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THE PACIFIC NORTHWEST: A REGION OF CONTRASTS

Two States with 104 million acres of land bearing 42 percent of the Nation's timber supply and with but 2 percent of the population. A people deriving one-third of its income from the forests, and through its labor providing one-third of the lumber used in the United States, and three-tenths of that exported. Bustling industrial cities; leisurely rural hamlets. Humming sawmills giving life to thriving communities; silent sawmills surrounded by deserted villages. The western termini of transcontinental railroads; the eastern termini of transoceanic steamship lines. Rainfall insufficient for tree growth; annual precipitation exceeding 100 inches. Thick absorptive layers of duff; bare areas subject to erosion. Endless vistas of sparse sagebrush; impenetrable walls of undergrowth tropical in density. Once lush range depleted by overgrazing; a range gradually being rebuilt. Cattle and sheep competing with each other for range; wild game competing with domestic flocks for forage. Forest areas abounding in fish and game; forest areas devoid of game and blackened by fire. Areas requiring planting to restore productivity; areas restocking completely by natural means. Forest lands returning profits to the owners; forest lands reverting to public ownership for unpaid taxes. Net growths expressible only with minus signs; potential growths the highest in the country. Trees with high positive conversion values mingling with trees of negative value. The largest sawmills in the country; the greatest average distance from markets. Complete utilization; enormous waste. Refinement in manufacture to the nth degree; shipment of much of the product direct from the woods.

Such is the Pacific Northwest, comprising the States of Washington and Oregon. A region of superlatives and contrasts? Yes. And a region presenting innumerable problems in the management of forest and range resources so as to provide the greatest long-time benefits to its people and to the Nation. The problems have been recognized and solutions have been sought by many agencies; industry, educational institutions, State and Federal organizations. Among the latter is the Pacific Northwest Forest and Range Experiment Station, established in 1924. Its staff of trained technicians is maintained at Portland, Oregon, by the U. S. Forest Service, Department of Agriculture, to conduct research, compile facts, and advance plans for the efficient management, use, and restoration of these natural resources.

The objective is "sustained yield"

The chief objective of forestry, be it upon private or public lands, is to bring forest management practices closer to the ideal expressed by the term "sustained yield." The present is controlled by what we have; the ideal is measured by the social end in view. Desire to approach the ideal is inherent in everyone. Progress toward the ideal is retarded largely by what we do not know and by economic obstacles to applying what
we do know. The long-range task of research is to widen the scope of knowledge; the immediate task is to determine the most urgent obstacles and how they may be overcome. These are the objectives of the Pacific Northwest Forest and Range Experiment Station, and this report summarizes conditions in the region, the most pressing problems, and the contributions of the Station staff, particularly during 1939, toward their solution.

The basic forest problems are quite similar throughout the two States, enabling application of knowledge and solutions obtained in one place to similar situations in other places with little or no change. On the other hand, the Pacific Northwest is divided by the Cascade Range into two regions distinctly different in geography and economy. West of the summit lies an area of moderate to heavy rainfall, a mild climate, low elevations, and luxuriant vegetation, and characterized by forests of Douglas-fir, western hemlock, and associated species and an economy dominated by industry. East of the summit lies an area of scanty rainfall, rigorous climate, high elevations, and sparse vegetation, and characterized by forests of ponderosa pine valuable for timber production and essential as summer grazing lands, enormous expenses of sagebrush and grassland, and an economy dominated by agriculture. In spite of many forest problems common to both regions, each has problems sufficiently different to require separate consideration.

THE DOUGLAS-FIR REGION

The Douglas-fir region, extending from British Columbia to California and from the Pacific Ocean east to the crest of the Cascade Range, covers roughly one-third of the Pacific Northwest. Along the coast is a belt having high precipitation, foggy weather, and forests of western hemlock, Sitka spruce, western redcedar, and red alder, with stands of Port Orford white-cedar and Douglas-fir becoming important to the south. The species in this belt extend eastward into the Coast Mountains, becoming intermingled with Douglas-fir, and finally yielding largely to this species in the lowland territory comprising the Puget Trough in Washington and the Willamette Valley in Oregon. The eastern part of the region, the slopes of the Cascade Range, are characterized by forests in which Douglas-fir predominates at the lower levels, giving way to admixtures of hemlock, true firs, and other species at higher elevations.
From the standpoints of industrial development, timber depletion, and market outlets, the Puget Sound region in the north is in marked contrast to the Willamette Valley in the south. The former is more highly developed industrially, so far advanced in timber depletion that lumber production is decreasing sharply, and markets its forest products chiefly by water. The latter is not so highly developed industrially, relies more on agriculture, markets its forest products chiefly by rail, and timber depletion is in its infancy.

The forest resources are enormous and varied

Fortunately, the Pacific Northwest has accurate estimates of its forest resources. In 1930, the first work on the Nation-wide forest survey was inaugurated by the Pacific Northwest Forest and Range Experiment Station in the Douglas-fir region. The work has been completed, so that timber volumes and growth by species, forest types, geographic subdivisions, and ownerships are known. The data are kept current, a few counties a year, and are available for analysis of forest resource problems and their solution. During the past year, for example, 6 counties were resurveyed and reports issued.

Approximately 82 1/2 percent of the total land area in the Douglas-fir region is forest land, and 74 1/2 percent, roughly 26 million acres, is commercial conifer land. Practically all of this will remain available for forestry. More than 14 1/2 million acres, or 56 percent, of the commercial conifer land bears forests of saw-timber size. Of this area less than half supports old-growth Douglas-fir forests and less than a fourth is comparable to the forests which supplied the bulk of past sawlog production.

