# Natural Reproduction of Ponderosa Pine in Central Idaho

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# STUDIES IN NATURAL REPRODUCTION

# of

# PONDEROSA PINE IN CENTRAL IDAHO

by

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# FOREWORD

The two studies presented here constitute a preliminary report on some phases of the reproduction problem in the ponderosa pine type of central Idaho. The review of previous investigations and statement of the problem, presented first, serve as a basis for the report on subsequent reproduction and also for a proposed later report on studies already begun on advance reproduction and the relationships between lesser vegetation and tree seedlings. If it is desired to get a general conception of the problem and the results with a minimum of reading, the section on climatic cycles in Report I, and the one entitled, "Subsequent Reproduction on Other Areas", in Report II, should be selected, besides the two introductory sections and the summaries and conclusions. The list of literature cited is to be referred to for both of the reports.

The writer wishes to express his appreciation to the School of Forestry of the University of Idaho, and to the Intermountain Forest and Range Experiment Station of the United States Forest Service for the opportunity to carry on the field work of these studies, and to Professors L.J. Young, D.V. Baxter, and J.R. Nelson of the University of Michigan for their helpful suggestions and criticisms of the methods of investigation and the manuscripts of the reports. Especial thanks are due the Experiment Station for the use of manuscript reports, photographs, and some unpublished data, and to the members of its staff for help and advice in the field.

# I

# PREVIOUS STUDIES OF PONDEROSA PINE REPRODUCTION

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# THE PROBLEM IN CENTRAL IDAHO

## PREVIOUS STUDIES OF PONDEROSA PINE[1] REPRODUCTION

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## THE PROBLEM IN CENTRAL IDAHO

Wherever the objectives in land management include the production of wood, the reproduction of stands after cutting is a vital step in the management of the timberlands. The ponderosa, or western yellow, pine lands of central Idaho, because of the quantity, intrinsic value, and accessibility of their timber, are certain to be called upon to continue in the production of wood crops. Second-growth stands of acceptable quality will not, however, result from any and all methods of cutting and land management. Just what measures should be taken in order to reproduce stands is not known, but it is conceded that, since artificial reproduction on ponderosa pine sites is always expensive and often unsuccessful, dependence must be placed upon reproduction by natural means.

It is the purpose of this report to analyse the problem of securing natural reproduction after logging in central Idaho, and to present pertinent results obtained by previous investigation in this and other regions, in so far as they seem applicable to conditions in central Idaho. An attempt is also made to evaluate these previous investigations, and, in so doing the writer has

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1 Pinus ponderosa, Lawson, previously called western yellow pine.

drawn upon what observations he has been able to make during two summers in the field. The report first presents a discussion of the ponderosa pine regions and subdivisions, with especial reference to the central Idaho subdivision; second, a discussion of advance reproduction; third, some considerations of subsequent reproduction; fourth, a study of the effect of climatic cycles; and finally an analysis of the principal factors influencing reproduction.

## PONDEROSA PINE REGIONS

Ponderosa pine is the most widely distributed pine in the United States. There are five generally recognized regions, namely; 1. the Southwest, 2. the central Rocky Mountains (Colorado and Northern New Mexico), 3. the Black Hills, 4. California, and 5. the Northwestern Region. In the first three of these regions the so-called Rocky Mountain form, sometimes considered a separate species called Pinus scopulorum, occurs, and in the latter two the Pacific Coast form (6). Differences in the climates and soils of all of these regions as well as differences in the characteristics of the trees themselves, which are both presented in detail by Baker and Korstian (6), are such that facts which obtain for one region cannot be given much weight in another until they are checked by field observations or investigations.

This fact should always be kept in mind, especially when considering results obtained in the Southwest or in Colorado.

Care must also be taken in the use of results obtained in different parts of the same region. The northwestern region, of which central Idaho is a part, contains a wide variety of sites upon which ponderosa pine grows. The sub-divisions which have come in for separate reproduction studies are; 1. the basaltic soils of eastern Oregon and Washington, and of the area west of the Weiser River in Idaho(26,27,28,50,51,52,53,54), 2. Southwestern Oregon where pumice soils predominate (27,28,37,44), 3. Northern Idaho and western Montana (12,16,19,22,23,47,48), and 4. central Idaho (2,3,4,5, 6,42,43). Of the investigations made in central Idaho, only one report, that by Baker (3) on a study made in 1920 of cut-over areas in Boise Basin, deals primarily with reproduction after logging, and even here reproduction orginating after logging was not clearly differentiated from the seedlings dating from before logging. The other studies were confined to virgin forests or dealt with reproduction after logging only incidentally in connection with other problems. The ponderosa pine type in the Northern Idaho and Western Montana sub-region is characterized by Koch and Cunningham (19) as being mainly transitional. In the others the type is undoubtedly permanent as shown by Weidman (51) and Korstian and Baker (21). In comparing the ponderosa pine type of central Idaho with that of eastern Oregon, Baker (2) says that Idaho stands are more open, moisture conditions are poorer, and that consequently light is less of a factor. This statement is not, however, borne out by the comparison of precipitation records presented by Baker and Korstian (6).

The ponderosa pine type of central Idaho is found in that region of granitic soils which extends from the eastern limit of the Columbia Plateau basalt in the Weiser River drainage eastward to the Beaverhead Mountains on the continental divide, and from the northern limit of the drainage of Salmon River south to the sagebrush of the Snake River Plains and upper valleys of Salmon River. The region contains over 8,000,000 acres of forest land of which all except something over 500,000 acres (2) is in the hands of the United States Forest Service, Regions One and Four. The portion which is in Region One is comparatively small and practically inaccessible and the ponderosa pine is broken in distribution. It need not be considered, therefore, as a significant part of the central Idaho ponderosa pine type, and will be omitted from further discussion.

Of the vast area of forest lying south of Salmon River and east of the Weiser National Forest there are 1,330,136 acres of the ponderosa pine type according to figures quoted by Baker (2). It is easily the most important and valuable timber type of the region, and cutting without adequate provision for replacement of stands cannot be justified. The magnitude of the reproduction problem is shown by the fact that, in normal years, 1909 to 1920 inclusive, about 20,400 acres of the ponderosa pine type were being cut over annually. It should be recognized, too, that the problem is largely one of private land management, for, of the annual acreage cut over, Baker estimated 20,000 acres were private land, and only 400 acres national forest land.

Approximately 64 percent of the area of the ponderosa pine type in this region is in the valleys of the Boise and Payette rivers. Within these drainages over half the pine area and about 42 percent of the stand in 1922 were privately owned. Practically all of the ponderosa pine studies which have been reported were made within this area and observations of the present writer have also been largely confined to these drainages. Throughout the rest of the central Idaho region ponderosa pine stands occupy much more restricted areas and are less accessible. Consequently the type in these localities is principally of local importance and few detailed reproduction studies have been thought necessary.

In central Idaho the ponderosa pine, usually associated with varying amounts of Douglas fir, occupies the elevation zone below the lodgepole pine type.

Englemann spruce and alpine fir are found at the higher elevations and extend along streams and northern exposures well into the ponderosa pine zone. On the dryer southern exposures and gravelly flats ponderosa pine is found in pure stands extending to the upper edge of sagebrush or grass types. The natural course of succession on pure pine sites, as brought out by Weidman (51), is ponderosa pine followed by ponderosa pine. This leads in natural forests to an uneven-aged condition of the stands. Even-aged stands may result from such accidents as a clean burn or from logging where successful clear cutting or shelterwood reproduction methods are used.

## ADVANCE REPRODUCTION

Second-growth stands may be composed of advance reproduction, of trees which germinated after logging, or of both. Seedlings which germinate after logging or currently with it are usually called subsequent reproduction. The term will be used in this sense throughout the report.

Advance reproduction is almost invariably to be found in the virgin ponderosa pine forest. It is usually made up of two classes, both of which have been described by Munger (27) Weidman (51) and Sproat (44) in Oregon and observed continually in Idaho. The first class, which is the more conspicuous, consists of dense groups of seedlings, saplings, or poles growing in the openings of the forest which have resulted from the death of groups of mature or over-mature trees. This class of advance reproduction usually makes fairly good growth in virgin stands, and makes rapid growth immediately after logging if it is not destroyed by the skidding or slash burning. Sometimes, however, the groups stagnate in the sapling stage on account of too great density or root competition with surrounding large trees. In such cases the removal of the surrounding trees, instead of causing accelerated growth, results in still slower growth or even death of most of the saplings. The writer has observed many such groups still in very unthrifty condition from two to eight years after release by logging. The removal of the larger trees creates a new and more severe effective climate for the advance reproduction, which appears in such instances to offset the beneficial effects of the reduction in root competition.

The second class of advance reproduction is described by Weidman (51) as, "uniformly distributed and suppressed little seedlings struggling along directly under the overwood." They are small and inconspicuous and have often been unnoticed. Seedlings have been measured which, though they were as old as 40 years, were less than two feet tall. On the one permanent reproduction plot on Big Pine Creek (43) upon which a good survival of seedlings of the crops of 1912 and 1913 occurred, 55 percent of the 65 seedlings present grew less than three feet in height in the 17 years between the 1914 and 1931 measurements. Only six percent grew as much as five feet and 15 percent grew less than one foot in the 17 years. Writers differ as to the capacity of this class of reproduction to respond to release by logging. Sprost (44) says that a large percentage show slow growth and poor form and are not good material for future stands, and concludes from extensive studies of cut-over lands that a large percentage of the seedlings and saplings that escape injury or death from logging of the mature stand die from exposure. Weidman, on the other hand, after equally as extensive studies, but in another part of Oregon, states (51) that this class of seedlings has a great power of recovery which, after the overwood is cut, enables it to make a wonderfully dense and even stand of flourishing saplings. This is but one example of many such conclusions found in the literature on ponderosa pine studies which seem to be in conflict. One reason may be that the characteristics of ponderosa pine trees and sites vary markedly from locality to locality. Another is that the same race of trees on the same site subjected to the same treatment may react differently during different phases of the climatic cycle. This possibility is one that has been largely overlooked by writers on the subject. The recent observations in central Idaho tend to confirm Sproat's conclusions rather than those of Weidman, although numerous instances have been recorded of seedlings 10 to 15 years old and less than three inches high at time of logging which have recovered so that after eight years they cannot be distinguished from eight year old subsequent seedlings except upon close examination. Very likely the power of recovery diminishes with age although no evidence is available on this point.

