Evaluating Mountain Pine Beetle Management in British Columbia

Special Report

Forest Practices Board

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Introduction

Lodgepole pine is an abundant species in the interior of British Columbia (BC) and is important to the region's forest economy. It is present in 9 of the 12 biogeoclimatic zones, occurring in 6 million hectares of forest across the region. Pine supplies as much as 80 percent of the annual timber harvest in some central interior forest districts and comprises 25 percent of the province's timber supply.

Mountain pine beetles (MPB) are native to BC. They feed on hosts such as lodgepole pine and other pine species, affecting an average of 50,000 hectares of forest in the province each year. Generally, lodgepole pine becomes susceptible to attack from MPB when the trees reach at least 15 centimetres in diameter, and the bark becomes thick enough to support large larval populations. Young trees can resist the larval attack initially but resistance decreases as the trees age. As MPB populations increase beyond a critical threshold, they can even overwhelm the defences of young trees. Populations then typically increase to outbreak levels and remain there until the supply of susceptible lodgepole pine is depleted, or a cold winter reduces MPB populations to below critical numbers.

A large area of BC's central interior is currently experiencing a MPB outbreak. Since 1997, MPB populations have increased dramatically; infesting over 80 million trees, spread over 300,000 hectares of forest within central interior districts. Recent data show their outbreak continuing to expand, with a fourfold increase of MPB population reported in the central interior over the past year.

The current strategy of the Ministry of Forests is to conduct aggressive sanitation harvesting, targeting recently infested or 'green attack' trees. The principal goal is to mitigate timber losses and to reduce the rate of MPB spread. Recently, this approach, termed 'leading edge harvesting', has formed up to 30 percent of all logging undertaken in the interior of the province, and over 80 percent in some interior districts. (By contrast, salvage refers to logging dead trees in order to capture their economic value before the timber is depleted beyond merchantability.) The 2001 *Bark Beetle Regulation* (BBR) was introduced to streamline the process of quickly harvesting newly infested stands. BBR provided an option for forest managers to pursue the current MPB management strategy with reduced administrative requirements.

Outbreaks of MPB have important economic and social consequences. For example, MPB are infesting 5 million cubic metres annually in the Lakes Timber Supply Area (TSA), twice the volume of timber cut each year in the district. In August 2001, pressure to mitigate and salvage MPB-killed timber prompted the chief forester to increase the annual allowable cut (AAC) substantially in the Lakes, Prince George and Quesnel district TSAs. Further increases to AAC levels are currently being proposed, primarily directed at salvage logging. These increases could disrupt forest plans, stretch harvesting capacity and oversupply markets.

A special report into MPB management is of public interest due to the size of the MPB epidemic and the potential impact of the infestation and related harvesting on forest health, the environment and the economic prospects of forest-dependent communities. This report focuses on:

- Compliance with the Forest Practices Code;
- Effectiveness of the forest health program in addressing the MPB epidemic and recovering timber losses; and
- Effectiveness of practices in protecting key environmental values.

Information in this report was obtained from field investigations in three landscape units, in two forest districts. A compliance audit was undertaken in the Hallett landscape unit in Vanderhoof district and effectiveness investigations were completed in the Cheslatta and Burns Lake East landscape units in Nadina district.

Compliance with the Forest Practices Code

The audit found the licensees operating in the Hallett landscape unit to be in compliance, in all significant respects, with the Forest Practices Code's planning and practices requirements as they relate to MPB management within the audit area for operational planning; harvesting; road construction, maintenance and deactivation; site preparation; planting; and fire hazard abatement, for activities between September 1, 2002 and September 26, 2003.

The Report from the Auditor (Part 2) provides further details on the location of the audit, scope of the audit findings and audit procedures.

Effectiveness of the Forest Health Harvest Strategy in Managing the Mountain Pine Beetle Epidemic

The efficacy of the MPB harvesting strategy in achieving forest health objectives, slowing the MPB infestation and meeting timber objectives was tested using a computer simulation model (SELES-MPB). The goal was to assess the actual forest harvesting that took place in two landscape units (Cheslatta and Burns Lake East) within the Lakes TSA between 1997 and 2003 to determine the effectiveness of this MPB management relative to other plausible management strategies.

