FOREST HEALTH MANAGEMENT PLAN FOR TREE FARM LICENCE 49, MARCH 1999

Riverside Forest Products Ltd, Armstrong Division

Prepared by
JCH Forest Pest Management
Lumby, B.C.
Phone 250 547 6452 • Fax 250 547 6453

ACKNOWLEDGEMENTS

The author wishes to acknowledge and thank Lorraine Maclauchlan, Hadrian Merler and Julie Brooks for editorial review and comments, and Bob Johnson and Rick Specht for approving and supporting the project.

Background

This Forest Health Management Plan was initiated by Riverside Forest Products, Armstrong Division, in recognition of the significance of insects and diseases in TFL 49. In addition the Operational Planning Regulation requires evaluation of forest health factors (OPR 13(1)(b)) and where significant risk occurs, identification of measures to reduce significant risk to forest resources, as directed by the District Manager (FDP-OPR 18(1)(t)).

Goals of the Forest Health Management Plan

The goals of this plan are to:

- identify the desired forest conditions for each biogeoclimatic zone within TFL 49 based on existing knowledge of ecosystem processes and capacity;
- identify forest health management strategies and tactics designed to reduce long-term hazards to forest insects and diseases and in doing so enhance forest productivity;
- identify short-term strategies aimed at managing pests as they arise;
- identify and understand factors responsible for present conditions;
- review and analyze historical pest incidence data;
- identify landscape level forest insect and disease hazard;
- conduct Surveys for Pest Incidence to determine distribution and risk.

It is important to note that this plan has been prepared in absence of higher level plans, more specifically the Local Resource Management Plan (LRMP). Upon completion of the LRMP, this document may have to be modified to reflect landscape level objectives, especially as it pertains to biodiversity.

Anticipated Benefits

Implementation of the management strategies and tactics outlined in this document will help ensure long-term economic stability by reducing losses to forest pests. An understanding of ecological processes, including disturbances, and management at a landscape level rather than stand or species level will help achieve this healthier forest state.

In the long-term the ability to reduce the forest insect and disease hazard and risk will rely upon implementation of:

- hazard reduction techniques;
- a forest health monitoring system;
- a training program for personnel developing prescriptions; and,
- adaptive management techniques to plan, monitor and evaluate management tactics.

Most important, the ability to create “forest conditions naturally resilient to damage” will be determined by eagerness of personnel to adopt the principles of forest health ecosystem management and applying this knowledge at a landscape level.

Links to Tree Farm Licence 49 Management Objectives

Goals outlined in the Forest Health Management plan compliment those of TFL 49. Some of the goals identified in the 1998-2003 Forest Development Plan and Forest Management Plan #3 (January 1, 1999 - December 31, 2003) are listed below. Adherence to the forest health concepts contained within this plan will help achieve the following goals while promoting a functioning ecosystem:

- prioritize harvesting towards infested, diseased or salvage stands or those which are susceptible to infestation;
- keep insect and disease losses to a minimum;
- maintain a long-term economically viable forest products operation while practicing sound integrated resource management;
- comply with the Forest Practices Code of British Columbia Act and Regulations and where appropriate, Okanagan Timber Supply Area Integrated Resource Guidelines for Timber Harvesting; and
- help fulfill land use and integrated resource management, timber management, silviculture, protections and biological diversity objectives.

Approach

Historically forest health referred to agents which affect tree health, generally insects, diseases and abiotic agents. Recently however, the term forest health implies the general well-being, or functioning, of all components of an ecosystem. The Ministry of Forests presently defines **forest health** as:

> *"A forest condition that is naturally resilient to damage; characterized by biodiversity, it contains sustained habitat for timber, fish, wildlife, and humans, and meets present and future resource management objectives."*

and **forest health agents** as:

> *"Biotic and abiotic influences on the forest that are usually a naturally occurring component of forest ecosystems. Biotic influences include fungi, insects, plants, animals, bacteria, and nematodes. Abiotic influences include frost, snow, fire, wind, sun, drought, nutrients, and human-caused injury."*

However, without an overriding goal or objective for a forest ecosystem, it is difficult to ascertain whether a forest ecosystem is functioning in a natural and healthy state. Therefor, the following objectives are defined for the various forest ecosystems occurring on TFL 49:

1) To maintain a standing inventory of mature, standing, live trees to satisfy the inventory needs of Riverside Forest Products Ltd, Armstrong Division, until second growth forests come on line;

2) To minimize unsalvaged losses by addressing forest health problems in an environmentally sound and timely fashion; and,

3) To regenerate and tend young stands so as to achieve optimum productivity and diversity goals while maintaining healthy and productive stands through to rotation.

The following document will focus primarily on forest health agents as they pertain to the timber resource found on TFL 49. Management tactics have been developed on an ecosystem/pest basis i.e. Interior Douglas Fir/western spruce budworm, but incorporate other resource concerns. This approach facilitates the development of a Forest Health Management Plan with emphasis on insects and diseases affecting tree health and ultimately ecosystem health.

The document is presented in a two-part format. The first examines the history and ecological characteristics, current situation, existing hazards and short-term implications for management, and future goals of each of the biogeoclimatic zones or landscape units. . A separate section has been allocated to pests of young stands. The second portion expands upon the historical significance of the major pests and outlines the biology, damage, population monitoring, sampling techniques and short-term management strategies. Portions of these sections are obtained from relevant FPC guidebooks.

Management tactics are directed at reducing short-term losses, whereas long-term strategies are directed at modifying high hazard ecosystems. These strategies and tactics are based upon the most recent scientific information and will not exceed the ecological capabilities of a site. In some instances they may actually reduce the ecological stress present in certain ecosystems.

Implementation of this Forest Health Plan involves identifying desired stand conditions and then deciding what actions can be taken to meet this goal. The role of previous natural and man-caused disturbances will be evaluated and new plans will be formulated to deal with future disturbance events in a pro-active rather than reactive manner. In the long-term, implementation of these strategies will ensure the flow of goods and services by creating a healthier forest ecosystem.

The intent of this plan is to provide managers of TFL 49 with options to maintain the desired level of forest health at both the stand and landscape level based on other resource issues, constraints, and landscape level hazards. Hazard can be determined based on information contained within this document and accompanying support material. The risk should be updated annually for most bark beetles. Interpretation of hazard and risk should be done when preparing the forest development plan and preparing silviculture and stand management prescriptions.

Management strategies and tactics presented are consistent with those provided in the Forest Practices Code guidebooks. In addition, every effort has been made to ensure that new technologies or ideas were identified and incorporated in this document.

GENERAL DESCRIPTION and FOREST HEALTH HISTORY

GEOGRAPHIC LOCATION and SIZE

The portion of Tree Farm Licence No. 49 administered by the Armstrong Division, covers an area approximately 99 000 ha, comprised of 3 different block allocations. Block A and B lie to the west of Okanagan Lake; while Block C is separated from the west of the TFL and is located northeast of Falkland. Seventy-five percent of the forested area is composed of mature stands (>=80 years old). The TFL covers 5 biogeoclimatic zones: Interior Douglas Fir zone (43%), Montane Spruce (29%), Engelmann Spruce Sub- Alpine Fir (22%), and the remainder in Interior Cedar Hemlock zone (6%). Fire history, selective logging and bark beetle infestations have played a role in shaping the landscape.

