REPLACEMENT OF YELLOW PINE BY LODGEPOLE PINE ON THE PUMICE SOILS OF CENTRAL OREGON

BY THORNTON T. MUNGER

Contributed

INTRODUCTION

In central Oregon, in the drainage basin of the Deschutes River, and chiefly within the Deschutes and Paulina National Forests, is an area of between one and two million acres on which forest conditions are decidedly unique. But two species—western yellow pine, the valuable commercial tree, and lodgepole pine, here a practically worthless weed—compose the forest; yet their silvical requirements are so unusual and their interrelation is so complicated that a most interesting and puzzling ecological problem is presented to the forester who seeks to explain the why and wherefore of their local distribution.

In some parts of this area the stand is absolutely pure yellow pine; in other places it is absolutely pure lodgepole pine; in others it is an harmonious mixture of the two, and elsewhere the two seem to be in violent conflict to occupy the ground. And each of these conditions prevails on areas that are so strikingly similar in their physical conditions that the change in cover type seems to be due not to the physical factors of site alone, but must be ascribed in part to the competition between the species. In this paper it is proposed to describe the local forest conditions as they exist, to discuss the supposed encroachment of the lodgepole pine upon the yellow pine, and to offer an explanation of its causes and processes. First, however, a word of explanation as to the physiography and local site conditions is necessary as a preliminary to the discussion of forest conditions and the local silvical characteristics of the species.

GEOGRAPHIC LOCATION

The region under discussion lies on a plateau at an elevation of a little over 4,000 feet, just east of the eastern base of the Cascade Mountains. A part of this plateau slopes southward to the Klamath watershed, a part toward the interior drainage basin, and a part toward the north. The region of which this paper treats is chiefly within the latter, in the Deschutes drainage basin. Here and there on the plateau are ridges and

cinder cones of volcanic origin, some of which are pronounced ranges that rise 2,000 or more feet above the level of the country. Over large areas, however, the level monotony of the country is broken only by a remnant of an extensive lava-sheet, 25 or 50 feet high, or by a cinder cone 100 or 200 feet high. Through the northern part of this plateau flows the Deschutes River, whose three branches come off the Cascades and unite to form the main river. From its headwaters in lakes on the Cascades the river flows northward on a gentle, sustained grade, and is but very slightly entrenched beneath the general level of the country.

Erosion has not been active in this region since the relatively recent last volcanic disturbance, and therefore the topography is chiefly one upbuilt by volcanic activity and not a relief due to erosion.

PHYSIOGRAPHIC TYPES

Three physiographic types may be distinguished in this region—(1) lowland, (2) bench, and (3) slope.

(1) *Lowland*

Along the several branches of the Deschutes River, through the greater part of their length, is a strip of lowland which is occasionally overflowed and upon which the water-table throughout the year is within 2 to 4 feet of the surface. This strip is usually about 200 feet in total width, but occasionally it broadens out to a quarter of a mile. A few patches of this type occur also along seeps and in topographic depressions away from the river.

(2) *Bench*

On each side of the Deschutes River, through much of its course, and reaching back from the river often for several miles, is a strip of flat country, which is very appropriately called "bench," whether it is generically a river bench or not. This bench land is apparently level, though it slopes with the general level of the plateau in several directions. There are two fairly distinct benches—upper bench and lower bench—and often an intermediate one as well. Sometimes the upper bench borders the river lowland directly; more often the lower bench is interposed between. The level of the former is usually at least 20 feet—more often 30—above the water, while the latter is only 6 to 8. The upper bench really marks the general level of the country; relief above it is due to volcanic lava flows which have been superimposed on the plateau, and the slight relief below the bench is due to the erosion of the river. In the vicinity of

Lapine the upper bench is some 6 miles wide and 20 or 30 long, and this seemingly perfectly flat piece of country goes by the name of the Walker Basin. A relatively small amount of country falls within the lower bench subtype.

(3) *Slope*

All the country above the level of the upper bench is classed as "slope," and usually the line between "bench" and "slope" is clearly marked by the change in grade. The cinder cones, the hog-back ridges made by old lava flows, the main slopes of the Cascades and of the Paulina Mountains, all fall in the slope physiographic type.