## SUBSEQUENT REPRODUCTION

To the casual observer the fine stands of reproduction sometimes seen on cut-over areas appear to indicate that the seed trees have been successful in restocking the area. Close observation, however, will show, in nearly all instances, that this reproduction is the result of seedlings present before logging, many of them perhaps so small at that time as to be hidden in the grass. This advance reproduction under present methods of logging and grazing, however, is rarely sufficient in any locality to produce adequately stocked stands. Baker (3) based his recommendations for seed trees on the assumption that three fourths of the reproduction should be from advance or immediately subsequent seedlings.

The attempt to fill the blanks in the advance reproduction by seeding in from seed trees has not been very successful, at least within the range of the Pacific Coast form of the species. After studying results of national forest cuttings in northern California, Dunning (15) states that the establishment of reproduction after cutting is evidently a long, tedious process, requiring as high as 20 years or more on poorer sites to secure even a fair stand. Perry (37) states positively;"the germination of new seedlings after logging is problematical, and complete restocking at best is a long drawn out operation. That has been our experience on tens of thousands of acres where, theoretically, a sufficient number of seed trees had been left at time of cutting". Sproat (44) is in essential agreement. He concludes, after reproduction surveys on about 15,000 acres of cut-over land in southwestern Oregon, that about one percent of the total area cut over on the Crater National Forest has subsequent reproduction.

Weidmans studies of an earlier date (50) present a picture more favorable to subsequent reproduction. On areas which had been logged from six to 27 years before his examination, 67 per cent of reproduction was advance and 33 per cent was subsequent, mostly following within three years after cutting. None of the investigators working in Idaho differentiated clearly between advance and subsequent reproduction, but the Forest Service marking rules call for the leaving of seed trees, showing that subsequent reproduction has been considered necessary and that it has been hoped for whether or not the hope had adequate basis in fact. Baker (3) recommended that 25 per cent of the original stand be left for seed trees.

Show (41) recommends leaving four seed trees per acre in California, stating that this number will scatter seed everywhere, but fails to show whether this seed will germinate and produce seedlings. It has not been proved that a seed tree method which leaves as small a percentage of the original stand as 15 to 25 per cent can result in even the majority of cases in an appreciable amount of reproduction. It may be that in the end, as some writers have suggested (36,51) the securing by some means of full advance reproduction may prove to be the most practical way, or perhaps even the only way, of insuring adequate reproduction of stands. In the meantime every effort should be made to determine the possibilities of subsequent reproduction from seed trees.

## THE EFFECT OF CLIMATIC CYCLES ON REPRODUCTION STUDIES

It is more than a matter of chance that investigators of one decade have come to conclusions that are not in agreement with those of preceding or succeeding decades. It has been recognized since the beginning of investigation, that ponderosa pine is a species which reproduces itself abundantly only in those years that are marked by the coincidence of good seed years and favorable growing conditions for seedlings. In the southwest, according to Pearson (35) waves of reproduction have swept the region, at intervals estimated at from 20 to 40 years. In eastern Oregon, Weidman (53) records good reproduction years occurring in 1897 and 1912, and Baker (2) states that such years occur in central Idaho at intervals of about seven years. Clements, Weaver, and Hansen (13, p.201) and Weaver (49) show that invasion by tree seedlings into chaparral or prairie is hastened by the wet phases of the sunspot cycle and retarded, or even converted into a retreat, by the dry phases. Retreat has certainly been taking place during the recent series of dry years on many ponderosa pine cut-over areas near the lower limits of tree growth.

Meyer (26) has pointed out from studies of annual rings of ponderosa pine in Oregon and Washington that there are definite cycles of alternating good and poor growth. He names the period from 1904 to 1916 as a period of good growth. Weidman made his studies of ponderosa pine toward the end of and immediately following this period, as did also all of the investigators working in central Idaho. Five of the six years 1911 to 1916 were above normal in precipitation in central Idaho. It would be expected that studies of areas cut over during this period of good growth and high precipitation would result in optimistic conclusions. Weidman's studies prior to 1916 (50) showed good reproduction conditions in Oregon at that time, and Baker on the basis of studies in 1920 (3) states, "It is clear enough that reproduction is simple and easy throughout most of the western yellow pine type." Korstian (20), who investigated reproduction problems prior to 1922, thought that, adverse climatic conditions, while still important influential factors, did not so completely dominate the reproduction problem in central Idaho as they did in the Southwest. This was before the results of the 1919 seedling crop in the Southwest had become apparent.

Meyer characterizes the period from 1917 to 1930 as one of poor growth in Oregon and Washington. At the weather station, at Boise, Idaho, which has an unbroken record for 64 years, the annual precipitations for 11 of the 15 years from 1917 to 1931 inclusive were below the mean for the preceding 49 years. It is no wonder that Sproat and Perry came to the conclusions already quoted in connection with subsequent reproduction. They made their reproduction surveys during the latter half of this period of poor growth. Nor is it surprising that as little reproduction was found on the areas cut over since 1912 as is reported in the writer's report on subsequent reproduction. Notwithstanding Baker's estimate of a reproduction year once in seven there has been no coincidence of favorable conditions resulting in a crop of reproduction in central Idaho since the abundant crops of 1912 and 1913, unless 1933 should prove to be one (21,43). It is plain that studies must be carried through a complete weather cycle before conclusions can be drawn in regard to reproduction which will be of any great usefulness.

Conditions in the Southwest have been analagous, the difference being that the period prior to the wet years of 1918 and 1919 was the period of poor germination and survival of reproduction (30,36), and that since the epochal seedling crop of 1919, forestry has been "looking up in the Southwest" (35).

## THE PRINCIPAL FACTORS INFLUENCING REPRODUCTION

The occurrence and extension or maintenance of a natural timber type is limited by the ability of the species to reproduce themselves under the conditions of the environment. Reproduction, whether advance or subsequent, is the result of a complex combination of factors included under the headings climate, soil, physiography, and the biotic factors. In the semi-arid mountain regions of western United States the climatic factors, particularly temperature and precipitation, determine the general distribution of ponderosa pine and of other species, and soil texture and exposure its local occurrence.

### General Discussion of Factors.

The factors primarily responsible for the location of the limits of reproduction under natural conditions are discussed in detail and from many angles by Pearson (34), Bates (7, 8), Larsen (23) and Baker and Korstian (6). It is agreed that the upper altitudinal limits of ponderosa pine are the result of low temperatures, probably low soil temperatures, but Bates and Pearson disagree (34p.115-119) as to whether low soil moisture or high temperature is the cause of the lower altitudinal limits of reproduction. By laboratory tests Marshall (25) and Pearson (31) have demonstrated the ability of ponderosa pine seedlings to survive in very dry soil, and Bates and Roeser (10) and Baker (5), have shown their comparatively high resistence to high surface soil temperatures. Roeser (38) has summed up the relationships between transpiration of seedlings and heat injury. Rather extensive observations in central Idaho indicate that here, as in the Southwest (29), in Utah (6 p.79), and probably in the other regions, soil moisture is the critical factor for reproduction. Whether its action is direct or through its effect on surface temperatures is not of great importance.

Soil moisture is affected by a multitude of factors, the most evident of which is precipitation. To quote from Baker and Korstian (6 p.17), "The facts---- strongly suggest that the distribution of western yellow pine in the inter-mountain region is determined chiefly by seasonal precipitation". The absence of ponderosa pine east of the Sawtooth Mountains in central Idaho is accounted for by the fact that the average rainfall in May in that region is less than two inches. Farther east in Idaho and in western Wyoming, May rainfall is sufficient for germination and the beginning of growth, but the low precipitation in June prevents seedling establishment.

The absence of a species cannot, however be accounted for entirely by the fact that average precipitations are too low for establishment, because invariably the precipitation for some years or periods of years will be sufficient for seedling survival. The work of Russell (39) indicates that the frequency of occurrence of "dry" and "desert" years determines some if not all vegetation associations in dry climates. From his map it appears that ponderosa pine may be found naturally where an occasional desert year occurs, providing that at least 50 per cent of the years come under his classification of "humid" years. This line of research is closely allied to the study of climatic cycles which has already been referred to.

Next to soil moisture, light is probably the factor of most importance in reproduction in forests. There are differences of opinion among investigators as to the part played by light in the establishment and growth of trees, although much of the apparent disagreement is due to the use of the word "light" in more than one sense. The conclusions reached by Toumey and Kienholz (46) in their work with trenched plots under conifer-hardwood stands of eastern United States apparently do not apply exactly to tree species of dry climates. The question is discussed in detail by Pearson (34 p.89-91), who shows that in the upper part of the ponderosa pine range in the Southwest, reproduction is often prevented or retarded to the north of clumps of trees by insufficient light or insolation, a deficiency which results in soil temperatures too low for this species, and not primarily by root competition for moisture.