FOREST HEALTH HISTORY

The historical information is based on Forest Insect and Disease Survey records of the Canadian Forest Service of Natural Resources Canada. Other pests have also played, and continue to play, important roles in the TFL but no historical records exist. These include root diseases, dwarf mistletoes, pests of young stands, foliar diseases and stem decays.

Mountain Pine Beetle, *Dendroctonus ponderosae*

Mountain pine beetle infestations have been recorded as far back as the 1920's and is currently the primary pest of TFL 49. Periods of activity include 1925-26, 1928, 1964-1966, 1972-76, 1979-1980, 1981, 1983 and 1985 to the present. The majority of these were found on the west side of Okanagan Lake, in the vicinity of Shorts, Whiteman, Bouleau and Naswhito creeks. Aggressive harvesting of infested trees, in combination with several cool wet summers, in the early nineties helped to remove much of the beetle risk in Block A. Infestations were first recorded in Block B in 1992 along Private Main and have expanded to 770 ha. This infestation is the largest recorded in this section of

TFL 49. The hot dry summer of 1998 led to 2 distinct adult flights, thereby increasing the number of currently attacked trees. Ground surveys conducted in late 1998 and early 1999 indicate a 10:1 current to red ratio. Harvesting of infested stands in the winter of 1998/1999 will help to reduce the risk in the summer of 1999.

Western Spruce Budworm, *Choristoneura occidentalis*

Western spruce budworm, a defoliator of Douglas fir and sometimes western larch, has also caused significant volume losses in Douglas-fir stands. High hazard Douglas fir stands, a result of selective logging and fire exclusion, are common at lower elevations. These stands are characterized by multiple layers with a high proponent of Douglas-fir.

Defoliation by western spruce budworm in TFL 49 was first noted in 1986 near Falkland and on the west side of Okanagan Lake near Naswhito Creek. Populations increased in 1987 and extended over much of Interior Douglas-fir zone; Monte Lake area, southwest face of Block C, including Mt. Connaught and along Whiteman, Nashwito and MacGregor creeks. While populations decreased elsewhere in the Kamloops Region, the area defoliated increased near Falkland and Shorts Creek in 1988. Populations decreased from 1989 to 1990 for a total of 11, 500 ha defoliated in 1990. Area of infestation increased slightly to 15, 693 ha in 1991, severe defoliation noted along the west side of Monte Lake, Mt. Connaught, the south side of Whiteman's Creek and north of Shorts creek. While the area infested remained static in 1992 the severity decreased, with light defoliation accounting for 94% of the infestation. Populations continued to decrease and essentially collapsed by 1994. (Table 1). Following a three-year absence populations are once again on the rise, with significant defoliation noted near Whiteman Creek, and forecasts for continued defoliation in 1999.

In the past, both industry and the provincial government have undertaken operational spray programs using biological insecticides to reduce the impact of western spruce budworm. Losses to western spruce budworm are expected to continue, as multi-layered stands resulting from selective harvesting and fire suppression, have increased the hazard across TFL 49.

Table 1. Area of defoliation by western spruce budworm from 1986-1998.
(Source: Canadian Forest Service, Forest Health Network, Victoria, BC and MOF)

Year	Area (ha)	Year	Area (ha)
1986	1390	**1991**	15693
1987	8472	**1992**	15098
1988	9273	**1993**	4045
1989	9217	**1994**	31
1990	11500	**1998**	300

Calculating volume losses for defoliators is more complex than that of bark beetles. Determining incremental losses requires information on stand volumes. Research in uneven-aged stands indicates that an average 5.9% reduction in total volume and 8.3% harvest volume can be expected in a 10 year period of which 7 years have experienced light defoliation.

Douglas-Fir Beetle, Dendr*octonus pseudotsugae*

Scattered pockets of Douglas-fir beetle have been recorded since 1962 in the Falkland-Monte Lake corridor and along the drainages on the west side of Okanagan. Douglas-fir beetle populations are currently being addressed in the Monte Lake and SugarLoaf Mountain areas. Tree susceptibility may have increased following the drought of 1998, therefore diligent monitoring via, aerial surveys will be required in 1999. Douglas-fir beetle prefers windthrow or predisposed trees. In the absence of windthrow, beetle activity usually coincides with defoliation by western spruce budworm or Douglas-fir tussock and/or drought.

.

Spruce Beetle, *Dendroctonus rufipennis*

Spruce beetle infestations are currently being addressed in the Bouleau Lake /Young's Creek area of Block A. In the past infestations have been recorded just north of TFL 49, in the Kernaghan Lake area and near Lambly and Shorts creek in the most southern section.

Western Balsam Bark Beetle, *Dryocoetes confusus*

Western balsam bark beetle is found in higher elevation spruce/balsam stands or mid-elevation mixed stands, and has been recorded since 1964 in TFL 49. Infestations have been noted in the upper drainages of Short and Whiteman creeks, Bouleau Lake and the Arthur Lake plateau.

Douglas-Fir Tussock Moth, *Orgyia pseudotsugata*

Three infestations have occurred since 1931 in the vicinity of TFL 49. In the most recent infestation (1982) approximately 55 ha., were defoliated along the southern portion of Mt. Connaught.

Two-year Cycle Spruce Budworm, *Choristoneura biennis*

Light defoliation of sub-alpine fir was noted in 1950 and 1956 in the Arthur Lake area and in 1959 near Whiteman creek.

Pine Needle Sheathminer, *Zellaria haimbachi*

Mature lodgpepole pine stands near Equesis creek and Bolean Lake were defoliated by pine needle sheathminer in 1962.

Interior Douglas Fir and Interior Cedar Hemlock

Note: The Interior Cedar Hemlock biogeoclimatic zone comprises only 6% of TFL 49. Although the ICH shares fire regimes similar to the Montane Spruce zone (NTD3), a large portion of the zone is composed of Fir-leading sites. Therefore the ICH has been considered within this section.

HISTORY and Ecological Characteristics

A history of selective logging combined with fire exclusion have played major roles in forming the species composition and stand structures in the Interior Douglas-fir and Interior Cedar Hemlock zones. Prior to fire suppression, these characteristics were directly related to periodic low-intensity ground fires and occasionally stand replacement fires. Species such as Douglas fir, ponderosa pine and western larch are all well adapted to the fire ecosystem by having thick bark. Douglas fir's low-growing branches and flammable foliage however, made this species more susceptible to crowning in both low intensity or stand replacing fires. Ponderosa pine's good self-pruning capabilities and larch's high open branching habits made them more resilient to fires. As a result the landscape was characterized by uneven-aged stands of mature Douglas fir, ponderosa pine, lodgepole pine, and in some cases western larch. The more shade tolerant Douglas-fir were likely found on cooler wetter sites, such as the IDFmw and ICHmk, which escaped frequent fires, and became better established elsewhere as the frequency between low-intensity fires increased. Low-intensity fire intervals varied depending on site conditions but were generally thought to occur every 5-40 years. The longer the interval between low intensity fires the greater the likelihood of Douglas-fir sapling survival. Occasionally stand replacement fires occurred that created conditions favorable to the establishment of seral species such as, ponderosa pine, and lodgepole pine at higher elevations. Stand-replacing fires were less frequent occurring every 150-250 years.

The occurrence of non-fire disturbance agents was likely restricted to pathogens such as stem decay and root disease and the occasional beetle populations attacking older suppressed trees. Their role in the ecosystem was integral by providing biomass and nutrient recycling, patch and landscape level diversity, and contribution to animal and plant habitat development (Hessburg 1994). In the IDFdk subzone, however, the role of mountain pine beetle, lodgepole pine dwarf mistletoe and fire were more significant (see Montane Spruce).

