ALTERNATIVE SOLUTIONS TO MOUNTAIN PINE BEETLE THE SILVICULTURE PERSPECTIVE

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Lodgepole pine (*Pinus contorta*) is considered by many the "Cinderella" species of the west. It grows rapidly under management, has fewer regeneration problems than most of its associates, has wide ecological amplitude, has the potential for short rotation management, grows in areas that encourage management for a variety of resources, and has very desirable wood qualities. In addition, it occupies millions of acres in the United States and Canada, and it is the primary timber resource for many communities in the west.

Fire, mountain pine beetle (*Dendroctonus ponderosae*), and dwarf mistletoe (*Arceuthobium americanum*) are three of the major natural factors affecting lodgepole pine forests. These three, plus a host of more subtle factors, are the driving forces in the successional patterns of lodgepole pine forests.

My intention in this paper is to briefly describe the ecological amplitude, the key silvical characteristics, some of the silvicultural methods available to the forest manager, the compatibility of these methods with the silvical characteristics, and, lastly, the information gaps that I feel need to be filled before effective management of these beetle-plagued forests can become a reality.

ECOLOGICAL AMPLITUDE

The ecological amplitude of lodgepole pine has been well described (Lotan and Critchfield, 1982), and I won't belabor those points here. Suffice to say, that lodgepole grows in climates of the western United States and Canada that range from warm to cool and dry to wet. Perhaps the best illustration of this is that it grows in 27 of the 55 western forest cover types recently delineated by the Society of American Foresters (SAF, 1980), occurring in mixtures with some hardwoods and a host of different conifers in various portions of its range. In some cases, it occurs in near pure stands.

Successional Role

Lodgepole pine is included in several of the forest vegetation classification schemes that have been developed, or are in the process of being developed, where lodgepole pine forms part or all of the forest. Most of these classifications, such as the Daubenmire and Daubenmire (1968) and Pfister et al. (1977) systems, are based on the climax vegetation association of overstory and understory, stratifying the vegetation into "habitat types". These classifications provide workable methods of stratifying these diverse lands and forests into productivity, capability, and potential management classes.

These habitat types and cover types provide us some of the tools we eventually need for stratifying lodgepole pine forests in terms of how, when, and where mountain pine beetle will be a problem, what will be the susceptibility and vulnerability of these forests, and, most significantly, what silvicultural options can be used to cope with the mountain pine beetle.

Although most of the habitat, or cover, types eventually need to be examined in terms of the mountain pine beetle, for simplification I have chosen to relate comments in the following sections to the four major successional classes for lodgepole pine forests, as described by Pfister et al. (1977) (see **Table 1**).

Table 1

Lodgepole Pine
Successional Classes

Successional Role	Description
Minor Seral	A component of even-aged stands replaced by shade tolerants in 50 to 200 years.
Dominant Seral	The dominant cover type of even-aged stands with vigorous understory of shade-tolerant species that replace lodgepole pine in 100 to 200 years.
Persistent	The dominant cover type of even-aged stands with little replacement by shade-tolerant species.
Climax	Self-perpetuating and all-aged because it is the only species capable of growing in that environment.

Silvical Characteristics

In addition to the more general descriptions of lodgepole pine forests provided by the different ecological classifications, specific silvical characteristics of the species need to be considered in silvicultural prescriptions. Several very general silvical characteristics of lodgepole pine are:

1. It is very intolerant of shade. It needs a lot of sunlight to develop properly, even though some shade during the germination period and first year of development is beneficial. Of the common associates of lodgepole pine, only western larch (*Larix occidentalis*) is more shade-intolerant.

2. Lodgepole pine is fire-perpetuated. Nearly all lodgepole pine forests owe their origin to fire. Its serotinous cone habit provides a ready source of seed for the highly-receptive seedbed created by fires. This gives lodgepole pine a decided advantage over many of its competing associates.

3. Lodgepole pine has wide adaptability to different soils, climates, and topographic situations. In some cases, severe edaphic conditions, such as droughty soils of volcanic origin, may exclude all species other than lodgepole pine and, thus, give it a distinct competitive edge.

4. Although lodgepole pine most comonly grows in association with other conifers, in the persistent and climax sccessional classes, pure and near-pure stands of lodgepole pine do occur.

5. Because lodgepole pine is highly susceptible to both the mountain pine beetle and dwarf mistletoe, these two factors must be strongly considered in any silvicultural prescription.

Some silvical characteristics of lodgepole pine that influence silvicultural practices with or without the mountain pine beetle are:

1. Seed

a. Occurs in both serotinous and non-serotinous cones and is considered a prolific seeder.

b. Produces good crops every 2 or 3 years.

c. Disperses about 100 to 200 feet under normal conditions, but may also skid over the snow for much greater distances. Serotinous cones disperse their seed from logging slash near the ground (in-place) or from cones opened by the heat of a passing fire.

d. Seed is produced at an early age, even on trees under 10 years old, thus, providing some secondary seeding after the initial establishment period.