In the Northwestern Region, Brewster and Larsen (12) show that ponderosa pine seedlings in nursery seedbeds develop best with no shade. This, however, may be a result of heat rather than of light in the more limited sense of the word. Many investigators have studied the light requirements of ponderosa pine in the laboratory (11,35); the general conclusion appears to be that, when moisture and temperature conditions are favorable, ponderosa pine seedlings, while they require more light than do most other species, will grow and develop under light intensities much lower than those usually prevailing in the forest. Bates and Roeser (11) found that one year old seedlings of ponderosa pine grew at an increased rate only at light intensities up to 11 or 12 per cent of full light. Some growth took place at light intensities of 1.8 per cent. Shirley (40) states that 10 to 15 per cent of full light is enough for growth of seedlings of most species. In central Idaho preliminary observations indicate that nowhere in natural mature stands on southerly exposures is light a limiting factor in reproduction. Seedlings are found even in dense shade under ceanothus brush and it is a common occurrence to find groups of young seedlings on the northeasterly sides of large trees where they receive shade during the hottest part of the day.

Among the soil factors which are not directly dependent upon climate, soil texture is most likely to be a limiting factor in ponderosa pine reproduction (6,18a,34). Haasis (17) states that clayey and cindery soils represent about the two limits for ponderosa pine in the Southwest, and Baker and Korstian (6) conclude that the generally calcareous, heavy, fine-grained soils of the brush lands of Utah and southern Idaho are prevailingly unsuited for western yellow pine, even where the precipitation and its distribution are suitable. Howell (18) has shown by soil tests that ponderosa pine in California will not grow on areas where clay pans cause an excess of moisture in the upper layers of soil.

The most obvious physiographic factor and one which requires no elaboration, is the change of vegetation universally observed in going from northern to southern exposures. The influence of other physiographic factors, such as altitude, degree of slope, and lay-of-the-land, are also so apparent as to require no discussion here.

Grazing and timber cutting are the biotic factors of greatest importance to the forester because they are the ones which are directly under his control. It is through wise use and regulation of grazing, logging, and fire that reproduction is to be secured, whether before or after logging.

Factors Affecting Germination.

The most important factors affecting germination, as distinguished from survival, are seed supply and litter. Logging greatly reduces the seed supply, but, as is brought out by Perry (37), leaves the number of seed-destroying rodents and birds (45) the same. As a result, there may be no seeds available for germination. The good stands of subsequent reproduction occasionally found are probably the result of logging during the one month in three to eight years when a good seed crop is being disseminated. That seed supply is deficient on cut-over areas of central Idaho, even on National Forests, is shown by the fact that practically no seedlings of current germination were found on the timber sale areas studied in 1932. A fair seed crop was produced in 1930 and 1931, as shown by cone counts under the seed trees, and the spring and summer of 1932 were very favorable to early survival. Under these conditions, if seed had been available, a few seedlings, at least in the more favorable situations, would have germinated and survived until the examination was made in July. Up until the present time, the seed trees on the recently logged sale areas examined have been, as seed-producers, a practically non-productive investment.

Litter is commonly supposed to discourage pongerosa pine reproduction by keeping the seed from reaching a soil layer suitable to germination. A mineral seed-bed is considered to be the most favorable to ponderosa pine, as reported, for example by Baker (2) in central Idaho and Larsen (22) in northern Idaho. It is a matter of common observation that seedlings do come in more readily on old grades, skid roads, and even on raw gravel upturned in placer mining operations (2). Sprost (44) concludes from his studies that soil disturbance is not always an aid to permanent establishment of seedlings, but may cause an increase in germination under favorable conditions, and concurs with Perry (37) that amount of reproduction depends more on amount of cover and seed than upon disturbance of the soil.

The writer's observations on the Clear Creek area do not exactly corroborate these latter statements, but are not conclusive as evidence on either side. On another area, a virgin stand on Bannock Creek, the seedlings of current germination were most abundant on the litter covered quadrats. The average litter depth of the stocked quadrats was one inch. There is some indication that the preference of ponderosa pine for mineral seed-beds may really be a preference for areas without root competition, since litter and root competition usually occur together (2). The effect, then, would be on survival of seedlings rather than on germination.

Litter may, on the other hand, favor <u>survival</u> of seedlings by preventing excessive evaporation of moisture or by protecting them from the results of extremes of surface soil temperatures and from frost-heaving (24).

Grazing has been mentioned by Sparhawk (42) as favorable to seedling germination, but none of the writer's observations are evidence on either side of the question. Three out of eight cut-over areas examined and one of two virgin stands had been moderately to heavily grazed, but there was no apparent relation between grazing and the amount of reproduction.

## Factors Affecting Survival and Height Growth.

By far the largest percentage of seedlings which germinate do not survive their first year (2, 43). Undoubtedly the limiting factor in first-year survival throughout most of the ponderosa pine type is soil moisture. Drought is usually given as the most common cause of death. When a seedling is recorded as dead from drought, the cause in some cases is probably heat injury, but usually it is a matter of inability to extract sufficient moisture from the soil in competition with other trees and lesser vegetation. Any condition, therefore, such as weather, exposure of slope, logging, fire, or grazing which affects the over-story of trees or the ground cover of lesser vegetation affects the associated seedlings. These effects are both beneficial and detrimental.

Here is the most baffling aspect of the reproduction problem in central Idaho; when and where do the benefits of protection over balance the effect of the competition which accompanies it. The protection afforded by trees and shrubs is usually necessary to seedling survival on southerly exposures, and yet, too much shade or root competition may be fatal. The solution will be found in methods of regulating, as to species and density, the overstory of trees and the lesser vegetation, with the objective of producing conditions under which a tree understory can become established and make satisfactory growth both as to quantity and quality.

Too little attention has been paid to the lesser vegetation in studies of ponderosa pine reproduction in the Northwest. Pearson's studies (30) analyze the situation in the Southwest, but the only work directly applicable to conditions in Idaho is that of Weaver (49) in southeastern Washington and Wahlenberg (48) in western Montana. Morever, the large amount of work which has been done in the attempt to correlate degree of cutting with amount of reproduction has not been very successful. Baker's studies (2) led to the conclusion that there is no correlation between the percentage cut and the amount of reproduction, and the surveys of Dunning (15) and Sprost (44) failed to bring out definite relationships. The percentage of the stand that should be left probably varies so much from stand to stand, and even more from one year of a climatic cycle to another as to make it impossible to set down blanket rules for timber marking. The same statement may also hold for methods of handling grazing, fire, and slash disposal, with the intention of regulating species and density of lesser vegetation.

It has already been shown that seedlings do become established and survive for many years under an overstory of trees. Apparently tree roots as competitors of the new seedlings are not as relentless as those of the herbaceous vegetation, or else trees compensate more abundantly by the greater protection offered. It has also been shown that removal of a large percentage of the overstory often results in decided slowing up or cessation of seedling establishment. The question naturally arises as to what role the shrubs and herbaceous vegetation play in this survival of reproduction.

The effect of shrubs must be similar in kind, though different in degree, to that of the larger trees; but the evidence is strong, as presented by Wahlenberg (48) in western Montana, that, brush cannot permanently suppress tree growth. This appears to be the greatest difference between trees and large shrubs in their effect on tree seedlings. Measurements of height growth of seedlings on the Clear Creek area failed to show any suppressive effects of lesser vegetation, although seedlings were less abundant where the vegetation was most dense. There were only seven seedlings overtopped by lesser vegetation, mainly ceanothus brush, but it is worthy of mention that their average height growth was nearly as great as that of the 61 wholly dominant seedlings and 16 per cent greater than the average height growth of the 14 that were overtopped by trees. Weaver (49) states, after extensive studies in southeastern Washington and adjacent Idaho, that ponderosa pine seedlings grow vigorously among the after-logging vegetation of _Opulaster pauciflorus, Spirea_ sp., and herbaceous vegetation. He states, however (p. 79) that the chaparral is often so dense as to prevent the establishment of the pines. This happened when the light under the shrubs falls to an intensity of 0.15. There are always spaces between clumps of shrubs, however, so it does not appear that the encroachment of species like ceanothus is greatly to be feared. Wahlenberg's instrumental records revealed that during dry summer weather under ceanothus brush atmospheric evaporation was less, relative humidity greater, soil temperature lower, and soil moisture greater in amount than in adajacent open areas. On Clear Creek the characteristic species under ceanothus brush were arnica, (_Arnica_ sp.), fireweed, (_Chamaenerion augustifolium_ L.), _Vagnera amplexicaulis_, Nutt., aster (_Aster spp._), and geranium, (*Geranium Viscosissimum* Fisch & Mey.), species which indicate relatively better soil moisture conditions, near the surface at least, under this type of shrub. On the Granite Creek timber sale area, two years after logging, the open areas which had not been touched by fire during the slash burning had been taken over by downy brome or cheat grass (*Bromus tectorum* L.), a type in which the writer has never observed a young seedling growing.

The herbaceous species, in general, and also low shrubs like spirea, do not appear to be so favorable to reproduction. All the evidence resulting from the present study of cut-over areas points to the conclusion that the herbaceous growth is more of a detriment to seedling survival than a benefit. The effects of vegetation are difficult to measure and data of this study are not yet either sufficient nor well enough controlled to warrant specific conclusions. If however the herbaceous vegetation is an important cause of the failure to get subsequent reproduction on the Clear Creek area, it would appear that the policy of eliminating grazing, which was carried out for the first three years after cutting, was not necessary, and perhaps was a detriment to reproduction by allowing the lesser vegetation to spread unchecked (36). Sparhawk (42) recommends that clear-cut areas, or plantations with seedlings up to 5 to 10 years old, depending on the site, should be grazed very lightly, and that under certain conditions, rarely met with, it may be good policy to eliminate grazing entirely for at least three years following the seed year. But, since on the Clear Creek area there is no evidence that there ever was a good catch of small seedlings to protect, and since restricted grazing was not necessary from the standpoint of erosion, it is difficult to see, now, that anything has been gained by especial restrictions on grazing. In this connection it is possible that the change in soil texture and plant species which the United States Forest Service has found (55) to have taken place on many parts of the Boise River watershed as a result of over grazing, may be acting to make establishment of reproduction more difficult recently than in former years.

