PROCEEDINGS OF THE JOINT CANADA / USA WORKSHOP ON MOUNTAIN PINE BEETLE RELATED PROBLEMS IN WESTERN NORTH AMERICA

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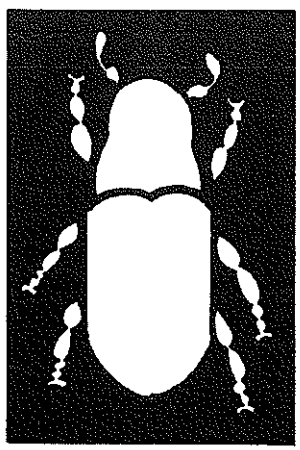

Environment Canada / Environnement Canada

Canadian Forestry Service / Service canadien des forêts

SUMMARY

Reports to the workshop covered: the biological interaction between beetles and lodgepole pine; the extent of current infestations; the economic effects; the options available to forest managers and problems requiring solution; the programs underway in response to the epidemics; and the information and procedures required to predict and respond to future epidemics.

The differing points of view of industry and resource agencies from both Canada and the United States were presented.

Major conclusions from the reports at the workshop were as follows. Mountain pine beetle is in direct competition with the forest industry for timber. At present, about 167 000 hectares (412 000 acres) of mostly mature lodgepole pine forest in western Canada and 1 900 000 hectares (4 700 000 acres) of pine forest in the western United States are under attack. A further 2 500 000 hectares (6 180 000 acres) in British Columbia are considered susceptible. In the western United States, in Kootenai National Forest, alone, more than 20 000 additional hectares (50000 acres) are rated susceptible to the beetle. Economic and attendant social effects are attributed to the epidemics through changes in allowable cut, value of products, resource flows, and increased protection and management costs, although many of these are hard to quantify.

In response to the epidemic, programs are in place to improve road access to lodgepole pine stands, although large areas of susceptible pine are still not accessible. Accelerated harvesting programs are in place. In many areas, this has involved a shift from harvesting a mixture of tree species to an almost exclusively lodgepole pine harvest. The allowable cut has been exceeded in some areas. Even so. many stands of effected timber will not be harvested because of difficult access or an insufficient dollar return from the salvage operation.

Conflicts were identified between the management objectives of national parks and wilderness areas and those lands managed for timber harvest. National parks in both countries expressed the desire to be good neighbors, however, problems result when natural phenomena–such as a mountain pine beetle infestation–move beyond park boundaries into adjacent lands managed for timber. Large sanitation cuts cause changes to wildlife habitat, streams, and the rate of water runoff. Resolution of conflicts in the future is expected to require full cooperation between agencies in the early formulation of management plans, which include regeneration, for each developing epidemic. Periodic reevaluation of the effectiveness of these plans is necessary. At this moment, in view of the continuing epidemics, the declining market for forest products is a major concern because lodgepole pine has been the first species to fall out of declining markets in the past and the last to reenter recovering markets.

Two approaches to the reduction of losses from the mountain pine beetle are possible–preventive management or direct control. Preventive management must start now with prompt regeneration and the planned application of silvicultural prescriptions to reduce the susceptibility of the next generation of pine stands. Direct control actions against epidemics are only effective when there is early detection, thorough treatment, and follow-up surveillance.

Areas in need of further research were enumerated.

In the field of biology, these included: outbreak prediction; role of blue-stain fungi; beetle activity in tree species other than lodgepole pine; silvicultural strategies: and control techniques.

In operational forestry, areas needing further research are: resource management; alternate products and improved processes; engineering research in harvesting and access systems; and fire management,

In the fields of economics and socioeconomics, areas in need of research are: methods for multiresource cost benefit analysis; investment analysis for alternative management strategies; effects on regional economics; definitions of effects on recreation, wildlife and range, and watersheds; and definition of future resource values.

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PROCEEDINGS OF THE JOINT CANADA-UNITED STATES WORKSHOP ON MOUNTAIN PINE BEETLE RELATED PROBLEMS IN WESTERN NORTH AMERICA

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ABSTRACT

This two-day workshop on the economic and social problems related to the current mountain pine beetle epidemics in western Canada and the United States was jointly sponsored by the Canadian Forestry Service and the United States Forest Service, in cooperation with the Alberta and British Columbia Forest Services. The workshop was convened because the consequences of the extensive and widely spread epidemics are now regarded as being of crisis proportions in both countries.

In attendance from both countries were representatives from government, the forest industry, universities, national parks, national and regional forest services, and the news media.

Reports at the workshop covered: the causative agents: the extent of the problem, economics and research needs: what is now being done and future plans: accomplishment barriers; and case studies. The differing points of view of private industry, forest services, and national parks from both countries were reported at the workshop. The workshop ended with a field trip through one of the oldest ongoing epidemics in British Columbia.

As a result of the workshop, a memorandum of understanding is being prepared between the two countries to further the cooperation at all levels in dealing with the problems related to mountain pine beetle.

Proceedings Editor: D.M. Shrimpton

RESUME

Le Service canadien des forêts et le Service des forêts des €tats-his, en cooperation avec les Services des forêts de l'Alberta et de la Colombie-Britannique, ont present6 conjointement cet atelier de deux jours touchant sur les problèmes economiques et sociaux par rapport aux présentes épidémies du dendroctone du pin ponderosa dans l'ouest du Canada et aux Etats-Unis. On a formé cet atelier parce qu'en ce moment on perçoit les consequences de ces épidémies vastes et repandues comme étant en proportion de crise dans les deux pays.

Des représentants des gouvernements, de l'industrie forestidre, des universités, des parcs nationaux, des Services nationaux et régionaux des forêts et des médias des deux pays ont tous assiste à la reunion.

Les rapports présentés à l'atelier ont compris les sujets suivants: les agents causatifs, l'ampleur du probldme, le côté économique et les exigences de recherches, ce qui est en voie d'être accompli à ce moment et ce qui est propose pour le futur, les obstacles face au progrds et les dossiers portant sur le problème. Les points de vue divergents de l'industrie privée, des Services des forêts et des parcs nationaux des deux pays se sont manifestés a l'àtelier. On a terminé l'atelier avec une visite à une des plus vieille épidémie persistante en Colombie-Britannique.

Cet atelier a initié la preparation d'un document d'entente entre les deux pays pour la cooperation à tous niveaux en traitant des probldmes concernant le dendroctone du pin ponderosa.

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OPENING STATEMENT

F.L.C. Reed
Assistant Deputy Minister, Canadian Forestry Service

Welcome to Canada and Fairmont Hot Springs, B.C.

You will be hearing a lot about the mountain pine beetle today and seeing some classic examples of its effects upon the forest tomorrow–so there is no need for me to detail the problem that faces forest managers in western North America.

I want to emphasize that this meeting is another example of the excellent spirit of cooperation between Canada and the United States that exists in forestry. There are many examples. For instance, there is direct collaboration in the control of forest fires–we hope to have the longdelayed agreement signed in the very near future. The Canada-United States Spruce Budworm Research Agreement is the basis for the largest forestry research project in the world. It will serve as a model for even more comprehensive cooperation between the researchers in our two countries. In British Columbia this summer, the B.C. Ministry of Forests, the Canadian Forestry Service, and the United States Forest Service built upon their earlier cooperative work on the Douglas-fir tussock moth and carried out control trials using pheromone and virus. This is a continuation of the free exchange of expertise, ideas, and research opportunities that has been developed over many years.

The present mountain pine beetle problem has brought the Forest Services of Alberta and British Columbia, Parks Canada, and the Canadian Forestry Service together to form an Interagency Action Committee.

Almost a decade ago, the scientists published guidelines on hazard assessment and the prevention of outbreaks. Several of those scientists have conducted field workshops throughout the region in the intervening years to transfer the technology. There was a good response by the forest managers.

The beetle also responded to the challenge by demonstrating that it was not about to give up its role in the management of lodgepole pine. The outbreaks in British Columbia and Alberta are of catastrophic dimensions. The epidemics we now face force us to come to grips with a complex of biological, economic, social, and institutional problems and issues; for example, wood supply, mill capacity, markets, interest rates, Reganomics, silviculture and forest management, wildlife management, water quality, wilderness, and National Park management–to name but a few.

We will neither solve all the problems, nor resolve the issues this week. I do hope, however, that your understanding will be improved and that you will support us in our efforts to develop a framework for cooperation that will assist everyone to benefit from each others' experiences and ideas.

OPENING STATEMENT

R. Max Peterson
Chief, United States Forest Service

It's gratifying to see so many of my Canadian and United States colleagues meeting together. The United States and Canada have long worked together to solve forest insect problems recently exemplified by the CANUSA spruce budworm program–an outstanding cooperative effort.

At this time, unfortunately, we are confronted with another serious insect problem. The mountain pine beetle has become epidemic throughout most of the western United States, covering 4 000 000 acres in 1980, As a result, approximately 31 million lodgepole, ponderosa, and other pines died–an enormous amount of tree-killing. In the United States, lodgepole pine covers 2 659 000 acres of commercial timberland in the Pacific Northwest and 9 816 000 acres in the Rocky Mountain Area–so it obviously is a resource of considerable concern to us.

As you know, the mountain pine beetle and the lodgepole pine forest evolved together. The mountain pine beetle, coupled with fire, has been a dominant influence in shaping the character of these forests. The insect is an integral part of the forest ecosystem, and although extensive tree mortality has occurred, it does not always represent a loss. At times, the insect is beneficial to the landowner because, in some cases, the tree-killing and subsequent fires aid management objectives. Out of control on a large scale, however, the insect saps our forest reserves and corrective action becomes essential. We know demands on our forests are increasing. As well as producing building materials, paper products, and fuel, they also provide scenic beauty, recreation, watersheds, wildlife habitat, and grazing areas for livestock. Where the mountain pine beetle adversely affects these resources, we must take corrective action.

Historically, preventive and suppression efforts have involved some form of direct control of the beetle. Millions have been spent on chemical solutions and silviculture techniques, such as peeling, burning, and accelerated logging. But, in spite of massive efforts, we cannot report an overwhelming success, although we have been able to delay tree-killing in a few areas.

More recently, intensive studies of interaction of the mountain pine beetle and their hosts have provided new insights and approaches to the problem. We have developed systems to identify and classify stands that may be susceptible to the beetle. Newer forest management techniques that reduce the impact of the beetle have been tested and accepted. Good management is the key and requires stand thinning in advance of beetle problems, patch clearcutting, and salvage of infested stands, where necessary. If we do not manage these stands, the mountain pine beetle will manage them for us, and we may not like the kind of job they do. The problem is that implementing these techniques on a large scale has been painfully slow. Constraints, such as lack of funds for access roads or lack of clear objectives for the forestland, severely limit our ability to use these silviculture techniques to reduce the losses. Additionally, the demand for smaller timber and roundwood products is less than the supply, and funding levels for intensive management have not met all the needs. Unfortunately, at this time, lodgepole pine does not have a high priority for funding.

As information is presented over the next day and a half, I'm sure we can demonstrate confidence in our technical ability to effectively manage the mountain pine beetle. The hard part will be to zero in on ways to overcome the most serious obstacles. Even in these days of poor markets and low budgets, however, we should be able to move forward with coordinated efforts to reduce losses from mountain pine beetle in both countries. We must continue to develop ways of working more closely together.

THE MOUNTAIN PINE BEETLE– IDENTIFICATION, BIOLOGY, CAUSES OF OUTBREAKS, AND ENTOMOLOGICAL RESEARCH NEEDS

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The mountain pine beetle, ***Dendroctonusponderose*** Hopkins, is the most important native insect that is infesting lodgepole pine, ***Pinus contorta*** var. ***latifolia*** Engelmann, and ponderosa pine, ***P. ponderosa*** Lawson. The beetle was described by Hopkins in 1902 from specimens collected in the Black Hills of South Dakota. The name ***Dentroctonus*** means "tree killer" and this bark beetle is truly worthy of the name. During endemic periods, only an occasional tree can be found infested by the beetle. Then, within a period of 5 to 10 years, from 25% to almost 80% of the trees having a DBH of 4 inches and larger will be killed by an epidemic of beetles. In 1970, the mountain pine beetle accounted for almost 80% of lodgepole and ponderosa pine timber loss (over 6 billion board feet) in the Rocky Mountain States alone. Contrast this with the total harvest of 11 billion board feet in all of the United States during 1970. In 1976, infestation of mountain pine beetle occurred on many national forests, with 3 million lodgepole pines being killed on a single national forest (the Targhee).

We generally equate infestations with losses in timber values. However, there are other impacts; for example: the reduction in the quality of recreational sites and the cost of cleanup; the loss of ornamental trees around permanent residences and summer homes; and the probable effects on the wildlife and on the water quantity and quality. Not all effects of infestations are bad. A study in Colorado showed a large increase in forage production within a couple of years following the loss of ponderosa pine. Therefore, the seriousness of the impact depends upon the management's objectives.

The epidemiology of the beetle, covering the period from the start of the population buildup through the epidemic, has been studied in considerable detail in lodgepole pine. However, there are still important gaps in our knowledge concerning epidemics. In addition, the endemic, or low population, period is an area in need of research. Studies during the endemic period should reveal factors that keep the beetle population at low numbers for many years and then suddenly allow release of the population. Important means of preventing losses to the mountain pine beetle should come from studies of the endemic period.

BIOLOGY AND ECOLOGY

Distribution and Host Trees

The mountain pine beetle can be found throughout pine forests from about 56° north latitude in British Columbia to northern Mexico and from the Pacific Ocean on the west to the Black Hills of South Dakota on the east. Elevationally, the beetle occurs from about sea level in British Columbia to 11,000 feet in Colorado.

The most important hosts of the mountain pine beetle. based on commercial value and intensity of beetle epidemics, are: lodgepole pine; ponderosa pine; western white pine, ***P. monticola*** D. Don; and sugar pine, P. ***lambertiana*** Douglas. Other pines within the beetles' range are also infested and killed.

Occasionally, native nonhost trees (such as Engelmann spruce, *Picea engelmanni* Parry; grand fir, Abies *grandis* (Douglas) Lindl.; and incense cedar, Libocedrus decurrens Torry) are infested, but usually little or no brood is produced. Some exotic trees, such as Scots pine and Norway spruce, also are infested and killed.

Life Cycle

The mountain pine beetle usually completes a single generation per year. Beetles mature in July; adults reach sizes up to 0.25 inch (6.4 mm) long and are dark brown to black in color. Prior to emergence, new adults feed within the bark to complete maturation. The feeding adults obtain fungal and yeast spores, which become packed into a special structure on the head. This structure is called a mycangium and is used to transport the spores to the new tree.

The emergence and flight of new adults usually begin after several days of relatively high temperatures. Beetles emerge only during the warm part of the day, starting when temperatures reach about 60°F (15.5°C) and ceasing in the afternoon when temperatures drop to about the same level. Maximum flight activity occurs between 11 a.m. and 6 p.m. in both lodgepole. and ponderosa pine forests.

Although emergence may be spread over a period of a month or more, about 80% of the beetles usually emerge in a 1- to 2-week period. Large numbers of beetles emerging over a short period appear to be important for the beetles to attack and kill the most vigorous trees in the forest.

Emerging adults select and 'infest living trees. In lodgepole pine forests, the beetles are strongly oriented to large diameter trees, and vision is believed to play a strong role in final tree selection. Once the female starts boring into a tree, she produces a pheromone–that is, a chemical messenger–that attracts other beetles to the tree. When the number of attacks reach a certain density, a second pheromone signals the newly arriving beetles not to attack the tree, thus preventing overcrowding. These beetles infest adjacent trees. Attacks on an individual tree are usually completed within 48 hours.

Evidence of beetle infestation consists of: pitch tubes where beetles have entered the tree; and boring dust in the cracks and at the base of the tree. Although pitch tubes may be absent, orange-brown boring dust around the base of the tree is a sure sign that the tree has been killed.

The adults bore through the outer bark into the phloemcambial layer where they construct vertical egg galleries. The late July attack period corresponds well with the beginning of a seasonal decline in tree resistance, as determined by the tree's response to inoculations of blue-stain fungi.

Fungal and yeast spores and bacteria, carried by the beetles, commence growth in the living tissues of the phloem and xylem soon after the beetle starts its gallery. Although the role of all of these is not completely known, the blue-stain fungi: invade and kill cells; aid in killing the tree by interrupting water conduction; and cause a rapid reduction in moisture of the sapwood.

Eggs are laid singly in niches, alternating in groups along the sides of the gallery. They hatch within a week or so, and the larvae feed in the phloem, usually at right angles to the gallery. The larvae become dormant for the winter in late October and November and begin to feed again in April, completing their development in the latter part of June to mid-July.

The beetle generally has one generation per year; however, there are exceptions that are primarily dependent upon weather and climate. One exception is that the parents may establish two broods in some warm years. After completing an egg gallery in one tree, adults emerge and attack a second tree. Another exception is that 2 years may be required for the beetle to complete a generation at high elevations. Cool temperatures during the summer delay develop ment of and emergence of beetles.

Infested trees can be detected by aerial surveys after the foliage has dried and changed color. As the foliage dries, it turns from green to pale green in the spring, then light orange, and finally a bright orange by July. The presence of emergence holes through the bark at this time signifies that the brood has left the tree to infest green trees.

Factors Affecting Brood Survival

During almost a year that the beetles are developing within the tree, many factors of mortality are reducing their numbers. These factors consist of: competition among the larvae; parasites and predators; pathogens; cold temperatures; drying of the bark; and pitch. Several comprehensive life table studies of the beetle and its mortality factors, including a 13-year study, showed that none of these factors, either individually or in combination, regulate the beetle population. Survival of beetles during the epidemic period is more closely correlated with the diameter of and the phloem thickness of the trees than any other factors.

The numbers of new beetles produced is directly related to: the thickness (quantity) of the inner bark (phloem) layer, the food of developing larvae; and the rate of phloem drying, which is slower in larger trees. The phloem layer, also, is generally thicker in large-diameter trees and is related to tree growth.

CAUSES OF BEETLE OUTBREAKS

Although we know a great deal about the biology and ecology of the mountain pine beetle in lodgepole pine, we still do not know what triggers an outbreak. The classical theory for bark beetle outbreaks emphasizes some form of tree stress, decline in vigor, or tree injury to which beetles are attracted. Some possible stressing agents are drought, tree competition for moisture and sunlight, insect defoliation, fire, mechanical injury, and tree diseases such as commandra rust, dwarf mistletoe, and the root rots. However, none of these has been studied in depth to provide a definitive answer of the role of stress in triggering outbreaks of mountain pine beetle.

My studies suggest that mountain pine beetle outbreaks are related to physiological changes of the tree associated with good vigor–not stress. There are four main conditions that must be met for epidemics of the beetle to occur–sufficient numbers of large-diameter trees; thick phloem in many of the large trees; optimal age of trees; and optimal temperature for beetle development.

Effect of Tree Diameter

The mountain pine beetle usually selects the largest trees in the stand to infest, at least immediately preceding and during a major epidemic. These usually are the most vigorous trees in the stand. Please keep in mind that I am referring to unmanaged lodgepole pine stands. We don't know how the mountain pine beetle will respond to managed lodgepole pine stands.

The preference of the beetle for large-diameter trees is apparent when the percent loss is calculated for each diameter class for an entire infestation. In two stands in northwest Wyoming, trees killed by the beetles ranged from 1% of the 4 inch (10 cm) trees to 87% of the trees having a DBH of 16 inches (41 cm) and larger. Other observations, particularly in Montana, show that losses are greater in each diameter class than observed in Wyoming, with 100% of the trees over 12 inches DBH being killed in some stands.

Epidemics usually start in full-crowned trees (but not necessarily the oldest or biggest) located usually on the outer edge of the timber bordering open rangeland or lake and stream shores. In the more open portions of stands, the proportional losses of lodgepole pine are much greater.

Effect of Phloem Thickness

Trees on the edges of stands or in the more open stands are usually growing faster than those within stands and, consequently, have thicker phloem, resulting in high beetle production. This provides the impetus for starting an epidemic. Estimates of beetle production from trees in northwest Wyoming ranged from 300 for trees 8 to 9 inches in diameter to over 15 000 for trees 18 inches in diameter. On the average, the number of beetles produced in small trees is less than the number of parent beetles that killed the tree. In contrast, a large surplus of beetles is usually produced in large trees.

Phloem thickness increases as diameter increases. Although this relation exists for all stands that we have measured, the phloem thickness for any given diameter will differ among stands, because of differences in stocking level and site quality.

Infested trees in dense stands produced fewer beetles than trees of the same diameter in more open stands. This is related to phloem thickness, which declines with increased stand density. Brood production from trees having thick bark in the least dense stands was over 4 times greater than in comparable-sized trees in the most dense stands.

Effect of Age

Age of host trees also is an important factor in mountain pine beetle infestations. infestations seldom occur in lodgepole pine stands less than

60 years old and there is only moderate, probability of infestation in stands 60 to 80 years old.

Although part of the beetle's selection of trees of older age may be associated with the generally smaller diameters of trees less than 60 years old, other elements also are involved. Phloem in young trees tends to be more spongy and resinous, probably because of more and larger cortical resin ducts. The blue-stain fungi, carried by the beetle and inoculated into such trees, do not establish well because of the greater resinous response of young trees. Although young trees are occasionally infested and killed. they tend to dry rapidly and few, if any, of the brood complete development. The average age and size of the trees infested by the mountain pine beetle at the start of an epidemic in northern Utah was 104 years and **13** inches DBH.

This apparent age requirement. essential for beetle epidemics, points to silviculture as a means of reducing losses' to the beetle. Trees probably can be grown to a fairly large size under intensive management and be harvested at 60 to 80 years old without significant loss to the mountain pine beetle.

Effect of Climate

Although the diameter and the phloem thickness are major items involved in the dynamics of mountain pine beetle populations, epidemics can develop only in stands located where temperatures are optimum for beetle development. Climate becomes an overriding factor at extreme northern latitudes and at high elevations. At these extremes, beetle development is out of phase with winter conditions, Consequently, stages of the beetle that are particularly vulnerable to cold temperature enter the winter and are killed. Because of reduced brood survival, infestations are not as intense and fewer trees are killed as elevation and latitude increase.

These observations have been used to develop a stand risk rating system for mountain pine beetle in lodgepole pine. The factors used are: elevation-latitude of the stand; average age of the trees; and average DBH of the trees.

Looking at the overall relationship of mountain pine beetle and lodgepole pine, one cannot ignore the apparent coevolution of the two and the benefits to both. The killing of the largest trees in persistent and climax lodgepole pine stands, as they become mature or slightly before reaching maturity, provides a more continuous supply of food, by breaking up the age and diameter structure of the stands. Infestations help maintain the vigor of the stand by eliminating some of the tree competitions, resulting in increased growth of residual trees.

In seral stands, lodgepole pine will be eliminated by climax species in the absence of fire. The large fuel loads that occur following beetle epidemics may result in fires that eliminate competing (climax) tree species and that perpetuate lodgepole pine. The serotinous cones of lodgepole pine open following a fire and the site is reseeded to lodgepole, thus assuring another generation of lodgepole pine and eventually food for the mountain pine beetle.