CURRENT SITUATION

As a result of fire exclusion succession to the more climax condition of multi-layered stands of Douglas fir and maintenance of even-aged seral stands of lodgepole pine, has occurred. These *replacement stands* are more vulnerable to insects and diseases due to one or more of the following factors:

- uneven-age stand structure composed of mostly Douglas-fir;
- low elevation lodgepole pine stands which are highly susceptible to mountain pine beetle;
- nutrient and moisture demands in some high density stands;
- selective logging; and
- relative susceptibility of Douglas-fir.

Based upon the existing age class structure, it appears that an extensive stand-replacing fire occurred in the MS and extended into portions of the IDF, approximately 110 years ago. This resulted in a landscape dominated by lodgepole pine in portions of Block B in the IDFdk1. Prior to fire suppression, frequent non-lethal fires helped reduce this homogeneity by promoting age class and species mosaics. As a result of fire exclusion, the lodgepole pine component of lodgepole pine/Douglas-fir stands or single species stands are relatively even-aged. Although the Douglas-fir component will decrease stand susceptibly, climatic conditions and larger diameter lodgepole pine in these stands favors growth of beetle populations.

While Douglas-fir may exhibit some fire resistant and shade tolerant characteristics it's susceptibility to insects and diseases is high. For instance western spruce budworm, *Choristoneura occidentalis*, Douglas-fir dwarf mistletoe, *Arceuthobium douglassii*, and root diseases, particularly laminated root rot, *Phellinus weirii,* are pests of Douglas-fir which have flourished as a result of selective logging practices and fire exclusion.

Research has indicated that defoliation intensities and duration of infestations of western spruce budworm, *Choristonuera occidentalis*, have increased as a result of uneven aged stands of predominantly Douglas fir (Swetnam et al 1995). Larval survival rates are higher due to the multi-storied stands which provide additional resting and feeding sites for budworm which may have otherwise fallen prey to predators when dispersing. In addition, the moisture and nutrient stress experienced in some of the higher density stands makes trees more susceptible to insects and diseases. Previous selective management practices gave little regard to root disease management and consequently stands with epicenters of root disease currently exist. Stem decay from *Phaeolus schewntizii, Phellinus pini,* and *Fomitopsis pinicola* are also common in these stands as a result of past logging injuries, stand decadence, and in some cases fire scars.

EXISTING HAZARDS and SHORT-TERM IMPLICATIONS for MANAGEMENT

Western Spruce Budworm

Defoliation by western spruce budworm occurred in 1998, on the southeastern portion of Block A, near Shorts Creek and Sugarloaf Mountain. Egg mass sampling conducted last fall, forecasts continued defoliation, with highest severities expected near Sugarloaf Mountain, Killney, Morden and Shorts creeks. A combination of high overwintering survival rates and egg mass sampling resutls, indicate an increase in both area and severity of defoliation. In addition aerial overview surveys and egg mass sampling, conducted in 1998 by the Ministry of Forests, in adjacent crown lands indicates increasing populations.

Current mulli-layered Douglas fir stands posses qualities capable of sustaining prolonged and severe infestations of western spruce budworm. Geographic Information Systems overlay analysis of consecutive years of western spruce budworm defoliation indicates that approximately 46% of the IDF is at risk to defoliation (Figure 1-3, Table 2). The areas, which have experienced the most prolonged infestations, are on the west side of Okanagan Lake in the IDFmw and the west side of Monte Lake in the IDFxh. The Forest Practices Code (FPC) Defoliator Management Guidebook indicates that the IDFxh and IDFdk are high hazard to spruce budworm while the IDFmw is considered moderate hazard.

Figure 1. Western spruce budworm risk for Block A. Based on number of consecutive years of defoliation. (Source: Canadian Forest Service, Forest Health Network).

Figure 2. Western spruce budworm risk for Block B. Based on number of consecutive years of defoliation. (Source: Canadian Forest Service, Forest Health Network).

Figure 3. Western spruce budworm risk for Block C. Based on number of consecutive years of defoliation. (Source: Canadian Forest Service, Forest Health Network).

Table 2. Area (ha) at risk to spruce budworm defoliation. Based on Canadian Forest Service, Forest Health Network, digital information and overlay analysis.

	Block		
Maximum # of Consecutive Years	A	B	C
1 - 3	9029	5123	2753
4 - 6	3574	412	2357
7 - 8	133	34	236
Total	**12 736**	**5569**	**5346**

Regeneration of a species mix

Scheduled harvesting activities in the Interior Douglas-fir zone are limited in terms of silvicultural systems options due to the other resource issues and constraints. Mule deer winter ranger concerns may result in patch clearcuts of blocks 1-5 ha in size. This block dimension will reduce both the budworm and root disease hazard, within the block, provided a species mix which is ecologically suited to the site, is regenerated. Elsewhere, a species mix and/or promotion of even-aged stands, where appropriate, should be prescribed. Where lodgepole pine dwarf mistletoe is present, the proportion of each species should consider the adjacent mistletoe hazard.

Thinning and Underburning

While the above strategy reduces the budworm hazard within the block it does not eliminate the risk or hazard from the adjacent stand. To reduce the risk to the regenerating Douglas-fir and possibly larch, the hazard of adjacent stands should also be addressed. This can be achieved by using thinning or underburning to reduce stand densities.

Priority for density reduction treatment should be given to areas meeting the following criteria:

1) highest risk (see figure 1-3 and support material);
2) adjacent to proposed cutblocks;
3) multi-layered Douglas-fir stands with high densities; and
4) selective logging history.

Underburning priorities should be given to areas where mule deer habitat has been identified in order to promote forage species. Thinning activities should favor the retention of non-mistletoe infected trees and seral species where possible. In areas where the fuel load is high, a combination of thinning and underburning will be necessary. Alternatively, a chipper may be used on the slash in areas where smoke or fire management concerns exist, and underburning is not feasible.

Pre-Commercial Thinning

Some multi-layered stands may provide the opportunity to undertake pre-commercial thinning as a means of density reduction This strategy should only be undertaken in areas where root disease is not present and Dwarf Mistletoe Ratings (DMR) are not greater than 4.

Aerial Surveys

Annual aerial surveys should be conducted to identify any visible defoliation. Subsequent egg mass sampling may be necessary to forecast defoliation for the following year. Based upon these results thinning or underburning prescriptions may have to be modified.

Douglas-Fir Tussock Moth

On a biogeoclimatic basis, only 5% of TFL 49 is considered high hazard (IDFxh) and 25% low hazard (IDFdk). Other parameters, such as site, species mix, stand density, stand structure, maturity and past harvest regimes influence the level of severity. Populations elsewhere should be carefully monitored through correspondence with the Regional Entomologist. Management strategies to reduce the risk are similar to that of western spruce budworm i.e. promoting even-aged classes and/or species mix.

Phellinus and Armillaria root diseases

Landscape level hazard and risk are presented in the root disease section of Part II. The majority of stands within the IDF are considered high hazard. Management strategies and tactics, which have been recently defined by the MOF Vernon District Office, require stratification of root disease strata for all high hazard ecosystems (see Part II). Sketchmapping results will help formulate the best strategy for the site. Promotion of a species mix, with a higher proportion of larch and ponderosa pine on suitable sites, will also serve to reduce the western spruce budworm hazard.