## SUMMARY AND CONCLUSION

There have been and will continue to be large areas of the ponderosa pine type cut over annually in central Idaho. The problem of how these areas can be successfully restocked by natural means has not yet been solved. A few investigators have made studies of natural reproduction in central Idaho and their work and the work of investigators in other regions has been reviewed. In Idaho the usefulness of the work has been limited to some extent by the failure of several workers to distinguish carefully between advance and subsequent reproduction. Furthermore, the conclusions reached by these investigators, as well as those in other parts of the range of ponderosa pine, have apparently been influenced by the phase of the climatic cycle during which the studies happened to be made.

There are three broad statements that appear, after a review of the literature on ponderosa pine reproduction and several months of observation, to sum up what is known about the reproduction question in central Idaho:

1. Advance reproduction is almost universally present in virgin stands but it is rarely sufficient under present methods of logging and grazing for adequate restocking after cutting, even if it all should survive the logging and slash disposal operations and the more adverse effective climate caused by the removal of the overwood.
2. It has not been proven that subsequent reproduction from seed trees can reasonably be expected on even a majority of cut-over areas if no more than 25 per cent of the original merchantable stand is left after logging.
3. Soil moisture, either directly or through its effect on surface temperatures, is the critical factor in establishment and growth of reproduction

on southerly exposures in central Idaho, light and heat not excepted.

The problem, then, of reproducing stands after logging is primarily whether it is more feasible and economical; 1. to secure reproduction before removal of the major part of the stand by encouraging in some way seedling establishment under virgin stands, or by a true selection or shelterwood method of cutting, or, 2. to depend definitely and to an appreciable extent upon reproduction from seed trees or seeding from the side after logging operations which amount to clear cuttings. Cutting policies that leave a heavy investment in seed trees which do not aid materially in restocking the stands are wasteful. Basically, the reproduction problem is one of determining how stands can be successfully reproduced under varying conditions of soil and climate at the least total cost, including any extra logging, slash disposal, grazing, fire-protection, or other costs necessary. If, when these necessary costs are added to logging and milling costs, there should result a negative stumpage value for the timber, the owner must choose whether to leave the timber standing, to cut at a financial loss, or to abandon plans for continuous timber production. In other instances it is conceivable that a modification of methods of handling logging and other uses of the land would result in successful reproduction at no extra cost or even at a saving; for example, if grazing could be used to prepare the site for reproduction.

In order to develop methods for reproducing stands the relationships between the overwood and reproduction, and between the lesser vegetation and reproduction, must be well understood. The former has been studied rather extensively and it is now apparent that it is not enough merely to set up a percentage of the stand that shall be left as a source of seed and shelter. Attention must also be paid to the lesser vegetation and methods devised for reducing competition between it and the reproduction, and making more use of its protective effects. Practically no work has been done in the Northwest on the relationships between ponderosa pine and its associated lesser vegetation. These relationships are complex and the plants themselves are more difficult to measure than is tree growth. Nevertheless, before the reproduction of ponderosa pine stands can be made reasonably certain and economical a great deal more must be known about; 1. the effect of lesser vegetation--its composition, density, and various methods of treating it--upon tree reproduction, and 2. the effect of the overwood and its treatment upon the vegetation. There two factors of the problem seem to be the ones upon which considerable study is warranted. It is recognized, of course, that regulation of grazing, fire, slash, and skidding are means of greatly modifying the lesser vegetation but it is not known at the present time what modifications are to the advantage of reproduction. When the relationships between tree growth and the lesser vegetation are as well understood, even, as those between the ponderosa pine overwood and the reproduction, and if natural advance reproduction and the periodic fluctuations of climate are given due consideration, it should be possible to devise means to reproduce ponderosa pine stands after logging with a considerably greater degree of success and economy than it has been possible to do in the past.

# II

## SUBSEQUENT REPRODUCTION

on

## SOME PONDEROSA PINE CUT-OVER AREAS

# SUBSEQUENT REPRODUCTION ON SOME CUT-OVER AREAS[1]

The extent to which reproduction has become established on ponderosa pine cut-over areas, and the factors influencing its establishment, are matters of considerable importance to persons interested in timberland management in central Idaho. Stands may be reproduced naturally by advance reproduction, by subsequent reproduction, or by a combination of the two. The report here presented is concerned only with subsequent reproduction. Under this term are included both seedlings germinating after logging and those originating during the year of logging.

The data upon which the report is based were collected on three timber sale areas on the Boise and Payette National Forests, several private cuttings, and two tracts of virgin timber, all in Boise Basin or on the South Fork of the Payette River in Idaho. Work was confined wholly to the southerly exposures because it is there that the reproduction problem seems to be more acute, and because these exposures usually support the valuable species, ponderosa pine, in pure stands.

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[1] The field work of this study was done while the writer was under appointment as instructor in forestry at the University of Idaho and employed as collaborator by the Intermountain Forest and Range Experiment Station, United States Forest Service.

Then, too, it was desired not to complicate the problem by carrying the study into the mixtures of pine with douglas fir and other species which are found on the northern exposures and stream bottoms. The two exposures really support two distinct forest types and cannot be discussed as one except at the risk of speaking inaccurately of both.

The study of subsequent reproduction was carried on as a part of a larger project upon which the writer was working during parts of July and August, 1931 and 1932. A search was made for subsequent reproduction on all of the cut-over areas examined, and studies of recent reproduction made in the uncut stands. Verification of the ages of seedlings was by ring counts at the ground line. On six of the areas examined temporary transects were laid out. Each transect was composed of from 32 to 94 temporary sample quadrats, each one square meter in area. Every odd quadrat was described as to; 1. location with reference to trees, stumps, and dead snags, 2. lesser vegetation by species, height, and density, and 3. reproduction by age in relation to logging, height, dominance, and height growth for the preceeding five years. The transects were so selected that exposure, density of original stand, and abundance of seed trees would be fairly constant or their effects determinable.

All this was part of the larger general study, and particular attention was not paid to subsequent reproduction until its extreme scarcity became apparent. It was then decided to make an intensive study of subsequent reproduction on one timber sale area. The Clear Creek area near Pioneerville, Idaho was selected because it was thought to represent about average conditions on Forest Service sale areas, and because of its accessibility. The purpose of this detailed study was, first, to determine how much subsequent reproduction had become established since logging, and, second, to ascertain by the location, time of germination, and thriftiness of the seedlings something about the relative importance of the several factors influencing germination and survival. Examinations made on the other cut-over areas and uncut stands were to serve as a check on the Clear Creek study, and to help explain the conditions found to obtain there. It was hoped that some conclusions of practical and immediate value might be drawn from the results of the studies, particularly as to methods of logging, slash disposal, and grazing most favorable to reproduction in this type. It is not claimed that the results are applicable to localities other than those studied, although general conditions throughout the ponderosa pine type in central Idaho are similar.

The methods and results of the Clear Creek study are presented first, and a comparison of subsequent reproduction on other areas follows.

## THE CLEAR CREEK STUDY

The Clear Creek Timber Sale area is located north east of Pioneerville, Idaho, on the Boise National Forest. The total area cut over was about 35,000 acres, but on by far the largest part some douglas fir, alpine fir, lodgepole pine, or Engelmann spruce was associated with the pine. An average of about 11,700 board feet per acre was removed by the Boise-Payette Lumber Company under Forest Service contract in 1924, 1925, and the early part of 1926. Approximately 15 per cent of the merchantable volume was left as a residual stand. The cut was 74 per cent ponderosa pine. With the purpose of favoring reproduction, grazing was kept out of the sale area for three years after logging. Since 1928 moderate grazing by sheep has been allowed.

The elevation of the area is from 4700 to 7000 feet, but the stands of pure ponderosa pine were at the lower elevations. Precipitation at the 5000-foot elevation in this locality averages about 27 inches annually[1], 85 per cent coming narmally between October1

[1] Grimes Pass, Sheep Hill, and Boulder Mine stations.

and May 30, the area has the uniform granitic soils, steep topography, and dry climate characteristic of all of the central Idaho ponderosa pine type.

__Methods Used in the Clear Creek Study.__

The part of the sale area containing the largest percentage of pure ponderosa pine type is a strip about a mile long and twenty chanins wide to the north of the main creek, in Section 31, Twp. 8 N., R. 6 E., Boise Meridian. It carried an original stand that was a little heavier than average for the area. As stated in the introduction, studies were restricted to the southerly exposures. As determined by a survey the south-southeast, south-southwest, and west-southwest exposures made up 67.5 per cent of the total area of this strip. Two or three weeks of work on other problems on this tract gave opportunity for inspection of a large part of this area of approximately one-hundred acres of southerly "faces". The procedure followed in the study of subsequent reproduction was as follows:

1. In the course of the other work, and at other available times, a sharp watch was kept for subsequent seedlings, and searches made into places where they might not be readily noticeable. Whenever a seedling was discovered that could possibly have germinated since logging, it was necessary to determine its exact age by whorl and ring counts and to ascertain the date

at which the surrounding area was logged. Date of logging could usually be determined by a study of logging scars on residual trees. The scarcity of small seedlings of any age made this work of checking up a relatively simple job.

2. Whenever a seedling was found which had germinated since logging, it, and the square meter quadrat surrounding it, were described in the same way as the reproduction and quadrats on the transects described in the introduction. In addition, the seedlings were classified into situation, fire, and soil classes according to their relation to stumps, logs, litter, rocks, skid trails, and other surface features. precaution was taken against describing the same seedling twice, either by cutting it off in the age determination proceds, or by marking it in some characteristic way.

