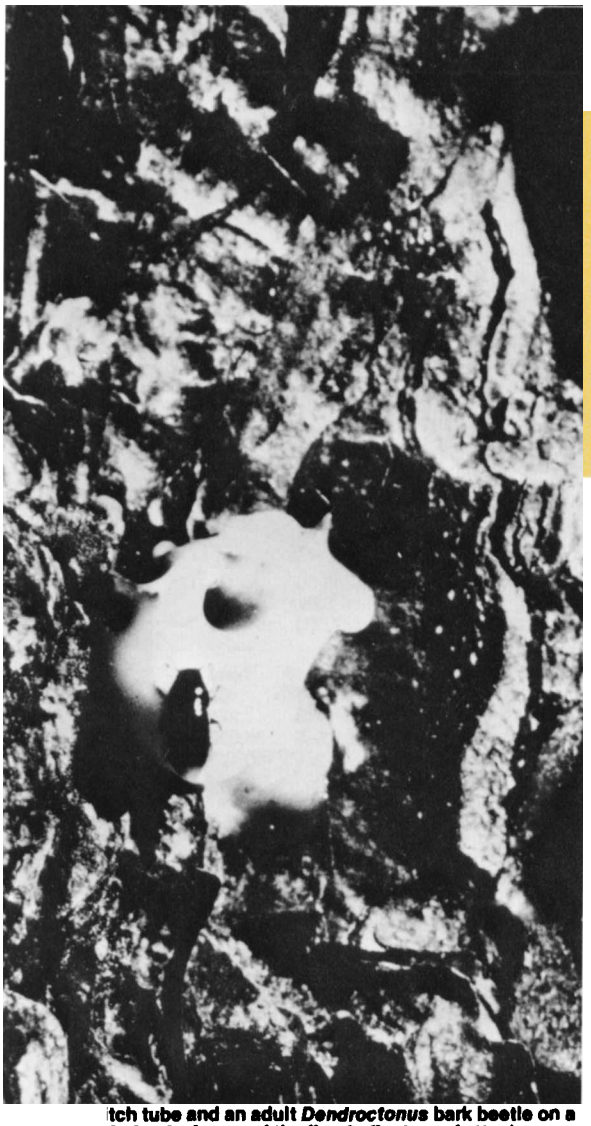

itch tube and an adult *Dendroctonus* bark beetle on a itch tube is one of the first indicators of attack.

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Mortality in second-growth Ponderosa pine timberlands caused by bark beetles, *Dendroctonus brevicomis*, the western pine beetle, and *D. ponderosae*, the mountain pine beetle (see fig. 1), may result in major economic losses in California. Widespread areas of pest-killed trees were evident during summer 1977 and spring 1978 because of the combined effects of two years of drought, insects, and diseases (fig. 3).

Blodgett Forest Research Station, University of California, is studying pest management problems faced by managers of public and private timberlands. It is located in El Dorado County's west-side mixed conifer-oak forest type of the central Sierra Nevada.

An infestation of bark beetles and the associated root disease fungus, *Verticicladiella wagnerii*, has been active at BFRS since 1955. Although extensive entomological and pathological research was undertaken, no attempts were made to silviculturally manipulate pine stands until summer 1977, when a thinning study was initiated on a 40-acre study area on the perimeter of the infestation.

This study used the "aggregation" approach to characterize groups of Ponderosa pines with high risk and low risk of bark beetle attack before stand harvest age. This approach recognizes that the mixed conifer forest is comprised of discrete vegetation aggregations (groups) which can be distinguished on the basis of species composition, forest structure (for example, height or basal area), and stand age. Each vegetation aggregation can change differently over time; therefore, accurate prediction of changes in forest vegetation requires recognition and analysis.

The present study characterized Ponderosa pine aggregations to predict what types of pine aggregations will suffer significant losses caused by bark beetles and root disease fungus. Other studies of pine mortality caused by bark beetles have used individual tree data or sample plot data. In the westside Sierra mixed conifer-oak forest type, individual tree risk rating systems have not correlated well with insect attack and mortality. Also, randomly or systematically located sample plots generally are placed independently of the heterogeneous character of forest vegetation and are therefore less effective at predicting accurately beetle- and disease-caused vegetation change.

The hypothesis of the present study is that susceptibility to beetle attack is related to the vigor of the aggregation as a collective unit rather than to growth rates of individual trees.

