MINISTRY OF
FORESTS AND RANGE

CRANBROOK TSA
FOREST HEALTH STRATEGY 2008

DISTRICT MANAGER APPROVAL **DATE**
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1.0 INTRODUCTION

The Cranbrook TSA Forest Health Strategy goal and objectives are in accordance with the Ministry of Forests and Range *Draft Provincial Forest Health Strategy* to**:**

Protect forest resources from damaging agents that threaten the resources' immediate and long-term value by maintaining a high standard of forest health practice across the land base.

OBJECTIVES

1. Maintain a detection program for damaging agents over the land base.
2. Assess current and future stand and landscape level hazard and risk from detected damaging agents including the impact of forest management practices on resource values.
3. Identify significant pest risks to resource values and identify appropriate management strategies and tactics, while considering constraints and limitations imposed by other resource management imperatives.
4. Implement mitigating strategies and tactics according to scientifically sound, forest health management practices.
5. Evaluate results of forest health management practices over the short and long-term and modify practices accordingly.

The Forest Health Strategy gives strategic direction for operational plans and serves to prioritise forest health investments in the TSA. The components of the plan that will aid in achieving the goals and objectives are as follows:

<u>Identification and ranking of priority forest health factors in the TSA:</u>
Identifying forest health factors in the TSA, and describing their current status; and
ranking each forest health factor as to their impact on forest management;

<u>Management strategies for managed stands and defoliators:</u>
Specifying management objectives for priority forest health factors; and
assigning specific strategies, tactics and proposed activities for addressing priority forest health factors.

<u>Bark Beetle Management:</u>
Identifying bark beetle management units for mountain pine beetle, Douglas-fir beetle, spruce bark beetle, and their assigned strategies;
detailing a tactical plan for carrying out detection and treatment activities and;
outlining a mountain pine beetle monitoring plan that identifies factors that collectively contribute to reviewing the need for requesting an uplift in AAC.

2.0 GENERAL DESCRIPTION OF CRANBROOK TSA

The Cranbrook Timber Supply Area (TSA) is within the boundaries of the Rocky Mountain Forest District and is administered by the district office in Cranbrook. It is situated in the southeastern corner of the British Columbia within the Kamloops Forest Region and covers approximately 1.48 million hectares. This TSA is bounded by the Skookumchuck Valley to the north, Canada-U.S. border to the south. B.C.-Alberta border to the east, and southern Purcell Mountains height-of-land to the west. Approximately 814,000 hectares of the TSA are considered productive forest in terms of timber growth. The remaining 634,500 hectares are not considered productive forest, or are not managed by the Ministry of Forests. Of the productive land base, about 464,000 hectares are available for harvesting, which represents 31% of the total TSA. About 47% of the timber harvesting land base (THLB) are dominated by lodgepole pine, while the remaining area is covered by 30% Douglas-fir and larch, 10% spruce and balsam, and 3% yellow pine, hemlock and cedar. Of the aforementioned stands, 20% are older than minimum harvest age, 16% of which are dominated by lodgepole pine.

The Cranbrook TSA contains six biogeoclimatic zones, an indication of the climatic and biological diversity in the area:

- The Ponderosa Pine Zone occurs at low elevations (700 to 900 metres) in very dry valleys of the Rocky Mountain Trench
- Interior Douglas-Fir Zone also occurs in the Rocky Mountain Trench, at elevations of 800 to 1200 metres, generally between the Ponderosa Pine and Montane Spruce Zones
- The Montane Spruce Zone is found at mid-elevations of 1200 to 1600 metres, often between the Interior Douglas-fir and Englemann Spruce Zones.
- The Interior Cedar-Hemlock Zone occurs at low to mid elevations (700 to 1500 metres) in the wetter portions of the Purcell and Rocky Mountains.
- Engelmann Spruce-Subalpine Fir Zone is the uppermost-forested zone, lying below the Alpine Tundra Zone form 1600 to 2000 metres.
- Alpine Tundra Zone lies above the Engelmann Spruce0-Subalpine Fir Zone, and is by definition treeless although stunted or krummholz trees are common at the lower elevations of this zone. Overall, rock, ice, and grassy meadows dominate this zone.

3.0 CURRENT FOREST HEALTH CONDITIONS

Aerial overview surveys conducted by the MOFR between 1999 and 2006 detected bark beetles, defoliators, needle casts, abiotic damage and impacts from feeding by mammals. The most significant impact during this time period has been from mountain pine beetle (Table 1). Other agents that have affected areas of 100 hectares or more include Douglas-fir beetle, western balsam bark beetle, pine needle cast, larch needle cast and western false hemlock looper. Agents affecting

less than 100 hectares in the last five years include impacts form geomorphic slides, western pine beetle, red turpentine beetle, white pine blister rust, and conifer sawflies. Often, other key forest health factors, such as Armillaria root disease, dwarf mistletoe and wildfire, have a significant impact on forest management but are not always detectable from the air, are ongoing, or have not occurred at time of aerial overview flight.

TABLE 1 - 1999-2007 CRANBROOK TSA AERIAL OVERVIEW SURVEY RESULTS

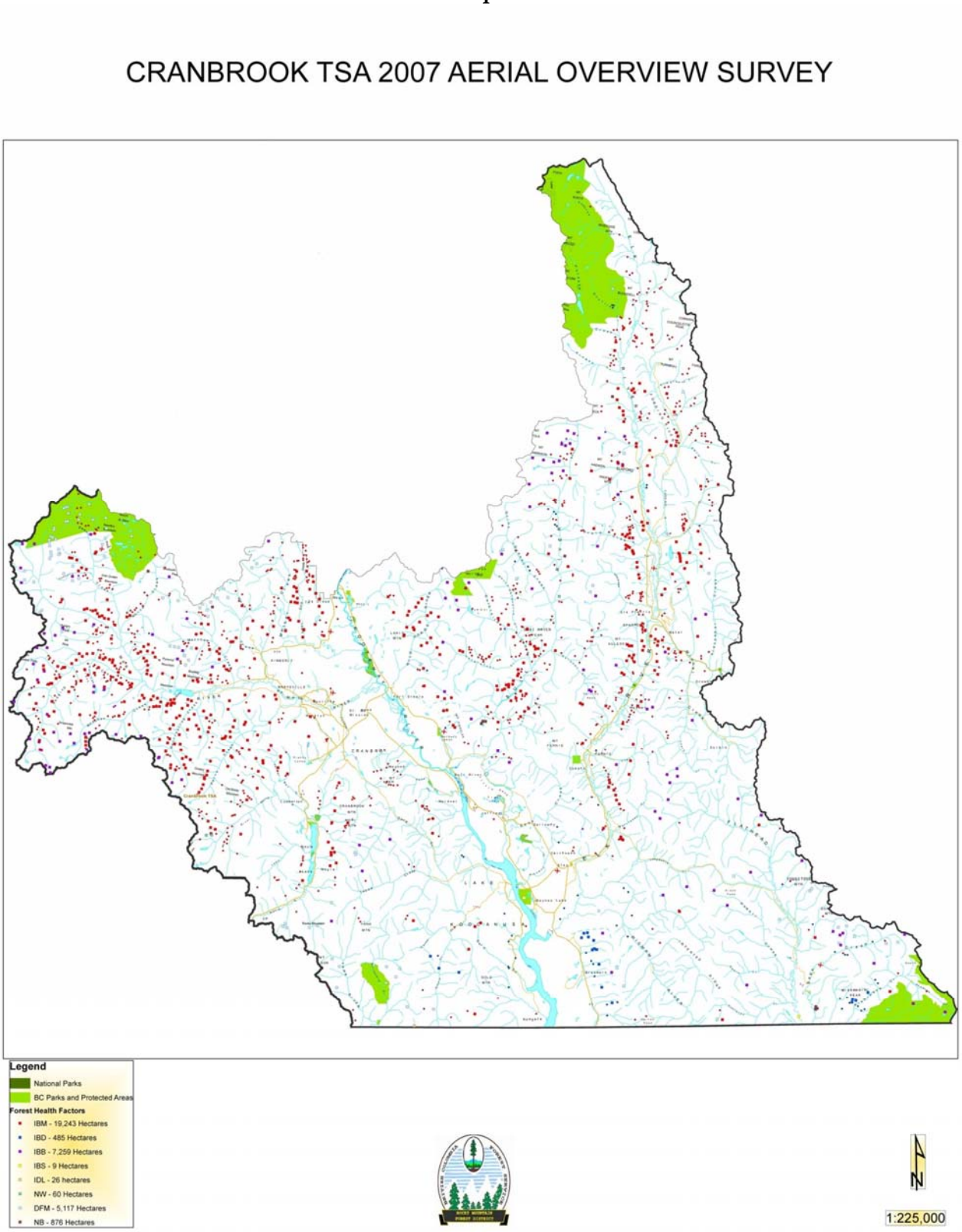
Type of impact: 1=quality, 2=growth reduction, 3=young tree mortality, 4=mature tree mortality