RESEARCH **NEEDS**

We know a great deal about the mountain pine beetle in lodgepole pine during epidemics, but keep in mind that, once an infestation reaches the epidemic stage, there is little that can be done to stop it. The entire epidemic for a given stand lasts *5* to *7* years. That simply doesn't give the land manager time to arrange a sale and to get the timber harvested before the beetle has killed most of the volume. Therefore, we believe the keys for minimizing losses to mountain pine beetle lie in the endemic, or low population level studies. Many of the entomological research needs listed by the research groups at Victoria and Ogden are similar. Some of the research needs are: outbreak prediction; the beetle blue-stain tree inter. action; silvicultural strategies; control techniques; and beetle activity in ponderosa pine.

Outbreak Prediction

A method of predicting outbreaks far enough in advance that the land manager can take measures to minimize or prevent losses. This would give the land manager considerably more flexibility than it appears he now has. We have models that can predict losses when a lodgepole pine stand becomes infested (although these need to be refined for a wide range of habitat types and stand conditions), but we do not have a method of predicting when a beetle epidemic will start in any given stand of lodgepole pine. Some of the questions that need to be answered are:

1. Are there changes in beetle quality, including genetic changes that are important in allowing the population to become epidemic?

2. Likewise, are they changes in quality or quantity of blue-stain fungi that result in increased beetle survival?

3. Do populations of natural enemies of the beetles decrease, thus allowing the beetle population to increase?

4. And there is still the question of the role of tree stress or tree injury in triggering the epidemic. Do the beetles take advantage of such factors to increase their population to a level that any tree in the forest can be killed?

The Beetle Blue-Stain Tree Interaction

Another area of research is the interaction of the mountain pine beetle with the host tree and with other species of bark beetles. Some of the questions that need research are:

1. How does the mountain pine beetle maintain a population when they are at very low levels and difficult to find?

2. What is the role of other less aggressive bark beetles, such as *Ips* and ***Pityopthorous,*** in main-maintaining these low level populations of mountain pine beetles?

3. What is the association of mountain pine beetles with diseased trees–diseases such as commandra rust, dwarf mistletoe, and the root rots?

Silvicultural Strategies

A third area of research is the improvement of development of silvicultural strategies to more effectively keep mountain pine beetle populations in check. Some of the questions are:

1. Is the mountain pine beetle dependent upon the secondary bark beetles in order to maintain a low level population? If so, can silvicultural practices be used to reduce or eliminate the suppressed, diseased or injured trees upon which such secondary beetles appear to depend?

2. Silvicultural methods presently being tested need to be extended and modified for different situations.

3. Cost-benefits for the various techniques need to be evaluated–not only for timber, but for other resource values.

Control Techniques

In the area of control, other than silvicultural practices, research is needed on host chemistry, as it relates to host selection by the beetle, and on behavioral chemicals produced by the beetle. Some of the questions that need to be answered are:

1. How does beetle dispersal relate to tree and stand characteristics and to the quality of the beetle population? Understanding dispersal characteristics may allow prediction of mass beetle movement and possible control through interception, decoy, and other disruptive treatments.

2. Are trees selected by the beetles on the basis of chemical composition? If so, can lodgepole be selected for particular chemical characteristics that would make it immune to beetle attack?

3. Can an effective attractant be developed? Some of the pheromone components have been identified, but others still appear to be needed before the synthesized pheromone can compete with natural compounds. An electro-antennogram approach through insect physiology offers promise of pinpointing specific compounds to which mountain pine beetles respond and which are important in their biology and ecology. A chemical bouquet that is competitive with natural chemical sources could provide the basis for trapping or decoying beetles, particularly at low population levels, thus keeping the beetle population at a low level indefinitely. Such compounds also could be used to monitor low level beetle populations in order to develop an index of outbreak probability.

Beetle Activity In Ponderosa Pine

The last area in need of research that I'm going to mention is other pine hosts, particularly ponderosa pine. Unfortunately, what has been learned from research in lodgepole pine cannot be directly applied to ponderosa pine. The behavior of the beetle is different in ponderosa pine and is more variable over the range of ponderosa than of lodgepole. For example, in eastern Oregon and westcentral Idaho, the beetles infest small-diameter ponderosa pine, in contrast to showing a strong preference for large, old-growth trees in northern Arizona and southern Utah. Therefore, we have much further to go in understanding the mountain pine beetle-ponderosa pine (MPB-PP) system than we do in lodgepole pine. Some of the research needs are:

1. Basic population dynamics studies to assess the role of natural enemies, phloem thickness, moisture, etc., and competitive insects—particularly the wood borer larvae.

2. Studies to identify the types of trees and stands selected by mountain pine beetle over the range of ponderosa pine and to identify tree losses.

3. Models that link growth projections with mountain pine beetle population dynamics for predicting probability of infestation and expected tree losses.

4. Silvicultural practices modified to fit different site and stand conditions over the range of ponderosa pine.

5. Behavioral chemicals as a means of monitoring or trapping beetles for the prediction of impending outbreaks and for control purposes.

THE MOUNTAIN PINE BEETLE SITUATION IN CANADA 1981

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The mountain pine beetle continues to be the most damaging insect in western Canada in 1981. In British Columbia, mature lodgepole pine are by far the most commonly affected tree species, followed by western white pine, occasionally ponderosa pine and other pines, and rarely other species. The distribution of currently active infestations in western Canada and the northwestern United States is shown in Figure 1.

Lodgepole pine is distributed throughout British Columbia and adjacent Alberta. In British Columbia, it covers more than 14 million ha and by volume comprises 14% of the provincial inventory, although in some areas it is much higher, reaching 50% in the Cariboo Forest Region. Lodgepole pine is now the third ranking species, comprising about 19% of the annual provincial harvest. It has not, however, always been a commercially sought species, accounting for less than 5% of the harvest in the 1960s and only 2% in 1955. Not surprisingly, then, a large proportion of this species is mature and overmature; by area, more than half is greater than 80 years old and almost three-quarters is more than 60 years old. It is these trees that are most susceptible to attack.

Outbreaks have been recorded within British Columbia at irregular intervals since at least 1910. Particularly notable early infestations occurred in the Princeton, Okanagan Valley, and Lillooet Areas, and:

> From 1930, 36 vast areas were infested around Tatla Lake in central British Columbia.
>
> From 1930, 43 large infestations were in the Kootenay, Yoho, and Banff National Parks.
>
> From 1946, 65 infestations were around Babine Lake in northcentral British Columbia and in western white pine stands on Vancouver Island.
>
> From 1972, 77 virtually all mature pine on more than 20,000 ha were killed in the Kleena Kleene Valley in central British Columbia.

Infestations generally persisted within individual stands for eight or more years or until the pine component of the forest was depleted, especially the larger (more than 25 cm) trees. The current outbreaks started during the late 1960s and early 1970s. In 1974, a total of only 3 300 ha at 35 scattered locations were affected. This included stands in the Elk Creek and White River Valleys, and there were areas just below the international border in Montana. The infestations expanded and intensified rapidly, and by 1981, heavy mortality of mature pine trees occurred in more than 5 000 separate locations covering more than 220 000 ha in the interior of British Columbia (more than 540 000 acres). it was estimated that the 1979 attacks alone killed more than 14 million trees, with a gross volume of 7.7 million metres^3. This represents more than 300 000 truckloads of logs. In Alberta, infestations encompassed more than 7 000 ha with 1.5 million recently killed trees.

Aerial surveys in 1981 showed red trees (that is, those killed in the past year) present over more than 160 000 ha in British Columbia. This is equal to the total area logged of all tree species in a year in the province. In individual forest regions, such as Cariboo and Nelson, the area with recent kill is 2% to 3% times the area of annual harvest. Not included in these estimates are the additional areas of more than 36 000 ha in the Kleena Kleene Area and 20 000 ha in the Flathead Area and the Elk Creek Stand, where most of the mature pine were already killed.

The cumulative loss to date and the potential loss–considering the extent and volume of the mature

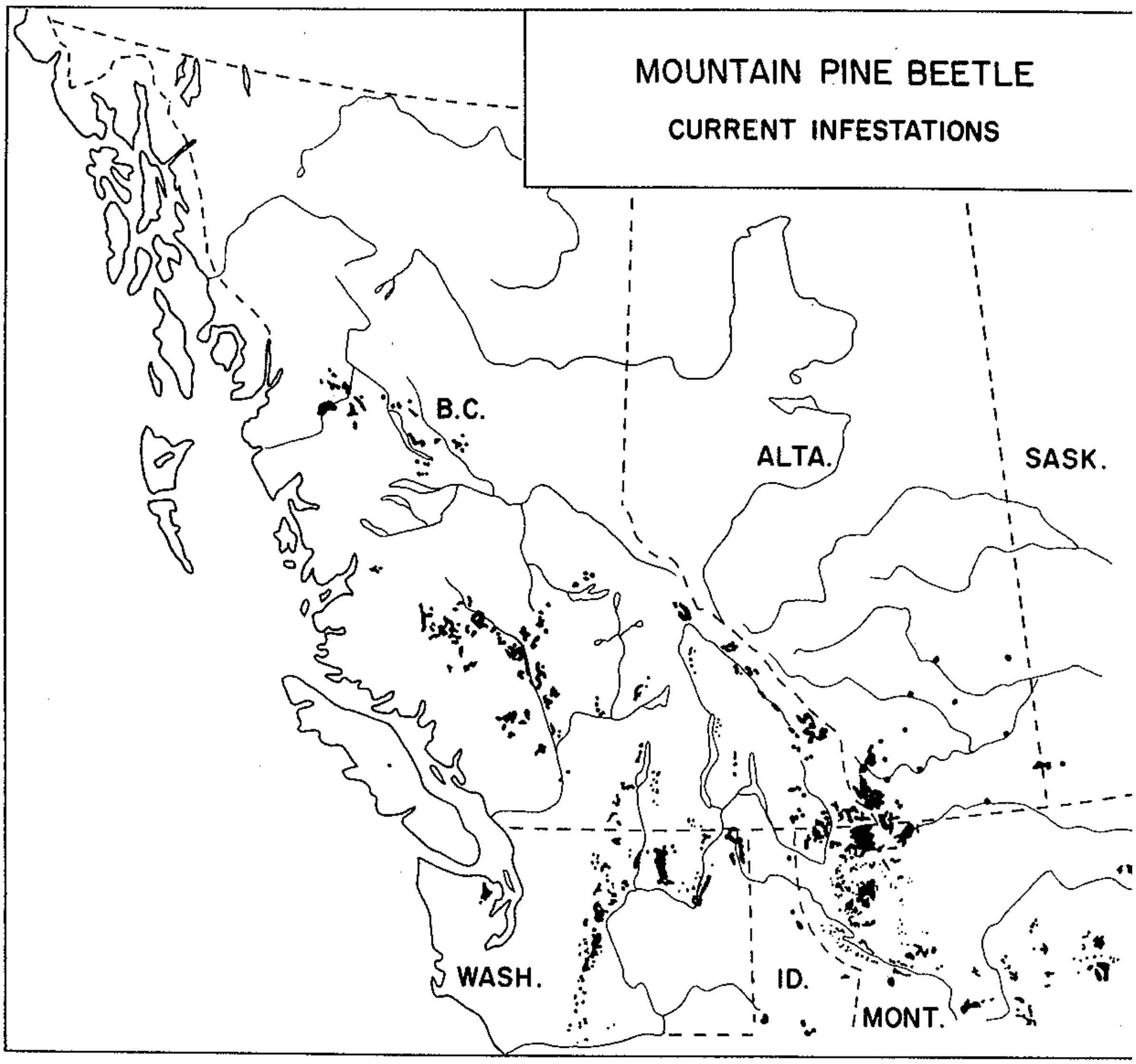

Figure 1

**Distribution of
Mountain Pine Beetle Infestations
In Western North America
In 1981**

susceptible stands–are many times greater. As two-thirds of the infestations mapped presently cover less than 20 ha each and another 17% were less than 50 ha, the potential for expansion is still considerable. Also, two-thirds of the area mapped was judged to be lightly or moderately infested, i.e., less than 30% of the susceptible host trees were recently attacked. Consequently, the potential is high for continued intensification of these attacks within many of these stands.

The majority of infested stands in Canada are on provincial Crown land, although major infestations occurred in the Akamina-Kishinina Park Reserve and the adjacent Waterton National Park, and the Cypress Hills Provincial Park and infestations are evident in the Kootenay, Glacier, and Yoho National Parks. In Kootenay National Park, infested trees were first observed in 1979 and currently more than 50 spot infestations and 2,000 recently killed trees are evident. This situation is similar to that during the 1930s following which up to 90% of the mature pine were killed in stands over 650 km^2 in the Kootenay and Banff National Parks by 1945.

In Alberta, a major infestation exists in the Waterton Lakes National Park and the adjacent southwestern corner of that province. Infested pine stands were scattered in the foothills from the United States border northward for approximately 120 km with outlying infestations in the Cypress Hills Provincial Park in both Alberta and Saskatchewan.

Extensive sanitation cuttings have been underway to constrain the beetle activity in these areas. In total, this has involved about 700 trees in the Cypress Hills and 42,000 trees in Alberta. The beetle has also been found in shelter belts and ornamental or street plantings at 35 locations in southern Alberta and in one tree at Maple Creek, Saskatchewan. Mostly, these were Scots pine in or near centres such as Lethbridge, Medicine Hat, Brooks, and Drumheiler.

In considering the information just presented, it should be remembered that the maps and area or tree estimates are based on newly faded trees, most of which were attacked the year preceding the annual aerial surveys. Recalling the biology of the tree and bark beetle interaction, foliage on trees attacked late in the summer of 1980 generally does not turn the characteristic bright red until July 1981. Recently killed trees that are still green or trees killed in earlier years are not reflected in the annual data. Resultsfrom ground cruises may more clearly indicate actual stand conditions. An overall average based on 48 stands cruised this year in British Columbia indicated that:

- 16% of the trees were red, having been attacked and killed in 1980.
- 22% of the trees were still green but fatally attacked this year, indicating a still expanding and increasing infestation.
- 19% of the trees had been killed from attacks prior to 1980.
- 3% of the trees were partially attacked and may survive, if only to be reattacked.
- 40% of the trees, usually smaller trees, were as yet unattacked.

However, the variation among stands is extreme. The percentage of currently attacked trees ranged from 0 to 72, and in some stands that had been infested for as few as four years, less than 10% of the trees were still alive.

In summary, the mountain pine beetle, a native pest, is currently epidemic in lodgepole pine and some white pine stands throughout central and southern British Columbia and adjacent portions of Alberta. Recent tree mortality is evident on more than 160 000 ha of forest land. Older, almost complete stand mortality, most of which is unsalvagable, covers more than 50 000 ha. Based on ratios of recent to current attacks, a doubling of tree mortality can be expected in 1982 in British Columbia (that is 1½ trees for every person in Canada).

THE CURRENT SITUATION OF THE MOUNTAIN PINE BEETLE IN THE UNITED STATES AND THE RESOURCES INVOLVED

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Lodgepole pine is one of the most widespread and important tree species in the coniferous forests of the western United States. It ranks fourth among timber types in area occupied–covering about **13.3** million acres, or **11%** of the total area of commercial forest-land in this region (Forest Statistics for the United States by State and Region, **1970).** When included with western white pine and ponderosa pine, it covers about **41** million acres, or about 30% of the total area of commercial forestland in the western United States.

The pine forests provide cover for watersheds; forage for livestock; habitat for wildlife; wood products; scenic and other recreational values; and air quality enhancement. Because of the large proportion of area covered by the major pine forests, they are often the major provider of many of the above forest resources in this vast area.

The beetle, like fire, has been active and has coexisted in the ecosystem almost as long as there has been lodgepole pine. The large increase in ground fuel and the associated increase in the probability of large high-intensity fires due to beetle epidemics suggests that the relationship between beetle infestations, fires, and lodgepole pine tends to perpetuate lodgepole pine, and hence mountain pine beetle infestations.

EXTENT OF CURRENT INFESTATIONS

In the western United States, reported mountain pine beetle infestations date back to the early **1900s.** Current outbreaks, which developed to epidemic status during the past two decades, are shown in Table **1** (see next page).

Management objectives should be directed toward preventing, or at least substantially mitigating, development of epidemic infestations. Once populations increase to an epidemic status and outbreaks become as large as we now are experiencing, management of beetle populations, as well as other resources, becomes more complicated.

Since mortality is known to vary widely between and within stands, various systems for assessing susceptibility of individual stands to mountain pine beetle outbreaks have been developed and implemented in some areas.

In the Northern Region, lodgepole pine stands on national forestland in Montana have been hazard-rated using the method developed by Amman et al. **(19771.** Susceptibility is based on: (1) climatic suitability (elevation and latitude) of the lodgepole pine stand for outbreak development; (2) average age of the lodgepole pine in the stand, more than *5* inches DBH; and (3) average DBH of the lodgepole pine in the stand, more than *5* inches DBH.

Climatic suitability is based on observed lodgepole pine mortality to mountain pine beetle for many different elevations and latitudes from Colorado to the Canadian border (see Figure **1**).

Average stand age is not **a** measure of tree vigor, but rather of phloem suitability. Young lodgepole

Table 1

Acres of Host Type
Infested By Mountain Pine Beetle
In Western United States Forest Service Regions
During 1981

Region	Host Type (acres)				Total Acres
	Lodgepole Pine	Ponderosa Pine	Western white Pine	White bark Pine	
Southwest	----------------	89 900	-----------	-----------	89 900
Intermountain	901 700	14 600	-----------	-----------	916 300
Rocky Mountain	186 800	322 000			508 800
Pacific Northwest	562 130	93 500	58 780	-----------	714410
Northern	2 334 537	76 623	9 026	10 386	2 430 572
Total Acres	3 985 167	596 623	67 806	10386	4 659 982

SOUTHWEST REGION: infestations increased in old- and secondgrowth ponderosa pine stands. Tree mortality is widely scattered (2.5 trees per acre), with about 224 750 trees being killed in 1981. An increasing trend is predicted in all infested areas in 1982.

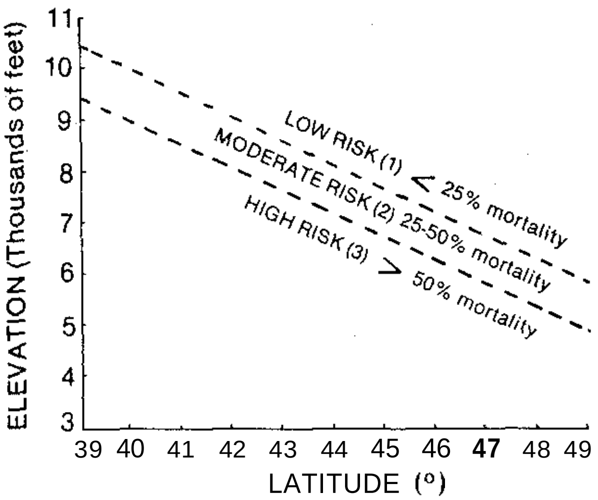
INTERMOUNTAIN REGION: More than 1.5 million trees were killed on 916 300 acres in 1981. Mortality of lodgepole pine and ponderosa pine stands is predicted to increase in Utah, southern Idaho, and western Wyoming in 1982.

ROCKY MOUNTAIN REGION: Infestations are declining in ponderosa pine stands along the Colorado Forest Rang, but a marked increase in acreage and in number of lodgepole pine mortality occurred in Colorado in 1981. A significant increase occurred in ponderosa pine stands in Wyoming. The outbreak remained 'static in Second-growth ponderosa pine stands in the Black Hills, South Dakota.

PACIFIC NORTHWEST REGION: in Oregon, the major outbreak in lodgepole pine stands in the Blue Mountains of eastern Oregon has persisted for 10 years, While mortality is continuing, damage is declining significantly due to host depletion. Mortality increased in mixed lodgepole-ponderosa pine stands on the Dechutes Plateau and Klamath Basin the past three years. In Washington, damage continues in white pine stands along the east side of the Cascade Range. Beetle infestations are increasing rapidly in lodgepole pine, particularly on the Colville National Forest.

NORTHERN REGION: Outbreaks started in 1969, with major infestations now occurring in lodgepole pine stands on the Beaverhead, Gallatin, Lolo, Flathead, and Kootenai National Forests and the Montana, Glacier, and Yellowstone National Parks. In the past tree years, infestations have developed in lodgepole pine stands on the Deerlodge, Helena. Custer, and Lewis and Clark National Forests: on the Blackfeet Indian Reserve in Montana; and on the Nezperce National Forest, Craig Mountains, and Bureau of Land Management lands in northern Idaho. In 1981, infested acreage increased in secondgrowth ponderosa pine stands on national forest, Bureau of Land Management, Bureau of Indian Affairs, state, and private lands. Major epidemics—in west Gallatin, in portions of the Beaverhead and Flathead National Forests, and an the west side of Glacier National Park—are declining due to host depletion. In 1982, significant mortality is predicted in some lodgepole and ponderosa pine stands on a localized basis.

Figure 1



Risk of mountain pine beetle infestation in lodgepole pine can be defined by zones of elevation and latitude. Percent mortality is for trees 8.5 inches DBH and larger (Ammanetal., 1977).

pine, greater than 60 years old, have phloem more spongy and more resinous than older trees. Such trees tend to dry excessively after being infested. These characteristics are less apparent in lodgepole pine 60 to 80 years old. Lodgepole pine greater than 80 years old tend to have phloem that is considerably firmer and that contains fewer and smaller cortical resin ducts. Such trees generally dry slower than young trees, thus providing adequate moisture throughout beetle development (McGregor et al, 19811.

The average DBH of lodgepole pine in the stand is used because of the beetle's strong preference for, and greater brood production in, large-diameter trees (Cole et al., 1976). The average DBH, greater than 7 inches, presents a low hazard; 7 to 8 inches, a moderate hazard; and more than 8 inches, a high hazard. Of these categories, only lodgepole pine stands with an average DBH of greater than 8 inches can be expected to have a sufficient number of large-diameter trees for the beetle population to build up and be sustained.

The average elevation, stand age, and DBH are obtained during a routine stand examination. For small stands, less than 20 acres, a systematic random or grid sample of 10 variable plots (10 BAF) is recommended. For larger stands, 20 variable plots are suggested. Age is obtained from increment cores taken at breast height from 3 trees nearest to plot centre, 5 inches DBH and larger. The average diameter for the stand is determined from measurement of all lodgepole pine trees 5 inches DBH and larger within each plot.

Risk values assigned to each of the three factors (climatic suitability, average tree age, and average DBH) are multiplied, to obtain the stand hazard, as shown in Table 2 on the next page.

In the Northern Region, the Kootenai National forest was the first to hazard-rate lodgepole pine stands for susceptibility to mountain pine beetle. Data from stand examinations showed 278 782 acres of high-hazard, 56 656 acres of moderatehazard, and 93699 acres of lowhazard. Results of the hazard-rating are shown in Table 3 on the next page.

