ANNUAL REPORT

1963 THE FIFTY AND FIFTIETH YEAR (S)

Pacific Northwest
FOREST AND RANGE EXPERIMENT STATION
U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
1964

Foreword

1963 marked the fiftieth anniversary of the establishment of the Wind River Forest Experiment Station near Carson, Wash.—predecessor of the Pacific Northwest Forest and Range Experiment Station.

This annual report sketches some of the progress made in the half century just ended as well as highlights of 1963.

Fifty years have brought tremendous changes to the Pacific Northwest and its forests. For one thing, population increased from 1.9 to 4.9 million—more than 2.5-fold. Such statistics as are available for 1913 indicate that the area burned by forest fires changed in inverse proportion to population. Half a century ago forest fires burned 200,000 to 250,000 acres in an average year in the Northwest, or about 2-1/2 times more than now. During the 50 years just ended, the volume of timber harvested doubled—from 6.5 billion in 1913 to 13 billion board feet last year. We have only rough estimates of timber growth in 1913, but the indications are that growth more than doubled from 3.5 billion to 8 billion board feet during the transition from wild to managed forests still under way. Part of the increase reflects the more intensive standard of timber measurement applied today, but actual forest increment also increased during 50 years of increasing timber harvest.

Use of Northwest forests for recreation increased even more spectacularly since the Experiment Station started work in the Wind River Valley. Recreational visits to our National Forests weren't accurately counted in 1913, but probably they didn't much exceed 100,000; the count for 1963 will probably approximate 12,000,000—an indicated increase of over a hundredfold.

Game censuses were undependable or unheard of in the Northwest in 1913. But the indications are that game populations are up, and that the legal harvest of big game has probably increased six- or eightfold since that time. The 1962 deer kill in Oregon was 163,939. Grazing of the forest and related ranges by domestic livestock is the one use that has declined —probably to about a third of the peak overuse that occurred during World War I.

Northwest forests contribute vastly more to the income and enjoyment of more people today than ever before because they are managed better and used more efficiently.

The area of forest planting in the Northwest during 1913 totaled 2,614 acres. But in 1963, planting and artificial seeding regenerated approximately 200,000 acres—77-fold increase. Timber stand improvement practices such as weedings, pruning, and precommercial thinnings, largely just in the idea stage in 1913, covered an estimated 60,000 acres in 1963. Range and watershed improvement measures in 1913 were confined to a few small experiments; during 1963, these rehabilitations were applied to hundreds of thousands of Northwest acres.

Research has had an important part in improving forest and range management over the past half century. Today's routine practices of timber and forage growing, protection, and use are based on the key research findings of yesterday—some developed by the Station, some by or with the help of our contemporaries and cooperators. Many of the most valuable research results of years past are now taken for granted as a part of operating technology.

Viewed in the perspective of 50 years, forestry in the Northwest is a thrilling success. We see dramatic progress as a result of effort.

But as the Pacific Northwest Station starts its second half century of service, we share with forest owners, managers, and forest-supported communities increasingly difficult tasks in the years ahead.

Our region produces one-third of the Nation's lumber, more than four-fifths of the softwood plywood, and more than one-sixth of the woodpulp. But our Northwest timber industry—by far the most important producer of wealth and employment in the region—hasn't recovered from the extreme competition and cost-price squeeze of the past several years to the extent that some other segments of the economy have.

At the same time, demands for nontimber products and services of the forest—recreation, wildlife, range forage, and water—are all sharply up.

Attempts to meet these demands will incur increasing costs also.

Our wood products industries reached their present situation while harvesting an exceptionally high-quality virgin forest.

In the future we shall have smaller, young timber to harvest, process, and market. And, in addition, we must add increasing expenses of timber growing to our already high costs of production and marketing. This will influence the costs and returns from both private and public forests, and the implied effects on forest-dependent communities, services, and utilities are worrisome to leaders in both industry and government.

Last year Northwest timber industries reduced some production costs, but they incurred some increases in costs, too, and prepared to face new competition from a Southern pine plywood industry, now just getting started.

These Northwest problems put heavy pressures on the timber industry, on forest-land managers, and on forest research.

Recent studies by the Society of American Foresters and by the U. S. Forest Service show that our forestry research must be strengthened more than threefold in the next 5 to 10 years if the most critical problems are to be solved in time to avoid serious losses to the resource and to the workers and communities dependent thereon.

The need was never greater to find ways to increase returns by improving tree quality and by developing new and improved uses for wood.

Equally urgent is the need to cut costs and to increase the efficiency of every forestry job —in reforestation, timber growing, protection, harvesting, processing, marketing. And at the same time we must increase the volume and quality of our game, forage, and water crops and greatly expand the opportunities for outdoor recreation.

These are the challenges to forestry research at the start of its second half century in the Pacific Northwest. The progress of the first half won't be good enough for the second. The job ahead is a lot bigger.

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FOREST AND RANGE EXPERIMENT STATION
Philip A. Briegleb, Director
Portland, Oregon

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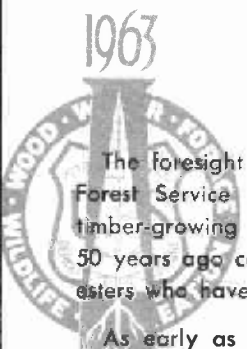
Timber Management Research

GEORGE S. MEAGHER, DIVISION CHIEF



The foresight and dedication of the pioneer Forest Service scientists who began the first timber-growing studies in the Northwest some 50 years ago continue to inspire research foresters who have followed them.

As early as 1909, hundreds of trees were felled and painstakingly measured to start the pool of data that has been used ever since for the construction of volume, taper, and bark thickness tables for major Northwest tree species.

In 1910, the first permanent growth plots were established in a 54-year-old stand of Douglas-fir on the Willamette National Forest. Additional growth plots were located on the Siuslaw National Forest in 1911.

By 1912, investigative work had been broadened to include studies in seed collection, seed storage, and sowing and planting practices to help solve operating problems at the new Wind River Nursery. The planting of 10 trees each of 16 different species in the same year marked the start of the Wind River Arboretum, the first in the Northwest. The groundwork for initiation of a first provenance study for Douglas-fir was also begun in 1912 with collection of cones from 120 carefully selected parent trees.

Pioneer foresters who planned or carried out these first studies included T. T. Munger, E. J. Hanzlik, C. R. Tillotson, C. P. Willis, A. A. Griffin, R. H. Weidman, and C. J. Kraebel. That so few, working under serious limitations in funds, facilities, transportation, and supporting personnel, could accomplish so much in so short a time is remarkable. That some of their studies were so well conceived and planned that they have continued to provide valuable information over a period as long as 50 years is truly amazing. Leo Isaac, who joined the staff in 1924, also contributed greatly to early silvicultural studies in Douglas-fir.

In commemorating the 50th anniversary of the establishment of the Wind River Experiment Station, we are therefore giving major attention to two projects that were started by these early scientists and that continue to be an important part of our program—growth and yield in Douglas-fir and provenance studies in Douglas-fir. Progress in other timber-growing research projects will be mentioned briefly.

Growth and Yield of Douglas-fir

Looking back over growth and yield for Douglas-fir, a fairly consistent chronological pattern becomes apparent. Beginning interest was in production rates for natural, unmanaged stands. Next came a concern about effects of initial spacing and thinning on growth and yield. This concern was accompanied by a need to also learn how individual trees of varying age, size, and crown class respond to different cultural treatments or degrees of competition and release. Finally, present interest focuses on yields attainable under intensive management practices and on levels of growing stock that are most efficient for achieving specific timber management objectives.

Natural Stands

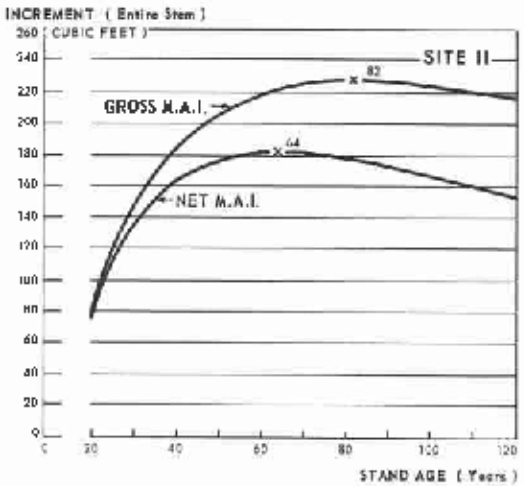
Between 1910 and 1939, a series of permanent plots to measure growth and yield of young-growth Douglas-fir was established in widely scattered parts of western Washington and northwest Oregon. Some plots were abandoned for various reasons, but 31 are still in existence and provide growth records covering 20 to 50 years. During the 1920's, these permanent plot records were supplemented by a very large number of measurements of temporary plots which sampled a much wider range of growing conditions.

Probably the most significant product of this early work was R. E. McArdle's derivation of a site index system and normal yield tables which were published in 1930 as USDA Technical Bulletin 201. Repeated checking of permanent plots has demonstrated the usefulness of this standard reference for forecasting net yields and growth of young Douglas-fir. In 1949, Bulletin 201 was revised to include yield tables based on average diameter, a contribution by Donald Bruce.

During the 1950's, the original net yield tables were supplemented and enhanced through the development of mortality and gross yield tables for normal stands of Douglas-fir. This contribution by G. R. Staebler was based on an analysis of tree mortality data from permanent growth plots. The new tables provided a first estimate of potential yields attainable under intensive management as well as a new approach to derivation of thinning schedules.

Although the Station's emphasis in growth research for natural stands has always been focused on young growth, a special study of periodic growth and mortality in virgin stands was undertaken on the Wind River Natural Area in 1947. A 12-year record from this area shows the stand is maintaining an approximate equilibrium in volume. Substantial gross increment is about offset by mortality. Clearly indicated are opportunities and advantages of periodic salvage operations in old-growth stands when final harvest cutting will be long deferred.

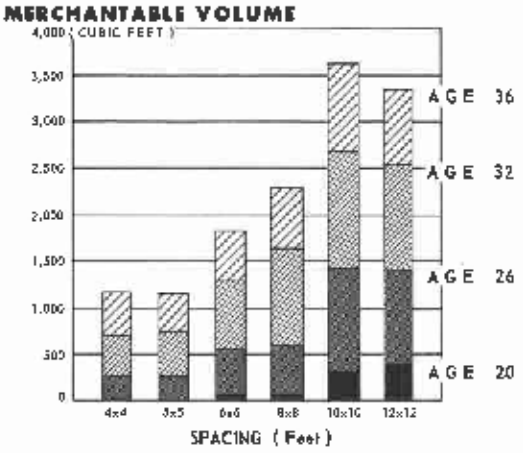
Gross increment not only greatly exceeds net increment, but its culmination is nearly 20 years later.



Effects of Thinning and Spacing

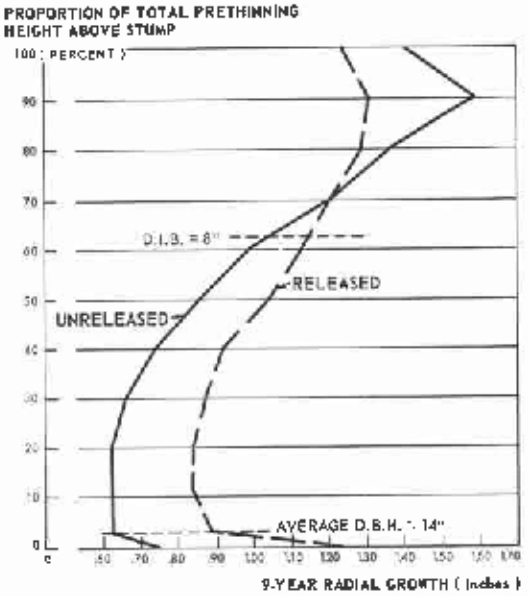
The first study of thinning in premerchantable stands was begun at Wind River in 1919. This work was soon expanded to include various types, frequencies, and intensities of thinning in stands of both merchantable and premerchantable size. A closely related effort was the plantation spacing study, begun in 1925. Starting in 1947, this work was further augmented with commercial thinning studies on experimental forests in western Washington which had been established through cooperation of industrial timber owners.

Studies in premerchantable stands have generally shown that spacing during formative years can boost usable yields substantially. Wide initial spacing in very young stands on low sites has produced trees that are not only larger in diameter but also taller. Thinnings in intermediate-aged stands have had virtually no effect on height growth or total cubic volume but have resulted in greater merchantable volume production. Thinnings in older stands, in contrast, have been chiefly salvage operations; growth capacity has not usually been fully redistributed to remaining trees.



Wider spacing produces taller and larger diameter trees and, thus, much greater merchantable volume.

Much of the significant information on commercial thinning of Douglas-fir was included in a comprehensive report by N. P. Worthington and G. R. Staebler published in 1961 as USDA Technical Bulletin 1230.



Release of codominant trees at age 40 improved growth on the merchantable portion of the bole.

Growth of Individual Trees

To fully understand growth and development of stands, knowledge of response of individual trees to management treatments is also essential. So far, individual trees have been studied under a limited range of conditions, but findings have been important. For example, a pruning study started in 1937 showed that the lower one-third of branches of the crown could be pruned off without lowering height or diameter growth. Effects of pruning on Douglas-fir wood quality have since been evaluated on both a theoretical and actual recovery basis.

As another example, trees of dominant crown class were found to respond more favorably to moderate release through thinning than trees in codominant or intermediate classes. Release of codominant trees at age 40 on intermediate sites was further shown to provide improved growth on merchantable portion of bole but without significantly affecting form class. Contrary to expectation, crown expansion did not follow release.

Levels of Growing Stock

For some time, the need for more precise information on stocking schedules for optimum production and yield estimates for intensively managed stands has been apparent. Starting in 1962, the Station has worked closely with other Federal and State forestry agencies as well as with forest industry to help launch a cooperative research project to meet this need. Based on a common plan developed by G. R. Staebler, four level-of-growing-stock studies have now been installed. Two by Weyerhaeuser Co. are on company lands representing Douglas-fir sites I and III. Oregon State University has established a study on site II lands owned by T.J. Starker; and the Station, in cooperation with the Olympic National Forest, has established a study on site IV land near Brinnon, Wash. An even wider range of environmental and geographic conditions are being explored at other field locations. We believe these studies represent a valuable research legacy for the future.

THE 1912 DOUGLAS-FIR HEREDITY STUDY

What is the Douglas-fir heredity study? Briefly, it is a provenance study of open-pollinated progeny of 120 known-parent trees from several local seed sources of our coastal Douglas-fir. Besides being 50 years old, the study is unusual for a number of other reasons.

First, the progeny, which are approaching rotation age, all tie back to known female parents. Consequently, each row now represents a family of trees with a common female parent.

Second, the original outplanting, which included 25,242 tagged trees, would be a major undertaking even by today's standards.

Third, although the original planners had never heard of our present statistical methods, the design provided for six identically arranged plantations which can be analyzed by today's rather sophisticated statistical procedures.

Fourth, it is the oldest experiment to provide information about the genetic structure of Douglas-fir populations from various elevations within a single drainage.

Seed Collection and Plantation Locations

The 120 parent trees chosen in 1912 grew in western Washington and northwestern Oregon. The bulk of the trees were in three main valleys. The Stillaguamish Valley furnished 27 parent trees with an elevational range of 400 to 900 feet. Thirty-one parent trees came from the Wind River Valley and represented elevations from 400 to 2,600 feet. The Santiam Valley furnished 31 trees growing at elevations from 900 to 3,800 feet. Samplings of the Puget Sound-Willamette Valley trough included 22 trees with an elevation range of 100 to 2,600 feet. A single collection representing the Coast Ranges included seven trees near Summit, Oreg., at 700 feet. Seedlings were raised at Wind River Nursery and outplanted as 2-year-olds, primarily in 1915 but with a smaller replication in 1916. Six outplanting areas were chosen: one near Wind River at 1,100 feet; three on a slope in the Still Creek drainage near Mount Hood at 2,600, 3,600, and 4,600 feet; one on Little Hebo Mountain in the Oregon Coast Ranges at 2,000 feet; and one at Walker Mountain near Verlot, Wash., on the Mount Baker National Forest, at 2,000 feet.

In the 1915 plantings, 10 parents were each represented by 100 progeny in each plantation, and the remaining 110 parents were represented by 20 progeny. Because of shortage in planting stock, only 10 progeny of each parent were used in the 1916 plantings.

Historical

Among forestry pioneers who participated in the Douglas-fir heredity study were T. T. Munger who authored the plan, Edward Hanzlik, Robert H. Weidman, Charles J. Kraebel, C. P. Willis, A. A. Griffin, and C. R. Tillotson who helped collect seed and take initial measurements. The

names of J. V. Hofmann and Julius Kummel also appear on many of the early measurement records.

Because there existed in 1912 the unusual combination of imaginative and well-trained scientists, a sizable forest nursery, and large and experienced planting crews, the job was done as competently then as it might be today.

Complete records were taken on all early phases of the study. Each parent tree was individually described, including location, height, and crown length. Data on number of seeds per pound were also recorded for each parent tree. Probably, the study of these cone and seed collections in 1914 is the largest ever reported for Douglas-fir. Height records at 2 (in the nursery), 3, 4, 5, 10, 15, 20, and 50 years and diameter records at 5-year intervals are now complete.

Damage from animals was severe on two plantations. The 1915 planting on the Mount Baker National Forest and the 1916 planting at Mount Hebo were destroyed by mountain beaver. A fire in 1919 burned the Mount Hood 3,600-foot planting, thereby eliminating what would have been an outstanding elevational provenance test. In all plantations, falling snags were a major source of early mortality. Mortality continues, and no decade has gone by without a major disaster. Animals and fires in the 1910's, falling snags in the 1920's, wet snows in the 1930's, an ice storm in the 1940's, and the "deep freeze" of the 1950's have all left a wake of mortality and damage. Surviving plantations today total 8 of the original 12. These include four 1915 plantations (Hebo, Wind River, and two near Mount Hood) and four 1916 plantations (Mount Baker National Forest, Wind River, and two near Mount Hood). Key results of the study after 50 years are outlined below.

Entrance to the Wind River, Wash., plantation, showing sign with 50-year-old study trees behind.

Gene-Environment Interaction

Probably no result was more striking or important than the evidence for a gene-environment interaction. This shows simply that a half-sib family that tests superior at one location may very well be inferior at another. The progenies of high- and low-elevation parents from the Santiam Valley illustrate this relationship. As might be expected, the low-elevation (900 feet) progeny performed slightly better than average at 1,100 feet, average at 2,000, and somewhat poorer than average at 2,600 feet. Likewise, progenies from high-elevation (3,000 to 3,850 feet) parents are superior at 4,600 feet, better than average at 2,600 feet, and distinctly inferior at 1,100 feet. As a group, progenies from high-elevation Santiam parents are distinct failures, however, at 2,000 feet in the coastal plantation.

A major generalization arising from this interaction is that within Douglas-fir of western Oregon and western Washington, there is a strong adaptation of seed for particular localities. From a tree improvement point of view, this suggests that progeny testing at a site different than that to be outplanted is a questionable practice.

An anomaly to the interaction exists in the following sense. Almost without exception, the progenies of every parent include at least one

superior individual at each location. For example, at Mount Hood—4,600 feet, where most families are obviously far off site—all seed sources show at least one individual whose height is 90 percent greater than the population average. This indicates surprising genetic diversity within a restricted source of germ plasm such as a single seed lot.

A portion of the Wind River plantation, showing trees from high-elevation Santiam seed. *A*, In 1934; *B*, the same trees in 1963 at 50 years of age.

Environment versus Heredity

Environmental effects are considerably larger than genetic effects. For example, at 50 years, average heights of the same progenies at Wind River are 72 feet but only 22 feet at 4,600 feet near Mount Hood. Genetic differences are not this great. Expressed mathematically at individual plantations, the genetic component of variance for these half-sib progenies is estimated at 20 to 44 percent of the phenotypic variance. This measures the relative genetic and environmental components. Every race seems to have capacity to produce some good trees on every environment. However, the more poorly adapted progenies result in fewer good trees than the best adapted. As sites become more severe, there is also correlation between good growth and high percentage of survival. On such plots, however, the extra growing space resulting from mortality was not utilized for extra growth by the unadapted groups.

Relation of Seedling to Mature Heights

Complete height records over a 50-year span permit correlation of seedling with mature heights. Such correlations are sought by geneticists to speed up breeding programs. Results generally have been disappointing. There was no correlation between 2-year and 22-year heights, based on 593 trees. A barely significant correlation was possible at 4 years. Correlation between 10- and 47-year-old trees was still weak. A more careful examination of factors involved shows that seed vigor and the gene-environment interaction predominate.

Nursery Culling

Information on long-range effects of nursery culling practice was also obtained. Early records on 89 families in the nursery can now be compared with their 50-year performance. If performance of the best nine seed lots is compared with the nine poorest lots, the differences today are meaningless. On half the plantations they are slightly better, the other half slightly poorer! With individual trees, records of the tallest 20 percent average almost identically with the poorest 20 percent over all plantations. As with seedling-mature correlations, the early size has a strong component related to parent tree vigor (seed size, crown size, age), and present heights reflect the interplay of genetics and environment. Culling would have favored nongenetic factors having to do with seed vigor—large cones, young trees, open-grown trees, large crowns. The seedlings from old-growth trees which resulted from their smaller cones and smaller seed would have been heavily culled whether or not they possessed the genetic potential for greater height growth.

Wood Quality

Exploratory studies in specific gravity and fiber length have been started in cooperation with Oregon State University. Consistent differences between family averages are found at 48 years in both traits for the five parents tested to date. Heritability of fiber length and specific gravity are estimated at 23 percent and 27 percent, respectively, in a combined analysis of three plantations. A remarkable feature about these traits is the consistency of ranking in average family values from one site to another. Families with low, intermediate, and high fiber-length values on one plantation are in essentially the same relative rank on the other two plantations. The same is true with specific gravity.

Bud Bursting

The easiest trait in which to observe genetic differences is bud-bursting date. In 1933, order of bud bursting for various races was found to be consistent in plantation after plantation, even if these varied over 3,500 feet in altitude, and bud bursting at higher elevations occurred 2 months later than at low elevations. A check in 1956 revealed the same consistency—that early and late races were unchanged with time. The pattern is not altitudinal. Wide-valley sources burst first, followed by those on open slopes. Those from narrow valleys burst last, probably representing a selection against frost susceptibility. No correlation between bud bursting and growth rate has been observed.

1955 "Deep Freeze"

The November 1955 freeze killed the largest trees in 22 percent of the rows on the Hebo plantation. Killing of such large trees at 42 years of age was unexpected, but illustrates that the only safe evaluation is a long-range one. Because killing occurred heavily in some families and was absent in others, susceptibility is considered to have an important genetic basis. Subsequent study of the susceptible families in other plantations suggests a phenological basis. In mid-November, a higher percentage of the susceptible families have cambiums that are still active and subject to freezing.

Some indication of inheritance of tree taper and of susceptibility to limb and stem galls has also been observed.

SELECTED EXAMPLES OF PROGRESS FROM OTHER STUDIES

Silviculture of Noble Fir

Research on noble fir, a major upper-slope species in the Pacific Northwest, is receiving increased emphasis in the Station's silvicultural project at Corvallis.