As a check on this method of random search, and to give quantitative data as to area covered by each situation, fire, and soil class, strips were run across the area at a 10-chain interval taking two 0.01-acre plots every two and one-half chains.[1] The 0.01-acre plots were examined closely for seedlings and the shade, exposure, and percentage of the area occupied by the

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[1] This spacing of plots was used so that the work could be carried on in connection with a residual stand and second-growth survey of the same area. Most of the strip cruise was done in the writer's absence by a regular Experiment Station field crew. The writer is indebted to the other members of the crew for going on with the collection of the subsequent reproduction data after he left the field.

several situation, fire, and soil classes were noted. The quarter-acre residual stand plots that were taken at the same time were also examined for subsequent reproduction and their ages noted. Only the plots on the southerly exposures were used in the tabulations.

## Results

Only one-hundred and fifteen subsequent seedlings were found in the random search, and seven on the eighty-one southerly 0.01-acre plots of the strip survey. This latter figure represents approximately 0.8 seedlings per acre and the former something over one per acre. The larger number found by the random search is due either to the error in sampling so scarce a commodity by the survey method or to the fact that the seedlings tended to be found within certain rather localized areas which may not have been adequately sampled by the strip survey. It tends to show that the random search discovered most of the seedlings, altho the value of the results of the study does not depend upon including all of the seedlings on the area, but only upon whether or not a reliable sample was secured. At first thought, 112 seedlings seems to be too small a number from which to draw definite conclusions, but, when one considers that it represents a very large percentage, if not all, of such seedlings on about one-hundred acres, and if it is assumed that they make up a representative sample, some rather definite conclusions may be drawn from a study of the locations and height growth rates of even this number of specimens. There is little doubt but that the 112 seedlings are a representative sample.

From the standpoint of evaluating the influencing factors, the scarcity of subsequent reproduction, unless their locations be attributed entirely to chance, adds to the usefulness of their study, for the factors responsible for their scarcity, by accentuating the differences in the favorableness of various immediate surroundings, have made the differences in the abundance and height growth of reproduction more apparent than they would otherwise have been. In favorable years, reproduction may take place on all types of sites and situations, but in the periods of adverse weather conditions, that reproduction which germinates and manages to survive must clearly show by its location and thriftiness where growth conditions are most suited to it. Then, by studying the situations thus shown to be favorable, as was the method of this study, it should be possible to arrive at a more complete knowledge of the requirements of ponderosa pine seedlings.

<u>Year of Germination</u>; Table I shows how the reproduction has taken place year by year since logging, and also the germination by calendar years. If logging had been done all in one year the figures for the two tabulations would

have been the same. From this table it is seen that practically all of the seedlings that were found on the area germinated the first three years after logging. There would be a tendency for the figures shown for the later years to be slightly lower than the actual relative numbers, since, the younger seedlings might not be as readily seen as those which were older.

Table I---Distribution of Seedlings by age and by year of germination in relation to year of logging.

| | Years | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Less than 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | total |
| | Number of seedlings | | | | | | | | |
| By ages | 3 | 1 | 0 | 6 | 3 | 8 | 38 | 56 | 115 |
| By number of years elapsing between logging and germination. | 44 | 35 | 20 | 6 | 5 | 1 | 1 | 3 | 115 |

The abrupt change from the numbers in the earlier years to those in the later ones however, indicates that this factor does not enter to any great extent. The differences in the relative favorableness of the earlier compared with the later years become even more apparent when it is remembered that the younger seedlings, especially the three of 1932 germination have relatively slight chances of ultimate survival (21).

The decrease in current germination with increase in time after logging has been noted by Baker (3) and Weidman (50). It may be ascribed most logically, perhaps, to increased root competition due to encroachment of the lesser vegetation, altho there are not enough data to support adequately any contention of this kind.

There is no correlation between year of germination as shown in Table I and the precipitation records of the United States Weather Bureau, unless part of the 1925 crop can be ascribed to the above-normal precipitation of that year.

Relation of Seedlings to Trees and Stumps: The trees left after logging may have both beneficial and harmful effects on subsequent reproduction. Their seed, except for those seedlings which come from seed of the trees cut in logging, is essential in the first place. On the Clear Creek Timber Sale area seed trees are spaced so that what seed is produced should be distributed fairly evenly over the area, the large patches of dense young growth excepted. But the seed trees are small,---few over twenty inches---, cone crops have been light and an unknown toll has been taken by squirrels and other seed destroyers. There was no apparent tendency for seedlings to be grouped about the seed trees.

Table II shows the occurrence and relative height growth of the seedlings according to zones around trees and stumps over ten inches in diameter. Seven zones were recognized, as follows:

<u>Tree Zone 1.</u> Within one meter (3.3 feet) of the bole of a tree.

<u>Tree Zone 2.</u> Definitely within the root influence of a tree.

<u>Tree Zone 3.</u> On the edge of the root zone and areas doubtful as to tree root influence.

<u>Stump Zone 1</u>, Zone 2, and Zone 3, were exactly corresponding to the tree zones.

<u>Zone 4.</u> Definitely beyond the root zone of any tree or stump over ten inches in diameter.

The division of the area between tree influence, stump influence, and Zone 4, as shown in Column D of Table II, was obtained by estimates on the eighty-one 0.01-acre plots of the strip cruise. Division of area between Zone 1, 2, and 3 in the Column C was computed from the known average diameters of trees and stumps on the area, and the measured widths and radii of each zone around representative trees and stumps of these diameters. Figure 1 shows relative areas of the six zones diagrammatically and the number of seedlings per unit of area by figures.

Table 2.- Occurrence and height growth of subsequent reproduction in relation to trees and stumps.

| Zone[1] | Ave. Width of Zone | Area per Tree or Stump | Ratio of Zone Area to Total Tr. or Stump Area[1] | Ratio of Zone Areas to Total Area of Tract[1] | Number of Seedlings in each Zone | No. per Unit of Area[2] | Ave. Height Growth Quotient[3] |
|---|---|---|---|---|---|---|---|
| | Col. A | B | C | D | E | F | G |
| | Feet | Sq.Ft. | % | % | | | |
| Trees | 18.4 | 1141 | 100.0 | 14.10 | 18 | 1.27 | 0.78 |
| Z. 1 | 3.3 | 48 | 4.2 | 0.60 | 1 | 1.7 | 1.17 |
| Z. 2 | 6.6 | 304 | 26.6 | 3.75 | 3 | 0.8 | 0.64 |
| Z. 3 | 8.5 | 789 | 69.2 | 9.75 | 14 | 1.4 | 0.79 |
| Stumps | 26.4 | 2487 | 100.0 | 25.50 | 89 | 3.4 | 0.80 |
| Z. 1 | 3.3 | 58 | 2.3 | 0.59 | 27 | 45.7 | 0.80 |
| Z. 2 | 13.3 | 901 | 36.2 | 9.23 | 48 | 5.2 | 0.79 |
| Z. 3 | 9.9 | 1528 | 61.5 | 15.68 | 14 | 0.9 | 0.89 |
| Zone 4 | - | - | - | 60.40 | 16[4] | 0.27 | 0.87 |
| Totals and Weighted Averages | | | | 100.0 | 123 | 1.23 | 0.82 |
| Used Twice | | | | - | 12 | - | - |
| Net Totals and Averages | | | | 100.0 | 111 | 1.11 | - |

[1]See text for description of zones and basis of figures.

[2]Size of unit is one per cent of the total area of the tract studied, the exact size of which is unknown. The area of one unit is, however, approximately one acre. The values in this Column F were determined by dividing the number of seedlings by the percentage figures in Column D.

[3]Height growth quotients were determined for each seedling by dividing its average annual height for the last five years (or since germination for 0-to 5-year olds) by a corresponding figure representing the average of a large number of seedlings <u>of equal height</u> measured by Weidman (50). A large height growth quotient indicates relatively good height growth. It is planned to discuss the construction of this standard in a report on advance reproduction.

[4]Twelve of these seedlings were within the influence of trees between three and ten inches in diameter.

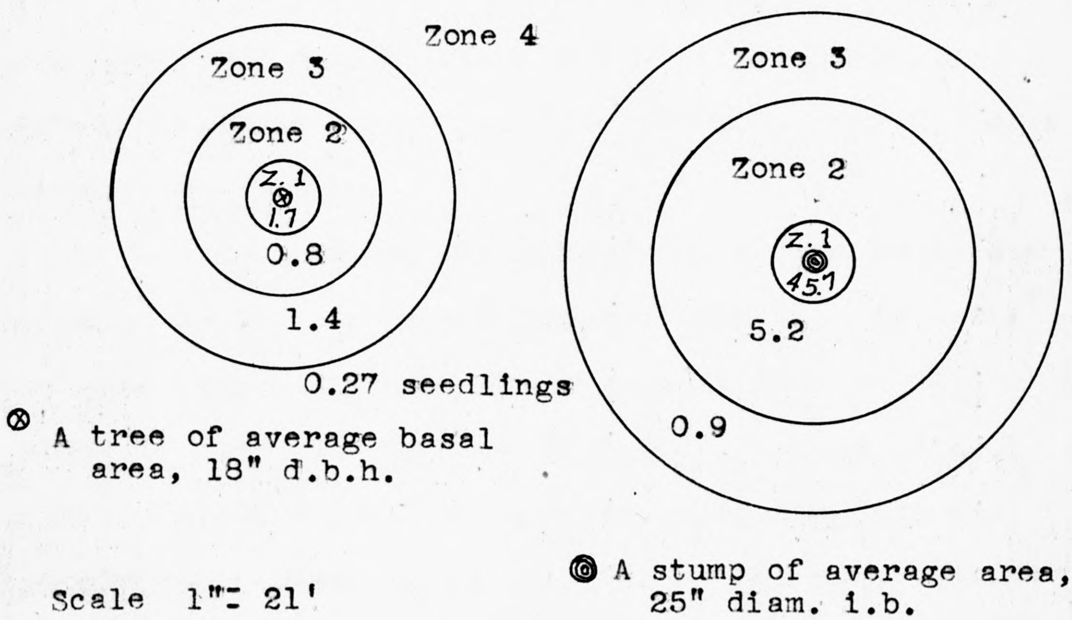


**Figure 1. Relative areas of Tree and Stump Zones around average sized trees and stumps and the average numbers of seedlings per unit of area on each of these zones and in Zone 4.**

The greater abundance of seedlings in Stump Zone 1, as shown in Column F of the table, is striking, ---27 times as many per unit of area in this zone as in the corresponding zone around trees. There were 360 times as many per unit of area near stumps as in Zone 4, the areas that were openings before logging. The frequency of the occurrence of vigorous young seedlings about stumps has been noted in general terms before (36,50).

