7 | "Waste" | 118,807 |
| 9 | Juniper | 2,798 |
| 10 | Broadleaf trees (aspen) | 1,408 |
| | Total | 302,877 |

The so-called "waste range" is a very important part of the summer range area. This type consists primarily of lodgepole pine thickets, with varying amounts of bitterbrush in the understory. In addition to producing forage, this type provides important cover for deer.

The study will be expanded later to the winter range area.

## Chemical Deer Repellents

A study was started in April by the Deschutes Research Center, in cooperation with the U. S. Fish and Wildlife Service and the Deschutes National Forest, to determine the effectiveness of three chemical repellents for reducing deer browsing on planted ponderosa pine seedlings. Two of the chemicals, ZAC and TMTD, had previously been tested in an exploratory study (reported in the Station's 1957 Annual Report, p. 55). A third chemical, copper omadine, was included in the new study. Also, some of the seedlings in the study plots were covered with brush to study the effect of this treatment on deer browsing.

No appreciable damage to ponderosa pine seedlings by deer occurred during the late spring and summer months. However, 20 percent of the total number of trees planted were dead after the first growing season (table 2). Twenty-three percent of these dead trees were killed by gophers,

Table 2.--Repellent-treated ponderosa pine seedlings (2-0) killed or damaged by deer or other animals, by treatment and kind of damage

(Basis: 180 trees per treatment)

| Kind of damage[1/] | Treatment | | | | |
|---|---|---|---|---|---|
| | None | Brush covered | Copper omadine | ZAC | TMTD |
| | Number | | | | |
| Dead | 37 | 22 | 42 | 41 | 39 |
| DT | 0 | 5 | 3 | 2 | 3 |
| DL | 4 | 0 | 0 | 0 | 0 |
| N | 6 | 0 | 4 | 1 | 2 |
| OT | 1 | 0 | 2 | 2 | 0 |
| OL | 0 | 0 | 0 | 3 | 0 |

[1/] Meaning of symbols:
DT - terminal buds browsed by deer
DL - lateral buds browsed by deer
N - needles clipped; responsible animal not identified
OT - terminal buds removed by some animal other than deer
OL - lateral buds removed by some animal other than deer

which either clipped the tree off at ground level or destroyed the roots. Although deer browsing may be an important factor determining survival of ponderosa pine plantations in some areas, the effects of rodents and other animals must also be considered.

## Elk Browsing Damage

First-year observations on elk browsing damage to Douglas-fir plantations on the Olympic National Forest in northwestern Washington suggest that other animals may have equally important effects on initial growth and survival of seedlings. Rodent girdling and nipping seem to be the most common types of injury. Several instances of bud picking by grouse were also recorded. Although not substantiated on the study area, informal observations in surrounding localities suggest that elk trampling damage may be of greater significance to seedling survival than elk browsing.

## Rehabilitating Big-Game Ranges

Legume planting.--After two growing seasons, birdsfoot trefoil seems far superior to previous legume plantings on deer range at the 6,000-foot level in Okanogan County, Wash. Heavy, early season deer use indicates that trefoil is also highly palatable and may provide a needed legume for high-elevation game-range reseeding mixtures. Second-season performances of bramble vetch and common sainfoin declined sharply after promising first-season germination and growth.

Tree thinning for forage production.--Overstocked and suppressed stands of ponderosa pine reproduction is a common problem in central Washington. In addition to falling short in potential timber yield, such areas also produce little browse or forage.

On the Methow Game Range, a combination study has been established to determine the effects of tree thinning on forage and browse. Three

Ponderosa pine thinned for release of trees, grass, and shrubs. Methow Game Range in central Washington.

hand-thinned spacings--13.2 x 13.2 feet, 18.7 x 18.7 feet, and 26.4 x 26.4 feet--are being used in three replicated blocks. The Washington Department of Game, U. S. Soil Conservation Service, Okanogan National Forest, and the Station are cooperating in this study. Past widely spaced trial-and-error thinnings by the State Department of Game have shown encouraging responses by bitterbrush and associated forage species.

## MANAGEMENT OF LIVESTOCK RANGES

### Seasonal Weight Gains of Cows and Calves

Five years of grazing treatment now have been applied in a test of rotated-deferred and season-long management systems at three intensities of stocking on forested mountain summer ranges at the Starkey Experimental Forest and Range. The 12 test ranges are stocked with 229 pairs of allotted cows and calves furnished by Cunha Brothers of Echo, Oreg.

Cattle gains for the 1958 season differed from those in the past 4 years of the study. During the 114-day season in 1958, cow gains were above average, whereas calf gains were below. Cows under light and moderate grazing gained 44 to 45 pounds, respectively, whereas heavy grazing produced average cow gains of only 18 pounds. Calf gains were down to 175 pounds for heavy grazing and 180 pounds for moderate. On lightly grazed range units, calves gained 194 pounds. The year's high cow gains and low calf gains were related to the increase in number of first-calving heifers used in the experiment. Growth of these young cows is reflected in the overall cow gains, and their smaller gaining calves under certain grazing treatments contributed to the lower average calf gains.

Rotated-deferred grazing has not yet been shown to be superior to the season-long system for animal weight gains. According to results at this early stage of the study, calves on the season-long ranges gained an average of 4 more pounds than those on rotated-deferred ranges. Cows under season-long grazing gained an average of 15 pounds over those under rotated-deferred treatment.

Cattle gathered for weighing on the Starkey Experimental Forest and Range.

The most remarkable aspect of the cattle weight data has been the sustained high production of moderately stocked ranges regardless of grazing system used. However, in 1958 total weight gains for moderately stocked ranges were slightly exceeded by those for heavily stocked ranges (table 3). Still the 17 extra animal units on heavily stocked ranges only produced 894 pounds more gain (about the weight of a single cow) than did moderately stocked ranges. This slight edge is a result of the moderately grazed units being stocked by chance with a disproportionate number of heifer calves and calves of first-calf heifers.

Table 3.--Cattle weight gains for three intensities of stocking, 1958

| Stocking intensity | Animal units[1/] | Gain per animal unit | Gains by-- | | Total gain |
|---|---|---|---|---|---|
| | | | Cows | Calves | |
| | Number | | Pounds | | |
| Light | 58 | 239 | 2,610 | 11,252 | 13,862 |
| Moderate | 77 | 224 | 3,388 | 13,860 | 17,248 |
| Heavy | 94 | 193 | 1,692 | 16,450 | 18,142 |

[1/] One cow and calf.

## Midseason Weight Gains of Cows and Calves

Midseason cow and calf weight gains were obtained for the first time on the Starkey Experimental Forest and Range.

Forty pairs of cows and calves were individually weighed and turned onto a ponderosa pine and bunchgrass summer range June 15. On August 1 and again September 15 the cattle were gathered and reweighed.

Weight gain data for the two summer periods highlight the importance of the green-feed period to cow gains. Nearly 90 percent of cow gains were made during the first half of the season (table 4). Calves, on the other hand, gained at a more even rate; only 55 percent of their total gain was made during the first half of the season. Also, during the first half of the season cows outgained their calves.

Table 4.--Midseason and final weight gains by cows and calves on mountain summer range, 1958

(Pounds per day)

| Class of cattle | Initial weight | Aug. 1 to midseason | Midseason to Sept. 15 | Entire season |
|---|---|---|---|---|
| Cows | 925 | 2.46 | 0.31 | 1.33 |
| Calves | 320 | 2.27 | 1.79 | 1.94 |

Further information on seasonal calf gains was obtained on 21 calves of a second lot grazed under a rotated-deferred system on a pine and pinegrass range. Although the rate of gain per day was different under the two range types and grazing systems, the proportion of gain made by calves during the first and last half of the season was exactly the same in each range unit, i.e., 55 percent and 45 percent, respectively. Thus, even though calves may gain at different rates, depending on kind of feed, their gain for the same period of the same year is probably proportional regardless of management system.

## Effect of Two Age Classes on Cow and Calf Gains

For the first time in the cattle-range management study at Starkey, it was possible to obtain data on performance of first-calf heifers and their calves. This was particularly important this year in that one-third of the cows stocking the experimental ranges were of this class.

Calves of first-calf heifers made about the same gains as calves of mature cows under light rate of stocking, but they made much lower gains at the moderate or heavier rates (table 5). This indicates the necessity for additional care of replacement heifers and their calves. Poor gains by calves of these young cows under moderate and heavy stocking rates indicates the calves could not be well provided for, despite the fact young cows are usually solicitous mothers. Evidently the young cows are not getting sufficient high-nutrient forage on the native range even at the moderate rate, whereas such range provides ample nutrition for mature cows and their calves. Furthermore, it appears that at the moderate rate the young cow continues good growth while her calf is retarded.

Table 5.--Average weight gains of cows and calves, by grazing intensity and class of cattle, 1958

(In pounds)

| Class of cattle | Mean weights | Grazing intensity[1/] | | | Weighted average |
|---|---|---|---|---|---|
| | | Light | Moderate | Heavy | |
| Cows: | | | | | |
| 1st-calf heifers | 731 | 53 | 55 | 33 | 45 |
| Mature cows | 933 | 41 | 38 | 11 | 28 |
| Calves: | | | | | |
| Of 1st-calf heifers | 171 | 194 | 168 | 155 | 172 |
| Of mature cows | 211 | 198 | 194 | 193 | 195 |

[1/] Light, moderate, and heavy intensities are 10, 7-1/2, and 5 acres per animal-unit-month, respectively.

## Range Riding

Studies in central Oregon indicate that range riding is necessary in conjunction with water hauling in order to orient cattle to new watering locations.

Central Oregon ranchers find that many animals will continue to frequent old water sites unless they are hazed to new locations. One water tank that had been in place for 4 years was moved to a new location less than a mile away. The first summer after tank removal, the old site remained a concentration area and evidenced extremely heavy use. Such situations can be avoided by moving tanks more frequently and by hazing cattle when the need is indicated by use patterns.

# RANGE CONDITION

## Soil-Vegetation Relationships

A soil survey has been completed on 12 experimental range units of the Starkey Experimental Forest and Range. Of the 5 series tentatively described and mapped, soils of Tolo, Underwood, and Rock Creek series are of major importance.

The Tolo soils occur primarily on north slopes and support dense stands of Douglas-fir, grand fir, larch, and lodgepole pine. These stands

are unsuitable for grazing by livestock. The Tolo series is well-drained silt to sandy loam, 24 to 40 inches deep, derived from wind-deposited volcanic ash underlaid by basaltic soils. Prominent understory plant species are whortleberry, snowberry, spirea, pinegrass, and elk sedge.

The Underwood soils are associated with open ponderosa pine—Douglas-fir sites suitable for grazing. They are well-drained silt loam soils, derived from basalt, and range in depth from 16 to 36 inches. Primary understory species are pinegrass and elk sedge on deep soils and Sandberg bluegrass, bluebunch wheatgrass, and Idaho fescue on shallow soils. Couse soils also occur on these sites, but in minor amounts on the primary study areas.

Soils of the Rock Creek series are found in open grasslands. They are very stony loam, lithosol-like soils, 3 to 12 inches deep, derived from basalt, with Sandberg bluegrass, bluebunch wheatgrass, one-spike oatgrass, western yarrow, and pussytoes as the prominent vegetation. A fifth soil, described as Albee series, occurs as the polygon mounds of biscuit scablands, a Rock Creek-Albee complex.

