# THE STUDY OF NATURAL REPRODUCTION ON BURNED FOREST AREAS

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It is not necessary herein to quote statistics on the areas and values of timberland destroyed each year in the United States. The losses are sufficiently large to attract attention and to present problems in forest management as well as in forest research. The situation is here and every forester must meet it, be he manager or investigator. This paper is an attempt to present the problems of the investigator whose job is to furnish certain information on reproduction of burned over forest land to the forest manager.

The questions which the forest investigator must answer are: How soon will the forest come back after the fire? What species will be coming? When and how will they come? What factors contribute toward a hasty regeneration and what are the reasons for the delay? Will the land again support the trees which grew there before the burn? Are all of the factors and conditions which affect the natural restocking after fires discernible and reducible to certain principles and laws which may be of assistance in shaping the policies of management?

While it is well known that natural restocking will take place promptly on most forest land burned once in western United States, nobody can satisfactorily explain occasional failures or give reasons why one species has succeeded in place of another, and far be it from anybody to venture to predict what the reproduction will be after this or that recent fire.

It was while studying natural regeneration on many of the larger burns in the Bitterroot Mountains that the author began to formulate certain theories and postulate certain hypotheses which would serve as methods of attack in solving these problems, or at least, give him a closer understanding of the subject. In the course of these studies it became evident from the start that every silvical characteristic of

the species, every factor of site, be it climatic, physiographic or edaphic, and every condition surrounding the fire itself, exerts itself in some way or other during this regeneration period. Furthermore, that these various factors or conditions have a definite time during which they occupy the stage or play their leading parts: Some remain potent or in force throughout the entire period, that is, both before, during and after the fire; others are operative previous to the fire only; a third set of factors are of importance only as they function during the fire itself; and a fourth set of factors and conditions begin to operate as soon as the ashes are cold and continue their influences until the new stand is well established. Let us look at these matters a little closer.

In the set of factors or conditions which operate both before and after the fire must be placed those which remain constant for the region, fires or no fires. These will fall on the climatic and physiographic group; general weather conditions including sunshine, air temperature, precipitation, relative humidity and wind movement from year to year and month to month. Also major topographic features of general elevation, aspect, gradient, and to some extent certain structural and chemical soil qualities which the fire is powerless to change. These general climatic, topographic and edaphic features serve to create conditions in one forest region which set it off from any other region. They are of local significance or influence as factors in determining the forest types or species which grow on any one slope, elevation or aspect, and they remain immutable by any number of forest fires.

In the second group are those conditions existing before the fire only. These discontinue altogether as positive or negative influences after the fire has ceased. They are age, composition, and density of the forest which burned and the amount of inflammable material on the ground.

The age of the stand destroyed plays no mean part in the restocking inasmuch as there is in young stands very little seed available for immediate restocking either on the trees or on the ground. In certain cases natural reproduction fails also because the previous forest was altogether too old for sufficient seeding.

From the standpoint of composition it is necessary to observe that like follows like and in very few cases does the second forest springing up after the fire contain species which did not exist in the locality before the fire. The composition of the forest may materially influence the rate of spread or the intensity of the flames and consequently the

degree of destruction wrought. The same may be said regarding density.

The amount of inflammable material on the ground, such as dead wood, grass, brush, litter and duff, are of importance since these intensify the heat and increase the damage to the stand itself, the seed which may be on the ground and to the soil itself. The effect is also to prepare the ground for the new seed and seedlings and to eliminate competition from certain vegetation.

In this class are also placed the local conditions of precipitation, air temperature, atmospheric humidity and soil moisture conditions preceding the fire, all of which affect the inflammability of the trees or the material on the forest floor. Furthermore, the exact time within the growing season at which the fire occurs must be known and carefully noted, it being recognized that fires burning early in the season are less destructive than those happening later on, and that these early fires are not followed by nearly as good reproduction as those of later origin. This is mainly a matter of seed ripening, for restocking does take place by seed which is on the trees at the time of the fire. There is the possibility, of course, that the early fire may leave many seed trees in such a condition that the seed continues to ripen. Another matter not to be overlooked in this connection is that of seed-year or off seed-year during the summer of the fire, and what species bore seed and what not. In many instances a complete change in the mixtures or composition of the new stand from that of the old can be explained on this basis only.

The investigator soon learns to differentiate between fires which occur on logged land and those burning in uncut or unexploited stands. In the latter case the main body of the flames and therefore the greatest heat and destruction is in the crowns of the trees, and though the duff burns, there is usually moisture in the soil underneath where some seed lies buried. On this account the deeply covered seed under a burning stand of timber often escapes destruction. On the logged over land on the other hand, the main body of the flames is concentrated near the ground and close to where the seed is buried. The ground and the duff on logged areas have, moreover, been exposed to wind and sun for a period of time, and have therefore become much more inflammable than the duff resting underneath the standing trees. For these reasons logged areas when burned, restock much less abundantly than areas supporting standing green timber.