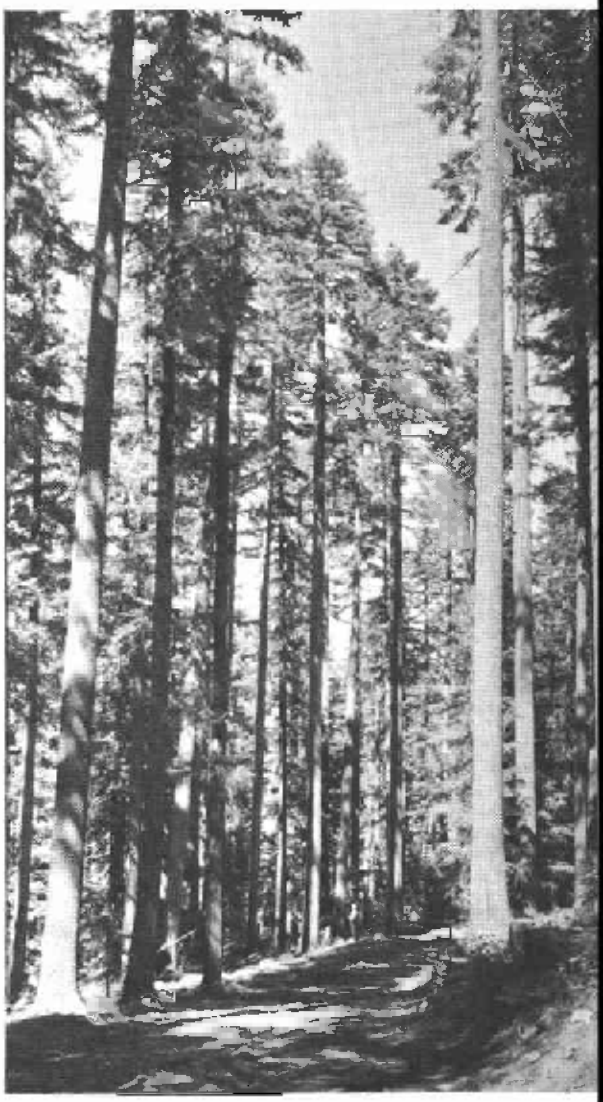
An initial step was a review of literature and publication of a bibliography with abstracts to serve as a guide to existing information. Exploratory field investigations show that noble fir is more tolerant and occurs in pure stands more commonly than has been previously reported. On the best sites, moreover, noble fir rivals Douglas-fir in productivity. For example, one 25-acre old-growth stand in southern Washington that is 78 percent noble fir has a cruised gross volume of 309,600 board feet per acre. The northern limits of noble fir are in the vicinity of Stevens Pass in northern Washington. The southern limits are not well defined, however, because noble fir merges with trees that show characteristics of not only noble fir but also Shasta red fir and California red fir. Artificial pollinations in cooperation with the genetics project have shown that noble fir and California red fir cross readily; this characteristic may account, in part, for the presence of populations showing a continuum in morphological features.

A comprehensive study of successional relationships and productivity of noble fir in various plant communities and on different soil types is presently in progress in the southern Washington Cascade Range, where the species obtains optimal development. Improved methods of regenerating noble fir are also receiving special attention. A 1961 study of the relation of cone-collection date to seed viability showed that cones of many trees collected as early as September 1 could yield high-quality seed if handled properly.

A long-term study of periodicity of cone production on selected trees throughout the range of noble fir has been established. Large annual variations in production are already apparent. For example, the average number of cones on 18 trees on a plot in northern Washington was 61,343, and 1 in 1961, 1962, and 1963, respectively. Significant variations between trees in a single locale and between locales were also apparent.

First-year results from a study on the time of initiation and cessation of height growth indicate that noble fir starts height growth considerable later than its associates.

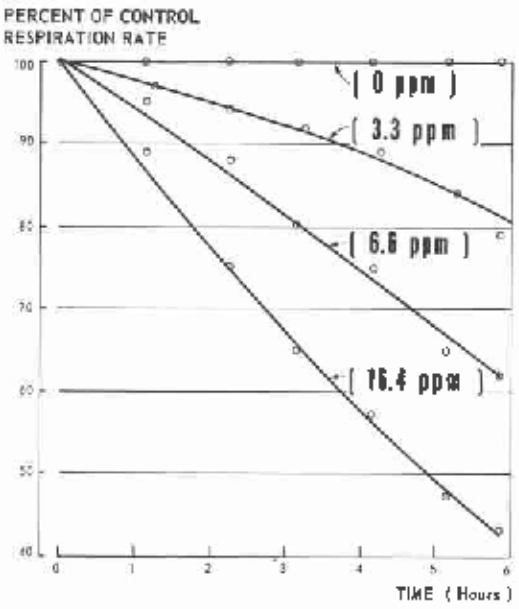
A stand of old-growth noble fir on the Mount Hood National Forest, age 190 years.



Shingle Tow as a Packing Material

Western redcedar shingle tow has been used as packing material around seedling roots since forest planting began in the Northwest. While thousands of acres have been successfully planted, cases of poor nursery stock performance and survival are numerous.

Recently, it has been found that the potent natural fungicides found in cedar wood are often incompletely leached from shingle tow prior to its use, and that these compounds are toxic to Douglas-fir. Low concentrations depress respiration strikingly, while slightly higher concentrations may cause death. Under drought or other stress conditions, even low concentrations might contribute to poor survival. Alternative seedling-packing methods were begun at Forest Service nurseries in the fall of 1963.



Respiration of Douglas-fir root tips was progressively slowed by increasing concentration of γ-thujaplicin, an extract of western redcedar shingle tow.

A Hypothesis on Death of Newly Planted Douglas-fir Seedlings

A recent study indicated that when 2-0 Douglas-fir nursery stock lost moisture, roots dried at a faster rate than tops. When seedlings were bundled at a fresh moisture content of 191 percent of dry weight, the ratio between top and root moisture was almost 1.00, indicating that water was well distributed within the plant. As plants lost moisture, however, tops contained relatively more water than roots.

These findings and those of published research on tree seedling moisture loss indicated that (1) tops of desiccated seedlings contain substantially more water than roots; (2) deleterious effects of desiccation are probably exerted first in the roots; and (3) living roots are not necessary to the maintenance of "live" plant foliage over a substantial period of time.

A Douglas-fir seedling may be in apparently good condition for planting, judged subjectively from needle turgidity, color, and general appearance. However, if significant amounts of water have been lost from the plant, roots may be impaired or even incapacitated in their ability to establish a continuing supply of water and nutrients from the soil. Dead roots, however, may continue to supply tops with water in the absence of soil moisture stress during cool, rainy weather.

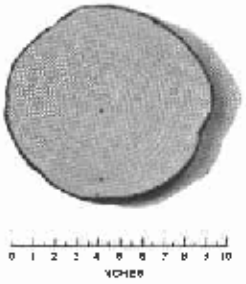
The seedling may thus continue to appear living for some time after planting. At the first onset of summer heat and soil moisture stress, the top turns brown and death of the seedling is at last evident. Coincidence of visible seedling death with seasonally increased air temperature and decreased soil moisture could thus lead to an erroneous conclusion as to the cause of mortality.

Spacing and Growth of Lodgepole and Ponderosa Pine

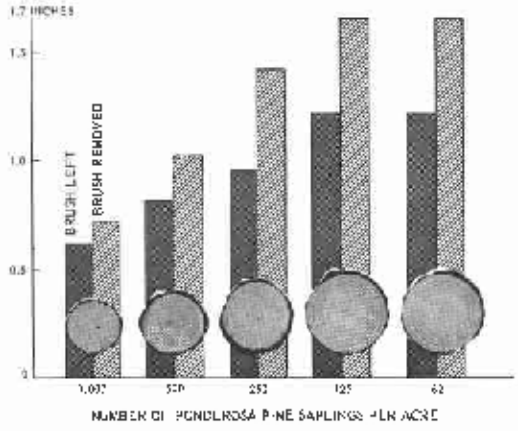
Wide variations occur in growth rates of lodgepole and ponderosa pine trees under natural or artificially created stand conditions. These differences illustrate in a striking way how growth can be controlled to meet specific management objectives.

Natural lodgepole pine stands, usually composed of numerous small diameter trees, attain gross yields comparable to those of ponderosa pine stands on similar sites. Natural lodgepole stands are not as commercially valuable as ponderosa pine stands, largely because of smaller tree sizes. However, open-grown lodgepole pine trees frequently exhibit average annual diameter increments of 0.5 inch at breast height. This observation indicates that under controlled spacing or level of growing stock, a range of desired tree sizes is feasible.

FREE GROWING LODGEPOLE PINE



4-YEAR DIAMETER GROWTH IN PONDEROSA PINE



Both lodgepole pine and ponderosa pine are capable of rapid growth under favorable environments. Above, a free-growing lodgepole pine grew at the rate of 4½ inches d.b.h. per decade. Below, ponderosa pine saplings under controlled spacing also showed outstanding growth rates. Diameter increment increased with removal of brush as well as with the decreasing number of trees per acre.

Growth of ponderosa pine trees is also greatly influenced by stand density. Trees in natural stands as dense as 7,000 stems per acre sometimes grow to a diameter of only 2 inches in 70 years. When artificial spacings of 62 and 125 trees per acre were imposed on these stands in a recent spacing experiment, an average of 1.7 inches of diameter growth took place in only 4 years. Growth of closer spacings was also good but was held in check slightly by competition which was noticeable on plots with as few as 250 saplings per acre. Removal of all brush increased diameter increment up to 45 percent.

Release of Ponderosa Pine from Overtopping Brush

Results of a study completed during the past year are expected to lead to large-scale aerial application of herbicides to release young ponderosa pine from brush competition. Thousands of acres of forest land in western Oregon and northern California have good stands of young conifers including ponderosa pines under dense brush. Where trees are not released, the brush overstory suppresses and kills many trees and slows growth of those that survive.

A new study revealed seasonal trends in development of natural resistance to herbicides in Douglas-firs and ponderosa pines and determined that associated brush species are still easily killed when the trees become resistant. This fortunate coincidence should allow aerial application of herbicides to release young pines from brush—killing the shrub species while leaving conifers undamaged.

Helicopter spraying varnish-leaf ceanothus to release ponderosa pines on the Umpqua National Forest.

Both ponderosa pines and Douglas-fir were undamaged in a preliminary trial of aerial spraying to release ponderosa pines from deerbrush ceanothus on the Willamette National Forest.

Pines on some public and private lands have already been laboriously released by hand methods, including basal spraying, but costs were excessively high. Development of aerial release methods is expected to result in a saving of $30 to $40 per acre.

Relative Resistance of Five Southwest Oregon Timber Species to Moisture Stress

Regenerating clear cuts in southwestern Oregon with desirable conifer species is often difficult. Hot, dry summers and rapid encroachment of other vegetation result in severe competition for soil moisture, especially on southern exposures. Thus, ability to survive under severe moisture stress is one of the important characteristics desired in species to be grown on dry problem sites.

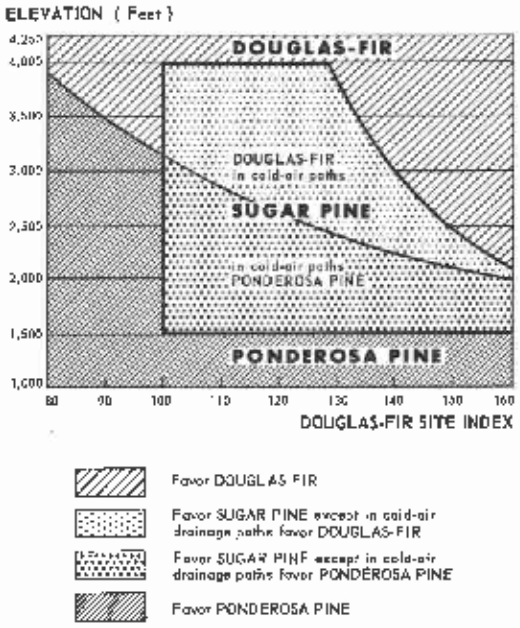
In a study of soil moisture stress, the soil moisture of builders sand at the death point was determined for five southwestern Oregon conifers. The ranking, starting with the species having lowest soil moisture content at its death point, was as follows: (1) ponderosa pine, (2) incense-cedar, (3) Douglas-fir, (4) grand fir, and (5) sugar pine. However, chances of survival under moisture stress condition may be enhanced by rapid root growth because untapped soil moisture may become available. In a study previously reported, it was found that ponderosa pine and incense-cedar 2-year-old seedlings had the most rapid root growth. Sugar pine was a close third, and Douglas-fir and grand fir were slowest.

Based on ease of establishment, either ponderosa pine or incense-cedar would be first choice and sugar pine second choice for regenerating dry southerly slopes.

Choosing the Species for the South Umpqua

Mixed-conifer forests occupy about 6,000 square miles of southwestern Oregon. These forests are characterized by a mixture of Douglas-fir, sugar pine, ponderosa pine, and other species. Although Douglas-fir is the most abundant, ponderosa and sugar pine grow faster on many sites.

Ponderosa and sugar pine usually occur as scattered trees. Consequently, direct comparison of yields for the three species is not possible at this time. Therefore, a study using site index as the best available means for comparing relative productivity has been made in the Upper South Umpqua drainage.



Recommended species to favor in upper South Umpqua drainage for Douglas-fir site index and elevation combinations based on comparison of site indexes.

Generally, site indexes for the two pine species exceed site index for Douglas-fir at lower elevations and where site index for Douglas-fir is also relatively low. Although comparative site indexes are a measure of relative productivity, which species to favor in management depends on many other factors. For example, blister rust on sugar pine is difficult to control in natural cold-air drainageways. Furthermore, the high cost of blister rust control makes sugar pine undesirable on poor sites. Differences in future marketability prospects also need to be considered.

Improving Application of TMTD Rabbit Repellent

Studies of TMTD rabbit repellent were carried out to improve properties of spray formulation, determine its effects on nursery soils, and develop improved rates and methods of application.

Cooperative laboratory and field studies on chemical and physical stability of TMTD on Douglas-fir nursery stock exposed to normal weathering and handling indicate that the repellent is not broken down chemically on needle surfaces. Volume losses, however, are significant, especially when nursery stock is sprayed during cold weather. Application, therefore, should allow for such losses, and spraying should be done when high temperatures and low humidities prevail. In addition, search should be made for an adhesive with better weathering properties than adhesives now in use.

Laboratory study was made of persistence and effects of TMTD reaching the soil during spray operations in the nursery. Results show that the chemical decomposes in the soil. However, rate of decomposition varies with the soil and may be accelerated by lowering pH through addition of either commercial fertilizers, well-decomposed organic matter, or a combination of the two. Results also show the chemical has an initial inhibitory effect on nitrification and general microbial activity in the soil, but soil micro-organisms usually recover as TMTD gradually decomposes under moist soil conditions. Evidently, the depressive effects of TMTD in the soil are not serious. However, nurserymen should attempt to minimize losses of TMTD to the soil, if only for economic reasons.

Investigations of rates and methods of application indicate that TMTD sprays are not applied uniformly to seedlings in the nursery and, furthermore, that seedlings often receive subprotective levels of the chemical. Further work is needed if the nurseryman is to make most effective use of the repellent.

Electronic computers, like the one shown here, have been responsible for a revolution in data processing procedures at our Station in recent years. They have increased our output of research information by a considerable amount and have even changed the direction of our research effort in some cases.

Biometrics Research

FLOYD A. JOHNSON, BIOMETRICIAN

Sample Scaling

A statistical study, completed in 1963, indicated that sample log scaling can be responsible for a considerable reduction in the cost of conducting a timber sale, and that this saving is only partially offset by sampling error. A sampling system, under which all loads of logs were weighed and a sample few loads were scaled, was found to be less efficient than another system which required sample scaling only and no weighing. However, this may have been caused by a rather high weighing cost and by a uniformity in the weights of the study loads. Uniformity in load weights is apparently common and is probably caused by the practice of consistently loading to the limit imposed by highway regulations. In this study, the weighing fee happened to be the most important factor in the cost of weighing, but truck delays for weighing also contributed to the total cost. These, and other results, were presented in the Journal of Forestry for May 1963.

Tree Volume Equations

Increased use of electronic computers for processing timber cruise data has created the problem of replacing tree volume tables by equations. Although volume tables can be used by electronic computers, equations have substantial advantages and will probably be the subject of a continuing research effort. An initial effort of this kind in 1963 led to the development of six tree volume equations, two of which are already being put to the very important use of calculating allowable cut by three large Federal agencies. The six equations, along with a description of procedures used for their development, have been presented in Research Note PNW-2.

Analysis Procedure for Developing Site Index Curves

The use of stem analysis data for developing site index curves has been receiving increasing attention in forestry literature over the past several years, but until 1963, no one seems to have presented details of an analysis procedure. During 1963, a procedure, based on research conducted at this Station, was made available in Research Paper PNW-7. It had previously been applied with apparent success to red alder and lodgepole pine in Oregon and Washington and to aspen in Alaska. The procedure is simple, direct, and easy to follow. Perhaps others will find it useful for developing site curves from stem data.

Load of Sitka spruce and western hemlock logs on Neskowin Timber Co. truck being scaled by the Columbia River Log Scaling and Grading Bureau at the Fort Hill scaling station.

DWARFMISTLETOE

Forest Disease Research

THOMAS W. CHILDS, DIVISION CHIEF

1963

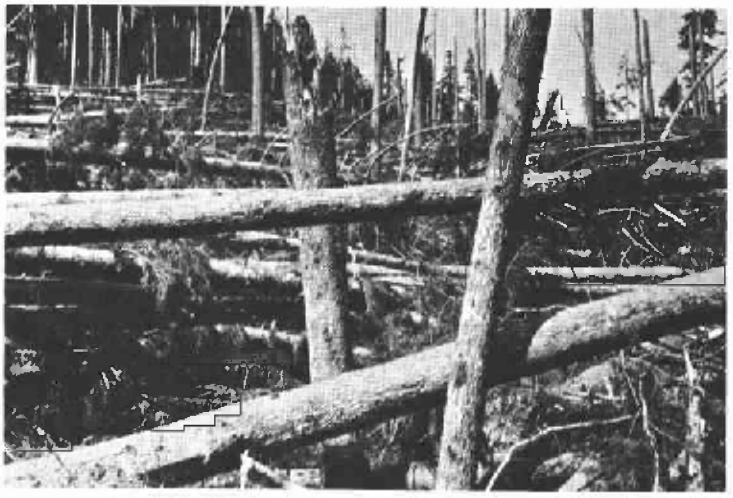
A few wandering botanists were collecting fungi in the Pacific Northwest more than 50 years ago, but real research on tree diseases began in 1913 when the Bureau of Plant Industry, U.S. Department of Agriculture, stationed a forest pathologist at Spokane. Since this pioneer pathologist's territory also included Idaho, Montana, and Wyoming, we can understand why he left untouched most of the problems in Washington and Oregon.

Early studies here were concerned almost entirely with the Elytroderma needle cast and dwarfmistletoe. The needle cast, after a period of harmlessness in the dry 1920's and 1930's, has become once again conspicuous and moderately damaging in some localities, while dwarfmistletoes have been major pests continuously, in wet years and dry, throughout the past half century.

In 1920 a pathologist was stationed at Portland, primarily to work on Douglas-fir heart rots. He soon had another big job—that of determining the rate of deterioration of several billion board feet of timber windthrown in 1921 on the Olympic Peninsula. Such information was needed in those days because killed timber often could not be reached by loggers for several years. In fact, unlike the wreckage left by Hurricane Frieda 41 years later, most of the Olympic blowdown was never salvaged.

Before these two jobs had been completed, the Portland pathologist's territory was extended to include the northern Rocky Mountains. The finding of white pine blister rust in the West gave it precedence over all other disease problems. Not until the late 1930's could much attention be given to other diseases.

After World War II, and especially after transfer of all Federal forestry research to the Forest Service in 1953, the Portland unit was enabled to concentrate on major problems in Washington and Oregon. Now, a modern laboratory at Corvallis permits a well-balanced research program and offers great opportunities for future progress.



Big blowdowns were even more of a problem before road systems were developed. This one occurred in 1921 and destroyed an estimated 5 billion board feet.

Root Diseases

Indirect or "natural" control methods are usually much more complex, and often somewhat less effective, than are fungicidal or other direct attacks. They require more research on fundamentals and may become operative only slowly as their effects accumulate. These disadvantages, however, are far outweighed in most circumstances by relative cheapness and lack of undesirable side effects. Perhaps their biggest advantage is that they almost invariably prove to be good cultural practices in addition to their effects on disease.

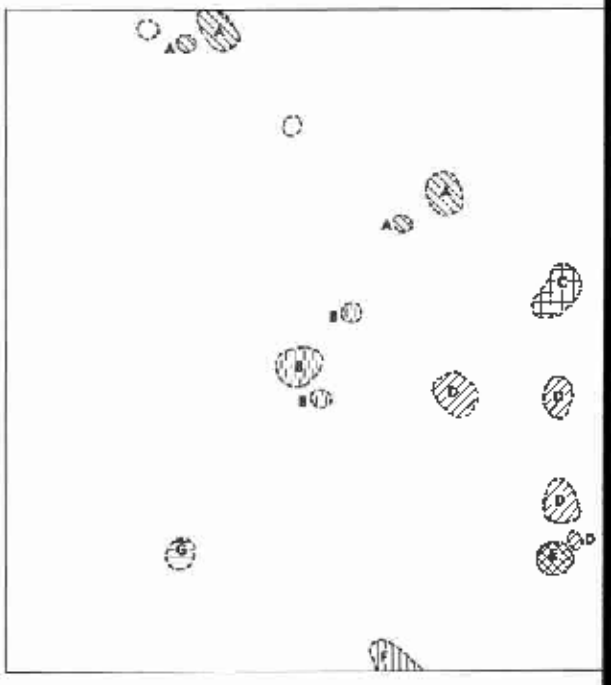
Before we can devise methods for indirect control of root diseases through modifications of ordinary silvicultural practices, we must learn where these diseases are most vulnerable, what factors affect them at their vulnerable points, and how these factors can be influenced. Studies of laminated root rot, caused by *Poria weirii*, exemplify the early stages of this process.

Canadian researchers found that *Poria weirii* spreads within infection centers by growing onto the surface of healthy roots in contact with infected ones and eventually penetrating into the new hosts. Their studies also indicated that infection can persist from one rotation to the next by survival of the fungus in killed roots and subsequent vegetative spread to roots of the new stand. During these two periods, the fungus appears much more vulnerable than when it is protected by living host tissues.

Recent work at this Station has shown (1) that the great majority of *Poria weirii* centers in present-day stands are "holdovers," that is, are the result of vegetative persistence and spread of infection that originated in earlier stands, and (2) that antagonistic soil micro-organisms can shorten the period of survival of *P. weirii* in dead material and presumably also hinder its spread across root contacts.

Laboratory tests of cultures from 138 centers, in 9 stands 35 to 120 years old, showed that 112 of the centers were caused by only 34 different *Poria weirii* clones each of which occupied 2 or more centers (as, for example, clones A, B, and D in the accompanying diagram). Since the only spores produced by *P. weirii* are sexual ones, which invariably give rise to different clones, the occurrence of the same clone in separate centers cannot have resulted from separate infections by spores. Nor can it have resulted from vegetative spread during the present rotation, since the centers are separated—often fairly widely—by zones of healthy forest. Even of the 26 "single center" clones, it appears probable, for reasons too numerous to be discussed here, that few if any originated from spore infections in the present stands.

It must be concluded, then, that a large majority and probably almost all of the *Poria weirii* centers now existing are holdovers. Although spore infections undoubtedly occur at times, our findings indicate that their prevention would do

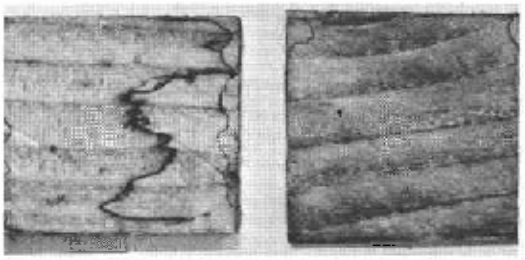


Poria weirii infection centers and clone distributions on a 10-acre plot in a 35-year-old Douglas-fir planting. Letters designate the different clones. Infection centers left blank are those from which no culture was obtained.

little to reduce damage and that, for any worthwhile degree of control, we must attack one or both of the vulnerable points that research has detected in the vegetative stage of the fungus.

When 2-inch cubes of wood pervaded by *Poria weirii* were buried in forest soil, the fungus in 84 percent of them died in less than 20 months. Survival was much poorer in blocks deeply invaded by antagonistic soil micro-organisms than in blocks where zone lines (see photo) apparently acted as barriers to invasion. These results suggest that practical control may be attainable through alteration of the environment to increase effectiveness of soil micro-organisms parasitic on or otherwise antagonistic to *P. weirii*.