Following rating, the National Forest personnel assigned harvest priorities to high-hazard stands. An interdisciplinary team, representing the various resources involved, discussed and developed plans for the management. Priority was given to high-hazard stands. Concerns were identified, alternatives were discussed, and management prescriptions were developed. Prescriptions involved road layout, grazing, recreation, big game, fisheries, watershed, soils, visuals, fuels buildup, type of cutting, and precommercial and commercial thinnings in low- and moderate-hazard stands. Site preparation and re-generation are prime concerns in the management prescriptions.

Since hazard-rating began in 1975, 791.9 million board feet of lodgepole pine have been logged in Montana from 95 574 acres from state, private, and federally managed lands.

IMPLICATIONS OF MOUNTAIN PINE BEETLE INFESTATIONS

Silvicultural Implications

Infestations leave mature, or nearly mature, stands in an understocked condition. The site is no longer completely occupied with an even-aged stand and growth loss occurs. Stands in this condition frequently fill in naturally and, with the resulting multiple age classes, the stand may never culminate MAI (Mean Annual Inr-ement). Stands developing naturally, following an infestation, will be uneven-

Table 2

Risk Classification of Lodgepole Pine Stands

Factors	Risk Values		
	1 = Low	2 = Moderate	3 = High
Elevation-latitude	high	moderate	low
Average age (years)	60	60-80	80
Average DBH (inches)	7	7-8	8

Table 3

Mountain Pine Beetle Infestation of Lodgepole Pine Stands
Kootenai National Forest, Montana, U.S.A.
1975-1981

Hazard Class	Acres Infested and Percentage Infested													
	1975		1976		1977		1978		1979		1980		1981	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Low	0	0	0	0	10	1	615	1	26	1	250	1	0	0
Moderate	0	0	0	0	837	1	495	1	455	1	850	1	1500	3
High	5 130	2	17 638	6	10 863	7	20 562	7	29 413	11	62000	22	71 270	26

aged. This type of stand structure, unless converted to a regulated distribution of age classes, cannot be managed effectively over time to contribute to the sustained yield projected for the area. Conversion strategies can be lengthy and require high administrative costs. It is desirable to increase the difference in ages between even-aged stands in the same area. Between-stand diversity represents an opportunity to avoid future large-scale infestations.

Species compositions, after an infestation, are likely to feature a high proportion of tolerant species. These can be difficult to manage through the next rotation. They are generally thin-barked species subject to damage from fire and logging equipment.

Wildlife Implications

The Forest Service is responsible for wildlife and fish habitat on national forestlands. This is accomplished by increasing habitat capability to meet established objectives, integrated with other resource programs.

One of the essential features of habitat is the cover-to-forage ratio. The removal of coniferous vegetation by either logging or insect outbreaks alters the balance of cover-to-forage ratios and thus. increases or decreases habitat capability. The optimum cover. to-forage ratio is 50 to 50.

The removal of cover creates openings. The use by wildlife of openings is related to eight independent variables:

1. Depth of slash–not over 1 foot.
2. Width of the opening–less than 1 000 feet from cover.
3. Orientation aspect–north versus south.
4. Vegetative habitat types–production of forbs and shrubs.
5. Road location and density.
6. Density of edge cover.
7. Age of the vegetation in the opening.
8. Livestock density.

Recommendations for salvage of insect-killed timber are as follows:

After harvest, close roads to reduce human disturbance and increase wildlife use in openings.

Broadcast burn slash or blowdown to stimulate production of forbs and provide wildlife access.

- Leave dead-tree buffer strips along roads to screen openings and provide security in openings.
- Leave 3 to 4 large, dead trees for cavity-dependent bird species. In addition, leave groups of dead trees, 1 to 2 acres, for diversity and wildlife security cover. This is to allow greater use of openings and key habitats.
- Timber removal should run the shortest period of time possible.
- Reforestation programs should be coordinated with future habitat requirements. Key wildlife areas around riparian zones, wet areas, and key forage habitat should receive high priority.

Recreation Implications

Insect control through timber harvesting in the wilderness system is contrary to our current direction.

Harvest of beetleinfested areas will unavoidably have effects on the visual resource. Normal measures for retention or partial retention of the visual quality will be difficult.

Large areas of beetle-killed timber are less usable for many dispersed recreation activities because of enormous amounts of downfall. On the other hand, activities such as snowmobiling or downhill/cross-country skiing could benefit by openings caused by logging and fire.

The beetle infestation will have a severe effect on many recreation sites by eliminating the overstory and screening. At West Yellowstone, Montana, the Hebgen Lake Ranger District has protected trees for two years in high-value sites by spraying with Sevimol-4. At McGregor Lake on the Kootenai National Forest, the public opposed the spraying of campground trees. All these trees were killed in 1981.

Fire Implications

The forests of the Northern Region were born of fire and, in the succession of plants in these northern ecosystems, fire plays a role. Short-lived species, like lodgepole pine, demonstrate fire's role very well. The mountain pine beetle seems to fit the pattern because it attacks the pine toward the end of the tree's life cycle. The pine dies and a fuel bed is prepared for fire spread. The serotinous cones on lodgepole pine open under the heat of the forest fire, the seed falls into the ashbed, and a new forest develops.

Currently, beetle attacks in the Northern Region are building enormous fuel beds that, unless treatment occurs, will burn in time. Protection capabilities are geared to the normal fire and fuel situation. Either logging or other treatment is needed to abate the hazard. If fire starts, the chances of having a large fire are increasing rapidly. One of the consequences is that a fire will move out of the dead pine into other timber stands. Another consequence is that, with fuels of this magnitude, a large number of areas will be burned, causing watershed and soil problems. A reduction in salvageable material would help reduce fire intensities and some value would be realized.

Land Development Implications

The following direct investments were made for construction and reconstruction of roads in support of timber sales related to mountain pine beetle infestations during the fiscal years of 1979 through 1981:

National Forests	Miles	$ (millions)
Flathead	101	3 705
Gallatin	7	579
Kootenai	57	1289
Totals	165	5 573

The regional total direct investment for road construction and reconstruction for this same time period was approximately $25 000 000. The biggest tradeoff is between specific timber management needs that require new road access and specific areas of infestation. Sufficient road construction funds are not available to meet all the needs, thus, priorities must be established. Another tradeoff is that higher standard roads may be required to haul greater timber volumes in a short time period for infestations. This increased cost may not have off. setting benefits.

GENERAL CONSIDERATIONS

The purpose of land management planning at national, regional, area, state, or National Forest level is to provide the necessary management direction to meet objectives and resolve public issues and management concerns. This is done by examining policies being considered for change because of public or management concerns. Management prescriptions and practices are then formulated to meet new objectives. The overall objective is to supply goods, services, and uses by maintaining or improving the productivity of the forest and rangeland, as well as to continually improve forest and rangeland conditions to minimize the effect of pests and other similar influences. Land management planning interacts with pest management by:

1. Specifying which pest management practices are acceptable and can be practiced in the forest. This also includes developing Land Management Plan coefficients to be used in yield calculation tables.

2. Specify management prescriptions that encourage forest and rangeland conditions that minimize the catastrophic effects historically associated with pests.

3. Specify. after reviewing options, pest management policies at the national, regional, and forest level that resolve public issues and management concerns.

4. Pest management interpretation of existing conditions and projection of future conditions is important in forming Land Management plans.

5. Evaluation of forest and region plan alternatives is important–to assure that pest management implementations and effects are fully understood, documented, and discussed, through the interdisciplinary team and with the appropriate line officer responsible for the plan.

6. Assist in implementing the plans by following an identified monitoring of evaluation responsibilities in the plan to assure objectives are met and necessary changes considered and implemented.

IMPACT OF
THE MOUNTAIN PINE BEETLE
ON THE ECONOMY OF BRITISH COLUMBIA

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My task in this paper is to outline for you some of the actual and/or potential economic impacts of the mountain pine beetle in western Canada and what we know and don't know about these impacts. My comments will largely be aimed at the situation in British Columbia, as that is currently the main focus of the epidemic in western Canada.

The statistics presented by Allan Van Sickle are devastating and more than adequately indicate the physical impact of the mountain pine beetle in Canada. There is little need to repeat them.

The economic impact, real or imaginary, actual or potential, revolves around the basic question of who manages the forest–little black beetles or foresters. The exact composition of this impact will vary but may be divided into five major components: (1) impact on allowable cut and value of output, (2) impact on resource flows, (3) impact on product values, (4) changes in protection costs, and (5) changes in forest management costs.

There are relatively few statistics in my presentation. This is because what we do not know about the economic impact of the mountain pine beetle far exceeds what we do know. and figures developed from panicky, half-baked analyses have a way of becoming "gospel".

The one set of figures we have developed, which I suspect are rather exaggerated, relates to the impact on allowable cut. They will at least serve to highlight my previous warning!

If. as one report suggests, there is no economically available uncommitted timber in British Columbia, each thousand metres^3 decline in allowable cut caused by the mountain pine beetle results in a loss of 1.87 jobs in the logging and sawmilling industries, with an income loss of 535,230 from forest industry employment. Applying a local multipler of 2, the employment loss is 3.74 and the dollar loss is $70.460. To this must be added lost revenue from stumpage ($0.30-$16.16/m^3) and tax revenue losses (provincial losses of $3.45/m^3, federal losses of $3.42/m^3), though these might not be incurred in total.

On the basis of these values and the estimated 5 million metres^3 loss in 1981, the economic impact from Annual Allowable Cut (AAC) losses in this single year was a possible 5450 million.

Now, just because an acre is infested, it does not fall out of the allowable cut. Further, in calculating allowable cuts, some allowance is usually made for anticipated, unsalvageable losses. In one timber supply area (TSA), Invermere, this figure for insects and disease is nearly 3%. It is very unfortunate that we don't know the unsalvageable losses and their relation to the loss allowance, but it is highly unlikely that the actual economic loss due to allowable cut impact in 1981 was anything like $450 million. The previous statements are not to be taken as an attempt to gloss-over the impact of the pine beetle. In the case of individual TSAs or individual firms, the impacts can be devastating.

On a regional basis, the impact may be shown for the Nelson Forest Region, where only 10% of the volume of mature timber is lodgepole pine, while in excess of 25% of the harvest consists of pine. Companies such as Crowsnest and Crestbrook, whose resources lean heavily to pine, will undoubtedly feel the pinch. One industrial case in point is the reported breakdown in the negotiations for sale of Crowsnest Industries (in Fernie) to Canfor. The reason given was excessive pine beetle infestation in Crowsnest's cutting area.

The wrap-up question is the extent of curtailment of planned regional economic expansion. At this point, we can fairly safely indicate loss, given the usual economist's assumption of "all other things being equal". The values lost by curtailment of expansion are approximately the same as those mentioned for allowable cut impact, or nearly \$90,000 per thousand metres^3.

The loss due to impact on resource flow (the problem of timing) may well be more important. The forest economy is a very cyclical thing. At present, we're in the midst of the worst slump in 25 years, according to some industry analysts. In the face of the slump, the beetles keep munching away. That which is salvageable must be salvaged or lost. Beetle-kill can't be stored on the stump. This wood, if not harvested, does represent a real loss, the value of which we can estimate if we know the volumes involved.

The question of product values must also be briefly mentioned. The value of products from beetle-kill logs is probably not as high as from green logs. The main culprit is blue-stain. A secondary problem is that pulpmills prefer chips from green wood for their superior pulping characteristics. Again, we must confess that we don't know the extent of the value loss.

There are two parts to the impact of increased protection costs. The first is the cost of the attempt to head off increased infestation. Other speakers will go into considerable detail on this point. The other part of the cost is increased fire protection costs. Extensive areas of fresh red beetle-kill appear to be an inferno waiting to happen. There is probably some marginal increase in fire protection costs due to pine beetle, but increased public awareness has, so far, kept increased suppression costs to a minimum.

Another impact to be briefly mentioned is that on forest management costs. A major component of this impact is increased road costs to salvage beetle-kill. Because the beetle dictates harvest patterns, orderly development of road networks is precluded. It is not uncommon for roads to be pushed for miles through harvestable, noninfested timber to reach a salvage area; or for roads to noninfested areas to be built and then sit idle as the beetle forces other roads to be built. This all costs government, industry, and ultimately the consumer a considerable but indeterminate amount.

I do not wish to go into the question of "nonmarket" impacts at this time. We are aware that there is the possibility of some impact on esthetic, hydrological, and recreational values. Further, there is the impact on wildlife, which should also be addressed at some time. However, the identification and measurement of these "nonmarket" impacts will require some iodepth review, which we do not have time to perform here.

If the foregoing sounds like an economist's litany of woe, it is. We have more "don't knows" than "knows". We know that there is an economic impact and that locally it may be severe. Because of the many facets of 'this impact, we cannot accurately estimate it at this time.

RESEARCH NEEDS: ENGINEERING, UTILIZATION ECONOMICS, SOCIOECONOMICS, AND FIRE

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With few exceptions, management practices intended to reduce losses to mountain pine beetle, to recover mortality, or to condition stands to resist attack, involve removal of a portion or all of the stand. Harvesting is the principal management tool available to the manager to enhance stand development and avoid losses to insects, disease, and fire. Consequently, harvesting systems and practices, access, and utilization strategies are of paramount importance.

The issue most frequently at hand is one of economic feasibility; that is, covering the costs of stand treatment with the value of products removed. Compatibility with nontimber resource management and environmental considerations can also be critical issues. Much of the research to date and much of the research needed in utilization, engineering, and economics relate to: (1) reducing harvesting costs, (2) enhancing product values, and (3) developing compatible multiresource management strategies. More efficient harvesting technology and expanded utilization alternatives can extend management to stands presently considered subeconomic.

STAND MANAGEMENT AND RESOURCE UTILIZATION CONSIDERATIONS

Harvesting system performance requirements and the economic feasibility of harvesting or cultural stand treatment are, heavily influenced by stand character and condition. Some of the principal stand conditions in lodgepole pine influencing harvesting system development and economic feasibility include:

1. Old-growth, decadent stands, frequently containing large volumes of down, dead material. Heavy concentrations of down, dead stems restrict the movement of personnel and certain kinds of ground-based equipment and also present a particular residue recovery opportunity.

2. Mature, green sawtimber stands, with a relatively clean forest floor, providing good access for personnel and equipment:

   a. With no significant understory.

   b. With a conifer understory that requires protection during harvesting operations.

3. Mature sawtimber stands with extensive recent mortality, usually without an excessive amount of down material:

   a. With no manageable understory.

   b. With a conifer understory to protect.

   Such stands offer immediate salvage opportunities and may involve some urgency in recovering recently dead stems before they deteriorate.

4. Pole stands that may or may not be severely overstocked. Thinning in overstocked stands requires particular care to avoid damage to residual stems.

5. Stands of small, stagnated 2- to 5-inch (5-13 cm) stems, frequently in excess of 5,000 stems per acre (12.000 stems per ha).

Harvesting systems that can effectively deal with removing overstory sawtimber are likely to be different from systems designed to efficiently handle several thousand small stems per acre. Anticipated stand conditions and treatment needs are important factors in establishing design criteria.

Harvesting prescriptions and utilization specifications are also significant determinants of system design. Major variations include:

- Clearcutting, in which all merchantable material is removed, typically without attempting to retain any understory. Clearcutting allows the greatest degree of freedom in system design and mode of operation.

- Partial cutting in mature or mixed age class stands, ranging from shelterwood to seed tree (even-aged management) and group to single tree selection (uneven-aged management). Partial cutting carries with it the constraints imposed by the need to protect the residual stand from damage, which is a significant concern for harvesting system design.

- Commercial thinning in pole stands, with a particular need to meet spacing guidelines and avoid damage, such as butt scarring, to the residual stand.

- Precommercial thinning, where the need to maintain spacing and avoid damage to residual stems is critical. Closer spacing also places particular constraints on the size and type of equipment that can be used. Recovery of small cut stems may also be considered essential to reduce fuel loading.

Within any silvicultural prescription, the level of desired or required utilization affects harvesting system productivity and influences system makeup. Intensive levels of prescribed utilization of normally submerchantable material may dictate whole-tree recovery systems and in-woods sorting and processing capability.

Product opportunities and product potential are a third determinant of harvesting and utilization system design. A system must be appropriate for intended product recovery objectives; e.g., an in-woods chipping system is inappropriate for recovery of roundwood products. Product considerations in lodgepole pine include:

- Commercial poles.

- Posts, fencing, rails, small roundwood products.

- Houselogs (frequently the product of highest value).

- Sawn lumber, principally dimension stock and studs.

- Chip and fiber products, ranging from clean pulp chips to whole-tree chips for fuel.

Increased product opportunities are facilitated by the development of harvesting systems oriented toward whole-tree recovery, leaving maximum product options open.

The enhancement of end-product values is also a valid research concern. Lodgepole pine exhibits some excellent stem form and wood quality features–straight stems, little taper, small knots, slow growth, uniform texture, and superior machine-ability. Although the species has historically been utilized for relatively low value kinds of products, the opportunity exists to develop end uses and markets that could substantially increase recovered product values.

Harvesting systems research, utilization strategies, and products research must be approached with a view to developing total systems that integrate stand management objectives, maximization of product potential, and economic efficiency. A major current research need is for the development of well-defined "management systems" for lodgepole pine that consider short- and long-term management objectives. Comprehensive management systems can set the parameters for harvesting and utilization system design. At present, there is a lack of consensus on the management needs that harvesting systems must satisfy and on the specific operational and economic criteria that system design should be addressing.

TECHNOLOGICAL ACCESS AND HARVESTING SYSTEM CONSIDERATIONS

Given the decision to harvest or treat a stand, the first technological problem is getting there–creating access to the site. Much of the lodgepole pine in the Northern Rocky Mountains is either under. accessed or totally unaccessed. Thus, road design and construction is a significant problem and a major contributor to economic infeasibility. Research is needed to develop acceptable alternatives to expensive system road design and construction practices. Alternatives need to consider both economic and environmental concerns and be directed toward developing cost-effective, lower standard access systems that can still satisfy performance and environmental protection requirements.

Once on the site, the technical question is one of equipment and practices to achieve maximum harvesting efficiency. On gentle terrain, the options are somewhat more numerous and less costly than for steep terrain. For example, feller-bunchers provide an efficient option for facilitating whole-tree recovery and for accomplishing bunching prior to skidding. Research to date demonstrates the importance of bunching as a subfunction in small stem harvesting systems and the general need for systems designed to handle multiple, rather than single stems. Following bunching, grapple skidders can move stems in whole-tree form to landings for further processing. One such procedure that offers promise is to employ any of several whole-tree processors that delimb and buck material to desired lengths. Logs may be recovered tree-length or to specified lengths: limbs and cull portions can then be chipped on the landing for fuel. Additional research in system makeup, operating strategy. and in-woods practices is needed to improve the economic efficiency of such systems.

Stands on gentle terrain may also allow consideration of more frequent entries into "tended" stands (i.e., intensively managed stands), following the European style of management. The development of permanently dedicated forwarding trails and the use of various kinds of fast-forwarding equipment can provide a systematized means of removing material at frequent (10- to 20-year) intervals.

In steep terrain, the technological problem is somewhat more difficult and usually more costly. Basic system design considerations include .developing reduced dependence on roads, achieving means of bunching small stems prior to yarding, and resolving anchoring needs for cable systems. One bunching concept currently under study uses a self-powered skyline bunching carriage. Bunched material can then be grapple-yarded in multiple stem turns. Anchoring needs, a major concern in small-stem stands, require the development of artificial anchoring methods for cable systems.

Where timber values allow, multispan cable systems offer potential for resolving difficult harvesting problems posed by limited access in steep, irregular terrain. Such systems are comparatively insensitive to road location and density. Smaller, lowcapital investment skyline systems are also badly needed. A significant research opportunity exists for develop ment of low-capital investment systems that retain running skyline capabilities and afford reasonable reach capability.

Alternatives to conventional cable systems are also possibilities. One concept currently under study proposes a steep slope ground vehicle, operating in conjunction with small, portable skyline towers and powered by cable. Permanent forwarding corridors are established, along which the cable-powered forwarding vehicle moves. This concept allows significantly reduced dependence on roads, facilitating operation at some distance from roads on irregular terrain.

To guide future harvesting systems development, a particular research need is for broad economic analyses of alternative harvesting system and access system combinations. Trade-offs between systems that require a relatively dense road network and the development of no-road harvesting technology need to be viewed in terms of economic consequences for both short- and long-run stand management. The issue of future road spacing has not been sufficiently addressed, yet it forms a critical basis for the direction of research efforts in harvesting methodology.

NONTIMBER RESOURCE MANAGEMENT AND PROTECTION CONSIDERATIONS

Timber harvesting and utilization practices dramatically affect other resources and use opportunities on an area. The effects can be beneficial–in fact, necessary–to achieving management objectives; they may also be viewed as detrimental to certain objectives. To the extent that alternative practices affect the opportunities, activities, and potential well-being of the public, they become socioeconomic issues. The real or perceived effects of alternative systems and practices on other resources and on people significantly influence the whole approach to timber access, harvesting, and utilization. Harvesting and utilization alternatives should be compatible with and facilitate meeting total resource management objectives and public expectations.

Specific resource management concerns with which harvesting and utilization systems and practices must interact include:

1. Adequate and timely regeneration.
2. Wildlife habitat effects (a concern that may often be reflected as a primary purpose of treatment).
3. Watershed management: water yields, timing, and quality.
4. Site quality: effects on nutrient capital, soils, and microbiology.
5. Esthetic quality: how it looks and how it is expected to change over time.
6. Residues management: level of utilization practiced and post-harvest site treatment.

Research is needed to more explicitly define the consequences of alternative harvesting and utilization practices for these and other resources and management concerns.

Residue management problems are a socioeconomic concern, as a question of esthetics, and a physical and economic concern in terms of fuels, fire management, and the high cost of residue treatment. The use of prescribed fire is frequently the chosen means of residue reduction and site preparation. Research is needed to develop a better basis for prescription to achieve desired effects and to better define the total consequences of fire on the ecosystem and on vegetative succession. Because lodgepole pine is favored by the appropriate use of fire, fire is likely to be included in any management strategy proposed for the species.

Fire—including fuels management, use of fire, and smoke management—is frequently an issue of public concern. A strengthened scientific basis for prescription and use of fire is essential to the acceptance of management practices that include fire.

Finally, the effects of alternative harvesting and utilization practices on local and regional economies is an issue. Particularly needed is research to define the probable effects of major changes in policy or practice on both large and small industry. Because lodgepole pine is frequently the major species in the area of interest, management direction for lodgepole pine is critical to the stability of the timber-dependent industry.

RESEARCH NEEDS: A SUMMARY

The foregoing discussion elaborates on a few research needs believed to be most critical to improvement of management opportunities in lodgepole pine stands. For convenience, the following tabulation summarizes those, as well as other research needs that relate to harvesting, utilization, economics, socioeconomics, and fire.

1. Resource Management
   - Improved resource inventory information.
   - Research in "Management Systems" for lodgepole pine (management direction and treatment needs).
   - Improved criteria for systems development.
2. Products and Processes
   - Improved multiproduct recovery systems.
   - Enhanced product values.
   - Specific product-process systems for small timber.
   - Concentration yard and merchandizing systems.
3. Harvesting and Access Systems: Engineering

   a Harvesting Systems
   - Systems for bunching, fast forwarding.
   - Efficient systems for whole-tree processing, small stems.
   - Reduced capital investment requirements.