The BFRS study area is located at approximately 4300 feet elevation on gently sloping Site Index 140 forest land —even-aged young-growth Ponderosa pine of the westside Sierra Nevada (Arvanitis, Lindquist, and Palley, 1964). Annual precipitation averages 66 inches. During the first phase of the study, 38 aggregations, dominated by Ponderosa pine, were characterized by structure and growth rate. These aggregations have from 60 to 100 percent crown cover with 70 to 100 percent of this total in Ponderosa pine. Other overstory species present are White fir, Sugar pine, and Douglas-fir. The predominant understory

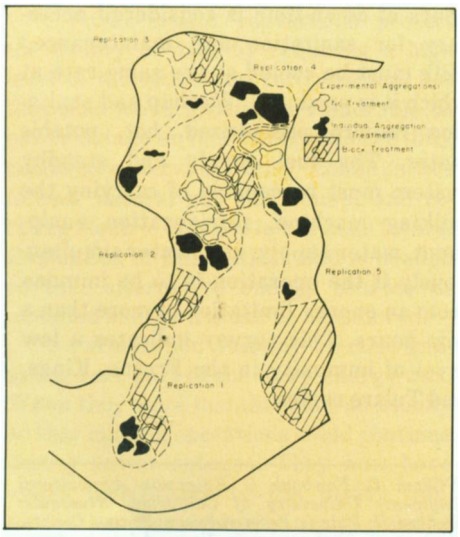

Fig. 2. Map of experimental replication groups in the BFRS study area, Compartment 450.

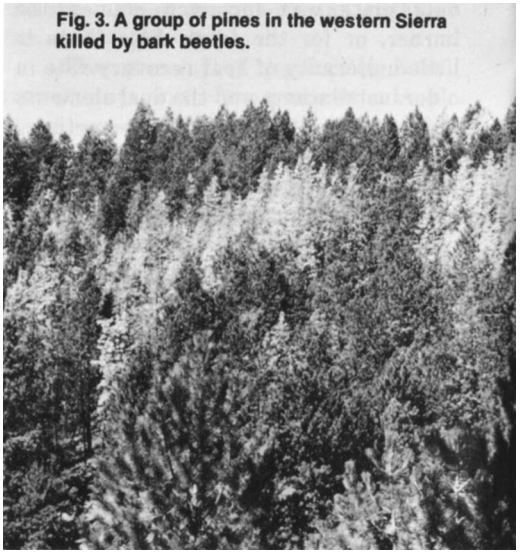

Fig. 3. A group of pines in the western Sierra killed by bark beetles.

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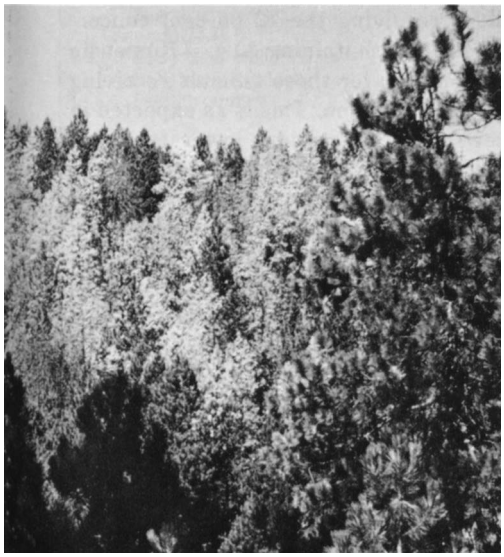
Stone ■ Donald L. Dahlsten ■ Robin Akers

species is Incense-cedar. Average aggregation size is one-tenth acre with a range from one-twentieth to one-half acre. All aggregations are second-growth and even-aged, with stand ages ranging from 40 to 70 years. Basal areas (estimated by 20 Factor prism) vary from 170 to 650 ft²/acre. Nineteen of the aggregations have past or present bark beetle activity (fig. 4), and 19 have no evidence of bark beetle attack.

Aggregation vigor was characterized by coring ten Ponderosa pines, measuring five-year radial growth, and calculating basal area growth rate for each tree. These individual tree values were averaged to determine a mean basal area growth rate for each aggregation.

Figure 5 shows a plot of the basal areas/acre against the mean basal area growth rates for the 38 aggregations. The symbol for each aggregation with past or present bark beetle activity is shaded. Pine aggregations with high risk of bark beetle attack can be characterized as having basal area greater than 350 ft²/acre and mean basal area growth rate of less than 0.26 ft²/5 years. For a 20-inch tree, this growth rate is equivalent to more than eight rings per inch.

The second phase of the study was to set up a silvicultural experiment to evaluate the effectiveness of thinning to reduce Ponderosa pine aggregation susceptibility to bark beetle attack. Fifty high-risk aggregations were identified and mapped on the 40-acre study area. All Ponderosa pine stems were cored to assess tree growth rates. All aggregations had basal areas greater than 300 ft² /acre and mean basal area growth of less than 0.26 ft²/5 years.