SOIL

Perhaps the most characteristic feature of this region, and the one that has the most marked effect upon the ecological problem under discussion, is its soil. The whole country is covered with a mantle of buff-colored pure pumice fragments, one-fourth inch to 1 foot in size, which were showered over the country from the volcanic vents on the Cascade and Paulina Mountains. Its depth also varies—in the Walker Basin it is uniformly about 10 feet, while farther south the pumice mantle is perhaps 40 feet deep. On the slopes it is apparently shallower, and in places the underlying lava rock shows through, suggesting that it has been washed off the hillsides into the flats (now benches), which were perhaps under water at the time the pumice was showered over the country. It is undoubtedly a sterile soil, and its texture is so loose that a man sinks 2 or 3 inches in it in walking, as in beach sand. In traveled roads it crumbles into a fine powder and packs when wet. On the lowland type the soil is a little silty and darker colored. Everywhere else it is pure pumice of very uniform quality and condition over large areas.

CLIMATE

The climate of this region is a characteristic continental one, with about 20 inches of precipitation a year, most of which falls in the fall and winter months. The days are bright and hot in summer, but the nights are cold throughout the year. Though from an agricultural standpoint the climate is very severe, it is on the whole favorable to both lodgepole and yellow pine.

SOIL WATER

In the summer time the surface of the pumice soil has the appearance of being excessively dry, and not without reason, for its extremely loose

texture, the absence of a real rain for two and a half or three months, the intense insulation and the drying winds, all tend toward its extreme desiccation. On the benches and slopes there is an almost total absence of herbaceous vegetation, and what little bushy growth there is on the naked soil is of a zerophytic type. In this whole region of a million or two acres there is not a drop of surface water in the summer except that in the three branches of the Deschutes River that come off the Cascades, in a single little tributary from the east, issuing from two lakes in the Paulina Mountains, and in a spring that forms a creek a hundred or two yards long. Considering the excessive dryness of the surface and the evident poverty of the vegetation, it is a matter of surprise that where wells have been dug on the high bench in the Walker Basin abundant very cold water has been found at a depth of 10 or 15 feet. It seems probable that on most of this bench type the water-table is at this depth, or a little deeper. The Cascade Mountains on one side and the Paulina Mountains on the other furnish an abundant source for this underground water, which probably gradually seeps toward the Deschutes River from each side.

Even in the dryest part of the year, when four to six inches of the bone-dry pumice is scraped away, the soil beneath shows moisture by its color, and measurements prove that at a foot down the soil has 12 to 16 per cent of water. This suggests that this subsoil water is evaporating into the air without wetting the surface, and at the same time it is undoubtedly cooling the soil very much. In spite of the abundant subsoil water, the surface seems to be physiologically dry to most kinds of vegetation. On the low bench the water-table is much closer to the surface, and the herbage is correspondingly more plentiful. On the slopes the water-table is undoubtedly deeper, but the surface vegetation shows no more signs of drought than that on the upper bench.

THE FOREST

All of this region was originally, and most of it is still, covered with a forest consisting either of lodgepole pine or yellow pine, or both, but, contrary to expectation in a region of this climate and general physical condition, the former is in the majority. The distribution of these species is somewhat as follows:

The lowland type is either open meadow, with willow brush, or pure lodgepole-pine thickets. Rarely is a yellow pine found here. The lower bench is commonly covered with pure lodgepole pine, occasionally with some yellow pine, but always with a characteristic herbaceous ground cover which the upper bench does not have.

The upper-bench type is sometimes pure lodgepole and sometimes predominatingly yellow pine. The characteristic undergrowth is *Kunzia tridentata* or *Ribes* (sp.). It is this alternation between pure lodgepole and the mixed yellow pine and lodgepole that furnishes the puzzling problem in this region. This type is the disputed territory.

The slope type is commonly yellow pine, with here and there some lodgepole pine, up to an altitude of 5,000 to 5,500 feet, where other species, such as Douglas fir, and much more lodgepole, sugar pine, white fir, become prominent, and the yellow pine drops out. In the slope type *Acrtostaphylus manzanita* and *Ceonothus velutinus*, together with *Kunzia tridentata*, characterize the undergrowth.

SILVICAL CHARACTERISTICS OF THE TREE SPECIES

The characteristics of the two pines in this region are not markedly different from those attributed to these trees in other regions, but one or two points deserve especial mention, since they have a bearing on the interrelation of the species. With a soil such as has been described, it is not surprising that the development of both species is very poor, and they show, therefore, that they have a hard struggle to live and develop. Their growth is very slow; their general development is very poor; they are short for their diameter, and are uncommonly defective. The lodgepole pine is particularly poor, it being usually very scrubby, limby, and short.

