United States
Department of
Agriculture

Forest
Service

Northern
Region

State &
Private
Forestry

Report No. 81-7
April 1981

Forest Pest Management

Incorporating Insect and Disease Considerations into the Planning Process on the Flathead National Forest

by

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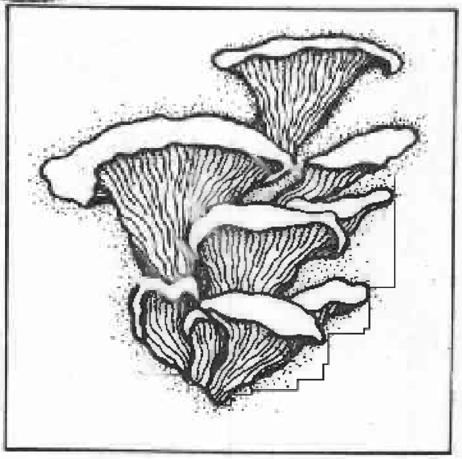

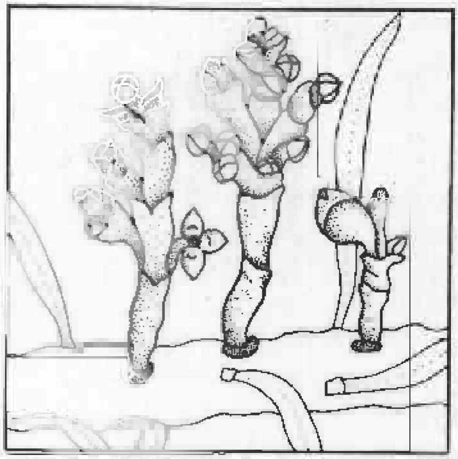

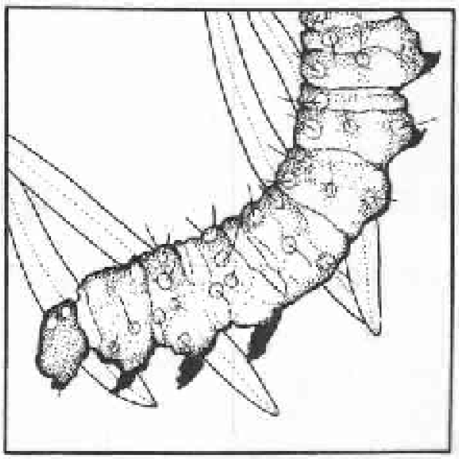

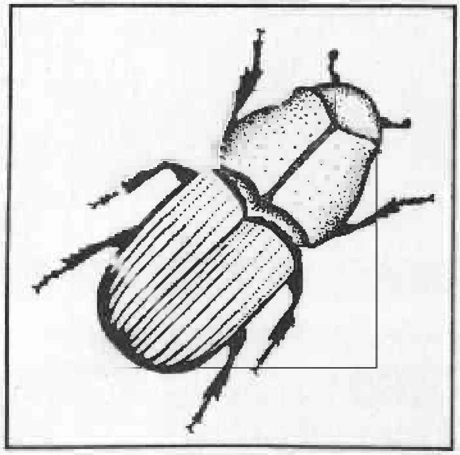

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INCORPORATING INSECT AND DISEASE CONSIDERATIONS INTO THE PLANNING PROCESS ON THE FLATHEAD NATIONAL FOREST

by

Kenneth E. Gibson

and

James W. Byler

INTRODUCTION

In accordance with the regulations established for the forest planning process by the National Forest Management Act, Forest managers are instructed to "protect resources from disease, pests, and similar threats." In order to do so, those insect or disease organisms capable of seriously affecting resource allocations and subsequent outputs must be identified as management concerns early in the planning process. As an integral part of the interdisciplinary approach to forest pest management, personnel from FPM must assist in the identification of major forest pests, provide biological data on those pests where necessary, and suggest management alternatives where appropriate.

MAJOR INSECT AND DISEASE PESTS ON THE FLATHEAD NATIONAL FOREST

Major insect and disease pests--those addressed as management concerns in the forest planning process--are those which presently affect management policy significantly, or have the potential to do so. The one pest currently impacting management direction on the Flathead National Forest is the mountain pine beetle in lodgepole pine.

Those having the potential to affect management decisions within the proposed planning period are:

(1) Spruce beetle in Engelmann spruce
(2) Douglas-fir beetle in Douglas-fir
(3) Root diseases
(4) Dwarf mistletoes
(5) Stem decays
(6) White pine blister rust

Following is a brief description of those pests identified as being capable of affecting management decisions. Included is a statement pertaining to the present status of the pest, present or potential damage attributable to the causal agent, and possible management strategies.

