FOREST RESEARCH LABORATORY
RESEARCH NOTE 65

a simple model of host resistance to bark beetles

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While studying why bark beetles attack certain pine trees and ignore others, we hypothesized that the amount of carbohydrate reserves available basically controls host resistance. Apparently the monoterpene chemistry of the phloem which attracts beetles differs when reserves are high or low. Moreover, the available carbohydrate reserves also determine the ability of a tree to produce oleoresin and other chemicals which protect it against beetles and subsequent blue stain.

A tree has certain requirements that must be satisfied if it is to live. The roots (Harris et al. 1978, Fogel and Hunt 1979), shoots (Gordon and Larson 1968, Rangnekar and Forward 1973), and even cones (Eis et al. 1965) take priority over stemwood growth. Thus, a decline in stemwood production should indicate a limitation by carbohydrate reserves—and, therefore, increased susceptibility to bark beetles.

Because large trees usually grow more stemwood each year than smaller ones, we faced the problem of generalizing the relative extent of carbohydrate reserves available. Growth in stemwood volume or biomass can accurately be estimated by extracting a small core from the stem and determining the cross-sectional area grown in the current year. Because foliage biomass or leaf area correlates linearly with the cross-sectional area of conducting tissue at breast height or 1.37 m (Grier and Waring 1974), we normalized growth in terms of a square meter (m^2) of foliage. We thus proposed that trees with high resistance would produce a relatively large amount of sapwood each year, whereas susceptible trees would produce much less. In lodgepole pine (*Pinus contorta* Dougl. ex Loud.), we can directly convert this ratio of basal-area growth/sapwood basal-area to stemwood biomass (kg)/m^2 of foliage by multiplying by 0.87 (Gholz et al. 1979).

We wished to establish the number of beetle attacks required to kill trees at different levels of resistance—that is, having different ratios of basal-area growth/ sapwood basal-area. After beetles attacked plots near our study in 1978, we surveyed 75 trees by measuring the diameters at breast height, counting the attacks in a 30-cm band (± 15 cm from breast height) encircling the tree, then calculating the beetle attacks per square meter of bark surface.

Figure 1 summarizes our findings. None of the attacked trees had vigor indices above 15 percent (15% of the sapwood laid down in the current year). No trees with vigor indices above 8 percent were killed because attack densities did not exceed 200/m^2. Trees with vigor indices below 8 percent could be killed if beetles attacked in densities equal to or greater than about 24 times the vigor index. For example, trees with vigor indices of 5 percent could be killed by attacks exceeding 120 beetles/m^2.

Having modified the vigor index of hundreds of trees by thinning, fertilizing, and stressing with additions of sugar and sawdust, we now are testing the accuracy of the model to predict mortality on more than 100 recently attacked trees.

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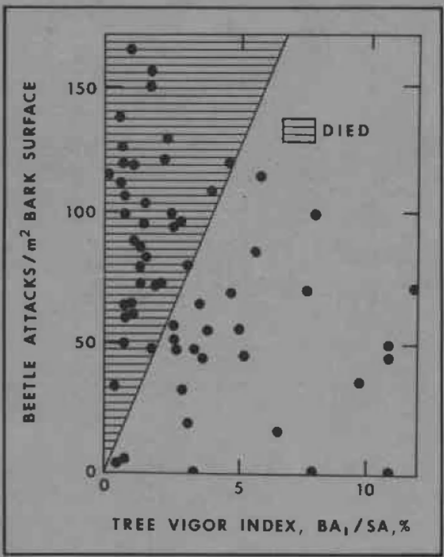

Figure 1.

Mortality of lodgepole pine in relation to intensity of beetle attack and tree vigor index.

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