Forest Health Factor	Hectares Affected 2007	Cumulative Hectares Affected '99-07	Type of Impact	% of THLB stands led by host species
Mountain pine beetle	19,243	107,480	4	47
Douglas-fir beetle	485	3,419	4	18
Western balsam bark beetle	7,529	25,149	4	8
Spruce Bark Beetle	9	732	4	10
Two-Year Budworm	0	281	2,3,4	10
Pine needle cast	0	5,772	2,3	47
Western false hemlock looper	0	2,673	2,3	18
Larch needle cast	5,117	32,908	2,3	13
Burned*	876	1,971*	1,3,4	100
Satin Moth	0	592	2,3,4	<1
Tent Caterpillar	0	648	2,3	<1
Serpentine Leaf Miner	26	658	2,3	<1

*Kootenay Fire Centre recorded 11,313 ha burned in the THLB in 2003

The following map provides spatial aerial overview survey results of forest health factor incidence for the Rocky Mountain Forest District.

Map 1


CRANBROOK TSA 2007 AERIAL OVERVIEW SURVEY
Legend
National Parks
BC Parks and Protected Areas
Forest Health Factors
IBM - 19,243 Hectares
IBD - 485 Hectares
IBB - 7,259 Hectares
IBS - 9 Hectares
IDL - 26 hectares
NW - 60 Hectares
DFM - 5,117 Hectares
NB - 876 Hectares
N
1:225,000

4.0 RANKING OF FOREST HEALTH FACTORS

The following tables lists forest health factors ranked according to their potential impact on forest management in the Cranbrook TSA. Those factors ranked as Very High or High are considered as priorities to address. The rankings were derived using data from MOFR aerial overview surveys (1999-2006), local knowledge and guidance from the Draft Provincial Forest Health Strategy which ranks forest health factors as to their importance in three forest health maintenance categories:

- Protection of current inventory (bark beetle and defoliator management pests with operational treatments available);
- Improving stand management practices activities (pests whose impacts are known or suspected to be minimised by modifying forest practices);
- Data management analysis to support the activities above, and other stewardship functions (pests whose impact is known or suspected to significantly alter timber supply in either the short or long-term).

Rational is provided where the TSA ranking is different from the Provincial ranking.

TABLE 2 – POTENTIAL IMPACT RANKING OF FOREST HEALTH FACTORS ON FOREST MANAGEMENT PROTECTION ACTIVITES ACTIVITIES IN THE CRANBROOK TSA

PEST	RANKING	RATIONALE (if TSA ranking differs from Provincial ranking)
Mountain pine beetle	Very High	
Douglas–fir beetle	High	If suitable conditions occur, potential for significant future impact in TSA could occur given 17% of the THLB is fir leading. Provincially ranked Medium.
Spruce beetle	Medium	Very little activity over the last 20 years due to better access & harvest practices. Provincially ranked Very High.
Western balsam bark beetle	Medium	
Gypsy moth	Medium	No occurrences in TSA to date. Monitoring program in place. Provincially ranked Very High

Table 3 – POTENTIAL IMPACT RANKING OF FOREST HEALTH FACTORS ON STAND MANAGEMENT PRACTICE IMPROVEMENT ACTIVITIES

PEST	RANK	RATIONALE (if TSA ranking differs from Provincial ranking)
Armillaria root disease	Very High	
Commandra blister rust	High	
Western gall rust Northern pitch twig moth Sequoia pitch moth	High	Widespread and in some cases severe incidence of DSG is occurring in the TSA between 1000-1500 metres in elevation. Concerns for achieving free growing are beginning to arise in some locales. Widespread and in some cases severe infestations of ISP and ISQ are occurring in young pine stands in the TSA. Concerns for achieving free growing are beginning to arise in some locales. Provincially ranked Very Low
Tomentosus root rot	Medium	Not of major concern in the TSA with light incidence in ICH, and rarely noted in ESSF. Provincially ranked as High.
Lodgepole pine dwarf mistletoe	Medium	
Larch dwarf mistletoe	Medium	Significant occurrence in portions of the TSA, impacts both pine and larch
Pine needle cast	Medium	
Spruce weevil	Low	
Stalitiform blister rust	Low	
Blackheaded budworm	Low	
Laminated root rot	Very Low	Minor incidence in TSA to date.
Red band needle blight	Very Low	Minor incidence in TSA to date.
Atropellis canker	Very Low	
Blackstain root disease	Very Low	
All other conifer foliar diseases	Very Low	
Hardwood cankers	Very Low	
Wood decay fungi	Very Low	
All other conifer & hardwood defoliators and bark beetles	Very Low	
Warren's root collar weevil	Very Low	
Lodgepole pine terminal weevil	Very Low	

Table 3 – POTENTIAL IMPACT RANKING OF FOREST HEALTH FACTORS ON STAND MANAGEMENT PRACTICE IMPROVEMENT ACTIVITIES (continued)

PEST	RANKING	RATIONALE (if TSA ranking differs from Provincial ranking)
All other conifer & hardwood defoliators & bark beetles	Very Low	
White pine blister rust	Very Low	0.5 % of THLB composed of whitebark (1230 ha) and western white (27 ha) pine. Provincially ranked as High.