Douglas-fir Beetle

Computer based hazard rating indicates that 22% of the IDF contains susceptible stands, of which 70% are considered low hazard (Figure 4-6, Table 3). Relying solely upon computer generated hazard ratings is not recommended for any bark beetle, but specifically for Douglas-fir beetle and spruce beetle. Windthrow plays a large role in Douglas-fir beetle population dynamics and is not a component of the hazard rating system. The hazard ratings should be used in conjunction with known areas of windthrow, in order to effectively mitigate the risk. Douglas-fir beetle can be kept to low levels through detection, clean harvesting practices and minimizing injury.

Table 3. Summary of Douglas-fir beetle hazard, TFL 49. Based on Forest Inventory Zone and stand attribute data.

Block	Area of Susceptible Douglas-fir (ha)*	% of stands Nil	% of stands Low	% of stands Moderate	% of stands High
A	1846	1	69	29	<1
B	1851	2	72	25	<1
C	488	2	71	26	<1
Total	**4185**	**1**	**70**	**28**	**<1**

* susceptible stands are those with a Douglas-fir component

Aerial surveys recorded 90 infestations, totaling 42 ha, near Salmon River, Monte and Drum lakes, Range Road, Pennies and Cain creeks, Stevens Meadow and Lucas Ranch. A combination of trap trees and harvesting has been scheduled for several of the sites.

Figure 4. Douglas-fir beetle hazard for Block A. Based on Forest Inventory Zone and stand attribute data.

Figure 5. Douglas-fir beetle hazard for Block B. Based on Forest Inventory Zone and stand attribute data.

Figure 6. Douglas-fir beetle hazard for Block C Based on Forest Inventory Zone and stand attribute data.

Aerial Surveys

Aerial surveys to detect new windthrow or current attacks should be conducted annually to identify areas where risk exists. Subsequent evaluation will determine the level of management required, if any, based upon the confirmed hazard and other management objectives.

Mountain pine beetle, lodgepole pine dwarf mistletoe, stem cankers and Blackstain root disease

A significant portion of the IDFdk1 is composed of mature lodgepole pine leading stands. These lower elevation stands are capable of supporting large mountain pine beetle populations due to the low overwinter mortality rates, resulting from thicker phloem and milder winters. The current mountain pine beetle infestation in Block B occurs solely in the IDFdk. However, to avoid duplication, further discussions on all of the aforementioned forest health concerns are presented in the Montane Spruce section.

FUTURE GOALS

An understanding of succession is vital to managing these forests on an ecological basis. The more climax condition of shade tolerant Douglas-fir and expanses of seral stands of lodgepole pine, are a result of fire exclusion and/or selective harvesting of large diameter ponderosa pine, western larch and Douglas-fir. The key to creating a healthier ecosystem is to return these stands to a “more natural state”, by identifying stand conditions prior to fire suppression activity and balancing this information with desired future conditions and ecosystem capacity. The underlying assumption is that forests were healthier as a result of frequent fires. This healthier state was due to lower stand densities and/or species diversity, which resulted in ecosystems more resistant to insects, diseases and catastrophic fires.

The most prominent feature of this ecosystem was it’s structural and vertical diversity created as a result of frequent fires. However, it is these very features which are also creating forest health hazards today. The factors responsible for creating the “less healthy” state of today’s forests are 1) the increased presence of more shade tolerant species 2) increased densities 3) selective logging and 4) mature expanses of lodgepole pine in the IDFdk. Recognizing the presence or absence of disturbance events which have led to this condition are integral to undertaking management processes. Developing strategies aimed at restoring or maintaining vertical and structural diversity, inherent to this ecosystem, while managing for forest tree health and wildlife concerns will be the goal and challenge of the Interior Douglas-fir zone.

LONG-TERM MANAGEMENT STRATEGIES

Strategies required to restore ecosystem health will involve alterations to the fir-dominated landscape through vegetation management and where possible, use of silviculture systems promoting even-aged patches. Stand modifications or removal of high hazard stands and regenerating to a species mix may be necessary in the IDFdk (these are discussed in the Montane Spruce section). The objective is to make forests less vulnerable to insects and diseases while maintaining or enhancing genetic, species and landscape diversity. This management strategy recognizes that insects and diseases are also integral ecosystem components and that by creating healthier ecosystems we are merely reducing the hazard and risk to these pests. The challenge is to implement these strategies in a manner which not only meet wildlife habitat criteria but also to ensure that the hazard from an adjacent protected stand does not pose a significant risk. Identification of wildlife corridors and habitat at the onset are therefore critical to achieving long-term goals. Management prescriptions to modify the Douglas fir component will vary based on site capabilities, existing vertical structure and density, past-logging history, present or past forest health agents, and other resource issues and concerns.

Thinning and Underburning

Underburning or mechanical thinning may be used to reduce or remove the Douglas-fir understorey. A combination may be necessary in areas where the fuel load and vertical structure have created conditions for intense fires. Subsequent planting and/or natural regeneration of seral species such as ponderosa pine, western larch and to a lesser extent lodgepole pine will create a species mosaic less vulnerable to disturbances.

Areas with the greatest densities which have been most altered as a result of fire suppression and past logging history, should be given the highest priority for thinning. By removing some of the smaller, shade-tolerant trees, thinning can increase resistance to fires insects and disease, facilitate the reintroduction of fires and reduce mortality of residual old-growth trees by reducing competition (Peters, Frost and Pace, 1997).

Forest ecosystem health would benefit with the re-introduction of fire by increasing biodiversity, promoting forage and shrub species required by ungulates and stimulating cone crops. In addition removing some of the ground and ladder fuels present in uneven-aged stands will reduce the likelihood of a high-intensity or catastrophic fire event, as experienced in the summer of 1998. However, sound fire management practices must be ensured in order to reduce the incidence of secondary insect outbreaks, such as bark beetles and woodborers, following prescribed fires. The long-term benefits of fire are the creation of more “natural”, healthier ecosystems which are less vulnerable to insects, diseases and catastrophic fires.

Thinning and Underburning as Adaptive Management Tools

The use of fire and thinning to restore the health of fire-dependent ecosystems is a relatively new tool, and some knowledge gaps still exist. For instance, the role of fire in nutrient recycling is still not clearly understood. Given these knowledge gaps, it is crucial that implementation of fire and thinning should be regarded as an adaptive management process.

Adaptive management is viewed as a continuous learning cycle allowing managers to modify and implement operational programs based on previous experience. Careful planning coupled with diligent monitoring is critical to the successful implementation of the adaptive management process.

Silviculture Prescriptions

Developing a landscape level approach to harvesting while improving forest health conditions will require use of a modified even-aged management system. Other resource issues or higher level plans will influence the ability to practice even-aged management. Uneven-aged silviculture techniques favored for this ecosystem may only exacerbate forest health concerns, *unless a species mix is prescribed.* Existing, unhealthy conditions would be maintained by promoting conditions favorable to the regeneration of shade-tolerant species such as Douglas fir and maintaining or creating multi-layered stands across the landscape. Given the mule deer constraints, the desired landscape level condition, and, the flow of goods and services, the most applicable techniques are the use of patch clearcuts, shelterwood, seed tree or group selection with regeneration of a species mix. Clearcuts should be prescribed on suitable sites (IDFdk1 and ICHmk) with regeneration favoring lodgepole pine but including other species. Patches of non-diseased mature trees should also be incorporated into the prescription.