The soil survey was conducted by the U. S. Soil Conservation Service.

## Vigor of Range Plants

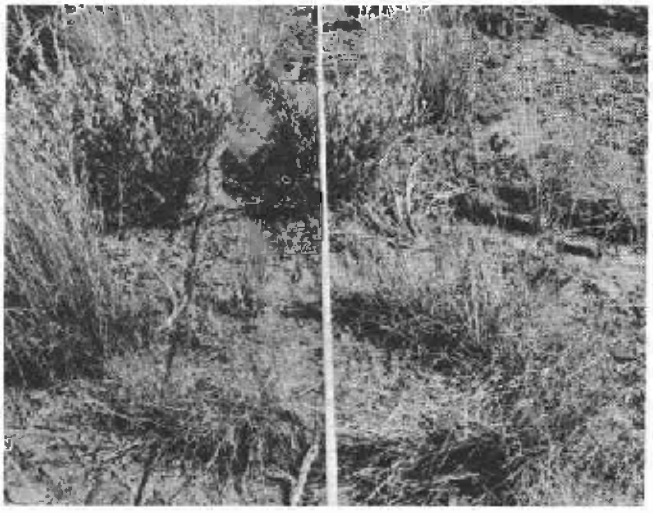
The averages of maximum leaf heights were used on 12 range units at Starkey as possible indicators of plant vigor. Measurements of bluebunch wheatgrass, Sandberg bluegrass, elk sedge, and pinegrass were obtained on transects confined to the same soil series in all range units.

After four summer seasons of cattle grazing, no relation between maximum leaf heights and grazing treatments could be found. To date, it can only be concluded that variability in the influence of site factors other than soil prohibits direct comparison of leaf measurements between differently treated range units. The possibility still exists that differences in leaf measurement will reflect increase or decrease in vigor on any single transect under one treatment. Vigor differences between seasons and rates of grazing may also show up as the treatments are continued.

## Juniper-Sagebrush Grasslands

In the juniper-sagebrush-bunchgrass type of central Oregon, new areas have been found that are suitable for detailed study of vegetation-soil-site conditions. Two of the areas represent slope and aspect

variations within the type. Measurements on these two sites show the following principal characteristics:

| | Area 1 | Area 2 |
|---|---|---|
| |  |  |
| Site: | A 28-percent north slope at 4,400 feet elevation. Annual precipitation is about 10 inches. | A 20-percent south slope at 4,400 feet elevation. Annual precipitation is about 10 inches. |
| Soil: | Silt loam derived from basalt, andesite, and shale, with a clay layer at 9 inches. Moderately stony surface. | Silt loam derived from colluvial basic igneous material, with a clay layer at 8 inches. Very stony surface. |
| Vegetation: (Basal area composition in percent) | Idaho fescue (60)<br>Bluebunch wheatgrass (26)<br>Sandberg bluegrass (4)<br>Junegrass (2)<br>Milk vetch (3)<br>--<br>--<br>Big sagebrush (3)<br>--<br>Juniper--scattered | --<br>Bluebunch wheatgrass (52)<br>Sandberg bluegrass (17)<br>Junegrass (3)<br>--<br>Cheatgrass (5)<br>Phlox (5)<br>Big sagebrush (10)<br>Bitterbrush--widely scattered<br>Juniper--scattered |
| General: | Shallow silt loam soil on a clay layer has slipped into narrow steps. Rock covers 2 percent of the soil surface. | Rock covers 23 percent of the soil surface. |

## ECOLOGY AND PHYSIOLOGY OF RANGE PLANTS

### Bitterbrush Root Systems

Bitterbrush plants in central Washington were found to have root systems that penetrated to a depth of nearly 12 feet. Commonly the single tap root was found to have grown to a depth of 2 to 4 feet. At this point it usually branched into three roots and continued downward but in a more meandering fashion and with fibrous branches.

Typical root systems were excavated as completely as possible and line-diagrammed to 10 or 12 feet. Reverse geotropism was encountered to some degree in most of the root systems. No explanation has been found for this tendency for upward growth of the tap roots, beginning at depths of 2 feet or more. Although most noticeable in the smaller size classes, several main tap roots were also found with nearly vertical upward extensions of 3 to 4 feet.

## INSECT-RANGE PLANT RELATIONSHIPS

A cooperative project with Oregon State College to study insects that attack range plants in Oregon was continued in 1958. Emphasis was placed on bitterbrush since this is one of the most important winter browse foods for deer.

Bitterbrush has a remarkable ability to recover the same year it is completely defoliated by tent caterpillars (Malacosoma pluviale). This was demonstrated in two ponderosa pine-bitterbrush communities on the Fremont National Forest.

The areas studied, one near Jack Creek and one near Davis Flat, contain approximately 15 and 20 acres, respectively. Bitterbrush in both areas was completely defoliated by the caterpillars by the second week in July. However, by the second week in September, the plants had produced a second crop of foliage nearly as dense as before defoliation.

In the Jack Creek area, crown cover of live and dead bitterbrush before defoliation was 24 and 5 percent, respectively. After regrowth was completed, live and dead crown cover was 22 and 7 percent, respectively. At Davis Flat, live and dead crown cover amounted to 20 and 6 percent before defoliation and 18 and 8 percent after defoliation and regrowth. All measurements were made by the line-intercept method.

Although a second foliage crop was produced, plant vigor was undoubtedly reduced. Plant food, which is normally stored in the roots for the subsequent year's growth initiation, was drawn on heavily. The defoliation and subsequent regrowth had a direct effect on reproduction also. None of the defoliated plants produced seed.

The insect-range plant study to date has raised many questions that can be answered only by further study: (1) what insects are present in a given plant association, (2) what are they doing there--are they beneficial or destructive, (3) how important are they in the given situation, (4) how important are they over the entire range of their host species' distribution, and (5) what can be done to minimize the damage of the destructive species?

The economic importance of insect infestations, as determined by the study in central Oregon, is indicated by the following examples taken from notes of a survey of different kinds of insect attacks:

Family Lasiocampidae--tent caterpillars

The Great Basin tent caterpillar is widespread on bitterbrush and other range plants. Small populations were found in almost all bitterbrush sites and populations of epidemic proportions--causing complete defoliation of plants--were found in several localities. An outbreak in the Bear Flat area of the Fremont National Forest was severe enough to necessitate relocation of sheep grazing allotments.

Family Geometridae--loopers or inchworms

A severe infestation by loopers caused extensive defoliation of an area of about 40 sections of bitterbrush in the Boardman-Hermiston area in 1957. Either plant leaves were consumed or enough of the leaf eaten so that the remainder died. The brush over most of this area was brown, with only an occasional green plant showing.

Family Acrididae--grasshoppers

The rusty locust, the pale spotted locust, the detestable locust, and several other species of grasshoppers were present in fairly large numbers in the Boardman-Hermiston area and were responsible for part of the defoliation of the bitterbrush in that area. One of the problems associated with grasshoppers is that they may move rapidly from cultivated crops, such as alfalfa, onto bitterbrush and other range plants after harvest of the crop.

Family Lyonetiidae--leaf miners

Damage by leaf miners was widespread on both bitterbrush and mountain-mahogany, particularly in the Klamath Agency area. These insects produce larvae that feed as true leaf miners when they first hatch. Then later they tie

several leaves together for protection and feed on these leaves and venture out to browse on other leaves at night.

Family Psyllidae--psyllids or chermids

A new species of Psylla was very abundant and widespread on bitterbrush. Large populations of this insect might be expected to cause any one of several kinds of damage, including premature yellowing of leaves, secretion of honeydew conducive to the growth of a photosynthesis-blocking sooty fungus, general devitalization of plants, or transmission of virus diseases of plants.

Family Eriophyidae--rust mites and gall mites

These tiny mites cause formation of wartlike or encrusting galls on new leaders and leaves of bitterbrush. Damage is widespread in Oregon, and a severe infestation has been reported from the Entiat, Wash., area.

Family Buprestidae--flat-headed borers

The larvae of Anthaxia aeneogaster feed on the cambium layer and girdle small branches. This species is widespread on bitterbrush and quite abundant in some areas. Foliage on branches attacked tends to turn yellow prematurely. Since this insect seems to prefer broken or heavily grazed branches, there may be a correlation between heavy grazing use and the occurrence of large populations of these beetles.

## SAMPLING AND TECHNIQUE STUDIES

### Modified Loop Transect

One of the major projects during the past year was to supplement the herbage production plots of the Starkey study with loop transects. This was accomplished by applying grids of loop observations over circular plots at the rate of 50 readings per 24-square-foot plot. The project was completed on 12 range units.

Adaptation of loop readings to circular plot work by means of tripod-type frame.

Accuracy in replacement of the loop reading frame over the plots will be aided in future observations by the fact that centers of all circular plots are in alignment, and a steel tape stretched along this axis of plot centers will permit consistency in orientation and placement of the frame.

Nested Sampling

The nested sampling scheme used to characterize and classify different habitat types in central Oregon has proved quite successful. Exploratory studies in four different habitat types--(1) ponderosa pine-bitterbrush-bunchgrass, (2) lodgepole pine-bitterbrush, (3) upland juniper-sagebrush-bunchgrass, and (4) 10-percent north-slope juniper-sagebrush-bunchgrass--show that five clusters of plots containing 4- to 50-foot transects each provide a good measure of the vegetation.

Based on 5-percent probability, the number of plot clusters needed to measure grass cover for a 20-percent sampling error varied from 2 in the upland juniper-sagebrush-bunchgrass type to 10 in the ponderosa pine-bitterbrush-bunchgrass type. To reduce the sampling error by 5 percent, the number of clusters needed in all cases would have to be doubled. Based on the dominant perennial grass plant in each area, the number of clusters needed for a 20-percent sampling error, 5-percent probability, varied from 2 to 9. As with total cover, the number of clusters needed to reduce sampling error by 5 percent is doubled.

## PLANS FOR 1959

Management of big-game ranges: Complete type mapping of the winter range for the central Oregon deer-habitat study. Start a sampling system on the herd range to determine amount, season, and intensity of forage use, and to determine amounts and kinds of vegetation on seasonal ranges. In central Washington, investigate: methods of increasing growth and survival of planted bitterbrush seedlings; hydrotropic response in bitterbrush roots; and effects of thinning dense stands of ponderosa pine reproduction on understory browse and forage species. Also, complete the study on seasonal levels of carbohydrate reserves in bitterbrush.

Management of livestock ranges: At Starkey, analyze herbage production changes in the cattle-range management study; continue records of cow and calf weight gains as a measure of range productivity; reinventory range exclosures; and continue herbage production and utilization surveys. Compile and analyze information from a seasonal forage-utilization study on ponderosa pine and bunchgrass summer cattle range.

Range condition: At Starkey, intensify work on ponderosa pine range ecology and begin initial reinventory of condition-and-trend clusters. In central Oregon, concentrate efforts in the juniper-sagebrush-bunchgrass type to classify various habitat types in different stages of range condition.

Sampling and measurement techniques: At Starkey, complete initial analysis of loop-transect data and correlate with plot data from the herbage production survey. In central Oregon, continue testing adaptation of the nested sampling scheme to different habitat types.

Insect-range plant relations: Continue study of the impact of tent caterpillars and other insects on production and vigor of bitterbrush. Emphasize determination of when and where epidemic outbreaks may occur.