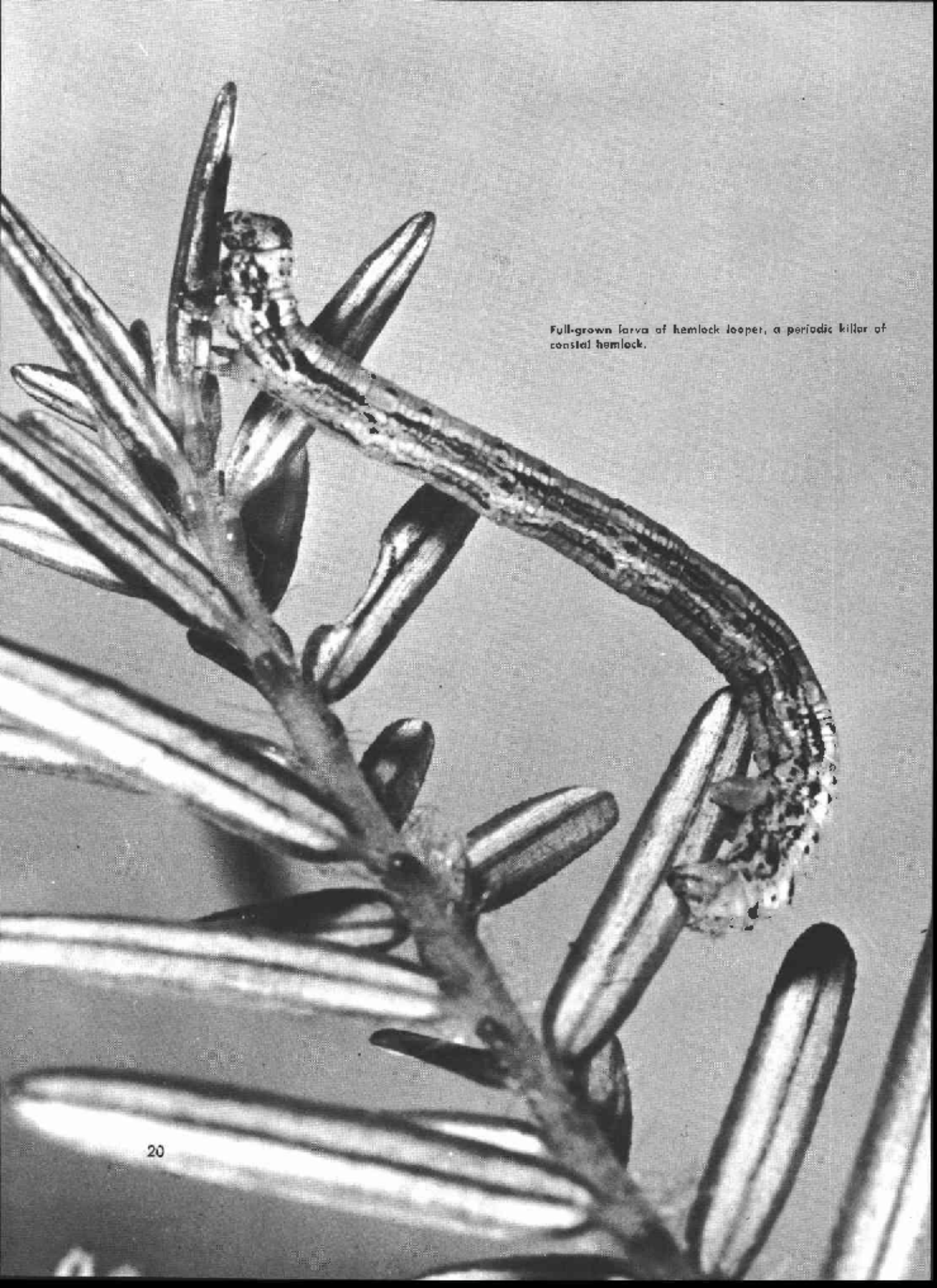
The exact alterations necessary in the environment and the best ways of effecting such alterations can be determined only through further and probably lengthy research, but there are several promising approaches to the problem. For example, micro-organic control of various agricultural root diseases is known to be most effective where nitrogen is abundant. Forest soils in this region are commonly deficient in nitrogen, and the use of mixtures or even rotations of nitrifying plants such as alder, or retention of fixed nitrogen through total exclusion of fire, may prove effective against *Poria weirii*.



***Poria weirii*-infected blocks, split after several months in forest soil, showing zone lines characteristic of blocks not invaded by soil micro-organisms.**

Plans for 1964

No major changes are planned in the disease research program.



Full-grown larva of hemlock looper, a periodic killer of coastal hemlock.

Forest Insect Research

ROBERT L. FURNISS, DIVISION CHIEF

In 1903, Dr. H. E. Burke, special agent in the U. S. Bureau of Forestry, set up a field station at Hoquiam, Wash., to study the span worm that had defoliated hemlock and spruce extensively in the Grays Harbor area about 1891. That marked the real beginning of forest insect research in the Pacific Coast States. In those early days, forest insects were identified and their habits studied, but years passed before they could be controlled.

The span worm proved to be the hemlock looper, an insect that periodically has killed, and continues to kill, large volumes of hemlock timber in the coastal forests of Oregon, Washington, and British Columbia. By 1945, it appeared that DDT spray applied from airplanes would solve the looper problem when outbreaks threatened. Subsequently, it was learned that DDT could, under some conditions, have harmful side effects, so research had a new goal—to find new and safer chemicals and to develop alternative control measures. Our research efforts now are heavily concentrated upon biological and silvicultural methods of control of forest insects.

In the beginning, entomologists went out to the woods on foot, on horseback, and by Model T. Their tools were few and simple—an ax, a hand lens, and some vials to collect insects in. Largely they observed. Observation of insects in the forest still is an important part of the research program, but it is strongly bolstered by specialists working in the laboratory with the most modern scientific equipment for making fundamental studies. The goal is to develop biological and silvicultural means of regulating pest insect populations so as to keep them within economic limits and minimize the need for chemical control.

Electron microscopist studying viruses to develop means of using them against forest insects.

Microbial Insecticide Tested

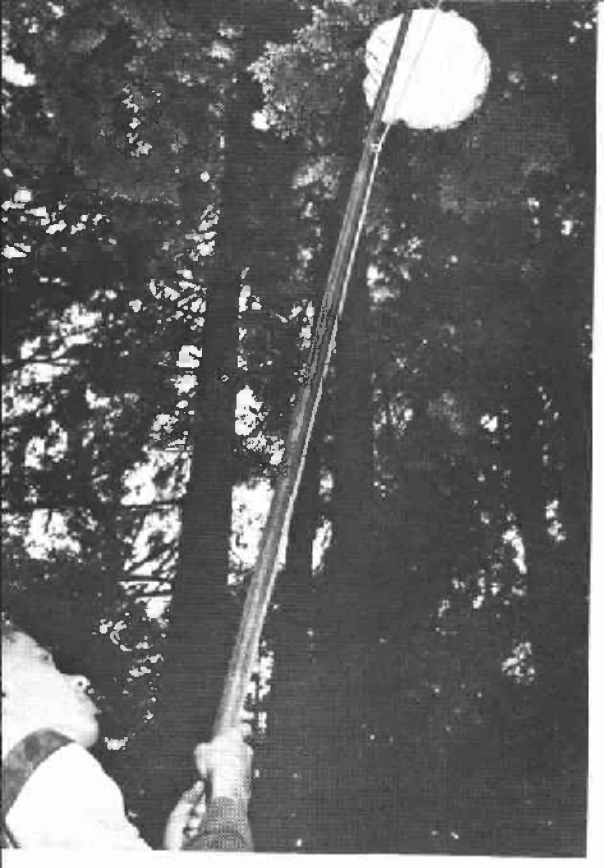
Threatened wholesale killing of timber by the hemlock looper in the vicinity of Willapa Bay, Wash., necessitated a large-scale aerial spraying project in 1963. It also brought into sharp focus an urgent need to find a satisfactory substitute for DDT. The project provided an opportunity to pilot-test the microbial insecticide, *Bacillus thuringiensis*, in a newly developed commercial form considered harmless to humans, shellfish, fresh-water fish, and wildlife.

Laboratory tests in 1962 had shown this bacillus to be lethal to the looper. A plan for field testing was developed which reflected the need to obtain definite results, either negative or positive, under operational conditions. The experimental process was accelerated by postponing other research and concentrating money and effort on planning and conducting the test.

Applying measured amount of a bacillus to hemlock foliage in feeding test.

Sample plots were established on a 325-acre test block on Long Island in Willapa Bay. Looper populations were measured, and plates to record spray deposit were placed out prior to spraying. On July 19, using a Bell helicopter, model G-2, the block was sprayed at a rate of 1 gallon of Thuricide 90-T plus 1 gallon of water per acre. Spray coverage was excellent, judged by the usual standards for forest spraying, and the looper was in the stage considered best for measuring effects of the bacillus.

Helicopter spraying test area with *Bacillus thuringiensis*.

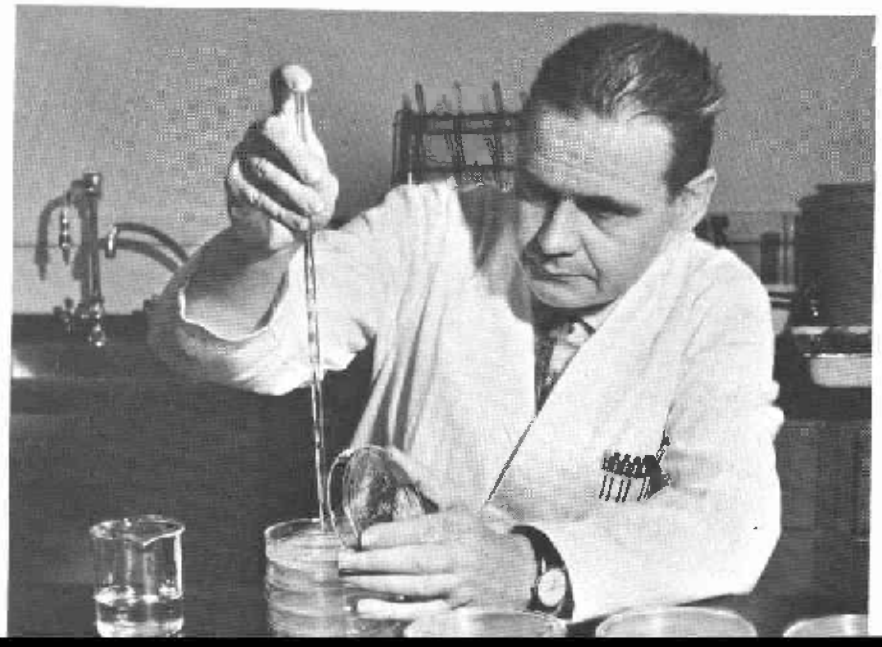


Determining survival and rate of development of Douglas-fir beetle on artificial medium.

Analysis of effects was based on both field and laboratory methods. In the woods, looper mortality was recorded periodically for a 20-day period following spraying by counting survivors on sampled foliage and dead larvae caught in trays under the sampled trees. In the laboratory, the cause of death of individual loopers was determined, and healthy loopers were subjected to bacillus-sprayed foliage to determine duration of toxicity. Spore and crystal counts were made from the sample plates in an attempt to relate looper kill to amount of spray deposit.

The results were clear cut. Significant reductions of the looper population ($p = 0.05$) occurred on only 3 of the 20 plots, 1 each in low, medium, and high population categories. These reductions ranged from 50 to 60 percent, and were only loosely related to the recorded amount of spray deposit. In forced feeding tests with sprayed foliage, effectiveness of the bacillus remained high for 7 to 10 days and decreased rapidly thereafter. On the plots, loopers killed by *B. thuringiensis* were found from the 4th to the 18th day after spraying, with the peak on the 10th day. No effect on natural control factors was recorded.

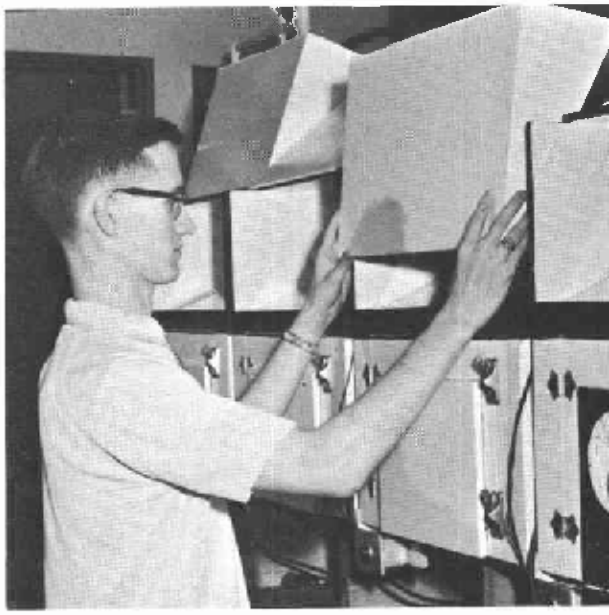
The test showed that *B. thuringiensis*, as presently formulated, is not effective enough for operational use against the looper; there is no other biological control method presently available to combat that insect. The test shed doubt on the potential usefulness against forest defoliators of materials that act as stomach poisons, and emphasized the continued need to develop other approaches to biological control. It demonstrated that thorough experimentation in the laboratory is essential to develop materials and procedures to the point that expensive and time-consuming practical tests stand a good chance of success. Finally, it showed that control operations and research can be successfully wedded.



Determining viable spore count from samples taken on test area.

Insect Physiology

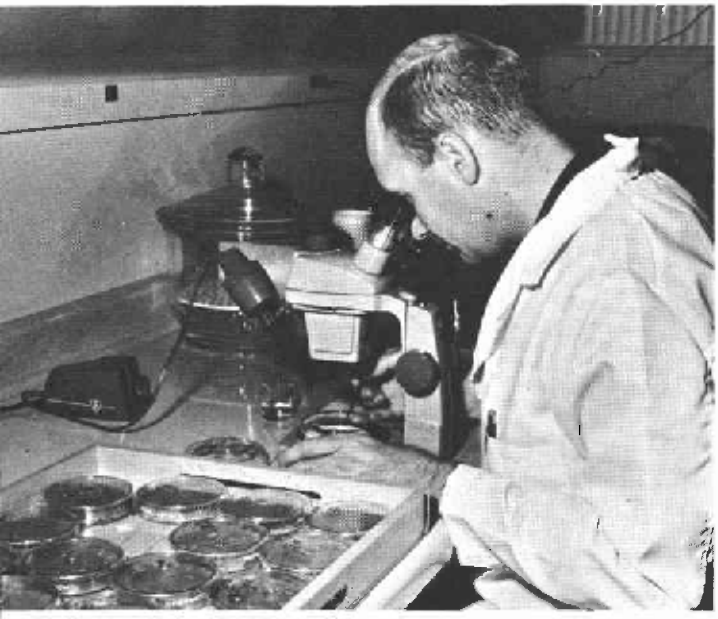
Progress was made toward developing an artificial diet for the Douglas-fir beetle, needed for mass rearing and study of this destructive bark beetle. An average of 50 to 60 percent of newly hatched larvae developed to the pupal or adult stages on some media in petri dishes in the laboratory.



Determining survival and rate of development of Douglas-fir beetle on artificial medium.

Biological Control

Studies on the development requirements of *Coeloides brunneri* Vier., an insect parasite of the Douglas-fir beetle, and of *Itoplectis 4-cingulatus* (Prov.) and *Apechthis ontario* (Cress.), insect parasites of forest defoliators, were continued. All three can now be produced in quantity in the laboratory.



Equipment for studying light, temperature, humidity, and air movement requirements of insect parasites.

Plans for 1964

Most of the research program will be directed toward developing and improving biological and silvicultural means for controlling forest insects. In the laboratory, fundamental studies of insect viruses will be increased, more effort will be exerted on insect nutrition and mass rearing techniques, and studies of the fundamental requirements of insect parasites will be continued. In the field, biological and host relationship studies will be made of pine bark beetles, European pine shoot moth, hemlock looper, balsam woolly aphid, and others, principally in an effort to develop methods of management for keeping these insects in check.

Forest Fire Research

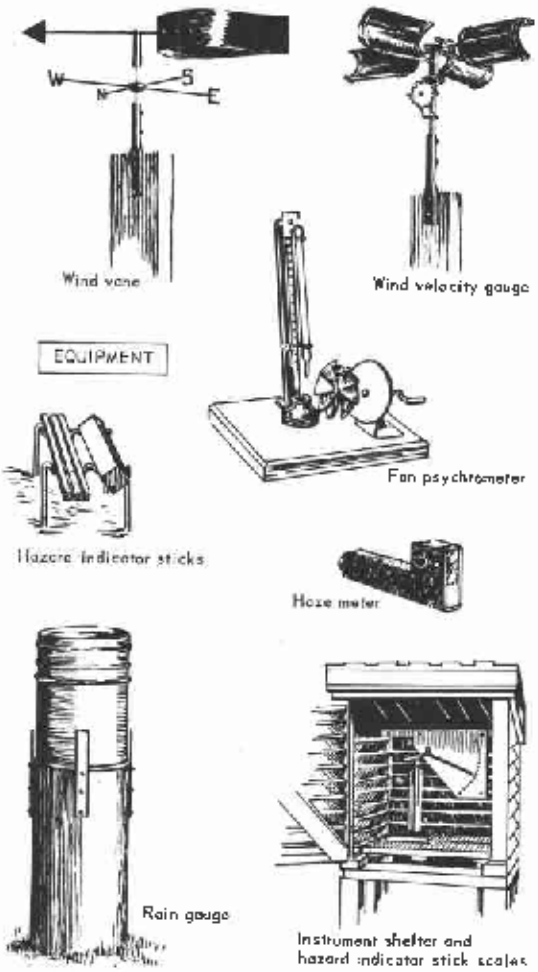
DAVID BRUCE, DIVISION CHIEF

Fire studies were started at Wind River before 1924, when the Pacific Northwest Forest Experiment Station was formally established. In 1922, a complete meteorological station was installed there, and Dr. J. V. Hofmann devoted much of his time that year to fire studies. The 1923 publication by Hofmann and W. B. Osborne, "Relative Humidity and Forest Fires," is one of the earliest major recognitions of the importance of humidity and the basis for the later 30-percent humidity woods closure rules and for much subsequent research on fuel moisture.

In the same year, studies of the relation of static to weather changes were started at Wind River. Although static could not be linked to general weather conditions, its relation to nearby lightning had been apparent from the beginning of radio communication. As part of those studies, A. G. Simson constructed five static meters in 1930 to determine their effectiveness in warning of lightning storms. Today, a similar study is underway elsewhere using more modern sferics receivers.

In 1925, 6 of the 14 studies undertaken by the Station were in the field of fire research. In the next 10 years, much important work on fire was done at the Station. A. G. Simson and later W. G. Morris studied lightning-storm frequency, occurrence, and behavior. R. H. Westveld and R. E. McArdle started major studies of slash disposal in ponderosa pine and Douglas-fir stands, results of which were reported in technical bulletins in 1931 and 1941. R. E. McArdle and G. M. Byram published several reports on visibility studies, eye tests for lookouts, and haze meters.

Also in this period, studies were made of fire control planning on the National Forests in Region 6 and of administrative methods of rating forest fire danger. One of the important contributions toward the end of this first 10 years was the development of relatively inexpensive instruments for use in danger rating. They were described in the September 1934 "Timberman" (pp. 30-32) by D. N. Matthews.



In subsequent years, the emphasis in fire research gradually shifted to the present program in response to the current needs of fire control organizations.

Weather Variations in the Mountains and Forest Fire Behavior

Our present fire-weather project is focused on the unknowns of weather variation in the mountain ranges that parallel the north Pacific coast. Scarcity of reporting stations offshore makes weather forecasting in this area difficult. Superficial knowledge of weather variation in these mountains is a serious handicap to prediction of forest fire behavior and to use of detailed weather information in fire suppression.

The weather variations in question are mostly undetected by the normal observation network. They include the small moving systems associated with thunderstorms, the configurations arising from influences of topography such as standing waves, and the finer details of large moving systems such as squall lines and fronts. Our first problem is to identify and describe these mountain weather variations, both at the surface and aloft. Our second problem is to apply this knowledge towards increasing the safety and effectiveness of fire control work.

Although the smaller weather systems, called mesosystems, have received much research attention in connection with the severe storms in the flat country of the Midwest, mesometeorological research in the mountains of the West has barely started.

In 1956, the Station cooperated with the Weather Bureau's fire weather research forecaster and the Oregon Forest Research Center's meteorologist in a 12-day sampling of weather variations in Oregon's Coast Ranges. The results showed terrain-linked patterns of temperature and pressure, at the surface and aloft, of which forecasters had been unaware. These were important patterns because they were closely related to atmospheric stability and surface wind patterns in the mountainous area. By implication, even more pronounced patterns might be expected at the surface and aloft over the bolder topography of the Cascade Range.

In the summer of 1963, we began the Cascades Fire-Weather Project in a 35-mile square of mountainous country, including the Clackamas River basin southeast of Portland and extending across the Cascades. An intensive observation program was launched with help from seven National Forest Ranger Districts, the Clackamas-Marion Fire Patrol Association and other adjoining forestry agencies, and the Region 6 Division of Fire Control.

Surface observations of pressure, wind, temperature, and humidity were made every 3 hours during 18 days at 26 stations. Various techniques were used to observe upper air conditions over the project area. Twice each day,

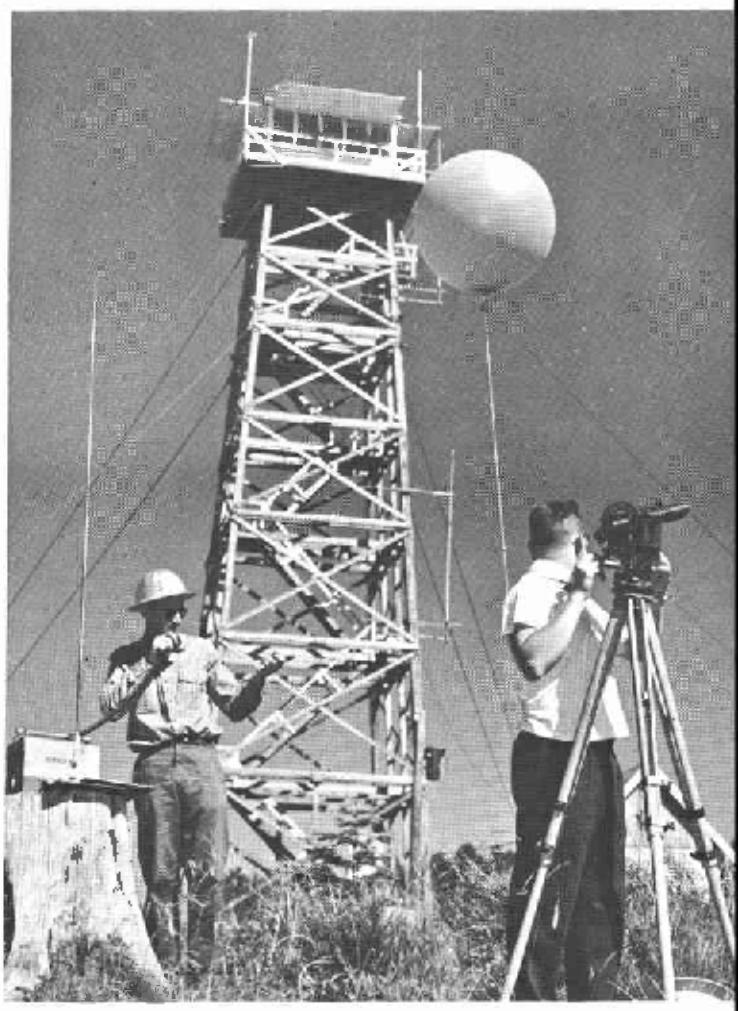
Summer fire control personnel from several agencies took weather observations every 3 hours. Here, Orlando Lange, of the Clackamas-Marion Fire Patrol Association, observes the humidity on Goat Mountain.

the Station's Cessna 180 made aerograph flights to record temperature and humidity along a 250-mile pattern that included seven vertical soundings between the surface and 8,000 feet. Rawinsondes were released during 2 of the 4 test weeks. Seventeen were released and tracked by the Meteorology Section of the 4th Infantry Division Artillery from Fort Lewis camped on the Cascade crest. Five were re-

leased by project personnel from Goat Mountain on the western edge of the range and tracked by the Weather Bureau at Salem, 40 miles distant. Upper winds were sampled by

Upper-air temperature, humidity, and wind were observed every 6 hours from Timothy Lake by an Army Meteorological Section, using this GMD-1 radiotheodolite which tracked and received signals from a balloon-carried radiosonde.