This system should create an age and species mosaic across the landscape. These may mimic natural canopy gaps provided that coarse woody debris is left on site. The hazard to western spruce budworm, and to a lesser extent dwarf mistletoe and root disease are not eliminated due to the potential risk from adjacent stands. Therefor, it is crucial that a species mix be regenerated in order to lessen the hazard or impact by these pests. Retention of mature ponderosa pine or western larch should be considered in order to maintain some vertical structure, provide an additional seed source of less susceptible species, and promote wildlife trees.

Montane Spruce

HISTORY and Ecological Characteristics

Much like today, vast tracts of even-aged lodgepole pine forests, with scattered islands of older trees, characterized historical Montane Spruce ecosystems. These ecosystems were regulated by wildfires and mountain pine beetle outbreaks. Fire frequency and intensity varied in the Montane Spruce, with authors quoting 25-50 years for low-intensity ground fires and an average of 150 years for stand replacing or high intensity fires (NTD3). Fire intensity was directly related to mountain pine beetle outbreaks. Mountain pine beetle outbreaks leave areas of dead trees and promote drier stand conditions created by openings. The longer the interval between fires the larger the lodgepole pine and the more intense the mountain pine beetle outbreaks.

Lodgepole pine dwarf mistletoe also proliferated when fire intervals were of longer duration. In absence of fire, openings created by mountain pine beetle encouraged release of residuals and development of uneven aged islands, which are highly susceptible to dwarf mistletoe. Dwarf mistletoe recovery and reinvasion rate following a fire is also directly related to fire intensity. The more intense fires, also known as "cleansing fires", reduced the dwarf mistletoe hazard. Lower intensity fires however increased the hazard by leaving islands of lodgepole pine, which may have been infected with dwarf mistletoe. Generally, the more intense the fire the denser the regenerating stand. The exception is avery intense fires which leads to crowning, thereby burning much of the seed source. Denser stands likely had higher incidences of Atropellis, other stem cankers and root disease due to the lower productivity and vigor of the site. All of these pathogens played roles as natural thinning agents under these conditions.

Unlike lower elevation fire origin species, which have adapted thick bark, lodgepole pine has thin bark with poor insulating qualities. Scarred trees resulting from lower intensity fires are more susceptible to insects such as the pine engraver beetle and stem decay fungi and root disease. Douglas-fir were much better adapted to these frequent fires and provided for structural diversity on appropriate sites; especially on the drier sites of the MSxk dry sites. Examples are the south facing slopes along the Salmon River.

Lodgepole pine is not a shade tolerant species and therefore cannot reproduce in the shade of its own canopy. Without fire, stands begin to break up between 100 and 200 years and are eventually replaced by shade tolerant species. Four distinct successional roles have been identified for lodgepole pine based upon the presence of shade tolerant species or their ability to become established; minor seral, dominant seral, persistent and climax. Succession to more shade tolerant species such as alpine fir and spruce is evident in Block C and southern portions of Block A, but not significant elsewhere. This is in part due to the frequent fires, which perpetuate lodgepole pine and stocking conditions in some stands which do to not permit establishment of shade tolerant tree species.

CURRENT SITUATION

The most recent high intensity fire in this ecosystem likely occurred in the early 1890's as evidenced by continuous tracts of Age Class 6 lodgepole pine in the northwestern section of Block B. These stands account for 26% of the Montane Spruce landscape. The current fragmented landscape reflects efforts to manage for mountain pine beetle by removing highly susceptible stands, and more recently to address infestations. Although these disturbance patterns may closely resemble that of fire, the structural diversity and plant communities normally associated with wildfires are absent.

The exclusion of fire may be partially responsible for the intensity and may prolong the duration of the most recent mountain pine beetle infestation. Currently the infestation is confined to the IDFdk, but will likely expand into the MS this year. Given the frequency of high intensity fires and the most recent fire event in this ecosystem, however, it is difficult to blame fire suppression exclusively. From an ecological perspective, mountain pine beetle is merely taking it's role in ecosystem processes. The stage is set to start the fire-beetle cycle. In the absence of harvesting and fire, the role of mountain pine beetle in seral lodgepole pine is to periodically remove the large dominant pines. This releases other species including lodgepole pine. The cycle may be repeated as the residual lodgepole pine become more susceptible.

Salvage activities have been, and are being undertaken in the TFL, thereby reducing the fire hazard, and effectively altering the fire-beetle cycle and decreasing the opportunity for a "cleansing fire". In essence, the removal of one hazard may have served to enhance another. Patch cutting for salvage purposes may result in islands of young pine within expanses of mature type, favoring spread and intensification of dwarf mistletoe and Atropellis stem canker (provided they are present in the adjacent stand). Dwarf-mistletoe infected boundary trees, produce large brooms in response to increased light thus increasing the infection potential. These brooms also act as fuel ladders.

Mountain pine beetle hazard reduction strategies combined with recent sanitation harvesting has created a patchwork of cutblocks. Fourteen of the landscape was harvested over the last 20 years. These young stands now account for 31% of the stands in the Montane Spruce ecosystem. Forest health agents, such as terminal weevil and stem rusts, are presently impacting these stands. The dynamics of these pests are not clearly understood but it is thought that the unnatural stocking regimes (low density) which exist may play a role in pest incidence. Hazard may also increase with other intensive silviculture practices such as pruning, spacing and fertilizing. Little is known of the pest population dynamics in these intensively managed stands.

Armillaria root disease is considered high hazard on fir-leading sites which accounts for approximately 8% of the stands within the Montane Spruce ecosystem. Armillaria may also be present in regenerating stands, which were fir-leading prior to harvesting. Therefor, management of root disease should not be restricted to silviculture prescriptions but also to stand management prescriptions.

EXISTING HAZARD and RISK and SHORT-TERM IMPLICATIONS for MANAGEMENT

Mountain pine beetle

Spot infestations were first recorded along Private Main in 1992. The area affected has increased to 770 ha; all within the IDFdk. Aggressive harvesting of infested stands, single tree treatments and use of semiochemical, are tactics being implemented to address the mountain pine beetle risk. However, a combination of a mild winter and two distinct adult flights in the summer of 1998 may help promote populations; especially in areas which were not addressed during the winter of 1988/99.

Based upon the current levels, a suppression strategy should be implemented in Block B and a prevention program elsewhere. The suppression strategy relies upon direct control actions and aims to reduce the beetle outbreak to a size and distribution that can be handled with normal resources. The prevention strategy aims at reducing stand susceptibility with a long-term management objective of creating an age and species mosaic (Macluauchlan and Brooks, 1998). The Kamloops Forest Region "Strategies and Tactics for Managing The Mountain Pine Beetle" by the aforementioned authors, should be referred to for a thorough description of strategy objectives and appropriate tactics.

Computer based hazard rating for mountain pine beetle indicates that out of 8021 susceptible stands, 53% were low, 34% moderate and 13% high (Figure 7-9). The majority

Figure 7. Mountain Pine Beetle hazard for Block A. Based on Forest Inventory Zone and Vegetation Inventory data.

were in the Interior Douglas Fir zone (42%), followed by the Montane Spruce (31%), Engelmann Spruce Sub-Alpine Fir (21%) and the remainder in the Interior Cedar Hemlock zone. Hazard refers to inherent stand qualities, which make a stand more susceptible to beetle i.e. basal area, age, density and elevation. Hazard rating results are meant to be used as a planning tool, and are appropriate for a prevention strategy i.e. in the absence of beetles, total chance planning should incorporate high hazard stands. In these situations the resources are available to direct harvesting activities or other silvicultural treatments, to stands with the highest hazard.