TABLE 4 - POTENTIAL IMPACT RANKING OF FOREST HEALTH FACTORS ON DATA MANAGEMENT NEEDS FOR TSR

PEST	RANKING	RATIONALE (if TSA ranking differs from Provincial ranking)
Mountain pine beetle Armillaria root disease	Very High	
Douglas-fir beetle	High	17% of THLB is fir leading. If suitable conditions occur, potential for outbreak given access and constraint issues
Lodgepole pine dwarf mistletoe Larch dwarf mistletoe	High	The TSA contains lodgepole pine stands, with significant incidence in the ESSFdk, ICHdw, ICHmk1, IDFm2 and the MSdk. Lodgepole pine is the leading species in 47% o THLB stands. Provincially ranked as Medium. The TSA contains lodgepole pine and larch stands, (multi-layered in particular), highly susceptible to dwarf mistletoes in the ESSFdk, ICHdw, ICHmk1, IDFm2 and the MSdk. A considerable percentage of THLB stands are lodgepole pine (47%) or larch (13%) leading. Not ranked Provincially.
Commandra blister rust	High	
Western gall rust	High	Widespread and in some cases severe incidence of DSG is occurring in the TSA between 1000-1500 metres in elevation. Concerns for achieving free growing are beginning to arise in some locales. Provincially ranked as meduim.
Spruce beetle	Medium	Very little activity over the last 20 years due to better access & harvest practices. Provincially ranked Very High.
Western balsam bark beetle	Medium	
Northern pitch twig moth sequoia pitch moth	Medium	Widespread and in some cases severe infestations of ISP and ISQ are occurring in young pine stands in the TSA. Concerns for achieving free growing are beginning to arise in some locales. Provincially ranked Very Low.
Tomentosus root rot	Medium	Not of major concern in the TSA with light incidence in ICH, and rarely noted in ESSF. Provincially ranked as High.
Abiotic disturbances	Medium	Wind and wildfire events are common in the TSA, and can often elevate activity of other forest health factors.
False hemlock looper	Low	Historically, periodic localised outbreaks occur every 10 to 15 years. Not ranked Provincially.
Two-year cycle budworm	Low	Periodic localised outbreaks occur. 10% of THLB dominated by spruce and balsam.
Spruce weevil	Low	

5.0 MANAGEMENT STRATEGIES FOR MANAGED STANDS AND DEFOLIATORS

Specific management strategies are provided for forest health factors ranked *very high* or *high* as to their potential to impact forest management activities and values. Forest health factors with a ranking of *medium, low* or *very low* will be monitored using the Provincial aerial overview surveys, silviculture surveys and pest incidence surveys where possible. If these factors threaten a specific value they should be managed accordingly. Responsible parties will be primarily the MOFR, unless the forest health issue affects preparation of site plans, free growing obligations, or licensees address the issue voluntarily or undertake activities eligible for FIA funding. Management strategies for priority forest health factors should incorporate the following principles of Integrated Forest Health Management:

- Know the land base and resource management objectives
- Manage from an ecological perspective
- Don't make the situation worse
- Practice adaptive management

There is a Provincial need to compile, centralise and extend forest health data and research. Currently much of the knowledge about the location and results of the operational trials and permanent sample plots resides with a few people in the Ministry and with licensees. As experts move, the knowledge often moves with them. Operational trials should be documented and added to a central, publicly accessible database. Results should be extended to licensees via peer reviewed, accessible reports and presentations.

5.1 *Armillaria ostoyae (DRA)*

Armillaria root rot is the most common disease in the Cranbrook TSA, particularly in the ICH and IDF and is scattered in pockets in other biogeoclimatic zones. Most tree species and age classes are susceptible. Armillaria is an important driver of structural diversity interior forests - e.g., 62% of 111 active nests of primary cavity nesters were associated with Armillaria centres in studied ICHdw stands in the Nelson Forest Region (Steeger and Machmer 1995). Armillaria is challenging to manage because it can be difficult to identify in the field, spread is exacerbated by partial cutting and thinning (Morrison et al. 2001), and given extensive calcareous and fine textured soils in the TSA, traditional management such as stumping and push-over harvesting may not be possible due to unacceptable levels of associated soil disturbance (Kishchuk et al. 1999, Curran et al. 2000).

5.11 *DRA Management Objectives:*

Avoid exacerbating spread in managed stands.

Quantify impact of DRA on long-term timber supply.

5.12 *DRA Management Strategies:*

Detect and manage according to the Armillaria Root Disease Guidelines for the Nelson Forest Region (Norris et al. 1998).

Support re-measurements of operational trials:
Hypholoma fasiculare is a common wood decay fungus that is being investigated as a possible control agent for DRA. This fungus has shown to out-compete DRA on woody substrates, and is easily inoculated into stumps (Chapman 2000).
Establishment of like operational trials to determine whether it may be an effective alternative management tactic in sites with calcareous soils in the Cranbrook TSA should be considered.

Support permanent plot establishment and measurements:
Re-measurement of the Fort Steele Operational Trial should occur to quantify long term impacts of DRA on volume. This would assist in improving estimates used in timber supply reviews.

Consider stumping and/or stand density control options:
In fire –maintained ecosystems it is suggested that as a result of fire exclusion these stands are overstocked relative to historic conditions (Morrsion et al.). Decreasing stand density with selective cutting, and reducing inoculum with stumping could decrease DRA impact and spread by reducing root to root contact.

Any research plans should dovetail with the Provincial Armillaria Research Strategy (Wienscyzk et al. 2003).

5.2 *Lodgepole Pine and Larch Dwarf Mistletoe (DMP and DML):*

Research has indicated that growth of severely infected lodgepole pine can be reduced up to 32% (Unger 1992). Dwarf mistletoe brooms can increase fire hazard as they contribute to ladder fuel load and are highly flammable (Kipfumueller and Baker 1998). Brooms and fruiting bodies also provide important habitat and food sources (Watson 2001).

5.21 *DMP & DML Management Objectives*:

Avoid exacerbating spread in managed stands.

Quantify impact of growth reduction on long-term timber supply.

5.22 *DMP & DML Management Strategies*:

Detect and manage according to the Dwarf Mistletoe Guidebook (1995)

Support operational trial re-mesurements:
In 1997 six permanent sample plots were established on a 1984 DML operational trial in the St. Mary drainage. Re-measurement occurred in 2001. These plots need to be maintained for statistical analysis and long-term measurements. Preliminary evidence suggests that to reduce the impact of DML on regeneration, retention and understory in partial harvests, the following should be implemented (D.G. Murphy & Associates and D. Smith Consultants 2001):
Removing infect overstory trees with or without juvenile spacing, and

Juvenile spacing without removing the infested overstory can increase infection levels, unless spacing specifically targets infected understory.

Support permanent plot establishment:
TSR3 in the Cranbrook TSA does not incorporate any specific impacts due to DMP or DML. Permanent sample plots to quantify long-term impacts on volume, particularly in infested stands that have been selectively harvested could improve estimates in future timber supply reviews.

5.3 Western Gall Rust (DSG) and Commandra Blister Rust (DSC)

In the Cranbrook TSA stands of lodgepole pine less than 15 years of age are highly likely to contain high incidence of DSG (Swift et al. 2003), and/or DSC. Incidence of DSG and DSC occur throughout the TSA, and is a major concern in regards to wood quality issues, growth reduction and in some cases mortality rates.

5.31 DSG and DSC Management Objectives:

Reduce spread and/or impact in managed stands.

Quantify impact on long-term timber supply.

5.32 DSG and DSC Management Strategies:

Detect and manage according to the Pine Stem Rust Management Guidebook (1996) and the Establishment to Free Growing Guidebook for the Nelson Forest Region.

Promote mixed species regeneration where possible (Swift et al. 2003)

Test provenances, where allowed under seed transfer guidelines (Wu et al. 1998, White et al. 2000).

Establish and/or support operational trails to test the effect of stand density on DSG incidence and severity.

Pursue means to quantify DSG and DSC incidence within the THLB, and refine hazard and risk rating to promote best management practices.

5.4 *Northern Pitch Twig Moth (ISP) and Sequoia Pitch Moth (ISQ)*

In the past several years, incidence levels of pitch moth have reached up to 70% of trees in young lodgepole pine stands in the adjacent TSA (Hodge 2002). Similar incidence levels have been observed in a number of locations in the Cranbrook TSA. In other areas of the Province some lodgepole pine stands regenerating after mountain pine beetle outbreaks are being severely impacted by ISP (Phero Tech Inc. 2000). Plantations tend to be more heavily attacked than dense, naturally regenerating stands (Henigman 2001). ISP preferentially attacks pine between 0.3 and 3.0 metres in height, although trees up to 10 metres may be attacked (Duncan 1996).