The poorest stocking found around trees and stumps was in Tree Zone 2 where competition for soil moisture may be assumed to be greater than on any other of these six zones. In Tree and Stump Zones 3 and in Zone 4 conditions are very variable, but the presence of denser lesser vegetation and more advance reproduction may account for the extreme scarcity of subsequent reproduction.

A study of the height growth of reproduction in the several zones, as given in Column G of Table II does not show any very significant differences, except that the few seedlings in Tree Zone 2 were growing at a rate considerably below the average for their sizes and ages. The greater height growth of seedlings growing beside stumps is discussed under "Situation Class".

Lesser Vegetation: The importance of the lesser vegetation and its interrelations with other factors is discussed in the preceding report. Only its apparent effects as shown by the Clear Creek data will be given here.

The density, height and species of the vegetation were taken into account. Density was estimated by the grazing reconnaissance method. There was some tendency for the subsequent reproduction to occur on the areas of lower vegetation density, but some were found growing under ceanothus brush (*Ceanothus velutinus*) at densities of up to 60 per cent. According to estimates made on 242 square-meter quadrats on nine transects taken in connection with another study on the same general area, 39.5 per cent of the area bears lesser vegetation densities of less than 15 per cent. But 77.5 per cent of the subsequent seedlings were found on these low-density areas. Only 3.9 per cent of the seedlings were found growing in densities of 50 per cent or over, whereas at least 15.7 per cent of the total area was of densities above this. Furthermore, the seedlings undoubtedly started under conditions of lower plant density than they are growing in to-day because of the progressive increase in vegetation, especially the brush species, that takes place on cut-over areas after logging. It should be mentioned in this connection that, since seedlings are undoubtedly easier to see where vegetation is less dense, there is a possibility that this apparent difference in favor of the lesser vegetation densities may be due to faults in observation. No pains were spared though, to look under brush clumps and in other areas of high density, and it does not seem likely that any considerable part of the difference is due to this cause.

Absolutely no correlation was found between height growth of reproduction and vegetation. Nor was there any relation determined between reproduction occurrence and vegetation height. There was little or no connection between subsequent reproduction and species of vegetation, either. There was some tendency for two of the more rare and water loving species, willow (*Salix spp.*) and bracken (*Pteridium aquilinum pubescens*), to occur in association with the seedlings, but no conclusions can be drawn from such slight indications. In general the species recorded as occurring most frequently where seedlings were found were the same species that were most common on the southerly exposures of the area. These are, roughly in the order of percentage of total density, *Spiraea corymbosa*, dogbane (*Apocynum ambigens*), ceanothus brush, various annuals such as *Gayophytum ramosissimum*, *Collinsia tenella*, *Polygonum douglassii*, and fireweed (*Chamaenerion angustifolium*), and the miscellaneous species Oregon grape (*Odostemon repens*), *Arnica cordifolia*, *Pentstemon spp.*, *Geranium viscosissimum*, *Agropyron spp.*, *Calamagrostis spp.*, and elk sedge (*Carex sp.*).

*Shade:* Shade as a factor influencing seedlings has been implied in the two preceding sections, but shade is related only remotely to distance from trees. The shade cast by a ponderosa pine seed tree falls mainly to the west, north, and east of the tree and very little underneath it. It was for this reason that estimates of shade were made independently, in terms of the number of tenths of the clear summer day during which the spot in question would be shut off from direct sunshine. Under this method of estimating shade it was found that subsequent seedlings were shaded by trees from 0 to 0.5 with an average of 0.13. This average is almost exactly the same as the average shade for the whole of the area as determined by the strip survey. If there is any distribution of reproduction in response to shade, either positively or negatively, it is largely obscured by other factors. On the south-southwest exposure there was some tendency for seedlings to occur in slightly more shaded locations, the average shade under which they were growing being 0.14 as against less than 0.11 for the average of the strip survey plots on this exposure. The three 1932 seedlings that were found were growing on the shady sides of trees or stumps.

It is believed that no amount of shading under 0.6 would, in itself, affect young seedlings detrimentally. Seedlings were found growing under dense clumps of ceanothus brush where the total shade was as high as 0.8. They were making normal height growth but tended to be somewhat spindling in form.

Attempt to correlate height growth with amount of shade showed no consistent relation. Baker states in his summary (2) that height growth of seedlings "has been found to be fairly uniform over large areas and many sites, the degree of shading being the chief influencing factor", but if the term shading is here used in its literal sense, his statement is entirely at variance with the writer's observations. Studies extending over many years (43) show that height growth varies widely within a single locality on different exposures and sites. The suppressive effects of tree shade on seedlings seem to be largely, if not entirely, obscured by the protective effects and by the root competition that invariably accompanies them.

<u>Exposure and Degree of Slope</u>: Since the study was confined to one special class of exposures, few differences due to exposure could be expected from it. It has been adequately shown (14,16,49) that northern and southern exposures have widely different effective climates. Alter (1) states that a 5° slope to the south

in southern Idaho is in the same solar climate as is a level field 350 miles nearer the equator. If the compass circle is divided into eight divisions, as has been done for this study, the south-southwest exposure is the one which has the hottest and driest climate in the northern hemisphere. Higher surface temperature, higher rate of evaporation, probably lower soil moisture (14), and, in the case of the Clear Creek area, greater exposure to drying winds combine to make it a difficult location for survival of seedlings. Notwithstanding these conditions, the frequency of subsequent seedlings on the south-southwest exposure was slightly greater than on either of the other two studied, namely, the south-southeast and west-southwest exposures. Height growth was a little less on the south-southwest exposures.

Such observations as were made on the other five exposures indicated that they were even more poorly stocked with subsequent reproduction than were the southerly ones. Here again, the explanation may lie in the differences in vegetation densities, altho Pearson (34) points out that the factor of heat deficiency cannot be overlooked. The northerly exposures are more densely clothed with lesser vegetation and residual Douglas fir than the southerly ones and there is less growing space for new arrivals.

The slopes varied in degree from 25 per cent to sixty-five per cent. It is interesting, at least, that the largest area that was well stocked with subsequent reproduction was a 65-per cent slope facing due south. It had supported a heavy stand of pure pine before logging, and the soil was still slipping somewhat due to the steepness of the slope and the scarcity of vegetation. The presence of considerable loose rock was also characteristic. Seed trees were 200 feet or more distant from most of the area and shade was practically nil. The upper part of it is shown in Plate 1. Altho this area combined

Plate 1.--An area where subsequent reproduction was comparatively plentiful. Private cutting on the left; national forest timber sale on the right. The vegetation clumps are ceanothus brush.

several of the factors now known to be favorable to reproduction, still, it cannot be known that it was not caused by some chance happening such as logging during the period of seed dissemination, or some other cause about which we know nothing. Certainly it cannot be ascribed to the effects of slope alone.

<u>Effects of Situation, Fire, and Soil Classes:</u> As has been stated, the subsequent seedlings found were classified according to their immediate surface surroundings. Fire and soil classes were first devised and then all the other surface features resulting from logging or other causes which might affect subsequent reproduction were grouped into eight classes and called, for lack of a more definite term, situation classes. The full classification used is as follows:

<u>Situation Classes.</u>

1. A permanent water table always within probable root zone of seedlings over one year old.

1a. Near an intermittent stream.

2. Beside stump.

3. Beside logs or trash over one inch shortest diameter.

4. In litter composed of needles and bark under one inch shortest diameter.

5. In leaves from present vegetation or reproduction.

6, and 7. In, or on the edge of, a denuded skid trail.

8. Bare mineral soil not included above.

(Lesser vegetation, being described separately was not considered in connection with situation class.)

<u>Fire Classes:</u>

1. Within the heavy burn where a slash pile had been burned.

2. Edge of slash pile burn.

3. Where light surface fire had resulted from slash burning.

4. No signs of fire since logging.

<u>Soil Classes:</u>

1. Gravelly loamy sand; no rock.

2. Loose rock present; same soil texture.

3. Beside solid rock outcrop.

Table 3 summarizes the relationships found between the conditions as here classified and the abundance and height growth of subsequent seedlings. One- and two-year old seedlings are excluded because their status is probably temporary.

Situation Classes 1 and 1a did not occur on the exposures being studied, but a few measurements were taken of seedlings on these situations for purposes of comparison, to actually measure the effect of unlimited soil moisture supply. In marked contrast to the paucity of reproduction and the slow growth of the seedlings on the slopes was the comparatively plentiful and remarkably fast-growing reproduction along the road that follows Clear Creek through the sale area. This contrast is illustrated by comparison of Plate 3 with plates 2,4,and 5.

