

ALTERNATIVE SOLUTIONS PREVENTIVE MANAGEMENT AND DIRECT CONTROL

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In developing alternative solutions to the mountain pine beetle problem, we must consider the main features of the evolved interaction between the beetle, with its associated microorganisms, and lodgepole pine forests. Principally, the mountain pine beetle is a pest of mature forests. Under endemic conditions, a large number of factors (such as: climatic effects, directly on the insect and indirectly through the tree; relations with blue-stain fungi and with the tree; competition for food and space; and parasitism, predation, and disease) interact to restrain the potential of such populations to increase. The relaxation of the effects of some of these factors may permit outbreaks to develop. There is evidence to indicate that a decline in host resistance and a decline in favorable climatic conditions for survival and multiplication of the beetle are the major causes of outbreaks. Host resistance (i.e., resin production in response to the blue-stain fungi carried into the tree by the beetle), as well as beetle production in trees following successful attacks, are strongly affected by tree parameters, site and stand factors, and climatic conditions. Thus, in the optimum range of its distribution, the beetle is food-limited in the endemic state, and outbreaks are a consequence of an abundance (epidemic?) of susceptible trees. These factors point to the following principles for developing alternative solutions to the mountain pine beetle problem.

- Focus must be on management of lodgepole pine forests, not the mountain pine beetle.
- Management will involve altering those stand conditions that favor the buildup of beetle

populations, with consideration for all resource values and for other tree mortality factors.

Thus, in lodgepole pine forests managed principally for timber production, alternative strategies and treatment procedures for reducing losses from the mountain pine beetle must emphasize biologically sound sustained yield silviculture that includes the beetle problem as one of the factors.

APPROACHES TO REDUCING LOSSES

Basically, there are two approaches to reducing losses from the mountain pine beetle in lodgepole pine forests: long-term (preventive) forest management and direct control.

The strategy of preventive management is to keep beetle populations below injurious levels by limiting their food base through forestry procedures designed to maintain or increase tree/stand resistance. Preventive management addresses the basic cause of epidemics, which is stand susceptibility, and is considered the most satisfactory long-term solution. In contrast, suppression of beetle populations by killing them, using various methods of direct control, treats a symptom of the problem (too many beetles) and therefore its effects are apt to be only temporary. However, when properly used, direct control can be effective both in reducing the rate of the spread of, and intensification of, infestations and in being a holding action until the susceptible trees can be

disposed of. It must be emphasized, however, that preventive forestry practices can reduce, but not eliminate, the chance of outbreaks in lodgepole pine forests. Therefore, both preventive and suppressive methods are needed for reducing losses to acceptable levels.

Preventive Management

Preventive management has three components:

1. Setting of management goals.
2. Definition of acceptable risk of loss from mountain pine beetle infestations.
3. Prescription of management practices.

Normally, the setting of management goals is based on: consideration of policy; productivity of wood and/or other resource values; the product requirement; and the economics of the operation. Because management goals and constraints are changeable, alternative methods of reducing the losses are needed. In areas of high hazard, with almost constant pressure exerted on lodgepole pine forests by the mountain pine beetle, the setting of management goals should consider the risk of loss in the event of an outbreak. This applies not only to forests managed for timber production, but to all areas where the buildup of beetle populations could pose a threat to adjacent commercial forests.

The risk of loss from mountain pine beetle depredation is determined by risk-rating. Definition of risk involves two components: (1) probability of an outbreak within set time periods; and (2) expected loss in the event of an outbreak. We do not have reliable methods for predicting outbreak probability, but we can predict stand depletion (i.e., the chance of a certain size tree being killed) in terms of stand structure. Because of our inability to predict outbreak probability, the risk-rating systems that have evolved predict risk of loss only in relative terms. To date, about 6 risk-rating systems have been developed, but they are all based on the climatic and tree/stand variables that have a major effect on beetle survival and distribution—such as: temperature (absolute, relative); tree age, size, and periodic growth rate; and stand density and purity.