Winds in the study area were observed by this Oregon State University radar which tracked aluminum chaff dropped in patterns by the Station's Cessna.



Winds above the terrain were sampled from five localities by computing successive positions of a slowly rising balloon followed by two theodolites a thousand feet or more apart. This is one of the theodolite stations.

double theodolite every 3 hours during the day from two of five locations.

Under a cooperative research agreement with Oregon State University, a radar set in the project area was used to determine winds aloft in the Clackamas basin, by tracking aluminum chaff dropped in designated patterns during aerograph flights.

It will take some time to complete analysis of this vast amount of valuable data.

For analysis of the Coast Ranges data, new techniques were devised to utilize temperatures

observed at the various elevations of observation stations. The terrain-surface, potential-temperature map (or sea level temperature map) was the result. It resembles a sea level pressure map but reflects real density of surface air instead of fictitious pressure values. With help from the Division of Fire Control of Region 6, we are preparing potential-temperature analyses of several contrasting fire-weather situations in western Oregon. These will help forecasters become better acquainted with the new analysis tool.

We are also making, in cooperation with the Region 6 Division of Fire Control, a mesometeorological study of the 1962 Columbus Day storm. It is an extreme example of wind during slash-burning season and provides an opportunity to study the relation between terrain, pressure, and temperature fields and the destructive wind velocities that modify forest fuels.

So far, we have found that certain analyses reveal otherwise undetected differences in temperature and pressure patterns that affect local winds. Further development of analysis techniques and detailed study of weather patterns in the Cascades promise to clarify many of the poorly understood features of weather and fire behavior in the mountains.

Effect of Moisture on Burning of Logging Debris

Our project on fire control and use has concentrated on the problem of safely and effectively burning logging slash. Moisture content of the outer shell of unmerchantable logs and other large pieces of debris greatly affect behavior of fire in this logging slash. We studied the variation of this fire behavior factor from day to day and month to month in summer as related to weather near the Wind River Experimental Forest in 1962. That summer, the study included measurement of moisture content with an electrical resistance moisture meter at 1/8-,

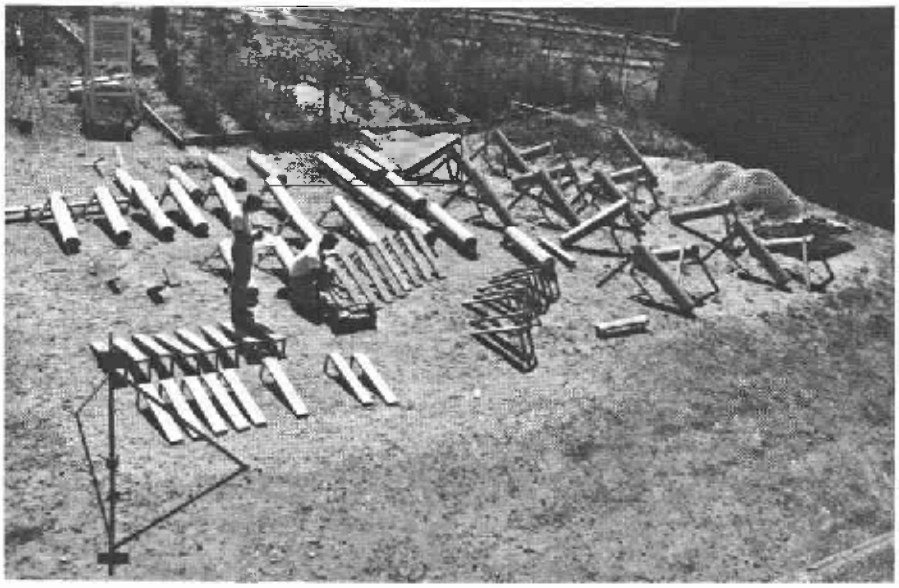
Logged unit in which moisture content of the outer shell of logs and other coarse debris was measured throughout the summer of 1962.

1/4-, and 1/2-inch depths in the barkless areas of many logs, parts of logs, and large limbs in the slash of a recently logged area.

At the peak of the dry season, a few hundredths of an inch of rain caused a highly significant increase in moisture to 1/4-inch depth and a slight increase to 1/2-inch depth. This increment disappeared in 2 or 3 days. Rains of several days' duration, totaling more than 1 inch, caused only a little greater increase. After prolonged rains in mid-September, moisture at the 1/2-inch depth did not disappear as rapidly as after similar rains in August. Owing to lag of log moisture in reaching equilibrium with relative humidity after rain, log moistures sometimes did not follow the direction of relative humidity fluctuations. Changes in log moistures to the 1/2-inch depth were generally in the same direction as changes in moisture in 1/2-inch-diameter wood dowels.

The exploratory study at Wind River led to more detailed and precise measurements on models of logs and log fragments in 1963 with the electrical resistance meter.

In mid-June, we exposed many freshly cut veneer core logs and 2-inch planks to the weather in Portland. These were raised from the ground at one end to represent three degrees of slope and were faced in different directions with reference to the sun's orbit. We measured moisture daily, or several times per day, using permanently inserted electrodes on the tops and bottoms of logs and planks and on the sides of some logs. We also recorded rainfall, relative humidity, air temperature, and moisture content of three sizes of wooden dowels. Results will be studied to determine effect of angle of exposure to the sun and variation in weather factors on log moisture and its relation to moisture fluctuations in wooden dowels.



Measuring moisture content of fuel models having different slopes and directions to the sun for comparison with records of rainfall, relative humidity, and temperature from weather station in background.

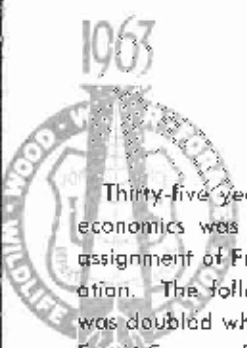
Plans for 1964

A new study of the moisture changes in logging slash will be based on the outcome of last year's work. The Cascades Fire-Weather Project will continue with emphasis on intensification and refinement of the observation program. We will try to identify pronounced stationary patterns and typical mesometeorological systems in the project area.


1928
1963
RURAL TAX RATES
FOREST RESOURCES of the Douglas-Fir Region
FOREST RESOURCES of the Ponderosa Pine Region
Mill Residues
Forest Statistics for
QUARTERLY STUMPAGE and LOG SUPPLY REPORT
timber trends

Forest Economics and Marketing Research

CARL A. NEWPORT, DIVISION CHIEF



Thirty-five years ago, the first study in forest economics was begun at the Station with the assignment of Fred Fairchild to study forest taxation. The following year, the Station budget was doubled when $30,000 was allotted for the Forest Survey of the Douglas-fir subregion. This Forest Survey project has continued from that time to be a main activity and was referred to in a history of the Station as, "one of the most important research projects ever to be undertaken by the Forest Service." In 1934 separate mimeographed forest statistics were released for each county in the Douglas-fir subregion, and detailed county forest type maps were made available to the public. Numerous such reports followed, and in 1940 the major report entitled "Forest Resources of the Douglas-fir Region" was published. Similar work and reports soon were released on the ponderosa pine subregion of Oregon and Washington.

These and subsequent reports and cooperative work with industries, forestry consultants, communities, and public agencies have contributed immeasurably toward more orderly development of forest industries in balance with the timber resource.

In July 1930, Harold B. Shepard started work on a forest insurance study in the Douglas-fir subregion. The results were published in 1935 and became the authoritative report on the subject for many years.

A comprehensive study of the economic aspects of forest management and exploitation was begun in June 1931. The first of several publications from this study came in June 1933, entitled: "Analysis of Logging Costs and Operating Methods in the Douglas Fir Region" by Axel J. F. Brandstrom. The late Colonel W. B. Greeley had this to say: "This report, in my judgment, gives the West Coast logging industry an extremely valuable handbook on logging costs and the selection of the most efficient equipment or method for a particular show."

In March of 1932, Sinclair A. Wilson was appointed as a senior forest economist and began a factual study of tax delinquency and land reversion in selected counties, directed at solving the problems created by instability of private forest ownership. Currently, the Division of Forest Economics and Marketing Research has five active projects under three functional activities: Forest Survey, forest products marketing, and forest economics.

FOREST SURVEY

Timber Trends in Western Oregon and Western Washington

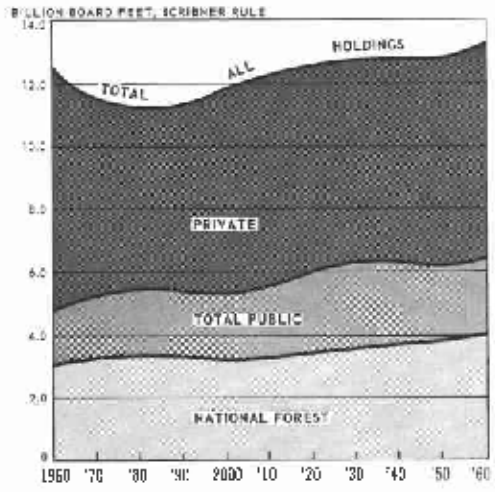
Following the completion of the initial Forest Survey inventory of the timber resources of the Douglas-fir subregion, a detailed analysis of the timber situation was made in 1940. This was followed by another such analysis in 1946 based on data from the 1945 Forest Resource Reappraisal. The rapid expansion of the timber industry during and following World War II and the increased competition from the Mountain States and western Canada have indicated the need for another searching examination. The timber trends study is just an examination.

This detailed study of the timber resources of the Douglas-fir subregion indicates that continuation of the present trend in utilization and management will result in a long-term potential

output of 13.1 billion board feet of saw logs and 400 million cubic feet of other material annually, or 14 percent above the average for the 1950's. Although this level of output will not be fully achieved until the decade of the 2060's and although output is expected to fall from the present level of about 12.5 billion board feet to a low of approximately 11.2 billion board feet in the decade of the 1980's, the average annual output during the 40-year transition period is expected to remain at or above the average of the 1950's, approximately 11.6 billion board feet annually.

The study further indicates that the long-term potential output of 13.1 billion board feet can be obtained on a substantially lower growing stock base of only 203 billion board feet as compared with the current 647 billion board

PROSPECTIVE ANNUAL OUTPUT, DOUGLAS-FIR SUBREGION



feet, or an average of 8,200 board feet of growing stock per acre instead of the current 25,000. This potential output will also be obtained on about 900,000 fewer acres of commercial forest land, most of it lost to forest roads, other than highways, installed for intensive management of the forest. Some currently marginal commercial forest land will be retired; some will be lost to increased recreational use and to power and reservoir developments.

Generally, over the long run, the region's production of timber will be influenced most by the more conservative timberland owners, large corporations, and the Federal Government, who will hold a little more than three-quarters of the estimated acreage of commercial timberland and a similar share of the best timber growing lands. These owners can economically produce about 82 percent of the saw-log yield and only a slightly smaller share of the total wood yield. These are the owners who use relatively long rotations, up to 95 years, to grow mainly saw logs, who manage their forests under close professional supervision, carry out light intermediate cuttings during the growth of the forest, bring about prompt regeneration after logging, and, overall, have a long view of the future. It is further expected that, following the transition period, approximately 48 percent of the long-term potential output will come from public lands and 52 percent from private lands, compared with 39 percent from public and 61 percent from private during the 1960's.

In developing these estimates, the study assesses the influences upon timber output in the Douglas-fir subregion, the potential timber supply in the long run, and the problem of reaching the potential during the conversion of an old-growth to a young-growth timber economy.

An economic model is developed to account for the major factors influencing timber output. One factor is the management practice followed on the forest lands. Another is land use—the acreage and quality of land allocated to timber growing. The third influence upon output is bound up in the time element as expressed in the guiding rate of return on forest investments. The economic model is used to demonstrate the considerable influence that the interest cost of building up or holding of growing stock has upon total output, primarily through its effect on the length of rotation. For example, those owners who have a high guiding rate of interest, actual or implied, will tend to choose short rotations of 40 to 60 years, whereas those owners operating under a lower guiding rate of interest, the conservative owners for example, will tend to choose longer rotations of from 70 to 100 years.

Toward Complete Use of Eastern Oregon's Forest Resource

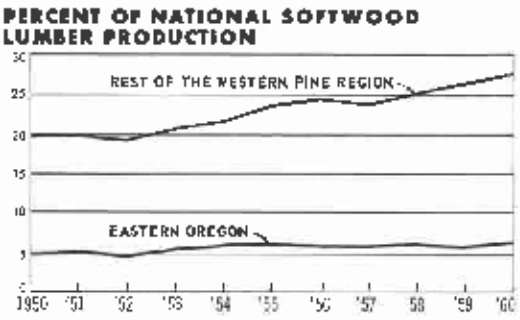
Forestry shares with agriculture a dominant role in the economy of eastern Oregon. Eastern Oregon should look to both these resources for future growth and development. A report just issued, "Toward Complete Use of Eastern Oregon's Forest Resources," is a detailed presentation of the situation and outlook.

In 1942, the Pacific Northwest Forest and Range Experiment Station published "Forest Resources of the Ponderosa Pine Region" in recognition of the need for a comprehensive report to assist in understanding the problems and opportunities of eastern Oregon. Now 21 years later, this new report of the forests and forest industries of eastern Oregon again reviews the past and explores the opportunities for the future. The forest economy of eastern Oregon has reached its present level largely through the manufacture of a single product—lumber. This is not a desirable situation, as it puts the timber economy at the mercy of a single market and, if the utilization of the tree is limited to lumber, it is impossible to realize the full potential of the forest.

With an economy limited largely to lumber, eastern Oregon is in competition with other softwood lumber producing areas in the Nation. Thus, increasing competition can be expected from the South, where softwood sawtimber supplies are building up after a period of overcutting had left them depleted. The increasing competition facing eastern Oregon can be seen in the changing pattern of production of the rest of the western pine region. That this situation is a very real threat to the continued

Eastern Oregon, a land dependent on agriculture and forestry.

growth of an eastern Oregon lumber economy can be seen in the following figure:



Over the past decade, eastern Oregon lumber production has remained level. At the same time the rest of the western pine region has increased its share of the national softwood lumber production from 19 percent in 1952 to 27 percent in 1960, and the trend of production can be seen to be increasing. Apparently, then, during the time when eastern Oregon was only holding its own, other comparable areas were increasing production.

This new report on eastern Oregon is based on the premise that the future growth and development will depend to a very great extent upon the full utilization of the forest resource obtained through product diversification and refinement by the forest industry. Diversification provides the means of using all the potential harvest from the forest and of serving the needs of people on a much broader market.

Other Forest Survey Activities

During 1963, inventory field work was completed in six counties in southwest Washington and compilation of the data started. Work is practically completed for the 1962 national recompilation of Forest Survey statistics. Compilation of new inventory data for western Oregon was completed and three inventory reports presenting the results are being prepared for publication.

Drawing to completion is a detailed study of the forest resources and forest products industries of the Columbia Basin made by the Experiment Station under a cooperative agreement with the Bonneville Power Administration. This is part of an economic base study to determine the probable economic development in the States of Oregon, Washington, Idaho, and western Montana over the next several decades.

A significant part of this study of forest resources is to determine future levels of employment resulting from the development of forest industries. To do this, an intensive investigation has just been completed to establish the past 10-year trend of productivity in the forest industries. The study showed that regardless of product, whether log, lumber, plywood, or paper, there has been a definite increase in productivity. The reduction in manpower needs between 1950 and 1961 has ranged from 15 percent for logging to 45 percent in the veneer and plywood industry.

Survey Techniques

Studies of survey techniques began in 1931 with the taking of aerial photographs of extensive forest areas in the Siuslaw National Forest in Clackamas County, Oreg., and Island and San Juan Counties, Wash. At that same time, a techniques study compared linear strip cruising with the compilation method in Lewis County, Wash., and was the basis for selecting the compilation method for the initial Forest Survey in the Douglas-fir subregion. Today, our research on survey methods continues along two lines, mensuration and photo interpretation.

In the mensuration field, we have developed some improvements in the stand table growth projection method. The basic method provides a means of estimating the future volumes of growth and growing stock under various assumptions of timber cut. The critical factors in such a projection are the estimates of future growth and mortality rates.

After we made several projections, it seemed apparent to us that the changing structure of the stand was the key to estimating these future

rates. We analyzed a considerable amount of Forest Survey data and found, as we expected, that those stands with the greatest basal areas had the lowest growth rates per tree and the highest mortality rates. Using these data, we developed a feedback system for the growth projection program in order to modify future rates of growth and mortality as stand basal areas change.

In the field of photo interpretation, we made substantial progress in getting our preliminary training manual ready for publication. Most of it has been rewritten, new material has been added, and new illustrations and stereograms are being prepared.

A test of stand-age determination from aerial photos showed that both stand height and crown closure were significantly related to stand age. However, we were able to classify only about one-third of the stands in their correct 20-year age class, substantially limiting the method's usefulness for gathering management data.

We also tested the accuracy of direct photo volume estimates on a series of cutting units from 20 to 40 acres in size. About two-thirds of the photo volume estimates were within 20 percent of the gross scale, indicating that the method can be useful when conditions preclude field work. However, a few of the estimates differed from the gross scale by as much as 80 to 135 percent, illustrating the risk involved in making photo volume estimates on small areas without any field checking.

FOREST PRODUCTS MARKETING

Pacific Northwest Quarterly Stumpage and Log Supply Report

The first of a series of quarterly reports on stumpage and log supply was published for the second quarter of 1963. This report provides information on stumpage supplies and prices, log and lumber production trends, log and lumber exports, and related current items bearing on the timber situation in the Pacific Northwest.

Some of the region's forest industries are becoming increasingly dependent on relatively short-term purchases of stumpage from publicly administered lands or of logs from independent logging operators or from other mills. At the same time, some of the larger firms have consolidated their holdings and are becoming more integrated in their production facilities. As a result, the amount of available logs has become an important strategic factor affecting production levels and long-term growth prospects of individual firms. Consequently, any uncertainties about the volume, quality, and price of available timber focus attention on factors influencing annual stumpage supplies. Public knowledge of these factors is essential if a strong forest economy is to be maintained.

LUMBER PRODUCTION

Year	Douglas-fir subregion	California	Mountain States	Eastern Oregon and eastern Washington	British Columbia coast	British Columbia interior
			Million board feet			
1950	10,108	4,263	2,449	2,227	2,512	997
1951	9,850	4,869	2,265	2,205	2,520	1,204
1952	10,364	4,578	2,598	2,180	2,276	1,421
1953	9,745	5,109	2,624	2,430	2,572	1,474
1954	9,283	5,113	2,988	2,596	2,684	1,695
1955	9,662	5,319	3,085	2,729	2,756	2,158
1956	8,759	5,882	3,587	2,608	2,454	2,281
1957	7,952	5,366	3,120	2,452	2,352	2,060
1958	8,439	5,321	3,381	2,527	2,565	2,284
1959	9,104	6,063	3,990	2,842	2,346	2,603
1960	8,100	5,175	3,383	2,679	2,850	2,455
1961	7,793	5,056	3,441	2,620	2,956	2,664
1962	8,077	5,002	3,621	2,819	3,090	3,164

Some of the data reported include:

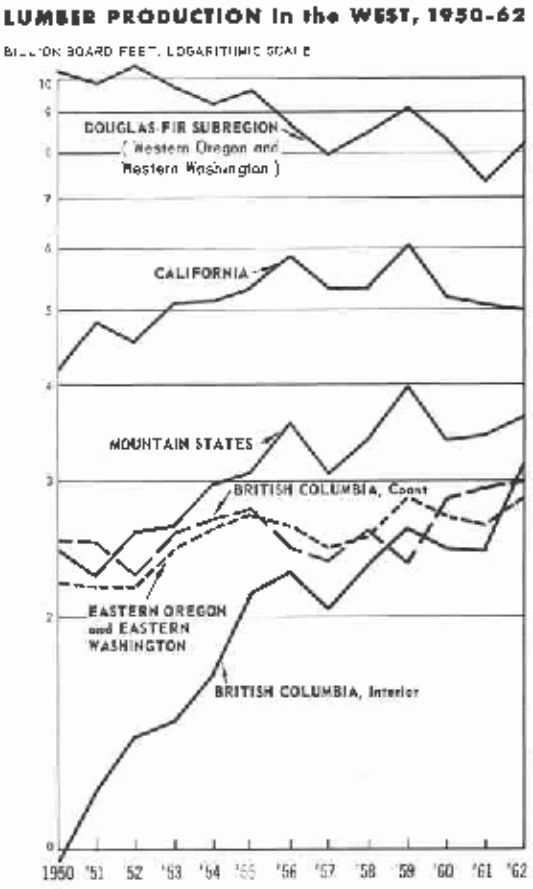
a. Volume and average stumpage price of public timber sales.
b. Volumes cut in relation to allowable cut.
c. Uncut volume under contract.
d. Average stumpage price by species.
e. Log exports by Customs District, species, destination, and average price.
f. Log and chip imports from British Columbia.

An important trend brought out in these reports is the rapidly growing lumber production in the Mountain States and Interior British Columbia, together with increased imports from coastal British Columbia. Much of this increased production is in the so-called associated species and competes with dimension lumber from the Douglas-fir subregion of western Oregon and western Washington.

Log exports, chiefly to Japan, continue in increasing volume as logging operators, mill owners, and industrial timberland owners seek to channel each log to its most highly valued market. Log exports are an important element in the region's external trade, and some of the ports have undertaken sizeable capital investments to enlarge and speed up their log handling facilities.

Cooperation in supplying data for our quarterly reports is received from the Washington State Department of Natural Resources, Oregon State Forestry Department, U. S. Department of Commerce, U. S. Bureau of Land Management, U. S. Bureau of Indian Affairs, and private industry.

Western U.S. and British Columbia lumber production, 1950-62.



Log and lumber exports are an important part of Pacific Northwest foreign trade.

Demand and Supply Relationships in the Douglas-fir Plywood Industry

Financial support under cooperative agreement was given to Oregon State University for a study entitled "Forecasting prices, production, and new orders in the Douglas-fir plywood industry." The resulting econometric analysis of demand and supply relationships describes plywood markets in mathematical equations. Further work is being done to test predictive ability of the equations and to suggest how such forecasts could be used by firms to optimize production and market planning decisions.

Log Production in Windthrown Timber

Salvage of timber from the October 1962 windstorm gave opportunity to compare production rates in windthrown and standing green timber on Cascade Head Experimental Forest. Two clear-cut settings were laid out, one in concentrated blowdown and the other in largely undamaged adjacent timber. They were logged by the same crew and equipment.

Felling and bucking production time in the blowdown area was greatly reduced, simply because only as much of it was done as was necessary to free the trees for yarding. Further bucking was not possible for safety reasons. Also, this situation resulted in lower yarding production time in the blowdown area because of the tree-length pieces yarded rather than the normal log lengths. This revealed possible cost savings by yarding in tree lengths when logging standing timber.

FOREST ECONOMICS

Predicting the Cost of Dwarfmistletoe Control

In the course of a comprehensive study of ponderosa pine dwarfmistletoe control opportunities, costs of eradication under various stand conditions were determined. Time studies were made of crews doing control work on National Forests in eastern Oregon.