These forest lands carry a present inventory of approximately 520 billion board feet, log scale, of which less than half is privately owned. Douglas-fir preponderates with a volume of 310 billion feet consisting of 130 billion feet of large old growth, 97 billion feet of small old growth, and 83 billion feet of second growth. About 57 billion feet of spruce and cedar has a definite commercial value, while of the 102 billion feet of western hemlock large quantities have little present commercial significance. Other species total 71 billion feet, much of which is of doubtful commercial value.
Depletion is 8.3 billion feet annually

The forests of the Douglas-fir region are being depleted at the rate of 8.3 billion board feet annually; cutting of saw timber accounts for 7.9 billion board feet annually. In contrast, current annual growth totals approximately 2.4 billion board feet, and potential annual growth should be in the neighborhood of 8.2 billion board feet, provided old-growth stands are successfully converted to second-growth stands. The data show the ultimate sustained-yield capacity of the region to be about 8 billion board feet annually. Before this can be attained, however, there will be a period of transition from liquidation to sustained yield during which a cut of from 6 to 6 1/2 billion feet per year is the maximum allowable.

Such regional averages tend to obscure differences between parts of the whole and ignore local deficiencies which cause serious economic disturbances. Production is declining, for instance, in the Puget Sound territory and increasing in the Willamette Valley; the center of production is moving southward. In 1938, for the first time in history, Oregon's lumber production exceeded that of Washington. Because of manufacturing facilities already established, and not transferable without considerable monetary loss, the Puget Sound industries are drawing an increasing proportion of their log requirements from Oregon. At the same time there is a growing tendency for new mills and plywood plants to locate in the Willamette Valley to be nearer the source of log supply.

Pressure to liquidate contributes to the problem

Since 1929 the depletion from cutting alone in the Douglas-fir region has averaged 7.9 billion board feet annually, decidedly in excess of the allowable cut during the transition stage. One of the major problems is that of overinstalled sawmill capacity; overinstalled when compared to either growth or markets. Many factors contribute—lack of industry control of new units, taxes, privately owned timber in blocks too small to permit sustained production—but probably the greatest is pressure to liquidate overmature virgin timber. Old-growth timber produces a high proportion of low-grade lumber which is a drug on a market reached only by long shipments. The unprofitable low grades reduce returns on the better grades, tending to make the whole operation unprofitable. The industry markets an appreciable part of its output in the form
of logs or in a partially manufactured state, partly because markets are remote, partly because most shipments are by water, and partly because of industry inertia. This problem has not been attacked by public agencies; perhaps it should be. The development of greater refinement in manufacture would eliminate freight now paid on unusable material, would permit greater utilization of low-grade material, and would increase regional income and buying power.

These problems and others resulting directly from past exploitation of forest lands are laid at no one's door. They are the product of a past philosophy of value and use of natural resources. It must be remembered that originally all forest lands were in Federal ownership; the present ownership pattern is the result of Federal grants, homestead laws, and other Federal timber and forest acts. When forest lands passed into private ownership only one value was recognized, the commercial value of the forest growing thereon. In removing this growth the operator had one objective in view, to obtain the maximum pecuniary return. This inevitably led to the destruction of other values of public concern not then recognized but which have since become important.

**Early logging was selective**

Early logging in the region was highly selective. Markets were limited by a sparse population and poor transportation facilities, and only high-value trees in the most accessible locations could be profitably harvested with the primitive equipment available. In the days of the jack-screw only trees within a short distance of water could be handled. The ox-team logger widened his sphere of action somewhat. But not until the introduction of the steam donkey and the logging railroad did timber exploitation really get under way. That this coincided with increased demand and widened markets through the settlement of the West Coast and the completion of transcontinental railroads was of far-reaching effect on the forest resource. Heavy equipment designed for handling big timber was developed and two adverse factors appeared; excessive cost of logging small sized timber with such equipment, and complete destruction of trees not economically removable. Mass production was necessary to obtain low costs; future values were sacrificed. Some of the most pressing current problems of forestry are the direct consequence of this phase of logging. The region now has 1.6 million acres of nonrestocked cut-over land, 1.1 million acres of poorly stocked cutovers, and only 2.7 million acres of satisfactorily stocked second growth. Non- or poorly stocked cut-over lands result quite largely from widespread clear cutting and subsequent
broadcast slash burning, abetted by recurrent fires which destroy seed trees and any reproduction which might remain or appear following logging. On many such areas it will be necessary to resort to expensive planting before they can be restored to production. In the coastal fog belt where hemlock, spruce, and cedar are important species the problem may be solved with less expense than on areas where Douglas-fir should be fostered.

Reforestation of cut-over lands studied

Past work at the Station has shown that broadcast seeding of the small-seeded species in the coastal belt is feasible, but that present methods of broadcast seeding of the large-seeded species is unprofitable because of rodents. Adequate rodent control over extensive areas is difficult. There is urgent need for additional research in broadcast seeding. One possibly fruitful field of investigation is that of the use of new or recently cheapened chemical compounds to be used as poisons or repellants. Most of the studies of artificial reforestation by planting have been conducted by the Regional Forester's staff in connection with extensive planting on national forests. The search for species especially adapted to certain purposes has been continued by trial of exotics in various places, particularly in the arboretum at the Wind River Experimental Forest. One especially interesting result is that Port Orford white-cedar, a valuable specialty species, has shown unusual freedom from rodent damage to both seed and seedling when planted well beyond the limits of its natural range. Recently developed hybrid poplars have been out-planted and are being studied with interest in the hope that they may excel in growth and in pulping characteristics. A test of Douglas-fir and ponderosa pine from varying localities has been under way for years for the purpose of determining superior races and strains suitable for artificial reforestation.

Fire research profitable

Fire is one of the important problems in the region, both in uncut forests and on cut-over land. Presence of slash and conduct of logging operations in high hazard areas greatly aggravate the problem. Two phases have been investigated by the Station—fire behavior and fire control. The work began some years ago with emphasis on the recognition and measurement of dangerous fire weather as the principal variable factor influencing fire behavior. Through a process of evolution, satisfactory low-cost instruments for measuring various elements of fire danger and a fire danger rating system now used on the national forests and elsewhere in the region have been developed. Fire danger rating is still in an active state of evolution. A new burning index table developed by the Station in 1939 is being tried on the national forests. During the year a statistical study was made of the number of stations required to obtain acceptable degrees of accuracy. Recently there has been a country-wide movement in favor of the development of a national fire danger rating.
scale. The study of the rate of spread of fires under different fuel and terrain conditions was continued during 1939 with field observations on seven large fires.