Although the reproduction of yellow pine in most parts of the State is vigorous, here it is poor. The seedlings seem to have great difficulty in surviving their first year in the loose surface—dry pumice; the few that do survive are those that start on the shady side of bushes or in the well-mulched soil at the bases of big dead trees. Many of the seedlings start from seed that has been buried by a chipmunk (by actual count 85 per cent of the one-year seedlings are in these chipmunk-sown clumps), showing the advantage that is gained by a substantial cover. A decided increase and improvement in yellow-pine reproduction is noticed with an increase in altitude on a uniform slope—due undoubtedly to an increase in surface moisture. On a little hill which had a uniform slope and exposure the yellow-pine reproduction increased fivefold in a rise of approximately 500 feet. This indicates how slight a change in the physical conditions effects a decided change in the trees' reproductive strength.

Lodgepole-pine reproduction is decidedly more vigorous than that of

yellow pine; its seed is borne annually in great abundance; the seedlings start readily, and they seem to be hardy. After fire its reproduction is especially prolific. The cones open commonly the year that they ripen, and therefore sealed cones are not here a contributory cause to the abundance of the reproduction. On areas freshly burned over, lodgepole reproduction is exceedingly dense, while on areas exactly similar, but not burned over, there is almost no reproduction. The chemical changes in the surface soil due to the fire seem to promote reproduction, and analyses show that there is a good deal of difference in it after fire. It is a matter of common observation that on the upper bench, if an area does not restock at once after a fire, but little reproduction comes in afterward, even in spite of abundant seed and plenty of openings. Many such openings on "sand flats," as they are called locally, are interspersed through the lodgepole-covered benches.

Neither species is here fast growing, but in early life lodgepole's height growth is decidedly more rapid. It is noticeable that when the two species stand side by side the lodgepole outstrips the yellow pine from the start. Lodgepole's growth, however, is not well sustained, and by the end of its first century it falls off decidedly. If the yellow pine is not then overtopped and suppressed, it forges ahead.

THE EFFECT OF PERIODIC FIRES

One of the very important silvical factors in this region is fire, and, as will be pointed out later, it is apparently an influence which has upset the natural interrelation between the two species. There is hardly an acre in the region that does not show signs of fire, and it is roughly estimated that every area has been burned over periodically on an average once in 30 years. In the pure yellow-pine forest, fire runs on the ground surface, scarring the bases of a few trees, eating out the butt and felling an occasional tree, and killing all the seedlings and a part of the saplings. But when the stand is mixed yellow pine and lodgepole, the fire is apt to be more severe, for the pole thickets carry it to the crowns. Where the forest is pure lodgepole, the fires are still more severe, and occasionally a 40 or 50-acre tract is denuded completely by a crown fire. After a hot fire, lodgepole reproduction usually comes up profusely, so that the next stand is as dense as the original forest; even the best stands, however, are patchy as a result of fire, and defective remnants of the previous generation are usually found mixed with the young growth.

LOCAL DISTRIBUTION OF EACH SPECIES

A very close study of the local silvical characteristics of these two trees and observations of their habits on a great variety of sites point to the conclusion that lodgepole will do well on the lowland and lower bench, fairly well on the upper bench, and poorly on the slope, and that yellow pine will do poorly on the lowland and lower bench, fairly well on the upper bench, and well on the slope.

On the lowland and upper bench type, therefore, lodgepole does so much better than yellow pine that it is able to hold practically undisputedly these moister situations. Lodgepole may be considered to be here the ultimate forest cover, chiefly because no other species is vigorous enough to give it serious opposition.

On the other hand, on the slope physiographic type, yellow pine seems to be the ultimate forest cover, for here lodgepole does but poorly. It may be said that on the slopes the rivalry between the two species is so slight that yellow pine easily holds almost exclusive possession. The slopes, therefore, present no particularly interesting ecological problem. Our interesting problem lies on the upper bench, for here there is a very evident rivalry between the two species for supremacy; for, as was stated above, both do fairly well here.

The present distribution of these two trees on the bench land of this region is most difficult of explanation. In one place the forest for thousands of acres is pure lodgepole. In another place it is a mixed and perfectly normal stand of all-aged yellow pine and lodgepole. In other places are scattered very old pines, with a dense understory of young lodgepoles. In still other situations the lodgepole pine is pure except for an old yellow pine here and there, occasionally yellow-pine saplings or evidences of yellow pines long since dead. The transition from the pure lodgepole pine to the mixed stands is usually at a change in the relative level, the former being found on the lower grade. Thus, in traversing a bench covered with pure lodgepole, if a rise in elevation of perhaps only 2 feet is encountered the higher ground carries some yellow pine. It is remarkable how slight a difference in relative elevation is accompanied by very great differences in the forest cover.