Table 5. Mountain pine beetle hazard for TFL 49. Based on Shore and Safranyik model.

Block	Area of Susceptible Pine (ha)*	% of stands Low	% of stands Moderate	% of stands High
A	19 352	72	26	2
B	32 403	41	40	9
C	4 785	69	26	5
Total	**56 540**	**53**	**34**	**13**

* susceptible stands refer to any stand with a lodgepole pine component

While a prevention strategy addresses both hazard and risk, a suppression strategy emphasizes removal of risk. Stand risk is a function of hazard and beetle pressure i.e. proximity to and size of the closest beetle infestation. Risk rating was completed for Block B to help prioritize infested stands. Beetle management activities should concentrate on the risk, and deal with the hazard only when beetle pressure has been eliminated or significantly reduced. This shift would also require a change in strategies.

Aerial Surveys

The key to early detection is diligent monitoring of mountain pine beetle. Aerial surveys should be conducted annually to identify new infestations. Procedures for determining risk using aerial survey results and stand hazard are outlined in the mountain pine beetle section in Part II. In addition, scheduling of other activities such as probing, baiting and overwinter mortality surveys should be determined once hazard has been confirmed and risk has been identified.

Hazard Reduction

Following ground confirmation of computer-based hazard results, stand manipulation techniques could be considered to reduce the hazard. Recent studies have indicated that stand conditions following thinning create conditions less desirable to the mountain pine beetle. This condition only exists until crown closure occurs. For this reason, pre-commercial thinning should be regarded as a temporary holding strategy and not a long-term management strategy. Stand thinnings should be approached from an adaptive management standpoint, requiring careful planning, evaluation and monitoring. Four-meter spacing is recommended and has been shown to reduce subsequent mortality caused by mountain pine beetle. Stands, which should be given the highest priority, are those with the highest hazard (Figure 7-9 and support material). If harvesting of these stands will be undertaken within a 10-year time frame, then the additional volume losses incurred as a result of dwarf mistletoe (where present) infections should be minimal. Mistletoe-infected stems however, should be removed during thinning operations while non-host trees with crop tree potential should be retained. This strategy should not be implemented in stands where root disease is present.

Harvesting and Subsequent Regeneration

Existing moderate-high hazard stands should be incorporated into development plans once desired volume levels are attained. Where ecologically appropriate, subsequent regeneration plans should emphasize a species mix to reduce the future hazard.

Lodgepole pine dwarf mistletoe

Proposed cutblocks in dwarf mistletoe-infected stands should be designed to minimize the spread of dwarf mistletoe into the young stand by leaving residual non-host species as border trees, minimizing the block to perimeter ratio, and incorporating natural barriers where possible. Shelterwood and selection systems are not recommended in stands where susceptible tree species comprise more than 50% of the total stems, and more than 20% of the susceptible overstorey trees are visible. Mistletoe-free trees should be used to fulfill wildlife patch obligations.

Atropellis stem canker

Recent surveys for pest incidence recorded Atropellis stem canker in 88% of all mature stands examined. Individual tree impact varies according to the number of cankers present, and the degree to which they are girdling the stem. Volume losses occur due to height growth reductions and wood degradation (due to staining). Severely infected stems can result in significant volume reductions and even stem mortality. Removal of all infected stems during harvest, favoring non-infected trees or other species for wildlife tree patches (where necessary) and planting a species mix (where adjacent infected stands exist) should help minimize the risk to the regenerating stand.

.

FUTURE GOALS

Maintaining ecosystem integrity and diversity in the Montane Spruce is challenging since it has historically been regulated by fire and beetles. Present fire abatement policies and beetle management could significantly alter the ecosystem. Distinctive features are the extensive even-aged stands of young and maturing seral stands of lodgepole pine intermixed with patches of older trees. The presence of Douglas fir at lower elevations or on south facing slopes is also unique. Therefor, an approach which recognizes the role of mountain pine beetle and fire in ecosystem processes is necessary in order to maintain or enhance ecological diversity in the Montane Spruce ecosystem. A more thorough discussion of long-term strategies is presented in the mountain pine beetle section.

Present fragmentation of some portions of the landscape resulting from harvesting or salvage activities is not typical of this ecosystem. Rather large continuous tracts of even-aged stands, intermixed with older patches are more characteristic. Unfortunately, creation of a single age class landscape also increases the opportunity for an extensive outbreak of mountain pine beetle. Stand or species manipulation will be necessary in order to reduce the long-term hazard. Alternatively even-aged management of lodgepole could be considered if the stands are removed before becoming highly susceptible. Where conditions permit, prescribed fire may be an option on low productivity sites. Fire will promote characteristics more typical of this ecosystem, such as development of fire-origin plant communities and structural diversity. In addition, it may help lower the incidence of dwarf mistletoe and Atropellis stem canker.

Mature Douglas fir can be found scattered throughout the Montane Spruce. Partial cutting regimes, in absence of root disease or high mistletoe levels, or retention of these trees as wildlife patches, should be considered in order to ensure their presence in this ecosystem. Regeneration of these species should also be encouraged on appropriate sites, or where they presently exist.

Forest health concerns in young stands must be addressed at the both the regeneration and stand management prescription phase in order to reduce future losses. Pest-related losses following spacing and pruning need to be identified and strategies defined to reduce losses. This will involve implementation of a monitoring system to identify pest incidence and impact, stand characteristics and treatment regime and overall stand response to treatment over time.

Ecological Implications of Mountain Pine Beetle Management and Suggested Options

The landscape ecology of the TFL is currently being modified through sanitation harvesting and salvage activities. Plant communities and stand densities associated with fire differ from those resulting from harvesting. Furthermore, while harvesting may resemble wildfires in terms of size the lack of groups of escaped trees on the landscape marks their difference. The following options have been developed to address these concerns. These options may be refined once biodiversity objectives for the TFL are identified and seral stage distribution determined.

Retention of Canopy Gaps

Where relatively small pockets of mountain pine beetle are present and hazard and risk are low (including adjacent hazard) the beetle should be left. Alternatively, MSMA or debarking treatments could be conducted. This tactic will provide pockets of wildlife trees, subsequent coarse woody debris and promote an age class mosaic typical of this disturbance regime. Suitability of MSMA-treated trees as wildlife trees is presently unknown, but these stems will provide for coarse woody debris.

Small patch harvesting of discrete pockets rather than harvesting entire stands should be considered when populations are low. This process should consider Section 1 of the Forest Practices Code Operational Planning Regulations which limits the content requirements for minor salvage operations and ensures that the beetle is removed in a timely manner. This will avoid major disruptions to planned harvesting activities and provide for age class diversity at a landscape level. This treatment should only be considered in absence of root disease and high levels of dwarf mistletoe.

Retention of Old Seral Stands

To maintain the integrity of old age class seral stage distribution, small localized pockets of beetle within infested stands could consider MSMA treatments or debarking. Alternatively existing mature moderate-high hazard stands could be thinned at approximately age 80 and once again when crown closure occurs. Characteristics of mature stands which have experienced a low intensity understory fire may be achieved through this thinning regime.