The 50 experimental aggregations were grouped in 15 geographical blocks (fig. 2). Each set of three adjacent blocks became one of five replications. Within each replication the three blocks were randomly assigned to (1) no treatment, (2) treatment of only experimental aggregations, and (3) treatment of all aggregations in the block.

The experimental thinning treatment will be applied during summer 1978 and will consist of a combination of crown and low thinning to reduce aggregation basal area to approximately 200 ft²/acre residual in overstory stems. Trees removed will be primarily co-dominants, with removal of some dominants guided by individual tree growth rates. All intermediate and suppressed crown classes will be removed. The objective is to create vigorous, even-aged Ponderosa pine aggregations, characterized by a 200 ft²/acre basal area residual stocking, the square-spacing requirements associated with 200 ft²/acre, and mean basal area growth greater than 0.26 ft²/5 years.

All residual stems in experimental control and treatment aggregations are tagged and will be monitored over a ten-year period for bark beetle-caused mortality and growth-rate response. Population densities of bark beetles will also be monitored throughout the study period. Subsequent evaluation of this experiment will determine the silvicultural and economic effectiveness of using basal area thinning guidelines to reduce the likelihood of bark beetle attacks on Ponderosa pine in the westside Sierra.

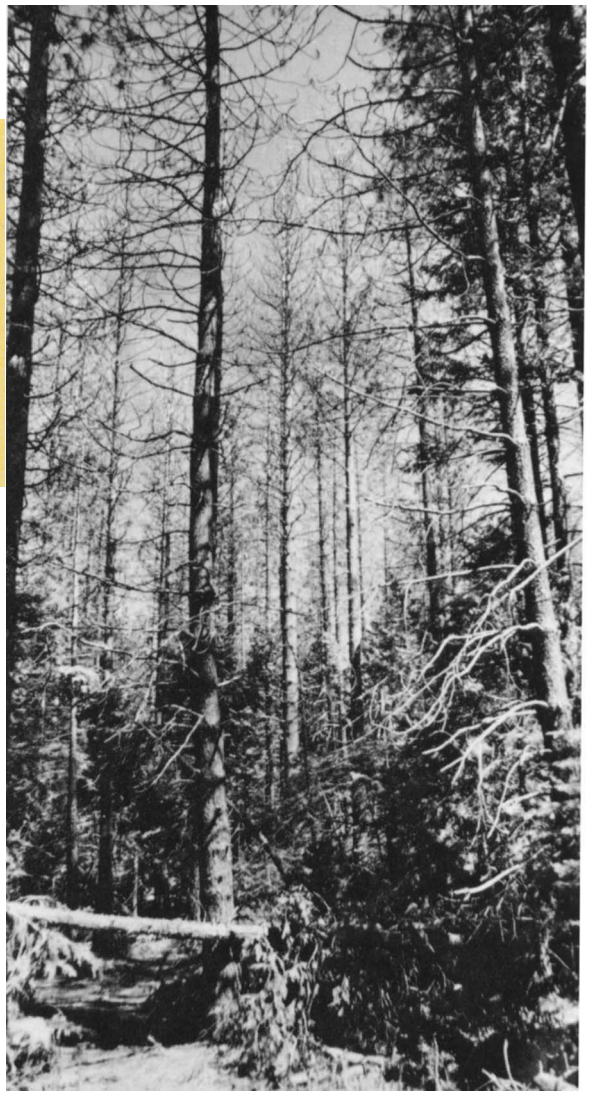


Fig. 4. An aggregation of Ponderosa pine at Blodg killed by the interaction of stocking, bark beetles disease.

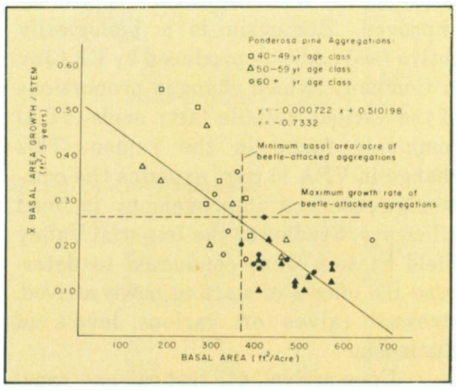


Fig. 5. Growth rates and basal areas of 38 Ponderosa pine aggregations at Blodgett Forest Research Station, El Dorado County. Solid symbols indicate past or present bark beetle activity.

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