But this distinction does not hold for the whole region; sometimes pure lodgepole covers the highest bench land, and occasionally mixed yellow pine is found on quite low bench land. As a general proposition, however, yellow pine is only on the higher places. It has been suggested that the upper bench is too wet for yellow pine, since the water-table is within 10 or 15 feet of the surface. This can hardly be the case, for it thrives

on much wetter ground elsewhere, and in this very region does well on some parts of this same bench.

REASONS FOR BELIEVING THAT LODGEPOLE TENDS TO REPLACE YELLOW PINE

The question that confronts us, then, is: Are certain parts of the upper-bench country foreordained by their physical characteristics to produce lodgepole and nothing but lodgepole, while other areas produce both lodgepole and yellow pine, or is there a progressive encroachment of the lodgepole onto the higher ground on which it is usurping the territory that it should naturally share with yellow pine?

The first conclusion which an observer would reach in passing through the country is that much of the upper-bench land belongs to lodgepole because it is unsuitable to yellow pine, and that the yellow pine is found on the highest ground because it is not adapted to grow elsewhere. But the facts as observed do not bear out this explanation, simple and plausible as it may seem to be.

The facts which upset this explanation and make necessary the finding of another hypothesis are chiefly as follows:

(*a*) Very good yellow pine is found growing and reproducing on situations exactly similar to those which have pure lodgepole.

(*b*) On areas now covered with pure dense lodgepole pine are found occasional yellow-pine snags, charred logs, and stumps, which are evidently the remnant of a yellow-pine stand that formerly occupied the ground.

(*c*) On areas which to all appearance are identical one with another is found every gradation from a harmonious mixture of yellow pine and lodgepole to one of pure lodgepole, with the various intermediate stages which illustrate the aggressiveness of the lodgpole pine and the gradual diminution of yellow pine.

We cannot but conclude, therefore, that both yellow pine and lodgepole pine *can* grow on all this upper-bench country. It might also be said that if there were no lodgepole pine in the country yellow pine would occupy the territory exclusively in a full and uniform stand, and *vice versa* if lodgepole had no competition, it would cover all the upper bench in a pure stand. To produce the kind of forest distribution that we now find in this locality we must still further conclude that during the last few thousands of years there has been a progressive increase in the lodgepole pine—an encroachment by it upon the yellow pine. The factors which have made possible this encroachment, this departure from the ultimate type, will be discussed later.

THE HYPOTHESIS OF THE ENCROACHMENT OF LODGEPOLE

To illustrate just how an encroachment by the lodgepole pine might be effected, it may be convenient to assume a hypothetical case:

Let us take an area of the upper bench which contains a harmonious mixture of yellow pine and lodgepole, in which each is growing and reproducing well enough to maintain its proportion in the forest. Now, suppose periodic surface fires begin to run through the forest about once in every thirty years. Each fire will kill most of the young trees of both species under 4 to 6 inches in diameter, and a few of the larger ones, and fire-scar a great many more. But after each fire the lodgepole reproduction over the whole area is very vigorous, and the yellow pine reproduces rather feebly, because the former is naturally a prolific reproducer after fire and the latter is quite the opposite. When both species start on the same ground simultaneously, every advantage is with the lodgepole during the first few decades, and in this way the reproduction of yellow pine is still further handicapped. After this process has been continued for, let us say, 200 years, there will be left the big yellow pines, over 200 years old, that have survived each fire, straggling middle-aged yellow pines, and old lodgepoles that have chanced to survive the last two or three fires and an understory of saplings that have started since the last fire—*i. e.*, under 30 years old—of lodgepole and yellow pine; principally the former. After two or three more centuries of like conditions, the few big old yellow pines of the original forest will have died either from old age or from the injuries of the repeated fires, and not enough of the middle-aged yellow pines will have survived the fires and the competition with the militant lodgepole to take their places. Thus yellow pine will gradually be burned out of the stand—eliminated from the forest—and its place taken by the irrepressible lodgepole. The resultant effect of this century-slow process is a pure stand of lodgepole, with here and there traces of former yellow pine or occasional stragglers that have not yet been eliminated from the stand. In the whole pumice-soil region every step in this process may be found, and it is this comparison of the several stages of the process on similar situations that furnishes strong evidence of the soundness of the above hypothesis.