MOUNTAIN PINE BEETLE IN LODGEPOLE PINE

Present Situation

At the present time, the mountain pine beetle is epidemic on the Glacier View, Hungry Horse, Tally Lake, and Spotted Bear RD's. Aerial survey estimates of federally-owned land infested by the beetle in 1980 totalled more than 122,000 acres. Another 86,000 acres of private land within the Forest boundaries were also infested.

On the Glacier View RD, where more than 85,000 acres are still infested, the epidemic is beginning to wane in response to accelerated harvests and host depletion. Ground surveys conducted throughout the District indicate an average of 12 trees per acre were killed there in 1980. In excess of 87 trees per acre were killed in 1979. Prior to the onset of the infestation, which began on the District in 1976, approximately 22,000 acres of lodgepole pine were classified high hazard for beetle susceptibility. Another 60,000 were regarded as lower risk. Since that time virtually all the lodgepole stands on the District have become infested. Ground data indicate that, over those areas surveyed on the District, the beetle is responsible for an average 108 standing dead trees per acre. This example is illustrative of the mortality which may be experienced--and the short time over which it may transpire--in such an extensive, and intensive, beetle outbreak.

The Hungry Horse RD has over 21,000 acres infested by the beetle to some degree. Another 11,000 acres of high-hazard lodgepole remain. The infestation is still building over most of the District. In 1980, ground surveys indicated an average of nine newly attacked trees per acre for those areas surveyed. The beetle will continue to attack uninfested stands, and mortality in infested stands will increase, until susceptible trees are removed.

On the Tally Lake RD, accelerated harvesting is scheduled in many of their high-hazard lodgepole stands. To date, however, little has been cut, and about 38,000 acres of high-hazard lodgepole are as yet uninfested. The infestation is beginning to build on the District--1980 ground surveys showed an average of six attacked trees per/acre in widely scattered locations. That figure was up from just over three trees per acre in 1979. The devastation experienced on the Glacier View RD illustrates the urgency of appropriate stand management on the Tally Lake RD and other high-hazard stands in the Forest.

Generalized Site Characteristics and Damage

The mountain pine beetle presents the most serious threat to the growth of lodgepole pine throughout its range. Populations of the beetle periodically increase and kill most of the large diameter trees before subsiding. The frequency of epidemics appears to be directly related to site quality, with stands on better sites growing into a susceptible condition more rapidly than those on poor sites. Frequency and intensity of outbreaks are related to tree age and diameter, and to elevation-latitude of the stand (Amman et al. 1977). In general, stands considered high hazard are more than 80 years old with an average diameter (d.b.h.) exceeding 8 inches. Tree mortality is inversely related to increasing elevation-latitude.

Phloem thickness distribution is an important characteristic determining beetle success in a stand. Because of the strong positive correlation between phloem thickness and tree diameter, and the relative ease with which diameter is measured, average stand diameter usually determines stand susceptibility. Generally, trees growing on good sites have thicker phloem and thus a greater brood-to-parent ratio than do trees growing on poor sites.

Further, stands of lowest density have the greatest proportion of large diameter trees with thick phloem. Therefore, beetle production will be greater in trees of succeedingly larger diameter classes in more open stands. Mortality in these stands will be proportionately greater than in dense stands.

Intensity of beetle infestations and subsequent numbers of trees killed differ with habitat type (Roe and Amman, 1970). In the Intermountain and Northern Regions, more mesic habitat types at midelevation ranges experience higher percentages of tree killing. This follows what has been previously established:

the more favorable the site, the thicker the phloem and consequently the greater the tree mortality once an infestation begins. Unless an infestation has reached a fairly severe level of intensity, however, such vigorous trees will probably not be attacked until they reach an age of 80 years. Management should therefore be directed towards lower elevation, older stands first.

There appears to be an inverse relationship between tree mortality and incidence of dwarf mistletoe infection. Data show that as the proportion of a stand infected with mistletoe increases, the proportion of the stand greater than 8 inches d.b.h. decreases. The converse is also true. Uninfected stands would be expected to be composed of trees with thicker phloem, so a beetle infestation would likewise be expected to be more intense, provided trees are of a susceptible age and size. Roe and Amman (1970) concluded that tree mortality was more severe in relatively mistletoe-free stands, and trees in those stands had thicker phloem than infected trees. Trees having medium-to-heavy mistletoe infection had thinner phloem than uninfected trees. In these more heavily infected trees, beetle production tended to decline.

