Influence of the Mountain Pine Beetle on the Composition of Mixed Pole Stands of Ponderosa Pine and White Fir

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It is a well recognized fact that insects exert a powerful influence on the development and structure of a forest. Although many beneficial effects accrue from their activities, the changes which they bring about are frequently at odds with the desires of man. Losses of mature trees caused by insects are usually keenly realized because they deplete resources of present economic value; but less direct losses, which may occur concurrently in stands of low present value, frequently pass unnoticed.

ONE of the results of insect damage which often escapes notice is the conversion of the forest type from species that are economically desirable to species that are inferior. This effect is well illustrated in second-growth pole stands composed of a mixture of ponderosa pine (*Pinus ponderosa* Laws.) and white fir (*Abies concolor* Lindl. and Gord.) in the North Warner Mountains of northeastern California, where attacks by the mountain pine beetle (*Dendroctonus monticolae* Hopk.) have depleted the pine to the point where fir is now the predominant species. Under our present concept of economic values this change is highly undesirable.

In the summer of 1938 a study was initiated[1] on the activities of the mountain pine beetle in the Fandango Logging Chance, Modoc National Forest, in northeastern California. The objectives of this investigation were to determine the extent of damage caused by this insect in pole stands of pine and fir, and to test the applicability of thinning in favor of the pine as a means of indirect control of the insect. This paper presents some of the information obtained on past losses and growth conditions in pine-fir stands, together with a description of the thinning experiment.

Development of the Stand

Ponderosa pine and white fir occur together in the Fandango area in dense pole stands which exemplify intensive competition between the species in the younger growing stages. Interspersed with the young growth there occur widely scattered, overmature trees.

The evidence at hand indicates that the development of the present stands has taken place since the occurrence of the last fires in the areas. At the present time they may be considered locked as far as development is concerned. Return to normal growth may have been attained in the past in such stands through either fire or insect activities. In theory, at least, light fires would tend to favor the pine over the fir, since young white fir is somewhat more susceptible to fire injury than is ponderosa pine of similar age. However, there have been no light fires in these stands within the past half century. Defoliation of the fir by the spruce budworm (*Cacoecia fumiferana* (Clem.)), as suggested by Craighead[2], may also have brought about liberation of the pine in times past. There is no evidence that the budworm is active at present, but it has occurred in the Warner Mountain area, as Keen[3] recorded heavy defoliation of white fir throughout the entire range in 1921. Proof that the mountain pine beetle can bring about type conversion by killing the pine and leaving the fir to occupy the site can be found in stands now present in the Fandango area (Fig. 1). Unpublished records in the files of the Berkeley laboratory show that this bark beetle has been active in this area for at least two decades.

Stand Characteristics

Composition.—The ponderosa pine-white fir mixture is most common on good sites between elevations of 5,500 and 6,500 feet, with pure pine at the lower levels and pure fir higher up. Practically no other commercial species occur in this mixture.

Stocking.—The stands are badly overstocked. Counts on 320 plots, one-seventieth of an acre in size, showed 4,700 trees per acre, 0.6 inch or larger in diameter. Meyer[4] found that the normal stocking for pure ponderosa pine stands of the same site index (60 feet in height at

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[1]By the Berkeley, Calif., laboratory of the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine. U. S. Department of Agriculture.

[2]Craighead, F. C. Forest insects and forestry. Penn State Sylvan, pp. 18-19, 85, 92. 1936.

[3]Keen, F. P. Examination of Fandango, Lassen, Buck Creek, Soup, and Mill Creek Basins, Modoc National Forest, California. Forest Insect Laboratory, Berkeley, Calif. (Unpublished report). 1922.

[4]Meyer, Walter H. Yield of even-aged stands of ponderosa pine. U. S. Dept. Agric. Tech. Bull. 630, 59 pp., illus. 1938.

100 years) is only 1,732 trees per acre at 50 years of age.

Age.—Pine and fir occur together in even-aged groups. Ring counts on increment cores show that the two species have approximately the same age distribution and were established at the same time. The average age is 45 years, with a range of from 20 to 70 years, for trees from 3 to 16 inches in diameter.

Growth.—Detailed analyses of increment cores taken from 320 dominant and codominant pine poles show that the growth rate for the same age class (i.e., growth rate for different groups of trees that were of the same age in successive decades) has gradually declined in recent years. (Fig. 2).