Seven permanent sample plots to measure long-term impacts of ISP in the Invermere TSA were established in 1999. The plots were re-measured in 2001, and incidence of ISP ranged from 300 to 6000 stems/hectare and averaged 1 to 4 nodules attacked per stem.

High incidence of ISQ has been reported in lodgepole pine stands in the Cranbrook TSA . Pine stands taller than 2 metres are susceptible, particularly those in open-growing or suffering from recent wounding (Henigman 2001). Occasionally, repeated attacks can girdle and kill small diameter trees, or predispose them to breakage.

5.41 Pitch Moth Management Objectives:

Prevent outbreaks of pitch moths.

Quantify impact on volume and wood quality on long-term timber supply.

5.42 Pitch Moth Management Strategies:

Detect and manage according to the Establishment to Free Growing Guidebook for the Nelson Forest Region.

Hodge (2002) recommends free growing standards use up to 70% girdling as acceptable on poor sites, and 80% girdling elsewhere.

Reduce risk of ISP and/or ISQ damage by planting mixed species where possible.

As ISP attack appears to decrease with age (Hodge 2002, Ives and Rentz 1993 from Hodge 2002) spacing should be delayed until trees reach at least 15 years of age in stands with high levels of Petrova.

Avoid pruning or spacing in stands with ISQ incidence, as attack will likely increase on wounded trees.

Support re-measurement and maintenance of the Invermere TSA permanent sample plots.

Consider restricting cattle grazing in stands with high levels of ISP or ISQ to limit stem breakage from animal rubbing (Hodge 2002).

Pursue means to quantify pitch moth incidence within the THLB, and provide information towards determining susceptibility and risk information to promote best management practices.

5.5 *Black Army Cutworm (IDA) and Rhizina Root Rot (DRR)*

There is a long history of large wildfires in the TSA, and the likelihood of future large fires is high. Black army cutworm has most commonly consumed white spruce and lodgepole pine in the ESSF and ICH zones. Rhizina infection tends to occur one or two years post-burn, particularly after those of moderate intensity in the ICH. Mortality of seedlings can reach up to 60% (Henigman et al. 2001).

5.51 IDA and DRR Management Objectives:

Monitor wildfire/burn areas for population/incidence levels to aid in making management decisions for reforestation requirements.

5.52 IDA and DRR Management Strategies:

Establish a monitoring program:

In areas recently burned by fire, pheromone trapping for Black Army cutworm moths from July through to September can indicate the risk of high populations of larvae occurring the following spring (Maher 1990).

The size of the population, it's stage and the availability of alternate vegetation for the larvae could influence which of the following management options is chosen and are listed in decreasing order of preference (Maher 1990):

1. Postpone planting until pupation has occurred to avoid larval feeding period.
2. Proceed with planting, conduct a survival survey the following year and re-plant spots of mortality.
3. Delay planting for one year.
4. Apply insecticide.
5. Avoid planting in dry sites when population levels are high as post-defoliation drought can significantly increase seedling mortality from black army cutworm attack (Maher 1990). Relay the importance of proper planting techniques and micro site selection to planting crews.

In high-risk DDR areas, consider delaying planting for two or more years after a burn http://www.pfc.forestry.ca/diseases/CTD/Group/Root/root8_e.html).

5.6 *Activities to Manage Priority Forest Health Factors*

1. Maintain a detection program for damaging agents across the land base.
2. Assess current and future stand and landscape level hazard and risk from detected damaging agents including the impact of forest management practices on resource values.
3. Identify significant pest risks to resource values and identify appropriate management strategies and tactics, while considering constraints and limitations imposed by other resource management imperatives.
4. Implement mitigating strategies and tactics according to scientifically sound forest management practices.
5. Evaluate results of forest health management practices over the short and long-term and modify practices accordingly.

To assign rank to meeting TSA objectives, strategies were prioritise in order of most to least important (1 to 8 respectively) by reviewing and ranking activities. The results are presented in the following Table 5. Commitment to most of the activities will be subject to availability of funds. Estimated costs are provided for those activities that could be undertaken by the District, or voluntarily by licensees.

TABLE 5- ACTION PLAN TO MEET TSA LEVEL OBJECTIVES
Priority 1-8 = Highest to lowest priority

PRIORITY	PROPONENT	District $ EST.	ACTION
1	MOFR Aerial Overview and Detailed Surveys	$12,000	Conduct detailed aerial and ground surveys, to maintain a detection program for damaging agents across the land base. Assess current and future stand and landscape level hazard and risk from detected damaging agents including the impact of forest management practices on resource values. Identify significant pest risks to resource values and identify appropriate management strategies and tactics, while considering constraints and limitations imposed by other resource management imperatives. Implement mitigating strategies and tactics according to scientifically sound forest management practices. Evaluate results of forest health management practices over the land base.
2	MOFR - TSA FH Strategy Licensee - Site Plans		Follow Armillaria Root Disease Guidelines for the Nelson Forest Region Follow Dwarf Mistletoe Guidelines. Follow Pine Stem Rust Management Guidebook and Establishment to Free Growing Guidebook for the Nelson Forest Region
3	MOFR Region District and Licensees		Establish and monitor PSPs for DMP. Re-measure/ stand density reduction trial in fire maintained ecosystem (Fort Steele operational trial) in 2007. Re-measure of St. Mary operational trial. Support model development. Establish and monitor PSPs for DML in 2011. Establish operational trials for effects of stand density (consider Gold Ck espacement trials). Coordination and extension of forest health research - archive and extend results from FH research. Maintain database of plots and operational trial locations.
4	MOFR District Licensees	$20,000	Monitor other forest health factors via: Pest Incidence Surveys (1,000 ha annually). .Silviculture surveys and Monitoring traps
5	MOFR District		Support re-measurement and establishment of further Hypholoma trials
6	MOFR Aerial Overview and Detailed Surveys Licensees	$10,000	Consistent aerial delineation and archiving of burns and windthrow events via special flights, as required.
7 MOFR	MOFR District Licensees		Support re-measurement of PSPs in Invermere TSA for pitch moth to quantify long-term impact on timber volume and wood quality (2006).
8 MOFR	MOFR Region	$7,500	Survey incidence of pitch moth in TSA (400 ha est. annually.). Develop SOP from Hodge (2002) work, modify free growing standards.