2. **Young Trees**

a. Seedlings establish best on disturbed sites, such as those produced by burning or scarification.

b. The combination of prolific seeding and excellent seedbeds, such as those following burns, commonly results in overstocking.

c. Once established, lodgepole pine grows best in full sunlight and poorly where overtopped by competing trees or other vegetation.

3. **Stand Development**

a. Young lodgepole pine grows rapidly in both diameter and height, if given adequate growing space, equaling or exceeding height growth of most of its associates for 50 years and longer.

b. If left untended, overstocking reduces height moderately and diameter growth severely.

c. On medium to good sites, cubic volume growth culminates at age 50 to 80 years and in board feet volume at age 110 to 140 years.

4. **Mature Stands**

a. Growth in old stands of lodgepole pine is normally slow, static, or in many cases negative.

b. The shallow rooting habit and closed stand characteristics make lodgepole pine highly susceptible to wind in or adjacent to stand openings.

WHERE SILVICULTURE FITS

In dealing with the mountain pine beetle problem, silviculture focuses the attention on the forest and not directly on the beetle. The goal is to alter the character of the forest enough to prevent or reduce losses to the mountain pine beetle, but yet be compatible with overall forest management objectives. For example, we might "beetle-proof" a stand through a cutting practice but, in the process, leave a reserve stand with no growth or regeneration potential—we cured the illness, but killed the patient syndrome. Prescriptions to reduce the mountain pine beetle should not be incompatible with good long-term silviculture.

Silviculture practices can be used to: change the physical and biological character of an area and, in the process, create environmental conditions more suitable for natural predators and parasites of mountain pine beetle; alter the temperature and moisture conditions in the stand; change the vigor, size, composition, and structure of the host stand; and eliminate or reduce the ecological niches required in the life cycle of the beetle.

Cole (1978) described a program to control losses to mountain pine beetle and showed how he felt the silviculture options relate to other direct and indirect methods in a flow diagram (see **Table 2**).

Practices in Mature Forests

The remainder of this paper addresses the silvicultural manipulation portion of Cole's (1978) diagram. The silvicultural options available in mature forests are:

- Even-aged stand objectives:
  - Clearcut
  - Seed tree
  - Shelterwood
- Uneven-aged stand objectives:
  - Group selection
  - Single-tree selection

The following are some of the factors that can be manipulated with these different harvest-cutting systems in mature forests:

- Size and shape of harvest-cutting units.

Table 2

Program
To Control Losses To The Mountain Pine Beetle
In Lodgepole Pine Forests

- COMMERCIAL FOREST STRATEGY
  - PREVENTION TACTICS
    - Increase Mortality of Beetle
      - Direct
        - - insecticides
        - - trapping (pheromones)
      - Indirect
        - - biotic limiters
        - * - sanitation cutting (partial cutting)
    - Increase Resistance of Stands
      - Silvicultural manipulation
        - * - block-cutting to gain age-size diversity of stands
        - * - stocking, size, vigor, and rotation control
        - * - manipulate species composition
        - * - prescribed fire
      - * Genetic resistance
  - UTILIZATION TACTICS
    - * - salvage-cutting after mortality
    - * - sanitation-cutting before mortality (partial-cutting)
- NONCOMMERCIAL FOREST STRATEGY
  - AMELIORATION TACTICS
    - * Manage natural fire
    - * Prescribed fire

* Indicates silvicultural practice is involved

- Topographic positioning of the cutting units.
- Density of reserve stand.
- Species composition of reserve stand.
- Structure of reserve stand.
- Seedbed preparation methods and timing (burning scarification, residue utilization and disposal).
- Regeneration methods (natural—subsequent or advanced) (artificial—seeding and planting).

Coupling any one of these silvicultural practices with the silvical requirements of lodgepole pine, as well as its associates, becomes the real challenge in developing silvicultural prescriptions; there is no blanket prescription. These prescriptions, in turn, are made more difficult when such significant pests as mountain pine beetle and dwarf mistletoe are added to the equation.

A key factor in developing any prescription is setting the objective. If the objective is to convert the mature forest as rapidly as possible to a thrifty, young forest, with no expectation of release growth in a reserve stand, clearcutting followed by site preparation is an obvious choice. This choice is also the most compatible with the ecological requirements of most lodgepole pine forests. If the objective is to retain some form of forest cover for esthetic reasons and if growth of the reserve stand and regeneration of lodgepole pine and its seral associates are of little consequence, then a single-tree selection method retaining a stand composed largely of the slower-growing tolerant trees might be appropriate. However, any treatment that increases the representation of shade-tolerant trees likely increases the susceptibility of the stand to spruce budworm (*Choristoneura occidentalis*)—another major forest insect pest. These kinds of tradeoffs cannot be ignored.