Re-introduction of Fire

Prescribed burning, or restriction of fire abatement, should be considered in dense stagnant stands where productivity is low and the cost of stand treatments would not exceed the gain in volume. By reintroducing fire into the ecosystem plant communities associated with fire will become established and dwarf mistletoe and Atropellis levels may be reduced. Where possible islands of older trees should be maintained. Although fuel loads in some of these stands may seem high the opportunity for crowning is low since very little crown exists. This option is particularly suitable to stands with poor site quality, which may not meet fibre production needs.

All of these tactics should be implemented while considering a balance of disturbance events and their relationship to biodiversity objectives.

Engelmann Spruce Sub-Alpine Fir Zone

HISTORY and Ecological Characteristics

Similar to the other biogeoclimatic zones in TFL 49, fire played a dominant role in regulating the landscape of the Engelmann Spruce Sub-Alpine Fir (ESSF) ecosystem. Low-intensity fires were less frequent than in other zones, while high intensity fires varied from 150-300 years. At higher elevations, the interval between fires was probably greater than in other ecosystems.

Sub-alpine fir and Engelmann spruce possess characteristics which make them extremely vulnerable to fire, including thin bark, shallow roots, low-growing branches, and moderate to heavy lichen growth. In addition, sub-alpine fir has highly resinous bark which readily ignites. These characteristics make them susceptible to crowning in high intensity fires, and bole girdling in lower intensity fires. Brooms associated with lodgepole pine dwarf mistletoe, fir broom rust and spruce broom rust may have increased crowning incidence. Both species do not regenerate well following a fire, unless surviving patches of cone-bearing trees remain. When mature trees do survive, both species will become established, providing seral species such as lodgepole pine are scarce; otherwise, lodgepole will dominate the site. If this is the case, spruce and fir will establish themselves as the understorey species and will eventually succeed the lodgepole pine component once it begins to deteriorate. In spruce/sub-alpine fir forests, regeneration of fir is more prolific, since it is able to establish in the duff, whereas spruce requires a mineral soil seedbed. As a result of fire and these silvical characteristics, a mosaic of different successional stages was common to this ecosystem.

Fuels accumulate quickly in this ecosystem which promotes highly destructive, stand-destroying fires. In stands where lodgepole pine was present, large areas of even-aged lodgepole pine stands may dominate. These are more susceptible to attack by mountain pine beetle. The fire-beetle history common to the Montane Spruce ecosystem has also played a role in this biogeoclimatic zone (although less significantly), and stands which were affected by mountain pine beetle, eventually were subjected to fire. Spruce beetle and western balsam bark beetle activity also increased fuel loads. The incidence of lodgepole pine dwarf mistletoe was likely lower due to high-intensity or “cleansing fires”.

The role of bark beetles, root diseases and stem decays all provided for structural diversity and coarse woody debris required for fuel buildup and subsequent fires. In stands where lodgepole pine was attacked by mountain pine beetle, succession to the co-dominant climax forest of spruce/sub-alpine fir occurred. Spruce beetle colonized windthrown trees which may have been infected by Tomentosus root disease, stem decay or severely girdled by a low-intensity fire. Other pathogens such as Armillaria root disease and/or western balsam bark beetle also attacked fire-scarred alpine fir. Indian paint fungus (*Echinodontium tinctorium*) infections on sub-alpine fir occurred at a young age and expressed themselves as they were released from the understorey. Heartwood defect associated with this stem decay provided for snags and cavity nesting sites for excavating bird species.

CURRENT SITUATION

Presently, 43% of the mature landscape is composed of lodgepole pine-leading stands, and 54% shared equally by spruce and balsam types. Twenty-two percent of the lodgepole pine hazard for the TFL occurs in this ecosystem, with 47% rated as low and 39% as moderate (Figure 7-9).

The functioning of this ecosystem is regulated by fire, with fuel provided by bark beetle disturbances and mortality of sub-alpine fir, and to a lesser extent spruce, as the species reach over-maturity. In endemic situations, western balsam bark beetle and spruce beetle function as ecosystem regulators. Historical data for mountain pine beetle, in other portions of the Kamloops Region, indicates that as beetle populations decreased in the Montane Spruce and Interior Douglas-fir, they increased in the ESSF. This suggests that as mountain pine beetle depleted resources in the lower elevation sites, they moved upward into less suitable stands, where the infestation eventually collapsed. Notwithstanding the role of environmental conditions and predators, high overwinter mortality rates, and stand structure and composition may have hastened the collapse.

Recent harvesting activities have created a fragmented landscape atypical of stand-replacement fires. These cutblocks have generally been regenerated to spruce or balsam or a combination. Engelmann spruce, sub-alpine fir and lodgepole pine will naturally regenerate in areas where a seed source or suitable seedbed is available. These species-diverse stands may be similar to historical stands with the exception of seral stands of lodgepole pine and size and plant communities normally associated with fire. Fuel loads have also increased, as a result of mature stands composed of multiple layers of shade tolerant species. At a landscape level, the even-aged vertical structure, and temporal and spatial distribution of patches generally associated with fire, have been modified.

In absence of fire, mature lodgepole pine stands start to deteriorate and the more shade tolerant understorey species, such as spruce and sub-alpine fir, eventually attain dominance. Without fire, lodgepole pine has limited regeneration capabilities, especially if sub-alpine fir is competing for the same resources. On the wetter or more zonal sites, sub-alpine fir is well represented in the understorey, increasing fuel loads and creating multi-layered uneven-aged stands. Fire exclusion will result in stands with a significant sub-alpine fir component, which are more susceptible to western balsam bark beetle.

EXISTING HAZARDS and SHORT-TERM IMPLICATIONS for MANAGEMENT

Spruce Beetle

Spruce beetle is currently active in mature spruce stands near Bouleau Lake and Young's Creek. Sanitation harvesting in these stands should reduce the risk to adjacent stands. Lethal or conventional trap trees should be used to "mop up" any residual beetle populations (particularly in stumps) following sanitation harvesting.

Hazard rating was conducted using GIS and a system developed by the Merritt Forest District (Figure 10-12). Parameters included basal area, age, elevation, site index, aspect and stocking. Stand hazard is meant to be used as a planning tool and is an indication of the potential volume losses associated with an outbreak. In absence of beetle, hazard rating can be used to prioritize stands for harvesting. Risk rating should be used in conjunction with hazard should an outbreak occur, to identify the stands with the greatest risk.

Table 5. Summary of spruce beetle hazard, TFL 49. Based on Forest Inventory Zone data and stand attribute data..

Block	Area of Susceptible Spruce (ha)*	% of stands Low	% of stands Moderate	% of stands High
A	2 563	69	27	3
B	3 938	69	21	10
C	878	62	27	8
Total	**7 379**	**69**	**24**	**7**

*susceptible stands are those where a spruce component occurs

Figure 10. Spruce Beetle Hazard Rating for Block A. Based on Forest Forest Inventory and stand attribute data.

Figure 11. Spruce Beetle Hazard Rating for Block B. Based on Forest Forest Inventory and stand attribute data.

Figure 12. Spruce Beetle Hazard Rating for Block C. Based on Forest Forest Inventory and stand attribute data.