6.0 BARK BEETLE MANAGMENT

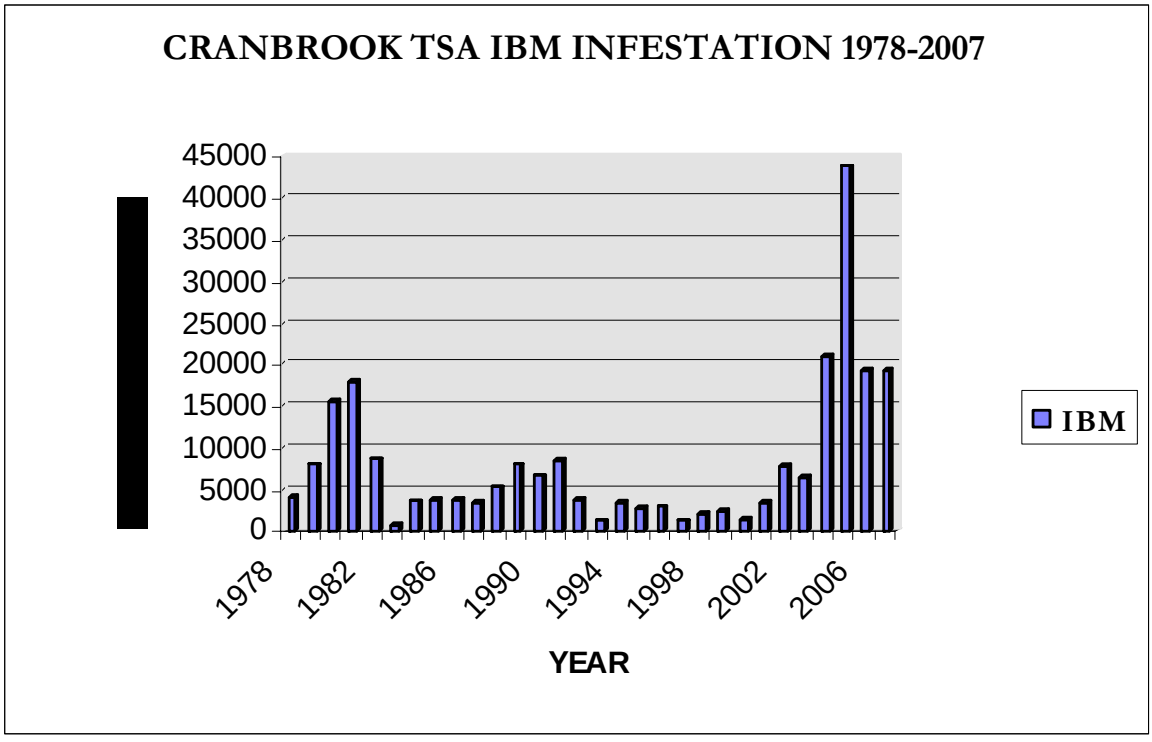
Within the Cranbrook TSA the mountain pine beetle (IBM), Douglas-fir beetle (IBD), and spruce beetle (IBS) are disturbance agents of pines, Douglas-fir, and spruce, respectively. While hosts differ between IBM, IBD, and IBS there are several similarities in biology and impacts. All three of these bark beetles are considered primary tree-killers, which are capable of attacking healthy trees when populations are high. These bark beetles pose a major threat to land management objectives as large-scale mortality could have a negative impact on timber and non-timber resources. Effective management techniques are required to mitigate and prevent losses. Priority ranking systems, such as susceptibility and risk analysis are key decision making tools. These systems aid in assessing potential impacts of insect outbreaks and the development of management plans.
Specific management strategies are provided for mountain pine and Douglas-fir beetle as they are currently ranked *very high* or *high* as to their potential to impact forest management activities and values. Spruce bark beetle currently has a ranking of *medium,* and will be monitored using the Provincial aerial overview surveys, silviculture surveys and pest incidence surveys where possible.

6.1 *Mountain Pine Beetle (IBM)*

Mountain pine beetle has historically influenced the landscape in the TSA. Two outbreaks have occurred in the last 25 years. In the Flathead area an outbreak peaked at 18,000 hectares in 1981, and in 1991 peaked at 8,530 hectares in the South Country and Trench areas. Currently 70,000 hectares of the TSA area is rated as moderate to high hazard to IBM attack (Spatial Mapping Ltd, 2002).

Aerial overview flight results for the TSA in 2007 indicate that 19,243 hectares have been attacked, with the population level remaining virtually unchanged from hectares mapped in 2006. Current to red ratios have declined marginally, with average numbers decreasing from 2.2:1 to 2.1:1 over the previous year. Temperature fluctuations and volatile winds during the summer resulted in a less concentrated flight period, thus current attack tends to be dispersed in scattered single tree or small pockets versus large contiguous patches. The most active, large concentrations of current attack in the TSA are located in the St. Mary area (Hellroaring and Matthew Creeks) which have caused a significant migration into the Kimberley Nature Park and Lois Creek as well as the Mark Creek drainage of the Kimberley Watershed. The following graph depicts the number of hectares attacked by IBM as detected by MOFR aerial overview surveys between 1978 and 2007.

FIGURE 1. 1978-2007 CRANBROOK TSA AERIAL OVERVIEW RESULTS OF IBM ATTACK

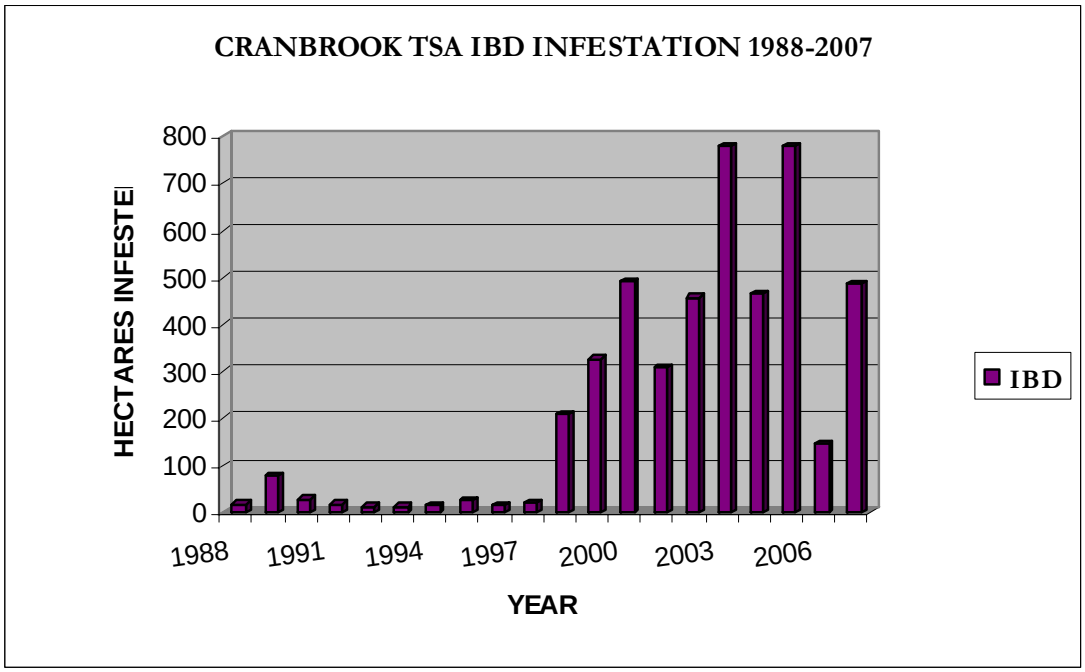


6.2 *Douglas- fir Beetle (IBD)*

Douglas-fir beetle has historically influenced the Cranbrook TSA landscape, although to a lesser degree than mountain pine beetle. The TSA contains 49,000 hectares rated moderate to high hazard to IBD attack (Spatial Mapping Ltd. 2002).

Aerial overview flight results for the TSA in 2007 indicate that IBD attacked 485 hectares, a 3.3 fold increase from 2006. Most of the current infestation is associated with scattered root rot, isolated windthrow or snow damage events and is located in the Flathead (Akamina and Kishnena Creeks). The following graph depicts the number of hectares attacked by IBD as detected by MOFR aerial overview surveys between 1999 and 2007.

FIGURE 2. 1978-2007 CRANBROOK TSA AERIAL OVERVIEW RESULTS OF IBD ATTACK



6.3 *Bark Beetle Management Objectives:*

Monitor population build-up and spread through annual survey program.

Reduce beetle populations to manageable levels, with the intent of minimising future losses and reducing rate of spread of infestations.

Reduce susceptibility of high hazard stands by harvesting or other modification, creating a forest mosaic of diverse species and age classes that are at lower risk to damaging agents.

Quantify impact on volume and wood quality on long-term timber supply.