- Anchoring systems (for cable operations).
- Reduced dependence on roads.
- Reduced sensitivity to road location.
- Labor and energy efficiency.

b. Access

- Development of lower cost access alternatives.
- Effective integration of access and harvest systems.
- Development of more efficient "large area" access and harvesting planning.
- Research in cost-effective alternatives for meeting both performance and environmental objectives with forest roads.

4. Economic and Socioeconomic Issues

a. Economic-Financial

- Methodology for multiresource cost-benefit analysis: marginal costs and values.
- Investment analysis for alternative stand management strategies,
- Effects of significant timber utilization changes on regional, local economies.

b. Socioeconomic

- Research defining influences of alternative harvesting practices on:
  - Esthetic and recreation values.
  - Wildlife, range.
  - Watershed management.
  - Future resource values.
  - Protection concerns.
- Research investigating public preferences for management of lodgepole pine timberlands.

5. Fire Management

- Research defining influences of fire on lodgepole pine ecosystems and succession.
- Development of prescription guidelines for use of fire to achieve management objectives.
- Refinement of beetle fuel-buildup fire relationships: fuels modeling over time.

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
Moderate	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	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 acfion 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 treelstand 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 priorized. 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 aresalvage 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.

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:

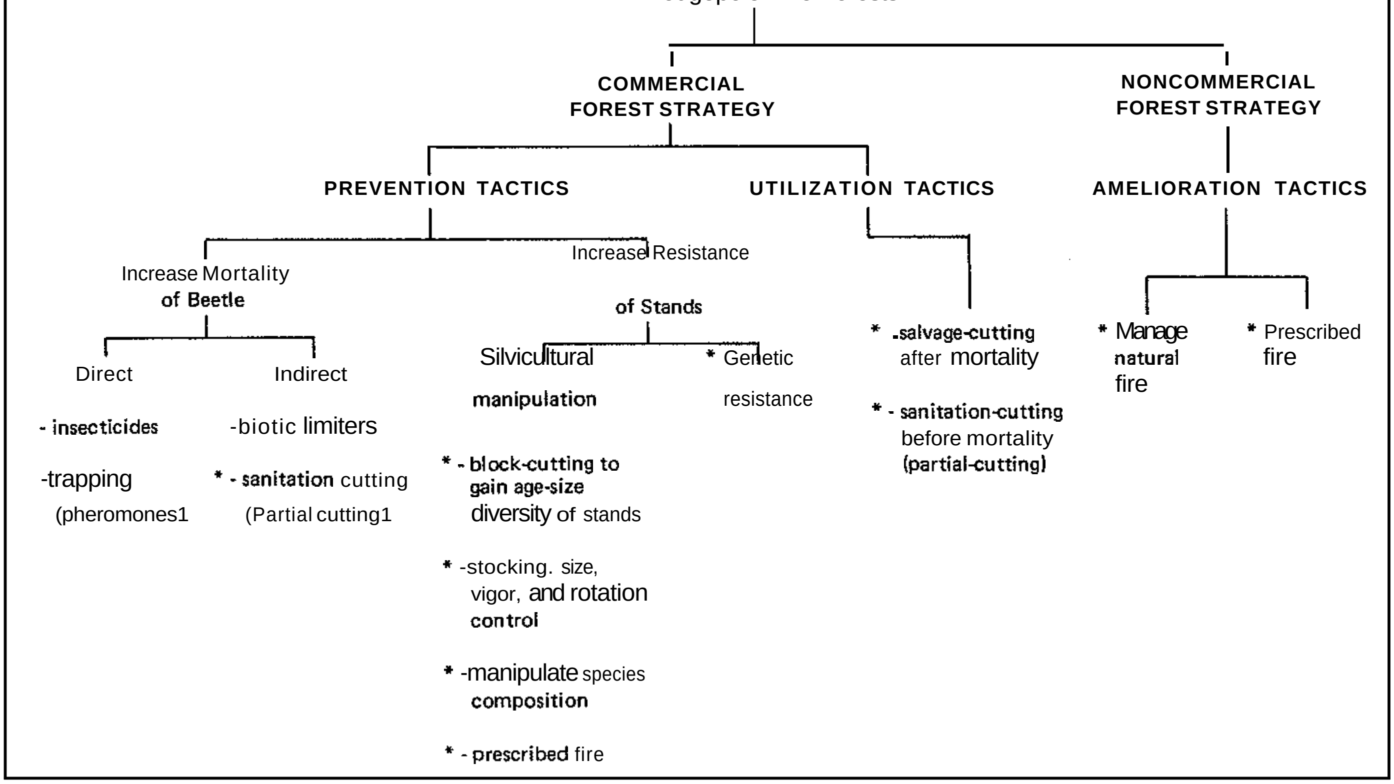
- Group selection
- Single-tree selection

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



* 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 eauation.

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 (*Choristoneora 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

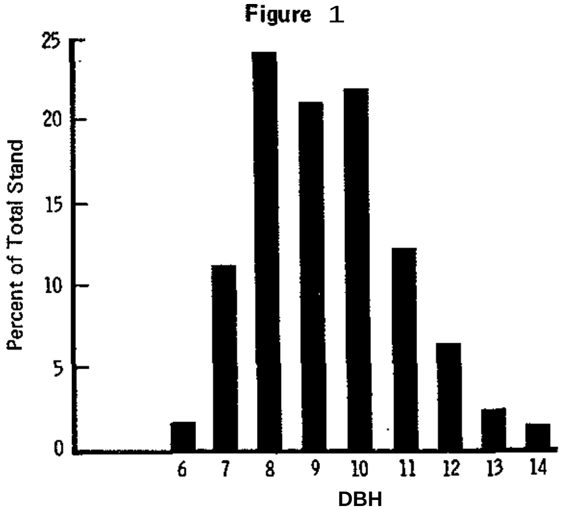
Immature forests offer, by far, the most opportunities for management in general and the mountain pine beetle problem specifically. This dynamic period in the life of the stand also permits relatively easy stand manipulation that can be used to adjust the following factors:

- 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, 19671

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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THE NEED FOR ACTION

WHAT IS BEING DONE IN THE FORESTS OF ALBERTA AND PLANS FOR THE FUTURE

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Although not proven conclusively, we believe the mountain pine beetle infestation in southwestern Alberta is a result of the spread of this insect from Montana and British Columbia. Beginning with a small infestation on the west side of Glacier National Park in 1972, the beetles moved up the Flathead River Valley into British Columbia. and, hence, into Alberta. The first infestation in Alberta was noticed in 1977. At that time, researchers who had been involved in previous beetle infestations indicated that, because of our severe winter climate. the beetles would probably not last the winter. Thus, no action was taken. However, with three consecutive mild winters, the infestation spread from five small patches to 8000 acres of dead trees within three years (exclusive of Waterton National Park). The most severely affected area was the forested area bounded by Montana, British Columbia. and Highway 3 in the southwestern corner of Alberta. At the same time, beetles continued to spread beyond this area. In 1980, hundreds of infested pockets of pines were found to the north and east in the Porcupine Hills and in the East Livingstone Range. Beetles were also found 200 miles east in the Cypress Hills of Saskatchewan and Alberta and 180 miles to the northeast in Drumheller. Trees in farm shelterbelts throughout southern Alberta had been attacked. Pine trees in urban areas such as Lethbridge were infested as well.

Recent surveys in British Columbia indicate there is some buildup of beetles along the Alberta boundary. Because of the dramatic buildup and long-distance dispersal of this insect, as indicated by the current infestations, we are concerned about further infestations along our western flank. Beetles know no political boundary and, unless coordinated action is taken, recurrence of this scenario is expected every time a beetle epidemic occurs. Researchers indicate that proper management of the forests would limit the problems. However, where management alternatives are limited. as in the national parks, these areas could be a haven for huge infestations, as witnessed in the past decade. The fear of further spread of the beetles from British Columbia and from the national parks required prompt action. Contacts were made with these agencies to promote direct communication, to review the problem area, and to initiate appropriate action.

ACTION TAKEN

In the spring of **1980,** the Alberta Forest Service reviewed the pine beetle problem. With already widespread infestation of the beetles in the area south of Highway 3, this zone was considered for salvage only. However, north of this highway in the Porcupine Hills and in the East Livingstone Range, a major infestation had not yet developed. Thus, a concerted control action was considered and initiated. The preliminary planning indicated that only one hundred spots of infestation were to be treated. However, once the control program had begun, many more spots were discovered, so that a major operation had to be initiated. Since no effective biological or chemical control of the beetle has yet been developed, the basic procedure was to cut the affected trees. These trees were then salvaged for lumber, with slabs and edges burned, or the trees were debarked on site. The other alternative, where salvage was not feasible, was to pile and burn.

Since the spring of 1980 to August 1981, 6 000 infested patches were treated, with almost 42 000 trees removed. Most of these trees were salvaged. The cost of the program, thus far, has been approximately $2.7 million. Both crown land and private lands were treated.

In the past year, helicopter logging was initiated in remote inaccessible areas and on private lands where the environmental impact was to be minimized. Although this was a costly operation (costing from $60 to $100 per tree), our staff feels the program was worthwhile.

Salvage of infested trees in the area south of Highway 3 was taking place concurrently with the control operation. The total volume of trees infested by the beetle in this area is 120 million board feet. To date, 45 million board feet has been salvaged. The salvage program was initiated in a period when the lumber market was very poor–a condition that has actually worsened since salvage commenced. Thus, in recognition of this situation, the government recently announced an incentive program, whereby a payment of $34 per 1000 board feet would be made to operators for salvaging fire, or beetle-killed, trees. We are therefore hopeful that eventually the majority of the merchantable timber will be salvaged.

In addition to the actual control and salvage operations, public relation and education programs were launched. Four public meetings were held; brochures and pamphlets were issued; posters warning residents and campers about the danger of transporting infested logs were posted in the area; and a major symposium on beetles was held.

Our most recent endeavor in our ongoing beetle control program was to request that both the Province of British Columbia and the National Park Service of Canada take some action on the beetle infestations in their jurisdiction that are threatening our forests. Early last January, a meeting initiated by Alberta was held with the Canadian National Park Service to discuss the ramifications of beetle spread from the parks to provincial land. In this discussion, Parks Canada indicated that unless British Columbia took action on adjoining areas, any proposed action would be ineffective. Thus, in the middle of January, representatives of four agencies–Canadian Forestry Service, Alberta Forest Service, B.C. Ministry of Forests, and National Parks Service–met and a senior mountain pine beetle management committee was proposed. In April, this committee was formalized and named "The Interagency Committee on Mountain Pine Beetle". The committee is chaired by Dave Kiil of the Canadian Forestry Service, with senior personnel representing the Forest Services of British Columbia, Alberta, and the National Parks. The objective of this committee is to communicate, coordinate, and discuss policy needs and action on the mountain pine beetle problems.

At the same time, a technical subcommittee was formed with the same agencies as members. The objective of the subcommittee is to keep abreast of action taken by members, to monitor and survey the problems, and to discuss research needs. The subcommittee was directly responsible to the interagency committee.

Thus far, two meetings of each committee have been held. A great deal of cooperation among the members has been shown. Certainly the committee formation was a step in the right direction.

SUCCESS OF THE CONTROL PROGRAM

The success of the control program is difficult to measure. By controlling spot infestations, we certainly decreased the population of the beetles within a stand. This would limit the spread of the beetles to adjoining stands. However, beetles from outside sources are always available to further infest the sanitized area. Thus, a continuing control program is necessary until the beetle population declines. Had we not taken action on the Porcupine Hills and the East Livingstone Area, we are certain that all the mature, and almost-mature, pines would have been devastated similarly to the B.C. Flathead Valley and our Castle River drainage. Further to this, if a population buildup had occurred in this area, the beetles would have had a greater opportunity to spread further north. Our lodgepole pine stands are almost continuous from the Peace River country along the east slope of the Rockies to the United States border. This area encompasses approximately 35 000 square miles. Our existing inventory indicates there are more than 6 million acres of pure, or predominantly pure, lodgepole pine type with a volume of approximately 8 billion cubic feet. Much of this forest is in a mature to overmature condition—just perfect for beetle attack. Within this area, there are four forest management agreement areas (a fifth one is presently being established), with a combined annual cut of 128 million cubic feet. Two major pulp mills, a plywood plant, and numerous sawmill complexes depend upon this growing stock. Besides the forest industry, a multimillion dollar recreation complex known as Kananaskis Country is located in the heart of the lodgepole pine stands. The mag nitude of the effect of a major beetle infestation would be difficult to comprehend. Whether the actual infestation or the fires after the infestation devastate the forest, both the long and short-term impact on the forest industry and on the economy of this province would be enormous.

FUTURE NEEDS

Research on the beetles has been carried on for the past decade; yet, the only recommended short-term method of control is the sanitation cut. Sanitation cuts are satisfactory but can be very costly. Biological control methods involving pheromones have shown some promise. However, more research is necessary to improve this method and to provide the forest managers with alternatives. Research is also needed in the area of flight dispersal of the beetles. The use of knowledge about dispersal could certainly assist in pinpointing problem areas and in decreasing the cost of control. Last, but not least, the use of silvicultural methods as a tool for beetle control has always been one of the major recommendations of many entomologists. Although limited studies have been initiated in the use of this procedure, there is need for silvicultural research programs that show positive results.

The gathering together of the agencies involved in pine beetle problems of the northwest is a right step toward greater cooperation and coordination of action. In the past, we have been remiss in communication with our counterparts in adjoining jurisdictions. However, in the future, we will see that this does not occur.

THE NEED FOR ACTION

WHAT IS BEING DONE AND PLANS FOR THE FUTURE IN BRITISH COLUMBIA

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The mountain pine beetle and the devastation that it has caused during the past five to six years will have a major negative impact on future timber supply projections in the interior of British Columbia. Twenty years ago, lodgepole pine was not one of the major species harvested in British Columbia. Whereas increased hatvesting of this species had begun in the better stands in the northcentral interior by 1960, the harvest of lodgepole pine in the southern interior was not significant.

Today, however, lodgepole pine has become one of our most important interior species–both for the manufacture of lumber and pulp. The percentage of the interior British Columbia harvest that was attributable to lodgepole pine increased some 350% in the twenty years prior to 1980, until today with the species comprising some one-third of the total interior harvest. In the Nelson Forest Region, the increase has been even more dramatic–with over a 900% increase in the percentage contribution since 1960. For a variety of reasons, including the poor market situation and the rate of infestation, it is becoming impossible to salvage all the dead and dying timber. For example, a recent submission by the Association of British Columbia Professional Foresters stated that, of the 23 000 hectares infested in the Flathead Valley of the East Kootenays, only 6000 hectares had been logged or was loggable.

Apart from some earlier, more localized infestations of spruce bark beetle, wood losses caused by insects up to 1975 were not excessive. Annual average losses were estimated at some 1 400 000 cubic metres. Recently, the losses from all forest insects have increased dramatically. These losses are currently estimated to be 46% of the total annual losses in the province from fire, insects, and disease combined. From 1975 to 1980, the area of infestation in British Columbia rose dramatically–from 38 700 hectares to approximately 550 000 hectares. Even more frightening is the fact that there are some 2 500 000 hectares of lodgepole pine considered susceptible to attack.

Canadian Forestry Service data in the Nelson Forest Region shows how the number of attacked trees has increased. To date, it is in southeastern and central British Columbia where infestations have been most serious. Many areas of attack involve steep slopes and inaccessible areas, which cause major, and often insurmountable, challenges to salvage operations.

The volume of wood lost annually during the 1975-1980 period was approximately 15 million cubic metres a year, or ten times the annual loss prior to 1975. Stumpage losses to the province have been considerable and are expected to increase. Of course, potential revenue to the federal government through other avenues is also lost. Losses from reduced exports are also substantial. Today, the problem is further aggravated because of the economic downturn, which is having major effects on the industry. Throughout British Columbia, the rate of harvest is beginning to be curtailed for this reason. Thus, while the beetle infestation is spreading faster, salvage is slowing down.

In the Nelson Forest Region of British Columbia and especially in the East Kootenays, the sawmills have been handling increasing volumes of lodgepole pine in a cooperative program with the Ministry of Forests to minimize losses and to help in the control program–that is, until the recent economic downturn. Major planning efforts against the mountain pine beetle have come through two active committees founded several years ago: the East Kootenay and the Kettle Valley Insect and Disease Control Committees. These committees are comprised of representatives from the Forest Service, major timber operators, Canadian Forestry Service, and other agencies concerned with land management, such as the Parks Branch (British Columbia) and the Ministry of Environment (British Columbia). The committees recommend changes necessary in harvesting plans to deal with the beetle situation, in order to speed up harvesting when necessary. The committees have achieved a large measure of success. A report from the Nelson Forest Region puts the problem into perspective. In part, the report says that mountain pine beetle salvage efforts have caused serious disruptions of normal harvesting plans: ". . .because the sustained salvage program has resulted in removal of extensive areas of lodgepole pine, there will also be long-term impacts on the species profile and on the location of future logging opportunities . . .most licensees in the East Kootenay have come close to their target of deriving 70% of their log supply from mountain pine beetle salvage. Intensive mountain pine beetle salvage has also been undertaken in the Kettle Valley Area. Overall, salvage production has not yet resulted in overcutting of the annual allowable cut (AAC) of any timber supply area (TSA). However, there are indications that we are facing another spruce bark beetle epidemic, in which case overcutting may occur. Because spruce stands are often not on common road systems with lodgepole pine, our ability to concentrate on mountain pine beetle will be further diluted."

A reanalysis of timber supply management programs and of the pertinent rates of harvest is currently being undertaken throughout the province, with 30 of the 34 timber supply areas completed. Throughout the interior of the province, this analysis is reconfirming that the timber supply areas usually have a significant imbalance of age classes.

Often, there is a larger component of mature and overmature white spruce and lodgepole pine, with a related shortage of older, immature age classes. The susceptibility of these old-growth forests of spruce and pine to bark beetle attacks has lead to the confirmation of an approved rate of harvest in excess of the long-run sustained yield level. This decision often results in a future fall-down projection in the short term. All the reforestation programs in the world will not solve a short-term timber supply problem. It can only be minimized (or eliminated) through increased utilization practices and through increased protection measures against fire, insects, and disease.

In August of 1981, the Government of British Columbia announced an $11.4 million program for bark beetle control, including the building of access roads into beetle-infested areas for selective sanitation logging. We emphasized that this is not a salvage operation. Rather, the top priority is getting to the margins of the infested areas in order to slow down the spread of the infestation and to buy time through pertinent control measures and selective harvesting programs.

As the Minister of Forests said at the time: "Up to now, the biggest barrier to sanitation logging has been the lack of road access to the threatened stands of timber. Now we are providing the money to build the roads. With the orderly planned harvest of threatened wood, we can take suppression measures to inhibit the spread of the beetle and to lay the foundation for reforestation programs that will minimize the recurrence of beetle infestations in the future."

Of the $11.4 million, $7 million is being spent in the current fiscal year.

What of the future? We know the biology of the mountain pine beetle. Our problem is to apply the existing knowledge to our land management practices.

Like all insects, the mountain pine beetle knows no political boundaries. What we need are mutual agreements for action, where the beetle invades another province, state, or country. Such agreements should include undertaking control programs, salvage logging, and rehabilitation and reforestation programs in areas adjacent to boundaries. In addition, arrangements for sharing fire-fighting equipment and services should be made. It is ineffective for one province, state, or country to undertake control programs and sanitation logging plans to inhibit the spread of an infestation, if it is allowed to spread unimpeded on the other side of the boundary. I believe these agreements should also include national, provincial, and state parks. Huge infestations in parks are just as explosive as they are on other forest lands.

Some horrendous future problems are anticipated as a result of the current infestation. Where salvage operations have not been undertaken, vast areas of dead and dying trees pose an explosive fire hazard. Cost of rehabilitation will be excessive.

The submission prepared by the Association of B.C. Professional Foresters estimated rehabilitation and reforestation costs in the Flathead Valley, alone, to be some $10 million. The briefs called for the valley to be given disaster status and for the Governments of British Columbia and Canada to jointly finance this rehabilitation project.

Of course, the threat from mountain pine beetle can be alleviated to a significant degree, in the long term, by forest management programs. A more variable mosaic of age classes, minimal areas of overmature timber, mixed species types, etc., will all contribute. While timber management and silviculture programs must work toward this end over the future decades, I've chosen not to develop this theme in my presentation today. I understand that the theme of this meeting is to clarify the "state of the nation" (or nations) today and to work toward short-term solutions to minimize the negative impacts of the mountain pine beetle infestation. I simply wanted to clarify that, in my opinion, long-term solutions lie primarily in the judicious choice of timber management and silviculture options.

I appreciate that this is not the appropriate time in today's program to discuss proposed options and programs. When that time comes later today, I'd suggest that we develop some cooperative and compatible programs between provinces, states, and countries to address the mountain pine beetle infestation simultaneously on five broad fronts: control programs; salvage programs; fire protection programs; rehabilitation and silviculture programs; and research.

THE NEED FOR ACTION

AGAINST MOUNTAIN PINE BEETLE ON COMMERCIAL TIMBER AND RELATED LANDS

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When small, privately owned woodlots are between 10 and 160 acres in size and when much of this acreage is in affected lodgepole pine, the owner usually cuts. In this circumstance, these owners are often at a disadvantage on the selling price and may have difficulty getting a good logger. These small acreages may face the same problems in the future, because there is no effective plan for regeneration, thinning, or a second harvest.

Large, privately owned lands between 160 and 20 000 acres are mostly ranches. The owners understand economics and may have considerable understanding of silviculture. Their goals are often different from foresters and timber is harvested whether infested or not. They are apt to suffer the same price disadvantage in a salvage situation as the small, private landowner, unless there is little federal timber on the market at the same time.

There are three large, private commercial timber-producing landholdings in Montana, and if you add Idaho and eastern Washington, there are three more. For the most part, those lands are developed and have been cut over, if only by a salvage cut. Burlington northern might be the exception because they do have considerable virgin lands, and these lands are being intensively managed for timber production. Except for the Burlington Northern lands, much or most of thesuceptible lodgepole pine has already gone to the mill. Ponderosa pine might be a different story, but so far, mountain pine beetle activity is not excessive on large, private landholdings, due to the lack of suitable host material. The large, private landholders do have insect problems, but not to the same extent as the federal lands. Affected timber on large, private landholdings is being salvaged as it is infested, or cut before infestation. Little will be lost.

For a generalization, on all private lands, the lodgepole that now is infested or might become infested is being cut on an accelerated schedule. Little will be left for snags. What are the effects of this? Ecologically, it interrupts a cycle (lodgepole–fire, lodgepole–fire) that occurs in nature. Thiscyclewould have happened regardless of beetle epidemics. The change due to salvage logging, as I see it, is not good or bad, it is just different. The cut areas are usually reforested promptly, though often not with pure, or even predominantly, lodgepole pine. In the future, these areas will be managed with increasing intensity, e.g., spacing control, possibly fertilization, and shorter rotations. The mountain pine beetle of the year 2050 will find private land "pretty poor picking".