FACTORS WHICH HAVE PROMOTED THE CHANGE IN THE FOREST COVER

The fact that a transformation in the forest-cover type is taking place, or has been taking place in the last few centuries—that is, that the present cover is not everywhere the ultimate forest type—implies that

some physical conditions have been different during the period. This abnormal condition is fire, which is everywhere, as is well known, a very potent ecological influence. There is every reason to believe, and none to doubt, that forest fires have been more abundant since the Indian occupancy of the region, certainly for some centuries, than they were before, due to the redmen's custom of intentionally firing the woods. This one changeable factor seems to be quite enough to upset the delicate relation between these two species. Without this extraordinary factor of frequent fires, this replacement of yellow pine by lodgepole could not have taken place. Though there is active root and crown competition between the two species, it must not be thought that by sheer competition the lodgepole could crowd out the yellow pine on land where the latter was adapted to grow. Quite the contrary, where conditions are favorable to both species, and fires are not abnormally abundant, yellow pine can, in the long run, undoubtedly hold its own against lodgepole, due principally to its much longer life. Since lodgepole does not seem to reproduce freely on the upper bench without the help of fire, it would have particular difficulty in maintaining itself here were fire eliminated.

In short, therefore, this whole transformation in the forest type is due to the increase in the frequency of forest fires. As contributory causes, the following must be mentioned in order to complete a logical explanation of how this process works out:

1. Especial vigor in the growth and reproductive characteristics of lodgepole and a corresponding weakness in yellow pine, thus lodgepole having the advantage in seed production, seed dissemination, germination after fire, rapidity of early development, and competition for crown and root space.

2. The fires must be severe and thorough, such as they are only when there is considerable lodgepole pine in mixture with the yellow pine.

With the advance of the process and an increase in the proportion of lodgepole pine, the fires are more severe and run more in the crowns, thereby hastening the process just so much by damaging yellow pine and promoting lodgepole.

It is reasonable to assume that the factor which has promoted this encroachment, namely, frequent fires, has had a chance to operate equally on all parts of the upper-bench land, yet the encroachment has not taken place uniformly on all areas where it might be expected. In some places, as was mentioned above, the two species are in harmonious mixture; in other places there is but a straggling amount of yellow pine, and in other places none; but usually the yellow pine is on the higher

ground. Two feet difference in relative situation is sometimes enough to make a marked difference in the amount of yellow pine. This fact may seem to be a stumbling-block to the satisfactory explanation of the above process; it is not, however, but rather a corroboration of it. In this locality, as in most semi-arid regions, the equilibrium between various forms of forest cover is very delicate, and an inch or two more or less of rainfall or an increase or decrease in the soil moisture will upset this equilibrium and bring forth a very different form of forest cover. The higher spots on the bench are less favorable to lodgepole (because of less soil moisture) and more favorable to yellow pine, and therefore yellow pine has been able to hold its own and resist the encroachment.

Similarly, on the lower ground lodgepole is more vigorous, and yellow pine less so (due probably to the colder soil), and therefore the process makes the most progress here. It has already been mentioned that on the really high, dry ground—that is, on the slope types—there is but little lodgepole pine and no evidence of its encroachment, simply because here yellow pine reproduction is so good and lodgepole so poor that the former can maintain itself in spite of fires and the competition of the latter. The very low ground—that is, the lowland and lower-bench types—belongs to the lodgepole undisputedly.

ECONOMIC ASPECTS OF THE ENCROACHMENT

How much of the upper bench that now is pure lodgepole was once covered in part with yellow pine, is a question that probably never can be answered. It has been estimated that pure stands of lodgepole cover nine times the area in this region that is really ultimate lodgepole pine land.

What its future will be is also a problem. So far as the present-day foresters are concerned, little can be done to change the composition. Since the cause for the transformation in type is fire, the elimination of fires will naturally restore the natural ecological factors to equilibrium and allow the forest to return to its ultimate mixture; but this is at best a very slow process. In forest management, principles such as the following will tend to favor yellow pine, and they are recommended for use:

1. The absolute prevention of forest fires.
2. Brush scattering, without burning, after cutting operations.
3. Cutting lodgepole to a low diameter limit and yellow pine to a high diameter in mixed stands.
4. Use of yellow pine in all artificial reforestation operations.