6.4 *Bark Beetle Management Strategies:*

There are 38 landscape units in the Cranbrook TSA. Each individual landscape unit is considered a Beetle Management Unit (BMU) for planning and reporting purposes. An annual review of each BMU occurs to assign appropriate management strategies and treatment tactics in accordance with the approach and guidance provided by the Provincial Bark Beetle Strategy and Provincial Bark Beetle Management Technical Guidelines. There are four possible management strategies for a BMU as follows:

1. Suppression - address all current attack within two years (80-100% brood kill targeted per year). The intent is to drive bark beetle populations down and stop the spread.

2. Holding - maintain beetle populations at a level that can be dealt with under current AAC by addressing 50-80% of current attack (at least close to rate of expansion).

3. Salvage – the priority is to salvage previously attacked timber to minimise value loss. This is relevant in areas where suppression or holding actions are no longer feasible.

4. Monitor - no action required beyond monitoring and recording.

The Cranbrook TSA has been designated as an Emergency Bark Beetle Management Area as a result of a mountain pine beetle outbreak. Thus, BMUs are also designated into provincial zones (aggressive and containment) that aid in high-level resource allocation.

The following Table 6 lists BMU names, assigned management strategies and provincial zones for the entire TSA., including Provincial Parks and Protected Areas.

TABLE 6 - CRANBROOK TSA 2008 BARK BEETLE MANAGEMENT STRATEGIES

BMU #	BMU Name	IBM Strategy	EMU Zone	IBD Strategy	EMU Zone	Provincial Park
C01	Moyie Lake	Holding	Containment	Holding	Containment	Moyie Lake
C02	Perry-Moyie	Holding	Containment	Holding	Containment	No
C03	Lamb Creek	Holding	Containment	Holding	Containment	No
C04	Hellroaring-Meachen	Holding	Containment	Holding	Containment	No
C05	Redding Creek	Holding	Contai0nment	Holding	Containment	Lockhart Creek
C06	Upper St. Mary	Holding	Containment	Holding	Containment	Purcell Wilderness
C07	White Creek	Holding	Containment	Holding	Containment	Purcell Wilderness, St. Mary's
C08	Kimberley Watershed	Holding	Containment	Suppression	Aggressive	No
C09	Yahk River	Suppression	Aggressive	Suppression	Aggressive	Gilnockie Creek
C10	Bloom-Caven	Suppression	Aggressive	Suppression	Aggressive	No
C11	Teepee Creek South Teepee FSR	Holding Suppression	Containment	Suppression	Aggressive	No
C12	Cranbrook Watershed	Suppression	Aggressive	Suppression	Aggressive	No
C13	Galton Range	Holding	Containment	Suppression	Containment	No
C14	Wigwam River	Suppression	Aggressive	Holding	Containment	No
C15	Lodgepole-Bighorn	Suppression	Aggressive	Holding	Containment	No
C16	West Flathead	Suppression	Aggressive	Suppression	Aggressive	No
C17	Upper Flathead	Suppression	Aggressive	Suppression	Aggressive	No
C18	East Flathead	Suppression	Aggressive	Suppression	Aggressive	Akimina-Kishnena
C19	Corbin Creek	Suppression	Aggressive	Suppression	Aggressive	No
C20	Alexander-Line	Suppression	Aggressive	Suppression	Aggressive	Crownest
C21	Fording River	Suppression	Aggressive	Suppression	Aggressive	No
C22	Upper Elk	Suppression	Aggressive	Suppression	Aggressive	Height of the Rockies, Elk Lakes
C23	West Elk	Holding	Containment	Suppression	Aggressive	No
C24	Lower Elk	Holding	Containment	Holding	Containment	Elk Valley, Mount Fernie
C25	Sand Creek	Holding	Containment	Holding	Containment	No
C26	Iron-Sulphur	Holding	Containment	Holding	Containment	No
C27	Upper Bull	Suppression	Aggressive	Holding	Containment	Top of the World
C28	Galbraith-Dibble	Holding	Containment	Holding	Containment	Top of the World
C29	Wildhorse-Steeples	Holding	Containment	Suppression	Aggressive	No
C30	Cranbrook	Holding	Containment	Suppression	Aggressive	Jim Smith
C31	Lost Dog	Holding	Containment	Holding	Containment	No
C32	St. Mary Prairie-HaHa Lake	Holding	Containment	Holding	Containment	No
C33	Wasa-Picture Valley	Holding	Containment	Holding	Containment	Norbury Lake, Wasa
C34	Jaffray-Baynes Lake	Holding	Containment	Holding	Containment	Elko, Kikomun Creek
C35	Tobacco Plains	Holding	Containment	Holding	Containment	No
C36	Mayook-Wardner	Holding	Containment	Suppression	Aggressive	No
C37	Linklater Englishman	Suppression	Aggressive	Suppression	Aggressive	No
C38	East Elk	Holding	Containment	Holding	Containment	No

6.5 Tactical Plan

The Tactical Plan prioritizes Suppression BMUs and estimates a budget for implementation of a single tree treatment program for 2007/08.

6.51 Prioritization

In order to assign resource allocation and treatments, Suppression BMUs have been biologically ranked in general order of importance according to the process outlined in the *Provincial Bark Beetle Management Technical Guidelines*. The ranking process is based on the relative severity of the outbreak (e.g. number of currently attacked trees and infested spots), and the amount of susceptible area

remaining. Each of these attributes is rated high or low relative to the median value for the attribute. BMUs containing community watersheds will be elevated to a high priority regardless of their biological ranking as a means of preventing long-term consequences of bark beetle impact in these sensitive areas. Tables 7 (IBM) and 8 (IBD) list the outcome of this process for the TSA.

TABLE 7 – CRANBROOK TSA 2008 BIOLOGICAL RANKING OF IBM SUPPRESSION BMUS

BMU #	BMU Name	Biological Ranking	Ha M-H Hazard	# Current Attack	# Infested Sites	G:R	Resource Value Comments
C09	Yahk River	3	5,140	20	3	0.3	
C10	Bloom-Caven	3	2,855	10	2	0.8	VQOs, wildlife, Ungulate winter range, recreation, domestic watershed
C11	Teepee	3	4,164	48	24	0.8	VQOs, wildlife, Ungulate winter range, recreation
C18	East Flathead	3	4,872	7	7	0.3.	Proctor Lake rare plant community, OGMA, wildlife, grizzly habitat, recreation, domestic watershed
C20	Alexander-Line	4	1,229	4,611	89	1.0	Ungulate winter range, recreation
C21	Fording River	4	744	1,260	45	1.4	Ungulate winter range
C27	Upper Bull	4	902	758	41	1.5	OGMA, wildlife, grizzly habitat, recreation, domestic watershed, range
C12	Cranbrook Watershed	4	6,667	758	187	1.0	VQOs, Community Watershed, ungulate winter range, recreation District ranks as Priority 1 as it is a Community watershed
C14	Wigwam	5	1,202	2	2	0.5	Biodiversity, wildilfe, recreation
C15	Lodgepole-Bighorn	8	540	248	17	1	VQOs, wildlife
C16	West Flathead	8	891	1	1	0.5	Biodiversity, wildlife, grizzly bear habitat, recreation, domestic watersheds
C17	Upper Flathead	8	239	110	43	0.5	Biodiversity, wildlife, grizzly bear habitat, recreation, domestic watersheds
C19	Corbin Creek	8	187	658	387	1.5	VQOs, wildlife, grizzly habitat, recreation, domestic watershed
C22	Upper Elk	8	171	1,885	579	1.2	Ungulate winter range, grizzly habitat