Among the factors or conditions operating or existing only at the time of the fire are the local climatic or unusual atmospheric conditions, temperature, humidity and wind movement which cause the fires to spread rapidly, acquire greater consuming power and destructive proportions than would have been the case had the local weather conditions been less extreme or accentuated. Under such conditions the fire will not only cover a very large area, but will eat further into the less inflammable stands than would otherwise have been the case. In not a few instances the fire will of itself give rise to wind movements of unusual or remarkable proportions. These winds uproot and destroy trees that would have remained standing to become prolific seedbearers.

The conditions existing at the time of the fire, therefore, which are chiefly of a local climatic nature, in a large measure influence the degree of destruction of the stand as well as that of the seed and seed trees.

By far the most effective factors for success or failure in natural reproduction after fires are increased air and soil temperature, intensified insolation, frost, evaporation and soil dessication. In addition to these are invasion of competing vegetation or the absence of its protecting, sheltering, and soil building qualities. To these must be added insect and fungous activities attributable to the fire and in not a few instances prolonged denudation, soil deterioration and erosion, all of which either curtail seed production, retard germination or reduce the survival of seedlings. It is in this phase of the subject that we recognize natural selection as it operates in forest succession, and those seedlings found to survive all of these superimposed conditions are of species structurally and physiologically able to withstand and survive the environmental conditions. Therefore, the more uniform the site following the burn the purer will be the new forest, and only where the exposed terrain presents diversified local conditions of moisture and shade will a mixed forest follow, the mixture then being chiefly group-wise according to high or low site or exposed or protected localities. The more exposed or critical the site after the fire the greater will be the proportion of xerophytic species and the more open the new stand.

The most remarkable thing about the natural regeneration of burned evergreen forests is the uniform density and distribution with which it covers the land even in cases where all of the mother trees are killed. There is very little evidence of seeding in from the adjacent

green timber afterwards. How may one explain this? It is again necessary to postulate certain causes and say that the seed must have come by one or more of the following methods: (1) distributed by the wind through the air or over the snow for long distance subsequent to the fire; (2) brought in by birds or rodents subsequent to the fire; (3) released from the very trees which burned soon afterwards and on the very same land and location; (4) deeply buried in the duff or in the top soil and thus escaping destruction by the surface fire; (5) carried in by the wind for relatively short distances from adjacent live stands or scattered by individual trees which lived on the burn for a year or two and produced seed; (6) released from the trees at the time of the fire itself and carried upward in the general vortex to be distributed soon after on the ashes.

While the author does not deny that seeding after the manner given in points 1 and 2 takes place, it is at best sporadic and irregular and utterly inadequate to engender the profuse and uniform natural reproduction witnessed on these burns. The first two methods are discarded as untenable hypotheses and we must look to the remaining hypotheses for a possible explanation.

3. The seed could be released from trees which were killed or partly burned by the identical fire. This matter is fairly easy to prove by prompt examination of the burned stand, the cones thereon, their state of preservation and the character of the subsequent reproduction. Evidence may be materially strengthened by observing what reproduction follows burned timber which was totally destroyed, where every particle of green foliage and cones were completely burned, and what reproduction follows partially burned stands, or stands which were too young to produce seed when burned. The author has consistently found more profuse and more abundant seeding after destruction of mature timber than after very young forests, and it is his conviction that as much or more restocking occurs in this manner as from buried seed.

4. Seed could have been deeply buried by mice and other rodents, thus escaping destruction by the ordinary surface burning which accompanies our usual western crown fires. To prove this point is a little more time consuming, but by prompt and close examination of the stand soon after the fire, by installation of permanent quadrats, mainly of three kinds but of parallel arrangement, one set open and undisturbed, a second screened to prevent subsequent seeding and a third having all duff or other material which might bear seed removed suffi-

cient evidence may be gathered. The data of field studies indicate unmistakably that restocking takes place in this manner but to what extent varies greatly according to species and site conditions subsequent to the fire.

5. The seed could have been carried in by wind for short distances from adjacent live trees or from certain trees on the burn which remained green and bore seed for a year or two subsequent to the fire. This is a common origin. To prove or disprove this hypothesis it is necessary to observe carefully the distribution of the new seedlings in relation to the parent trees both in the point of species and degree of stocking at given distances from such parent trees. Such lateral seeding usually shows progressive steps. The data may be obtained by age counts and distribution maps of the new stock. One should study this progression by permanent quadrats as well as by seed traps. That seeding takes place in this manner is undeniable, but it is confined to relatively narrow strips from 5 to 10 chains wide bordering the green timber.

6. Still another much less plausible origin, but not entirely impossible, is the release of seed from cones during the heat of the fire. Some of this seed may be shed over the burned or unburned ground while the fire is still in progress, some may be carried upward by strong vertical currents of the heated air, smoke and flames and distributed at considerable distance from the active area of the fire. Obviously seeding in this fashion can take place only when there is ripe or nearly ripe seed available in the cones. Seeding by this means has not been proven but it is known that small unburned twigs are thus distributed for miles and these are heavier than the seed, so why is this impossible in the case of seed. Ranger Haun residing at Haugan, Montana, during the 1910 conflagration told the author that pieces of tin from a burning barn were picked up later at a distance of six miles to the leeward. It has been stated on good authority that during this same fire green cedar twigs fell on the streets of Missoula and that the cedar and the fire which carried these into the air were fully 30 miles to the west. To date, it is merely speculation how much seeding occurs by this agency.