Methods which have been developed for rating fuel hazard have been improved during the year, particularly as they apply to partial-cut areas. Studies have been made of factors affecting the rate of hand-constructing fire line. It was found that efficiency diminishes inversely with crew size. A 15-man crew averaged 0.49 chain of line production per man per hour; a 75-man crew only 0.20 chain per man per hour.

During the past 10 years various analyses of fire records made as the basis for planning presuppression and suppression activities, principally on the national forests, have been used in planning improvements, such as roads and lookout stations, and in determining the number and placement of guards. Studies of the detection system and its problems led to the development of the haze meter and colored eye glasses for lookouts. This year, at the request of the Forest Research Council, attention was directed to means of bettering protection on private lands, in the belief that the weakest link in the protection system is control of fires on logged-off lands, located chiefly outside the national forests. Snohomish County, Washington, was selected as a representative study unit. The physical and economic factors of fire protection have been analyzed and the results discussed with land owners, State officials, and protective association representatives. The next step is to draw conclusions and make recommendations for improvements in fire protection.

Logging trends during the past decade have been away from heavy equipment and from large, clear cuttings even when heavy equipment is used. The practice of clear cutting in strips or blocks so that no part of the logged area will be without a natural source of seed supply is being adopted in some operations and tree selection in others. Hence, from logging alone, there should not be an increase in the extensive non-restocked areas; however, such areas may result from fires. Loggers are adopting lighter and more mobile equipment, and are finding it economical. Tractors and auto trucks permit greater selectivity in logging, whether this be tree selection or area selection. Only trees known to be profitable at the time need be logged. The remainder can be left until increased size, increased quality, increased prices, or a change in market requirements render them marketable.

Intelligent selection of trees to be cut or left is predicated upon advance knowledge of present and future values. This Station has used as the net value of a tree the sum of the values of the logs it will yield minus the cost of logging, transporting, and milling these logs. Logging costs for different types of equipment under different
topographic conditions were established a few years ago but need revision and amplification because of changes in methods and equipment. Log values are determined from mill production studies, explained more fully under the discussion of east-side problems. No mill studies have been made in Douglas-fir; such studies are urgently needed. Coincident with such studies, which will be made as soon as funds and personnel permit, a study of relative efficiency of sawmills as affected by equipment and size will be undertaken.

Valuable information on commercial log values and utilization, and on the relation between tree values as predicted on the stump and as determined by actual selling price of the logs in the open market was accumulated during 1939 in a study of installment cutting on a 160-acre tract.

Selective cutting in west-side forests has its attendant problems. Douglas-fir, the most desirable species at present, is not wind-firm, and partial cutting may lead to excessive windfall losses of residual trees. Many Douglas-fir forests have an understory of tolerant western hemlock. Selective cutting may convert such a stand into one in which hemlock predominates. Under present conditions hemlock is considered a less valuable species.

Selective cutting is being studied from several angles. Analyses indicate that costs are usually lower with the more modern equipment, but that on difficult terrain the lighter equipment may not be as efficient. In the belief that equipment has not yet reached its highest efficiency, studies on design and on new equipment possibilities are being undertaken by the Station in cooperation with the Region 6 equipment laboratory.

Another approach to the problem of selective cutting in Douglas-fir stands is by increasing the demand for the so-called inferior or minor species. Western hemlock, for instance, has admirable properties for some uses but is difficult to market in competition with Douglas-fir lumber. It is in demand by the pulp mills, but not by sawmills. A study conducted cooperatively by the Douglas Fir Plywood Association, the Forest Products Laboratory, and the Station will be undertaken in 1940 to determine the practicability, both technical and economic, of manufacturing high-grade plywood from western hemlock.

Production and utilization statistics important

The Station is constantly called upon for information as to sources of supply of many species in the region, and as to proper manufacturing, seasoning, and utilization procedures for these woods. Several hardwood species, red alder, Oregon white oak, bigleaf maple, and northern black cottonwood, have been the subject of articles and bulletins in past years. Data on other species, western paper birch, tan oak, Oregon myrtle, and Sierra juniper, are being accumulated as time permits.
Record is also kept of production, use, and price statistics of many of the forest by-products such as Oregon fir balsam, cedar leaf oil, and cascara bark. Those, together with accurate statistics on the production of lumber, logs, lath, and shingles obtained in cooperation with the Bureau of the Census, provide the basis for many of the regional plans prepared by this and by other public agencies.

New management problems coincident with partial cutting

The silvicultural aspects of the changed logging methods and the trend toward partial cutting loom high in the Douglas-fir region. The problem has been recognized by the Station, and permanent sample plots have been established whereon results of partial cutting on growth, mortality, fire hazard, and logging injury may be observed and quantitatively measured over a period of years. It is too early to draw conclusions, because the heterogeneity of conditions in the region make necessary large samples and long-continued observations to smooth out normal variations.

Another factor in partially cut stands and one which will determine the choice of a selection system is the silvicultural requirements of the species. How much light is required for regeneration and for the proper development of seedlings? How large an opening must be made in the canopy to insure maximum requirements? The light requirements are being measured in slat houses at the Wind River Experimental Forest where light may be regulated and under tree canopies of various densities.

The Port Orford white-cedar type in the extreme southwestern part of the region offers peculiar and special silvicultural and utilization problems. The species is important because of its scarcity and high value. An experimental forest established by the Station in this type near Powers, Oregon, has been unoccupied this year because of lack of personnel. Likewise, practically nothing has been done this year on the study of silvicultural problems in the spruce-hemlock type and the alder type so characteristic of the coastal fog belt. The Cascade Head Experimental Forest, near Otis, Oregon, is being developed to study these problems more intensively. Problems in these types have points in common with those of the Douglas-fir types but must be solved through the development of special techniques.