TABLE 8 – CRANBROOK TSA 2008 BIOLOGICAL RANKING OF IBD SUPPRESSION BMUS

BMU #	BMU NAME	Biological Ranking	Ha M-H Hazard	# Current Attack	# Infested Sites	G:R	Resource Value Comments
C30	Cranbrook	3	6,312	0	0		VQOs, recreation, range, ungulate winter range, domestic watersheds
C36	Mayook-Wardner	3	1,679	0	0		VQOs, ungulate winter range, recreation
C09	Yahk River	4	5,571	108	14	1	Wildlife, Eco Reserve, recreation, range
C10	Bloom-Caven	4	2,974	428	30	1.7	Ungulate winter range, wildlife, range, recreation, domestic watersheds
C21	Wildhorse	4	1,655	307	33	1.2	VQOs, wildlife, range, recreation
C37	Linklater-Englishman	4	4,964	24	8	0.5	Wildlife, range, recreation, domestic watershed
C23	West Elk	7	1,400	33	8	0.8	Community watersheds, biodiversity, recreation, VQOs, grizzly habitat, ungulate winter range, private timber (TF 27). District ranks as Priority 1 as it is a Community watershed
C08	Kimberley Watershed	8	332	26	3	0.8	VQOs, Community Watershed. District ranks as Priority 1 as it is a Community watershed
C11	Teepee Creek	8	860	6	6	0.5	Ungulate winter range, wildlife, range, recreation, domestic watersheds
C12	Cranbrook Watershed	8	330	48	6	1.2	VQOs, Community Watershed, Ungulate WR, Recreation. District ranks as Priority 1 as it is a Community watershed
C16	West Flathead	8	288	0	0	0	Grizzly habitat, recreation
C17	Upper Flathead	8	29	0	0	0	Grizzly habitat, recreation
C18	East Flathead	8	96	0	0	0	Grizzly habitat, recreation
C19	Corbin	8	24	0	0	0	Private timber (MF 27), grizzly habitat, recreation, wildlife
C20	Alexander-Line	8	68	0	0	0	Wildlife, range, recreation,
C21	Fording River	8	26	0	0	0	Private Timber (MF 27)
C24	Lower Elk	8	491	78	19	1	VQOs, wildlife, range, recreation, domestic watershed

6.52 Proposed Activities for Single Tree Treatment:

All single tree treatments under the tactical plan are to be carried out in Suppression BMUs only. Standards for these activities must follow the guidelines established for the Rocky Mountain Forest District and the Bark Beetle Management Guidebook (1995). Activities will be undertaken in a collaborative management effort between licensees, stakeholders, Ministry of Forests and Range, Ministry of Environment, private land holders and other concerned government agencies. Other management efforts that will form an integral part of an effective beetle management program will include timely harvest removal via single load or pockets of current attack, as well as larger block removal of infested or high risk stands.

Proposed single tree treatment activities in the Cranbrook TSA for 2008/09 include:

1. Detailed aerial surveys of all red attack identified in the MOFR Aerial Overview Surveys, including inoperable stands.
2. Ground surveys of detailed survey sites, and moderate to high susceptible stands in areas where risk of spread is identified as high.
3. Single Tree Disposal (Fall and Burn or Peel), focusing efforts in remote and/or inoperable areas along the BC/Alberta corridor.
4. Pheromone Baiting for anti-aggregation in high value stands, or for mop-up following single tree disposal.
5. Funnel Trap Monitoring and Mortality Surveys.
6. Tracking treatment activities and annual update of the TSA Forest Health Strategy.

6.53 Proposed Suppression Budget:

Funding has been allocated to the district from two different sources: Ministry voted funds and a Mountain Pine Beetle "spread control" funding initiative from the federal government (for use in forest district's that have a shared border with the Province of Alberta). Lead licensees will manage federal funds through recipient agreements with PricewaterhouseCoopers (a company that supplies the Province with audit and assurance services), and in consultation with the District Forest Health Specialist. Provincial funds will be managed at the district level by the Forest Health Specialist. The budget request detailed in the following tables identifies BMU treatment priority, estimated treatment activity units and estimated funding levels. It is realised that figures provided are based on a best estimate using historic survey and treatment data, along with local knowledge. As a result, the following Tables 9 and 10 will be utilised as a starting point and revision will occur periodically during the course of program delivery if/when funding allocations are assigned, when updated survey data becomes available, and when ongoing assessments of management strategy targets are jointly conducted by the lead Licensee and Forest Health Specialist.

TABLE 9 - CRANBROOK TSA 2008/09 SUPPRESSION BMU FEDERAL SPREAD CONTROL PLAN FOR IBM

BMU NAME	AGENCY	PRIORITY	AIR SURV $	AIR SURV HOURS	SURVEY $	SURVEY HA	F&B $	F&B TREES	TOTAL BMU $ REQUEST
Cbk Watershed	MOFR	1	6000	4	117000	1800	90000	500	$ 213,000
West Flathead	Crown-Tembec E	1	3000	2	2275	35	4500	25	$ 9,775
Upper Flathead	Crown-Tembec E	1	4500	3	22750	350	27000	150	$ 54,250
East Flathead	Crown-Tembec E	1	3000	2	1625	25	4500	25	$ 9,125
	Parks- (Ak Kish)	1	1500	1	0	0	0		$ 1,500
Corbin	Crown-Tembec E	1	6000	4	39000	600	76500	425	$ 121,500
	Tembec – MF 27	1	1500	1	11375	175	45000	250	$ 57,875
Alex-Line	Crown-Tembec E	1	4500	3	22750	350	72000	400	$ 99,250
	Tembec – MF 27	1	1500	1	6500	100	54000	300	$ 62,000
	Tembec – Private	1	1500	1	4875	75	9000	50	$ 15,375
	Parks (Crowsnest)	1	0	0	2600	40	3600	20	$ 6,200
Fording River	Crown-Tembec E	1	6000	4	19500	300	108000	600	$ 133,500
	Tembec – MF 27	1	1500	1	11375	175	36000	200	$ 48,875
	Tembec – Private	1	1500	1	11375	175	9000	50	$ 21,875
Upper Elk	Crown-Tembec E	1	12000	8	19500	300	90000	500	$ 121,500
	Parks (Elk Lks)	1	4500	3	13000	200	21600	120	$ 39,100
	Parks (HOTR)	1	6000	4	32500	500	90000	500	$ 128,500
Upper Bull	Crown-Galloway	2	6000	4	19500	300	63000	350	$ 88,500
Yahk River	Crown-Tembec E	2	3000	2	17875	275	9000	50	$ 29,875
	Crown-Tembec C	2	3000	2	9750	150	9000	50	$ 21,750
	Parks-(Gilnockie)	2	3000	2	6500	100	9000	50	$ 18,500
Bloom-Caven	Crown-Tembec E	2	4500	3	6500	100	12600	70	$ 23,600
Teepee Creek	Crown-Tembec E	2	4500	3	11375	175	12600	70	$ 28,475
Wigwam River	Crown-Tembec E	2	3000	2	6500	100	6300	35	$ 15,800
Lodgepole-Bighorn	Tembec E	2	3000	2	6500	100	6300	35	$ 15,800
	Tembec – MF 27	2	3000	2	6500	100	6300	35	$ 15,800
14 BMUs			$ 97,500	65	$ 429,000	6600	$ 874,800	4160	**$ 1,401,300**