Grazing and timber production: Continue studies on elk browsing of Douglas-fir, response of range forage to thinning of overstocked ponderosa pine stands, and effects of chemical spray repellents for reducing deer browsing damage to ponderosa pine seedlings.

# Watershed Management Research

During 1958 the watershed management research program shifted emphasis from planning to active studies, some designed to provide early answers to pressing land-use questions and others that are necessarily long-range in scope.

Much attention during the past year was devoted to studies of soil erosion on logged areas. In this phase of land management, there are serious gaps in knowledge and understanding. Absence of factual information has led to wide differences of opinion concerning the extent and importance of soil disturbance caused by logging. The Station's objective is to evaluate the magnitude of soil erosion on logged land as well as the factors contributing to it, and then test methods of preventing or curtailing damage.

Increased attention has also been given this year to the basic relations between forest cover and snow. Eventually these studies will lead to cutting practices designed to increase drifting and storing of winter snow and to prolong melting in spring and early summer. A primary objective is to build up runoff in late summer when it is so badly needed.

## LOGGING AND EROSION

### Normal Erosion

It is a generally accepted fact that very little erosion occurs in undisturbed forest stands. Certainly this is true of the west slope of the Cascade Range. Under the influence of a dense protective cover and abundant rainfall, most of the soils found on forested slopes have developed a strong resistance to erosion. Yet some gradual soil movement takes place, even under ideal conditions.

Without precise measurement, it is difficult to detect normal erosion. On the H. J. Andrews Experimental Forest, careful observations have been made on three watersheds that typify undisturbed forest conditions on the west slope of the Cascades. Two-year records from silt basins showed that under natural conditions, 2.4 cubic feet of silt and debris moved down the streams each year for each acre within the watersheds. This is an average of only 0.036 acre-foot per square mile of drainage, a rate that probably approximates the geological norm. Under flood conditions in early winter in 1957, the maximum suspended load in the water was only 200 parts per million (ppm).

## Accelerated Erosion

Natural contributions to sediment loads are only a minor part of the material carried by major streams of the Pacific Northwest during winter periods. Compare, for example, the maximum of 200 ppm measured on the H. J. Andrews Experimental Forest with concentrations such as 6,850 ppm measured downstream from cultivated and logged areas in the South Umpqua River at Brockway, Oreg.

What happens to forest soils when the protective cover is removed? A study last winter in the Bull Run watershed near Portland, Oreg., has shown that considerable soil disturbance can be expected in a standard logging operation, even when reasonable precautions are observed. Logging was done by a combination high-lead and tractor operation in an area being cleared for a storage reservoir.

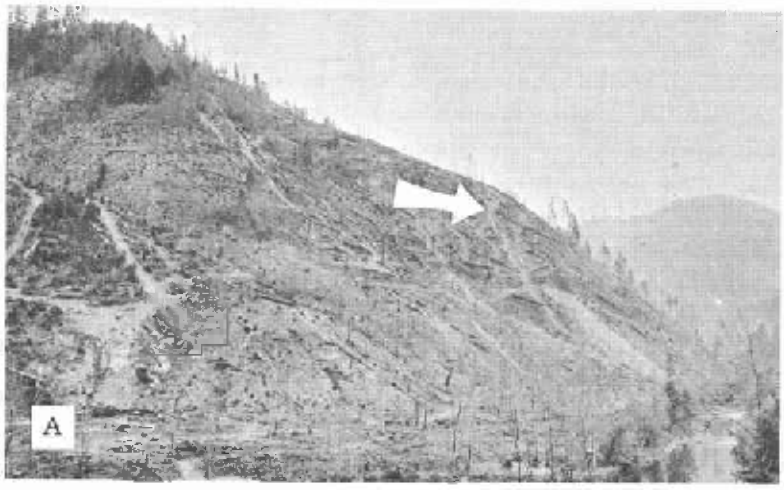
Analysis of data from the study indicates that an average of 113 tons of soil per acre moved during a winter season. No provision could be made for measuring the amounts of soil that eventually got into the streams.

## Skid Trails

Some soil disturbance must be expected in logging, but precautions should be taken to prevent excessive soil losses. There are many examples of neglect. A common one is seen in the aftermath of tractor logging operations on steep hillsides when no effort is made to divert water out of skid trails.

Frequently, the remedy for soil movement on skid trails is less obvious. Many factors influence erosion hazard, and they all should be considered when choosing measures to prevent damage. In some situations, soil types and steepness of topography rule out the use of tractors entirely.

In southwestern Oregon, erosion plots have been established on tractor skid trails in two soil types. Soil losses on these plots are being measured at cross-section profiles spaced at 20-foot intervals. Catchments are placed at the lower end of some plots to help determine the quantity of soil moved. The study, which will run for three years, is designed to test variations in soil loss caused by differences in length of slope, degree of slope, precipitation, soil permeability, soil stoniness, topographic position, and gradient of the skid trails.







Yarding logs with tractors on steep hillsides often leads to accelerated erosion. A, Pattern of skid trails after logging. Arrow indicates location of skid trail shown in B (1 year after logging), C (2 years after logging), and D (6 years after logging). Greatest soil movement from this steep skid trail took place during the first 2 years, when the friable top soil was exposed; erosion of the hard-packed subsoil proceeded at a slower rate during the next 4 years. It will be many more years before the soil is again protected from accelerated erosion.

## Logging Roads

Truck roads are also known to be one of the most important sources of erosion in logging operations. Because roads are an integral part of the timber harvesting process, however, it is difficult to assess their relative contribution to sediment in streams. A study now under way in the Andrews Experimental Forest is designed to meet this problem by providing for measurement of the separate effect of logging roads.

Approximately 1.6 miles of logging road, enough to high-lead yard the 250-acre test drainage where a timber sale has been made, will be built during the summer of 1959. Then, logging will be delayed for three winter seasons while effects of road construction on streamflow and siltation are measured. Any radical change in sediment load after road building can be attributed to construction.

All practicable precautions will be taken during road construction to avoid excessive disturbance, without attempting special measures that would not ordinarily be followed in a logging operation. After the roads are completed, they will be studied to pinpoint causes of erosion that does occur.

In the meantime, a study of existing roads was begun last year in cooperation with the Bureau of Land Management and Oregon State College to determine key sources of erosion. Soil movement from plots on road banks is being measured in a specially designed filtering system to separate eroded material from surface runoff. Data will be analyzed to determine what soil properties, slopes, and other conditions contribute most to erosion from cut banks. A second phase of the study is to find methods of minimizing this soil movement.

Road-bank erosion plot, with catchment for filtering out soil.

## Use of Fertilizer in Seeding Grass

After a logging operation has run its course, control measures are often needed to prevent serious erosion. Grass seeding is one practice that has demonstrated its value when used in the right place and done in the proper manner.

A test on the west side of the Cascade Range indicates the importance of using fertilizer in obtaining adequate stands of grass. The experiment was conducted on an abandoned road that penetrates a typical old-growth Douglas-fir stand and traverses soils derived from andesitic and basaltic rock. During most of the year, it is a moist and shaded site. Seed (7 pounds per acre) consisting of Tualatin oatgrass, alta fescue, English ryegrass, and white and Alsike clovers was broadcast by hand over the road surface. A 6:10:4 (nitrogen--phosphorus--potassium) commercially available fertilizer was applied at the rate of 450 pounds per acre.

Results of the experiment showed that establishment of a grass cover was aided by application of a fertilizer. Scarification treatment, which consisted of raking the compacted road surface, did not add significantly to successful establishment. Ocular estimates on 60 plots showed poor to fair success on all unfertilized plots; better than two-thirds of the fertilized plots were classed as good or superior:

| Treatment | Poor and fair (Number) | Good and superior (Number) |
|---|---|---|
| None (control) | 15 | 0 |
| Scarified | 15 | 0 |
| Fertilized | 5 | 10 |
| Scarified and fertilized | 4 | 11 |

## Use of Fertilizer on Native Grasses

Benefits of fertilizer application were shown in tests on two severely depleted Swauk sandstone sites in Mission Creek watershed near Wenatchee, Wash. Significantly increased growth of native grasses resulted from application of nitrogen, phosphorus, and potassium in various combinations. A nonorganic wetting agent was also tested. Best response in both study areas was obtained with $N_3P_2K_2$. Air-dry yields (pounds

per acre) of plant cover used to evaluate effects of fertilizer treatment were as follows:

| Treatment | Area 1[1/] | Area 2[2/] |
|---|---|---|
| $N_3P_2K_2$ | 610 | 1950 |
| $N_3$ | [3/] 260 | 1770 |
| $N_2P_1$ | 450 | 1480 |
| $N_1P_1K_1$ | 510 | 1350 |
| $N_1P_1K_1$ + wetting agent | 490 | 1330 |
| None (control) | 130 | 920 |

[1/] First year after fertilization.

[2/] Second year after fertilization. (No clippings taken previously.)

[3/] Not significantly greater than production on control plots. All other yields from fertilized areas were significantly greater than yields from control plots.

## Wetting Agents and Infiltration Rate

Other tests in the Swauk sandstone soil type show that a wetting agent can substantially increase the rate at which water enters the soil. After application to small runoff plots on a denuded slope of 30 percent, measurements were made to determine the effect on sediment production and on infiltration of water into the soil. The treated soil took in water more rapidly, as indicated by significantly reduced runoff, and sediment production was significantly lower:

| | Total runoff (ml.) | Infiltration rate (in. per hr.) | Volume of sediment (cc.) |
|---|---|---|---|
| Treated | 415 | 4.94 | 81 |
| Control | 965 | 3.53 | 234 |

## FOREST COVER AND SNOW

Low summer streamflows constitute a growing problem in the Pacific Northwest. At this time of year, when water supplies are lowest, demands for water are at their peak. Since a large part of the flow originates from melting snow, there has been considerable interest in the possibility of improving on the natural storage of water in the yearly snow pack. Two related possibilities present themselves: one is to increase accumulation of snow on the ground by removing timber in patches, and the second is to slow rates of melting by cutting the patches in a pattern designed to provide maximum shade and shelter. As a preliminary step to cutting studies, however, it is important to learn how snow accumulation and melt are affected by the natural environment of a forest.

### Natural Variations in Snow Accumulation and Melt

Examination indicates considerable variation in snow accumulation and rates of melt in forested areas. These characteristics were measured during spring in two areas of the Blue Mountains in Oregon--Anthony Lakes and Tollgate.

Stands in both areas were patchy and consisted primarily of lodgepole pine and white fir. Snow water content was sampled in 50 natural openings of varying size in each area during the melting period. Analyses show wide differences between these two areas in the relation of environmental factors to snow. Seven factors--elevation, degree of slope, aspect, shade from trees, shelter from wind, radius of opening, and area of opening--were used to represent conditions affecting snow at each measurement point. Points were selected to include a full range of available conditions.

Near Anthony Lakes, in a basin sheltered by mountains, snow accumulation (water equivalent) at the measurement points was significantly related to the environmental conditions characterized by the above seven factors. At the same measurement points, rate of melt was not significantly related to environmental factors. At Tollgate, where sample points were located along or near an exposed ridge, the converse was true: rate of melt was related to environmental factors, but amount of snow accumulation was not. Since approximately the same range of environmental factors was sampled at each area, the differences must be due to topography.

Results of this preliminary study will be used in designing controlled experiments on the effect of forest cutting on snow. They also emphasize the importance of cautious application of research results to different areas.

Measuring snow depth and moisture content in a late-season drift in a forest opening.