Treatment of infected stands on public lands is combined with silvicultural thinning to secure desired stocking and involves several steps. First, all merchantable overstory trees are removed, since no effective means of sanitizing large trees have been found. Next, a thinning operation using "brushcutters"—circular saws powered by chain-saw engines—reduces stocking to about 550 stems per acre. In this study, chain saws were used to fell trees over 5 inches in diameter. Leave trees were chosen from dominants without stem infections and with as few branch infections as possible. Third, prun-

Thinning this ponderosa pine stand would cost $16 per acre if it were uninfected. However, 1 percent of the trees are infected with dwarfmistletoe. Searching each tree for infection adds $88 per acre to treatment cost.

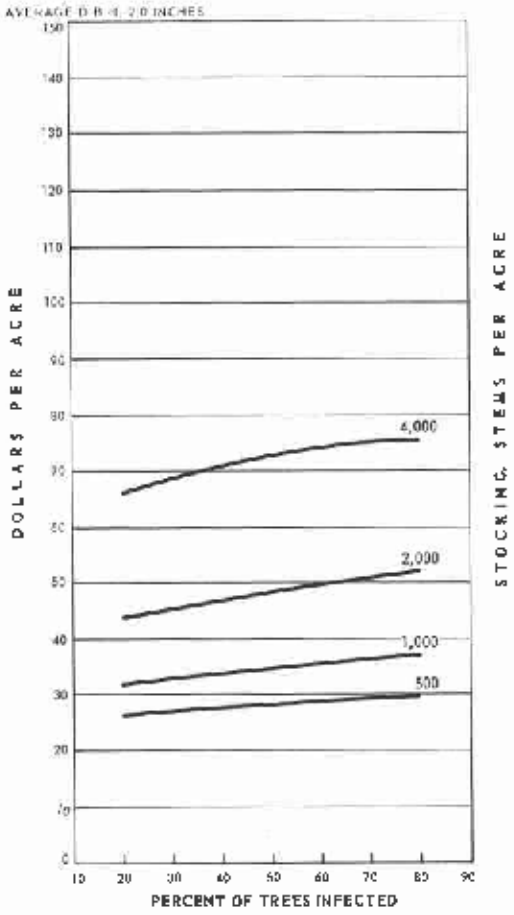
ing saws are used to remove branch infections from residual trees. In the final step, selected crop trees are pruned for quality improvement.

Over 80 combinations of stand density, tree size, and infection intensity were treated in the study. Accompanying graphs show how treatment cost values depend on stand conditions. Because mistletoe control is practiced concurrently with silvicultural thinning, the curves were developed by subtracting the cost of silvicultural treatment of uninfected stands from the cost of treating infected stands of the same stocking and average diameter.

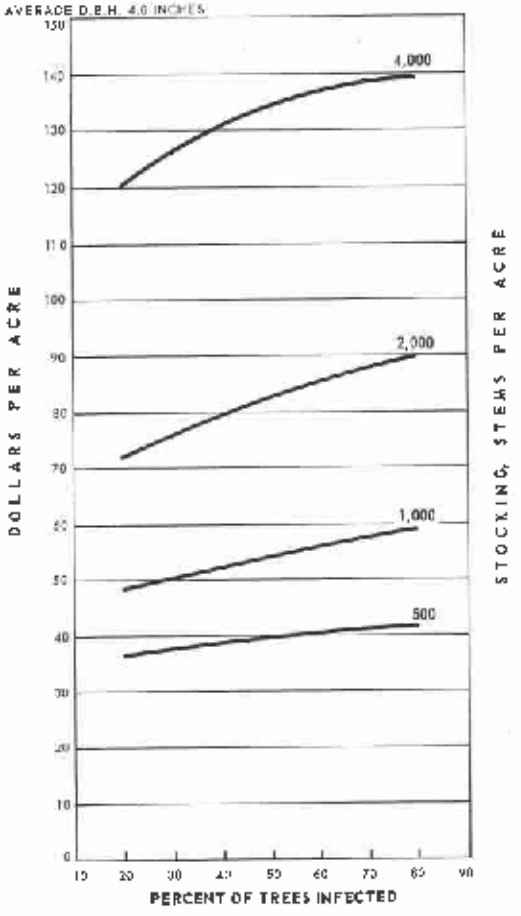
Not included in the charts is the cost of recleaning the stand several years after initial treatment to remove latent infections that were imperceptible earlier. Studies of recleaning cost are in progress.

Whether a particular infected stand should receive priority for treatment over some other stand depends only partly on treatment cost. Returns from treatment—that is, the amount and value of growth saved from loss—must also be considered. Study of returns from dwarfmistletoe control will continue in 1964, based on estimates of growth impact, rate of spread, and other information being developed by the Divisions of Forest Disease Research at the Rocky Mountain and Pacific Northwest Forest and Range Experiment Stations.

COST OF DWARFMISTLETOE CONTROL
IN YOUNG PONDEROSA PINE STANDS



Note: These costs are those in addition to the cost of silvicultural stand improvement and overstory removal. In-



cluded are costs of travel time (1 hour per 8-hour workday), vehicles, supervision, plus 16 percent for overhead.

Trends in Reforestation and Its Cost

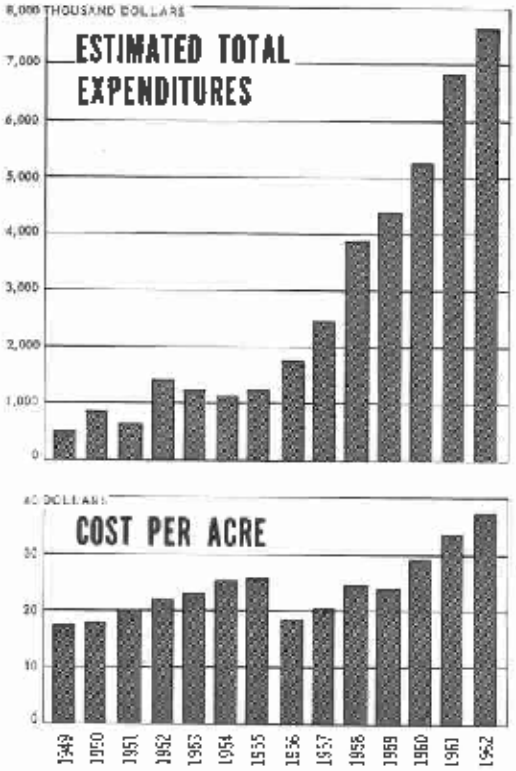
Artificial reforestation in the Pacific Northwest during 1915 amounted to 2,500 acres of plantations. In 1962, nearly 205,000 acres were reforested, 102,000 by direct seeding and 103,000 by planting.

The total cost of reforestation in 1962 was $7-1/2 million, an average of $37 per acre. From 1949 to 1962, total acres reforested annually increased sevenfold, while total annual expenditures for reforestation (in current dollars) increased tenfold, despite the advent of direct seeding. Per-acre reforestation costs vary widely between sites. In 1962, planting costs ranged from less than $15 to more than $100 per acre and averaged $56.85 per acre for the region as a whole. Seeding costs ranged from less than $7 to more than $80 per acre and averaged $15.25 per acre.

In contrast to the expenditure for seeding and planting, one-third of a million dollars was spent for reforestation research in 1961.

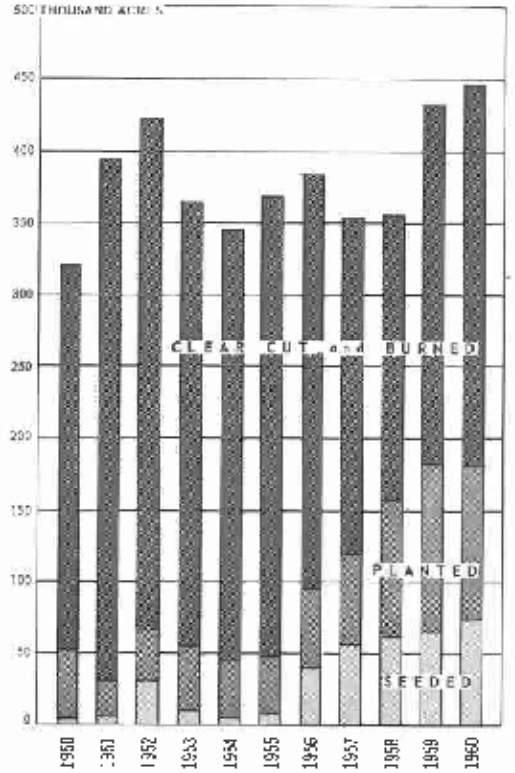
Approximately 255,000 acres of commercial forest land are denuded each year by clear cutting and by fire in immature timber. In addition, there is a backlog of about 2 million unstocked acres. While reforestation of every backlog acre is an attractive goal, some areas of high cost and low potential return probably should be deferred, especially if progress in research toward less costly or more successful reforestation techniques is in prospect. Certainly, treatment priority should be given to sites where return to reforestation effort is highest.

Artificial reforestation in the Pacific Northwest, 1949-62, in current dollars.



Note: Overhead is included. Costs per acre calculated by dividing total expenditure by total acres reforested and, thus, represent an average value for both planting and seeding.

Acreage seeded, planted, and clear cut and burned in the Pacific Northwest.



Note: Acreage clear cut and burned shown to nearest 5,000 acres.

Multiple Use

Although Forest Service research has for a long time been in multiple use forestry, our newest project, multiple use economics research, illustrates a growing need for coordinating forest-land uses. Our current study of wilderness land allocation in the Pacific Northwest reflects several multiple use coordination problems summarized in the question, "What facts should be considered, and how can they be related to determine how much wilderness and where?" Several classes of fact (political, economic, sociological, etc.) are required to resolve this kind of problem, but the appropriate techniques for relating them are still to be determined. The timeliness of this study has been underscored most recently by our participation in the joint study by the Departments of Agriculture and Interior of land uses in the North Cascade Mountains area of Washington, where wilderness-type recreation and other uses of forest lands are becoming increasingly competitive with each other.

Other Economic Research

To fill a need expressed by practicing foresters, tables of compound growth percent have been prepared for Douglas-fir trees. Based on a volume table and previously published height-diameter relations, the tables indicate present and near-future volume growth percents for an individual tree of a particular diameter, age, site, and expected rate of diameter growth.

An economic evaluation of alternative spacings, using 35 years' data from Douglas-fir spacing trials at Wind River, is near completion. Optimum spacing appears to be near the maximum spacing used in the experimental plantations.

Advance roading is the focus of two studies. One, concerned with old-growth timber on the Umpqua National Forest, explores the economic implications of an accelerated construction program. The second, a cooperative project with University of Washington and Weyerhaeuser Co., appraises advance roading in young growth under alternative thinning and harvest schedules.

A report on small forest ownerships has just been completed. This study offers a critique of previous work in this field. Synthesizing the findings of other investigators, the author concludes that forest management practices of nonindustrial forest-land holders can be explained in an economic context. An economic model is employed to suggest a least-conflict allocation of timber production investments between public and private owners.

PLANS FOR 1964

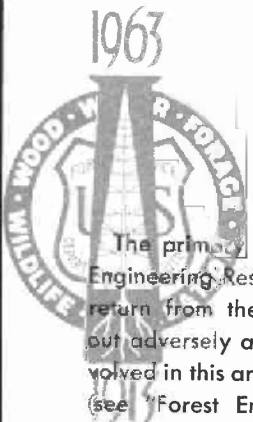
Forest Survey field work will be carried out in a 10-county area of central Oregon. Techniques research will further emphasize work on mensurational aspects of problems in forest inventory and resource analysis.

In marketing research, we will return to a study of production rates and costs in thinning Douglas-fir now that the disruption by the 1962 blowdown is past. A study is planned on the optimum use of Douglas-fir logs in an integrated forest economy.

Work will begin on a study of the economics of thinning in Douglas-fir stands. Mathematical relationships will be used to estimate rate of return on thinning investments in terms of wood as well as dollars and interest rate. A preliminary analysis will also be made of the problem of alder versus conifers on conifer sites.

Forest Products and Engineering Research

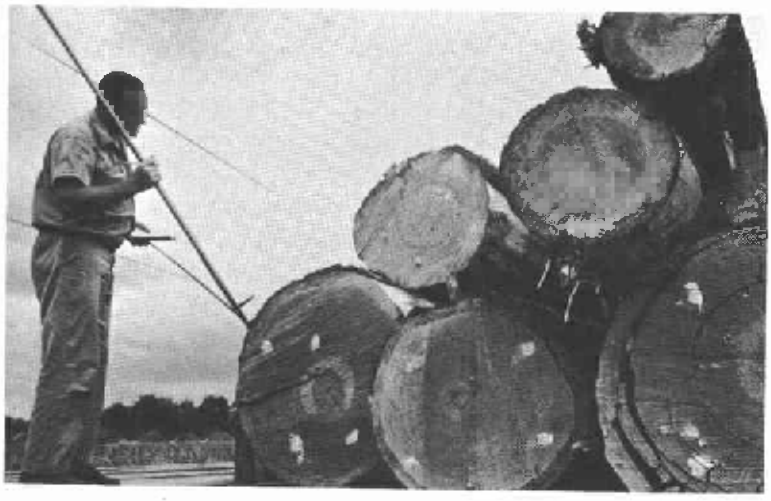
JOHN B. GRANTHAM, DIVISION CHIEF



The primary concern of Forest Products and Engineering Research is to obtain the maximum return from the region's timber harvest, without adversely affecting other forest values. Involved in this are new concepts of timber harvest (see "Forest Engineering"), improved systems of evaluating timber stands (see "Timber Quality Research"), and our general program for utilization improvement, mentioned only briefly in this year's report.

In brief, the last-named program—utilization improvement—includes identifying and analyzing regional utilization problems, stimulating a coordinated attack on these problems by public and private research agencies, and maintaining a close liaison between regional technical interests and the Forest Products Laboratory at Madison, Wis., where products research of the Forest Service is centralized.

A current example of utilization effort is our study of internal tree damage produced by severe windstorms. This study was prompted by the Columbus Day storm of 1962, which not only resulted in a loss of growing stock but also created many problems in utilizing timber. Some forms of internal damage, such as splits, windshake, and cross breaks, are quite apparent. Other forms, such as compression failure, are not easily detected and therefore pose grading and use problems. The current study aims to develop means of: (1) identifying significant structural damage at the earliest possible point in processing, (2) characterizing damage as to degree, and (3) defining acceptable limits of wind damage in products. The study is being made in cooperation with local industry, regional research agencies, and the Forest Products Laboratory.



Timber damage caused by Columbus Day storm in 1962.

FOREST ENGINEERING

The complex task of achieving multiple use forestry goals under existing economic restraints emphasizes a need for sound engineering. The need is particularly evident in planning the harvest of heavy, old-growth timber stands of the Pacific Northwest and Alaska. To centralize the engineering resources, the Station's program of forest engineering research has been established at Seattle. This location provides a valuable complement of university and industry facilities to augment Forest Service efforts.

To help orient the program to the problems ahead, a subcommittee on forest engineering has been appointed as part of the Station's research advisory committee. The subcommittee, composed of leading members of the logging industry will meet periodically to review research plans and progress.

A newly designed skyline crane logging system in operation. (Photo courtesy Washington Iron Works.)

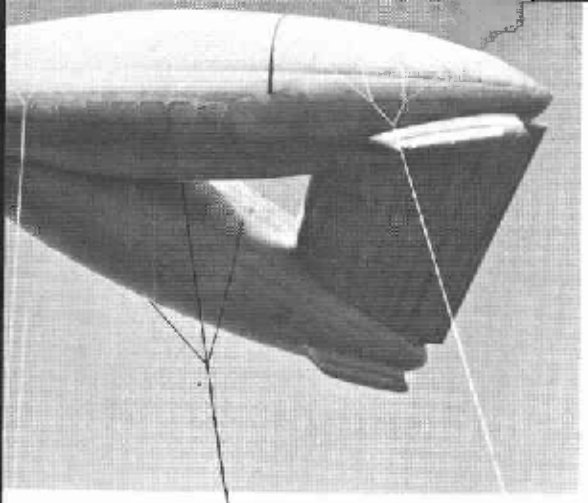
Substantial contribution to the excellent start on the engineering research program has been provided also by the cooperation of National Forest Administration and the University of Washington. The support of Regions 6 and 10 and that of the colleges of engineering and forestry at the university have been particularly noteworthy.

Logging Steep Hillsides

The study of logging steep hillsides with minimum road construction illustrates the need for engineering research to achieve major forestry goals. Successful development of fully suitable and economic means of downhill yarding will make a substantial contribution to the forest economy by permitting timber harvest in stands now considered inoperable. Also, this development could permit improved practices in watershed management, timber management, and forest recreation.

This study is being approached in two directions to find the optimum solution. One approach is to review the capabilities of existing skyline logging systems to determine areas needing further improvements. Included with this is a study of multispan skyline cable tensions and deflections to provide much needed information on properly engineered layouts.

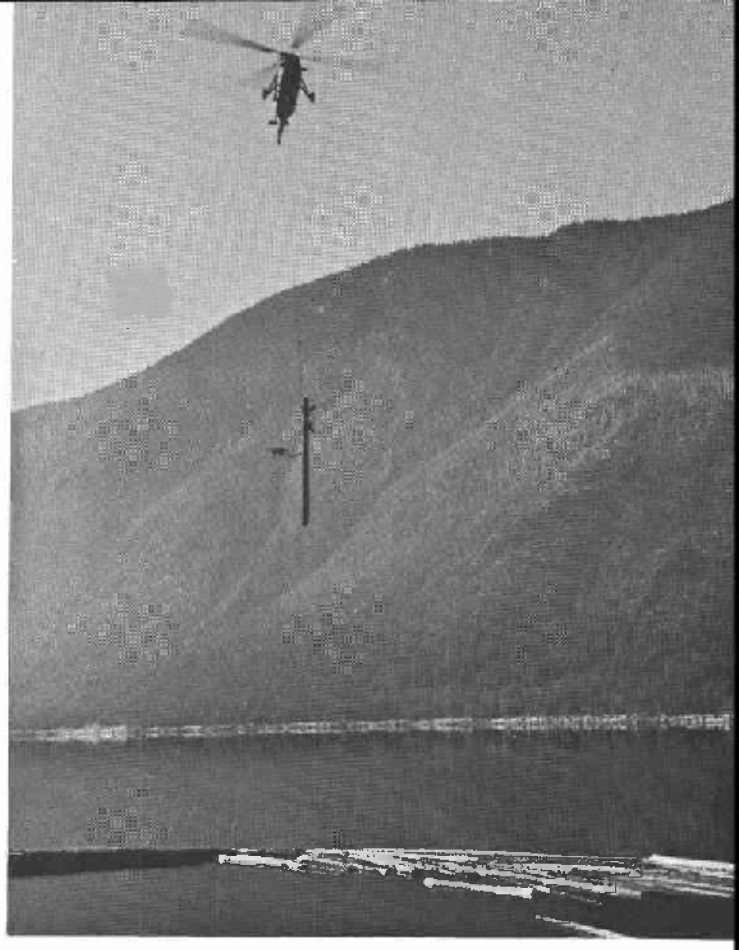
The second approach covers an extensive investigation of the feasibility of logging with balloons. This concept envisions the use of balloons to provide a lift to one end of the logs during yarding. An advantage of the balloon concept is elimination of many serious problems inherent in erecting and supporting a multispan cableway. One of the disadvantages being carefully investigated is the susceptibility of the balloon to severe wind and weather conditions.



Trial of balloons to provide lift in downhill yarding — 2,600-foot yarding distance.

Helicopter Yarding

The study of helicopter logging continues with the prime objective of developing power-operated log grapples which will facilitate log pickup and release. Concurrently, substudies are being conducted to determine a log weight estimating procedure, the mechanics of helicopter yarding, and systems operating procedures for helicopter logging.



Test-yarding a log from ridgetop to water by helicopter.

Lift provided to a log in balloon yarding.

Road Design and Cost Reduction

The first phase of a road-design, cost-reduction study has been completed and documented on the subject of truck-tire research. This phase covered a static test and evaluation of dual and wide, single, off-highway truck tires and proposed a road-test program for necessary dynamic tests. Results of the road-test program should indicate where design revisions can be made to achieve a reduction in road-construction costs.

The second phase of this study, covering dynamic tests on a logging road, is subject to construction and operation of a road-test section.

Wide, single tires (in place of duals) on a heavy-duty logging truck. (Photo courtesy Kenworth Motor Truck Co.)

Dryland sorting of logs facilitates the task of diagraming log characteristics before processing.

TIMBER QUALITY RESEARCH

The Station has long been concerned with lumber grade studies as a means of evaluating timber quality. From 1912 through 1916, studies were made at eight mills to develop lumber yields from several western species. Activity in this field has varied over the years. During the thirties, major attention was given to ponderosa pine. More recently, the emphasis is on comprehensive grade-yield studies that would provide a basis for improving existing log-grading systems or developing tree-grading systems. Current studies carefully characterize each tree and each log in order to better relate the subsequent yield of lumber or veneer to tree or log quality.

The principal concern of the Forest Service and other public timber agencies in timber quality research is to more accurately estimate tree value; the main concern of industry is to more adequately estimate log value for specific products as an aid to proper log allocation.

The Station's major activities in timber quality research during 1963 were to:

1. Develop an improved system for grading logs in standing inland Douglas-fir sawtimber.

2. Begin a comprehensive investigation of the quality of coast Douglas-fir to improve the means of estimating its value for conversion to lumber or veneer. Major emphasis is on improvement of the log-grading system used by public agencies to evaluate the quality of standing timber, but findings of the investigation will be available to those concerned with log use.

3. Conduct lumber grade recovery studies for ponderosa pine in accordance with an improved log-grading system recently developed by the Pacific Southwest Forest and Range Experiment Station.

Study logs can be graded, scaled, and decked in the log yard before use in a grade recovery study.

Improving Inland Douglas-fir Log Grades

During 1963, development of an improved system of grading inland Douglas-fir sawtimber neared completion.

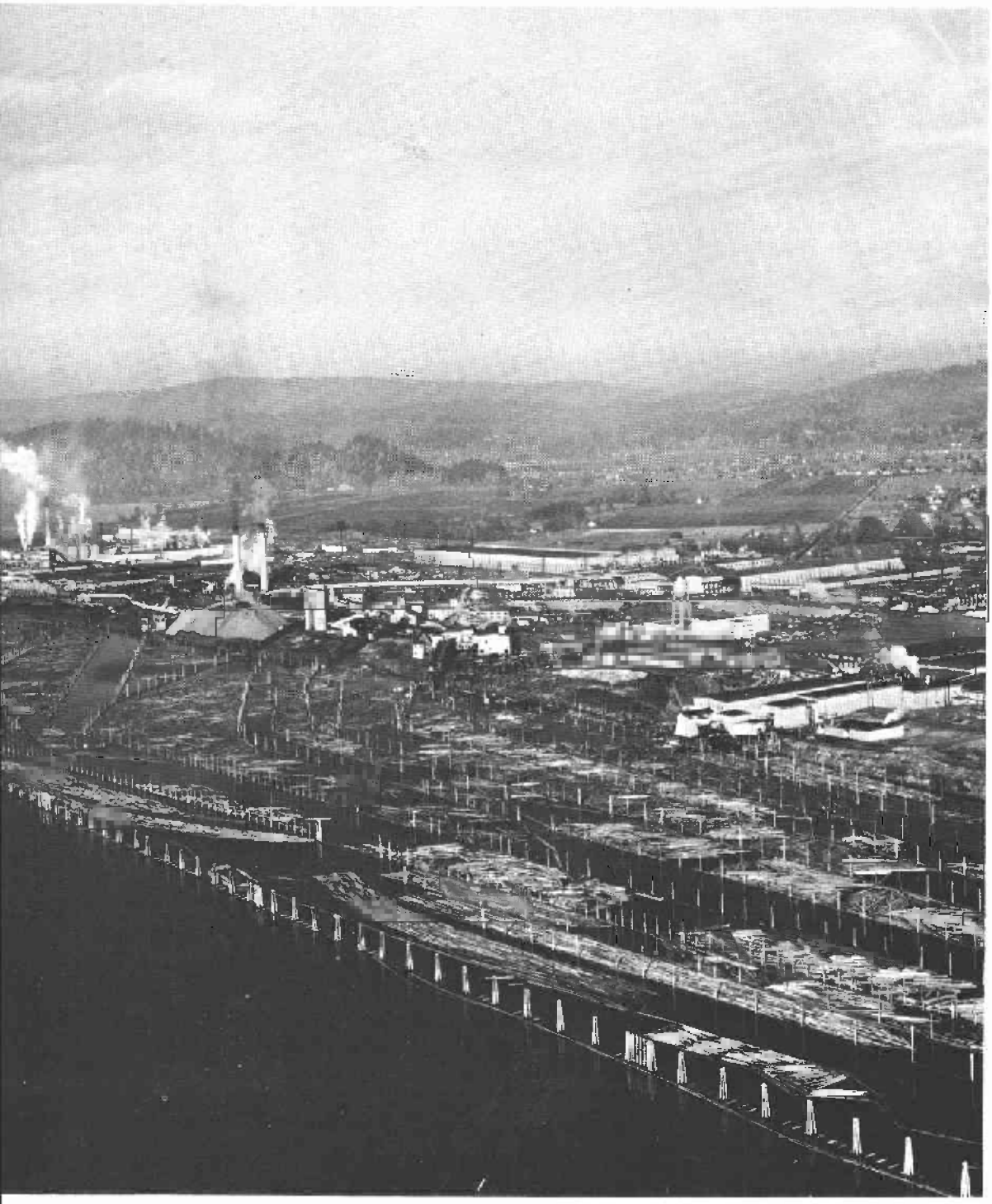
Timber-quality and lumber-yield data from about 5,000 logs were analyzed to learn which stand, tree, and log characteristics were most important in evaluating the quality of inland Douglas-fir sawtimber. From these analyses, a preliminary grading system was developed that is significantly better than either of two systems currently used in cruising timber. Developing and testing the grading criteria will continue until the most accurate system, consistent with practical application in timber cruising, has been obtained. An improved log-grading system should be ready for use early in 1964.