All of the methods have some pluses and minuses that bear on the forest resource as a whole. Some provide short-term solutions but predispose the area

Table 3

A Ranking of
Regeneration and Release Potential
Where Lodgepole Pine has a Dominant Seral Role

Silviculture Systems	Lodgepole Pine		Other Seral Species		Tolerant Species	
	Regeneration	Release	Regeneration	Release	Regeneration	Release
Uneven-aged:						
Single-tree selection	P	P	P	P	G	G
Group selection	F	--	F	--	G	--
Even-aged:						
Clearcut	G	--	G	--	F	--
Seed tree	F	--	G	--	F	--
Shelterwood	F	P	G	F	F	F

P = Poor
F = Fair
G = Good

Dashes indicate there are no reserve trees to release

to long-term problems, and some cause short-term problems (esthetics, for example) but solve the long-term problems.

If the objective is to retain some type of forest, two factors must always be considered in any cultural practice in mature lodgepole pine forests—regeneration and growth release (of reserve trees) potentials. A subjective ranking of these potentials in a dominant seral lodgepole pine forest is shown in **Table 3.** The same ranking could be done for the other successional classes, but the rankings would, of course, be different—particularly where lodgepole pine is climax.

Practices In Immature Forests

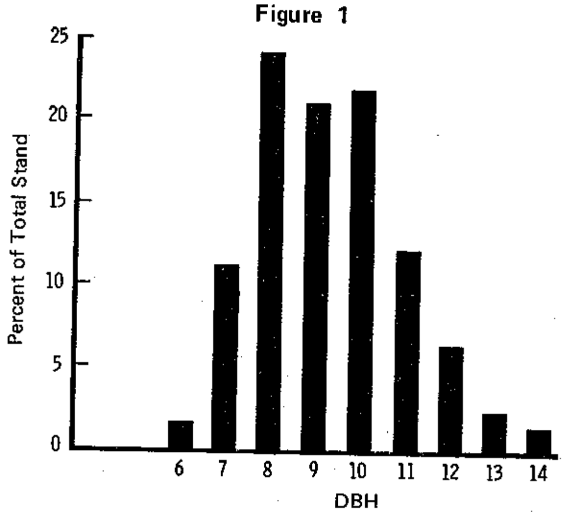
Immature forests offer, by far, the most opportunities for management in general and the mountain pine beetle problem specifically. This dynamic period in the life of the stand also permits relatively easy stand manipulation that can be used to adjust the following factors:

- Stand density.
- Species composition.
- Stand structure.
- Residues after thinning.
- Size of treated unit.
- Stand and individual tree vigor.
- Type, amount, and timing of fertilization.
- Resistant trees.

Most importantly, these manipulations can be done while the stand has the youthful vigor it needs to capitalize on its new conditions. With age appearing to be a significant factor in beetle susceptibility, it is prudent to start the cultural operations early enough to reach the desired tree and stand size and configuration before they reach the more susceptible ages. Small tree size, rather than wood quality, has always been a nemesis for lodgepole pine in the competitive market. Therefore, thinning at an early age to prevent the diameter and height suppression caused by overstocking seems logical with or without the beetle. Reducing stand densities early in the life of the stand allows lodgepole pine to grow at its potential—a far cry from individual tree growth found in heavily overstocked stands.

Growth projections for managed stands on medium- to good-quality sites indicates much larger trees than those found in natural unmanaged stands (Lee, 1967). As shown in **Figure 1**, 8 to 10 inch (20 to 25 cm) diameter lodgepole pine trees will apparently account for 60% to 70% of the stand at age 80 on medium- to good-quality sites, but sizes will range between 6 and 14 inches (15 and 36 cm) in diameter.

Figure 1



Stand projections of diameter distribution for managed lodgepole pine on a medium- to good-quality site at age 80 (from Lee, 1967)

Thus, these stands will reach those diameters and phloem depths that are attractive to the beetle at a much earlier age than normally found in unmanaged stands. With age appearing to be a factor in beetle attacks—those stands exceeding 70 to 80 years old are more attractive to the beetle than those under that age—there are many questions that need to be answered about the interactions of increased tree vigor, diameters, phloem depths (Cole, 1973), and age in relation to beetle susceptibility and vulnerability (Cole and Amman, 1980; Amman, 1978).