Stands depleted by the beetle and not subjected to fire are eventually succeeded by more shade-tolerant species--Douglas-fir at lower elevations and subalpine fir and Engelmann spruce at higher elevations (Amman 1977). Starting with a stand generated by fire, lodgepole pine grows more rapidly than spruce and fir seedlings established at the same time; therefore, lodgepole pine will soon occupy the dominant position in the stand. With each mountain pine beetle infestation, the large, dominant lodgepole pines are killed. After the infestation, both residual lodgepole pine and other shade-tolerant species increase their growth. When the trees are again of a susceptible size and age, another beetle infestation occurs. This cycle is repeated at 20- to 40-year intervals depending upon tree growth, until lodgepole is eliminated from the stand.

Where lodgepole pine is seral and fire is allowed to occur naturally, the species is perpetuated through the effects of periodic fires. Fires tend to eliminate competitive tree species such as Douglas-fir, true firs, and spruce. Accumulations of dead material resulting from periodic beetle infestations result in very hot fires. Such fires eliminate competitive species, and serotinous cones of lodgepole pine usually seed the burned area abundantly. Following such regeneration, the mountain pine beetle/lodgepole pine interactions would be similar to those described in the absence of fire. Fires may interrupt the sere at any time, reverting the stand back to pure lodgepole pine.

In other stands, lodgepole pine may be more persistent or, because of special climatic and soil conditions, even the climax species. In such cases, the forest consists of trees of different sizes and ages, ranging from seedlings to mature and overmature trees. In these forests, the beetle infests and kills most of the trees as they reach larger sizes. Openings created as a result of these larger individuals being killed are seeded in by lodgepole pine. The cycle is repeated as younger trees reach maturity, are killed, and replaced. The result in these stands is a mosaic of small clumps of differing ages and sizes. The overall effect may be more chronic beetle infestations due to a continual food supply. Actual tree mortality may be less per acre during each infestation than occurs in even-aged stands where lodgepole pine is seral.

Hazard Rating Stands

Stands can be hazard rated for mountain pine beetle susceptibility (Amman, et al., 1977). By multiplying risk factors for elevation-latitude by those for average age and average d.b.h., where 1=low; 2=moderate; 3=high; a stand susceptibility classification is obtained. Hazard ratings are 1 to 9, low; 12 to 18, moderate; and 27, high. The following table lists these factors:

Elevation-latitude		Average age (years)		Average d.b.h. (inches)	
High	(1)	<60	(1)	<7	(1)
Moderate	(2)	60-80	(2)	7-8	(2)
Low	(3)	>80	(3)	>8	(3)

For example, a stand at high elevation (hazard rating 1) more than 80 years old (3), with an average d.b.h. of 9 inches (3) has a hazard rating of 9 (1x3x3=9). This would be a low hazard rating, despite the stand characteristics, because of its elevational position. A similar stand at low elevation (3) would have a high hazard rating (3x3x3=27).

Management Alternatives

Stands where mortality is predicted to occur, or continue at a severe level, can be managed for timber in several ways. These management alternatives are dependent upon land-use objectives and whether the stands are pure or mixed species, even or uneven aged.

Recognizing that the beetle concentrates on large diameter older trees, continuous forests can be broken up by small clearcuts. This will result in different age and size classes and reduce the amount of area likely to be infested at any one time. When individual stands approach high hazard conditions, they should be harvested. Where composition is pure lodgepole pine and form is even-aged, practices can be limited to: (1) stocking control in young stands; (2) organized clearcutting in blocks to create age, size, and species mosaics from mature stands; and (3) salvage cutting to reduce losses in stands under attack. Sanitation salvage cutting should, however, be considered only a delaying action at best. This strategy will do little to eliminate an infestation already underway. For the two former strategies to be of value, current inventory data must be used to identify commercial forest land which is vulnerable but not yet infested; and stands which will attain susceptible size and age within about 15 years.

Many uneven-aged lodgepole pine stands occur as mixed species stands. They contain a mature-to-overmature lodgepole pine overstory and an understory of a mixture of shade-tolerant species and younger lodgepole pine. Another common situation is one or more other species occurring in the overstory with lodgepole pine and climax species in the understory. Mature stands which are uneven-aged or mixed with large lodgepole pine in the overstory can be clearcut as a preventive; or if already infested, losses can be reduced by salvage cutting. Immature stands are candidates for stocking control with species discrimination possible in older mixed species stands. Discrimination against lodgepole pine is possible in older mixed stands by removing only susceptible lodgepole in a series of partial cuts.

Partial cutting of large diameter trees can reduce infestation potential of susceptible stands. However, partial cuts will be effective where only a small proportion of the trees are in diameter and phloem thickness categories conducive to beetle population buildup and where enough vigorous trees remain to maintain stand productivity (Amman 1976). Maintaining adequate growing stock in such a stand may require a subsidy of development costs.