Temporarily, the hydrologic balance–that darling of Forest Service planners–may be upset. I believe hydrologic balance is an ideal situation. Cutting certainly affects the balance, but no worse than the inevitable fire in an undisturbed forest. The land has been through it all before.

Visual quality is changed, but this is subjective, and opinions vary regarding visual quality. It is not a fit point for scientific debate.

Environmentally and ecologically, I see our treatment of the epidemic as change. Accelerated change, if you will – but not a disaster. Larger and more perplexing problems come from man's legal regulation of man. So here I must look at the public sector.

State-owned lands are of no excessive concern to neighboring, private landowners, as they are basically managed for a profit, as are private lands. Being pretty well managed, I see no problems here.

Federal commercial forestlands are of no excessive concern–their foresters manage them for timber within their system. Their heart is in the right place and their goals are reasonable. The system does, however, tend to keep a lot of land in a roadless category. If anyone wants further enlightenment, they should look up the results of visual management, hydrologic constraints, Senate Bill 393, and RARE II.

Two federal land classifications pose broad legal and moral problems for timber companies who own their land–wilderness and national parks.

Wilderness, taken by itself, in isolation from the real world and from politics, presents no problems. If a wilderness is a forest of lodgepole pine, it grows, matures, gets mountain pine beetle, dies, catches fire, and burns. It's a natural cycle. The lodgepole comes back after varying degrees of erosion and, in the fullness of time, does it all over again. However, in practice, it doesn't work that way. Let's ignore all the people problems that occur when the status quo is disturbed. Let's just look at the legal problem. When an insect epidemic appears and, because of legal direction, is allowed to spread beyond the wilderness, is the federal government liable for my dead trees, my loss of profit, and my increased costs for changed cutting plans?

When the inevitable fire occurs in the unharvested downfall, how about air quality? We have laws that are very specific about the amount of smoke we can put in the air. Do we, can we, ignore the smoke from a "natural" fire? What happens if and when a conflagration leaves a federal wilderness and enters my property? Who foots the bill for damage? Who is responsible for the effects after such a fire, in view of the Clean Water Act? Although erosion can occur, it is not usually serious.

How about the currently popular Endangered Species Act? For example, let's look at mountain caribou that are not in it yet and grizzly bear that are. Both of their habitats are altered drastically by insects. Trees are killed and fall down into an impenetrable tangle. You, I, the caribou, and the bear cannot walk through it. Where do they go? They go out to commercial timberland that is well taken care of. Next, an outcry arises to restrict the commercial land to protect the wilderness animals. Legally, we are bound by the laws regarding endangered species. When the inevitable wilderness fire comes and burns the windfalls and all else flat, it is a long time before the land will provide cover, and perhaps food, for caribou or bear. Were the animals wiped out, we might gain. I have seen few problems arising from dinosaurs, saber-toothed tigers, or dire wolves. Morally, extinction would be questionable. Land that is near a wilderness may have grave problems that are not all biological but quite as real. I have not even touched the bogey man of "integral vistas" either.

Since I have taken a poke at wilderness, I cannot let the national parks escape "scot free".

In a park, as in a wilderness, an epidemic can be started, harbored, and exported to neighboring lands–as an example. look at the north fork of the Flathead and its proximity to Glacier National Park. If we owned land in the north fork, I would try to have the park administration in court! The same is true for the animal problems. Where will the grizzly range when the north fork burns out?

There are some other problems too. The wilderness philosophy does not necessarily cater to people. The visitor is tolerated, but not sought for–not so with a national park. Parks are for people, although the actions of Glacier do make me wonder if that one is not for grizzly bears first. Roads, campgrounds, trails, etc., are built and maintained. Clearly, people have a place in the park. It is my deep feeling that it should be a safe place where possible and that it be the responsibility of the park administration to make it so. By blatantly ignoring fire possibilities, the Bowman and Kintla Lake campgrounds are death traps. From my personal knowledge, those in charge in 1980 were ignorant of the possibilities. Should a dozen or so tourists be broiled some day in a fire, the mountain pine beetle would be basically responsible. Perhaps I am somewhat responsible too. I knew of the condition and did not violently object to park policies.

Federal lands and federal laws, policies, and actions add a new dimension to a serious biological problem. Some of these directly impinge on industry–for instance, the Clean Air and Clean Water Acts and the Endangered Species Act. Trying to be a good neighbor to adjacent landowners and adjacent countries, adds to the problem. The policy of cutting or of not cutting is setting us up for a rerun of the mountain pine beetle problem in 100 years, or perhaps sooner. I started to work in 1952 during a spruce beetle epidemic and now the beetle is back in some of these areas.

I was asked to discuss innovative practices. I wish I could say we had done something innovative. *So* far, we have cut green timber, salvaged dead timber, thinned immature timber, and regenerated some lodgepole. There is nothing innovative there. The thinning has not been a complete success, but I would like to try a heavy fertilization in conjunction with it because, if it increases growth and vigor, it could also be a help against insects.

One thing I would like to see tried that is both innovative and scary, would be to deliberately burn some of the unsalvaged. uncut lodgepole acres– a planned forest fire of large magnitude. You could at least pick your time, place, and weather and not rely on nature for ignition. It is an opportunity, but one that is full of dangers.

Where do we go from here? Onward, I guess, and try to do the best job that we can and the best that we dare.

THE NEED FOR ACTION

WHAT IS BEING DONE IN THE NATIONAL FORESTS OF THE UNITED STATES AND PLANS FOR THE FUTURE

John Emerson
Forest Supervisor
Flathead National Forest
Montana, U.S.A.

I will discuss the mountain pine beetle on national forestlands in Montana and, more specifically, describe the forest management problems caused by this pest in both the Flathead and Kootenai National Forests. Near the Flathead National Forest, we observed an outbreak of activity in Glacier National Park in the Kintia Lake Area south of the Canadian border in 1972. Substantial mountain pine beetle activity did not cross the north fork of the Flathead River to national forestlands until 1975. By that time, the epidemic had spread on national parkiands from 1200 acres in 1972 to 13000 acres by 1975 and to over 200000 acres by 1979. On national forestlands around the north fork of the Flathead River, the mountain pine beetle epidemic spread from EO acres in 1975 to over 50 000 acres by 1979; also, approximately 30 000 acres of state and private lands were infested during the same period.

Also. in the same area, but as a result of the spruce bark beetle epidemic, large quantities of Engelmann spruce were removed during the early 1950s, late 1960s. and early 1970s. Now we are back in the same area salvaging the merchantable-sized lodgepole pine. During the past two years, the beetle has also spread to white pine and white bark pine stands. With the exception of a controversial and potentially roadless area involving high grizzly bear use, we have salvaged, or have under contract, the bulk of the merchantable infested timber in the north fork. The spread of mountain pine beetle infestations was similar on the Kootenai National Forest. Approximately 700 acres were infested in 1974; this increased to over 100000 acres by 1981. Table 1 shows the acres of forest infested by the mountain pine beetle in Montana and Idaho on all private lands, plus Glacier National Park and the Flathead and Kootenai National Forests, for the period 1972-1981.

As the mountain pine beetle infestation spread in the area around the north fork of the Flathead River, we recognized that we had extensive areas with susceptible lodgepole pine stands throughout the entire Flathead forest. The greatest concentration of susceptible stands existed in the western portion of the forest. Mountain pine beetle activity had increased above endemic proportions to the north and south of these stands but, by 1978, had not moved into them. In July 1978, district personnel began to inventory and evaluate all lodgepole pine stands for susceptibility (risk) to mountain pine beetle infestation.

Risk was evaluated with the method described earlier in these proceedings by Mark McGregor. The mountain pine beetle attack the most susceptible lodgepole pine trees–trees that are at least EO years old and over 8 inches DBH. with a thick phloem layer; in other words, the best trees.

In the Flathead Forest, the inventory identified about 600 million board feet of lodgepole pine susceptible to the beetle. In the Kootenai Forest, approximately 900 million board feet were highly susceptible.

In October 1978, an interagency and industry informational meeting was held to discuss the mountain pine beetle situation in both national forests and to establish the means to coordinate management responses. The agencies and industry in attendance included the U.S. Forest Service, the State of Montana Division of Forestry, Champion Timberlands, St. Regis Paper Company, Plum Creek, and other smaller land and timber owners. A result of this conference was the creation of the "Northwest Montana Mountain Pine Beetle Task Force".

In November **1978,** the task force met again and drafted alternative strategies for the coordinated management of stands threatened by the bark beetle. Plans were developed for a public information and involvement program, and a study was initiated of the local industry's capacity to handle increased lodgepole pine volumes. The task force considered a range of alternatives–from salvaging dead and dying infested trees to accessing and harvesting the most susceptible lodgepole pine stands before they were infested. The latter alternative was elected. Timber sales were to be laid out in the most susceptible stands and harvested through logical cutting units, giving consideration to other resources. We expected to harvest about one-half of the total susceptible volume before attack. Access roads would be constructed to all threatened stands. Salvage sales would be arranged to harvest the remaining timber as it was attacked.

The program called for: **(1)** a substantial increase in the rate of harvesting lodgepole pine in both the Kootenai and Flathead National Forests; **(2)** a slight increase in the total timber offered for sale; but (3) a reduction in the quantity of other species offered for sale for the period **1979** to **1982.** After **1982,** we would reevaluate the program. See Table 2 for the proposed sales volumes, volume under contract, and lodgepole pine harvested in each year of the program.

Timber on the national forests in the United States is advertised and sold either by oral auction or sealed bid to the highest bidder. The agency, not industry, determines which timber will be prepared for sale and auctioned.

The timber companies involved in the program were agreeable to an increase in lodgepole pine sales and to a decrease in the utilization of other species. The Forest Service agreed to extending the time limits on the sale contracts for noninfested timber, so that industry could concentrate on logging infested timber.

These agreements were reached between the Forest Service and the timber companies during a period when the lumber market was good. We now have more difficulty in arranging lodgepole pine sales because of the depressed lumber market. Currently, the total uncut volume of all species under contract, including lodgepole pine, is at a record high. The fiscal year **1981,** ending September **30,** had the lowest total timber harvest on the Flathead National Forest since **1955.**

About one-half of our lodgepole pine volume is harvested by clearcutting, primarily in pure lodgepole pine stands. Shelter wood, seed tree, and salvage harvesting methods are used in mixed stands.

The cleanup and site preparation of cutover stands vary with the method of cutting and the topography. Dozer piling and broadcast burning of clearcuts have been very successful. Problems developed as topography became steeper and cutting shifted to seed tree or shelterwood harvesting methods. Air quality standards have prevented burning during periods when some of the best burning conditions prevailed.

We' are planting species other than lodgepole pine (Douglas fir, spruce, and western larch) in 'regenerating clear-cut areas. This will result in mixed stands and should reduce the problems due to mountain pine beetle 80 years from now. Lodgepole pine is expected to reestablish naturally as we prepare the site.

Providing suitable access to all lodgepole pine stands early in the program was a major objective. This was designed to provide a rapid salvage capability for the anticipated infestations. About **250** miles of access roads have been constructed in both forests, using **12** million dollars of appropriated funds from congress (see Table **3).** An equal or greater number of road miles were constructed through the timber sales. Continued support from appropriated funds is essential for the next **5** years. especially if the lumber market does not improve.

We anticipate the mountain pine beetle epidemic will run its course over the next **5** to **10** years and destroy the bulk of mature lodgepole pine stands. The industry's ability to utilize this tree species to a maximum degree is our major concern. Other concerns are: (1) removal of large amounts of lodgepole pine under threat from beetle epidemic may cause hydrologic problems; (2) salvage will cause us to excede the allowable cut in areas where maximum limits have already been met; and (3) with the current energy conservation thrust, we are responding to a heavy increase in demand for beetle-killed lodgepole pine for domestic fuelwood.

For the most part, we are pleased with the progress made to date in accessing and harvesting green merchantable timber before it is infested and its quality reduced. We should be able to salvage most of the beetle-attacked timber as it becomes infested with the access roads now in place.

Table 1

Thousands of Acres
Infested By Mountain Pine Beetle

Year	Total Montana and Idaho	Glacier National Park	Flathead National Forest	Kootenai National Forest
1972	----------	1.2	--------	---------
1973	----------	3.6		---------
1974	295.3	4.6	---------	.7
1975	787.6	13.4	.4	5.8
1976	897.8	103.9	1.2	20.4
1977	575.7	142.9	12.9	17.2
1978	780.0	164.5	48.4	23.2
1979	1336.5	---------	61.9	40.8
1980	2137.7	---------	122.6	84.0
1981	2334.6	--------	108.6	108.8

Table 2

Lodgepole Pine
Proposed Sales Volumes,
Volume Under Contract, and
Amount Removed (MMBM)

Year	Proposed Sales Volumes		Volume Under Contract for the Flathead and Kootenai National Forests	Amount Removed for the Flathead and Kootenai National Forests
	Flathead National Forest	Kootenai National Forest		
1978	30	40	---------	-------
1979	25	40	114.9	66.4
1980	60	90	192.7	57.5
1981	60	90	237.4	70.0

Table 3

Access Roads Constructed
and
Dollars Appropriated

Year	Access Roads Constructed (miles)		Dollars Appropriated (thousands)	
	Flathead National Forest	Kootenai National Forest	Flathead National Forest	Kootenai National Forest
	---------		18.6	6.1
	---------	3.0	-----------	401.7
	6.9		177.3	284.7
	---------	14.5	-----------	1446.0
	7.9	0.5	462.1	68.3
	55.5	35.1	1713.4	2797.1
1980	45.2	12.3	2037.0	784.2
	15.4	57.1	738.8	1285.8
Total	130.9	122.5	5147.2	7073.9

UNITED STATES NATIONAL PARK SERVICE MANAGEMENT POLICIES AND THEIR RELATIONSHIP TO MOUNTAIN PINE BEETLE PEST MANAGEMENT PROGRAMS

Robert C. Haraden
Superintendent
Glacier National Park
Montana, U.S.A.

I appreciate the opportunity to represent the Director of the U.S. National Park Service and to share with you the management policies of the National Park Service (NPS), as they potentially impact mountain pine beetle management programs in the western parts of the United States and Canada. My remarks are organized into four major segments:

- An overview of NPS mission and management responsibilities.
- The ecological role of mountain pine beetle in NPS park ecosystems.
- Management alternatives and the relationship of those alternatives to NPS lands.
- Current status and future plans

NPS MISSION AND MANAGEMENT RESPONSIBILITIES

National parks, as broadly defined by the U.S. National Park Service, are areas set aside by statute containing regions of outstanding natural beauty, characteristic of the finest scenery in different parts of the country, nature's curios, relics of historic interest, and native fauna and flora to be maintained forever, as closely as possible to the unspoiled, original state and preserved for the benefit and enjoyment of the people.

The United States manages a national park system comprised of over 320 natural, historic, recreational, and cultural parks, embracing approximately 80 million acres in 50 states, Puerto Rico. and the Virgin Islands, together with the National Capitol Park System of metropolitan Washington, D.C.

In the planning and management of the parks that comprise this system, we are guided by the unifying management principle that protection of ecological health and historic integrity is our first consideration and priority; and that these resources are conserved for the benefit and inspiration of the people through understanding, appreciation, and enjoyment of the values being preserved. Thus, park uses are limited to those activities that are dependent upon, and protective of, the natural and historic values each park was established to preserve. Furthermore, the level, frequency, and duration of permitted uses is limited, where necessary, to protect park resources from alteration or loss.

NPS planning provides for the zoning of all park areas into one, or all, of four land classifications: natural, historic, park development, and special use. Each zone, in turn, may have various subzones. Use and resource management within these zones and subzones are guided by the management policies and carried out through the planning process. Policies valid only for any particular zone or subzone are the same for any unit of the system, except where legal requirements or valid, existing rights provide exceptions.

Natural Zones

Management of parklands possessing significant natural features and values (such as are found at Glacier and North Cascades National Parks along the Canadian border) is concerned with ecological processes and the impact of people upon those processes and resources. The concept of perpetuation of a total, natural environment or ecosystem, as compared with the protection of individual features or species, is a distinguishing aspect of the Service's management of natural lands. This policy is enhanced in Glacier National Park by its designation as an International Biosphere Reserve. Waterton Lakes National Park is also so designated.

Historic Zones

In historic zones. the maintenance of the historic scene and of the integrity of cultural resources is the primary management objective.

Park Development Zones

Park development zones are managed and maintained for intensive visitor use. It is understood that roads, walks, buildings, and other visitor and management facilities may occupy much of the area and that the natural aspect of the land may accordingly be altered. Management of the park development zone aims at maintaining a natural environment, if possible, given the uses of the zone. Such management may be accomplished through the manipulation of the natural environment, although any manipulation will be the minimum necessary to achieve the planned use.

Special Use Zones

For special use zones, legislation establishing some parks has permitted various uses (such as grazing, mining, and hunting) that are generally not allowed in the National Park System. In some parks, legislation and policies also provide considerable latitude for active management of certain resources. Even in such areas, resource management must seek to avoid unnecessary alteration of the natural scene or interference with natural processes.

Resource Utilization

As a general policy, the Service does not allow consumptive utilization of renewable or nonrenewable resources, except as otherwise provided by law.

Disposal of Trees and Other Natural Resources

For natural areas, Service policy dictates that residue resulting from natural phenomena–such as storms, fires, and native insect and disease infestations–will be recycled through the ecosystem, if feasible. However, when it poses a threat to human safety or cultural resources, it may be salvaged or disposed of, in accordance with applicable laws and approved procedures.

Management of Animal Populations

Our policies dictate that the Service perpetuate the native animal life of the parks for their essential role in the natural ecosystems. The Service defines native species as those that occur, or occurred, due to natural processes on parklands. These do not include species that have moved into those areas, directly or indirectly, as a result of human activities. Natural processes are relied upon to regulate populations of native species to the greatest extent possible.

Insect and Disease Control

Native insects and diseases, existing under natural conditions, are viewed as neither good nor bad, but rather as natural elements of the ecosystem. Accordingly, populations of native insects (such as the mountain pine beetle) and the incidence of native diseases are allowed to function unimpeded, except where control is required:

- To prevent the loss of the host, or host-dependent, species from the ecosystem.

- To prevent outbreaks of the insect or disease from spreading to forests, trees, other vegetative communities, or animal populations outside the area, where possible.

- To conserve threatened or endangered or unique plant specimens or communities.

- To conserve and protect flora and fauna in developed zones.

For reasons of public health and safety.

The measure of control in wilderness areas is, by policy, the minimum necessary to prevent escape from the wilderness environment.

In the case of the mountain pine beetle, there has been no effective control yet developed.

Pesticide Use

Chemical pesticides of any type are used only as a last resort, when feasible alternatives are not available or acceptable. The use of all pesticides requires the approval of the Director and, in some instances, the Secretary of the Interior.

THE ECOLOGICAL ROLE OF MOUNTAIN PINE BEETLE

The phenomenon of bark beetles killing forest trees is a complex interaction of organisms responding to changes in their environment. Clearly. from a natural processes standpoint, the mountain pine beetle plays a highly important role in park ecosystems. Consequently, our general management policy for these areas is to allow the outbreak to function unimpeded.

MANAGEMENT ALTERNATIVES

National Parks Service policy does permit control efforts of insect outbreaks in select instances, including some situations where the potential exists for outbreaks to spread to adjacent neighbors outside the park. Within the past several years, much valuable information has been obtained concerning manipulation of mountain pine beetle populations through appropriate stand management. Infested and high-risk stands can be managed in several ways. depending upon land use objectives and stand composition, through removal or organized clearcuts to help eliminate stands conducive to large population buildup of the beetle.

Dr. Safranyik has noted that "experience, with direct control of mountain pine beetle epidemics by chemical sprays, salvage logging, or other techniques aimed at reducing beetle numbers, indicates that the effects of suppression work are temporary. These control techniques are primarily useful for holding stands until all potentially susceptible trees can be removed."

These management techniques are well suited for forest stands being intensively managed for harvestable timber production. The National Park Service's mission mandates management for natural system preservation. Policy directs that dead tree residue, resulting from beetle attack, be left in place to be recycled through the ecosystem. Salvage operations that would remove the residue and disrupt the ecological cycle are not compatible with National Park natural area management. Roads and equipment, required for salvage operations and water quality impacts, are incompatible on parklands and on many lands that drain onto parklands or are, by geographic location, a part of the visual park scene.

CURRENT STATUS

For infested areas within Glacier National Park, the park has: provided increased fire detection flights; removed hazard trees in developed areas; developed an evacuation plan in the event of fire; and embarked on a fire ecology study through a $50,000 "Man and the Biosphere" grant to the University of Montana. We have already completed studies of birdlife and fuel buildups in the beetle-killed forests.

PLANS FOR THE FUTURE

In the wake of the beetle epidemic, our management approach is to restore fire to its natural role to diversify stand age, thus preventing future outbreaks of large magnitude. This is ecologically equivalent to timber management, including fuel reductions.

In some cases, where appropriate to do so, this process may be advanced through prescribed burning; however, the utlimate goal is for accomplishment through a natural fire management policy.

CONCLUSION

Just as you look to the park to aid in the protection of lands you manage adjacent to the park, the park looks to its adjacent land owners to manage their land along the park boundary in such a manner as to protect park values and to aid in fulfillment of its mandate to manage for perpetuation of natural processes.

This needs to consider: the necessity, location, and design of access roads; pesticide use; soil disturbance; channel erosion; the effects on wildlife and fisheries; and the monitoring of all environmental disturbances.

We appreciate the efforts made by the British Columbia Forest Service to reduce the possibility of sediment pollution resulting from both timber harvesting operations and road construction. The cooperative approach taken in recent land-use planning adjacent to Glacier National Park and the recognition of intangible resource values have helped each of us to have a better understanding of the problems faced by the other.

Viewed as a disaster by the professional forester and as a natural occurrence by the plant ecologist, beetles are a part of all lodgepole forests and no management will exterminate them. Like grizzly bears and bald eagles, they will not respect park and forest boundaries or state, provincial, and international boundaries.

Thus, we need a cooperative approach that recognizes the differences in our management policies and that seeks solutions in consonance with our legislative mandates. We wholeheartedly support interagency and international cooperative efforts along these lines.

