# MOUNTAIN PINE BEETLE INFESTATION:
# CYCLING AND SUCCESSION IN LODGEPOLE PINE FOREST

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## Objectives

A research project was initiated in 1980 to study the effects of outbreaks of the mountain pine beetle (Dendroctonus ponderosae) on lodgepole pine forests (Pinus contorta spp. latifolia) in Yellowstone National Park and surrounding areas. This native bark beetle recently has killed millions of trees over thousands of square kilometers in the central and northern Rocky Mountains. Major outbreaks first occurred in Grand Teton National Park in the 1950's and in Yellowstone National Park in the 1960's. The outbreak in Yellowstone Park is still spreading.

The immediate effects of bark beetle outbreaks are well documented (Roe and Amman et al. 1977), and much research has been directed toward understanding the beetles' population dynamics and the causes of outbreaks (Coulson 1969, Berryman 1976). However, much less work has been done to clarify long-term effects of outbreaks on ecosystem processes and phenomena such as primary productivity, nutrient cycling, and succession. Mattson and Addy (1975) and McNaughton and Coughenour (1981) suggested that phytophagous insects like the bark beetle may regulate primary productivity through their effects on resource distribution and availability. Therefore, our research focuses on the effects of beetle outbreaks on (1) rates of growth in surviving trees and total stand productivity, (2) dead woody fuels and fire risk, (3) stand succession, and (4) nutrient cycling.

## Methods

To measure effects on surviving tree growth, we selected a chronosequence of ten stands affected by a major beetle outbreak from 1-20 years ago. In each stand we collected increment cores from surviving canopy, subcanopy, and understory trees, and measured mean annual ring width during the 5 years immediately preceeding the beetle outbreak and during various periods after the outbreak. We also collected cores from two control stands unaffected by the beetles but otherwise similar to the affected stands, and measured mean annual ring width during comparable time periods.

To determine effects on total stand productivity, we sampled tree density before and after the beetle outbreak in four of our stands using belt transects in which we tallied living trees and trees killed by the beetles. We then calculated mean annual bole volume increment during 5-year intervals before and after the outbreak using radial growth and tree height data. We multiplied mean annual increment per tree by the number of trees per hectare to estimate total annual bole volume increment per hectare before and after the beetle outbreak.

We studied dead woody fuels using two methods. The first was a comparative stand approach in which we inventoried fuels using the planar intersect method (Brown 1974) in a chronosequence of 11 stands affected by beetle outbreaks from 0-20 years ago. All 11 stands had been similar prior to the outbreaks. This work has been completed. Our second method is a simulation approach, which we expect to complete in February, 1983. We collected data on tree size, density, and pre-outbreak fuel loads in three stands not yet affected by the beetles. We are simulating a beetle outbreak in these three stands by selectively killing trees of certain size classes at various times in accordance with descriptions of the course of a major outbreak in this area (Parker 1973). The fuels contained in these dead trees are estimated using regressions developed by Brown (1978). By adding these new fuels to already existing fuel levels on the forest floor, and including the effects of normal background rates of litterfall and decomposition (Fahey 1982), we will simulate changes in dead woody fuel mass for 15 years following a beetle outbreak.

To measure effects on nutrient cycling, we established 36 tubetension lysimeters (Parizek and Lane 1970) in 1980 in two stands near West Yellowstone. Leachate was collected during the snowmelt periods of 1981 and 1982, and will be collected again in 1983. Elemental concentrations will be determined in our laboratory in Laramie, and will be used with our stand level hydrologic model for lodgepole pine forests (already developed with NSF funds) to estimate the magnitude of nutrient loss associated with a beetle outbreak.

## Results

We have completed our analyses of the effects of beetle outbreaks on surviving tree growth and stand productivity, and are presently writing this portion of our final report. In all 10 stands sampled, most surviving trees grew significantly faster after the outbreak than before. Total stand productivity decreased during the first 5 years after the outbreak, due to the death of many large trees, but after 10-15 years it had returned to its pre-outbreak level as a result of accelerated growth the survivors (Figure 1). Annual wood production actually increased after the outbreak in stand #1 (Figure 1).

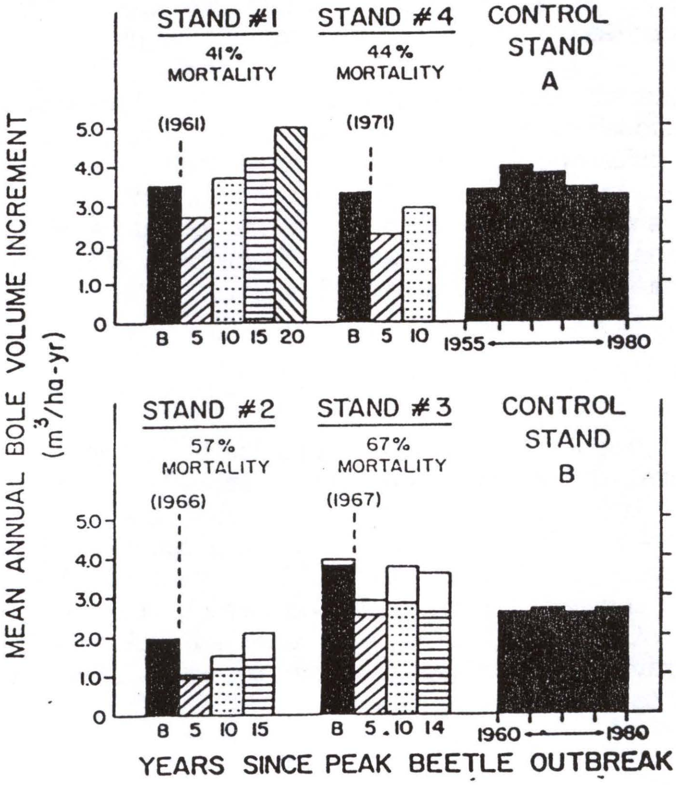

Fig. 1. Mean annual bole volume increment before a beetle outbreak (B), 1-5 years after the outbreak (5), 6-10 years after (10), 11-15 years after (15), and 15-20 years after (20) in four stands. Mean annual increments during comparable 5-year periods are also shown for the two control stands. The open portions of the columns represent understory production; the shaded or striped portions represent canopy and subcanopy production.

In our comparative stand approach to fuels, we found that total dead woody fuels (kg/ha) increased significantly with increasing number of years since the beetle outbreak. However, most of this fuel mass consists of large tree boles which do not ignite readily. Analyses of individual fuel components revealed no significant relationships between fuel quantities and time since the outbreak, nor significant differences between stands affected by beetles and stands not affected. Even with careful stand selection, inherent variability in fuel characteristics among lodgepole pine stands obscures the effects of beetle outbreaks in this type of approach. Therefore, we expect that our fuel simulation approach will be more rewarding.

## Conclusions

Mountain pine beetle outbreaks dramatically alter stand structure and accelerate natural forest succession by selectively killing a large fraction of dominant canopy trees, thus releasing understory trees from suppression. Total productivity decreases for ca. 5 years after the outbreak, but usually returns to pre-outbreak levels or higher within 10-15 years. The beetle-killed trees contribute to an increased total fuel load, which may lead to higher fire risk. Massive beetle outbreaks of the type that we studied do not appear to regulate primary productivity in lodgepole pine forests, although smaller endemic populations may function in this manner.

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