Western balsam bark beetle

Scattered patches of western balsam bark beetle have been identified near Blackjack Creek and in the Monte Hlls. Unlike other bark beetles, western balsam bark beetle can persist in a stand for many years. Mortality estimates were recently examined at the Sicamous Creek research trail, which found that beetle-induced mortality (green attack, reds and greys) accounts for 7.8-13.1% of the losses, while snags represented another 17.7-23.8% of the stands basal area (Harder and Macluauchlan, 1997). Work by the same authors also indicated that use of semiochemicals is effective in containing western bark beetle when used in a patch or partial cut silvicultural system. The use of partial cut systems will also help maintain mature forest attributes.

Aerial Surveys

Annual aerial surveys will identify any new areas of beetle infestation. Subsequent ground surveys to determine status and extent of infestation will provide the forest manager with the information required to formulate an action plan, if necessary.

FUTURE GOALS

The effect of fire exclusion has had the least impact in the Engelmann Spruce Sub-Alpine fir forests since suppression policies have been in effect for a much shorter time period than the mean fire interval. The presence of successional stands of spruce, sub-alpine fir and lodgepole pine are indicators of forest communities inherent to this ecosystem. Over time, the landscape will be altered as large stand-replacement fires and resultant even-aged stands are excluded.

Maintaining species diversity and representative successional stages will help maintain ecosystem integrity, and ultimately forest health, in the absence of fire. Regeneration of a species mix of Engelmann spruce, sub-alpine fir and lodgepole pine (on suitable sites) and retention of some advanced sub-alpine fir regeneration will ensure that attributes of historical forests are preserved. This strategy will not only reduce bark beetle hazard but also provide a desirable future crop. Additionally, identification of seral stage distribution will provide for representation of age classes and species mosaics intrinsic to this ecosystem. This approach will allow endemic populations of insects and diseases to function as normal components of the ecosystem; assuming their role in shaping the landscape.

The effects of climate change may significantly modify the landscape, ecological processes and pest dynamics. Warmer temperatures may create more favorable overwintering conditions for mountain pine beetle, thereby increasing the hazard across the landscape. Careful monitoring of bark beetle populations, combined with climate change awareness should alleviate potential losses, by allowing time to restructure existing management strategies and tactics.

Pests of Young Stands

Young stands are the future forest resource. They not only represent a significant investment on the part of forest companies, they also represent a commitment to the maintenance of the integrity of that forest resource. Following harvest, stands are regenerated to maximize yield and site potential, while managing for other resource issues and concerns. Stand tending activities are conducted to further increase these investments with the objective of enhancing growth and increasing wood quality. However, timing of these stand tending activities are often more legislatively than biologically driven, therefor anticipated outcomes are not always realized. Unforeseen impacts due to various forest health agents could significantly alter the expected yield, quality and functioning of these stands in both the short and long term.

Forest health agents that could potentially impact young stands must be identified at the silviculture prescription stage. Site-resident pests, which are generally less discriminatory, affecting trees of all ages, are fairly easy to recognize at this phase of the planning process. These include dwarf mistletoe, root diseases and to a lesser extent defoliators. Identification of other pests that could potentially impact young stands is usually based upon conditions within, or adjacent to the stand, or is based on known landscape level hazards. Local knowledge of pest hazard, and information from guidebooks, can also be incorporated into prescriptions. However, because our overall knowledge on the response of young stands to various treatment prescriptions is lacking, not all forest health agents that have the potential to impact these stands can be predicted.

Landscape level awareness of potential hazards at the pre-harvest and pre-stand tending stage will help reduce risks and potential losses. However, quality and volume losses following treatments may still be incurred. If proper identification and assessment are completed at these stages, then problems which may arise are not through lack of awareness, but rather a lack of knowledge about these forest health factors and their response to stand treatments. A recent examination of treated stands concluded that more care and attention must be given to identifying pests at the Stand Management Prescription phase and that monitoring plots should be established to track pest incidence and impact

(Macluauchlan and Brooks, 1998). Existing management strategies to address specific pests and their impacts are examined and presented in the second section.

Current Conditions

Fourteen per cent of TFL 49 is occupied by stands less than 40 years of age. Forty nine per cent of these immature stands are pine-leading, 18% subalpine fir leading, 13% spruce leading, and 13% Douglas-fir leading. Rather than presenting the information on an ecosystem basis, all pests will be contained in the following section. Pest hazards at an ecosystem level could then be re-defined once surveys for pest incidence are completed over the entire TFL.

The most significant pests of young pine stands on the TFL are Armillaria root disease, Comandra stem rust cankers, lodgepole pine terminal weevil and animal damage. Information on the former three are provided in relevant biogeoclimatic zone sections either under the free-growing guidelines or stand management prescriptions sections. In addition, defoliator damage to multi-layered Douglas-fir stands is dealt with in the western spruce budworm section of the Interior Douglas-fir zone.

Recommendations

The biological and economic impact of stand treatments must be quantified. To quantify the effect of treatments on stand health, adaptive management techniques will be required. Monitoring plots should be established in stands which have been treated in the past and in those that are scheduled to receive future treatments. Distribution of these plots should be stratified to cover the range of treatments, stand age, density and ecosystems. Plots should be assessed annually for 2 years following treatment, and then at approximately 5 year intervals. This will identify immediate forest health concerns, as well as more chronic problems. Data gathered from these plots will provide information that may correlate the effects of stand treatment, timing, tree and site parameters, and pest impacts. This information could then be used to make recommendations or amendments to existing stand tending guidelines.

Pest Occurrence in TFL 49

Surveys for pest incidence were conducted in portions of Block A and B , during the summer of 1998. These surveys encompassed 4 ecosystems, although it is still premature to identify hazards at the biogeoclimatic level. Table 6 summarizes the pests identified in these surveys with additional information derived from the Kamloops Region Free Growing Guidelines and relevant forest health guidebooks.

Table 6. Incidence or relative hazard of forest health agents in young stands, by biogeoclimatic zone, in TFL 49. An "X" indicates that the pest was observed during a survey and low, moderate or high ratings refer to hazard as defined in the Free Growing Guidelines or relevant FPC guidebooks. When a hazard is **bolded**, this means that the pest was also recorded during a survey.

	IDF xh	IDF dk	IDF mw1	ICH mk1	MS dm2	MS xk	ESSF xc	ESSF dc2
Lodgepole pine dwarf mistletoe	High	**High**	**High**	High	**High**	High	High	
Douglas-fir dwarf mistletoe	High	High	High					
Larch dwarf mistletoe			High	High				
Comandra stem rust		**High**		High	**High**	High		**High**
Western gall rust		**High**	**X**	High	**High**	High	**X**	**High**
Stalactiform blister rust		High		High	High	High		
Atropellis stem canker		X	X		X			
Laminated root disease	High-fir leading	High	**High**	High				
Armillaria root disease	High-fir leading	**H** Fir leading	High	High	H Fir leading			
Blackstain root disease					X		X	
Larch needle diseases								
Spruce broom rust		X						
Pine needle cast								
Warren's root collar weevil		X						
Yosemite bark weevil					X			
Lodgepole pine terminal weevil		**High**	High		**L-H**	L-H	Low	Low
Spruce weevil							Low	Low
Western spruce budworm	High	High	Mod	Low	Low	Low	Low-Sx	
Douglas-fir tussock moth	High	Low						
Giant Conifer aphid		X			X			X
Cooley spruce gall adelgid					X		X	X
Pitch nodule moth					X			X
Drought		X					X	X
Animal damage		X	X		X		X	X