Recent evidence in Montana (McGregor, 1981) indicates that trees in thinned stands appear to be attacked much less than their counterparts in adjacent unthinned stands. Although the evidence is new and relatively short-term, it is supported by similar results in Oregon (Mitchell et al., in preparation). Although the preliminary evidence is favorable, it is too early to know if thinning creates more than short-term resistance to the beetle. A better understanding of where, why, and how these changes occur in thinned stands would help in developing guidelines for thinning practices.

Fertilization is in its infancy in the lodgepole pine type, and we do not know if fertilization will affect susceptibility and vulnerability of lodgepole pine to the mountain pine beetle. Preliminary results from a Montana study show lodgepole pine diameter growth increasing significantly after fertilization (M. Behan, pers. comm.). Lodgepole pine commonly grows on nutrient-deficient soils. One test hinted that fertilization on a nutrient-deficient soil may have actually reduced lodgepole pine growth because the associated vegetation responded immediately to the fertilizers and competed strongly for the limited available moisture (Lotan and Critchfield, 1982).

There could be rationale for predicting both positive and negative responses of the beetle in fertilized stands of lodgepole pine. Evidence in young western larch forests indicates that nitrogen fertilization made larch more attractive to the western spruce budworm and resulted in more feeding damage (D. Fellin, pers. comm.). At this point, it is difficult to predict what the beetle response will be in fertilized lodgepole pine forests. An increase in tree vigor would likely be accompanied by a more nutritious phloem.

MAJOR TIMBER MANAGEMENT RESEARCH NEEDS IN HOST FORESTS

Few will argue the need for getting on top of the mountain pine beetle problem. The questions are: Is the Knowledge that is available being used; Is there enough knowledge to develop meaningful management guides? or Are the knowledge gaps so wide we throw our hands up in despair? In reality, there are likely both positive and negative replies to these questions.

I feel that two approaches should be used to meet the major timber management research needs in mountain pine beetle host forests. First, the short-term work that can be accomplished in about 5 years. This includes completing work already underway, refining corollary information to make it applicable to the mountain pine beetle problem, and collecting and analyzing data from existing on-the-ground conditions. We should:

1. Complete evaluation of habitat type as an indicator of mountain pine beetle susceptibility and site productivity.

2. Integrate management of other resources with timber and mountain pine beetle considerations and develop guides.

3. Evaluate effectiveness of partial cuttings (diameter limit) in reducing mountain pine beetle losses in an overall forest context.

4. Determine sustained yield-allowable cut consequences of alternative silvicultural treatments (varying in scale and timing).

5. In a survey of existing thinnings:

   a. Evaluate differences in mountain pine beetle caused mortality in thinned versus unthinned stands.

   b. Determine effectiveness of leaf area index as an indicator of susceptibility to mountain pine beetle under expanded site and stand conditions.

   c. Supplement the data base for refining growth simulation models where mountain pine beetle is a factor.

Second, long-term work should be initiated to test some of the conclusions reached with the short-term approaches and to develop some of the basic information needed for more intensive management in the long run. These would generally involve the establishment and repeated evaluations of long-term silvicultural studies that will answer not only mountain pine beetle questions but will also answer other insect and disease relationships in the context of the whole forest resource complex. This includes:

1. Establishing and evaluating controlled thinning studies in varying age, site, and density classes to:

   a. Provide long-term tests of various hypotheses on susceptibility of trees and stands to mountain pine beetle infestation.

   b. Improve and verify managed stand growth and yield models.

   c. Relate the above to other forest resources and related insect and disease problems.

2. From item 1 results, develop improved silvicultural guides for intensive management in mountain pine beetle susceptible forests.

3. In controlled studies, evaluate valid regeneration cutting systems in terms of reserve stand susceptibility to mountain pine beetle; e.g., shelterwood cuttings in high visibility areas where lodgepole pine has a minor seral role.

4. Evaluate fertilizer effects on mountain pine beetle susceptibility.

SUMMARY

There is good reason to be optimistic that silvicultural practices can be used to cope effectively with the mountain pine beetle problem. Fortunately, it appears that the most promising silviculture "beetle-proofing" can simultaneously accomplish other intensive management goals. On the other hand, not all strategies that deal effectively with the mountain pine beetle in the short term are compatible with the management of the forest resources as a whole.

The interaction of the silviculturist and entomologist in developing silvicultural prescriptions in lodgepole pine forests is essential. Questions must be asked: Is the silviculture prescription meeting most management objectives but predisposing the stand to mountain pine beetle problems? or Is the prescription taking care of the immediate problem with the mountain pine beetle but, in the process, substantially reducing the regeneration and growth potential of the site for many years to come?

The major studies that have been completed or are underway in Canada and the United States, concerning the beetle and the forest, need to be integrated and the results implemented as soon as possible.

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