Another problem created by logging is that of the management of second-growth stands. The future depends upon these stands, because eventually the bulk of the virgin growth will be converted to second growth. Undoubtedly, it will never be profitable to grow Douglas-fir to the sizes and ages now harvested. This species is slow to prune its bole of dead branches; obviously, artificial pruning will be necessary if clear lumber is to be produced on short rotations. The time may not be far distant when pruning will be economically justified. A study has been made by the Station of pruning under natural conditions, and pruning
operations conducted by CCC crews on a number of localities have been observed. Other stand improvement practices such as thinning may be profitable in second-growth stands. In order to determine the silvical effects of various types of thinnings, seven permanent sample plots were established on the Wind River Experimental Forest following a sale of piling from a second-growth stand.

Additional data on the life cycle of even-aged Douglas-fir stands are being obtained from periodic measurements on many permanent growth plots. These furnish a check on normal yield tables previously prepared by the Station. This year's measurements of 25 plots confirm the conclusion that both overstocked and understocked stands trend toward the normal. Information is needed, however, on growth in uneven-aged stands, in mixed stands, or following partial cutting. And the important problem of quality growth is still unanswered.

The utilization phases of second-growth fir should be analyzed as soon as possible. Logging in immature stands will differ from that in mature stands, and costs at hand for the latter are not applicable. Milling procedures and costs must also be established. A few preliminary time studies and lumber-grade recovery analyses have been made. More detailed studies must be preceded by the development of a set of log grades adapted to second-growth Douglas-fir—a system of grades analogous to those developed for ponderosa pine. At present the mills cutting second growth are usually underfinanced and underpowered, and are at a disadvantage in the marketing of their products.

Many of the problems so far considered are symptomatic, not causal. Each may be isolated for study, but the improvements suggested by such studies can be but alleviatory. Until the underlying causal problem is revealed and studied and until the improvements suggested by studies of the isolated parts are correlated with the causal problem, we are but nibbling the edges of the great forest resource problem in this region.

Change in philosophy of natural resource use

Basically, the present problem results from (a) damage accumulated under an old philosophy of resource utilization and (b) the failure of the economic structure to recognize that this philosophy is outmoded. Briefly, the old philosophy held that a natural resource should be "mined" for the creation of wealth; the new philosophy holds that the creation of physical wealth should be correlated with the derivation and maintenance of full social values from these resources. The second is a mature development of the first encouraged by the trends of settlement and development. Whereas in the early days there was an apparently inexhaustible reserve of forest resources in this region and it was logical to exploit it in order to provide the wealth for developing the country, it is now realized that these resources are exhaustible, that
their perpetuation is necessary to the well-being and security of this and of future generations, that remaining resources must be wisely used and maintained, and that those which have been depleted or destroyed must be restored.

Taxes and land use highly correlated

During the early days of forest exploitation, taxation problems, for example, were inconsequential or nonexistent. The resource was boundless, the needs of the sparse population few. Cut-over land was sold or even given away to settlers. Most of this was suitable for agricultural use because logging was restricted to the bottomlands. As logging progressed the taxable resource decreased, but population increased and its demands for service became more and more insistent. Logged-off lands were still sold for farming, but they were less suited to this use—they were primarily forest land. The deeds to these lands were merely invitations to failure, loss, a low standard of existence to the owner, and additional burdens upon the community for services. Continued cultivation of such lands contributed to erosion and soil deterioration. Cut-over lands no longer found a ready market, partly because they were of poor quality and partly because the wave of settlement had subsided. The logger could see no future value in them and allowed them to revert to the county through nonpayment of taxes. But the county had no use for them, had no provision for administering them, and made every effort to sell them, usually at low prices, in order to bolster decreasing assessment rolls. The cycle was complete; the income-producing resource had been reduced, population had been increased and dispersed hither and yon in the hinterland, demands for service increased all out of proportion to the values and income created, taxes on the remaining resource increased until finally the burden became so onerous that even the virgin resource is reverting to public ownership at an alarming rate.

Tax delinquency studied

Recent studies indicate that between 1933 and 1936 there was a 54 percent increase in the acreage of forest lands involved in long-term tax delinquency and reversion to public ownership. The situation is far more critical in the highly productive Douglas-fir region than in the pine region. Though the principal trouble spots are deforested lands and lands bearing second-growth stands of less than saw-timber size, an amazing amount of virgin timber and a considerable acreage of residual old growth from which only the high-value trees have been removed are also involved.

Two of the immediate problems of the region are (a) what to do with these forest lands being forfeited to the public for unpaid taxes, and (b) what may be done to stem the flow of tax delinquency. The Station is approaching these through studies of the extent, causes, effects, and possible cures. Investigations reveal that the existing situation
is symptomatic of fundamental breakdowns in private forest land ownership and is in part traceable to management practices under existing economic conditions. No one remedy will cure the situation—no panacea exists. However, measures have been found which may be applied with remedial results and which may pave the way for the development and application of additional remedies and eventually reduce adverse pressures sufficiently to permit self-correction. Some of the wasteful processes of the past may be averted by classifying tax-forfeited lands as to best-known long-term use and ownership; public sale of those best suited to private ownership, and public ownership and management of those suited best to public ownership. The flow of delinquency will not be stopped but may be retarded by economies in local government, improvement in tax administration, and modification of property tax laws in keeping with the deferred income nature of forest properties. It should be remembered that as long as social order is maintained there will be taxes, as long as there are taxes there will be tax delinquency. Our efforts should be directed to reduction of wasteful processes and retardation of delinquency.

Among the serious problems of the private forest owner is the unpredictability of the property tax. Investigations reveal wide variations in tax rates from year to year. Although this condition creates hazards in ownership of all classes of property, it creates unusual hazards in the case of forest properties and to the practice of private forestry. If property taxes, which take a substantial proportion of gross income from a forest property cannot be predicted, then liquidation is favored and stable private ownership discouraged. Studies in progress reveal that local government may be adapted to forest use in the forest areas of Washington and Oregon and that by so doing taxes can be made more predictable without impairing governmental efficiency in these or contiguous areas. Other economic studies needed are: (1) assessed valuation with particular reference to deferred yield properties; (2) deferment of tax payments in keeping with deferred income nature of forest properties; and (3) the nature of the forest investment in this region under various existing and future local, national, and international forest situations.