## FOREST COVER AND STREAMFLOW

Since the fall of 1952, runoff records have been collected from streams of three small watersheds in the H. J. Andrews Experimental Forest. Average precipitation during this period was 83.4 inches. Average annual flow was equivalent to a volume of water that would cover each watershed to a depth of 60 inches, indicating that 71 percent of the precipitation appeared in the stream as runoff.

Minimum flow occurred in either September or October each year, with high flows extending from December through March. The highest flow recorded for 1 month was 23.75 inches in December 1956. This represented 26 percent of the total for that year. Thus, natural streamflow ranged from superabundant in the winter to very low in late summer. When roads are built and timber is removed from these small watersheds, the study should reveal (1) whether logging makes significant changes in the streamflow pattern, and (2) the effect on high and low flows.

## EVAPORATION FROM A FREE WATER SURFACE

Farmers, ranchers, and municipalities are all interested in minimizing water losses during periods of low water availability. During hot summer months, water evaporated from ponds, lakes, and reservoirs constitutes a severe loss that is not easily replaced. An experiment was conducted near Portland, Oreg., to determine the efficacy of hexadecanol (cetyl alcohol) in reducing evaporation. Results corroborated other work done both in this country and abroad, and indicated that hexadecanol reduces evaporation by 42 percent.

## PLANS FOR 1959

Logging and erosion: Continue collection of streamflow and sediment data from experimental watersheds on the H. J. Andrews Experimental Forest. Now that a 6-year calibration period has been completed, major effort will go into planning treatments, applying them on the watersheds, and measuring results.

In southwestern Oregon, continue measurements of erosion on tractor skid roads, expanding the study by adding more plots.

In western Oregon, continue studies in an effort to determine when logging debris can be safely left in stream channels. An attempt will be made to define critical values for some of the more important factors influencing this decision, such as drainage area and stream gradient.

Erosion control: Continue measurements in Mission Creek watershed to determine duration of the stimulating effects of fertilizer. Soil analyses will also be made on fertilized plots to evaluate changes in physical and chemical properties of the soil.

At Starkey Experimental Forest and Range, start observations on four runoff plots of the depleted grass site. A 3-year period will be required for determining the hydrologic characteristics of the plots, after which rehabilitation treatment will be applied and the effects measured.

Grazing and erosion: Continue a study on the Starkey Experimental Forest and Range for determination of possible differences in soil erosion under light, moderate, and heavy intensities of cattle stocking and two systems of grazing management. Debris basins for each pasture treatment and ungrazed check watershed will be remeasured to determine the extent of any changes in volume of deposited sediment.

Forest cover and snow: Establish plots in lodgepole pine stands in the Blue Mountains of eastern Oregon as a first step in determining optimum size and shape of patch cuttings for maximum snow accumulation and minimum rate of melt.

In the Bull Run watershed, corridors of varying widths have been laid out in an old-growth Douglas-fir stand. Next year, plans call for measuring the snow stored in these unlogged areas. Subsequent measurements will be made after removal of timber from the strips.

# Forest Disease Research

Inadequacy of available basic information about forest diseases is more noticeable as forest pest control becomes more intensively practiced. Enough is known, for example, about dissemination of ponderosa pine dwarfmistletoe so that control can be undertaken with reasonable assurance, yet frequent failure of the parasite to conform to predicted distribution patterns suggests that control could be obtained more cheaply, and with less interference with other management considerations, if the reasons for the parasite's departure from expected behavior were understood.

The Station's forest disease research has been largely concerned with "whats"--what agencies are responsible, what conditions favor their activity, what are their effects. Answers to these questions are necessary, but they are not enough. They do not indicate where diseases can be most successfully attacked, nor do they permit safeguards against costly failures that may result from factors of unsuspected importance. Efficient control of forest diseases demands knowledge of the "hows and whys" of their behavior.

## NURSERY AND PLANTATION DISEASES

### Survival of Planting Stock

Sugar pine seedlings were found to survive better if planted soon after digging than if dug in the fall and stored under refrigeration during the winter, as shown in the following tabulation:

| Treatment | First-year survival (Percent) |
|---|---|
| No storage period (600 trees) | 49 |
| Stored during winter (600 trees) | 36 |

Transit periods of 2 weeks or less appeared to have little effect on survival of either refrigerated or nonstored stock.

Survival of ponderosa pine seedlings taken from refrigerated storage was not affected by heel-in periods up to 5 weeks in length, nor by leaving seedlings in unopened bundles for 1 week. However, survival was reduced when seedlings remained in unopened bundles for 2 weeks after leaving storage.

## Control of Damping-Off and Fusarium

In greenhouse tests with ponderosa pine seedlings, germination was increased and mortality decreased by addition of fresh pine sawdust to nursery soil at a rate of 100 cubic yards per acre. Captan used as a soil dust also reduced disease losses. Field applications of pumice, peat, and pulverized cones as soil mulches; variation in depth of sowing, and sowing in the fall proved less effective in reducing losses than previously reported results indicated.

In field tests at the Bend (Oregon) Nursery, sawdust used as a soil amendment continues to reduce disease losses (table 6).

Table 6.--Final stand of ponderosa pine seedlings per square foot, soil amendment tests

| Bed Number | Untreated soil | Sawdust (cu.yds. per A.) | | | Pumice (100 cu.yds. per A.) | Peat (100 cu.yds. per A.) |
|---|---|---|---|---|---|---|
| | | 100 | 200 | 400 | | |
| | Number | | | | | |
| 1 | 18 | 25 | 30 | 26 | 14 | 14 |
| 2 | 23 | 28 | 36 | 35 | 29 | 25 |
| 3 | 31 | 31 | 36 | 43 | 28 | 30 |

# ROOT DISEASES

## Poria Weirii Root Rot of Douglas-Fir and Other Conifers

Further work has strengthened the conclusion that western hemlock often survives and grows to sawtimber size in centers of infection, whereas Douglas-fir is largely or entirely destroyed. Mountain hemlock, on the other hand, appears highly susceptible. Characteristic infection centers, with severe damage, have been found in mountain hemlock types where no Douglas-fir is present. These observations, together with the known high susceptibility of some of the true firs, suggest that this disease may be an important factor in management of upper-slope types.

Mountain hemlock stand damaged by Poria weirii.

## Phytophthora Disease of Port-Orford-Cedar

This killer is continuing its spread into the natural range of Port-Orford-cedar. Newly invaded areas include the Rogue River drainage near Gold Beach, Hunter Creek in western Curry County, and Rock Creek on the Powers-Agness road. At McGribble Guard Station, where the disease was first found in 1957, it has continued to spread and intensify, indicating that damage will not be confined to river bottoms and the coastal shelf.

## SCARS AND DECAY IN YOUNG TREES

Scarring of residual poles during thinnings appears unlikely to result in serious decay in Douglas-fir but may cause appreciable volume loss in western hemlock. In one locality in western Washington, dissection data from 45- and 57-year-old Douglas-firs in two localities and 61-year-old western hemlocks were as follows:

| | Trees dissected (Number) | Scars (Number) | Scars infected (Percent) | Gross volume lost (Cubic feet) |
|---|---|---|---|---|
| Douglas-fir | 34 | 73 | 22 | 0.9 |
| Western hemlock | 28 | 82 | 56 | 3.4 |

Scar ages ranged from 3 to 10 years; scar sizes, from less than 0.1 to more than 5 square feet. Studies of older scars are needed.

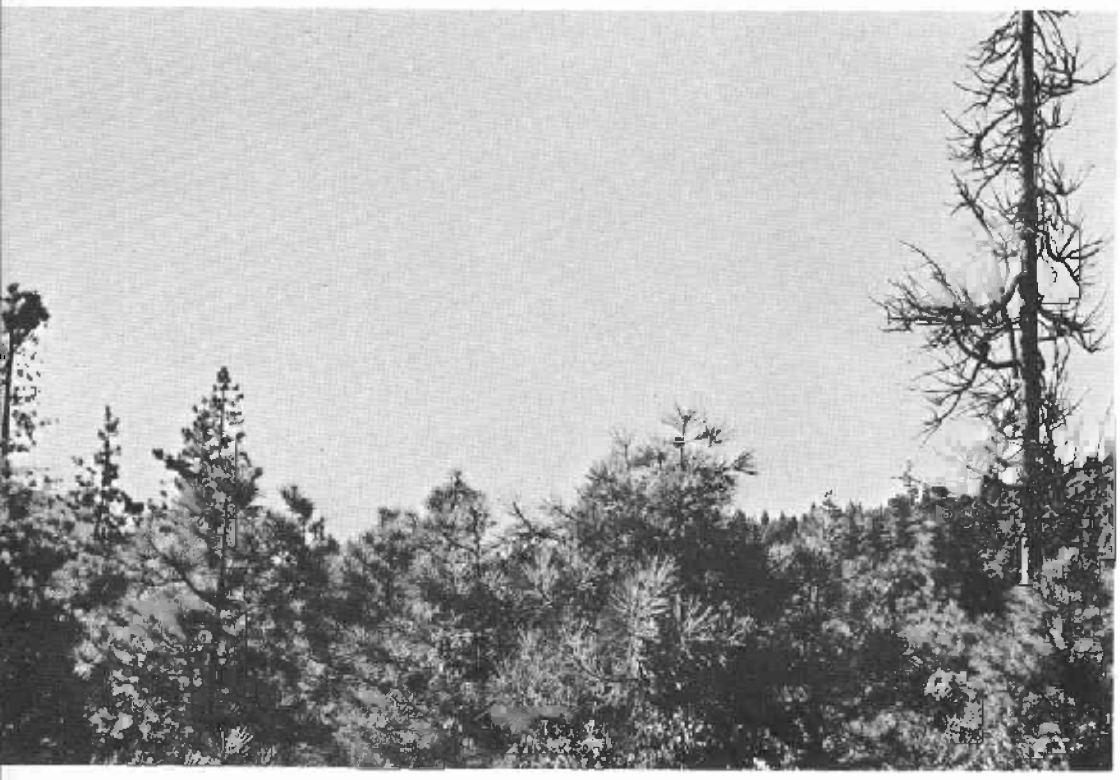
## DWARFMISTLETOES

### Damage to Douglas-Fir in Southwestern Oregon

Dwarfmistletoe is abundant and recent losses have been heavy in many of the mature Douglas-fir stands in this part of the region. An aerial survey of three ranger districts on the Rogue River National Forest located a number of areas where immediate salvage is necessary. Moderate to severe damage was observed on more than 8 percent of the acreage surveyed. On at least an additional 30 percent, infection is abundant but has not yet killed many trees.

### Distribution on Ponderosa Pine

Dwarfmistletoe is widely scattered, usually in small patches, through young stands on old clear-cut areas on the Deschutes National Forest. Most of this infection is closely associated with infected residuals too



Mistletoe infection in residual overstory trees spreads to surrounding reproduction. Tree at right was killed by mistletoe, but not before nearby reproduction was ruined. Note "broom" in top of young sawtimber tree at left.