In the United States, the stand hazard-rating system, developed by Dr. Amman, has been used operationally during the past 4 to 5 years. This system involves

a 3-point rating (1, low; 3, high) of each of 3 factors—elevation/latitude, average age (years), and DBH (inches). Risk is determined as the product of the scores for these factors: low = 1 to 6, moderate = 8 to 18, high = 27. All lodgepole pine types on the national forests in Montana have now been hazard-rated. Implementation of hazard surveys, on the Kootenai National Forest and subsequent salvage logging of infested and susceptible stands, has slowed the mountain pine beetle infestations.

In western Canada, we have developed a regional hazard-rating system, based on the suitability of climate for the survival of and multiplication of the beetle. In this classification, areas where the climate is favorable to the beetle in most years received a high-hazard rating and areas where climate is usually unfavorable, received a low rating. During the 1970s, this system performed quite well in most areas, with the exception of southwestern Alberta. Generally, in areas with the three highest outbreak ratings, all infestations are likely to develop into outbreaks. In view of the relatively high probability of recurring infestations in mature lodgepole stands in these areas, rotation age, based on attainment of maximum wood production rate (physiological rotation) is the best guideline to minimize losses. Within each climatic hazard area, stand susceptibility can be appraised based on a simple system involving stand characteristics, as shown in Table 1.

Table 1
Stand Susceptibility

Rating	Description
Low	Stands less than 60 years old
Moderate	<ol style="list-style-type: none"> 1. Stands older than 60 years, prior to culmination of Mean Annual Increment (MAI) 2. Stands past the culmination MAI, average DBH less than 20 cm
High	<ol style="list-style-type: none"> 1. Well stocked stands past culmination of MAI, average DBH greater than 20 cm 2. Open stands past the culmination of MAI, average DBH greater than 20 cm

Using either of these systems, we can predict risk of loss from mountain pine beetle in lodgepole pine forests. When this risk is acceptable, management plans need not consider mountain pine beetle depredation. However, when the risk is too high, the manager needs to consider the following options: (1) shortened rotation (based on the greatest acceptable risk); (2) type conversion; (3) mixed species stands; (4) age and species mosaics; (5) partial cuts; (6) stocking control; and (7) do nothing. The choice among these management options should be based on silvicultural considerations, resource values, and consideration of other pest problems.

Shortened rotation is a viable option when lodgepole pine is the desired species and when a smaller tree size than originally specified can be grown at an acceptable risk, which would still satisfy the product requirements and the economics of the operation. Type conversion can be an attractive choice when most of the objectives of management can be met equally well with different forest types. Even though the mountain pine beetle appears to infest mixed stands as readily as pure stands, following an outbreak, the overall stocking and wood production would be higher in mixed than in pure lodgepole pine stands. Achieving a mosaic of age classes and tree species places a minimum area in stands susceptible to the beetle, making fast removal and/or application of direct control action more feasible. This option takes careful long-range planning, good roads and markets, and, above all, time. Partial cuts can be used to advantage in order to reduce the losses from impending outbreaks through overwood removal, shelterwood, and group selection cutting under the following conditions: (1) clearcutting is not compatible with multiple use objectives; (2) combinations of high forest and openings are desired; and (3) regeneration after clearcutting is difficult. This method is especially attractive when environmental and visual impacts preclude clearcutting. However, dwarf mistletoe infection and windfall susceptibility can be serious drawbacks on some sites. This form of treatment has been used with excellent results in Middle Park, Colorado (all 12 inch-plus trees and as many 10 to 11 inch trees were removed as necessary to make up the remaining basal area of the cut). Experiments with diameter limit cuts indicated that removal of the infested and susceptible trees from the stands (trees greater than 10 inches DBH) is also effective in reducing further losses.

The first five management options listed above are viable, regardless of the nature of tree/stand

susceptibility. The sixth option, stocking control (which is a very important practice in managed, pure, even-aged lodgepole pine forests), offers two exciting options, in view of the increasing evidence on the role of tree vigor in host resistance. Firstly, through stocking control, diameter and phloem thickness could be controlled and held to distributions that are not favorable to the mountain pine beetle. Or alternatively, early stocking control and management practices for increasing the rate of growth (thinnings, genetic improvements, and fertilization) could raise the vigor of trees so that present age/size limits of tree susceptibility would not be restrictive.