The growth rate of the fir has decreased somewhat, but not to the same extent. There are several factors contributing to the slowing up of growth in these stands, but perhaps the two most important are a deficiency of rainfall and excessive competition. Precipitation records from meteorological stations near the Warner Mountain Range show that the rainfall has been below normal almost constantly during the last three decades.[5] At the same time competition between individual trees in the pine-fir type has become more intense with the increase in age of the stand. The slowing up of growth which has resulted from the interaction of these factors is indicative of a gradual weakening of the trees, which may help to explain their susceptibility to attack by the mountain pine beetle.

Effects of Mountain Pine Beetle Activity

In the summer of 1938 quantitative information was obtained on the extent of damage caused by the mountain pine beetle. Strip cruises were run through the pine-fir pole type and an inventory made of living and dead trees. The stands were arbitrarily classified in the field by three categories based on the degree of loss in ponderosa pine, i.e., (1) areas of high past loss, (2) areas of high current loss, and (3) susceptible areas.

From the results of this survey, shown graphically in Figure 3, it is apparent that prior to attack by the mountain pine beetle pine and fir occurred on all areas in approximately equal proportions. Following a protracted period of damage the quantity of pine in areas of high past loss dropped from 44 to 15 percent. In areas of high current loss the quantity of pine has thus far decreased from 47 to 27 percent, whereas in susceptible areas the proportion of pine to fir is still nearly the same, having been 41 percent originally as compared with 38 percent at present. The greater part of the losses in pine have occurred in the diameter classes between 4 and 12 inches.

The loss by tree species, based on the total amount of each present in the original stand, is shown in Figure 4. From 10 to 20 percent of the fir has died in each area, chiefly because of the activities of the fir engraver beetle (*Scolytus ventralis* Lec.). In comparison the mountain pine beetle has killed as high as 80 percent of the pine in severely damaged stands. In areas of high current loss the mortality in pine is over 60 percent, about evenly divided between current and past injury. Susceptible areas show a current loss in pine of about 2 percent, whereas past losses total 25 percent.

Indirect Control Through Thinning

The conversion of the pole stands of ponderosa pine-white fir to pure fir is not resulting in the production of the most valuable crop of which the land is capable, according to present standards. To find a remedy for this situation in stands in which the pine has not yet been seriously depleted, an experiment was set up to test the efficacy of thinning in favor of the pine as a means of indirect control. This experiment is predicated on the supposition that the mountain pine beetle tends to select, in pole stands, the weaker, less vigorous trees, particularly during periods when infestations are endemic. Thus if the growth rate and vigor of the pine can be improved by the removal of competition, it is expected that the trees will be less readily killed by the insect.

To avoid some of the difficulties usually en-

Table 1.—Summary of Thinning Treatments

Radius of area cleared around crop tree	Number of trees treated	Maximum stocking trees per acre	Theoretical spacing of crop trees under maximum stocking
Feet			*Feet*
0	80	2,057[1]	4.95 x 4.95[1]
4	80	786	8 x 8
8	80	196	16 x 16
12	80	87	24 x 24

[1]Present stand, trees 1 inch d.b.h. or larger.

[5]Antevs, Ernst. Rainfall and tree growth in the Great Basin. Carnegie Inst., Washington, D. C., 97 pp. 1938.

Fig. 1.—The results of mountain pine beetle activity in what was once a mixed stand of ponderosa pine and white fir poles. Surviving trees are white fir.

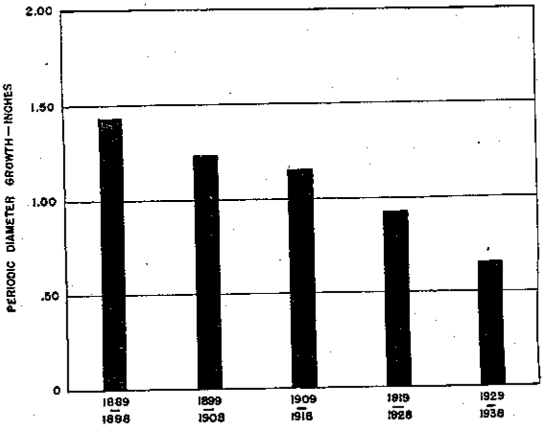

Fig. 2.—Periodic growth of 35-year-old ponderosa pine poles during past five decades.

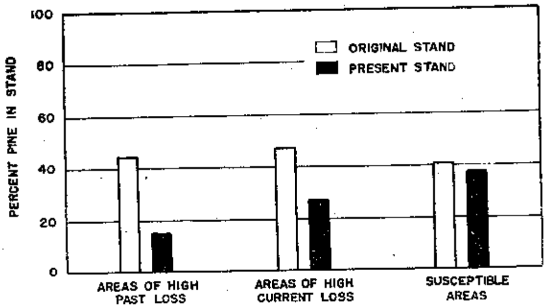

Fig. 3.—Effects of losses on composition of ponderosa pine-white fir pole stands.
Based on number of stems per acre above 4 inches d.b.h.