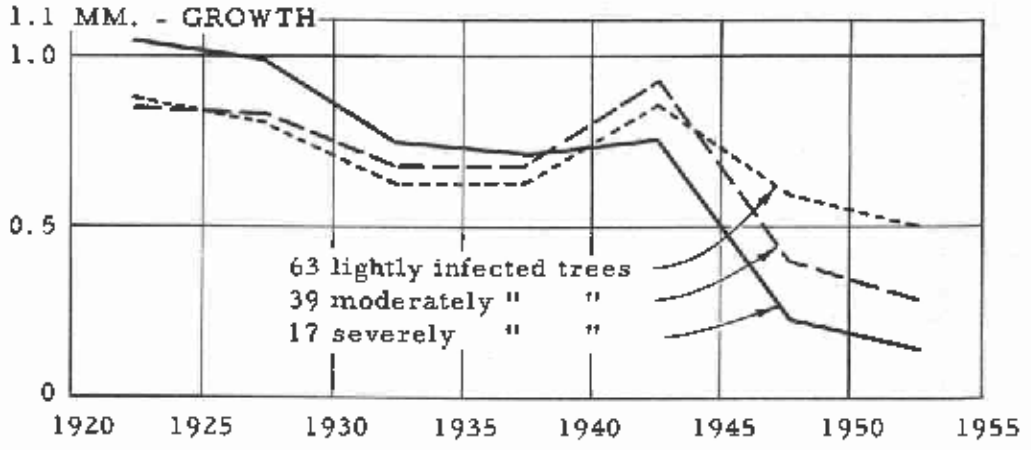
small at time of logging to be merchantable. In an extensive precontrol survey of 35,000 acres, infection on reproduction was found on or near one-quarter of the stocked sample plots, and on two-thirds of the quarter sections sampled. Nevertheless, even where infection is most severe, enough uninfected or prunable infected trees are present to permit elimination of the parasite without excessive reduction in stocking. On four infected areas selected for pilot-scale control, more than half of the sample plots were infected but more than four-fifths of the trees were uninfected.

## ELYTRODERMA NEEDLE BLIGHT OF PONDEROSA PINE

Infection intensities have changed only slightly in most localities during the 9 years that study plots have been under observation. On 2 plots in northern Washington and 1 in eastern Oregon, however, a large increase in infection was apparent in the spring of 1958. These new infections will hasten injury or death of trees already severely infected, and will increase the number of trees likely to be damaged eventually.

Evidence accumulated during the past several years shows that infections in ponderosa pine are perennial, and that most of them continue to kill the year-old foliage each spring until the affected twig dies.

Increment cores from 200 mature trees indicate that the current outbreak of this disease started in the early 1940's--at least in two centers of severe infection in eastern Oregon--and that reduction in growth rate since 1945 has been generally proportional to severity of infection. Growth prior to 1940 was about the same, or perhaps slightly better, on trees that are now severely infected as on trees that are only lightly infected. Core analyses are complicated by frequent absence of growth rings, especially since 1945, in severely infected trees.




Average annual diameter growth, by 5-year periods, of overmature ponderosa pines infected by needle blight on a plot in eastern Oregon.

## MISCELLANEOUS DISEASES

Verticillium wilt of bigleaf maple was unusually common and damaging in most of western Washington and northwestern Oregon during 1957 and 1958. Although few trees were entirely killed, large parts of many crowns were destroyed. In some instances, large trees that had been killed back to ground level in 1957 sprouted freely from the base in 1958.

Foliage scorch was common on hardwoods in several localities as a result of the exceptionally hot, dry summer. Larch needle blight was again abundant, as were a few other foliage diseases in some stands. Damage, however, seems to have been negligible.

Killing of Douglas-fir by sudden cold during the "deep freeze" of 1955 has proved somewhat more common than it appeared to be during the first year after the freeze. In one locality, small groups of Douglas-firs, amounting to 1 or 2 percent of a several-thousand-acre stand, were girdled by freezing of the cambium on the lower trunks. These trees survived through the summer of 1956 and died in 1957.

## PLANS FOR 1959

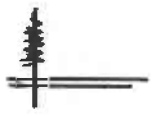
1. Give increased attention to Poria weirii, Armillaria mellea, and other root rots, especially those attacking Douglas-fir and ponderosa pine.

2. Continue studies of distribution, effects, and control of dwarfmistletoe in ponderosa pine stands. Continue observations preliminary to intensive research on dwarfmistletoes of Douglas-fir and lodgepole pine.

3. Continue studies of needle blight behavior and damage on ponderosa pine.

4. Test effectiveness of Acti-dione (a systemic fungicide) against various forest diseases, especially white pine blister rust and ponderosa pine needle blight.

5. Continue cooperation with other organizations in a program for production of white pine and sugar pine planting stock resistant to blister rust.



# Forest Economics Research

Increasing interest in the overall, long-term timber supply situation in the Pacific Northwest materially influenced the economics research program of the Station in 1958.

A major study, begun about the middle of the year, was designed to bring together and interpret the best available data regarding the amount and quality of timber that the forests of the Douglas-fir subregion (western Oregon and western Washington) might contribute to the Nation's total supply. Any analysis of the region's present or potential timber supply must consider the forest-land ownership pattern. Consequently, work was started to develop techniques for the collection, classification, and analysis of forest ownership data as to size of holding, intent of ownership, and management policy.

Another important factor in the analysis of timber supply is the degree to which the timber is utilized, both in the woods and in the conversion plant. Development of a procedure for determining the intensity of woods utilization was the objective of a study completed during the year. A related study was begun to determine the economic feasibility of increased utilization of woods and plant residues, and another study was established to develop an estimate of the volume and value of salvable mortality in old-growth Douglas-fir stands.

As in recent years, the Forest Survey periodic county reinventory program was closely correlated with national forest administration's working-circle inventory program. This cooperative effort seeks early completion of the working-circle inventory work in order to provide reliable information for revising annual cutting schedules on the region's national forests.

Cooperation continued with the Portland regional office of the Forest Service in development of aerial photo techniques for forest inventory work in the Pacific Northwest. (See Aerial Photo Techniques section.)

## ECONOMIC STUDIES

### Timber Trends in the Douglas-Fir Subregion

During the year the Station began a study of the long-range timber-supply outlook in the Douglas-fir subregion. One purpose of the study is to estimate how much timber the subregion can produce economically. Another

is to analyze the problems of reaching potential timber output. A third purpose is to furnish some useful general guides to forest-land owners and wood-using firms for use in management planning.

This study began with recompilation of Forest Survey plot records and inventories of commercial forest lands and timber, with emphasis on details of ownership, site quality, and age class. From this starting point, an effort will be made to project the development of the resource, period by period, through the time of old-growth harvest and into the ensuing young-growth era. Some predicting will be done, but the main effort will go into studying the consequences of alternative future developments--for example, alternative lengths of rotation and alternative trends in industrial growth and in wood utilization.

As a guide to assumptions and predictions, the study has been discussed with a sample of forest-land owners--private landowners both large and small, and representatives of public land-management agencies. Through these discussions it has been possible to learn the consensus about the future of timber production in the Douglas-fir subregion, and also to focus upon the production problems most worthy of analysis.

The analytical phase of the study will be undertaken early in 1959.

## Estimation of Forest-Land Area by Ownership Class

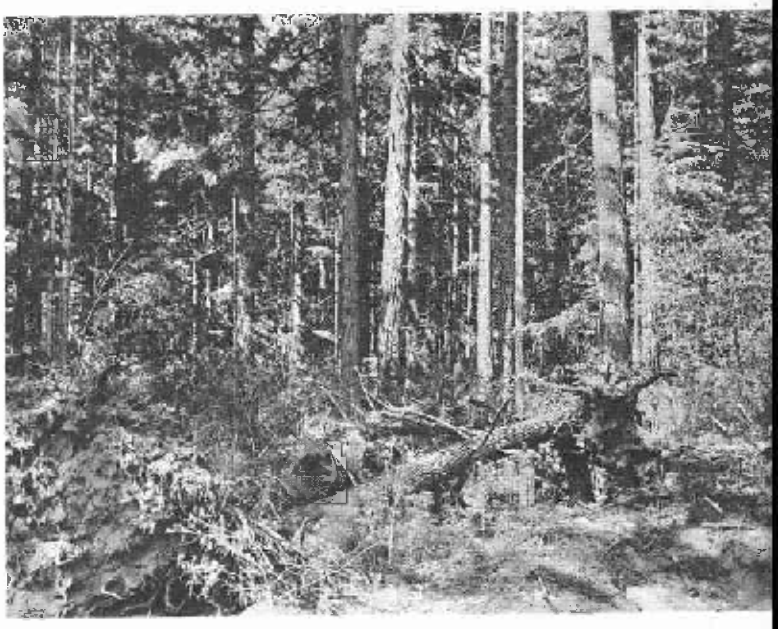
A study was completed during the year to develop a technique for classification of forest-land ownership in more detail than has heretofore been done in the Pacific Northwest. The resulting technique, based on random-point sampling, utilizes current Forest Survey type maps and 100-percent, in-place records of forest ownership to (1) separate the broad class of private forest-land owners into nonindustrial and industrial owners, (2) subdivide the industrial owners into large, medium, and small classes, and (3) estimate the extent of forest ownership by stand-size class of timber within each owner class.

The technique was found to be practical, and an article describing it has been accepted for publication in Agricultural Economics Research.

## Amount and Value of Mortality in Old-Growth Douglas-Fir

Preliminary estimates indicate that old-growth Douglas-fir stands in western Oregon and western Washington sustain an annual volume loss due to mortality of approximately 1 billion board-feet. Because this material is not harvested and processed, the region's forest economy suffers a substantial annual loss in terms of stumpage values, values of manufactured products, and wages. Some of this material is currently being recovered through salvage operations and some will still be salvable when the stands are logged many years from now. Much more, however, could be utilized

promptly under favorable economic conditions, thus adding to the annual log harvest or reducing the pressure to cut live timber.



Scattered windthrown trees and other losses present a challenge for development of mobile equipment capable of promptly salvaging this material.

Although much depends on the construction rate of access roads into the old-growth Douglas-fir stands, it was estimated in 1956 that some 25 percent of this forest type was within 1,300 feet of existing roads.

## Wood Residues and Minor Species

As log harvest in the region approaches calculated allowable annual cuts, greater interest is expected in the utilization of logging and plant residues and minor species. Consequently, an analysis of the situation was made in preparation for studies of the economic obstacles to increased use of this material. As a result of the analysis, research under consideration includes economic availability of logging and plant residues, demand for timber from minor species, and several aspects of salvage logging.

## Christmas Trees

During 1957, the most recent year of record, 2.7 million Christmas trees were produced in Oregon and Washington. Two-thirds of this production was shipped out of the region, principally to California markets. Approximately 40 percent of the number exported was shipped by truck; 60 percent by rail. Private lands furnished 90 percent of the harvest. Major

commercial production occurred in Mason and Kitsap Counties, Wash., and Klamath and Josephine Counties, Oreg.

Douglas-fir was the principal species harvested, representing 94 percent of all species produced in Washington and 56 percent in Oregon. Average price for a 6-foot Douglas-fir in Oregon was: stumpage, $.30; roadside, $.65; wholesale, $.90; and retail, $2.50. In Washington, corresponding prices were $.25, $.45, $.70, and $2.25.

## FOREST SURVEY PROGRAM

### Forest Inventory

Cooperative effort in the Forest Survey program for reinventorying the region's forests continued to be productive in 1958.