Susceptible lodgepole pine stands will not maintain good productivity when either partially cut or attacked by mountain pine beetle unless the residual stand is less than 50 years old. Beyond that age, periodic annual increment steadily declines for most lodgepole pine. In such stands, overstory removal may be better than partial cutting for growth of the understory. Future productivity could be seriously reduced by logging damage, dwarf mistletoe infection, and windthrow--depending on which cutting practices are used. For these reasons, managers should be cautious in the use of partial cutting where maintaining a sustained timber productivity is desired.

Partial cutting can be applied as a last-resort salvage of beetle-killed trees. An increased utilization of sound material and a degree of direct control by removing beetle-preferred trees provide time to accomplish block cutting.

When implementing a partial cut to reduce stand susceptibility, two factors must be carefully considered to avoid doing more damage than the mountain pine beetle would:

1. Only those trees that are preferred by the beetle should be removed. Guidelines have been developed by Cole and Cahill (1976) and Amman et al. (1977).

2. Beetles apparently remove from the stand the faster growing genotypes because they have thicker phloem. Consequently, these trees will be removed during a partial cut. Despite the beetle's preference for these trees, they

should be regenerated in the stand because they put on volume faster and are the most vigorous. As these trees are removed from the stand, seed should be collected for onsite regeneration.

An additional management alternative for particularly susceptible stands is to favor nonhost trees such as Douglas-fir. Stocking will be reduced less in stands of mixed composition than that in stands of pure host type should an outbreak develop. The beetle infests lodgepole pine in a mixed species stand as readily as in a pure one, but proportion of total stocking affected will be reduced. Conversion to another species may, however, result in depredations by insect pests of that species when those stands mature (McGregor 1978).

A final management option, useful where esthetic values are primary, is preventive chemical treatment prior to beetle attack. Gibson (1978) has shown Sevimol® 4 to be effective in preventing beetle attacks in lodgepole pine. Data now show a single treatment will protect trees through a second beetle flight period.

SPRUCE BEETLE IN ENGELMANN SPRUCE

Generalized Site Characteristics and Damage

All known major outbreaks of the spruce beetle have originated from stand disturbances. Areas experiencing widely scattered blowdown have been especially conducive to increases in beetle populations. Logging operations resulting in slash accumulations, high stumps, or decked but unremoved logs have also been known to initiate population buildups. Where large stands of mature spruce are harvested in successive years, spruce beetle problems are more likely to occur. With proper management, serious outbreaks may not always develop.

The spruce beetle prefers downed material to standing trees. The size of a downed tree is less important than the exposure of its bark to sunlight or contact of the bark with the ground--both of which reduce susceptibility. If downed material is unavailable, standing trees may be attacked.

Large diameter standing trees (>16 inches d.b.h.) are preferred to small diameter trees (6-8 inches d.b.h.). The most preferred are those relatively free of live branches on the basal section. These are found growing in a competitive stand where natural pruning occurs. Open growing trees without competition and with live limbs in the basal portion are less susceptible to attack (Schmid and Beckwith 1975).

Hazard Rating Stands

Spruce susceptibility can be rated more easily and precisely on a stand basis than for individual trees. Knight et al. (1956) outlined the order of susceptibility (in order of decreasing hazard):

1. Stands in creek bottoms.
2. Better stands on benches and high ridges.
3. Poorer stands on benches and high ridges.
4. Mixtures with lodgepole.
5. Stands containing all immature spruce.

Unmanaged stands can be rated by using the average diameter of spruce, basal area, species composition, and physiographic location; three hazard levels are recognized: high, medium, and low (Schmid and Frye 1977). Table 1 illustrates how a stand is rated:

Table 1.--Hazard rating system for spruce beetle in Engelmann spruce

Hazard category	Physiographic location	Average d.b.h. of live spruce >10" (inches d.b.h.)	Basal area (ft)	Percent spruce in canopy
High	Well-drained sites in creek bottoms; site index > 120	≥ 16	≥ 150	≥ 65
Medium	Site index 80 to 120	12-16	100-150	50-65
Low	Site index 40 to 80	< 12	< 100	< 50

During infestations, large, old-growth trees containing most of the stand volume are killed. This results in reduced average age of surviving trees, average diameter and height of stand, and spruce component and density. Stand basal area is reduced by 25-40 percent before infestations subside.

Management Alternatives

The use of trap trees is recommended to reduce losses in managed stands. Trap trees are living merchantable-size spruce that are felled to attract beetles. Trap trees effectively attract beetles from up to one-fourth mile away. Shaded trap trees sustain more attacks than those exposed to the sun. Unbucked trees are more attractive since branches help shade the bole and hold it above the ground. When held off the ground, the undersides of logs attract more beetles than tops of logs do.