Investigating Coast Douglas-fir

Specific plans, procedures, and preliminary arrangements were made for a comprehensive investigation of coast Douglas-fir to improve the evaluation of standing trees for either lumber or veneer.

This investigation will require a high degree of cooperation between industry groups, individual companies, public agencies, and research workers, since timber-quality and product-yield data must be obtained from representative samples of merchantable trees throughout the commercial range of coast Douglas-fir. Product recovery studies will be needed at about 10 sawmills and an equal number of veneer mills in Washington, Oregon, and California. Arrangements are being made for the initial lumber and veneer recovery studies in southwestern Washington in February 1964. It is expected that the fieldwork will extend into 1965.

Although this research is designed primarily to develop an improved system of evaluating the quality of standing trees, data will be obtained on the characteristics of the timber stands, the individual trees, and the logs from each tree. Yields of lumber or veneer will be recorded for each log in order that the value of an individual tree can be related to its characteristics. The relationship of log characteristics to product yield and value should be useful to the cooperating industry groups and companies in considering refinements or modifications of current log-grading systems.



Complex of forest industry plants, at Longview, Wash., illustrates the opportunity to allocate logs for maximum utilization.

Lumber Grade Recovery under the Improved Ponderosa Pine Log-Grading System

To implement the improved ponderosa pine log-grading system, National Forest Administration in Region 6 required up-to-date lumber grade yields. The needed yield data is being developed through a series of cooperative studies at two mills in eastern Oregon and one in eastern Washington. Representative samples of ponderosa pine timber tributary to each of three mills were selected with the assistance of the National Forests and several companies.

Complete information was recorded for each of 318 sample trees, including environment, risk class, tree grade, and the log grades contained. The Western Pine Association assisted with the tree selection and photographed each tree.

The logs from each of the trees were identified, and the lumber yield of each log determined. Thus, the grade yield and lumber value of each log and each tree is available. The lumber recovery will be analyzed to develop estimating equations of lumber value, by log grade and diameter class, for each of the three studies and for the combined data. Lumber grade recovery will be tabulated, by log grade and diameter class, for the improved grading system and for the previously used grading system. Lumber grade yield and value by tree grade or tree size will not be tabulated, but tree data will be made available to the Western Pine Association or others interested in such analysis.

Batch Method of Measuring Lumber Grade Yield in Relation to Log Input

To answer the question of whether or not detailed grade yield studies reflect the overall experience of representative mills, a new batch study method was developed this year. The method is already in use in Region 5, but its initial use in Region 6 awaits the early development of an improved log-grading system for inland Douglas-fir.

The batch method compares actual lumber value obtained from any mix of logs with the predicted value of those logs. The predicted value is based on the lumber grade obtained by detailed studies of a species. Although the detailed grade yield studies are elaborate and time consuming, the subsequent batch studies can be simple. An adequate series of batch studies can increase the usefulness of the base yield studies by revealing how lumber values are influenced by log origin, mill type, or sawing practices and thus indicate the overall applicability of a general performance table. Even more important, a series of batch studies at the same mill can reveal the effects of log origin, sawing practices, or order files on its lumber value output. A mill must determine the average ratio of its recovered lumber value to that predicted by the general performance table. This ratio becomes the mill standard, and variation from the standard indicates the effect of a new factor or factors.

PLANS FOR 1964

Complete the development of a log-grading system for inland Douglas-fir and expedite its use. Through a series of batch studies, compare log grade performance data for the inland fir grading system against industry experience. Examine the feasibility of developing a tree-grading system for inland Douglas-fir.

Analyze yield data collected from 3,800 larch saw logs for development of log grades and, if possible, tree grades.

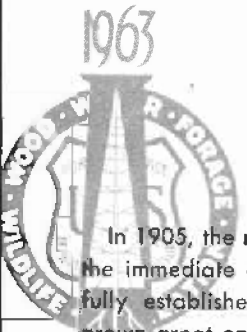
Give major emphasis to collecting timber quality information and lumber and veneer recovery data for coast Douglas-fir.

Conduct lumber recovery studies on other species that are urgently needed by National Forest Administration.

Continue current studies in forest engineering. Place emphasis on completing helicopter studies to permit expanding the scope of other studies.

Range, Wildlife Habitat, and Recreation Research

DAVID F. COSTELLO, DIVISION CHIEF



In 1905, the newly formed Forest Service had the immediate and urgent task to deal with a fully established grazing industry which had grown great on free range. The need for regulation of grazing, establishment of grazing fees, restoration of forage, and protection of watersheds led the Forest Service to start studies on which to build a sound grazing enterprise. Some of these early efforts at range research began in the Pacific Northwest.

These studies were handled by James T. Jardine and Arthur W. Sampson, the two pioneers in National Forest-Range research. Their first publication, based on studies on the Wallowa National Forest in Oregon, included reports on use and management of the range, the bedding-out system of grazing for sheep, water development, better seasons of grazing, deferred and rotation grazing, and methods for making range surveys. The efforts of these men led to establishment in 1910 of the Office of Grazing Studies in the Forest Service in Washington, D.C., and the recognition of range research as an important field of investigation.

In 1911, grazing study offices were organized in the Pacific Northwest, Intermountain, Rocky Mountain, and Southwestern Regions. Similar offices were established in the Northern Rocky Mountain Region in 1913 and in the California Region in 1915. From these beginnings, range research gradually expanded in the West. A special study in 1926 of the needs for range research along with a consideration of the whole need for forest research, under the direction of Earle H. Clapp, formed the basis of an extended and intensified program of resource investigation authorized by the McSweeney-McNary Forest Research Act of 1928. This Act was followed by the consolidation of all Forest Service range experimental work under Regional Forest and Range Experiment Stations.

In the Pacific Northwest Station, research in the Division of Range, Wildlife Habitat, and Recreation Research has expanded and intensified through the years to include studies of grazing capacity, range condition and trend, methods of handling livestock on ranges, control of losses from poisonous plants, use of fire in improving range condition, relation between grazing and timber production, improvement of big-game ranges, competition between big game and livestock, artificial revegetation of the range, ecological and physiological reactions of vegetation to grazing, and studies of wilderness recreation dynamics. Results of two of these phases of study are highlighted below:

FORAGE PRODUCTION in relation to TIMBER MANAGEMENT

Two of the major resources whose interrelationships are being investigated are timber stands and understory cover. A descriptive study of the impact of logging on herbs and shrubs and their recovery has been underway for more than 10 years. This study has furnished information on the amount of soil and understory disturbance by tractor, jammer, horse, and Wyssen systems of logging.

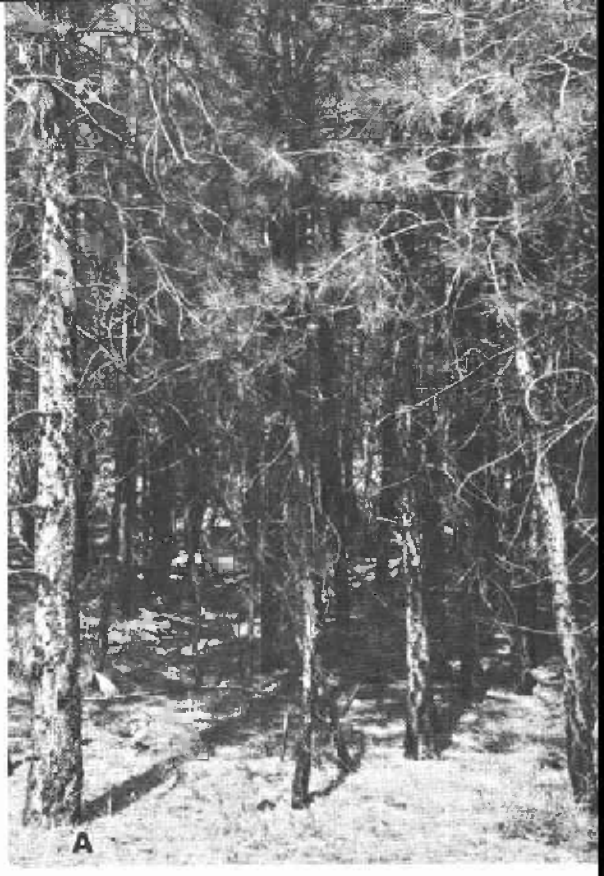
The immediate effects of tractor logging were found to be of major consequence to the forage resource on forested rangelands. Deep soil disturbance occurred on 15 percent of tractor logged areas. Such disturbance at depths of 1 inch or more resulted in consistent heavy losses of the valuable grasses and grasslike plants because of their shallow roots. Tractor logging on steep terrain caused deeper soil disturbance. Areas of 40 percent or greater slopes averaged 2.8 times more soil disturbance than areas with slopes of less than 40 percent. Logging with jammer, horse, or the Wyssen skyline system created deep soil disturbance on only 3 percent or less of timber sale areas.

In 1959, we established a combination pine spacing—growth increment and forage production study in cooperation with the Washington Department of Game, Okanogan National Forest, and U. S. Soil Conservation Service to gather combined and comparative yield data. The changes in yield of understory vegetation are particularly interesting at this time.

After three growing seasons, increases in average total understory yield on the thinned spacing-treatment plots were significantly greater ($P = 0.002$) than on the unthinned plots, but differences between thinned plot averages ($P = 0.09$) were not significant at the 5-percent level. It should be pointed out that although total yield of all vegetal classes is being considered here, grasses showed a much greater response to tree spacing than did either forbs or shrubs.

Treatment, in this experiment, was analyzed in three aspects: (1) growing area per tree (spacing squared), (2) percent pine canopy, and (3) basal area of pine in square feet per acre.

When growing area per tree was used as treatment, there was a positive linear trend ($P = 0.07$) with 63 percent of the total variance related to the regression. When percent canopy or basal area of pine was regarded as treatment, there were significant negative linear effects on understory yield ($P = 0.001$). Portions of total variance attributable to regression were 95 percent for canopy and 89 percent for basal area. Residual variation was nonsignificant in all three cases.

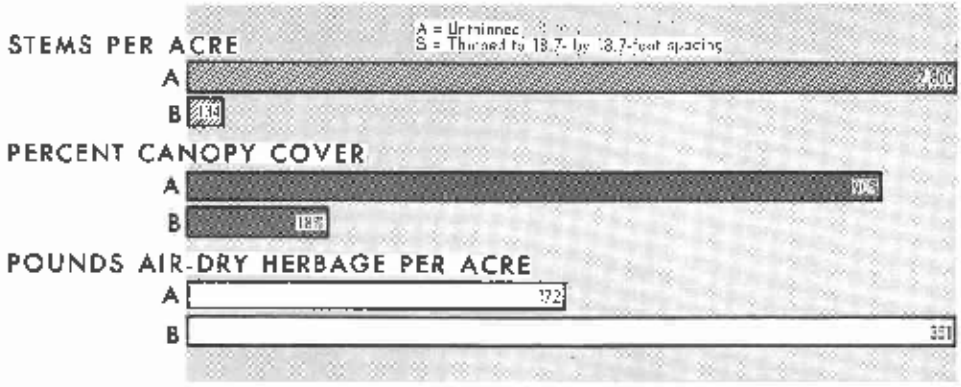


Since tree spacing treatment effects were influenced by percent canopy, total understory yields were adjusted using percent canopy as a covariate. This analysis showed that all significant differences in treatment averages could be explained by canopy percent. In other words, tree spacing produced its effect on understory yield through canopy.

Although the preceding adjustment was not made using tree basal area as a covariate, the same general result would be expected. Basal area and canopy percent are both influenced by tree spacing, and testing for linearity gave approximately the same result regardless of the attribute used as expression of treatment.

A companion pine spacing study in central Oregon has been expanded to consider quality as well as quantity of forage for deer grazing. Laboratory analysis showed that ash content of bitterbrush was significantly higher and crude fiber significantly lower in unthinned pine stands, but there was no significant difference between different levels of thinning. The analysis also indicated that thinning had no immediate effect on crude fat or crude protein content of bitterbrush.

Dense stands of ponderosa pine respond to thinning with significant increases in understory herbage the third growing season after thinning.



WILDERNESS RECREATION DYNAMICS

In the past two decades, pressures for all land uses have increased tremendously. Pressures for wilderness and other recreation areas have conflicted with commercial uses of the same resources. As a consequence, public land administrators are often in a quandary trying to serve all needs appropriately and yet protect the resource for future use.

Current studies seek to develop basic knowledge about the key characteristics and experiences of wilderness users and the values that arise from wilderness recreation. This knowledge is immediately useful for resource managers who seek maximum values from recreation on present backcountry areas; it can lead to better allocation of land for wilderness.

We completed development of practical and statistically sound methods for describing the characteristics of wilderness use, based on use of unmanned registration stations on wilderness access trails.

The design of unmanned registration stations affects the response of trail users. The most effective signs used were those with (1) firmness and directness of wording and tone and (2) a brief, honest statement of why users should register. In addition to the signs, an attraction device such as a plastic-protected map providing desired information was found helpful in eliciting response.

Stations placed at all access points into study areas provided accurate data about several use and user characteristics when adjustments were made for nonresponse. Methods of adjusting for nonresponse were tested to determine which were most effective and efficient. A carefully devised interviewing system best satisfied adjustment needs. With proper design and installation and subsequent adjustment, unmanned registration stations are highly effective and efficient tools for gathering several types of objective information from wilderness users.

A study to test participant-observation techniques indicated that important information can be obtained about forest recreation by properly designed, systematic observation. Representative findings are as follows:

> Two or more camping groups occupied 27 percent of the filled single-family campsite units, even though there were empty and available single-family units. Some variation in campground design may be desirable to protect areas from deterioration and to satisfy the desires of these gregarious groups.
>
> Problems of site control by the land manager may be hindered in those campgrounds having a large proportion of repeat users who feel they have squatters' rights on "their" campground. Their feelings and traditions will need to be considered if management decisions are to be effectively carried out on minimally policed campgrounds.
>
> To improve resource protection, enhance individual satisfaction, and solve problems of control, campgrounds need to be designed for varying activities deemed desirable for a given recreation site. For example, water skiing campgrounds need different unit spacing and screening requirements than family fishing campgrounds.

Wilderness campers and roadside campers were compared in an exploratory study to test variables associated with leisure activity choice, commitment, and persistence. This study is yielding information useful to land administrators who must identify the important user groups, determine how many of them there will be in the future, and estimate what their future demands may be. Initial findings based on 741 family groups using the Three Sisters Wilderness Area in Oregon and adjacent roadside campgrounds are as follows:

> Forest campers as a whole have significantly higher family incomes than the population at large.

Using unmanned registration stations adjusted by interview information, we learned that most users of the Three Sisters Wilderness Area in Oregon were visiting the area for a day hike.

The majority of forest campers come from urban areas but have rural or small town family backgrounds.

Forest campers who use both auto and wilderness camp areas make more visits to forest areas than other camper groups. This group's camping trend indicates a leveling off in auto camp participations with a significant increase in the number of overnight visits to wilderness areas.

These campers who use both auto and wilderness camps desire a wide range of developments with none infringing upon the other—e.g., elaborate camps by paved roads, more primitive camps reached by dirt roads, and more wilderness areas.

Exposure to any mechanized trail scooters would decrease the hiking or camping enjoyment of 92.7 percent of wilderness campers, 88.9 percent of those compers using both wilderness and roadside camps, and 82.6 percent of roadside campers.

Questionnaires are an extremely valuable and inexpensive means for collecting a large amount of data from these classes of forest users. The detailed, 7-page questionnaire used in this study received an 89.7-percent response.

PLANS FOR 1964

Plan for completion of 10 years of grazing management studies on the Starkey Experimental Forest and Range. Analyze the data and prepare reports for publication. On the basis of final results, develop a new program, with greater emphasis on basic research, for the Starkey.

Develop an integrated program for wildlife habitat research involving both deer and elk studies on east-side forests in Oregon and Washington. Place increased emphasis on rehabilitation and maintenance of big-game ranges through management, reseeding, and coordination with timber-cutting practices

Complete analysis of data and publish the results of recreation research on the Three Sisters Wilderness Area. Prepare a plan for expansion of research to other wilderness areas and to other phases of the recreation problem in the Pacific Northwest.

Watershed Management Research

EARL G. DUNFORD, DIVISION CHIEF

Watershed management investigations have been a separate function in the Station only since 1955. Prior to that time, research in soil and water was included in forest management investigations and often referred to as forest influences studies.

During its 50-year history, Wind River Experimental Forest was the locale for early forest influences research. It was here in 1918 that A. A. Griffin obtained part of his data to show that forest cover causes significant delay in snowmelt. In 1931, A. G. Simson measured summer rainfall in old-growth Douglas-fir forests at Wind River and found that a considerable portion of these rains did not reach the ground because of crown interception. Cutover lands in and near Wind River Experimental Forest have also been used for a series of studies of effects of slash burning on soil properties. Studies reported in 1937 by Isaac and Hopkins, and later by Tarrant, defined the relation of burning intensity to changes in physical and chemical characteristics of soil.

World War II brought new industries, more people to the Pacific Northwest, and a surge of interest in water. Disastrous 1948 floods in the Columbia River basin focused attention on need for better control of our water resources and better information about watersheds. Beginning in 1950, the Station participated in development of the Columbia River Basin Area Agricultural Program and, in 1955, organized a Division of Watershed Management Research to conduct investigation in soil-plant-water relations.

First efforts of the Division were centered on a watershed study begun in 1952 in H. J. Andrews Experimental Forest. In 1956, the City of Portland Water Bureau agreed to help finance another watershed study in the Bull Run drainage. During the same year, we began watershed investigations in north-central Washington near Wenatchee and a year later in the Blue Mountains near La Grande and the southwestern Cascade Range near Roseburg.

Today, these activities are concentrated in two main projects with headquarters in Wenatchee, Wash., and Corvallis, Oreg. At both locations, laboratory facilities have been developed for basic studies. Field research is carried on in widely separated locations, including H. J. Andrews, Starkey, and South Umpqua Experimental Forests, Bull Run watershed, and drainages tributary to the Columbia River in north-central Washington.

The Forest Hydrology Laboratory, Wenatchee, Wash. Designed for studies of soil and water, and activated in July 1963.

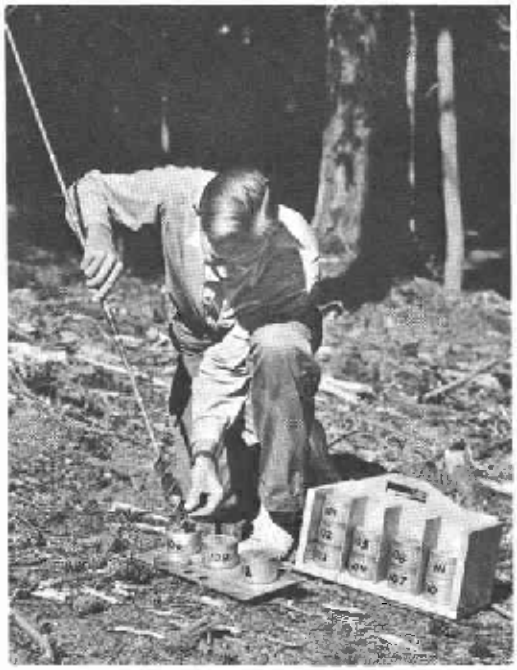
WATERSHED LOGGING METHODS AND STREAMFLOW REGULATION

Corvallis, Oregon

In our annual report of 1952, we noted the installation of stream gages in three small experimental drainages at the H. J. Andrews Experimental Forest. Our aim was to study behavior of streamflow from small forested watersheds and to measure effects of logging and roadbuilding on soil stability and timing of streamflow. Each year since 1952, we have reported progress in some phase of the watershed study. Such increments of information have added up to better understanding of the influence of Douglas-fir forests on streamflow and the effects of converting old-growth timber to managed stands.

The Andrews Experimental Forest is typical of Douglas-fir forests in western Oregon and Washington. Vegetation ranges up to 90 percent in density. Mean annual precipitation has been 92 inches since the stream gages were installed, and an average of 61 area-inches per year has been discharged as runoff. Precipitation is high during winter and low in summer, causing wide seasonal fluctuations in streamflow.

Soil samples indicate data on moisture used by trees.



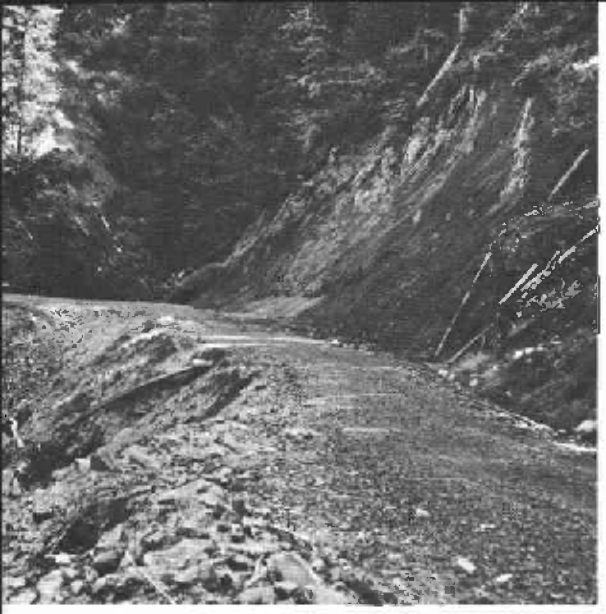
How Much Water does a Douglas-Fir Forest Use?

Empirical formulas for this region indicate that potential evapotranspiration is about 25 inches. Our measured figure is 31 inches—a residual between 92 inches of precipitation and 61 inches of runoff.

Part of this 31-inch residual is chargeable to interception. We have found that about 14 percent of the annual precipitation is caught by tree crowns and evaporated back into the atmosphere. However, there are wide deviations from this average, depending on size of storms and when they occur. Interception claims almost 100 percent of the light summer showers of 0.05 inch or less but proportionally little of the major winter storms exceeding 8 inches.

During summer months, another large portion of water is used by trees and other vegetation. Our studies show that about 6 inches of water is removed from the top 3 feet of soil during the growing season. This deficit provides storage for part of the fall rains. In areas where timber is cut, less water is removed from the soil, soils are wetter in late summer, and less storage is available for early fall rains.

Water enters the surface soil so freely that surface runoff is virtually unknown in Douglas-fir forests. In 10 years, no samples with greater than 200 parts per million of sediment were measured in the undisturbed watersheds. Even this is cloudier water than we care to drink (drinking water is under 10 p.p.m.), but such concentrations happen less than 1 percent of the time.



