

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

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Objectives

A research project was initiated in the summer of 1980 to study the effect of mountain pine beetle (Dendroctonus ponderosae Hopkins) outbreaks on forests dominated by lodgepole pine (Pinus contorta Dougl. ssp. latifolia) in Yellowstone National Park (YNP), Wyoming. In the past twenty years, beetle outbreaks have become an increasing problem in the Park. These series of infestations first appeared in the Bechler Meadows area in the early 1960's, and have since spread northward with the most recent outbreaks occurring in stands along the Gallatin River. Based on aerial surveys, the highest concentration of beetle activity is currently centered in the West Yellowstone-Madison River Canyon area of the Park. Since bark beetle infestations are a natural disturbance or perturbation similar to fire, knowledge of the structure and function of the forest on disturbed patches is vital to the ecological understanding of the landscape. Although the population ecology of mountain pine beetle in pine forests has been well documented (Coulson 1979), little has been done on their effect on ecosystem characteristics. Our approach has been to study 1) various nutrient cycling characteristics, 2) surviving tree growth, 3) succession, and 4) fuel accumulation patterns in a series of stands with different histories of beetle disturbance. The stands were selected to represent a chronosequence of beetle activity, dating from about 1965 to the present.

Even under outbreak conditions the beetles do not kill all the trees in a stand, infecting the larger trees instead (Safranyik et al 1975, Geiszler et al 1980). The recycling of larger, mature trees through beetle-caused mortality should release bound nutrients, and therefore benefit the growth of surviving individuals. However, the accumulation of dead trees in a stand should also create fuel conditions which increase the probability of fire (Brown 1975).

The data on ecosystem characteristics in disturbed and control stands will be used to develop a conceptual model for the interaction between fire and mountain pine beetle in the lodgepole pine forest of YNP. The model should prove useful for predicting the re-establishment of stands following beetle disturbance.

Methods

Nutrient outflow from two beetle infested stands and suitable controls in the West Yellowstone area is being sampled using 36 tube-tension lysimeters (Parizek and Lane 1970) imbedded in the soil to a depth exceeding the major rooting zone (50 cm). Initial collection of leachate samples will be performed during the 1981 spring snowmelt period and periodically during the snow-free period. Samples will be preserved and returned to the University of Wyoming-Botany Department for analysis. In order to quantify the volume of water leaving the stands we will apply a stand level hydrologic model for lodgepole pine forests. This model, which is available on the University of Wyoming computer, will predict water flux from the infested and control stands using relatively easily measured parameters of forest structure. By multiplying water output by the elemental concentrations of the leachate, total nutrient output will be calculated.

Growth response of trees in 9 beetle infested stands will be determined from annual growth increments based on increment cores taken during the summer of 1980. Although it is often difficult to assign an increase or decrease in growth to one specific environmental factor, our use of tree ring analysis will provide a relative measure of growth response of residual trees in beetle-infested stands.

Forest succession was studied in 18 closely adjacent stands that are in the same habitat but have different histories of beetle disturbance. In each stand overstory trees were sampled using 20 point-centered quarter (Cottam and Curtis 1956) placements in a stratified-random design, while saplings were sampled in 20 randomly placed 2 X 2 m quadrats. Using these methods, stand structure was evaluated in terms of species frequency, density, and basal area. Understory structure has not been evaluated at this time.

To evaluate the likelihood of fire in relation to beetle disturbance, fuels will be sampled during the summer of 1981. The planar intercept method (Brown 1974) will be used to sample larger fuels and the quadrat method for fine fuels (duff and litter). Approximately 20 transects or planes will be counted in each stand. In order to evaluate fuel accumulation patterns, relationships of fuel components (size classes) to the age of the disturbed stand and time since infestation will be examined.