The number of trap trees needed depends on the beetle population and the size of trap trees. A trap tree may absorb 10 times the number of beetles a similar standing tree would, so the number of traps will be less than the number of standing infested trees. A ratio of 1:10 (trap trees to standing infested trees) should be used for static infestations, and a ratio of 1:2 for increasing infestations. Once infested they must be removed from the stand before new adult emergence, which occurs 2 years later. This program can be continued until the susceptible stand can be logged.

Precautions should be taken to reduce the possibility of a population buildup in logging residue. Some recommended practices are:

1. Cut trees as low to the ground as possible to reduce stump height, preferably less than 1½ feet.

2. Cull logs and tops should be limbed and branches removed from the surface. After limbing, cull logs and tops should be left exposed to full sunlight.

3. Logs and tops should be cut into short lengths--the shorter the better. Complete removal or destruction of all cull logs and tops would eliminate significant host material.

4. If trees are full-length logged, the diameter of the small end should be 3 to 4 inches.

5. Where a substantial spruce beetle population exists in the adjacent forest, it is better to leave logging residues than to remove or destroy them immediately after cutting. Suitable logging residue will attract emerging beetles and reduce mortality of standing trees. Infested residuals must be burned or removed.

Alexander (1973) suggests several modifications in silvicultural treatments to threatened stands. If spruce beetles are present in low numbers in the stand to be cut, or are present in adjacent stands in sufficient numbers to pose a threat any attacked and all susceptible trees should be removed in the first cut. This will remove most of the larger spruce and is, therefore, a calculated gamble in above average wind-risk situations. Subsequently attached trees should be salvaged.

If more than the recommended percentage of basal area to be removed is in susceptible trees, three options are available:

1. Remove all the susceptible trees.

2. Remove the recommended basal area in attacked and susceptible trees and accept the risk of future losses.

3. Leave the stand uncut.

If the stand is left uncut, probably less than half the residual basal area would be lost, but most of the surviving merchantable spruce would be of small diameter.

The guideline for windthrown trees is to salvage as soon as possible, or after they are infested, before hibernating adult beetles emerge. The exception is where removal encourages further uprooting at the edge of the stand. In some clearcut areas, trees have been windthrown along the edges. Within 1-2 years after having been removed because of the potential beetle threat, further windthrow occurred. Rapid removal prevented the edge trees from developing wind firmness. It might be better to leave windthrown trees, even at the risk of losing a few surrounding trees. An intensive evaluation of the adjacent stand and the beetle population, using the hazard rating system of Schmid and Frye (1977) and the blowdown prediction system of Schmid, 1/ would determine whether to salvage or leave windthrown trees.

Though spruce seedlings need only partial shade, full sunlight causes considerable mortality and logging infested trees may reduce the number of established seedlings below minimum stocking. The spruce component will increase in time because of two factors:

1. Even though true fir seedlings vastly outnumber spruce seedlings, the original removal of the canopy by beetles favors the less shade-tolerant spruce more than it does the highly shade-tolerant fir.

2. Animals damage leaders of fir seedlings more readily than those of spruce; therefore, spruce gains valuable height dominance. In the absence of beetles, spruce lives longer, grows larger, and becomes dominant over fir.

DOUGLAS-FIR BEETLE IN DOUGLAS-FIR

Generalized Site Characteristics and Damage

Like the spruce beetle, the Douglas-fir beetle prefers blowdown, logging slash, fire-scorched trees, or trees damaged by ice or snow. When this material is not available following a population buildup, beetles will attack vigorous green trees. Usually, an infestation in healthy trees lasts only a few years (Bedard 1950).

In drier portions of the Rocky Mountains, beetles attacking standing trees prefer those weakened by drought or defoliation over fully vigorous trees. Western spruce budworm or Douglas-fir tussock moth often predispose Douglas-fir to attacks by beetles. There is also an apparent correlation between root diseases and beetle-caused mortality in old-growth Douglas-fir. The beetle's success in killing trees is greatest during warm, dry summers. At such times, low-vigor, moisture-stressed trees are more likely to succumb than vigorous trees on better sites.

The beetle will produce about three times as much brood in blowdown or logs as in standing trees, particularly if the windthrow is shaded. In some timber sales in British Columbia, sufficient debris, stumps, cuttings, and log butts have been left on the ground to produce enough beetles to kill eight large trees per acre. In another area, sufficient slash was left to produce enough beetles to kill 31 trees per acre.

As populations increase in logging debris or blowdown, a few beetles attack susceptible living host trees, setting up a strong secondary attraction which, in time, attracts more beetles to the area. If weather conditions are favorable, mass attack of initially infested logs or trees occurs. Though attack density is usually higher in living trees, more brood is produced in slash. When the host material becomes saturated with beetles, the population spills into nearby green trees, and an outbreak develops. That behavorial mechanism which induces mass attacks is responsible for the beetles' ability to attack and kill living trees. Sparse beetle population can be maintained in dead or dying host material. Small numbers of beetles attacking a green tree, however, are usually pitched out.