Table 3. - Occurrence and height growth of subsequent reproduction in relation to situation and fire classes.

| | % of Total Area in Class [2] | Number of Seedlings | % of Total No. | No. per Unit of Area [3] | Ave. Ann. Height Growth (Feet) [4] | Ave. Height Growth Quotient [5] | Ave. Shade from Trees | Ave. Total Shade Trees and Veg. | Ave. Veg. Density |
|---|---|---|---|---|---|---|---|---|---|
| | Col. A | B | C | D | E | F | G | H | I |
| **Situation Class[1]** | | | | | | | | | |
| 1. Stream | - | 2[6] | - | - | 1.25 | 1.80 | 0.05 | 0.35 | 0.85 |
| 1a. | - | 6[6] | - | - | 0.38 | 1.32 | 0.06 | 0.10 | 0.20 |
| 2. Stump | 0.3 | 16 | 9.8 | 53.4 | 0.20 | 0.87 | 0.12 | 0.12 | 0.05 |
| 3. Logs | 10.7 | 29 | 18.7 | 2.7 | 0.22 | 0.97 | 0.13 | 0.25 | 0.13 |
| 4. Litter | 45.3 | 53 | 34.2 | 1.2 | 0.12 | 0.67 | 0.16 | 0.18 | 0.08 |
| 6&7. Skid. | 6.7 | 15 | 9.6 | 2.2 | 0.24 | 0.99 | 0.16 | 0.22 | 0.09 |
| 5. Leaves | | 14 | 9.0 | | 0.18 | 0.81 | 0.10 | 0.23 | 0.29 |
| 8. Bare | | 29 | 18.7 | | 0.18 | 0.82 | 0.07 | 0.10 | 0.09 |
| 5.&8. | 42.5 | 43 | 27.6 | .65 | 0.18 | 0.82 | 0.08 | 0.14 | 0.15 |
| Totals & Ave. | | 156 | 100.0 | 1.56 | 0.18 | 0.83 | 0.13 | 0.18 | 0.11 |
| Used Twice | | 44 | - | - | - | - | - | - | - |
| Net | | 112 | - | 1.12 | - | - | - | - | - |
| Basis, Seedlings | | - | - | - | 51 | 61 | 81 | 81 | 80 |
| **Fire Class[1]** | | | | | | | | | |
| 1. Heavy | 2.6 | 1 | | 0.4 | | | | | |
| 2. Edge | 1.1 | 9 | | 8.2 | 0.19 | 0.98 | 0.13 | 0.15 | 0.06 |
| 3. Light | 3.5 | 13 | | 3.7 | 0.18 | 0.83 | 0.09 | 0.16 | 0.12 |
| 4. None | 92.8 | 89 | | 1.0 | 0.18 | 0.80 | 0.13 | 0.18 | 0.11 |
| Tot. & Ave. | 100 | 112 | | 1.12 | 0.18 | 0.83 | 0.13 | 0.18 | 0.11 |
| Basis, Seedlings | | 112 | | - | 51 | 61 | 81 | 81 | 80 |

[1] See text for detailed description of classes.

[2] Basis, the eighty-one 0.01-acre plots taken on the southerly exposures on the strip survey.

[3] Column C divided by Column A. See footnote 2, Table 2.

[4] Since germination, 6-, 7-, and 8-year olds only

[5] See footnote 3, Table 2.

[6] Seedlings selected for purposes of comparison. Not included in totals.

Examination showed that in nearly all of this valley bottom reproduction started on the old railroad grade during logging or on the large landings and main skid roads afterward. Many were growing beside stumps on the narrow flat along the creek. The extraordinary height

Plate 2.--Typical thrifty seedling beside stump, 7 years old.

growth made by these seedlings undoubtedly is due to the extra soil moisture available to their roots. The shade of aspen, alder, and other vegetation did not appear to affect them in the least.

The tendencies shown in Table 3 require some discussion. Columns A to F give the seedling data and Columns G, H, and I are included to answer any question as to the effect of shade and vegetation density on the abundance and height growth of the seedlings. It will be noticed here also (Column D) that the greates abundance of seedlings per unit area is found near stumps, altho, for some reason, the height growth (Columns E and F) in that situation is only moderately good. This greater


Plate 3.--An 8-year old seedling growing along edge of old railroad grade about three feet above water level of stream. Height, 11 feet. Compare with seedlings in Plates 2 and 5.

abundance around stumps may be due to the extra activity around the stump at the time of cutting which would cover seeds, if any were on the ground, and expose mineral soil. This does not seem sufficient,

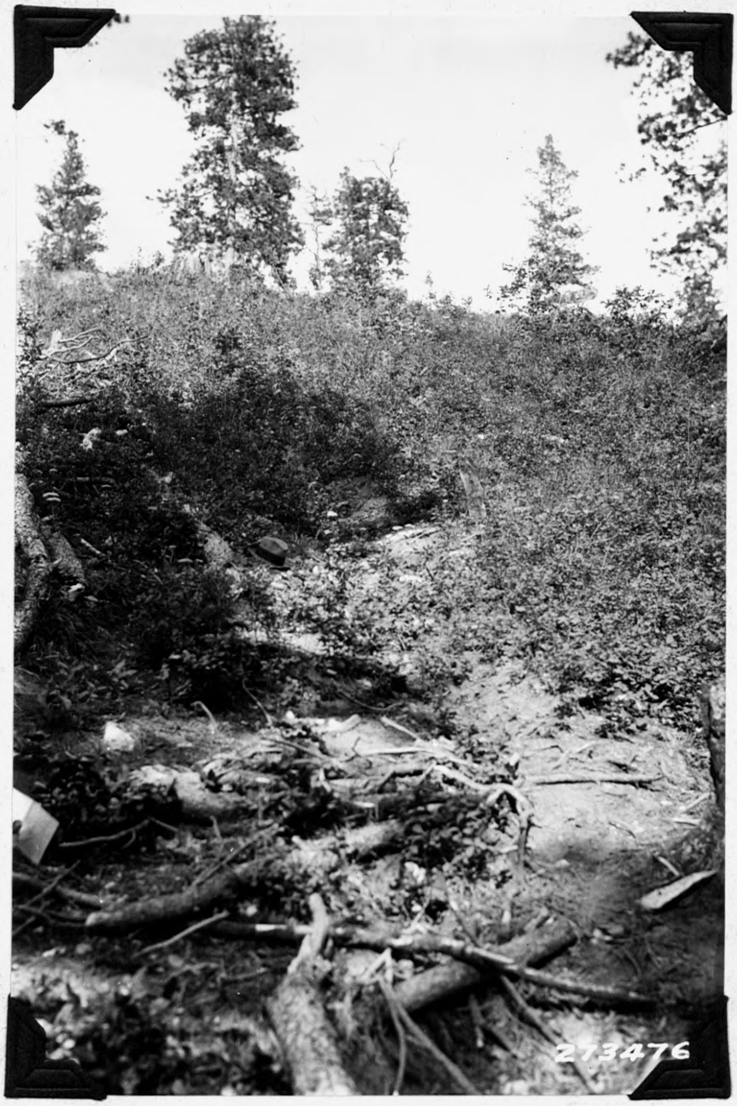

Plate 4.--A combination of conditions favorable to occurrence of reproduction. Six subsequent seedlings from 2 to 6 years old are growing along this section of skid trail and beside the slash pile burn and trash in the foreground. Vegetation mainly Spiraea corymbosa.

however, to fully explain the condition, and the writer would give some credit to the extra moisture under the stump that is protected from evaporation by the stump itself. Vegetation is usually absent around stumps, also. A set of soil moisture determinations showed that the moisture content of the soil beside a

Plate 5.--Some situations favorable to reproduction. Stumps, logs, and a slash pile burn with its surrounding debris. Three seedlings are shown, all 7 or 8 years old. The conspicuous vegetation is dogbane, *Spiraea*, *Calamagrostis*, *Anaphalis*, and willow.

pair of stumps was 89 per cent higher in July than at 16 feet southwest of them. Samples were taken at 12 inches in depth, and where vegetation density was 0.05, in both cases. The actual figures were 11.7 per cent soil moisture beside stumps and 6.25 per cent in the open.

In comparing the abundance of seedlings on the other situation classes, Table 3, Column D, it is apparent that, next to Class 2 discussed above, Classes 3,6, and 7 are the most favorable situations for seedlings. Class 3 represents the effects of logs more than of smaller sticks and it could not be inferred that scattering of slash would be beneficial. Since these four classes are the situations where the ground surface is protected from evaporation by being covered, or where the vegetation has been removed in skidding logs, soil moisture is again indicated as the limiting factor and lesser vegetation as more of a competitor for this moisture than a help in protecting it from evaporation.

Table 3 also shows that the four situations that lead in seedling abundance, lead in height growth as well. The classes where both height growth and abundance are lowest are Classes 4, 5 and 8 which are unprotected from root competition and evaporation by any ground covering except litter. That the litter might have a protective effect as well as the larger material is a hypothesis that was not borne out by the data. Altho seedlings were a little more abundant on the litter covered areas than Classes 5 and 8, height growth averaged less than on any other situation class.

The effect of the fires caused by slash burning is shown in the second section of Table 3. The more seedlings per unit area found around the edges of the spots where slash piles had been burned corroborates general observation. Munger (27) cites instances in Oregon where hot fires have undoubtedly favored reproduction, and similar instances have been observed by the writer in different parts of Idaho. The better height growth made by seedlings in this situation is thought to be mainly just another example of the effects of removal of lesser vegetation. That fire has been common in the ponderosa pine type is shown by the fire scars on trees and stumps. Ring counts on the Clear Creek area showed that there have been general fires as recent as 1918 and as long ago as the 1730's, with some indications of a period of frequent fires between 1860 and 1885.

The comparison of "soil classes", due to the small percentage of the area in the solid rock outcrop class, shows an indication only of what other writers have reported (6,27,30,34), namely, that rocky points and stony places are favored locations for ponderosa pine reproduction. The soil of the Clear Creek area is an exceedingly uniform, gravelly loamy sand, approaching a loam. Other areas studied had very similar soil. Sixty-five per cent of the area was classified as being free from loose rock or outcrop. Due to the disproportion in area between the classes no conclusive results were obtained, but in general they check with the conclusion from observation that rocky and stony areas have a much better chance of being reproduced. The explanation probably lies in the protection afforded from evaporation, competition of lesser vegetation, and surface soil temperatures.