New forest values recognized

In keeping with the transition from a philosophy of timber mining to one of recognition of the full public interest in forest resources is the initiation of studies dealing with forest values other than timber production. Since the Station was founded it has not been possible to divert resources from studies dealing with the many and complex problems developing from forest growing and cropping to the problems connected with the indirect forest uses. Recently attention has been directed, partly by disasters and partly by forward-looking agencies, to the stupendous and irretrievable losses of soil and downstream damage through water and erosion stemming from misuse of land. A program of flood control surveys is commencing in this region. It will include an investigation of the way forests act to prevent flood damage and soil
losses on specific critical watersheds. Participation of this Station in the cooperative program of flood control surveys launches it on a new era of forest research with greater responsibilities and greater opportunities. It marks the departure from studies limited to direct use of the forest resource for studies that recognize the complete social use of forests.

THE PONDEROSA PINE REGION

Domination of the geography of Oregon and Washington by the Cascade Range has created east of the summit an area totally different in climate, vegetative cover, and economy from that on the coastal slope.

This area, known as the ponderosa pine region, is characterized by vast expanses naturally treeless because of insufficient rainfall, mountains with an open park-like forest cover, and extreme seasonal and diurnal climatic variations which because of a limited growing season create an entirely different set of physical factors in the forest problems. Exclusive of three counties in northeastern Washington, which for administrative reasons are not included in the territory of this Station, the ponderosa pine region has an area of 65 million acres, only one-third of which is forest land, in sharp contrast to the Douglas-fir region where seven-eighths of the total area is forest land.

The treeless two-thirds of the region is made up of intensively farmed, irrigated orchard and crop land, wheat land, grass-covered range land, and sagebrush plains. The economy of the region is largely rural, and agriculture is the principal source of livelihood. Water is the key factor in agricultural land use and its presence or absence dictates the type of agriculture. It is only natural that multiple use of forest land should find full expression here. Agriculture and forestry are in harmony and conflicts between these two primary uses of land are inconsequential. The forest research program of the Station is being shaped to fit these conditions. The two major forest land uses are timber production and forage production. Despite the close integration of the two they will be considered separately here to facilitate discussion.
Ponderosa pine the important timber species

The forest land in the ponderosa pine region as shown by the forest survey covers 22.1 million acres, of which 16.2 million acres is commercial forest land. Of the latter, 85 percent is occupied by forests of saw-timber size, 15 percent by second-growth stands less than saw-timber size, and the remainder is deforested. Ponderosa pine, the predominant species, covers 10.4 million acres in stands of saw-timber size, and 1.4 million acres in second-growth stands. The total saw-timber volume in the region is 127.1 billion board feet, of which 64 percent is ponderosa pine. The other species are of low commercial value, and their utilization is an important problem.

Current annual depletion from all causes is estimated by the forest survey to total 2.3 billion board feet divided as follows: cutting, 1.3 billion; insect loss, 0.8 billion; fire and wind throw, 0.2 billion. Current annual net growth totals 219 million board feet, and potential annual growth under intensive management is computed to be approximately 2 billion feet. If the best type of selective cutting is universally adopted an allowable cut of 1.1 billion board feet is possible from the pine types alone, which approximates average annual sawlog depletion for the 1925-36 period. The ultimate sustained yield is 1.4 billion board feet from the pine types. Region-wide the situation is not seriously unbalanced, but certain units, Klamath Plateau and Deschutes River, are heavily overcutting.

Selective cutting well advanced

Timber exploitation in the pine region is not of such long standing and has not been as devastating as that in the Douglas-fir region. So-called clear cutting was the rule in the early days, but this meant
the cutting of trees above 12 inches or 14 inches stump diameter. Many of the residual trees remained because slashing fires are not as intense and as extensive due to lighter stands and less debris. So except on areas recurrently burned, a certain degree of restocking, not always satisfactory, of course, has been attained. Some operators still follow these practices. Beginning in the late 1920's there was a tendency to scrutinize tree values more closely and to cut only those with positive margins. A 16-inch tree was found to be the smallest that should be cut. Since then many operators have followed this zero-margin cutting policy, with diameter limits varying between 12 inches and 20 inches, depending upon market conditions. The result is removal of 75 percent of the stand volume and gives expectation of a second cut in approximately 60 years. The Forest Service policy has been to mark 30-35 percent of the volume, and to require brush disposal usually by spot-burning.

Beginning in 1935 the Station developed and advocated a selective cutting system, called the economic-maturity system, in which present and future values formed the basis for decision as to which trees to cut. Economically mature trees, i.e., those with a low earning capacity as shown by growth rate and quality increment, were selected for removal in the first cut, leaving in the residual stand only those trees with the greatest earning capacity. Analyses of several stands indicated optimum returns to the operator when removing from 30 to 50 percent of the volume. Coupling this with the adoption of the best use of tractors and trucks, a considerable increase in returns per thousand feet was indicated. At the same time, an area was opened twice as fast, permitting conversion of stands with negative growth rates into producing units at twice the old rate, and permitting the salvage of insect or fire-killed trees when necessary. It is also believed that under the economic-maturity selection system most of the insect-susceptible trees are removed, thus reducing losses from this source. The system is finding favor with private operators and with national forest administrators.

Knowledge of log and tree values essential

The determination of tree values is predicated, according to procedures adopted by this Station, upon a knowledge of the value of the logs into which they will be cut, and this in turn is predicated upon a system of log grades applicable to standing timber as well as to logs. A set of grades, based entirely upon external characteristics, has been developed. Lumber-grade recoveries from logs of these grades have been established by intensive mill production studies. Analyses have been made of timber from widely separated localities within the region, and from one locality in Arizona, and under the range of manufacturing procedures encountered within the region. Each of the six log grades in this system yields characteristic lumber recoveries, the differences in recoveries being attributable to manufacturing practices rather than to inherent differences in the timber from which the logs came. Publication of the mass of material pertaining to these log grades is being
deferred pending integration with a newly proposed set of grades applicable throughout the range of ponderosa pine. This new system resulted from a conference called late in 1939 by the California Forest Experiment Station, and also attended by representatives of the Northern Rocky Mountain Forest Experiment Station and this Station. To date, no studies in which the new grades were used have been made by any of the three stations.