Hazard Rating Stands

A comprehensive hazard-rating system is currently being developed for Douglas-fir stands. Presently, stand susceptibility classifications are based on characteristics associated with past infestations. According to Furniss et al. (1979) stand susceptibility to Douglas-fir beetle is positively correlated with proportion of Douglas-fir in the stand, its density, and its age. While any of these factors can limit damage, high density may result in younger trees being attacked. Stand resistance to population expansion increases as (1) susceptible trees are killed or logged, or (2) environmental conditions improve, promoting growth and relaxing water stress. As the beetle population declines, the influence of natural enemies is more apparent.

1/ Schmid, J. M. 1978. Personal communication. Report in preparation.

Beetle populations are maintained at endemic levels by natural enemies and resistance of vigorous trees.

Management Alternatives

Preventive management is the most effective and economical method of reducing damage. Most outbreaks can be prevented by (1) thinning young stands and maintaining desirable spacing until harvest, and (2) removing susceptible trees such as those that are windthrown, snow broken, or infected with root disease.

A more comprehensive management system has been developed in British Columbia (LeJune and McMullen 1961). There beetle management has been delineated into three broad categories: prevention, remedial, and brood destruction. Some of their techniques may be applicable on the Forest:

1. Preventive measures:

   a. Stands should be hazard rated, with logging priority given to overmature or decadent stands--especially those where Douglas-fir beetle is active.

   b. Prompt removal of infested trees resulting from blowdown, wind breakage, top-killing by defoliators, or fire damage.

   c. Removal of infested logs prior to beetle emergence, i.e., the spring following attack.

   d. Minimize slash and cull buildup more than 8 inches diameter. Chemically treat or burn infested slash.

   e. Tree-length logging desirable where practical.

   f. Trees with root damage should be inspected for beetle attack. If infested, remove before beetle emergence.

   g. Take care to avoid mechanical damage to residual trees.

2. Remedial measures: Occasionally infestations develop in standing trees despite precautions. Recommendations listed under "Preventive measures" should be continued or intensified. Maintain emphasis on high-hazard Douglas-fir stands where mortality may be highest, i.e., oldest and largest trees.

3. Methods of brood destruction: Treatment of infested material by piling and burning, by spraying with toxic chemicals, or tree-length logging should facilitate brood destruction.

ROOT DISEASE

Root disease losses on the Forest may be substantial, although no Forest-wide surveys have been completed. The major effect of root disease is tree killing, either directly or by predisposing trees to windthrow or bark beetle attack. Mortality may occur as scattered individuals or as centers of dead and dying trees up to several acres. Timber productivity of areas occupied by large centers is reduced or lost entirely because regeneration typically dies before reaching merchantable size. Root diseases may be especially important in plantations where host susceptibility and inoculum levels are high; impact in such stands may be substantial because of large investments in regeneration.

The pathogen most commonly associated with root disease on the Flathead NF is *Armillaria mellea*, although other pathogens are known to be present. Some of these other fungi include *Ceratocystis* (*Verticicladiella*) *wageneri*, *Fomes annosus*, and *Polyporus schweinitzii*. Stand prescriptions should be based on an evaluation of the individual or complex of root pathogens present and tree species most affected.

Stand Susceptibility

Stands of all sizes and ages are affected. Most large centers are in Douglas-fir and subalpine fir habitat types. The North Fork of the Flathead and the Swan River drainages are known to have many root disease centers. Most large centers apparently occur on shallow or rocky soils, or other soils with poor moisture-holding capacity.

Management Implications

Economic loss is a function of land management objectives.

Timber management. Root diseases cause timber losses in several ways. They cause mortality of merchantable and unmerchantable trees and growth loss on trees that eventually reach merchantable size. They also take areas out of production as long as susceptible species are regenerated and killed within active centers.

Developed recreation sites. Most root pathogens decay root systems, making infected trees hazardous to people and property. Extensive tree mortality also makes recreation sites less desirable.

Wildlife habitat. Openings created by root pathogens are quickly occupied by tree regeneration and shrubs, some of which are desirable big game browse species. Expanding centers continue to add new area for browse production.

Management Strategies

Root pathogens may persist saprophytically in root systems of stumps and dead trees for several decades. Disease is carried over from one rotation to the next when roots of regeneration come in contact with the persistent inoculum. Stands with root disease should be documented in the stand history record so prescriptions can be modified accordingly.