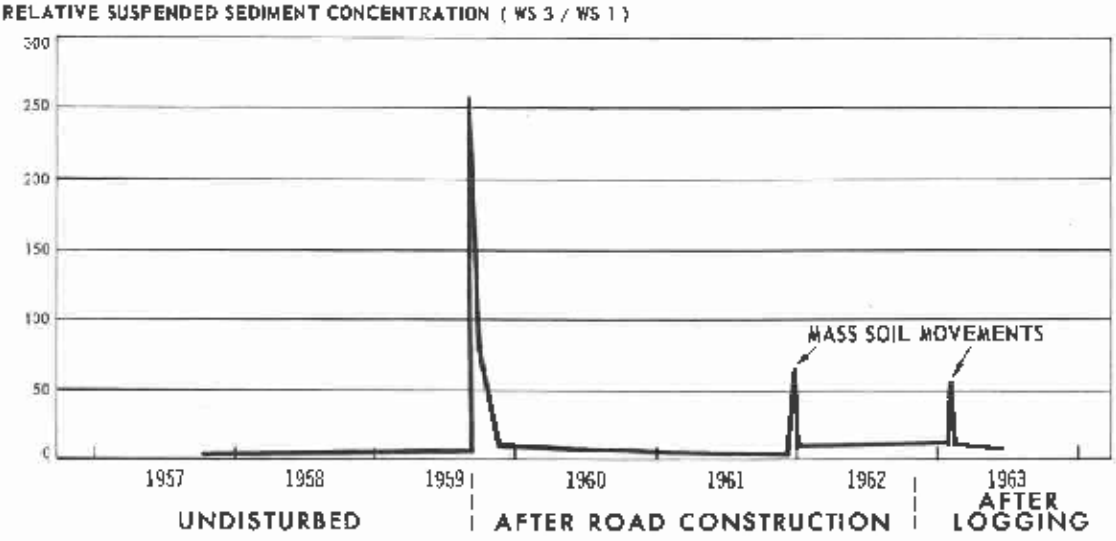
Typical section of access road in experimental watershed 3. Main cross drain is at bottom of fill, not visible in photo.

Road Construction Studied

After observing one of three watersheds for 7 years in its natural condition, we built a system of standard roads in the summer of 1959 to provide access for logging in 1962. A 3-year record was accumulated from the roads before timber harvesting, which tells us something of the effect of disturbing 6.2 percent of the drainage area and removing 8 percent of the timber stand for the road right-of-way. Initial fall rains, when roads were nearing completion, resulted in sediment levels almost nine times as much as we had measured before. Freshly exposed bare soil in a small area near the creek crossing was the principal source.

Combined effects of revegetation and settling of disturbed soils were clearly evident over the months following road construction. During the next 2 years, sediment in the roaded watershed streams decreased to almost normal. A subsequent slide in unstable soils below one of the roads then caused a sharp increase, and a new stabilization period began. Water samples show that even after a major disturbance, periods of high sediment concentrations are short, limited primarily to brief periods of high streamflow. During summer months and throughout interstorm periods, sediment movement in the roaded watershed was not greatly different from the two watersheds without roads.

Relative suspended sediment concentration of paired samples from watersheds 1 and 3 before and after logging and roadbuilding in watershed 3.



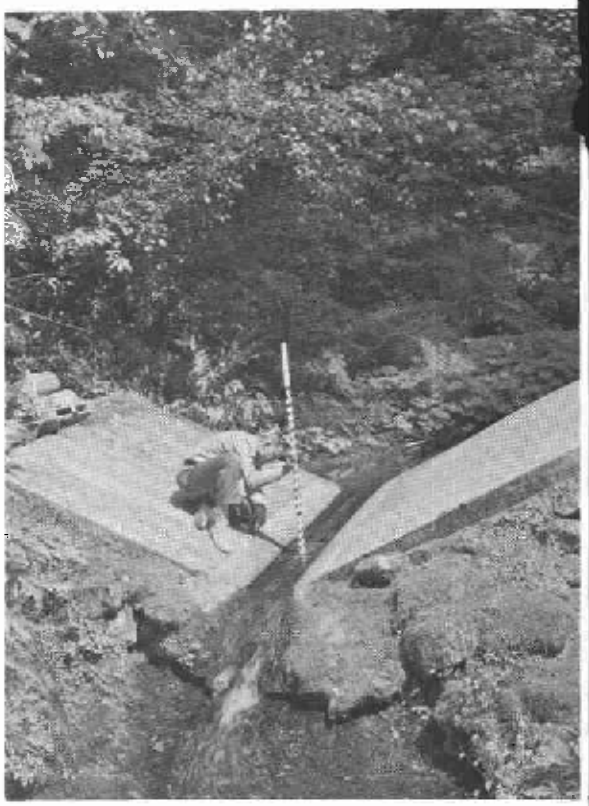
Logging on an experimental watershed removed 25 percent of the old-growth timber.

Summer Flows Increased

We were also interested in knowing how road construction affected volume and timing of streamflow because 8 percent of the timber volume was removed for right-of-way. A strip approximately 95 feet wide with a combined length of 9,000 feet was cleared to provide road access at three elevational levels in the watershed. To date, no measurable change has been detected in winter streamflow, but runoff during the period of lowest flow in summer has shown a consistent increase. Although the increase is about 16 percent of the minimum flow, volumes of water approximate only 34 gallons per acre of watershed per day.

These studies continue. In the watershed with roads, three units, totaling approximately 25 percent of the drainage, have been logged by the high-lead method. A companion drainage is now being completely logged by a Wyssen skyline crane. Results are not yet available, but in a few years, they can be expected to provide substantial evidence of the effect of timber harvesting and road construction on water supply and erosion from a typical old-growth Douglas-fir forest.

Effects of roadbuilding and timber cutting are measured in gages designed to continuously record rates of runoff.



WATER YIELD AND EROSION
Wenatchee, Washington

Watershed management research at Wenatchee treats with problems of water yield and erosion in eastern Washington and Oregon. The Forest Hydrology Laboratory, completed in July 1963, is equipped to handle much of this research, but a substantial part is also conducted in the field.

Soil Moisture Use

It is generally accepted that timber cutting results in increased streamflow but that local conditions can cause wide variation in the amounts. First results of a soil moisture study of two lodgepole pine stands in north-central Washington indicate that deeper soils offer most promise for significant streamflow increases.

Age and seasonal development of tree roots also appear to affect moisture use. Laboratory studies of Douglas-fir roots showed that water absorption by young elongating root tips was much more rapid than by older roots. This is the first step in an attempt to determine diurnal and seasonal trends in transpiration of major forest species.

Sample cores of soil taken from various depths provide information on physical characteristics.

One of three stream gages installed in Entiat River watershed to measure water yield.

Radioisotopes Trace Soil Movement

Radioactive ferric^{59} chloride, applied in solution to bare soil surfaces, has proved to be a useful method of tracing erosion. The experiment verified our assumption that leaching and chemical reaction in the soil would not significantly impair the usefulness of iron ^{59} as a tracer. All of the isotope was retained in the surface inch of the soil profile and 92 percent remained in the surface 0.3 inch.

Evidence of soil movement was determined by radiation intensity measurements. On an exposed Swauk-sandstone soil, maximum downslope movement of 1-1/2 feet was observed during a 2-week period in November 1963. Cause was attributed to snowmelt and frost heave. Soil movement of such limited extent over a short timespan would have been difficult to measure by any other method.

Energy available for evaporation of water can be related to solar radiation measured on a watershed.

Solar Radiation and Evapotranspiration

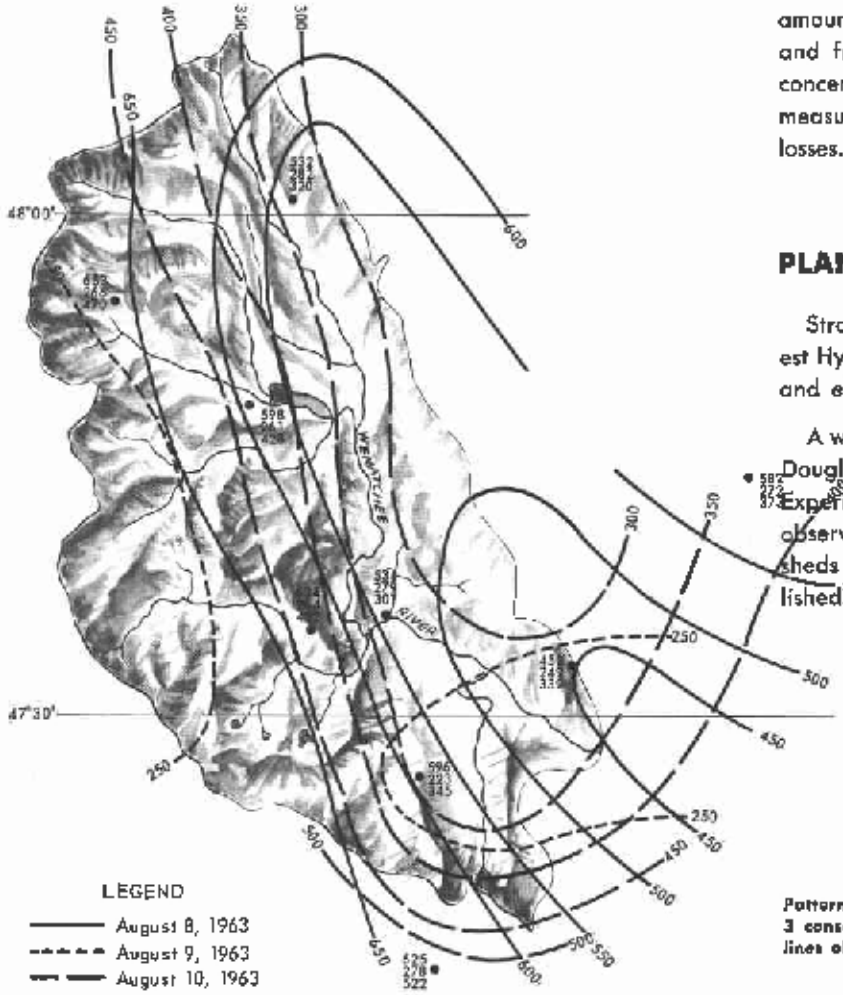
Water loss from soil and plants is an energy-requiring process, the major source of the input energy being solar radiation. A measurement of solar energy which accounts for such losses as reflection and heating of soil and air is possible with the net radiometer but is not considered technically feasible for large areas. An easier element to measure is direct solar input which, fortunately, can be correlated with net radiation, based on ground cover and condition.

To provide some data for exploration of these relationships, a recording network of 10 stations was established in the 1,200-square-mile Wenatchee River watershed. Preliminary analyses indicate enormous energy input is available, but amounts are highly variable from day to day and from place to place. Future studies will concentrate on methods of using solar energy measurements to estimate evapotranspiration losses.

PLANS FOR 1964

Strong effort will be made to develop the Forest Hydrology Laboratory into a fully operating and efficient research establishment.

A watershed study in 110-year-old even-aged Douglas-fir will be started at H. J. Andrews Experimental Forest, and a 10-year summary of observations on the three experimental watersheds in old-growth Douglas-fir will be published.



Pattern of solar radiation in Wenatchee watershed for 3 consecutive days in August 1963. Isograms represent lines of equal energy in cal. per cm.²

Publications and Addresses

Forest Economics and Marketing

PUBLICATIONS

ADAMS, THOMAS C.,
SMITH, RICHARD C., and
SYVERSON, MARTIN L.

Marketing timber products. *In* Woodland Handbook for the Pacific Northwest. Coop. Ext. Serv., Oreg. State Univ., Corvallis, Oreg. pp. 203-217. (Reprints not available.)

(Describes the various market outlets for timber products and suggests desirable marketing arrangements.)

BEUTER, JOHN H.

1961 Washington log production. U. S. Forest Serv. Resource Rpt. PNW-1, 2 pp.

(The 1961 production of 4.4 billion board feet was 6 percent less than 1960, with most of the decrease occurring on private lands.)

BINKLEY, VIRGIL W.

Factors to consider when selecting skyline yarding systems for site protection. *In* Forest Watershed Management Symposium Proc., Oreg. State Univ. pp. 259-269. (Reprints not available.)

(Describes design, layout, and operating methods for skyline logging systems for minimizing soil disturbance on steep slopes.)

GEDNEY, DONALD R.

Timber supply and demands. *In* Where Is Oregon Going in the Wood Products Industry? Univ. Oreg. Internatl. Assoc. Personnel in Employment Security Seminar Proc. pp. 6-14. (Reprints not available.)

(An analysis of the supply of timber in Oregon and an estimate of future output by product.)

Toward complete use of eastern Oregon's forest resources. U. S. Forest Serv. Resource Bul. PNW-3, 71 pp., illus.

(A comprehensive analysis of the forest resource situation in eastern Oregon. Presents the importance of the forest resource to eastern Oregon's economy and evaluates in relation to other competing areas. Current forest resource is defined in terms of the physical resource and the use made of it. Future opportunities for growth through management of the forest resource are developed. Extensive statistical tables presenting new inventory and industry statistics are included.)

HAZARD, JOHN W.

Forest statistics for northeast Washington. U. S. Forest Serv. Resource Bul. PNW-4, 30 pp., illus.

(Commercial forest area has decreased slightly since the 1948 inventory, but total timber volume has risen approximately 30 percent due primarily to changing utilization standard and inventory techniques.)

Forest statistics for Chelan and Douglas Counties, Washington, 1959-60. U. S. Forest Serv. Resource Bul. PNW-5, 26 pp., illus.

(Compared with the previous inventory of 1936, commercial forest land has decreased slightly while total timber volume has increased by 80 percent, primarily due to changed utilization standards and inventory techniques.)

HUGHES, JAY M.

Book review of "Scarcity and Growth: The Economics of Natural Resource Avail-

ability," by Harold J. Barnett and Chandler Morse. Jour. Forestry 61: 603. (Reprints not available.)

(This reviews a study which is the most rigorous economic interpretation to date of the massive compilation of natural resource inventory and cost data by "Resources for the Future." The study points out that physical reservation of resources does not prevent scarcity in an economic sense.)

MacLEAN, COLIN D.

Improving forest inventory area statistics through supplementary photo interpretation. Jour. Forestry 61: 512-516.

(Combined photo and field surveys are from 6 to 15 times more efficient than surveys based on field plots alone for estimating commercial forest area. This increased efficiency is achieved without weakening other estimates based entirely on field plot data.)

McMAHON, ROBERT O.

Forestry—an investment enterprise. *In* Woodland Handbook for the Pacific Northwest. Coop. Ext. Serv., Oreg. State Univ., Corvallis, Oreg. pp 1-3. (Reprints not available.)

(Stresses investment aspects of small-owner forestry as a business enterprise.)

——— and FLORA, DONALD F.

Book review of "Concepts of Financial Maturity of Timber and Other Assets," by M. Mason Gaffney. Forest Sci. 9: 107. (Reprints not available.)

(Reviews a publication published in 1960 by North Carolina State College.)

METCALF, M. E.

1962 Oregon log production. U. S. Forest Serv. Resource Bul. PNW-2, 2 pp., illus.

(Production for 1962 was the highest since 1959. Production from public lands continues to climb, with 52 percent coming from public lands in 1962.)

NIELSEN, RICHARD L.

1962 Washington log production. U. S. Forest Serv. Resource Bul. PNW-6, 2 pp., illus.

(Production for 1962 increased significantly over 1961, reaching the highest total since 1941. The proportion of the total coming from public lands continued to climb, reaching 42 percent of the total in 1962.)

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION.

Pacific Northwest quarterly stumpage and log supply report, 2nd quarter 1963. 22 pp., illus.

(First in a series of regular reports to provide information on stumpage supplies and prices, log and lumber production trends, and related items bearing on the timber situation in the Pacific Northwest.)

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Pacific Northwest quarterly stumpage and log supply report, 3rd quarter 1963. 27 pp., illus.

(Continues reporting of current stumpage supplies and prices. Notes sizeable increase in log exports, chiefly to Japan. Also notes growing competition to Pacific Northwest lumber producers from other Western United States and Canadian regions.)

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Timber trends in western Oregon and western Washington. U. S. Forest Serv. Res. Paper PNW-5, 154 pp., illus.

(This is a thorough economic analysis of the timber production potential. Projections of cut and growth are applied to the timber inventory of the 1950's to trace future development of the resource under various assumptions. The economic model, the projection procedure, and the inventory now and in the future are described in detail.)

Unpublished Talks and Papers

ADAMS, THOMAS C.

Economics of small-owner forestry in Columbia County, Oregon. Farm Forestry Short Course sponsored by Columbia County Agricultural Agent, Oregon State Cooperative Extension Service, St. Helens, Oreg. February 13.

(Discussed current and prospective rates of return from small forest investments, as related to alternative investment opportunities, curing income needs, and owners' skill in timber marketing functions.)

BINKLEY, VIRGIL W.

Research objectives and developments on the concept of vertical logging with helicopters. Auburn Forestry Forum, Auburn University, Auburn, Ala. June 4.

(Described helicopter logging systems and discussed need for research in operational techniques, automatic hooking and release mechanisms, and study of tree and log weights.)

NEWPORT, CARL A.

A look at the future of the pine industry. Grant County Chamber of Commerce, John Day, Oreg. January 7.

(Presented the highlights of a forthcoming publication on the potential of forestry and the forest industry in eastern Oregon.)

To what extent do nontimber values help justify reforestation? Annual meeting of Western Reforestation Coordinating Committee, San Francisco. December 10.

(Presented a general method for evaluating the relative importance of water, timber, wildlife, and esthetic values in determining the amount of reforestation needed.)

SMITH, R. C.

Changing labor requirements for the major forest industries of Oregon. 14th Annual Institute, Oregon Chapter, International Association of Personnel in Employment Security, University of Oregon. May 2.

(An analysis of labor productivity in the forest industries during the period 1950 through 1961.)

Timber Management

PUBLICATIONS

BARRETT, J. W., and YOUNGBERG, C. T.

The effect of tree spacing and brush density on water use in a pumice soil. (Abs.) Amer. Soc. Agron., Agron. Abs. 1963: 63. (Reprints not available.)

(Rate of moisture depletion in a pumice soil in central Oregon increased significantly with increased density of a sapling ponderosa pine stand. Soil moisture measurements started 2 years after thinning and continued for three successive growing seasons showed total amount of depletion to be 1.6 times greater on plots containing 1,000 trees per acre than on plots containing 62 trees per acre.)

BARRETT, JAMES W.

Dominant ponderosa pines *do* respond to thinning. U. S. Forest Serv. Res. Note PNW-9, 8 pp.., illus.

(A 6-year record after thinning in a pole-size stand shows that dominant trees respond markedly to complete removal of all adjacent subordinate stems.)

DAHMS, WALTER G.

Correction for a possible bias in developing site index curves from sectioned tree data. Jour. Forestry 61: 25-27, illus.

(Shifts in relative height of individual lodgepole pine trees as stands grow older introduced a bias into height over age curves developed from height growth of individual trees. A method for eliminating the bias is presented.)

DAHMS, WALTER G.

Dispersal of lodgepole pine seed into clear-cut patches. U. S. Forest Serv. Res. Note PNW-3, 7 pp., illus.

(Through seed traps spaced at varying distances from a timber edge, size and frequency of seed crops, time of seed fall, and distance and direction of seed dispersal were studied over a 4-year period. Findings indicate width of clear-cut strips, patches, or blocks should not exceed 400 feet to provide ample seed for prompt natural regeneration.)

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Silvical characteristics of mountain hemlock. (Rev. by Jerry F. Franklin.) Pac. NW. Forest & Range Expt. Sta. Silvical Ser. 11, 18 pp., illus.

(Presents compilations of existing knowledge on the range, habitat conditions, life history, and special features of mountain hemlock.)

DIMOCK, EDWARD J. II, and
HERMAN, FRANCIS R.

A guide to the Hemlock Experimental Forest. Pac. NW. Forest & Range Expt. Sta., 19 pp., illus.

(Describes the Experimental Forest, its purpose and administration, and the research projects in progress.)

FRANKLIN, JERRY F.

Natural regeneration of Douglas-fir and associated species using modified clear-cutting systems in the Oregon Cascades. U. S. Forest Serv. Res. Paper PNW-3, 14 pp., illus.

(Strip and small patch clear cuttings and a seed-tree cutting were adequately stocked with seedlings of Douglas-fir and associated species within 4 years after logging and slash burning. A staggered-setting clear cut of comparable age was not adequately stocked. Chief value of modified cutting systems appeared to be reduction of insolation losses by shading.)

———

A proposed physiographic subdivision of the true fir-hemlock forests of the Pacific Northwest. (Abs.) Northwest Sci. 37: 159. (Reprints not available.)

(The extensive true fir-hemlock forests at middle to high elevations in Oregon and Washington are subdivided into 11 relatively homogeneous geographic units. The provinces are based on variation in geology, climate, soils, topography, and vegetation and should be useful as a basis for silvicultural prescriptions and further research.)

——— and TRAPPE, JAMES M.

Plant communities of the northern Cascade Range: a reconnaissance. (Abs.) Northwest Sci. 37: 163-164. (Reprints not available.)

(Outlines predominant plant communities in the major forest zones, avalanche tracks, subalpine zone, and alpine zone of this botanically diversified mountain area.)

GRATKOWSKI, HENRY JOHN.

Heat as a factor in germination of seeds of *Ceanothus velutinus* var. *laevigatus* T. & G. Diss. Abs. 23(6): 1890-1891. (Reprints not available.)

(Laboratory experiments showed that heat stimulates germination of varnishleaf ceanothus seed. Field experiments further showed that broadcast burning of logging slash resulted in greater germination than burning of piled slash. Ceanothus seedlings were least numerous where slash was left unburned.)

HERMAN, FRANCIS R.

Seed-trap liners of nylon tent screening. Jour. Forestry 61: 531, illus.

(Rapid, accurate collection of seed and litter samples is possible when inexpensive, nylon seed-trap liners are used. Liners are especially convenient when seed and litter collections are wet.)

JOHNSON, FLOYD A.,
RUTH, ROBERT H., and
MADISON, ROBERT W.

Sample scaling for timber sales. Jour. Forestry 61: 360-364, illus.

(Sometimes it is better to endure a little sampling error than to pay a high price for scaling all logs in a timber sale.)

_____ and WORTHINGTON, NORMAN P.

Procedure for developing a site index estimating system from stem analysis data. U. S. Forest Serv. Res. Paper PNW-7, 10 pp., illus.

(Data from dissected trees can lead to a set of site curves by taking the seven simple steps described in this publication.)

KRUEGER, KENNETH W.

Compounds leached from western redcedar shingle tow found toxic to Douglas-fir seedlings. U. S. Forest Serv. Res. Note PNW-7, 6 pp.

(Western redcedar shingle tow, used for packing material in forest nurseries, sometimes contains harmful concentrations of thujaplicins. Preliminary evidence questions the continued use of shingle tow around roots of tree seedlings.)

RADWAN, M. A.

Protecting forest trees and their seed from wild mammals. (A review of the literature.) U. S. Forest Serv. Res. Paper PNW-6, 28 pp.

(Presents a review of methods used to control wild mammal damage to forest tree seed, seedlings, and trees; gives references to mammals causing damage, their motivation and types of damage; and effect on forest resource. Review suggests damage is increasingly serious and that control methods are still inadequate.)

REUKEMA, DONALD LYNN.

Patterns of crown and stem growth of *Pseudotsuga menziesii* var. *menziesii* (Mirb.) Franco as influenced by cultural and environmental variations. Diss. Abs. 23(8): 2647. (Reprints not available.)

(Influence of thinning on development of individual trees was investigated with emphasis on crown expansion and its relation to stem radial growth. Stem growth was apparently dependent more upon factors such as increased light, moisture, and nutrients than on increased crown surface.)

RUTH, ROBERT H.

Site preparation in the high elevation types of the west Cascades and coastal forests. *In* Western Reforestation 1962. West. Forestry Conserv. Assoc. Proc., pp. 14-16. (Reprints not available.)