There is now some experimental evidence to indicate that spacing and fertilization can, in fact, reduce the incidence of attacks by mountain pine beetle. Since the possibility of using stocking control for reducing losses from the mountain pine beetle has such important practical implications, much more intensive research is urgently needed on this subject.

The do-nothing policy may be a viable option on forested areas not included in commercial timber production. As far as esthetics are concerned, infestations (both far and close views) may have little impact on the viewer. However, dead timber can have an enormous impact on access for recreation and wildlife, buildup of fuel, fire hazard, and plant succession. Therefore, a fire management program, utilizing prescribed fires in combination with some "safe" wild fires, may be more appropriate and ecologically more desirable than the no action policy.

Direct Control

Direct control is expensive in time, effort, and resources, and in spite of its long history, there is no general agreement among scientists and foresters regarding its effectiveness in reducing losses. Recently, however, both theoretical work and field experiments indicated that direct control can be a sound strategy and that tactics can be developed to implement it. Experience suggests that, in order to be effective, suppression work should be based on the following principles:

- Early detection and control action over the entire infested area within 1 to 2 years.
- Continue control work as long as necessary.
- Thorough treatment and follow-up surveillance.

Since direct control is expensive, it is usually prohibitive to treat all infestations. Therefore, susceptible lodgepole pine forests need to be prioritized, based on economic or other value criteria, and control work needs to be applied only to the most valuable stands. These stands are to be resurveyed yearly for mountain pine beetle activity, and as soon as an infestation is discovered, a decision should be made on the feasibility of control action. If control action is not feasible, the options are salvage logging or no action. If control action is feasible, direct treatment is applied, involving sanitation cutting, controlled burn, single tree treatment, or a combination of these methods. The direct control techniques are as follows.

1. Methods to kill beetles under the bark:
 - (a) Pesticides (systemic, bark-penetrating) on unbaited or pheromone-baited trees.
 - (b) Heat (burning, solar).
 - (c) Mechanical (debarking, processing).
 - (d) Water (sprinkling, submersion).
2. Methods to protect trees from fatal attacks:
 - (a) Lethal trap trees baited with pheromone and treated with insecticide.
 - (b) Protective chemicals.

In practice, sanitation salvage logging is favored because it is usually more cost effective than individual tree treatment. Also, salvage operations utilize infested timber and reduce both the number of beetles and their potential food source. Individual tree treatments usually do not yield any salvage value and it is difficult to thoroughly treat large areas. However, these methods are more suitable for treating isolated spot infestations, especially in remote locations or in areas where logging is not permissible.

SUMMARY

There are two basically different strategies for reducing the losses from mountain pine beetle in lodgepole pine: (1) preventive management and (2) direct control. Preventive management is based on manipulation of tree and stand conditions to reduce stand susceptibility, and it offers a satisfactory long-term solution to the mountain pine beetle problem. Preventive management involves: (a) setting an acceptable level of loss; (b) determining the long-term management goals; and (c) prescribing silvicultural procedures to attain these goals. Six silvicultural treatments are identified. The choice among these treatments is dictated by the resource values, forest pathology conditions, and, in the case of commercial timber lands, sound, renewable-resource silviculture. Direct control is expensive, difficult to implement, and, at best, offers only a short-term solution to the mountain pine beetle problem. Protective management and direct control complement each other and, ideally, should be combined in an integrated program for reducing losses from the mountain pine beetle. Further research is implicated in the following areas:

- The predicting of, and probability of, attack for various stand types.
- The potential of stocking control and other stand improvement methods in preventive management.
- The effectiveness of selective cutting in reducing losses.
- The effectiveness of early direct control action.
- New and improved techniques of direct control.

The potential benefits from such work, regarding the reduction of losses from the mountain pine beetle, would be considerable.