Current management recommendations to reduce root disease losses include (1) salvaging dead and dying trees; (2) removal of susceptible trees within 1 to 2 chains of a center border; and (3) regenerating with site-suited, least affected species. Western larch is usually disease tolerant. Lodgepole pine and ponderosa pine are sometimes suitable alternatives to Douglas-fir and subalpine fir. Unfortunately, all commercial species are killed in some areas; perhaps such severely affected stands should be removed from the timber base, and allotted to nontimber use such as wildlife habitat. Effectiveness of removing infected stumps and root systems before regeneration has not been demonstrated in the Region.

Partial cutting is usually not desirable in heavily infested stands unless adequate numbers of tolerant species (like western larch) are available for leave trees. Partial cutting can lead to windthrow, decay behind logging injuries, and increased mortality of residual susceptible trees.

DWARF MISTLETOES

Three dwarf mistletoe species are present on the Forest: Arceuthobium americanum on lodgepole pine, A. douglasii on Douglas-fir, and A. laricis on western larch.

A Forest-wide survey made in 1980 showed that larch and pine dwarf mistletoes are widespread and cause considerable growth loss; 33.7 percent of the larch stands and 18.4 percent of the pine stands are infested. Douglas-fir dwarf mistletoe distribution is limited on the Flathead, causing losses in localized areas (0.7 percent of the Douglas-fir stands are infested). The main effect of dwarf mistletoes is growth loss, although severe infestations may result in premature tree death.

Stand Susceptibility

Hosts of all ages and sizes are susceptible. The risk of a stand becoming infested is directly related to fire and cutting history. If all infected trees in the previous stand were killed by fire or removed by cutting, and if reinvasion has not occurred from surrounding stands, dwarf mistletoe will be absent from the current stand. If any infected trees were left, the current stand will be infested.

Losses are greater on poor sites than on high productivity sites, and greater in dense, stagnated stands than in released stands. Losses are greatest in dense, old-growth stands on poor sites that were infested at an early age.

Management Implications

Dwarf mistletoes cause economic loss to stands managed for timber. Growth loss can occur each year from the time of infection until harvest; accumulated loss may be substantial. They also negatively impact recreation sites by hastening tree mortality. Some small beneficial effects may occur where stands are managed for big game browse, water production, or range where tree mortality results in stand openings.

Management Strategies

Dwarf mistletoe losses can be effectively reduced in managed stands through silvicultural treatments. Methods are well documented (Scharpf and Parmeter 1978). Major management options include (1) regenerating the infested stand using treatments which eliminate the pathogen, (2) removal of infected trees and improving tree growth by thinning, (3) changing stand composition to nonsusceptible hosts, and (4) removing infected residuals from logged or burned stands. Seed tree and shelterwood cuts are suitable regeneration methods, provided overstory removal promptly follows establishment of regeneration. When thinning, lightly infected trees may be suitable crop trees if they will otherwise release.

STEM DECAYS

Stem decays are responsible for much defect and cull, especially in old-growth stands. *Fomes pini*, the cause of white pocket rot, and *Echinodontium tinctorium*, the Indian paint fungus, are probably the most damaging of the many decay fungi. Root pathogens, especially *Polyporus schweinitzii*, also cause stem decay of old-growth trees.

Stand Susceptibility

F. pini is common on most conifer species, including Douglas-fir, western larch, Engelmann spruce, ponderosa and lodgepole pine. Site-related factors affecting disease are unknown.

E. tinctorium is especially important on true firs and western hemlock. Greatest losses are associated with wet, poorly drained sites at lower elevations such as flats or bottoms. Defect is estimated in old-growth stands by examining trees for external indicators such as conks, fire scars, logging wounds, and punk knots, and then applying appropriate cull factors (Forest Service Handbook 2409.24 R-1, November 1980).

Management Implications

The major effect of decay fungi in commercial stands is loss of wood volume. These fungi also cause hazards in developed recreation sites.

Management Strategies

Reducing losses from stem decays is accomplished in two ways: removal of defective trees, and prevention of damage to leave trees during stand entries. Wounds created by fire and logging result in decay. Large basal wounds are especially serious. Decay develops most rapidly in nonresinous species such as true firs. Guidelines for hazard tree management are available (Mills and Russell 1980, Johnson and James 1978).

WHITE PINE BLISTER RUST

White pine blister rust (*Cronartium ribicola*) is an introduced pathogen which causes considerable mortality to western white pine and whitebark pine, especially to seedlings and saplings.

Stand Susceptibility

Amount of infection and damage are dependent on stand and site conditions. Small trees are usually killed quickly, whereas larger trees with many infections may live for years. Greatest mortality occurs in stands with a large proportion of small white pines. Infection requires cool, moist conditions during late summer. Therefore, greatest losses occur on moist, shaded, poorly drained sites, narrow creek bottoms, north- and east-facing slopes, and flats along lakes and streams.