Coincident with the analyses of grade recoveries and selling values of the logs, time studies were conducted in order to allocate correctly milling costs against logs of different sizes and qualities. Time studies of the woods operations have also been made, so that the Station is in position to analyze conditions and predict results under any of a variety of conditions.

Silvicultural problems studied

Because of climatic and species conditions, the silvicultural problems in the ponderosa pine region differ from, but are no less important than, those in the Douglas-fir region. Pringle Falls Experimental Forest and the Blue Mountain Experimental Forest have been established as research centers in this region, though sample plots are scattered throughout the timbered area. One of the main problems being studied is that of mortality in selectively cut stands. This year's annual check of 520 acres cut by seven different methods of selection at Pringle Falls showed a loss of only 4 trees of saw-timber size—a small loss out of 5,000 trees. On 50 miles of transects on the Malheur National Forest, cut by the maturity selection system, there was a loss of 59 board feet per acre during the past year.

Stand improvement in the ponderosa pine region promises to pay dividends, and the technique for such improvement work is now being developed. Using CCC labor, crop-tree pruning and thinning have been conducted on a number of areas, and records of costs have been obtained. Among the 25 permanent sample plots remeasured this year at Pringle Falls, 3 were in lodgepole pine thickets, 2 of which had been thinned. Mortality on the thinned plots was half that on the unthinned check plot; net annual growth on the thinned plots was from four to eight times that on the unthinned plot.

Forests and summer range are correlated

The range in this region is a virtual empire of 62 million acres of grazing land over which grass and water rule. More than 125 million dollars is invested in land, livestock, and equipment in the region and annual expenditures for feed, fertilizers, and labor amount to 10 million dollars. Capital assets of the industry include 2 million range sheep, 375 thousand range cattle, and 6,500 home ranches. Profits are curtailed by service costs on mortgages on many ranches.
Owing to the long transcontinental trek to markets and unstable prices of lamb, wool, hides, and beef, the industry in this region is totally dependent on a yearly abundance of the cheap nature-endowed range forage crop as determined by occurrence of spring rains, summer drought, and winter snow in its competition with the pasture and feed lots of the Midwest and corn belt.

Unlike forest industries, the range livestock business is dependent on a crop that grows, matures, and is harvested annually. Drought, especially when the range is heavily stocked, reduces the year's forage supply below the amount needed to maintain the grazing animals. Whole-sale and ruinous selling, starvation of livestock, or the purchasing of costly feed supplements, any of which is destructive to the economic welfare of the graziers, occurs when range forage supply sinks below the level of demands made by the grazing herds.

Of still more serious consequence is the damage done to the range resource during years of overdemand. While graziers are waiting for rains that fail to come, or for increase in prices that changes loss to profit, the range forage is overused, its roots are starved from close cropping of the food-manufacturing leaves and stems, plants die, fertile soils once safely root-bound wash or are blown away, fewer and less valuable range plants remain, and the dimension of the feed resource for range sheep and cattle thereby is semipermanently reduced. Regardless of current opinions that feed now "short" will return in abundance with future rains, rebuilding of the forage resource on ranges seriously depleted by drought and heavy grazing is a slow, tedious process. If destructive erosion has occurred, rebuilding may require generations.

The function of the Experiment Station is to obtain a constructive solution to this viciously circling problem. A solution based on sound economics, yes; but a solution that also will deal intensively with the best long-time management of the soil and the forage resources. Permanent stability in the range livestock business rests on a healthy condition of the basic resource.

**What are safe levels of stocking?**

The Station is interested in determining safe levels of stocking range lands that will avoid undue forage waste in years of abundant moisture and at the same time prevent range destruction in years of rainfall deficiency. To do this, minimum requirement for perpetuation of important range types and key forage species under grazing use must be determined. Ways and means of revegetating depleted ranges either naturally or by artificially reseeding must be found. Above all, managerial methods that are successful in respect to the grazier, to the grazing animals, and to the range resource must be developed.
Solution of the summer-range problem is the key to a large part of the regional range problem. The summer range, limited to mountainous areas, is most usable and available when summer drought has dried up waterholes and parched feed on lower sagebrush and grassland ranges. Mountainous range lands in Oregon and Washington can safely carry for the summer period not more than 70 percent of the livestock that is supported on semiarid ranges or in feedlots during the remainder of the year. This shortage results in heavy use of summer range, which in turn results in lowered production of summer range forage, thus further unbalancing the seasonal range forage supply. Moreover, accelerated erosion bespeaking lowered ability to grow forage, and rapid run-off inimical to a dependable supply of usable irrigation water, accompanies the reduction of plant cover that results from harmful grazing on these steep lands.

Despite the great values involved, the summer range forage crop has been harvested for many years without adequate knowledge of the requirements necessary to sustain or increase the yield or to protect the soil from accelerated erosion. To determine these requirements, quantitatively and qualitatively, is the first step that the Station contemplates towards a constructive solution to the range problem.

Summer range in Oregon and Washington is more than 90 percent timbered. The small acreage of untimbered range mostly at elevations near timberline and in mountain meadows, however, is potentially high in grazing capacity in relation to the timbered range. Investigations indicate that these choice open ranges have been seriously depleted because of their desirable species and the ease of livestock management in grazing them. It is estimated that if these open ranges could be restored to their original capacity, a substantial amount of the present discrepancy between grazing capacity of summer and other seasonal ranges could be eliminated.

Overgrazing is detrimental

Studies indicate that untimbered green fescue summer range in prime condition will support 5 sheep months' grazing per acre; in average depleted condition only 0.5 sheep months per acre. This loss in grazing capacity results from a lowered plant density of from 62 to 83
percent and, more important, a loss of more than 90 percent of green fescue, which furnishes the bulk of the feed even on depleted ranges. In addition, there may be a loss of approximately 450 tons of fertile topsoil to the acre from accelerated erosion because of the wholesale destruction of the deeply rooted green fescue. Chief of the invading species on depleted green fescue range are the shallow-rooted needlegrasses and weeds such as horsemint and fleeceflower. Poor forage species ill-equipped to arrest accelerated soil erosion. These plants in virtually the same amounts and association are to be found on ranges that formerly were thought always to have been needlegrass-weed ranges.