(Conditions that require site preparation to facilitate regeneration of upper-slope forests are described. Methods currently in use include slash disposal, scarification of mor humus layers, and brush control by herbicides combined with scarification.)

SILEN, ROY R.

Effect of altitude on factors of pollen contamination of Douglas-fir seed orchards. Jour. Forestry 61: 281-283, illus.

(Upslope progression of pollen shedding and female receptivity was studied by weekly observations at stations along four transects in western Oregon and Washington, ranging from 25 to 4,250 feet in elevation. Significance of findings discussed from standpoint of possible pollen contamination in Douglas-fir seed orchards.)

SMITH, FRANK H., and
SILEN, ROY R.

Anatomy of heat-damaged Douglas-fir seedlings. Forest Sci. 9: 15-32, illus.

(Douglas-fir seedlings were subjected in the laboratory to various intensities of radiation from heat lamps for various periods. Anatomical changes associated with heat damage are, in order of increasing severity, (1) loss of water to intercellular spaces and loss of turgor, (2) progressive collapse of epidermis and parenchyma cells of cortex and pericycle, (3) collapse of phloem and parenchyma cells in the xylem, and

(4) collapse of cambium and inner phloem progressing upward from the constriction.)

STEIN, WILLIAM I.

Pleocoma larvae, root feeders in western forests. Northwest Sci. 37: 126-143, illus.

(Feeding by rain beetle grubs on taproots of young ponderosa pine, sugar pine, Douglas-fir, and grand fir in southwestern Oregon was sufficient to kill some seedlings and reduce growth and vigor of others. The present case appears to be the first recorded instance of such damage in forests.)

TARRANT, ROBERT F., and
MILLER, RICHARD E.

Accumulation of organic matter and soil nitrogen beneath a plantation of red alder and Douglas-fir. Soil Sci. Soc. Amer. Proc. 27: 231-234.

(Soil nitrogen accumulation beneath a plantation of red alder and Douglas-fir was compared with that under a pure fir segment of the same 30-year-old stand on the Wind River Experimental Forest in southwestern Washington. Beneath the mixed plantation, there were significantly greater amounts of nitrogen in the forest floor and in the upper 24 inches of the mineral soil.)

TARRANT, ROBERT F., and
SILEN, ROY R.

Growth and nutrient uptake of young ponderosa pine after heavy fertilizer treatments. (Abs.) Amer. Soc. Agron. Agron. Abs. 1963: 72. (Reprints not available.)

(Ammonium nitrate and treble superphosphate were applied together with supplemental water to 7-year-old ponderosa pine growing nearly free from competition on Deschutes sandy loam in central Oregon. Height growth and foliage N and P content were affected by treatment but diameter increment was not. The N-P interaction shown to depress growth of many forest trees is demonstrated here for ponderosa pine.)

TRAPPE, JAMES M.

Some probable mycorrhizal associations in the Pacific Northwest. IV. Northwest Sci. 37: 39-43.

(An additional listing of specific fungi thought to form mycorrhizae with particular tree species.)

TRAPPE, JAMES MARTIN

Cenococcum graniforme —its distribution, ecology, mycorrhiza formation, and inherent variation. Diss. Abs. 23(10): 3579. (Reprints not available.)

(This widespread, beneficial root fungus forms mycorrhizae with numerous tree species found in a great variety of habitats.)

WILLIAMSON, R. L.

Growth and yield records from well-stocked stands of Douglas-fir. U. S. Forest Serv. Res. Paper PNW-4, 24 pp., illus.

(In 1910, establishment of a series of permanent sample plots was started in young-growth stands of Douglas-fir in western Oregon and western Washington. Thirty-one of these plots have been remeasured periodically to determine growth, mortality, and yield. This paper describes the plots, presents essential stand data, and briefly discusses past and potential uses for this information.)

WORTHINGTON, NORMAN P.

Thirteen years of thinning in a Douglas-fir woodland. U. S. Forest Serv. Res. Note PNW-8, 4 pp., illus.

(Annual commercial thinnings in a 40-acre tract of site II 50-year-old Douglas-fir provided a total net return of $10.23 per acre annually. A compound interest rate of 5.7 percent annually was really on the value of the growing stock at the start of the 13-year period.)

Unpublished Talks and Papers

TARRANT, ROBERT F.

Top and root moisture content of stored Douglas-fir planting stock. Northwest Scientific Association, Spokane, Wash. December 27.

Biometrics

PUBLICATIONS

JOHNSON, FLOYD A.

Board-foot tree volume equations for electronic computers. U. S. Forest Serv. Res. Note PNW-2, 13 pp.

(Two of the equations presented in this paper have been used to calculate billions of board feet of annual cut on the Federal forests of the Pacific Northwest.)

Some lessons on electronic data processing for Forest Service research. *In* Range Research Methods. U.S. Dept. Agr. Misc. Pub. 940, pp. 11-13. (Reprints not available.)

(Recommends that each Experiment Station have local access to electronic computers and other data processing equipment.)

See other publications by Johnson listed under "Timber Management" heading.

Disease

PUBLICATIONS

CHILDS, T. W.

Poria weirii root rot. Phytopathology 53: 1124-1127, illus.

(A brief summary of present knowledge of the disease, with suggestions for further research.)

Dwarfmistletoe control opportunities in ponderosa pine reproduction. Pac. NW. Forest & Range Expt. Sta., 19 pp., illus.

(Discusses factors to be considered in selection of control areas, and procedures recommended for control in connection with thinning projects. A preliminary guide, based on the scanty information now available.)

SCHEFFER, THEODORE C.,
VERRALL, ARTHUR F., and
HARVEY, GEORGE

On-site preservative treatments: their effectiveness for exterior millwork of different species used in various climates. Forest Prod. Jour. 13(1): 7-13, illus. (Reprints not available.)

(A 3-minute dip treatment of precut stock with 5 percent pentachlorophenol in light oil apparently can effectively protect exterior woodwork of a variety of softwood species against decay in a variety of climates for 7 or more years.)

WRIGHT, ERNEST,
HARVEY, GEORGE M., and
BIGELOW, CHARLES A.

Tests to control Fusarium root rot of ponderosa pine in the Pacific Northwest. Tree Planters' Notes 59: 15-20, illus. (Reprints not available.)

(Soil fumigation and acidification gave partial control, but showed undesirable side effects. Best results were obtained through control of soil temperature and aeration by heavy watering during the hottest months.)

Fire

PUBLICATIONS

BRUCE, DAVID

Current forest fire research activities in the West. *In* NW. Forest Fire Council Ann. Meeting Proc., 6 pp. (unnumbered). (Reprints not available.)

(A summary of current fire research at the Pacific Northwest Forest and Range Experiment Station and an outline of studies underway at the Intermountain and Pacific Southwest Stations.)

How many fires? Fire Control Notes 24 (2): 45-50, illus. (Reprints not available.)

(Describes a mathematical model which improves the estimates of numbers of fires per day as danger rating changes.)

CRAMER, OWEN P.

How to interpret humidity, temperature for a given area. Forest Indus. 90(4): 50-51, illus. (Reprints not available.)

(A resume of how to use suggested charts for converting afternoon humidity and temperature values from one elevation to another in the same vicinity during summer fair weather. The complete explanation is given in Cramer's "Adjustment of Relative Humidity and Temperature for Differences in Elevation." Pac. NW. Forest & Range Expt. Sta. Res. Paper 43, 21 pp., illus. 1961.)

STEEN, HAROLD K.

Relation between moisture content of fine fuels and relative humidity. U. S. Forest Serv. Res. Note PNW-4, 6 pp., illus.

(The moisture content of some fine fuels responded quickly to changes in relative humidity. Excluding bracken, whenever the humidity was below 50 percent, fine-fuel moisture was less than 10 percent. When the humidity was about 30 percent, fine-fuel moisture was about 5 percent.)

Unpublished Talks and Papers

MORRIS, WILLIAM G.

Moisture content variations in logging slash. 1963 International Symposium on Humidity and Moisture, Washington, D.C. May 23.

(Described an exploratory study of day-to-day and week-to-week fluctuations in moisture content in the outer half inch of barkless logs and log debris as related to summer weather in the Douglas-fir region.)

Insects

PUBLICATIONS

CAROLIN, V. M., and
COULTER, W. K.

Eradicating European pine shoot moth in commercial nurseries with methyl bromide. U. S. Forest Serv. Res. Paper PNW-1, 11 pp.

(A small commercial nursery in the Puget Sound area of Washington was fumigated in late fall, using previously developed chambers but testing modifications to improve operational efficiency. Adjustment of treatment period according to chamber temperatures is described.)

JOHNSON, NORMAN E.,
MITCHELL, RUSSELL G., and
WRIGHT, KENNETH H.

Mortality and damage to Pacific silver fir by the balsam woolly aphid in southwestern Washington. Jour. Forestry 61: 854-860, illus.

(The degree of damage was greatest on dominant and codominant trees on the best sites; forest managers can minimize damage by using a penalty rating system in determining cutting priorities.)

RYAN, ROGER B.

Contribution to the embryology of Coe*loides brunneri* (Hymenoptera: Braconidae). Ann. Ent. Soc. Amer. 56: 639-648, illus.

(Describes the egg and traces development through blastoderm formation, segmentation, and formation of the organ systems. Drawings and photomicrographs illustrate successive stages of the process.)

WITTIG, G. C.

Techniques in insect pathology. *In* An advanced treatise in insect pathology. v.2. Ed. by E. A. Steinhaus. New York: Academic Press, Inc. pp. 591-636. (Reprints not available.)

(Reviews and describes currently used techniques in insect pathology, such as: isolating, culturing, and storage of pathogens; infecting insects artificially; sterilizing equipment and test insects; diagnosing insect diseases; electron microscopy. Includes a comprehensive review of the literature.)

Unpublished Talks and Papers

CAROLYN, V. M. and
THOMPSON, C. G.

Bacillus thuringiensis field-tested against western hemlock looper. Annual meeting of Entomological Society of America, St. Louis, Mo., December.

(A commercial preparation of *Bacillus thuringiensis* diluted 1:1 with water was applied to looper-infested hemlock in southwestern Washington. Significant kill of the looper was obtained, but it was not enough for practical control.)

FURNISS, R. L.

Safeguards for the use of pesticides. Izaak Walton League meeting, Portland, Oreg. March.

(Efforts to develop alternative methods of forest insect control are discussed.)

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Protecting forest resources against insects. Rotary Club, Portland, Oreg. March.

(Chemical pesticides are essential for protecting forest resources against insects, especially during outbreaks. Foresters are using chemicals carefully while efforts are being made to increase their safety and to develop alternative methods.)

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Biological control, the other way to control forest insects. Portland Chapter, Columbia River Section, Society of American Foresters, Portland, Oreg. October.

(Biological control is considered to be a promising tool in forest protection. Much research to perfect this method of prevention and control is in progress; much more lies ahead.)

THOMPSON, C. G., and
CAROLYN, V. M.

Potentialities and limitations of *Bacillus thuringiensis* in the control of forest insects. Annual meeting of Entomological Society of America, St. Louis, Mo. December.

(Spray coverage is more critical for microbial insecticides than for contact insecticides. Successful use of insect pathogens of the *B. thuringiensis* type may be limited by climate, host tree, and habits of the insect in addition to susceptibility of the insect to the pathogen.)

Forest Products and Engineering

PUBLICATIONS

GRANTHAM, JOHN B.

Broadening kiln club activities. 15th Ann. Meeting West. Dry Kiln Clubs Proc. 1963: 6-7. (Reprints not available.)

(Suggests specific ways of increasing the stature of kiln clubs by broadening the scope of activities.)

——— and HUNT, DOUGLAS L.

Lumber yield and log values of Shasta red fir. U. S. Forest Serv. Res. Paper PNW-2, 30 pp., illus.

(Reports lumber grade yield and values of Shasta red fir logs from southern Oregon, when graded and scaled in accordance with practices used either east or west of the Cascade Range.)

HENLEY, JOHN W.,
WOODFIN, RICHARD O., JR., and
HASKELL, HENRY H.

Recommended veneer grades for the development of hardwood veneer log grades. Forest Prod. Lab. U. S. Forest Serv. Res. Paper FPL-9, 12 pp., illus.

(Reports research conducted for the purpose of establishing hardwood veneer grades to be used in developing hardwood veneer log and bolt grades.)

HUNT, DOUGLAS L.

Seasoning and surfacing degrade in kiln-drying western hemlock in western Washington. U. S. Forest Serv. Res. Note PNW-6, 8 pp.

(This study measured loss in value and volume of western hemlock kiln-dried and surfaced under usual industry practices.)

LANE, PAUL H.

Evaluating log and tree quality for wood products. Forest Prod. Jour. 13(3): 89-93, illus.

(A discussion of timber quality evaluation with emphasis on characteristics of good grading systems, the adequacy of existing systems, the problems of evaluating timber quality, and research needed for the development of better grading methods.)

JACKSON, GEORGE H.,
HENLEY, JOHN W., and
JACKSON, WILLARD L.

Log diagraming guide for western softwoods. Pac. NW. Forest & Range Expt. Sta., 32 pp., illus.

(A guide to the measurements, definitions, and procedures required to diagram western softwood tree segments for timber quality research purposes.)

THOMAS, DAVID P., and
ERICKSON, HARVEY D.

Collapse and honeycomb in western red cedar in relation to greenwood liquid permeability. 15th Ann. Meeting West. Dry Kiln Clubs Proc. 1963: 7-14. (Reprints not available.)

(Describes the extreme variability in longitudinal permeability to water of green western redcedar and the relationship of permeability to collapse during kiln-drying. This was a cooperative study supported in part by Forest Service funds.)

WORTH, HAROLD E.

New hardwood uses will help industry. West. Conserv. Jour. 20(3): 56-57, illus. (Reprints not available.)

(An editorial abridgment of a talk given before the Northwest Hardwood Association in 1960. The author suggests that the Northwest hardwood industry profit by the examples, both good and bad, of the softwood industry. He discusses means for overcoming some disadvantages of hardwoods and suggests some new processing and marketing techniques.)

Quality—tool or tyrant? 18th Ann. NW. Wood Prod. Clinic Proc. 1963: 70-76.

(The author discusses "quality" as a concept and as a tool for management of forest enterprises. Several aspects and ideas of quality as related to timber and wood products are described. Some implications of the "quality" idea, as defined by the author, are suggested in relation to the forest industries as a whole, for research and for management.)

Range, Wildlife Habitat, and Recreation

PUBLICATIONS

COSTELLO, DAVID F.

Space-age thoughts for the beef-cattle producer. Amer. Hereford Jour. 53(17): 12-13, 142-143, illus. (Reprints not available.)

(Discusses the impact of mechanization, automation, and intensified research on modern range management and beef-cattle production.)

Measurement of the holocoenotic environment. *In* Range Research Methods. U. S. Dept. Agr. Misc. Pub. 940, pp. 4-8. (Reprints not available.)

(A clear, concise statement of specific objectives of study should always precede selection of methods to be used.)

DRISCOLL, RICHARD S.

A larger bitterbrush. Jour. Range Mangt. 16: 82-83, illus.

(Describes a large antelope bitterbrush plant found in central Oregon and proposes rules for establishing a register for big shrubs.)

Production and floristic composition of vegetation as measures of site potential. *In* Range Research Methods. U. S. Dept. Agr. Misc. Pub. 940, pp. 77-82. (Reprints not available.)

(Attempts to facilitate better understanding concerning plant community interpretation and terminology.)

Repellents reduce deer browsing on ponderosa pine seedlings. U. S. Forest Serv. Res. Note PNW-5, 8 pp., illus.

(Evaluates the effectiveness of spraying three different chemicals on ponderosa pine seedlings to reduce deer browsing. ZAC was more effective than TMTD, or copper omadine. Covering the seedlings with brush also reduced browsing.)

Sprouting bitterbrush in central Oregon. Ecology 44: 820-821, illus.

(Tabulates the percentages of antelope bitterbrush sprouting after two fires in central Oregon. Degree of sprouting was not closely related to intensity of burn but was strongly related to soil factors.)

JULANDER, ODELL,
FERGUSON, R. B., and
DEALY, J. E.

Measure of animal range use by signs. *In* Range Research Methods. U. S. Dept. Agr. Misc. Pub. 940, pp. 102-108. (Reprints not available.)

(Discussion and evaluation of four methods of assessing range use by wildlife and livestock by the signs they leave.)

McCONNELL, BURT R., and
SMITH, JUSTIN G.

Estimating bitterbrush age from stem-diameter measurements. Ecology 44: 579-581, illus.

(Once the initial regression has been established, a single easily taken measurement, maximum stem diameter at root crown, may provide a useful index to age of antelope bitterbrush plants.)

REED, MERTON J., and
SKOVLIN, JON M.

Estimating grazing values for layout and calibration of experimental ranges. *In* Range Research Methods. U.S. Dept. Agr. Misc. Pub. 940, pp. 142-148. (Reprints not available.)

(An evaluation of the methods by which range units needed for a grazing study can best be established on a specific piece of land.)

SMITH, JUSTIN G.

A subalpine grassland seeding trial. Jour. Range Mangt. 16: 208-210, illus.

(Of 14 grasses and 8 legumes planted at high elevation in north-central Washington, 7 grasses were rated excellent or good after eight growing seasons. Most legumes declined rapidly in the first 3 or 4 years.)

STRICKLER, GERALD S., and STEARNS, FOREST W.

The determination of plant density. *In* Range Research Methods. U. S. Dept. Agr. Misc. Pub. 940, pp. 30-40, illus. (Reprints not available.)

(This paper is limited to a discussion of the problems associated with the definition of density, the methods used in its determination, and some recent applications of density measures to range plant populations.)

Unpublished Talks and Papers

BURCH, WILLIAM R., JR.

The play world of camping: Research into the social meaning of outdoor recreation. American Sociological Association 58th annual meeting, Los Angeles, Calif. August 26-29.

(Observations of water skiing and family fishing campgrounds indicate the possibility of classifying recreation action systems. The discussion indicated the relevance of such observations for social science studies.)

COSTELLO, DAVID F.

Forestry and social customs in Europe. Tillamook-Clatsop Chapter, Society of American Foresters, Tillamook, Oreg. December 6.

(A discussion of forestry, pasture management, and recreation in relation to social customs in the United Kingdom, Germany, France, and Italy.)

COSTELLO, DAVID F.

Grazing management techniques in Scotland and Wales. Range Management Graduate Seminar, Oregon State University, Corvallis, Oreg. February 6.

(A description of technical methods of botanical analysis and pasture research on grazing lands used by cattle and sheep in Scotland and Wales. Objectives of the Hill Farming Research Organization, The Nature Conservancy, and the British Forestry Commission also were discussed.)

GARRISON, GEORGE A.

Research trends which may affect forest grazing management. Monument Livestock Operators meeting, Monument, Oreg. January 31.

SKOVLIN, JON M.

How to improve cattle distribution. Washington State University Range Management Workshop. February.

(A discussion of how to obtain more uniform use of forage by salting, herding, fencing, and water development on mountain summer ranges grazed by cattle.)

Watershed Management

PUBLICATIONS

BETHLAHMY, NEDAVIA

Soil-moisture sampling variation as affected by vegetation and depth of sampling. Soil Sci. 95: 211-213.

(Samples taken in a Douglas-fir forest indicate that soil-moisture variation increases with density of vegetative cover and decreases in proportion to depth of profile.)

Rapid calibration of watersheds for hydrologic studies. Internatl. Assoc. Sci. Hydrol. Bul. VIII(3): 38-42.

(A method is suggested whereby two or more watersheds may be calibrated for hydrologic studies within a period of 2 to 3 years, based on comparative reactions of the watersheds to the same storm. The technique is illustrated by an example in which increases in streamflow are caused primarily by rainfall and is used to detect hydrologic effects of road construction in a watershed.)

DUNFORD, E. G.

Vegetative manipulation for controlled water supply. *In* Forest Watershed Management Symposium Proc., Oreg. State Univ. pp. 77-87. (Reprints not available.)

(Reviews status of knowledge concerning the influence of forest cuttings on water yield with emphasis on snowpack management.)

DYRNESS, C. T.

Effects of burning on soil. *In* Forest Watershed Management Symposium Proc., Oreg. State Univ. pp. 291-304. (Reprints not available.)

(A summary of available information with particular reference to studies of slash burning in the Douglas-fir region.)

FREDRIKSEN, R. L.

A case history of a mud and rock slide on an experimental watershed. U. S. Forest Serv. Res. Note PNW-1, 4 pp., illus.

(An illustrated description of a landslide typical of many which occur during winter storms in steep forest lands of the Pacific Northwest.)

ROTHACHER, JACK

Net precipitation under a Douglas-fir forest. Forest Sci. 9: 423-429, illus.

(Describes results of a 3-year study of interception and stemflow in mature Douglas-fir stands of western Oregon. Data are given for both winter and summer storms, and an equation is developed to show relationship between storm size and throughfall.)

Unpublished Talks and Papers

CORLISS, JOHN F., and
DYRNESS, C. T.

A detailed soil and vegetation survey of the Alsea area in the Oregon Coast Ranges. 2nd North American Forest Soils Conference, Corvallis, Oreg. August 26-31.

(Described methods and results of a soil-vegetation classification in an important drainage of the Oregon Coast Ranges.)

FREDRIKSEN, R. L.

Sedimentation following logging road construction in a small western Oregon watershed. Federal Interagency Sedimentation Conference, Jackson, Miss. January 28-February 1.

(Reported effect of road construction on sediment concentrations in a stream draining a 250-acre experimental watershed.)

ROTHACHER, JACK.

Hydrology of small watersheds in the western Cascades of Oregon. Third Western National Meeting of American Geophysical Union, Boulder, Colo. December 26-28.

(Described precipitation, streamflow, sediment movement in three experimental watersheds, based on 10 years of record.)

WOOLDRIDGE, DAVID D.

Soil properties related to erosion of wild land soils. 2nd North American Forest Soils Conference, Corvallis, Oreg. August 26-31.

(Developed relation between erodibility of soils in eastern Washington and some common physical soil characteristics.)

General

PUBLICATIONS

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION.

1962 annual report. 70 pp., illus.

(A summary of the Station's accomplishments for the calendar year 1962 and plans for 1963.)

Forest Hydrology Laboratory. 16 pp. (unnumbered), illus.

(A brochure illustrating the design and purpose of the Forest Hydrology Laboratory in Wenatchee, Wash.)

Unpublished Talks and Papers

BRIEGLEB, PHILIP A.

Is economic analysis alone the appropriate yardstick for reforestation? Annual meeting of Western Reforestation Coordinating Committee, San Francisco. December 10.

(Because some trees are planted for aesthetic or noncommercial purposes and until our economic yardstick for reforestation is improved, economic analysis alone is not enough and many decisions must still be made on speculation or intuition.)

A summary of progress in forest research at the Pacific Northwest Station, 1954-1963, and a look ahead. Meeting of the Pacific Northwest Forestry Research Advisory Committee, Portland, Oreg. Nov. 21.

(Examined progress in forest research by output of results, extent of application, ability to produce future results compared with that of cooperators and in other fields, and by comparison with what is needed.)

Addendum

The following publications were omitted from the bibliography of the Station's 1962 Annual Report:

DECKER, FRED W.,
CRAMER, OWEN P., and
HARPER, BYRON P.

The Columbus Day "Big Blow" in Oregon. Weatherwise 15(6): 238-245, illus. 1962. (Reprints not available.)

DRISCOLL, RICHARD S.

Characteristics of some ecosystems in the juniper zone in central Oregon. (Abs.) Jour. Range Mangt. 15: 347. 1962. (Reprints not available.)

HAYES, G. L., and
HALLIN, WILLIAM E.

Tree species to grow in the South Umpqua drainage. Pac. NW. Forest & Range Expt. Sta. Res. Note 221, 7 pp., illus. 1962.

(Results of a study comparing site index of Douglas-fir, sugar pine, and ponderosa pine in the South Umpqua drainage of southwest Oregon are reported and preliminary recommendations given on choice of species to grow.)

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