PARKS CANADA

MANAGEMENT POLICIES AND THEIR RELATION TO MOUNTAIN PINE BEETLE PEST MANAGEMENT PROGRAMS

W.C. Turnbull
Director, Western Region
Parks Canada

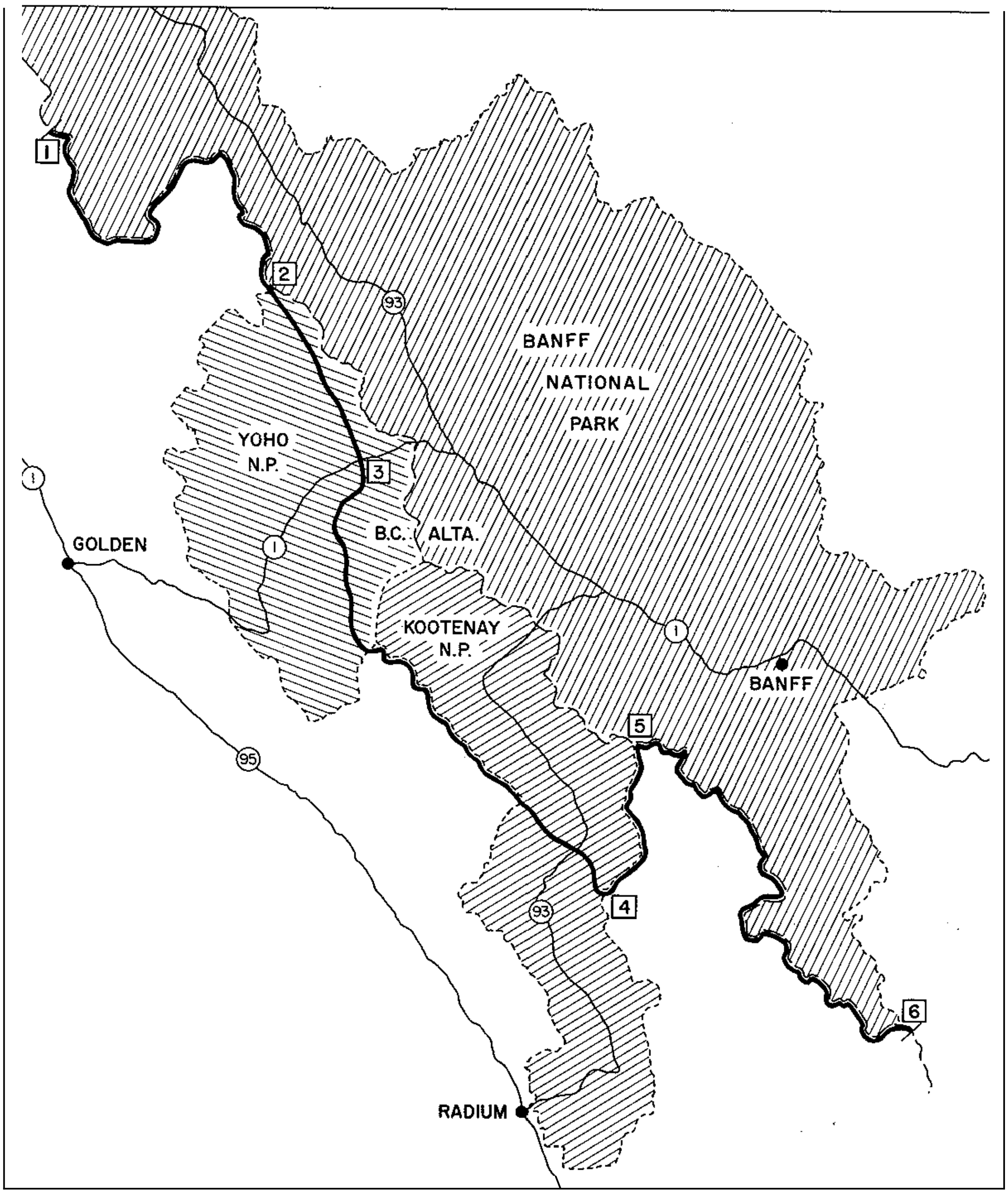
(Mr. Turnbull's speech was delivered extemporaneously)
(This summary was prepared later for inclusion in the Proceedings)

I must compliment the superintendent of Glacier National Park, Montana, for his very comprehensive paper describing the policy in the United States National Parks concerning forest infestations and, in particular, the mountain pine beetle. In fact, he covered the subject so well and, since our policies are so similar, he has left me with very little to say.

In the ordinary course of events, we would let nature take its course and a mountain pine beetle infestation would be allowed to run unchecked in national parks. But, in the circumstances, we have a responsibility as good neighbors to mitigate, where possible, the effect of natural events on the lands adjacent to the parks. We have, therefore, established a battle line in the Kootenay and Yoho National Parks (see map on the following page), and we will vigorously attack all infestations to the north and east of the line, as they are detected. We have already increased our surveillance in this regard.

There is an important aspect that has emerged from the discussions today, which I would like to emphasize, and that is–that the objectives of the various interests represented here are different. I think it is important that we respect the differences. I know that, when we communicate with the public, we will continue to state our objectives regarding natural processes, but we will not criticize the objectives of the forest industry or forest managers.

In closing, I would like to explain that Parks Canada obtains advice and assistance in many forestry matters in parks from the Canadian Forestry Service. This advice and assistance is ably given in a spirit of cooperation, which I greatly appreciate.



BANFF, KOOTENAY AND YOHO NATIONAL PARKS

Mountain pine beetle infestations to the north and east of the heavy black line will be subjected to control actions. Numbers in squares along the line are reference points–from north to south, between 1 and 2, the line follows the park boundary; from 2 south, follows the Yoho River to Highway 1 at number 3; then follows the height of land to Mount Goodsir; then follows the west boundary of Kootenay Park and across Highway 93 to Split Peak number 4; and then follows the national park boundaries to Mount Sir Douglas at 6.

MANAGEMENT LIMITATIONS AND BARRIERS OF LODGEPOLE PINE

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My assignment is to define the limitations or barriers that forest land managers must face and overcome in dealing with mountain pine beetle epidemics. The barriers and limitations, which I have defined, are those which I see as a manager of national forestlands in the United States. However, given a wide diversity of management situations, some of these barriers may not exist for other management situations. Conversely, I may not mention barriers or limitations that may be controlling in other situations.

As an "operational" manager whose primary task is seeing that timber on the national forest gets properly and efficiently grown, sold, and harvested: it is neither natural nor comfortable for me to discuss why I can't do something. My natural and strongly ingrained inclination is to spend my time and effort generating solutions–rather than enumerating problems.

Consequently, you need to be forewarned that I have not been able to confine myself exclusively to defining the problems: some suggested solutions or approaches to solutions have crept in.

SILVICULTURE OF LODGEPOLE PINE IN THE PACIFIC NORTHWEST

Lodgepole pine occupies about 2 million acres (or **809.4** thousand hectares) in the national forests of the Pacific Northwest. Current standing inventories are estimated at **15** billion board feet, or 5.6 billion cubic feet **(67.95** million cubic metres). About 70% of the acres of lodgepole type are located in eastern Oregon and Washington.

Lodgepole pine grows under two distinctive ecological conditions. Firstly, lodgepole pine is a pioneer species that enters a site after a major disturbance–usually fire or insect epidemic followed by fire. The understory in such stands often consists of more tolerant species, e.g., true firs or, at higher elevations, mountain hemlock. This situation is typical of lodgepole types in the Cascade transition forests, the Blue and Wallowa Mountain, and the Okanogan and Colville National Forests in eastern Washington. Secondly, on Deschutes Pumice Plateau (Deschutes. Fremont, and Winema National Forests), lodgepole pine is the only commercial species capable of growing, due to soil, topography, and climate. In this area, pure lodgepole stands cover 860 thousand acres.

Stands originated on the Oeschutes Plateau and northeast Oregon after large fires in the late **1800s** and early **1900s.** About **88%** of these stands exceed **80** years in age. About **80%** of their total volume **(4.5** billion board feet) is in sawtimber-size trees (9"+ DBH). Average sawtimber volumes range from 4 to *6* thousand board feet per acre.

Many stands are heavily infected with mistletoe. Commandra rusts and western gall rust are also present in some stands. Epidemic conditions of mountain pine beetle have occurred sporadically for the past **10** to **15** years and, currently. are again widespread.

Silvicultural Management Objectives and Constraints

Where lodgepole pine exists as a pioneer species, the management objective should be to convert the stand through removal of lodgepole overwood, whenever commercially possible. The understory should be cleaned and thinned. The resultant tolerant species stand should be managed to rotation, then replaced with a managed stand favoring the tolerant species.

In mixed species types, management should favor the more tolerant species and remove the merchantable lodgepole pine in early and intermediate entries, along with any other more intolerant species, e.g., larch or Douglas-fir, then manage the tolerant species to sawtimber rotation.

In pure lodgepole types, the principle problem is a heavy imbalance to mature and overmature age classes. There is a need to schedule regeneration efforts towards creating a more balanced condition of age classes over the existing very large acreage of uniformly overmature types. Seed tree or shelter. wood cuts in lodgepole pine are not often successful due to windfall, snowbreak. and mistletoe, but they may be needed where daily temperature extremes demand some amelioration of the microclimate for successful regeneration. The usual harvesting method for lodgepole pine is clearcutting 30 to 40 acre blocks or strip cuts followed by natural or planted regeneration.

Existing lodgepole pine stands in Region 6 have an average net growth of 24 cubic feet per acre per year (100 board feet per acre per year). It is projected that managed stands in Region 6 will have an average net growth of 39 cubic feet per acre per year (165 board feet per acre per year). A 63% gain is expected with prompt regeneration, i.e., within 3 years; stand-cleaning at 4 years for mistletoe; a precommercial thinning/cleaning at 12 to 15 years; and regeneration at 70 to 80 years. Target tree size at harvest is 14 to 16 inches DBH.

OPERATIONAL CONSTRAINTS

Market Constraints

The primary markets for lodgepole pine have always been either chips or random-length lumber and studs. Some 1 inch lumber is produced from green lodgepole but, because of log size, special kiln schedules required, and low grades of lumber produced, it does not compete well in the market with other common species. Dead lodgepole pine, because of grade specifications that substantially lower the value of blue-stained lumber, does not enter the normal board market and is confined primarily to studs or chips.

Lodgepole pine has always had a market history as a marginal species. During periods of normal and high markets, it has been readily accepted for dimension lumber and studs. During declining markets, however, it has been first to fall out of the market and last to re-enter a recovering market.

Figures 1 to 4 show the changes in costs of harvesting and processing lodgepole pine between 1973 and 1981. Costs for ponderosa pine are given for comparison.

Lodgepole is usable for other than sawmill products. Table 1 lists these products, compares their value by oven dry ton, demand, percent of volume per acre usable, and the probable market. This table is by Thomas Fahey, 1980, The Forest Products Journal. It reflects market conditions in late 1979 and early 1980, an era of relatively high markets.

The ability to make commercial products from beetle-killed lodgepole pine depends on the market for these products and the relative cost of alternatives. The potential to use significant volumes (Table 1) depends on how well the resource meets specifications for products and the volume of products that the market will accept. There are problems with using beetle-killed lodgepole for any of the products discussed (Table 1). The highest priced outlets for dead timber have very limited or moderate demand and can use only very select portions of the total available. The best solutions, in terms of land management, have relatively limited demand and, therefore, little potential for using volume from many acres. Lumber and veneer production has some potential for using relatively large volumes, but mills are more profitable operating on green timber sales.

Utilization of beetle-killed lodgepole pine will require creative timber appraisal and sales contract approaches. Log sorting, log concentration yards, and land management contracts–all "high cost" items–are the most common suggestions and probably the most appropriate. Complete tree logging, with sorting at the landing for roundwood and solid wood products, allows an in-the-woods chipper to operate on concentrations of wood that would not otherwise be commercially possible. Development of a structural particleboard product and energy fuel markets show the greatest potential for increasing the demand for dead lodgepole pine.

Table 1

Value, Probable Demand, and Potential of Various Products To Remove Significant Volume of Dead Lodgepole Pine

Product	Value/Ton ($)	Demand	Volume/Acre Usable (%)	Probable Market
Power poles	300 to 400	small	5 to 15	small
House logs	110 to 260	moderate	30 to 60	moderate
Corral poles	120 to 150	small	10 to 20	small
Dimension lumber	90 to 130	large	70 to 85	large
Studs	80 to 120	large	70 to 85	large
Veneers	90 to 130	small	60 to 75	moderate
Paper (chips)	35 to 50	moderate	90	variable
Particleboard	5 t0 15	none	90	none
Fuel	30 to 55	small	95	possible

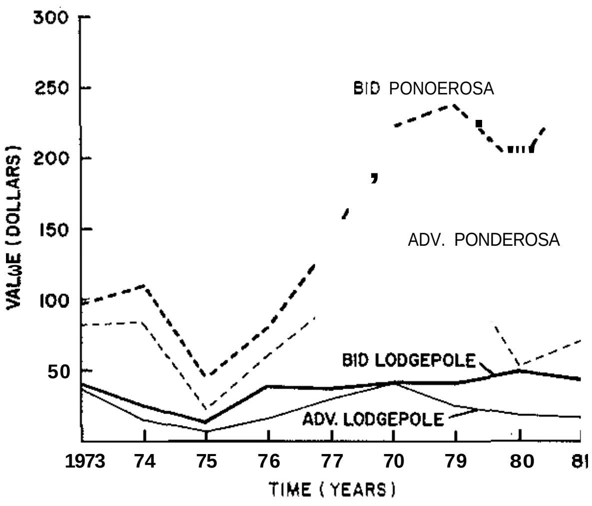

Figure 1

Advertized and bid stumpage per thousand board feet for lodgepole and ponderosa pine from 1973 to 1981.

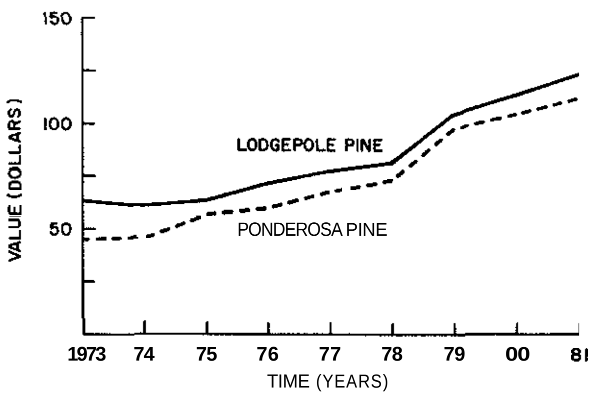

Figure 2

Logging costs, per thousand board feet, including transportation for lodgepole and ponderosa pine from 1973 to 1981.

Access Constraints

There are many large contiguous blocks of timber without road access. Individual sales cannot support the cost of a main arterial access. Normally, a sale will only support "on sale" log collection and spur road construction out of stumpage.

From a long-term standpoint, given the 63% potential increase from managed stands, the eco nomics of preroading investments are reasonably attractive if:

> The discount rates used in any cost/benefit investment analysis represent "real dollar" cost and return rates of change, that is, with inflation effects removed. Such discount rates normally range between 4% and 7.5%.
>
> The true costs of "doing nothing" are completely and objectively assessed. Such an assessment would consider in detail: firstly, the increased protection costs for fire and insect and disease; and, secondly, the true dollar value of potential fibre, wildlife, and fisheries benefits which would be foregone under a "let nature take its course approach".

Harvesting and Processing Constraints

There is a pressing need to accelerate the current slow transition in our logging systems towards efficiency in handling "small wood" like lodgepole. Traditional logging methods and machinery are not economic in small wood. The biggest need is for a consistent and assured level of "small wood' sale offerings and conversion of today's logging philosophy from "big, stout, and powerful is better" to "small, lean, and tight is right". For a substantial period, we will need to maintain both types of equipment. Sale offering programs in thinnings and in lodgepole management will need to be of significant size, maintained at a consistent level once started, and persist for at least 8 years, so that investment in the new skills and equipment required can be amortized. Without an assurance of such a consistent, significant, and maintained sales program, industry cannot be expected to make the substantial investments needed to efficiently harvest, transport, and manufacture products from "small wood".

OTHER RESOURCE USE CONSTRAINTS

In the Pacific Northwest, approximately 31 species of mammals and 47 bird species utilize lodgepole pine stands for feeding, reproduction. or cover. Several species **of** reptiles. amphibians, and invertebrates are also endemic to lodgepole communities. Rocky Mountain elk and mule deer are commercially important game species associated with lodgepole stands in eastern Oregon and Washington. Both species of wildlife utilize lodgepole stands as cover year round, as forage areas, and as fawning and calving habitat.

Given the extensive dense and unbroken expanse of lodgepole pine stands, astute scheduling and execution of properly designed harvesting activities could improve wildlife production. Habitat of the two prime ungulate species, deer and elk. can be improved **by** stand management to achieve a diversity of stand structure, size, and seral condition. Properly spaced and sized regeneration units would create edges between managed units, therefore, maintaining optimum forage palatability and providing cover. After "regulation" (i.e., an array of age classes), is achieved in lodgepole types, silvicultural prescriptions that follow the guidelines in Chapter 8 of Agriculture Handbook No. 533 would provide and maintain optimum wildlife habitat for most species associated with lodgepole stands.

Under the current mountain pine beetle epidemic, regulation has very little possibility of being achieved. The inevitable result of following "the bug" will be a reversal of the current situation from too much cover and too little and poorly distributed forage openings, to too little cover, particularly thermal and calving protection cover, and too much opening and forage area. Timber management, designed to mitigate the loss of this vital cover and to restore cover as rapidly **as** possible, can reduce the impact, for instance, leaving some uncut, dead stands to provide cover needs to be considered.

In riparian areas, the primary effect of mountain pine beetle infestations will be a reduction of shading with an increase in water temperature, some additional organic material in the streams, and, eventually, increased numbers of logjams. Uncut, dead areas may need to be left alongside streams where existing temperatures are critical to existing fisheries.

There are threatened and endangered species dependent upon lodgepole. In the Pacific Northwest, only caribou, on the Colville, is in this category. However. in the Rocky Mountains, grizzly bear, wolf, and caribou are included.

In areas inhabited by caribou, the forest management problems are the same as those for elk, maintaining an optimum cover-to-forage ratio, plus poaching and disturbance, and their effects on a limited population.

In areas inhabited by grizzly bear and wolf, most of the problems are conflicts between man and bear and wolf, rather than effects on vegetative habitats. Simply put, grizzlies or wolf and man don't mix. When they are brought into close and sustained association, conflicts occur and the wolf and the bear are the eventual losers.

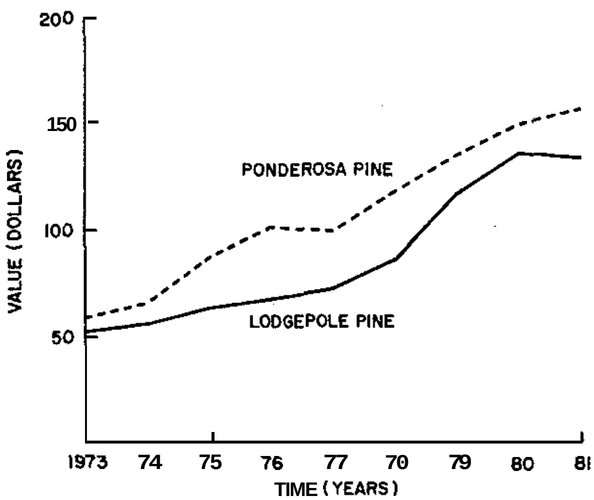

Figure 3

Milling costs per thousand board feet for lodgepole and ponderosa pine from 1973 to 1981.

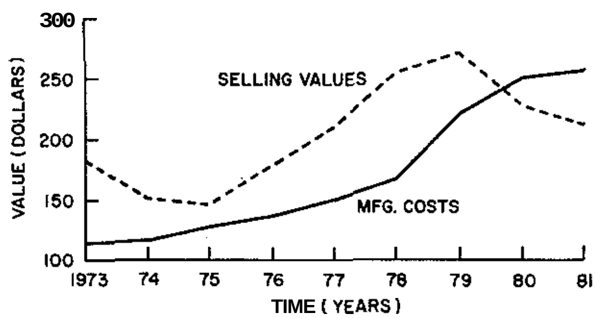

Figure 4

Lumber selling values, adjusted by overrun and manufacturing costs, from 1973 to 1981. Costs are per thousand board feet.

A CASE STUDY

IMPACTS OF MOUNTAIN PINE BEETLE AND THEIR MITIGATION IN LODGEPOLE PINE FORESTS

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The mountain pine beetle, Dendroctonusponderosae Hopkins, is a periodic forest pest in most lodgepole pine (Pinus contorta Douglas var. Latifolia Engelmann) stands. Extensive areas of lodgepole pine have been destroyed at various times in the past by this insect (Amman et al, 1977; Safranyik et al., 1974). It has been active in the ecosystem as long as there have been lodgepole pine trees.

Other than effects on timber and bulk wood production, little is known of the impact of mountain pine beetle infestations on forest resources such as soils, water, fish and wildlife, recreation, and esthetic values. The National Forest Management Act of 1976 demands that equal attention be given to all forest resources in planning and management of public lands. This paper describes a recent anempt to address the mitigation of effects of a severe mountain pine beetle outbreak on all forest resource values.

The mountain pine beetle is currently causing serious timber losses in lodgepole pine stands on the national forests of northeast Oregon. The present outbreak started in 1968 in the Grande Ronde River drainage and covered approximately 972 hectares (2 400 acres) at the end of that year. The outbreak has expanded during the past 10 years and now encompasses over 405 000 hectares (1 million acres) in the Blue Mountains of Oregon (Figure 1). Ground surveys indicate that, in many of the areas where the insect has been epidemic for 7 or more years, there is an almost total loss of all lodgepole pine over 10 cm (4 inches) in diameter (Gregg et al., 1976). Total lodgepole volume loss to date is over 1 billion board feet. The insect has also moved into ponderosa pine stands and is epidemic on approximately 254 000 hectares (628 000 acres) in the Blue Mountains. Both old- and second-growth stands are being attacked. Ponderosa pine mortality to date totals 582 million board feet. Salvage logging operations have begun in the accessible portions of the outbreak area. The fire hazard is extreme and will persist until the dead wood is removed, treated, or consumed by decay or wildfire.

A "Mountain Pine Beetle Interdisciplinary Team", consisting of silviculturist, soil scientist, wildlife biologists, fisheries biologists, forester, hydrologist, logging specialist, and landscape architects, was organized in October 1974 to prepare guidelines and prescribe treatment for the infested lodgepole pine stands of the Umatilla and Wallowa-Whitman National Forests in northeast Oregon (Umatilla National Forest, 1974). This was a special coordination effort involving four ranger districts and was designed to ensure that all resources were adequately considered in meeting the following management objectives developed by the two forests:

1. Clean up the mess and reduce the fire hazard.
2. Mitigate adverse effects on soil, water, and wildlife.
3. Regenerate the timber stands as quickly as possible.
4. Utilize the wood fibre to accomplish objectives 1, 2, and 3 above.