In view of the foregoing study, it is a valid argument that needlegrass-weed ranges, if not definitely proven to be retrogressed from a more stable climax vegetation such as green fescue, should be considered to be in a developmental stage, unstable as to soil-vegetation balance and worthy of careful management in order to promote better range and watershed conditions.

From utilization studies on these two range types it is tentatively concluded that green fescue should not be used closer than 50 percent of its current herbage production under any circumstance; that when this use is made of the fescue, associated needlegrasses are used only to 15 percent of their foliage production. On needlegrass-weed range the use of the needlegrass herbage to from 40 to 60 percent, such as is common practice, should be discouraged if the type is to be allowed to build up. Probably not more than 15 percent use of needlegrasses, and certainly not more than 30 percent, should be countenanced if the range is to be rebuilt.

Exploratory studies on timbered pinegrass ranges that form the bulk of summer range in Oregon and Washington indicate that up to 50 percent of the forage comes from small meadows that may constitute as little as 4 percent of the area. The forage from the timber feed proper, moreover, is observed to come in large measure from relatively sparse species such as lupine and vetch. Therefore, it is tentatively deduced that grazing management of pinegrass range should be based not on the low-value pinegrass which ordinarily makes up a large percentage of the vegetation, but on small areas of meadow clothed with choice forage plants and upon
the good forage species that grow sparsely in association with pine-grass under the timber canopy.

Wise range utilization standards essential

In developing standards for wise range forage use, or for estimating range grazing capacity, or for checking range utilization, it is essential that the measuring sticks used are calibrated. The Station has devoted considerable effort along these lines and has found that, in general, variability of range vegetation is such that more than 10 percent accuracy in measuring it is not ordinarily to be expected. To obtain this accuracy in estimating plant density and composition with a 2 to 1 probability of successful repetition requires about 125 sample plots on subalpine grassland types and about 225 plots in the timbered pine-grass type. This means that an area of from 6 to 10 sections sampled at the intensity of 20 plots per section is required to obtain estimates within 10 percent accuracy limits. If similar accuracy is desired on smaller acreages, more plots per section must be taken. Percentage utilization of range species may be estimated dependably with from 25 to 50 plots.

It was found that personal error of estimating range forage when divorced from errors due to inadequate sampling is also approximately 10 percent and that individuals tend to estimate consistently higher or lower than the true values. The individual estimates, whether high or low, were found to be equally consistent and of relatively the same accuracy, however. It is concluded that personal error within a crew can be nullified largely by scheduling each day’s work so that all crew members are involved in making the estimates of the unit worked on that particular day.

First flood control survey in the region

It is fitting that the first detailed flood control survey undertaken by the U. S. Department of Agriculture in the Pacific Northwest should be on the Walla Walla River Watershed. This area contains both forest and range land with conditions varying from complete cover to almost an absence of cover. Its waters irrigate some of the most intensively cultivated farms in the region, and annual flood damage is excessive. Because of the recent establishment of flood control studies at the Station no specific contributions can be mentioned.
SUMMARY OF 1939 RESEARCH

Forest management research

A large-scale experiment in installment cutting in old-growth Douglas-fir and hemlock was made to determine silvicultural damage and effect on fire hazard of each of five degrees of cutting. After the first cut 5 percent of the reserved Douglas-firs and 19 percent of the hemlocks were injured, after the second cut 11 percent of the Douglas-firs and 32 percent of the hemlocks were injured, and after the third cut 15 percent of the Douglas-firs and 36 percent of the hemlocks were damaged.

Instruction in methods and tools for thinning and pruning Douglas-fir and ponderosa pine forests were given 10 foremen and hundreds of CCC workers through demonstration and training on 10 national forests. The "Hebo Club", a simple instrument adapted to rapid and inexpensive pruning was developed.

Information was released concerning effect of crew size upon man hour output of fire line, number of fire danger stations required per ranger district to get reliable fuel moisture and wind velocity averages for daily fire danger rating, and fuels most likely to be ignited by smokers. In the first-named study it was found that a 15-man crew would produce 0.49 chain of fire line per man hour and a 75-man crew but 0.20 chain per man hour. Improvements were made in fire danger rating specifications.

At the suggestion of forest protective agencies a study was initiated of the fire control system in effect on private lands, primarily to determine cost of effective protection.

Twenty permanent sample plots aggregating 72 individual acres, re-examined or established this year on partially cut areas, are beginning to yield results as to character of reserve trees compared to trees cut, logging damage, windfall incidence, insect loss, etc. For example, one area shows a loss of over 50 percent of the reserve stand in 3 years, while another shows a loss of less than 1 percent in the same period. In some cases removal of high-grade material only results in doubling cull percent of the reserve stand; in other cases the same selection practice does not deteriorate the reserve stand. This wide variation emphasizes the need for a large number of observations over an extended period.

Range research

Erosion and grazing capacity losses measured. An acre of green fescue range in prime condition will carry 5 sheep per acre for one month; in average depleted condition 10 acres are needed. Depleted range
may have lost up to 450 tons of fertile topsoil per acre. Deep-rooted, highly palatable green fescue is replaced by shallow-rooted, poor quality needlegrass and worthless weeds.

Use of green fescue and needlegrass compared. Not more than 50 percent of green fescue herbage should be grazed under any circumstance. At this use intensity only 15 percent of admixed needlegrass is grazed. Needlegrass growing in the absence of green fescue should not be grazed to exceed 30 percent in the interest of range and soil conservation.

Forage use estimated with few plots. Use of a key forage species such as green fescue may be estimated on a grazing allotment with observations on from 25 to 50 impersonally selected sample plots.

Forest products

All previously conducted production studies in ponderosa pine mills brought to completion by preparation of the necessary reports.