Management Implications

The disease causes major economic losses by killing white pines grown for timber. Effects on other forest management objectives are probably minimal.

Management Strategies

Use of genetically resistant stock is the primary management tool where rust hazard is high and western white pine a desired species. IPM techniques may also be used to reduce losses, especially on low hazard sites (McDonald 1979). Hoff and MacDonald (1977) outline guidelines for selecting leave trees during thinnings and regeneration cuts.

OTHER INSECT AND DISEASE PESTS

The addressing of these few major insect and disease organisms does not imply our belief that these are the only ones which will, from time to time, affect management decisions on the Flathead NF. Others will undoubtedly develop at future times and in parts of the Forest presently unseen. Those problems will have to be addressed in specific project designs written for that purpose.

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APPENDIX

PROCEDURES FOR INCORPORATING INSECT AND DISEASE CONSIDERATIONS INTO THE PLANNING PROCESS

Following is an overview of the planning process and an identification of the steps at which we believe the effects of insect and disease pests must be considered. This "checklist" could assist the planning team members as they progress from step to step in the development of the Forest Plan.

Identification of issues and concerns:

1. Are insects or diseases present which will so affect allocations and scheduling that they must be identified as management concerns?

2. Have insect or disease problems been identified as public issues?

The mountain pine beetle and its effect on lodgepole pine has been identified as a management concern on the Flathead NF.

Inventory data and information collection:

1. What data are needed concerning major insect and disease pests?

2. Where appropriate, have stands been hazard-rated to show potential insect and disease mortality?

3. Are mangement prescriptions available which can lessen the effects of major pests?

Most lodgepole pine stands have been hazard-rated for mountain pine beetle susceptibility according to the system described by Amman, et al. (1977). Acreages by hazard class and/or maps are available from FPM as needed. Appropriate management strategies for lodgepole pine have been described.

Analysis of the management situation:

1. Are models available which illustrate the effects of insects and diseases over time?

2. Can they be used, and are they compatible with FORPLAN?

A "loss" prediction model has been developed as a subroutine for the Lodgepole Pine Prognosis Model now being used by TM. It is currently being evaluated. Other outbreak prediction and mortality prediction models are available but are not presently compatible with the Lodgepole Pine Prognosis Model or FORPLAN.

Formulation of alternatives. Insect and disease management concerns previously described will affect the formulation of alternative management plans.

Estimate of effects:

1. Which management prescriptions are best able to respond to adverse insect and disease conditions, and what are the effects on all resources of that management option?

2. Which management precriptions are least capable of responding to insect and disease outbreaks, and what are those effects?

Hodgeboom has described a method for providing evaluation criteria for a particular management prescription based on the ability of the land manager to respond to insect or disease problems while implementing that prescription. Using that method, each goal or objective provided for in a management prescription is assigned a weighted coefficient (a number between 0 and 1) which represents the relative importance of that management objective in responding to actual or potential pest problems. These coefficients are then summed for each prescription. Finally, the summed coefficient, whose value is a maximum of 1 and a minimum of 0, is multiplied by the number of acres allotted to that prescription for each management area. These figures are totalled for each alternative as an evaluative criterion for that alternative. This criterion, or index, provides a scale of the relative difference between alternatives regarding insect and disease management opportunities and costs. 2/

2/ Hodgeboom, F. Personal communication.

Evaluation of alternatives. Using the above information, show how insect and disease considerations and their effects on outputs influence alternative evaluations.

Alternative selection. Insect and disease impacts and their management must be considered in the process of selecting the preferred alternative.

Documentation

Draft Environmental Impact Statement:

1. Where applicable, have pertinent insect and disease data influencing each alternative been included?

2. Have insect and disease effects on outputs for each alternative been identified?

Proposed Forest Plan--Management direction:

1. Do insect and disease considerations influence long-range Forest goals?

2. Do insects and diseases affect long-range Forest objectives in terms of measurable outputs?

3. What is established Forest policy concerning Integrated Pest Management (including pesticide use policy)?

4. What management standards and guidelines specifically address insect and disease management? Are they sufficient to insure the prevention or minimization of unacceptable insect and disease mortality or growth loss?

5. Are monitoring and evaluation procedures sufficient to assure management response to insect and disease outbreaks in keeping with established Forest policy? Do these procedures recognize the need to evaluate insect and disease responses to prevention or suppression activities? Do they assure that insect and disease considerations have been incorporated into all management activities?

6. What would enable the land manager to better manage insect and disease outbreaks that could be provided by additional research? What research is needed to prevent or minimize unacceptable insect and disease mortality or growth loss in stands of various developmental stages?