Good progress was made on an intensive forest inventory of the Spokane and Colville Indian Reservations in northeastern Washington. This project, which was started late in 1957 under a cooperative arrangement with the Bureau of Indian Affairs, includes a survey of the range-forage resource on reservation timberlands. Computation of field data and analysis of inventory results for the Spokane Reservation were completed and a statistical report prepared for the Bureau. Also prepared were an intensive forest type map, showing dual types (understory as well as overstory), and an up-to-date ownership status map, both on a scale of 4 inches to the mile. Field work on the Colville Reservation, which contains some 900,000 acres of forest land, was completed and work was begun on computation of data and preparation of the forest type map.

Close cooperation again existed between Forest Survey and national-forest administrators in the joint inventory of approximately 900,000 acres of commercial forest land in four national-forest working circles. In addition, eight working circles were inventoried to Forest Survey standards by national-forest crews. These 12 working circles are located in several counties of both Oregon and Washington, and the data will be incorporated with data from subsequent Forest Survey work on lands in other ownerships. Forest Survey completed field inventory work on lands outside national forests in Grant and Union Counties, Oreg., and in Asotin, Columbia, Garfield, and Walla Walla Counties, Wash. Work was also begun in Okanogan County, Wash., an area in which cooperation was initiated with the inventory section of the Washington Department of Natural Resources.

Results of reinventories of the forests of Wasco, Baker, and Malheur Counties, Oreg., were analyzed and published.

### Forest Growth

During the year, an analysis was made of growth and mortality data from an inventory of the Middle Fork Working Circle on the Malheur

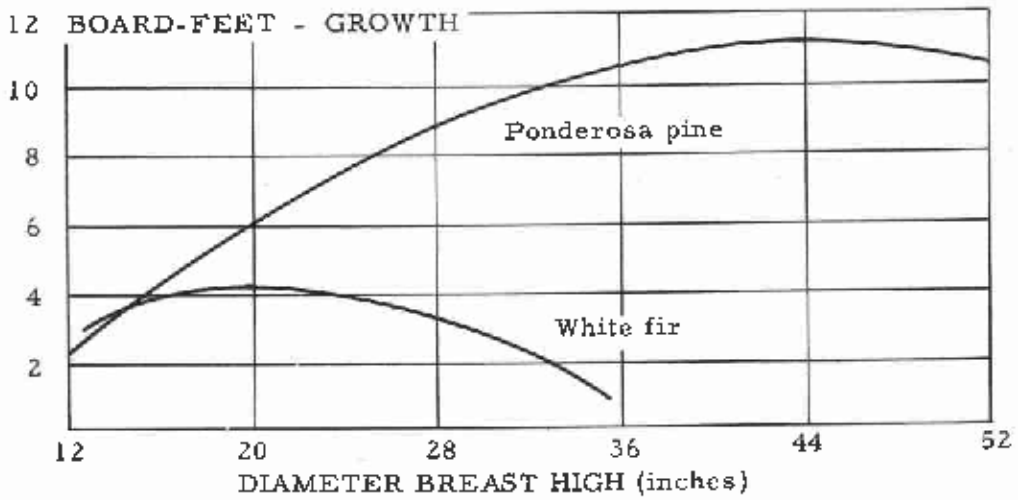
National Forest in eastern Oregon. Gross-growth, mortality, and net-growth estimates were calculated by forest types. In calculating gross growth, adjustments were made for the increase of cull volume in live trees.

Growth and mortality estimates for sawtimber stands were:

| | Volume, per acre per year (Board-feet) |
|---|---|
| All types: | |
| Gross growth | 132.5 |
| Net growth | 94.5 |
| Mortality | 38.0 |
| Ponderosa pine type: | |
| Gross growth | 112.9 |
| Net growth | 78.1 |
| Mortality | 34.8 |
| "Other" types:[1/] | |
| Gross growth | 149.2 |
| Net growth | 108.5 |
| Mortality | 40.7 |

[1/] Includes Douglas-fir, white fir, western larch, Engelmann spruce, and lodgepole pine types.

Net stand per acre for all types averaged 9,087 board-feet; for the ponderosa pine type the average was 8,952 board-feet, and for the "other" types it was 9,200 board-feet.




Average annual gross growth of ponderosa pine and white fir trees, Middle Fork Working Circle, Malheur National Forest.

Ponderosa pine, in terms of individual trees and not as a stand, has a greater potential for growth than does white fir, according to inventory data. This is true because ponderosa pine, as a rule, is less affected by cull increment. In the study area, the effect of cull increment in white fir is apparent from the data, which show a gross-growth decrease beginning in trees of about 20 inches d.b.h. The ponderosa pine data show no growth decrease until after a diameter of about 48 inches has been reached.

## Logging Utilization Factors

A study was begun in eastern Oregon to determine what the annual reported volume of timber harvested for a county, State, or region represents in drain on the Forest Survey inventory volume of sound, live timber. The study is designed to answer the following questions:

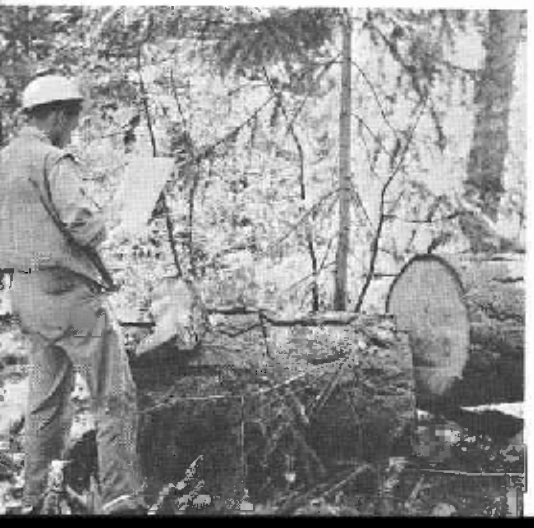
1. In harvesting timber, what part of the Forest Survey inventory volume felled or killed in logging is removed from the woods in the form of timber products, and what is left as logging residue?

2. What volume of timber products is removed from tree tops, cull logs, cull trees, and dead trees not included in the inventory of sound, live timber?

3. What are the sizes, shapes, and possible uses of logging residue material?

4. What are the differences in scaled volume under various scaling practices as logs are moved from the woods to conversion plants?

This study is the first attempt by the Station to determine these factors by means of a "hot" logging study. A survey crew, working with various felling crews on seven different operations throughout eastern Oregon, "cruised" trees to standard Survey specifications before felling,

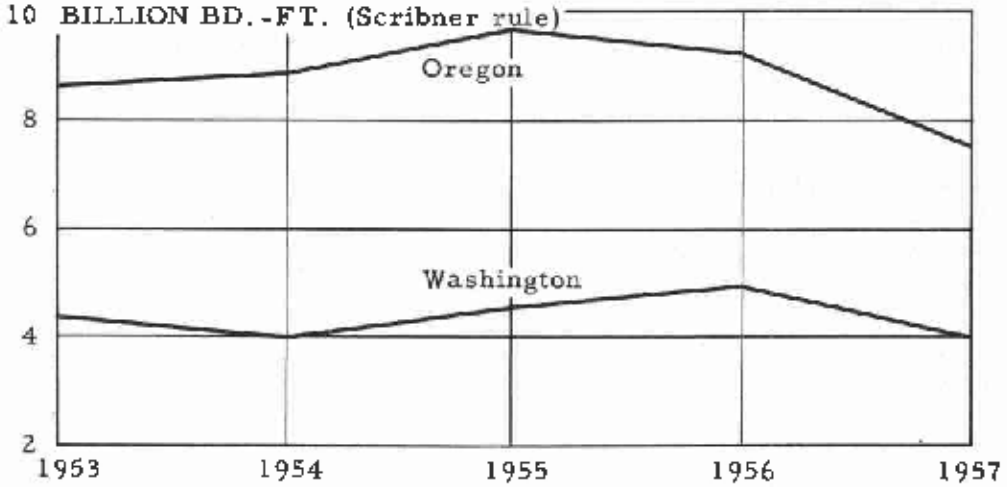


Logging utilization studies were begun in 1958 to determine the relation between inventory volumes, logging residue, and actual log harvest.

scaled the logs after felling and bucking, and measured and classified the residue remaining after yarding. Perhaps a unique feature of the study was the identification of each part of the tree's bole by a distinctive paint color in order to facilitate identification of residual material after logging had been completed.

## Effects of 'Recession' on Log Production

The slump in business activity during 1957 had a significant impact on the output of timber products in Oregon and Washington. Decreased production of lumber, plywood, and pulp resulted in a materially reduced demand on the forests for raw material. The annual log harvest in Oregon had been generally increasing since 1953, going in that year from 8.6 billion board-feet (log scale, Scribner rule) to 9.3 billion in 1956. In 1957 it dropped to 7.6 billion, a decrease of almost 23 percent from the previous year's harvest and a 14-percent decrease from the average for the previous 5 years. Production in Washington had also been trending upward for several years before 1957. However, production in 1957 dropped to 4.0 billion, a decrease of 20 percent from the 1956 output of 5 billion, and a 9-percent decrease from the previous 5-year average.



Production of logs in Oregon and Washington, 1953-57.

## Data Processing Programs

During 1958, electronic computer programs were developed for calculating estimates of average growth per acre by species for both the Douglas-fir subregion and the ponderosa pine subregion. (A program for processing forest inventory data from all parts of the region was developed in 1957.) These programs have been of considerable interest both locally and outside the region, as they can be adapted for other extensive inventory and growth projects. Several Federal and State agencies and private corporations have used them.

## PLANS FOR 1959

1. Complete field work for reinventory of forests in Okanogan, King, Pierce, Clallam, and Jefferson Counties, Wash.

2. Complete computations and analyze results of the inventory of Colville and Spokane Indian Reservation forests, conducted in cooperation with the Bureau of Indian Affairs.

3. Complete computations and analyze results of reinventories of Umatilla, Union, and Grant Counties, Oreg., and Asotin, Garfield, Columbia, and Walla Walla Counties, Wash. Prepare statistical reports for these counties and also for Wallowa County, Oreg., and Skagit and Whatcom Counties, Wash.

4. Complete calculation of net forest-growth estimates for the central Oregon, south central Washington, and Wallowa-Blue Mountain units, all in the ponderosa pine subregion. Prepare reports on results.

5. Prepare a report on the study of timber trends in the Douglas-fir subregion.

6. Analyze for publication, results of the logging utilization factor study in eastern Oregon, and continue studies in other parts of the region.

7. Conduct 100-percent canvass of forest industries in eastern Oregon to determine kind, number, capacity, facilities, annual raw-material consumption, and annual product output. Correlate results of canvass with Forest Survey inventory, growth, and timber-cut data in the preparation of an analytical half-State report.

8. Prepare for publication, programs for IBM-650 electronic machine computation of forest-inventory and growth data.

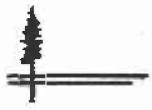
9. Prepare a report on amount and value of mortality in old-growth, Douglas-fir stands.