A comprehensive mill production study of ponderosa pine grown in mixture with Douglas-fir initiated and completed. The high-grade logs were quite similar to the same grade in other studies using material from pure pine stands. All other logs were low line within their grade and showed lower pond margin values than were expected.

Regional lumber-grade recovery expectancies compiled on basis of the Pacific Northwest system of log grades.

The 1938 sawlog depletion was compiled by counties. Total for Oregon was 3.8 billion board feet; for Washington; 3.5 billion board feet.

The 1938 annual lumber census showed production 21 percent below 1937. In 1938 Oregon production was greater than Washington for the first time in history.

Arsenic paste preservative records on experimental pole lines show effectiveness of the treatment.

Forest survey

The preliminary draft of a comprehensive report on the forest resources of the ponderosa pine region of Oregon and Washington was prepared. It includes, in addition to inventory, growth, and depletion data, an analysis of regional timber supply and sustained yield possibilities. The report shows that if current production levels are to be maintained permanently pine forests must be rapidly converted to a growing condition best accomplished through light selection cutting and other types must be utilized.
"Volume Distribution in Saw-Timber Types in the Ponderosa Pine Region", Forest Research Notes No. 28, was published and distributed. The report gives the average volume per acre of each saw-timber type by survey-unit and State. It also gives volume distribution by diameter class of the two important ponderosa pine types. In both these types about half the volume is in trees over 28 inches d.b.h.

Field inventory revision was completed for 6 counties aggregating 4.1 million acres of forest land.

Published revised type maps of 4 counties and statistical inventory reports for 3 counties. The latter 3 counties—Pierce, Pacific, and Snohomish—showed a net depletion between the original inventory and the revised inventory of 4.7 billion board feet, or 10 percent.

Prepared manuscript report, "Forest Resources of Washington", for publication by Washington State Division of Forestry. The report shows, among other data, that the State has 290 billion board feet of standing timber and is exceeded only by Oregon in this respect.

Forest economics

The acreage of forest lands in Oregon and Washington tax delinquent for 3 years or more and forfeited for unpaid taxes increased 54 percent between 1933 and 1938, according to conservative estimates made in 1939.

Advice and information was given public and private agencies concerning tax delinquency, disposal of tax-forfeited lands, land classification, rural land planning, simplified county records, and remedial measures applying to land use.

Preliminary, unpublished studies of adapting local government to forest use in forest areas of Washington indicate possibilities of stabilizing property taxes in these areas without impairing governmental efficiency in these or contiguous areas.

A statistical study pertaining to the yield tax laws of Oregon and Washington was conducted.

Cooperation continued with national forest administration and a number of private operators in studies and experiments in selective cutting and related problems of logging economics.

The realization value of each of five installment cuts was obtained through detailed record of each tree's volume, log grade, and logging cost.
Preliminary reports to determine the feasibility of flood control by land use practices which retard run-off and prevent soil erosion were prepared for the watersheds of the Nooksack, Puyallup, and Moses Coulee Rivers, Washington, the Willamette River, Oregon, and the Tanana River, Alaska. Flood damages on each of these watersheds warrant a detailed watershed survey to determine control methods best suited to flood protection.

Work outlines for watershed surveys were prepared for the Walla Walla River Watershed, Washington, and the Willamette River Watershed, Oregon.

ACKNOWLEDGMENTS

The work of the Station during the past year has been materially advanced through the assistance of the WPA. The loyal and efficient services of a corps of office workers made available through a WPA project have enabled the technical staff to devote a larger proportion of their time to the analysis of results and the preparation of reports.

Credit is also due the CCC organization with whose assistance we have been able to man the experimental forests and make marked progress on thinning, pruning, and other stand improvement work.

ADVISORY COUNCIL

The Advisory Council is a group of men, representative of the varied forest interests in the region, appointed by the Secretary of Agriculture to advise as to the problems which should be studied. These men, because of their knowledge of and practical association with the region, keep the staff in touch with the trends and needs of the forest users, and through their advice keep the work of the Station pointed toward practicality. The Council members serving during the past two years are listed below:

E. T. Allen  E. C. Manning
C. S. Chapman  D. T. Mason
Donald S. Denman  L. T. Murray
Geo. L. Drake  Paul Neils
J. W. Ferguson  Herman Oliver
S. V. Fullaway, Jr.  Geo. W. Peavy
Geo. T. Gerlinger  Wm. A. Schoenfeld
T. S. Goodyear  A. R. Watzek
W. B. Greeley  Hugo Winkenwerder
E. C. Johnson

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Director

Stephen N. Wyckoff

Technical

Thornton T. Munger
Axel J. F. Brandstrom
Sinclair A. Wilson
J. Elton Lodewick
Wade DeVries
Raymond H. Chapler
Robert W. Cowlin
Gerald D. Pickford
Donald N. Matthews
Leo A. Isaac
Herman M. Johnson
Ernest L. Kolbe
Floyd L. Moravets
Philip A. Briegleb
Warren H. Bolles
William G. Morris
Edward D. Buell
Eric A. Anderson
Elbert H. Reid
Theodore Kachin
Douglass C. Welch
Earl G. Dunford
Morten J. Lauridsen
D. Lester Lynch
Donald F. McKay
Walter G. Petersen
Edwin A. Erickson
Charles Herold
Bert C. Baker
Paul F. Liniger
William J. Allyn
Orville B. Cary
Kermit B. Peterson
Robert M. Porter
Fremont McComb
J. Hollis Lenox

Principal Silviculturist
Senior Forest Economist
Senior Forest Economist
Senior Silviculturist
Senior Forest Economist
Senior Forester
Senior Forest Economist
Senior Forest Ecologist
Silviculturist
Associate Silviculturist
Associate Forester
Associate Silviculturist
Associate Forester
Associate Forester
Associate Forester
Associate Forester
Assistant Silviculturist
Assistant Forester
Junior Forester
Assistant Range Examiner
Junior Forester
Junior Forester
Junior Forester
Assistant Field Assistant
Assistant to Technician
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CALENDAR YEAR 1939


Buell, E. D. Forest statistics for Pacific County, Washington, from the inventory phase of the Forest Survey. Apr. 10, 1939.

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