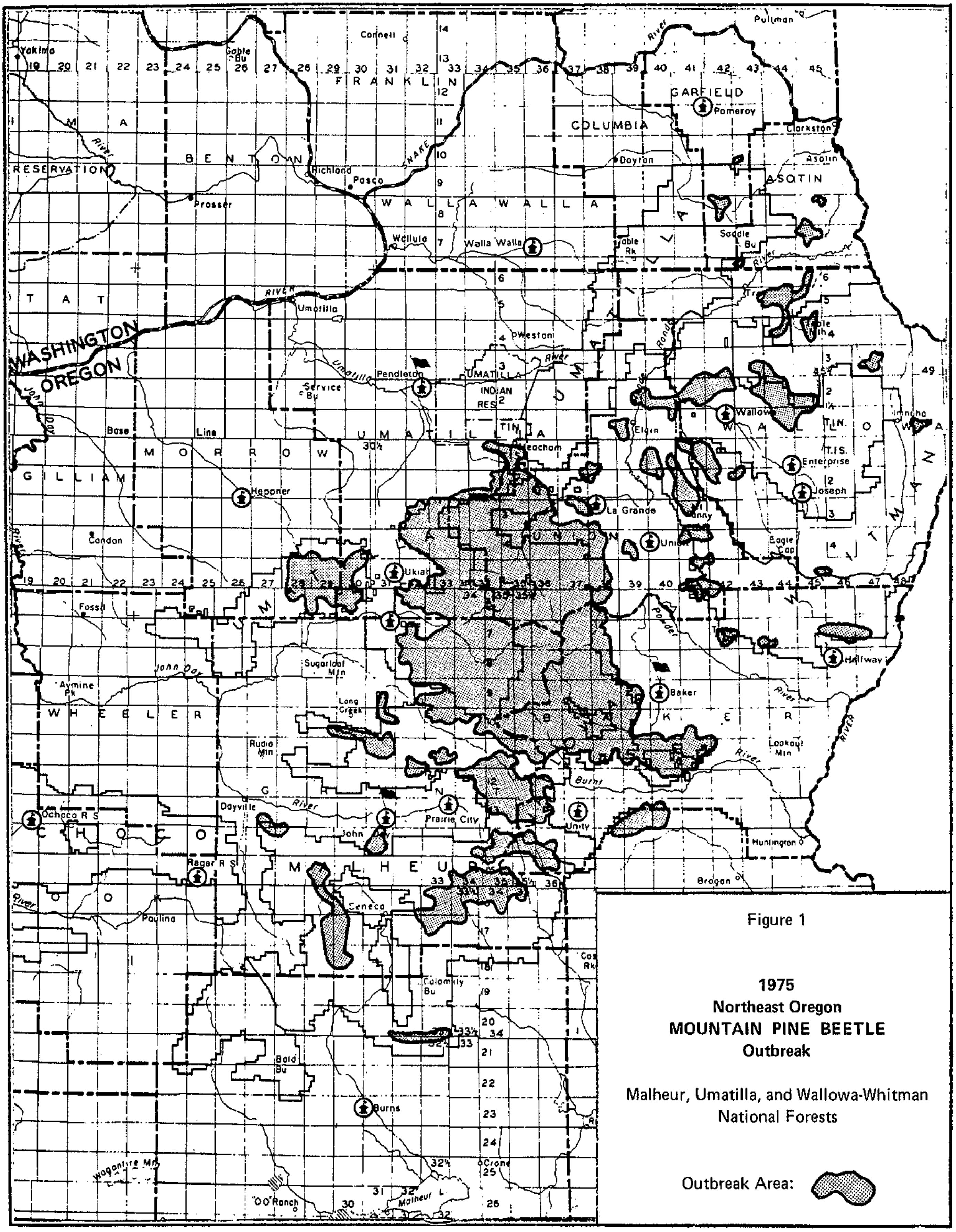

Figure 1

1975
Northeast Oregon
MOUNTAIN PINE BEETLE
Outbreak

Malheur, Umatilla, and Wallowa-Whitman National Forests

A 30 600 ha (75 700 acre) area, referred to as Lane-Peet, was selected for the initial intensive study by the team. Four plans were carefully considered: (A) no action; (B) a two-phase harvest program over a 14-year period; (C) a two-phase harvest program over a 22-year period; and (D) a three-phase harvest program over a 21-year period.

Each plan was evaluated and ranked from the most to the least desirable for each resource (Table 1). On this basis, Plan D, the three-phase 21-year harvest program, was selected. It was determined that this plan would utilize the wood fibre, meet all three of the other prescribed management objectives and be applicable to all infested areas. Acomplete description of this analysis procedure is contained in the report cited. The following are highlights of the Lane-Peet study.

Table 1

Alternative Treatment Preference

Resource	Management Plan			
	A	B	C	D
Timber	4	1	3	2
Wildlife	1	4	3	2
Fisheries	1	4	3	2
Water	1	4	3	2
Soil	1	4	3	2
Grazing	4	1	3	2
Utilization	4	1	3	2
Recreation	4	1	3	2
Hunting	1	4	3	2
Fire	4	1	3	2
Visual	4	3	2	1

1 = first preference
2 = second preference
3 = third preference
4 = last preference

The costs of implementing the chosen plan, Plan D, and the miles of new access road needed to follow this plan are listed in Table 2. Because of the costs of constructing the initial access roads called for by the plan, it has not been possible to implement the plan in all parts of the forested area covered by the plan.

RESOURCE CONSIDERATIONS AND RECOMMENDED MANAGEMENT PRACTICES

Timber

The lodgepole pine stands in this area originated from fires that swept through the Blue Mountains between 1870 and 1910. These stands are typically overmature, small-diameter, overstocked, and stagnated. Ages range from 80 to 110 years; sizes range from 5 to 15 cm (2 to 6 in.) DBH, with 2 500 to 12 500t stems per ha (100 to 5 000+ stems per acre) to 15 to 25 cm (6 to 10 in.) DBH, with 750 to 1 500 stems per ha (300 to 600 stems per acre). The stands are heavily infected with dwarf mistletoe, atropellis canker, and western gall rust. In some areas, stands are breaking up due to natural causes (snow, wind, maturity, etc.). White fir, grand fir, Douglas-fir, western larch, and lodgepole pine regeneration are commonly found under lodgepole stands where the canopy is beginning to deteriorate. In the past, harvesting has been mostly on a selective basis for sawlogs, poles, or posts.

The silvicultural objectives for the outbreak area are to harvest and promptly regenerate the lodgepole pine stands while complying with guidelines developed to meet the objectives for other resources managed in this area.

Lodgepole pine in the Blue Mountains is a prolific seed producer from serotinous and nonserotinous cones. Juvenile growth is rapid in the dense new stands until stagnation occurs. Growth then becomes very limited. Without management, stands similar to those already existing will develop and eventually become susceptible to mountain pine beetle attack.

Table 3 contains specific guidelines to meet the silvicultural objectives for the lodgepole pine plant communities found in the Blue Mountains (Hall, 1973). It is for field use with timber-typed maps and aerial photographs available on the forests. Site factors, harvest method alternatives, constraints, and post-sale work are discussed for each lodgepole timber type. It is an aid for prescribing treatment for individual sites, whereas other guidelines in Lane-Peet are developed on an area basis because of the nature of the resources (wildlife. water, visual, etc.).

Wildlife

All forms of wildlife within the lodgepole pine habitat type will' be affected to some extent–some will benefit to the detriment .of others. Based on animal numbers and recreation use, Rocky Mountain elk are the most important big game animal in the outbreak area. Other wildlife species are also important and maintenance of suitable habitat to sustain 'all existing species in optimal numbers is considered important.

Four big game management units lie within the outbreak area. These units support 36% of Oregon's Rocky Mountain elk hunters (23 130) and generate 135830 man days of recreation per year in the harvesting of 3542 elk. Mismanagement of cover within the lodgepole type could effectively reduce the elk hunting recreation potential by more than **50%.** the result of easier harvesting of elk and the consequent overhunting of the population.

The desired situation for maintenance of elk habitat is a scattered, irregular pattern of timber harvest units and dense cover areas. "Dense cover" is defined as any area where human sight distance is restricted by trees or other vegetation to a point where 50% or more of an elk (or similar-sized object) is hidden from view at a distance of 46 m (150 ft) or less. If possible, areas should be interconnected. Timber harvest units and adjacent cover units do not necessarily have to be of equal size, but the' amount of dense cover should never be less than one-half the 1974 amount. This applies not only to lodgepole but to all timber stands. It is intendedthat dense cover areas will remain undisturbed until adjacent harvest units have regenerated and replacedthe cover areas lost (at least 12 years).

Around nearly all openings, there will be a fringe area. These areas are usually zones of transition, showing complex plant succession different from the three major Blue Mountain lodgepole pine types. Depth of the fringe area will vary and can be determined by examination of ground vegetation. Adjacent to openings, there will often be rocks showing on the surface. These fringe areas are high in value as elk forage and as habitat for a variety of other species of wildlife. At least 50% of the fringe areas around meadows, grasslands, and other openings should be left undisturbed in the initial entry.

Closure of some roads to motorized vehicles is recommended. This will mean closing certain roads or areas during and after the timber harvest operation for at least the period of September 25 through to November 30. As a rule, there should be no more than 1.6 km (1 mile) of road open to vehicle travel during the deer and elk season per 5.2 km^2 (2 $miles^2$) of land. This will provide sufficient areas of elk sanctuary to help offset the temporary 12-to 15-year loss of escape cover. An exception to this would be during active salvage logging when most roads will be needed for timber sale activities. Clearcuts that will make good elk forage areas should definitely be included in road closure plans.

As much as possible, roads should be located in natural openings, except meadows, or in areas of more open timber that are not considered important for dense escape cover. Special emphasis should be placed on protecting meadows, riparian vegetation, elk travel routes, and on road alignment and sight distances when locating roads.

Grasses palatable to elk should be seeded promptly on all soil disturbed by logging. A rate of 2.3 to 4.6 kg per ha (2 to 4 lbs. per acre) will not be detrimental to establishment of tree seedlings. A legume should also be seeded if an adaptable species can be found.

Special effort should be made to complete all management activities (road construction, logging, slash treatment, and rehabilitation) within a sale unit or cluster of units within two field seasons.

In larger areas of continuous timber (405 ha or more) where natural openings are limited, it is desirable to create or maintain small (2 to 8 ha) blocks of grassland. These would be considered "managed" wildlife forage openings. Location, size. and number of these openings will vary according to the natural conditions.

Habitat for those species of wildlife dependent on snags, cull trees, down logs, or patches of larger-sized (greater than 50 cm DBH) trees (lodgepole, associated species, ponderosa pine) should be provided in each 12 150 to 16 300 ha (30 000 to 40 000 acre) harvest block. A snag is any standing dead tree or portion of the stem of a standing dead tree with a minimum of **25** cm (10 inches) DBH and a minimum height of 30 m (100 feet) that still contains at least 10% sound wood. Recommendations are to leave:

1. Eight existing snags per hectare (3 per acre) in harvest units.

2. Five live trees (46 cm DBH or over) per hectare (2 per acre) for future snags in harvest units.

3. Various 0.4 to 4.0 hectare (1 to 10 acre) snag patches to total 20 hectares per 405 hectares (50 acres/1,000 acres) of timbered area.

4. Eight cull logs (1.1 metre^3 or larger) per hectare (3 per acre) in harvest units.

Availability of various snag and cull materials will determine what is actually left on specific harvest areas.

Streamside Fisheries

The beetle epidemic area contains some of the most productive steelhead and salmon spawning streams in the Columbia River system. Maintenance of high quality and quantity of water during low-flow periods is essential to maintain desirable levels of these important races of anadromous fish.

The Lane-Peet Area has two major stream systems—Camas Creek, which is a tributary of the John Day River, and Meadow Creek, which is a tributary of the Grande Ronde River. Camas Creek and its tributaries support a large run of summer steelhead estimated as high as 2 000 fish. As many as 1200 of these fish spawn in the Lane-Peet Area. Meadow Creek and its tributaries support a smaller run estimated as high as 289 fish. Nearly all of the tributaries within the Lane-Peet Area are important for providing spawning and rearing habitat. Steelhead spawn in the months of May and June. Most of the fry are out of the gravel by July 15. Many of these spawning streams dry up in August and September; the fry in these cases migrate downstream until a perennial flow is found to sustain them. Because of this trait, a tremendous number of kilometres of stream qualify as spawning habitat in the Lane-Peet Area.

Streamside trees and vegetation, duff, and organic matter are important for providing shade and for filtering and trapping sediment during surface runoff, preventing this sediment from reaching the stream. Higher-than-normal amounts of sediment can be expected to reach stream courses from overland flows during the lodgepole logging operation.

Maintenance of stream shade is an important part of the State Water Quality Standards. Even dead trees without needles and branches provide valuable shade. Therefore, dead lodgepole from the infestation should be allowed to stand near streams where they can provide stream protection for a number of years. Understory vegetation and reproduction will fill in shade voids as dead trees fall.

To avoid stream and streamside environmental degradation, a buffer strip is needed along all Class I through IV streams:

I: Perennial or intermittent stream used as a direct source of water for domestic use and by large numbers of anadromous fish.

II: Perennial or intermittent stream used by large numbers of anadromous fish.

III: All other perennial streams not meeting higher class criteria.

IV: All other intermittent streams or segments, thereof, not meeting higher class criteria.

Within this buffer, a reduction in stream sedimentation can be achieved by providing an undisturbed layer of duff, organic matter, soil, and understory vegetation on both sides of the stream. Wood fibre can be removed from part of the buffer zone if it is not needed for shade–provided the soil, duff, and ground vegetative layers are left undisturbed.

Streamside buffers needed for shade and sedimentation purposes are:

Class I, II, and III Streams

1. Forty-six metres (150 feet) of undisturbed ground, measured horizontally from the edge of the flood plain due to meandering.

2. On each side of streams having north-south exposures, a 30 metre (100 foot) strip of dead lodgepole next to the stream for shade.

3. A 15 metre (50 foot) strip next to the stream left uncut for shade requirements on each side of streams having east-west exposures.

4. Where other species are present within the strip and are providing

shade, harvest of lodgepole within the strip with careful logging. on a case-by-case basis.

Establishment of these buffers will withdraw about 6% of the total lodgepole pine volume from the timber salvage program in the Lane-Peet unit.

Class IV Streams
Including Spring Seeps

Fifteen metres (50 feet) of undisturbed ground, measured horizontally from the edge of the flood plain; 30 metres (100 feet), measured horizontally when the stream is in very shallow silt loam soils overlying basalts on south exposures.

To minimize stream sedimentation sources away from buffer strips, landings and skid trails should not be located in ephemeral drainways and should be water-barred before the fall rains. Ephemeral streams carry only surface runoff and, hence, flow only during and immediately after periods of precipitation or the melting of snow. They form in slight depressions in the natural contour of the ground. surface, but do not normally develop sufficient flow to wash or scour their channels; they can usually be identified by the presence of needles or other litter in the depressions.

Water

The Lane-Peet Area averages 63 to 76 cm (25 to 30 inches) of annual precipitation, with over half the amount occurring as snowfall. Mean monthly temperatures range from the low -10s in December and January to the high +10s in July and August. Temperature extremes 'range from -46° to over +38°C (-50° to +100°F). The frost-free season is very short and frost can occur in every month of the year.

Streams are the main source of flows for the lower drainage systems, with very high-quality water being provided.

Water yield from the sale areas has been or will be affected by the beetle epidemic, with or without any salvage operations. The degree of water yield depends largely on the amount of lodgepole pine in the stand, the soil type and mantle, the amount of snow that was intercepted by the original stand, and how rapidly the understory vegetation consumes the increased soil water.

Melt rates in a pure green lodgepole stand within these sales average 0.3 cm (0.1 inch) per day. while an open area melt rate averages 0.7 cm (0.3 inch) per day during the peak melt season.

The degree of increase in the peak runoff will depend largely on the number of small openings added in the timber type. Summer base flows will be higher until roots of the understory vegetation reoccupy the soil mantle.

Soils

Generally, in the Lane-Peet Area, the soils of lodgepole pine stands are shallow to moderately deep and are developed from volcanic ash over basalts. They have thin (0 to 2.5 cm) organic horizons, exhibit low moisture storage capacity, and exist along cold air drainages.

Under these lodgepole types, there is a lack of organic matter which is related to the tree species and ground vegetation. A thin organic horizon limits the site fertility and the chemical interactions (weathering) that breakdownthe mineral soil and release nutrients. The organic horizon also provides soft mat to break up rainfall impact and permits rapid infiltration. Without duff, the direct impact of raindrops on disturbed ash soils results in soil erosion. In addition, this organic layer holds the soil moisture and reduces the soil evaporation rate. On lodgepole sites, this layer then is especially important to protect the soil's limited moisture reservoir.

Slash should be utilized for soil site and regeneration protection. Slash on logged areas should be lopped and scattered on site, with chips from landing residues scattered across disturbed trails and landings. This will provide additional organic matter, shade, and protection to these sites. In clearcuts, the slash should be utilized and scattered evenly over the unit. Burning of the slash is not an acceptable solution from the soil resource standpoint because it could destroy all the organic layers within the lodgepole community types.

Frost heave is present in the fall and spring, affecting seedlings on the protected northern sites and soil resources on the shallow southern exposures. These latter sites have pedestalled soils and suffer severe rill and sheet erosion annually. Site disturbance will further degrade the sites and add to stream siltation. These silts are also generally shallow and, thus, have low. moisture storage capacity. This, plus exposure, leads to overland flow and mostly peak runoff discharge. Slash can entrap silts and, thus, retard the surface flows and contribute to fertility in these areas.

Recreation

The primary detrimental effects of beetle-killed trees on a recreation site are the hazard to life and limb and the loss of shade. Secondary negative effects can be many, including diminished attractiveness of site, reduced protection from weather, etc. All of the above could contribute to lower or, in some cases, no use of the recreation site. Therefore, the objective for developed recreation sites is to provide young shade at the earliest time possible with the least visual evidence of man's management activity to rehabilitate the site.

The phrase "least visual evidence" refers to such items as minimum mineral soil and sod disturbance, low stumps or removal of stumps, protection of shrubs and young trees, and minimum disturbance to campground roads during salvage logging to rehabilitate the recreation site.

The following recommendations are offered to provide recreation sites within timber stands with young shade at the earliest time possible:

1. Close campgrounds or portions of campgrounds to facilitate rehabilitation work.
2. Develop alternative sites in young shaded areas when available.
3. Thin stands in recreation sites to improve their vigor.
4. Replant lodgepole pine or other conifers with fast juvenile growth. Plant fast-growing deciduous trees, such as willow or alder, adjacent to streams or meadows.

Visual

The outbreak of the mountain pine beetle will leave many acres of lodgepole pine dead or dying within the next few years, which will have a negative visual effect on the forests involved. This will be true, even though there are stands of mixed conifers and ponderosa pine in the area which will not be affected by the beetle. Visually speaking, the sooner the dead lodgepole is replaced with regenerated vegetation, the better. However, if those cutting methods selected for regeneration are visually more undesirable than the effect of standing and fallen dead timber, the visual discontinuity of the landscape will have been aggravated or even magnified instead of lessened.

The following recommendations are offered to reduce visual impairment of landscapes in the outbreak area:

1. Insect kill lines should be followed and sharp-edged rectangles or other geometric patterns should be avoided when laying out cutting units. Units should also vary in size, thus repeating the variety of meadow and opening sizes that occur in nature. (Three general size groups would accomplish this: ca 4 ha, ca 8 ha, ca 12 ha).
2. Leave trees in shelter-belt units should be in groupings, instead of rows, to eliminate the straight-line effect.
3. The location of roads should be as well planned as in green sales, with thought given to such things as minimum clearing widths.
4. Fill slopes and ditches of system roads, especially in light-colored soil areas, should be seeded immediately to grasses. Temporary spurs should be seeded as soon as salvage operations cease.
5. A "dead screen" may be useful in slowing down or stopping the eye as it travels over or through large open spaces created by the salvage activities. It is understood that the dead trees will need to be managed as they begin to fall.
6. Existing regeneration groupings should be used as screens wherever possible. Landings may be screened from a major travel route, even though most of the sale area is not.

DISCUSSION AND CONCLUSIONS

Timber

Plan D comes closest of the four plans to meeting the silvicultural objectives: harvesting and prompt regeneration while meeting the guidelines for other resource objectives for the areas.

Utilization of volume available for harvesting within the other resource guidelines in Plan D is about 10% less than in Plan B, which maximizes utilization.

Regeneration processes are lengthened over 21 years, instead of 14. The extra time allows additional discretion in choosing stands for treatment and for refinement of regeneration techniques. It is anticipated that, in the first entry into the area stands with the highest site qualities and potential for regeneration or overstory, removal (leaving a quality understory) will be selected. The overall result will be a better distribution of age classes within the managed forest.

Plan D has factors that mitigate the harvest and regeneration effects on other resources. While this alternative is not optimum for fibre production, it best meets the multiple-use objectives for this area.

Wildlife

Plan A would have the least impact on big game habitat because it involves no activity with resultant cover losses.

Plan D is the second choice over B and C because it is believed to best meet the stated goal for maintenance of big game habitat. This is primarily the result of spreading the removal of the timber over three entries rather than two. This plan will result in the most diversification and maintenance of dense cover. Plan B would have a significant adverse impact on Rocky Mountain elk. Plan C would also meet the overall goal. but not as well as D.

Hydrology Fisheries

Plan A would alter the flow regime the least and have the least impact on water quality because it involves no activity.

Plan D is the second choice over B and C because:

1. Less country will have activity on it with each entry, so peak flow will be kept at a minimum level.
2. There will be fewer bare soil areas as sources of sediment.
3. More of the acres have a chance to recover hydrologically before other areas are disturbed, thus reducing the peak flow and other hydrologic impacts.

Soils

Generally, this area is composed of discontinuous timber cover separated by natural drainways and shallow scabland side slopes. Timber occurs in fringe units adjacent to drainways, along side slopes, between shallow rocklands. and within closed canopy areas of undisturbed cover.

Because this unit is of open nature, with generally shallow soils, fringe timber stands, and dissected rainways. the three-phase harvest plan appears to produce the least impact on the soil resource. By operating in only 30% of the area at one time, instead of 50%. there will be less area exposed at any one time. Three stages will also allow one more evaluation period in which to assess the results of the guideline decisions. The opportunity to alter the guidelines at 30% will give a better chance to adjust prescriptions to reach soils management objectives.

Recreation

Management is forced to treat beetle-kill sites immediately because of the hazard to life and limb, especially in developed campgrounds; therefore the safety hazard is removed under every plan but that of "no action".

Basically, the faster the site is rehabilitated, the sooner new shade is established to replace that lost. Plan B produces relatively rapid rehabilitation with new shade. Plan D offers less evidence of man's management activity in the surrounding environment because of its three-stage entry with moderate delay in rehabilitation time.

Visual

From the standpoint of the visual resource, Plan D is the most desirable because it spreads out the treatment activity over a longer period of time, it returns the visual landscape to its original condition in a moderate amount of time, and it treats only one-third of the total affected area at one time, thus creating more visual variety.

The forest supervisors of the Umatilla and Wallowa-Whitman Forests have elected to use the Lane-Peet guidelines to treat the current mountain pine beetle outbreak area. Salvage efforts are under way in the accessible portions of the area as funding becomes available. The National Forest Management Act of 1976 (PL 94-588) has been helpful by setting up the Salvage Sale Fund under Section 14h.