Results

Mountain pine beetles kill approximately 50% of the lodgepole pine trees (46% of the stand basal area) during a 6-11 year infestation period (Table 1). In stands in late years of an infestation (period 1), tree-fall of beetle killed trees lowered the density and basal area of standing dead trees. Approximately 22% of the standing trees were beetle-infested in stands in early ages of infestation (period 4), although many green trees showed evidence of beetle attack (per-

Table 1. Mean (and standard error) density (stem/ha) and basal area (m²/ha) values for lodgepole pine, spruce, and fir in stands with five histories of beetle disturbance. All data was collected in early summer 1980.

	Time period*				
	1 1965-1970	2 1969-1974	3 1972-1976	4 1976-1980	5 Control
<u>Density</u> Live LPP\$	650 (290)	370 (60)	490 (60)	640 (170)	1020
Dead LPP	340 (200)	350 (150)	120 (20)	--	40
Red LPP	17 (8)	12 (12)	20 (5)	180 (17)	80
Spruce	--	--	11 (7)	--	--
Fir	--	--	26 (18)	--	--
<u>Basal Area</u> Live LPP	21 (4)	20 (2)	26 (4)	16 (3)	38
Dead LPP	12 (3)	17 (2)	7 (1)	<1	<1
Red LPP	1 (<1)	2 (1)	2 (1)	9 (1)	6
Spruce	--	--	<1	--	--
Fir	--	--	<1	--	--
<u>Number of</u> <u>Stands</u>	3	4	5	5	1

* - Periods of highest beetle activity; 1 = Oldest infestation;...; 4 = recent infestation.

£ - Dates represent the years of highest beetle activity in the stands.

\$ - LLP = lodgepole pine: live = not attacked; dead=standing beetle killed; red = beetle infested.

sonal observation). The control stand, which is presumably pre-infestation, had 80 infested trees and 40 dead trees $\cdot \text{ha}^{-1}$, indicating that a low level, endemic beetle population exists in the lodgepole pine forests of YNP.

Although beetles were observed to attack large and small trees, data analysis for infested trees (Table 2) suggest that larger trees are preferentially attacked. The smaller mean diameter for dead trees indicates tree-fall occurs primarily for the larger sized beetle-killed trees. The high variance of diameters of dead trees in periods 1-3 indicates a wide size range of trees that were attacked by beetles in the later stages of an infestation. These results are opposite those of Geiszler et al (1980) who found that beetles in lodgepole pine forests in Oregon were more selective (lower variances) in the later years of the infestation.

Preliminary data analysis suggest that beetles continue to be active in lodgepole pine stands for at least 10 years after their highest activity, although their influence on forest stand structure changes between initial infestation and the later stages of the attack.

Conclusions

From the preliminary data collected, it is evident that mountain pine beetles alter stand structure of lodgepole pine forest by killing about 50% of the individual trees. Continued study of the surviving individuals and fuel accumulation patterns will enable prediction of the rate and course of succession in beetle disturbed stands.

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Table 2. Mean (and variance) diameter (dbh cm) of live, dead, and red lodgepole pine in stands with five histories of beetle disturbance. All data was collected in early summer 1980.

Time period [*]	1	2	3	4	5
Years [‡]	1965-1970	1969-1974	1972-1976	1976-1980	Control
Live LPP [§]	22.76 (24.21)	26.80 (38.40)	25.96 (41.12)	17.32 (9.04)	21.23 (11.33)
Dead LPP	22.53 (25.00)	26.14 (38.81)	28.02 (34.29)	11.76 (1.00)	15.16 (1.60)
Red LPP	32.31 (30.56)	34.77 (4.01)	33.53 (79.76)	25.63 (12.37)	29.72 (6.45)
Number of Stands	3	4	5	5	1

* - Periods of highest beetle activity; 1 = Oldest infestation;....; 4 = recent infestation.

‡ - Dates represent years of highest beetle activity in the stands.

§ - LPP = lodgepole pine: live = not attacked; dead = standing beetle killed; red = beetle infested.

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