TABLE 10 - CRANBROOK TSA 2008/09 SUPPRESSION PLAN FOR IBD

BMU NAME	AGENCY	PRIORITY	AIR SURV $	AIR SURV HOURS	SURVEY $	SURVEY HA	TREAT $	TREAT UNITS	TOTAL BMU $
Kimberley Watershed	MOFR	1	0		1125	25	2250	10	$ 3,375.00
Yahk River	MOFR	1	0		450	10	0		$ 450.00
Bloom-Caven	MOFR	1	0		450	10	2250	10	$ 2,700.00
Teepee Creek	MOFR	1	0		450	10	0		$ 450.00
Cranbrook Watershed	MOFR	1	0		2250	50	0		$ 2,250.00
Corbin Creek	MOFR	1	0		450	10	0		$ 450.00
Alexander-Line	MOFR	1	0		450	10	0		$ 450.00
Fording River	MOFR	1	0		450	10	0		$ 450.00
Upper Elk	MOFR	1	0		450	10	0		$ 450.00
West Elk	MOFR	1	0		1125	25	2250	10	$ 3,375.00
Lower Elk	MOFR	1	3000	2	1125	25	2250	10	$ 6,375.00
Wildhorse-Steeples	MOFR	1	1500	1	1125	25	2250	10	$ 4,875.00
Cranbrook	MOFR	1	0		450	10	0		$ 450.00
Mayook-Wardner	MOFR	1	0		450	10	0		$ 450.00
Teepee Creek	MOFR	1	0		450	10	0		$ 450.00
West Flathead	MOFR	1	3000	2	450	10	0		$ 3,450.00
Upper Flathead	MOFR	1	1500	1	450	10	0		$ 1,950.00
East Flathead	MOFR	1	3000	2	2250	50	2250	10	$ 7,500.00
18 BMUs			$ 12,000	8	$ 14,400	320	$ 13,500	60	**$ 39,900.00**

6.6 Performance Measures for Beetle Management

Beetle management in the TSA will be assessed annually using the following three performance measures required by the Ministry of Forests and Range:

1. Survey and Detection
   Area (ha) and % of susceptible forest land base that has been surveyed and where existing infested areas have been identified, evaluated, and assigned a management strategy.

2. Treatment
   Percent of currently infested trees (can also use volume/ ha. or sites to track, but must be reported in tree units) removed/treated annually, prior to the beetle flight period (does NOT include areas baited where no other action was carried out). Aerial overview survey data provided by MOFR will be overlaid onto detailed aerial survey data collected by the Lead, and other licensees. Overlapping infestations recorded in both surveys will be used as the maximum number of infestations to be treated by the next beetle flight. Lead licensees will be required to track which of the "target" infestations have been treated. The percentage of target infestations treated will be reported by July 1st annually.

3. Plan Achievement
   Percent of each strategy that has been achieved.

6.7 *Bark Beetle Monitoring Plan for IBM*

At the current harvest level the term to address the mature Pl component of the timber profile on the Timber Harvesting Land Base is 49 years. In order to assess harvest capacity in managing recent exponential increase in mountain pine beetle populations, the TSA Forest Health sub-committee has identified the following four "trigger" factors that must be collectively examined bi-annually (pre and post-flight) to determine if an AAC uplift request is warranted.

Factor 1 - Landscape level outbreak
Experiencing increasing current to red attack ratios, less spot and more patch infestations building, continued exponential population expansion predicted from mortality survey results, and decreasing chance of reducing/maintaining populations despite aggressive management activities.

Factor 2 **-** Unattainable BMU Treatment Targets:
If treatment targets are not being achieved, requiring management shifts from suppression into containment BMUs, and non-recoverable losses are increasing beyond 6% of AAC (DM direction – which equates to at or above, 56,000m^3/yr).

Factor 3 - Unacceptable proportion of AAC containing affected volume not being addressed before next beetle flight:

Pre-flight (June):	Carry-over of Priority 1 & 2 volume exceeds 25% of AAC:
Post-flight (September):	75 to 125% of AAC contains infested volume

Factor 4 – Determining proportion of Priority 1 & 2 volume that is unconstrained

7.0 REFERENCES

British Columbia Ministry of Forests. 2003. Provincial Bark Beetle Management Technical Implementation Guidelines http://www.for.gov.bc.ca/hfp/health/fhdata/bbstrategy.htm

British Columbia Ministry of Forests 2003. TSA Forest Health Strategy Template http://www.for.gov.bc.ca/hfp/health/fhdata/template.htm

Chapman, Bill. 2000. Hypholoma Fasiculare Inoculation Evaluated as a Means to Control Armillaria Root Disease on Calcareous Soils. Extension Note EN-54. Nelson Forest Region, BCMOF. Nelson, BC.

Curran, M., Sacenieks, K., and Begin, E. 2000. Effects of Harvest Season and Root Rot Treatment on Sensitive Soils in the Rocky Mountains: trail establishment. Extension Note EN-49. Nelson Forest Region, BC MOF. Nelson, BC.

Duncan, R.W.. 1996. Common Pitch Moths of Pine in British Columbia. Forestry Pest Leaflet 69. Pacifac Forestry Centre, Canadian Forest Service, Victoria, BC.

Henigman, J., Ebata, T., Allen, E., Westfall, J., and Pollard, A. 2001. Field Guide to Forest Damage in BC. Joint Publication Number 17. Canadian Forest Service and BC Ministry of Forests.

Hodge, J. 2002. Third Year Assessment of Northern Pitch Twig Moth. Permanent Sample Plots in the Invermere TSA; including interim management and free growing damage criteria recommendations.

Kipfumueller, K.F. and Baker, W.L. 1998. Fires and Dwarf Mistletoe in a Rocky Mountain Lodgepole Pine Ecosystem. Forest Ecology Management. 108:77-84.

Kischuk, B., Maynard, D., and Curran, M. 1999. Calcareous Soils. Technology Transfer Note Number 15. Pacifac Forestry Centre, Canadian Forest Service. Victoria, BC.

Maher, T. 1990. Damage Appraisal and Pheromone Trapping Studies for the Black Army Cutworm in British Columbia. FRDA Report 117.

Morrsion, D.J., Pellow, K.W., Nemec, F.L., Norris D.J., and Semenoff, P. 2001. Effects of Selective Cutting on the Epidemiology of Armillaria Root Disease in the Southern Interior of British Columbia. Canadian Journal of Forest Research. 31:59-70

Murphy, D.G., and Associates and D. Smith Forestry Consultants Ltd. 2001. Larch Dwarf Mistletoe Operational trail, St. Mary's River Road Plot Re-measurement. Unpublished report to BCMOF, Cranbrook Forest District, Cranbrook, BC.

Norris, D., McLaughlin, J., and Curran, M. 1998. Armillaria Root Disease Management Guidelines for the Nelson Forest Region. Technical Report Number 14. Nelson Forest Region, BCMOF, Nelson, BC.

Phero Tech Inc. 2000. Bark Beetle Management Plan for the Invermere Forest District. Unpublished report prepared for BCMOF, Invermere Forest District, Invermere, BC.

Steeger, C., Machmer, M.M. 1995 Wildlife Trees and Their Use by Cavity Nesters in Select Stands of the Nelson Forest Region. BCMOF Technical Report Number 10.

Swift et al. 2002. Stand Establishment Decision Aids. http://www.forres.org/projects/2002/seda/homepage.asp

Watson, D.M., 2001. Mistletoe: A Keystone Resource in Forests and Woodlands Worldwide. Annual Review of Ecology and Systematics. 32-219-340.

White, E.E., Allen, A., Ying, C.C., and Ford, B.M. 2000. Seedling Inoculation Distinguishes Lodgfepole Pine Families Most and Least Susceptible to gal Rust. Canadian Journal of Forest Research. 30:841-843.

Wu, H.X. and Ying C.C. 1998. Stability of Resistance to Western Gall Rust and Needle Cast in Lodgepole Pine Provenances. Canadian Journal of Forest Research. 28:439-449