Table 2

Mountain Pine Beetle-Lodgepole Pine Harvest Program

Projects and Appropriations

(Volume = millions of board feet; Dollars = thousands)

	FY 1977		FY 1978		FY 1979		FY 1980		FY 1981		FY 1982-1997		Total	
	Volume	Dollars	Volume	Dollars	Volume	Dollars	Volume	Dollars	Volume	Dollars	Volume	Dollars	Volume	Dollars
Forest Land Management														
Sale prep. ($5.30/M)	70	371.0	82	479.6	101	490.3	76	435.8	112	—	662	3 508.6	1 103	5 845.9
Sales admin. ($3.50/M)	5	17.5	24	84.0	71	248.5	90	315.0	84	294.0	829	2 901.5	1 103	3 860.5
Reforestation ($80/A)	—	—	900	72.0	4 020	321.6	12 328	986.2	15 776	1 262.1	113 036	9 042.9	146 060	11 684.8
Range 1051,053 fence-mi.)	5	25.0	10	51.0	5	26.0	10	51.0	5	26.0	5	80.5	—	259.5
Wildlife (080)	—	24.0		26.0	—	26.0		26.0		27.0		211.0	—	340.0
Soil, water, and air (091)	—	33.0	—	28.5	—	28.5	—	28.5	—	28.5		108.0	—	255.0
Fire protection	—	223.4	—	223.4	—	223.4		223.4		223.4	—	2 370.0	—	3 487.0
Fuel treatment	120	780.0	120	780.0	120	780.0	120	780.0	120	780.0	75	5 037.5	—	8 937.5
Subtotal	—	1473.9		1 744.5	—	2 144.3		2 845.9		3 201.6		13 260.0	—	34 670.2
Funds Collected From Purchaser														
CWFS-KV ($80/A)	—		300	24.0	980	78.4	3 107	248.6	3 894	311.5	28659	2 292.7	36 940	2 955.2
CWFS-other (1% sale, $20/A)	—	—	52	1.0	176	3.5	532	10.6	638	12.8	6468	129.4	7 866	157.3
Total CWFS	—		352	25.0	1156	81.9	3 639	259.2	4 532	324.3	35 127	2 422.1	44 806	3 112.5
BD (1% sale, $20/A)	—	—	40	0.8	172	3.4	516	10.3	642	12.8	6496	130.0	7 866	157.3
Subtotal	—		392	25.8	1328	85.3	4 155	269.5	5 174	337.1	41 623	2 552.1	52 672	3 269.8
Forest Roads and Trails (miles)														
Supplementation (miles)	669	7 694.0	550	6 376.0	—					—	—		1 219	14 070.0
Engineering:														
- preconstruction	—	4 098.0		1839.0	—	531.0			—				—	6 468.0
- construction	—	918.8	—	2 085.8	—	1292.0		919.0		420.0	—	—	—	5 635.6
Preroading (miles):														
- construction	390	11 700.0	551	16 530.0	861	25 830.0	70	2 100.0		—	—		1 872	56 160.0
- reconstruction	102	1 628.0	110	1 756.0	56	899.0				—	—	—	268	4 283.0
- main access projects	130	6 702.0	43	1828.0	6	360.0	—	—	—	—	—	—	179	8 890.0
Subtotal (preroading)	622	20 030.0	704	20 114.0	923	27 089.0	70	2 100.0	—	—	—	—	2 319	69 333.0
Subtotal (FR&T)	1291	32 740.8	1 254	30414.8	923	28 912.0	70	3 019.0	—	420.0	—	—	3 538	95 506.6
Grand Total	—	34 214.7	—	32 185.1	—	31 141.6	—	6 134.4	—	3 958.7	—	25 812.1	—	133 446.6

Table 3

Silvicultural Guidelines

Timber Types	Site Factors	Harvest Method Alternatives	Constraints	Post-Sale Work
I. Lp3=,Lp3=,Lp2=,Lp2= and combinations of above with: 1. Other species over-story (<37 trees/ha). 2. Other species under-story (<750 TPH crop class). 3. Lpp or other species seedlings (<750 TPH, 15-30 cm, good quality).	A. S-Sw exposures. 1. Shallow soil (25-60 cm). 2. 0-2.5 cm depth of soil organic matter. 3. Ground vegetation lacks variety and density. 4. Advanced regeneration not usually present. 5. Cold air drainage or pocket. 6. May have slopes 25-45%	Shelter belt: 1.2-1.8 m leave strip between 18-36 m harvest strip (HSH Belt). **or** Shelter group, 10-20 stems, 10 cm DBH+, live or dead, left in groups 12-18 m apart (HSH Group).	1. 12 ha size. 2. Shelter belt strips perpen-dicular to sun. 3. Soil disturbance limited to breaking duff layer; ex-posure of mineral soil on 20-30% area evenly dis-tributed. 4. Minimize machinery on ex-posed rocky areas. 5. Logging residue to be left for additional soil cover. 6. No soil compaction on 25-45% slopes.	1. Clean stand of shelter belts and groups, scattered poles and saplings that are disease infection source within 7 years (SCN). 2. Planting required in 20-40% of area to meet minimum stocking of 250 acceptable seedling/ha at end of 5 years (RPL). Lodgepole pine preferred species.
	B. N-NE exposures. 1. Moderately deep soil (60-100 cm). 2. 2.5-3.8 cm organic matter. 3. Ground vegetation has variety and density. 4. Advanced regeneration usually present. 5. No cold air drainage or pocket.	Clearcut. patch (HCC Patch). Clearcut strip (HCC Strip) in narrow-long strips.	1. 6-8 ha size. 2. Site preparation 3040% of area. 1. 6 ha size. 2. Less than 0.4 km long. 3. On the contour. 4. Site preparation 3040% of area.	1. 'Clean stand of residual disease-infected poles and saplings. 2. Plant 10-20% of area. Lodgepole pine and wes-tern larch preferred species.
II. Similar to type I but with at least 750 Lpp seedlings 15-30 cm/ha. Minimum of 250 Lpp seedlings/ha following all activities 1st entry.	I.A. or I.B. above	Overstory removal (HFR).	1. 16 ha maximum. 2. Minimize machinery on ex-posed rocky areas. 3. Minimize soil disturbance. Seedbed preparation not needed. 4. Logging residue to be left for additional soil cover. 5. No soil compaction on 25-45% slopes.	1. Clean stand. 2. Release crop trees if needed. 3. Control stocking level through prompt revegeta-tion.

III. Lp1–,Lp1=,Lp1≡ Some of this type may be merchantable 10 cm+ DBH.	A. Same as I.A.	No treatment (NTM). Same as I.A.	Same as I.A.	Same as I.A.
	B. Same as I.B.	No treatment (NTM). Same as I.B.	Same as I.B	Same as I.B.
IV. Lp2 or Lp3 with other species overstory (at least 37 trees/ha)	A. Same as I.A.	Shelterwood of other species with shelter belt if needed to modify site.	Same as I.A.	Same as I.A., overstory to be removed when new stand established.
or Other species overstory over Lp2= or Lp3= Example W13– / Lp2=	B. Same as I.B.	Shelterwood of other species.	Same as I.A. except site preparation on 30-40% of area.	Same as I.B., overstory to be removed when new stand established.
V. Lp3–,Lp2–,Lp1– Light stocking may indicate extreme site conditions.	Same as I.A.	No treatment Same as I.A.	Same as I.A.	Same as I.A
VI. Lp2 or Lp3. Over other species saplings and poles (must have 250 TPH in crop trees class following all activities this entry).	Same as I.B.	Same as II.	Same as II plus log length skidding, prelocated skid trails, stage logging.	Same as II

Lodgepole pine-big huckleberry CL-S5-11 (7LM)

Similar to Lpp-grouse huckleberry-pinegrass.
Productivity a bit lower, silvicultural guidelines are the same,

Lodgepole pine-grouse huckleberry CL-S4-11 (7LS). May be a mixture with subalpine fire communities.

Higher elevations, colder sites.
Regeneration and other revegetation limited by temperature and growing season factors.
Do not clearcut; maintain shelter over site; protect ground cover; limit site disturbance to minimum.

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A CASE STUDY

THE MOUNTAIN PINE BEETLE IN THE EAST KOOTENAYS

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I am very pleased that the sponsors of this workshop selected the East Kootenays for the meeting and field trip, as this area has been subjected to one of the longest and most severe mountain pine beetle outbreaks in recent history. In the East Kootenays, through trial and error and cooperation of all forest users, we developed an Action Sanitation Salvage and Control Plan, which was too late to provide control in many parts of the Kootenays but could be used as a model for control actions against future outbreaks of mountain pine beetle or, for that matter, any other insect.

Some of the East Kootenay mountain pine beetle attacks could have been controlled, barring unforeseen circumstances, if we had developed our "Five-Year Master Control Plans" prior to the outbreak. None of us recognized the explosive nature of this small insect. I find it ironical that, in British Columbia, we have developed the most modern fire-control plans and suppression organizations, but have not developed comprehensive insect and disease control plans. Perhaps this is because fire is spectacular and the press and public love the excitement attached to it.

If we are to avoid major reductions in allowable cut and social dislocation, we must quickly develop salvage and control plans for all areas, ensure execution of these plans, and ensure adequate funding for access and site rehabilitation.

THE HISTORY AND EXTENT OF ATTACKS IN THE EAST KOOTENAYS

The first attack area was identified by the Canadian Forestry Service in **1966** near the lower end of Elk Creek in the White River drainage, approximately **15** miles southeast of Fairmont. The Service placed a study plot of approximately 80 acres around the attack. This plot was discontinued in **1968.** In **1969,** the beetle attack spread rapidly along the lower end of Elk Creek to the confluence of Elk Creek and the White River. In about **1970,** small groups of attacked trees were found in the middle portion of Elk Creek and, in **1971,** in the upper portion of Elk Creek. No master salvage plan was developed and the attack spread at an ever accelerating rate until the beetle was far ahead of salvage attempts in most areas, as it is today.

The second attack area was noted in the Golden Area in **1971** and, like the White River Area, spread in spite of attempts to control it.

The third attack area was in the Flathead Valley in **1975.** This attack was identified as spreading from the United States like a wall of fire, with the result that effective control action has been impossible. In some areas, the insect has chewed through the mature timber and is now working on immature timber in the 60-year-old age class, which unfortunately is unmerchantable today.

EXTENT OF MOUNTAIN PINE BEETLE SUSCEPTIBLE STANDS

The four timber supply areas (TSA) in the East Kootenays contain 45 **900** 000 cubic metres of susceptible mature pine, located on **228** 400 hectares. The percentage of pine varies from area to area, and the following figures indicate the various percentages for each timber supply area (the Creston public sustained yield unit [PSYU] is being incorporated into the Kootenay Lake TSA):

Cranbrook TSA:	37%
Invermere TSA:	36%
Golden TSA:	13%
Creston PSYU:	15%

The high percentage of lodgepole pine in the East Kootenay forests, coupled with the fact that lodgepole pine comprises of a very high proportion of the immature stands, is of grave concern, particularly as mountain pine beetle attacks are continuing unabated.

AREA AND VOLUME UNDER ATTACK

The forested area, currently under attack by the mountain pine beetle in the East Kootenays. is startling. The extent of the epidemic in mature pine is as follows:

Timber Supply Area	Volume (m^3)	Area (ha)
Cranbrook	3 500 000	17 500
Invermere	5 400 000	27 000
Golden	120 000	600
Kootenay Lake (east)	45 000	225
Total	9 075 000	45 325

While this acreage is under varying degrees of attack, it amounts to approximately 4 to 5 years of the allowable cut of the East Kootenays!

In addition, it is estimated that more than 20 000 hectares of immature pine are decimated or under attack.

DEVELOPMENT OF A CONTROL PLAN BY THE EAST KOOTENAY INSECT AND DISEASE CONTROL COMMITTEE

The East Kootenay Insect and Disease Control Committee was re-formed in 1973 to address the rapidly spreading mountain pine beetle outbreaks, through both government and forest industry cooperation. A major goal was to eliminate the misunderstandings and conflicts among forest users. This committee had been formed in 1969 to combat the large spruce bark beetle attacks in the East Kootenays. The committee efforts were recognized as providing the basis for control actions against spruce beetle attacks, which had subsided by 1971.

The committee was broadened in 1973 to include the B.C. Forest Service, forest industry. Fish and Wildlife Branch, Canadian Forestry Service, and recreation (Forest Service) and parks (on occasion), The committee organization included a steering committee and working committees for each of the four timber supply areas. The terms of reference included the "development of master salvage and control plans" for the East Kootenays, within the framework of the allowable cuts for all tenures. It was recognized that overcutting would be required in some tenures, but that, hopefully, this would be offset by undercutting in other areas. The Steering Committee meets semiannually, or more regularly if necessary. to set priorities and guidelines. The Working Committees meet as often as required and are charged with the development of "Five-Year Master Salvage and Control Plans", which I will describe later. Committee accomplishments, direct and indirect, in many different areas, have permitted the preparation of master salvage and control plans.

Committee Work On Fish and Wildlife

Elk/Logging Studies

The committee, with the guidance and participation of the Fish and Wildlife Branch, sponsored an Elk/Logging Study from 1975 to 1978. The report, "Relationships Between Elk, Snow, Habitat Use, and Timber Management in the White River Drainage of Eastern British Columbia", prescribes:

- Select cuts on south aspect, leaving abundant browse.
- Protection of riparian areas.
- Temporary forested travel corridors.
- Sheltered cover in temporary reserve blocks.

Properly engineered clearcuts:

Optimum size under 30 hectares, but larger where heavy attack occurs.

Providing protection of ridge-top cover for escape routes.

Located on the lee side in windy areas.

Preserving deep-rooted tree species on windward side.

- To afford windbreaks and cut down wind-crusting of snow.

Controlled burning activities, when necessary.

- Large select logging area, leaving **10%** of stems (fir/larch) ideal browsing areas.

Grizzly Bear Study

The Border Grizzly Bear Study, which includes the Flathead Valley of British Columbia, has two members of the East Kootenay Insect and Disease Control Committee on the Steering Committee.

The Grizzly Bear Study Committee recognized that logging and grizzly bear management could be carried on, but the question was "how to log".

The "Akamina-Kishinena Grizzly Project Report" concluded that timber salvage can occur without detrimental effects to grizzlies, if activities are carefully planned and diligently supervised. Salvage plans must be contingent upon:

1. The establishment of population centre and high-density areas.

2. The protection of basic needs within these areas through:

The retention of a minimum amount of wilderness area by limiting development and by an active road closure program.

Maintenance of as much of the existing ground cover as possible.

- Protection of breeding, denning, and spring feeding areas.

- Improvement of feeding areas through controlled burning and seeding of clover.

- Retention of temporary timbered corridors to protect travel routes.

- Avoiding road construction through avalanche shutes.

The work of the Grizzly Bear Study group has been instrumental in the development of sanitation and control salvage programs in the Akimena-Kishinena Area, which is a highly controversial area.

A policy of access control for hunters and of physical road closure plans has developed from the "Elk/Logging" and "Grizzly Bear" Studies. Coordinated use plans, were initiated into British Columbia by the Fish and Wildlife Branch and have been very successful in resolving conflicts.

Utilization Studies
for the Committee

The Western Forest Products Laboratory, now Forintek of Vancouver, reported in "Lumber Values and Beetle-Killed Lodgepole Pine" (1976) that, under normal markets, positive conversion returns for manufactured lumber can be obtained until trees start shedding their bark and have severe checking. To ensure positive values, attacked trees should be harvested prior to complete foliage loss, normally within two years of attack. Tree with green or red foliage yielded similar values per cunit of logs with positive conversion returns. Trees with no foliage, but tight bark, also yielded positive returns, but at a lower level. For trees with sloughy bark, the returns were negative. This excellent report has been used by all forest companies for guidance and has been instrumental in stumpage value assessments.

B.C. Forest Service Cooperation

The B.C. Forest Service has encouraged salvage and control by:

- Providing incentives in the stumpage appraisal system by reducing lumber recovery factors, increasing "crash" road construction, planning and logging costs, and allowing salvage rates for specific degrees of attack.

- Giving priority to chart or planning areas and cutting permits.

- Reducing or eliminating, the cruising require. ments, depending on the degree of attack.
- Preparing intensive fire protection plans because of the extreme fire danger associated with beetle attacks.
- Placing insect foresters in each region

CooperationWith The Kootenay Steep Slope Committee

The Kootenay Steep Slope Committee is developing guidelines for road and harvesting systems to remove lodgepole pine from sensitive sites on an economic and environmentally sound basis. Logging systems include conventional, mechanical, small tractors, two sizes of light flotation systems, and cable. I would suggest that, with proper planning, supervision, and an optimum combination of equipment, beetle. attacked timber could be salvaged in parks with little, if any. detriment.

Forest Industry Cooperation

The forest industry has played it's part in salvage and control plans by:

- Investing in new equipment for harvesting on critical sites and making mill modifications to utilize lodgepole pine. All companies in the East Kootenays have agreed to utilize 70% of lodgepole pine in their plants, compared to the normal profile of **25%.** This has had a definite impact on the profitability of operations.
- Longer hauls have been required, in some cases, at a considerably increased cost. At least one company is hauling lodgepole pine an extra 50 miles.
- Accelerating the planning process and holding planned areas in abeyance because of the out-breaks.
- Accelerating access construction into high-priority areas. Large sums of money have been spent. Previously developed areas have been held in abeyance.

Canadian Forestry Service Surveys

The Canadian Forestry Service, by providing annual and periodic reports on insect intensity and direction of attack, has facilitated plan preparation.

SALVAGE AND CONTROL PLANS FOR STANDS DAMAGED BY INSECTS AND DISEASES

The East Kootenay Insect and Disease Control Committee, through cooperation and implementation of study results, has modified or eliminated many of the hurdles that prevent the preparation of a meaningful salvage and/or control plan. Our plan may not be perfect, but it is an effective "blueprint" for control and/or salvage.

The planning process for a Five-Year Master Salvage Plan includes:

- Identification of all infested and susceptible stands.
- Establishment of priority criteria
- Identification of priority areas.
- Estimation of affected volumes.
- Estimation of accessible annual allowable cuts versus volumes.
- Establishment of cut volumes for each company.
- Submission to the Steering Committee of the East Kootenay Insect and Disease Control Committee for approval and amalgamation with adjoining timber supply areas.

The preparation of plans for harvesting include:

- Developing access plans for all infested stands and for susceptible stands.
- Establishing data collection requirements (cruise required, logging production infor-mation) on each infested stand, together with the Ministry of Forests.
- Recommending post-logging treatments to the East Kootenay Insect and Disease Control Steering Committee, i.e., extra funds required, additional staffing, etc.

- Reviewing performance semiannually or more often, as required, to ensure that objectives of master plans are being met.

- Revising the plan annually, if required.

The Master Salvage Plan update will be completed in January 1982 and will be reviewed shortly after. This plan will include addressing the spruce and balsam beetle attacks, which are now reaching major proportions in the East Kootenays. Heavy emphasis will be placed on site rehabilitation. Areas that require rehabilitating include large areas of mature lodgepole pine that are inaccessible and immature stands that are unmerchantable. If these areas are not .treated, there will be a substantial reduction in annual allowable cut.

CONCLUSIONS

Multi Discipline Committees, formed on a federal, provincial and county level, need to develop "Master Control and/or Salvage Plans". The elimination of technicalities and friction points in advance is mandatory, and a full commitment is required to the plan.

Federal and provincial governments must provide substantial funding for access and site rehabilitation. These funds must be allocated on a priority basis within a "Five-Year Master Control or Salvage Plan", otherwise, they will be largely wasted.

Public education and awareness programs must be developed to make everyone aware of the tremendous damage caused to the forest by insects and disease.

APPENDIX I

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APPENDIX II

Available Literature

Anon. 1981. A pilot study investigating the suitability of using low-level, fixed base, 70 mm aerial photography to determine the extent, stage, and severity of mountain pine beetle infestation. Report for Revelstoke Sawmills Ltd. Timberline, 1698 West 3rd Avenue, Vancouver, B.C. 8 pp.

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McLellan, B.N. 1981. Akamina-Kishinena grizzly project progress report, 1980 (Year 2). B.C. Fish and Wildlife Branch, Cranbrook, B.C. 86 pp.

Mutch, D.W. 1981. The effect of the mountain pine beetle on the Flathead Valley Forest. East Kootenay Public Affairs Committee Brief. Assoc. of B.C. Professional Foresters. 8 pp.

Safranyik, L., D.M. Shrimpton. and H.S. Whitney. 1974. Management of lodgepole pine to reduce losses from the mountain pine beetle. Forest Tech. Rep. 1. Pacific Forest Research Centre, Victoria, B.C. 24 pp.

APPENDIX III

List of Displays

1. British Columbia Ministry of Forests

   Photographs, map, and text showing the areas visited on the field trip.

2. Pacific Forest Research Centre

   Specimens, photographs, and text showing the interaction between the mountain pine beetle and lodgepole pine and listing the options available to forest managers in response to this beetle. Scientists were in attendance to answer questions.

3. Pacific Forest Research Centre

   Distribution map of the current mountain pine beetle outbreaks in British Columbia.

4. I.S. Timberline
   Suite 204, 1698 West 3rd Avenue
   Vancouver, B.C. V6J 1K3

   a. A camera boom for twin 70 mm cameras, remotely controlled from within a helicopter when in operation.

   b. Light table and stereo-viewing equipment and examples of stereo-paired photography.

   c. Enlarged photographs with both infrared and true-color film.

   Staff members were in attendance to describe methods and their effectiveness and to answer questions.

APPENDIX IV

Introduction to the Field Trip
Mountain Pine Bark Beetle Tour
White River
November 4,1981

Welcome to the Invermere Forest District!

This tour package has been a collective effort of three members of the East Kootenay Insect and Disease Control Committee, Revelstoke Sawmill (Radium) Ltd., Crestbrook Forest Industries Ltd., and the Invermere Forest District.

A brief history is in order. The first indications of a more than "normal" population of pine bark beetle was noted in the Elk Creek drainage during the early mid-1950s. Monitoring of this outbreak was undertaken by the Canadian Forest Service, however, it was believed that the population would eventually collapse. The outbreak appeared to remain more-or. less static until the early 1970s. It was then obvious that an epidemic of major proportions was possible.

During those early years, control efforts were fragmented because of limited communication between the private sector and government agencies. The need to improve communication and coordinate the control effort was recognized by all involved. This need resulted in the formation of the East Kootenay Insect and Disease Control Committee (EKIDCC) during 1972. The magnitude of the problem and the importance of this committee was not fully appreciated until 1976.

Since 1976, the East Kootenay Insect and Disease Control Committee has been functioning extremely effectively in the war against the "beetle".

With the communication channels between governments, industry and other resource users open the combined efforts of the committee members has spawned a cooperative approach to control of insects and diseases. The Five-Year Mountain Pine Beetle Control Plan is one example of the commitment to the control of this forest insect the individual members of the EKIDCC have made.

This field tour will highlight some of the control efforts that. have taken place over the years and should obviate the need for a lengthy discourse on our insect control problems, as well as the impact the epidemic has on other resource values and uses.

Personnel from the two companies, as well as the Forest Service, will accompany the tour–they are prepared to answer your questions. Feel free to ask!

Don Hendren
Operations Superintendent
Invermere Forest District

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