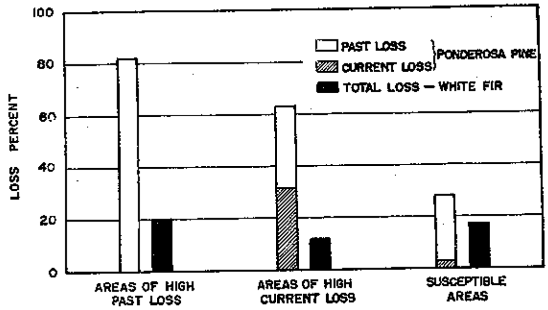

Fig. 4.—Comparison of loss by species in ponderosa pine-white fir pole stands.
Based on number of stems per acre above 4 inches d.b.h.

countered in setting up thinning studies, the present experiment was designed to follow the reactions of individual trees distributed throughout the stand, rather than to attempt to interpret the reaction of the entire stand on the basis of small plots as is ordinarily done. The plan necessitated the establishment of duplicate plots of approximately 7 acres in size, on each of which 160 ponderosa pine poles were selected which could be considered crop trees. Each crop tree was then taken as the center of a circular subplot having an arbitrarily defined diameter of 28 feet. The selection of crop trees was based on the dominance of the tree and the number of competing stems within the subplot. An attempt was made to secure a range of diameters and heights representative of the entire stand, and all competing trees within certain arbitrarily defined radial limits of the selected crop trees were removed. The treatments are summarized in Table 1.

The spacing and stocking indicated in the last two columns of this table would be attainable only under ideal conditions. Owing to the manner of occurrence of trees growing under natural conditions, and because of mechanical limitations in the experiment which cannot be described here, it was necessary to select crop trees from stands several acres in extent.

Complete descriptions and comprehensive measurements of diameter, height, crown length and width, growth rate, competition, and release have been prepared for all selected trees. These data will serve as a basis for showing the response of the trees to the thinning operation. It is hoped that the experiment will demonstrate that losses due to the mountain pine beetle may be prevented through the production of more vigorous trees.

It is much too early to expect any conclusive results from the thinning study. The foregoing description has been included in this paper because it represents a method of approach to the problem of thinning young stands that seems to merit wider use than it has had in the past.

SUMMARY

In northeastern California the mountain pine beetle is attacking and killing pine in young stands of ponderosa pine and white fir—a type commonly found on old burns and cut-over areas. In some areas the injury has been severe enough to change the ratio of the two species from approximately 50:50 to nearly 100 percent fir.

The effects of excessive competition in these stands, aggravated by a prolonged deficiency in precipitation, are reflected in a marked reduction in growth rate, particularly in the pine. Slow growth rate in young ponderosa pine is held to be indicative of low vigor, which appears to be associated with susceptibility to mountain pine beetle attacks.

A brief description is given of an experiment in thinning pine-fir stands in favor of the pine in order to produce more vigorous trees capable of resisting insect attack.

Tung Trees Tested

More than 40,000 tung trees — the beginning of what U. S. Department of Agriculture scientists hope will be a successful tung oil industry in the United States — were planted this spring in test orchards throughout the Gulf Coast region.

Sharp reduction in imports of tung oil because of the war in China and the generally unsettled conditions in the Far East have stimulated interest in growing tung trees in this country. Tung oil is an indispensable ingredient of quick-drying paints and varnishes.

For three years Bureau of Plant Industry specialists have been scouting tung orchards in the South for superior trees. Combing these orchards, they selected some 500 trees which were hardy, high yielding, and early maturing. Nuts from these trees yield a high percentage of good quality oil. About 80 of the best trees from this selected lot of 500 were then chosen for propagation. Thousands of young trees were produced from them. Many of these were killed in the freeze of last November, but the rest were planted in 13 test orchards — one in Texas, two in Louisiana, two in Mississippi, one in Alabama, four in Georgia, and three in Florida.

Besides breeding tung trees better adapted to the climate of this country which will yield larger quantities of oil, Department of Agriculture scientists are studying various problems of growing the trees. Chemists in the Bureau of Agricultural Chemistry and Engineering have found a way to recover practically all the oil.

These research men warn prospective tung growers, however, that the industry is still an expensive and speculative enterprise if attempted on a large scale. Tung trees do not bear for at least five years. They do not do well on infertile or poorly drained soil. Chances of loss because of freezing or some other cause are high.