10. Begin study of a classification system for small forest-land owners in the Pacific Northwest region.

11. Begin studies of economic availability and utilization of wood residues and minor species.

12. Make exploratory studies of lumber marketing problems in the Pacific Northwest.

13. Continue development of the master sample grid procedure for conducting inventories of large forested areas.



# Aerial Survey Techniques Research

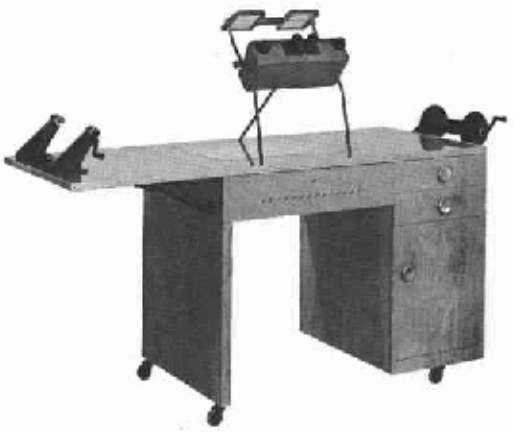
Aerial surveys are becoming increasingly useful for forest inventories, management planning, and assessment of forest insect damage. Purpose of the Station's program of research in this field is to develop and improve aerial techniques for increasing survey accuracy and for reducing the field work, time, and cost involved. The Portland regional office of the Forest Service is actively participating in the program.

Specific objectives of this cooperative research on aerial survey techniques are: (1) to determine the most suitable types of photography or methods of aerial observation for specific surveys, (2) to devise interpretation techniques for getting the most information from aerial photos, and (3) to develop methods for combining photo and field data into an integrated survey. Study results should be of use to forest-land managers, both public and private, throughout the West.

The 1958 season was highlighted by the initiation of two major studies in the field of forest inventory: one to develop improved aerial photo volume tables, and the other to determine if forest site class can be estimated from photos. Also, current studies on the photographic assessment of bark-beetle-caused mortality were essentially completed, and work was continued on studies to obtain from aerial photos more information useful in management planning.

## EQUIPMENT

A light-table was designed and constructed primarily for viewing of color transparencies with a mirror stereoscope. Individual control is provided for each of the 14 fluorescent lights so that uniform illumination can be achieved, even though the transparencies are of unequal density. The new table should materially improve the accuracy and speed of photo interpretation work in the many studies employing aerial color transparencies.



Light-table designed for interpretation of color transparencies. Note switches for control of individual lights.

## FOREST INVENTORY AND MANAGEMENT TECHNIQUES

In the field of forest inventory and management techniques, studies are under way for improvement of aerial-photo volume tables, photographic assessment of forest site class, and extraction of more detailed forest management information from aerial photos. Progress on these studies mostly involved collection of data, but this resulted in the following supplementary investigations.

### Stand-Height Measurements

The effect of instrument magnification on height measurements made on aerial photos was examined. A number of stand heights were measured by the parallax method on 1:12,000-scale photos, using stereoscopes with three different powers of magnification. Although not statistically significant, there was some evidence that increasing the degree of magnification resulted in poorer height-measurement accuracy. In general this confirms the results of other studies on image enlargement. Along with increased scale and print enlargement, magnification does not seem to be a promising way to improve height measurements.

### Slope Measurement

A test was made to determine the accuracy with which slopes could be measured on aerial photos. It was found that when elevation differences were measured, either by parallax instruments or by a simple templet, the resulting estimates of slope were generally within 10 percent of the actual slope. This applied to photo scales ranging from 1:12,000 to 1:20,000.

### Douglas-Fir Site Curves

While determining site index on a large number of field plots, it became apparent that the standard site curves were unhandy to use. The Douglas-fir curves were replotted in a different form, resulting in a series of straight lines that greatly facilitate necessary interpolation. These new site index charts were published in a Station research note.

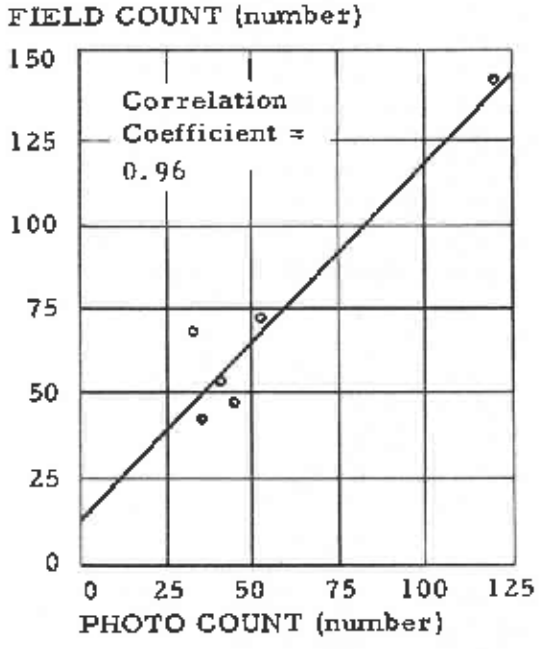
## INSECT DAMAGE EVALUATION

### Douglas-Fir Beetle

For several years, the Station has cooperated with Weyerhaeuser Timber Co. in studying the photographic assessment of mortality caused by Douglas-fir beetle epidemics. An analysis of the data has been completed and several significant findings have resulted.

Photographic counts of trees dead less than 1 year were highly correlated with corresponding field counts. This gives promise that during insect outbreaks, current annual mortality can be obtained from aerial photos, with only a small amount of field checking necessary and at a substantial reduction in overall survey cost.

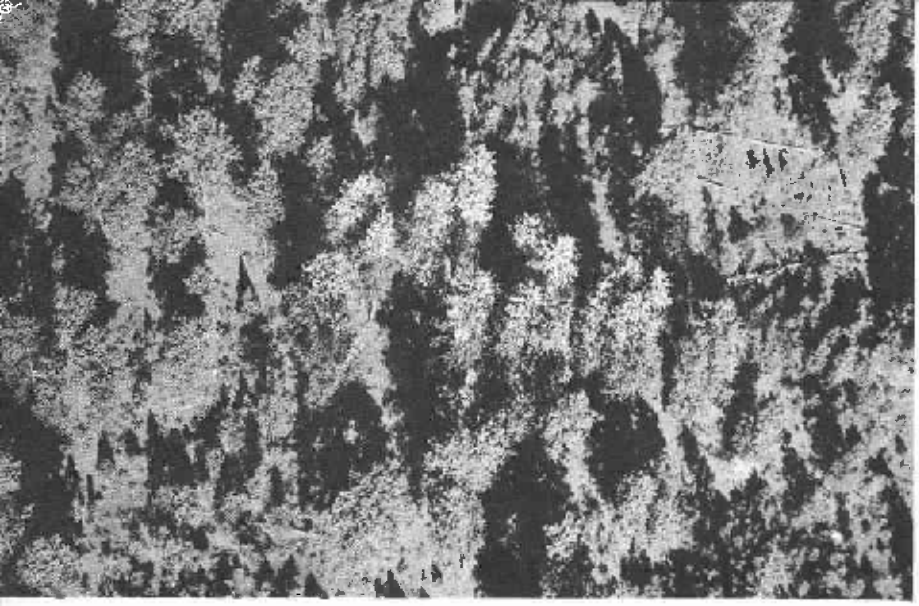
There is also an indication that the identification of current annual mortality is more accurate on color film than on panchromatic film, though the evidence is not conclusive. Current mortality is readily recognized during the first year of an insect epidemic because it is the only mortality of that kind present. However, identification of current mortality becomes progressively more difficult each succeeding year because it is mingled with mortality from previous years. If photography is delayed until an outbreak has been going for several years, even color film may give marginal results. This difficulty can be overcome, however, by taking photographs of the same area each year. By comparing these sequential photographs, interpretation accuracy can be maintained at a high level, even in the later years of an outbreak.




A study showed high correlation between photo and field counts of current mortality caused by the Douglas-fir beetle. Photo counts were made on color film by a single observer.

## Western Pine Beetle

Previous studies have indicated that when the western pine beetle is epidemic, aerial photographs can be used to replace a major part of the field work normally required to assess the loss. However, before this technique can be used to evaluate mortality under endemic conditions, photo-interpretation accuracy will have to be improved.



Large-scale aerial photo taken at an angle of 30° from the vertical. Trees with light-toned foliage are dead or top-killed as a result of western pine beetle attack.

A study to test several possible methods of improving interpretation accuracy was conducted in cooperation with the California Forest and Range Experiment Station. The methods tested included the use of very-large-scale photos and photos taken at an oblique angle of 20° from the vertical.

The standard (control) photography was 1:5,000 vertical, using color film. On these photos, the coefficient of correlation between photo count and field count of trees that were dying, or had died in the previous year, was 0.84. This confirmed previous experience on the usefulness of aerial photography in appraising epidemic losses. Preliminary analysis of the test results suggests that there is little hope of improving interpretation accuracy by increasing scale of photos, or by using obliques instead of verticals.

## PLANS FOR 1959

In the field of forest inventory, the major effort will be to complete the study on forest site evaluation and to develop improved aerial-photo volume tables and methods of application.

Forest management studies will be aimed at developing a simple method of making in-place volume estimates from aerial photos, preparing guides for mapping two-story stands in the Douglas-fir subregion, and testing large-scale photos for unit-area-control management in ponderosa pine types.

The principal goal in the forest insect survey field will be to improve photographic recognition of trees that are still infested with bark beetles, and to report the results of terminating studies.

# 1958 Publications by members of staff and cooperators

## FOREST ECONOMICS

Adams, Thomas C., and Syverson, Martin L.
Production and marketing of Christmas trees in the Pacific Northwest in 1957. 20 pp., illus. Pac. NW. Forest and Range Expt. Sta.

A survey of Christmas tree production and shipments in Oregon and Washington, including review of prices and marketing methods.

Bones, James T., and Hightree, Paul E.
Forest statistics for Baker and Malheur Counties, Oregon. Pac. NW. Forest and Range Expt. Sta. Forest Survey Rpt. 132, 43 pp., illus.

A statistical report presenting results of a recent reinventory of forests in the two counties. Contains information about land classification, forest-land area and ownership, and timber volumes and utilization. Some descriptive and interpretative information is included.

Choate, Grover A., and Johnson, Floyd A.
Site index charts for Douglas-fir in the Pacific Northwest. Pac. NW. Forest and Range Expt. Sta. Res. Note 161, 6 pp., illus.

A series of six charts based on height-age relationships facilitates determination of site index.

Gedney, Donald R., and McMahon, R. O.
Here is what is happening to logs in Lane County, Oregon. The Lumberman 85(8): 52-53, illus.

A flow chart is used to present a comprehensive picture of annual log consumption, processing, and products in the county.

_____ and Spada, Benjamin
Forest statistics for Wasco County, Oregon. Pac. NW. Forest and Range Expt. Sta. Forest Survey Rpt. 127, 33 pp., illus.

A statistical report presenting results of a recent reinventory of forests in the county. Contains information about land classification, forest-land area and ownership, and timber volumes and utilization. Some descriptive and interpretative information is included.

## FOREST MANAGEMENT

Berntsen, Carl M.

A test planting of 2-0 and 3-0 Douglas-fir trees on a steep south slope. Pac. NW. Forest and Range Expt. Sta. Res. Note 165, 4 pp.

Describes survival and growth of 2 ages of planting stock on a south slope where conditions are unfavorable for regeneration.

Bishop, Daniel M., Johnson, Floyd A., and Staebler, George R.

Site curves for red alder. Pac. NW. Forest and Range Expt. Sta. Res. Note 162, 7 pp., illus.

A preliminary report presenting site curves developed in the process of yield table construction. The curves are based on stem analysis of 43 felled and sectioned trees throughout western Washington.

Dimock, Edward J. II

Litter fall in a young stand of Douglas-fir. Northwest Sci. 32: 19-29, illus.

Annual fall of needle, twig, and small branch litter, studied for 6 consecutive years, reached a significant maximum rate during the month of October. Amount of fallen litter varied inversely with thinning intensity.