The effects of a combination of favorable situations is shown in Plates 2,4, and 5. The locations where seedlings were most abundant and most thrifty are all either areas where the vegetation had been disturbed or was kept out by some means. This fact points to soil moisture, more than to any other one factor, as the dominating influence in seedling establishment and growth.

Studies of the effects of the various plants and plant densities upon soil moisture would probably discover useful information.

## SUBSEQUENT REPRODUCTION ON OTHER AREAS

The Clear Creek sale area was the only one upon which an intensive study of subsequent reproduction was made. More or less detailed observations were made, however, on eleven other cut over areas, two virgin stands, and one accidental burn. The results as shown in Table 4 bring out some interesting comparisons of subsequent seedlings on these areas. All are for southerly exposures except minor parts of the Carpentier Creek and Big Pine Creek transects and all of them exclude landings, old railroad grades, roadsides, and stream banks. The data for the other subsequent reproduction is not as reliable as that for the 1932 seedlings because time was not taken to determine accurately the ages of all seedlings that might possibly have originated since logging. A considerable number, however, were examined on each of the six areas for which figures were given.

It will be noticed that none of the areas examined that had been cut-over since 1916, with the exception of Clear Creek timber sale, bore any new seedlings when inspected in 1932, and the number on the Clear Creek area is seen to be so small as to be almost negiligible. Furthermore, no subsequent reproduction whatever was found on any of these areas except the Clear Creek timber sale. Possibly the more intensive search made there accounts for the meager stand of 112 seedlings which were found there. The principal difference between private and national forest areas was in the amount of advance reproduction. The scarcity or total lack of advance reproduction observed on some of the private cuttings can be traced to uncontrolled fire as the cause. Table 4 presents striking evidence that both private and national forest areas which have been cut-over in recent years either have produced practically no seed

Table 4. - Comparison of subsequent reproduction on cut-over areas, under virgin stands, and on a burned area.

| Location | Date of Logging | Approx. % Cut | Date of Examination 1932 | Number of 1932 Seedlings Found | Other Subs. Seedlings |
|---|---|---|---|---|---|
| **Cutover Areas:** | | | | | |
| Clear Creek Timber Sale | 1924-6 | 85 | July | 1 per acre[1] (960 milacres) | 26[1] |
| Granite Creek Timber Sale | 1929 | 90 | July 8 | None | 0 |
| Granite Creek Private Ctg. | 1929 | 100 | July 8 | None (burned 1930) | 0 |
| Clear Creek Private Ctg. | 1923-5 | 98 | July | None | very few |
| Private Ctg. W. of RyeFlat | 1917 | 90 | June 20 | None | 0 |
| Private Ctg. E. of C'ville | 1921 | 95 | June 20 | None | 0 |
| Carpentier Cr. Timber Sale | 1913 | 80 | Aug. 7 | 213 per acre (80 milacres) | |
| Bannock Cr. Private Ctg. | 1911 | 50 | July 7 | 1444 per acre (9 milacres) | |
| **Uncut Stands:** | | | | | |
| Big Pine Cr. Virgin Stand | - | - | Aug. 8 | 195 per acre (240 milacres) | - |
| Bannock Cr. Virgin Stand | - | - | July 9 | 7900 per acre (10 milacres) | - |
| Boise Basin 1931 Burn[2] | - | - | August | 241 per acre (628 milacres) | - |
| **Other Areas:** | (Data furnished by IF&RES by letter) | | | | |
| Lowman Timber Sale | 1907 | Light | Sept. | 13.3% frequency on 128 0.01-A. plots. | Plenti-ful |
| Timber Sale near Cascade | 1924 | Heavy | Oct. | 3.1% frequency on 96 plots | 9.4% freq. |
| Timber Sale near McCall | 1922-5 | Mod. | Oct. | None on 128 plots | 12.5% freq. |

[1]Data from vegetation transects and the strip survey in order to have figures with an accurate area basis.

[2]Data taken from field sheets of the fire damage study.

availavle for germination or that some factor prevents its germination and survival after it reaches the ground. In general, a scarcity of seed is indicated, but along with this, and due to the same policy of leaving but a small percentage of the stand after logging, the site conditions are so severe that few seedlings, if any did germinate, would be able to establish themselves.

Conditions in virgin stands are considerably better for germination. The Bannock Creek virgin stand, for example, had 79 current seedlings on 10 representative milacres. But even here, their ultimate chance of survival is slight (20, 27). Very few of the Bannock creek seedlings were thrifty enough to survive their first summer, 29 per cent being classed as in poor condition or dying, even in early July of an unusually moist season. The same was true under the other virgin stand and on the older cutover areas. The fact that there were seedlings on the older cut-over areas is accounted for, not so much by the change in conditions due to time, in all probability, as to the fact that these better stocked areas were cut over more lightly in the first place. It will be noted in Table 4 that the only area where "Other Subsequent Seedlings" were plentiful was on one that was cut before the heavy seedling crop of 1913.

That the germination of large numbers of seedlings, even in virgin stands, is not an annual occurrence is shown by the records of a number of permanent sample plots (43). These plots were located on Carpentier and Big Pine Creeks most of them under virgin stands. They were remeasured in 1914, 1916, 1919, and 1920 by Sparhawk and Korstian (21) and by the writer in 1931. All new seedlings were recorded and almost no current reproduction is reported for any year of examination. They were visited again in 1932 and enough current seedlings were counted to show that 1932 was a better year for reproduction than any of the others for which there are any records. This year does not compare, however, with 1913, when more seedlings survived until their second year than have been recorded in all the years since, including 1932. From this evidence, it appears that 1932 was a year of about average germination if there can be said to be any average years under the ponderosa pine system of periodic reproduction.

It was outstanding that the only area where it appeared that the 1932 seedling crop would be noticeable in the years to come was on some of the moderately burned parts of the Boise Basin Burn west of Pioneerville. Most of the trees and all the herbaceous vegetation were killed by the fire and the seedlings germinating the next spring were practically without root competition. Shade, however, was almost as dense as before the fire, as the dead and injured trees still retained most of their needles. These seedlings on this area were of a large size and dark green color which was in marked contrast to the short, slender, light-colored seedlings that were found elsewhere. This comparison adds more weight to case for moisture as the dominant factor in seedling survival.

As has been noted in the foregoing report, the results of reproduction studies are bound to be influenced by the phases of the climatic cycles which they cover. More time is necessary before it can be told whether the results of this study present an unduly pessimistic picture of the subsequent reproduction situation.

## SUMMARY

In this report are presented and discussed the results of a study of subsequent reproduction on several ponderosa pine cut-over areas in the Boise Basin and the Payette River drainage in central Idaho. Work was confined to the southerly exposures. The general procedure was to study in detail the situations where reproduction was found on one timber sale area and to check these results by less intensive studies on other areas.

Only 115 subsequent seedlings were found on the Clear Creek sale area after a search over approximately one-hundred acres of southerly exposures. Study of the ages, rates of growth, and immediate surroundings of these seedlings brought out the following facts:

1. 83 per cent had germinated the year of logging or within two years afterward, while only 21 seedlings on the whole area were found that had germinated during the six-year period 1926 to 1932 inclusive.

2. The zone within 3.3 feet of stumps was the part of the area best stocked with subsequent reproduction.

3. There was a tendency for seedlings to be more abundant where the density of the lesser vegetation was lowest but no correlation was found between height growth of dominant seedlings and density of vegetation. The few seedlings that were overtopped by ceanothus brush and other vegetation were not suppressed in height growth as compared to the average of all of the seedlings.

4. No consistent effects of shade on either abundance or height growth of reproduction were shown.

5. Next to the areas around stumps, the situations where both abundance and height growth of seedlings were greatest were those beside logs and debris, along old skid trails, at the edges of slash pile burns, and on rocky soils.

A comparison of current (1932) reproduction on eleven areas gave the following results:

1. Seedlings at the rate of 338 per acre on the two

areas that had been cut over prior to 1916;

2. An average of 503 per acre under two virgin stands;

3. An average of 241 per acre on some areas which had been moderately burned the year before; and

4. Practically a total absence of current seedlings on the six areas, both private and national forest, that had been cut since 1916.

5. The seedlings were in a uniformly vigorous condition only on the burned area.

## CONCLUSIONS AND APPLICATIONS

The following general conclusions appear to be warranted.

1. Subsequent reproduction was found to be so meager on the cut-over areas examined on both private and national forest lands that it appears questionable whether subsequent reproduction can be relied upon, even under present Forest Service marking rules, to assist materially in restocking lands after cutting.

2. On southerly exposures of cut-over areas in central Idaho, soil moisture as the limiting factor in the survival and growth of ponderosa pine in the seedling stage is of much greater importance than any other single factor including shade from trees and from lesser vegetation.

3. Since the principal means open to the forester of increasing the soil moisture available to seedlings is by regulation of tree and other vegetational cover, attention should be paid in logging, grazing regulation, and slash disposal, to methods which decrease either the direct evaporation or the competition of lesser vegetation. The indications are that skid trails, stumps, landings, slashpile burns, rocks, logs, debris, and, in general, the areas of relatively sparse vegetation present favorable opportunities for seedlings to gain a foot-hold. Any method which results in an increase of areas of this kind, without decreasing the seed supply or the protective cover, should result in better reproduction.

Before any far-reaching conclusions are drawn, subsequent reproduction should be studied on other areas and over long enough periods of time to determine the effects of the various phases of the weather cycle. Should the extreme scarcity of subsequent reproduction which this study discloses, be found to be a merely local or temporary condition, adequate restocking can probably be obtained by intelligent selection and application of methods in logging, slash disposal, and grazing which are now known to encourage this reproduction. If, on the other hand, it should be found to be anything approaching a general condition, some changes in cutting policies or methods are indicated.

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