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Don't sell western hemlock short. Pulp and Paper 32(13): 112-114, illus.

Prodigious growth of young-growth western hemlock stands on the Olympic Peninsula was revealed through measurements of permanent sample plots over a 5-year period. Net yield exceeded that of Douglas-fir on comparable sites by 25 to 39 percent.

Gratkowski, H. J.

Natural reproduction of Shasta red fir on clear cuttings in southwestern Oregon. Northwest Sci. 32: 9-18, illus.

Detailed records of the pattern of natural regeneration of Shasta red fir on one setting after clear cutting were substantiated by results of a survey of nine additional units. The results indicate that the staggered-setting system of clear cutting with natural reproduction is a satisfactory silvicultural system for Shasta red fir in southwestern Oregon, but cuttings should be restricted to 20 acres or less in size.

James, George A.

Port-Orford-cedar plantations in the Pacific Northwest. Pac. NW. Forest and Range Expt. Sta. Res. Note 164, 2 pp.

Port-Orford-cedar is not a desirable tree for reforestation projects outside its natural range because it is highly susceptible to animal damage, slower growing than Douglas-fir, more susceptible to cold injury than native species, and subject to a very destructive root rot.

Krygier, James T.

Survival and growth of 13 tree species in coastal Oregon. Pac. NW. Forest and Range Expt. Sta. Res. Paper 26, 20 pp., illus.

A history of mortality and height growth in 9- to 19-year-old plantations of mostly introduced species. Compares surviving plantations with local stands of native species.

Meagher, George S.

Some silvicultural aspects of pest control through tree improvement. Soc. Amer. Foresters Proc. 1957: 55-57.

A primary silvicultural requirement is the need to develop trees not only resistant to a specific insect or disease but that are also well adapted to climate and soil of the planting site.

Morris, William G., and Mowat, Edwin L.

Some effects of thinning a ponderosa pine thicket with a prescribed fire. Jour. Forestry 56: 203-209, illus.

Fire of moderate intensity applied to a dense stand of ponderosa pine saplings produced the following results in the first 6 years on the well-stocked stand of potential crop trees that remained: (1) competitors were reduced from 2,400 to 900 per acre; (2) crop trees on the burned area grew 36 percent more in diameter and 7 percent more in height than those on the unburned area; (3) growth in both diameter and height showed a beneficial effect of burning in addition to the thinning effect.

Silen, Roy R.

Artificial ripening of Douglas-fir cones. Jour. Forestry 56: 410-13, illus.

Douglas-fir cones picked as early as August 1 were successfully ripened when stored in damp peat moss at 63° F. Resulting seed germinated equally as well as seed from tree-ripened cones. Dry storage of the cones or wet storage in a running stream gave poor results.

Staebler, George R.

Some mensurational aspects of the level-of-growing-stock problem in even-aged stands. Jour. Forestry 56: 112-115, illus.

Purely mathematical relationships between growth and growing stock are developed by expressing both in terms of tree diameter and radial increment for basal area; and diameter, height, and radial increment for cubic volume.

Tarrant, Robert F.

1957 bibliography of Pacific Northwest forest soils publications. Pac. NW. Forest and Range Expt. Sta. Res. Note 158, 3 pp.

Compilation of forest soils research publications pertaining to the region, issued during calendar year 1957.

Trappe, James M., and Harris, Robert W.
Lodgepole pine in the Blue Mountains of northeastern Oregon. Pac. NW. Forest and Range Expt. Sta. Res. Paper 30, 22 pp., illus.

A comprehensive description of habits and stand characteristics of lodgepole pine. Its greatest potential use in this area is for pulpwood.

Worthington, Norman P.
How much Douglas-fir will grow on an acre? Jour. Forestry 56: 763-764, illus.

Near-maximum yield of virgin Douglas-fir has been recorded on a 1-acre area on the Olympic National Forest near Lake Quinault, Wash.

## Silvical Series

The silvical series presents compilations of existing knowledge on the range, habitat conditions, life history, and special features of 13 tree species native to the Pacific Northwest. Number 1, covering red alder, was released in 1957; the following 12, released during 1958, complete the series.

Berntsen, Carl M.
Silvical characteristics of western hemlock. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 3, 16 pp., illus.

Dahms, Walter G.
Silvical characteristics of mountain hemlock. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 11, 8 pp., illus.

Dimock, Edward J. II
Silvical characteristics of Pacific silver fir. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 4, 12 pp., illus.

Hayes, G. L.
Silvical characteristics of Port-Orford-cedar. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 7, 11 pp., illus.

Isaac, Leo A., and Dimock, Edward J. II
Silvical characteristics of Douglas-fir var. menziesii. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 9, 18 pp., illus.

Ruth, Robert H.
Silvical characteristics of Sitka spruce. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 8, 19 pp., illus.

_____ and Muerle, Gerhard F.
Silvical characteristics of bigleaf maple. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 13, 10 pp., illus.

Silen, Roy R.
Silvical characteristics of Oregon white oak. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 10, 13 pp., illus.

Sowder, James E., and Mowat, Edwin L.
Silvical characteristics of western juniper. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 12, 9 pp., illus.

Staebler, George R.
Silvical characteristics of noble fir. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 5, 12 pp., illus.

Stein, Wm. I.
Silvical characteristics of California-laurel. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 2, 16 pp., illus.

Tarrant, Robert F.
Silvical characteristics of Pacific madrone. Pac. NW. Forest and Range Expt. Sta. Silvical Ser. No. 6, 10 pp., illus.

## FOREST PROTECTION

### Disease

Harvey, George M., and Cohen, Leon I.
The extent of blister rust mycelia beyond bark discolorations on sugar pine. Pac. NW. Forest and Range Expt. Sta. Res. Note 159, 4 pp.

The usual allowance of 4 inches between canker discoloration limits and pruning cut will usually be adequate for elimination of blister rust infection. In spring and early summer, however, the pruning allowance should be increased to 6 inches to allow for the occasional instance when mycelial extent exceeds 3-1/2 inches.

Wright, Ernest, and Tarrant, Robert F.
Occurrence of mycorrhizae after logging and slash burning in the Douglas-fir type. Pac. NW. Forest and Range Expt. Sta. Res. Note 160, 7 pp., illus.

In one locality, the number of mycorrhizal seedlings was inversely related to severity of burning; in another locality, a significantly smaller proportion of the seedlings was mycorrhizal on burned areas but no real difference was found between intensities of burn. In both localities, a larger proportion of 2-year-old seedlings had mycorrhizal roots than did 1-year-old seedlings.

### Fire

Cramer, Owen P.
Using fire-weather forecasts and local weather observations in estimating future burning index for individual fire-danger stations. Pac. NW. Forest and Range Expt. Sta. Res. Paper 28, 33 pp., illus.

A report on a test of climatological aids for estimating fuel moisture, relative humidity, and wind speed. Some increase in accuracy of burning-index estimates can be achieved through use of these aids in adapting the fire-weather forecast to individual fire-danger stations.

_____
Forest fire weather in western Oregon and western Washington in 1958. Pac. NW. Forest and Range Expt. Sta. Res. Note 163, 9 pp.

The hottest April-October fire season of record for these two half-State areas saw severer-than-normal fire weather in western Washington but near-normal fire weather in western Oregon.

Morris, William G.
Records and experience of discovering fires from aircraft. U. S. Forest Serv. Fire Control Notes 19(1): 25-26.

Reports describing discovery of 250 fires by aerial observers on national forests show that lightning started 96 percent of them, discovery time averaged 15 hours for those discovered in less than 3 days, distance from observer to fire averaged 1.3 miles, and only 3 percent of the fires covered more than one-quarter acre when discovered.

_____
Influence of slash burning on regeneration, other plant cover, and fire hazard in the Douglas-fir region (A progress report). Pac. NW. Forest and Range Expt. Sta. Res. Paper 29, 49 pp., illus.

Several years of record show that stocking of coniferous seedlings firmly established after logging did not differ significantly on many paired plots in which slash was burned on one and unburned on the other. Burning reduced brush cover, did not affect total cover of herbs, and affected species composition of both brush and herbs. Burning reduced estimated rate of spread and resistance to control of a fire for 5 years or more.

_____
Slash fire behavior correlates with fuel moisture indicator stick readings. The Timberman 59(10): 59-60, illus.

Fire behavior and fuel moisture indicator stick records for 171 slash burns on national forests showed that for the average fuel, slope, aspect, wind, and technique of firing, fires spread readily but did not spot when sticks read 14 percent in the slash and 20 percent or more in nearby timber. When sticks in slash read 16-1/2 percent, fires did not spread as readily, and when sticks were slightly drier than 14 percent, fires spotted outside. Results are averages for fall burns in drying periods after a rain.

## Insects

Whiteside, J. M.
Forest insect conditions in the Pacific Northwest during 1957. 49 pp., illus. Pac. NW. Forest and Range Expt. Sta.

Detailed summary of principal forest insect infestations, showing acreage and intensity of damage by insect species for private, State, and Federal forested areas.

Wright, Kenneth H., and Lauterbach, P. G.
A 10-year study of mortality in a Douglas-fir sawtimber stand in Coos and Douglas Counties, Oregon. Pac. NW. Forest and Range Expt. Sta. Res. Paper 27, 29 pp., illus.

Mortality, caused principally by the Douglas-fir beetle and wind, exceeded growth by more than 5 to 1 during the study period 1946-55.

## FOREST PRODUCTS UTILIZATION

Selbo, Magnus L., and Knauss, A. C.
Glued laminated wood construction in Europe. Amer. Soc. Civil Engin. Proc. 84 (ST7-1840): 1-19.

Traces development and practices of European laminating techniques and compares a European design with an American design for a given span.

## RANGE MANAGEMENT

Driscoll, Richard S.
New answers to old problems. West. Livestock Jour. 36(14): 33-39, illus.

An account of how improved grazing management practices and installations on the Starkey Experimental Forest and Range in eastern Oregon have bettered the range and increased beef production.

_____
A loop method for measuring ground-cover characteristics on permanent plots. Jour. Range Mangt. 11(2): 94, illus.

Describes a method for adapting the loop transect technique to range-plant cover inventory of circular plots.

## WATERSHED MANAGEMENT

Bethlahmy, Nedavia
Forests and water yield. Amer. Soc. Civ. Engin. Proc. 84 (SA6-1848): 1-5.

The forest environment can be manipulated to manage its water resources, but this must be accomplished without impairing soil characteristics.

_____ and Anderson, H. Kenneth
Watershed research in Portland, Ore. Jour. Amer. Water Works Assoc. 50(1): 110-114, illus.

Describes the physical characteristics of the Bull Run Watershed (source of Portland's water supply) and the problems that must be solved before proper watershed management measures can be undertaken.

Dunford, E. G.
Watershed management research in the Pacific Northwest. Jour. Soil and Water Conserv. 13: 23-26, illus.

A review of watershed management problems in the Pacific Northwest and a summary of a planned research program.

## GENERAL

Cramer, Owen P.
Review of "Experiences With the Weather," by William M. Bergman III. Jour. Forestry 56: 778-779.

Reviews a book that gives a chronological account of weather in the Chesapeake Bay area from 1930 to 1956.

Pacific Northwest Forest and Range Experiment Station
1957 Annual Report, 82 pp., illus.

Summary of Station research accomplishments during calendar year 1957 and plans for 1958.

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