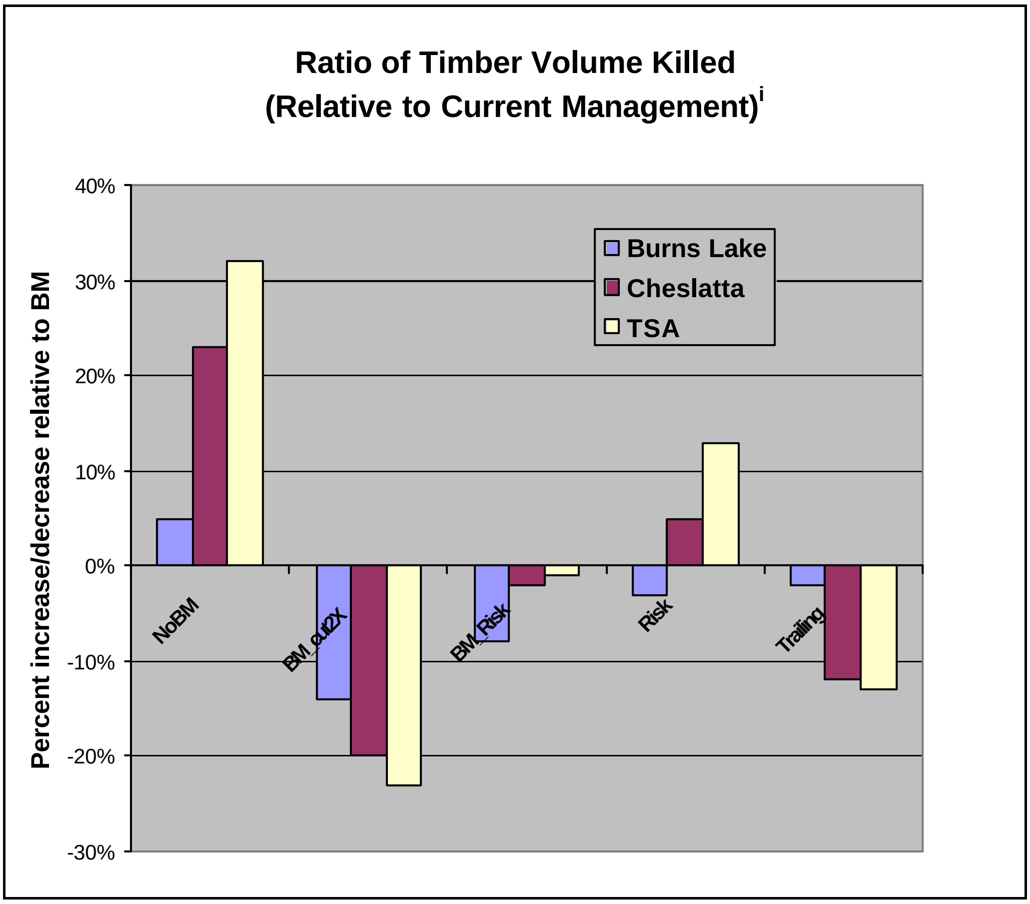
The harvest scenarios that were modelled and compared were:

- The main reference scenario (actual beetle management or BM). In this scenario, stands identified as 'leading edge' (trees attacked within the last year) have highest priority, followed by high levels of salvage and then stands at high risk of MPB infestation.
- NoBM: Same level of harvest as in reference scenario, but applying an oldest-first harvest rule that ignored MPB.

- Variations on the reference scenario (BM), by varying the amount of harvest in the landscape units (LUs) and the Lakes TSA.
- BM_RiskFocus: Harvest priority is first targeted at 'leading edge' as in the BM scenario, but secondary preference is changed to stands at high risk of MPB infestation instead of salvage.
- RiskFocus: Harvest priority first targets stands at high risk of MPB infestation, followed by 'leading edge' and then salvage opportunities.
- TrailingEdge: harvest priority first targets stands with high levels of salvageable timber, followed by 'leading edge'.

Figure 1 presents the modelling results of the percentage change in timber volume killed under various management strategies relative to actual management.

Figure 1: Relative increase (positive values) or decrease (negative values) of timber volume killed in the total harvesting landbase under various management strategies over 'actual beetle management' (BM).



[i] A value of +x% means the scenario resulted in an increase of x% volume killed over the level estimated for current management.

Changing harvest priorities, compared to actual MPB management, had the following effects:

- NoBM: The timber volume killed was 32 percent higher in Cheslatta LU and 50 percent higher in the TSA.
- BM_cut2x: Doubling the cut resulted in 10-20 percent less timber loss.
- BM_RiskFocus: Changing the secondary focus from salvage to high risk stands (but otherwise targeting 'leading edge' first) had little impact.
- RiskFocus: Shifting to a risk focus (i.e., targeting high risk stands before 'leading edge') led to increased MPB-killed timber in Cheslatta and the Lakes TSA (by over 10 percent), but a slight reduction in Burns Lake East. This strategy appears to be reasonable at low infestation levels where tree removal has the potential to circumvent the outbreak. However, it does not appear to be effective in areas with a large MPB outbreak and a substantial amount of MPB-infested trees.
- TrailingEdge: Shifting to a 'trailing edge' focus reduced MPB-killed timber impacts significantly in Cheslatta and the Lakes TSA, but not in Burns Lake East. Such stands likely contain a mixture of recent attack, attack that is one to a few years old and some unattacked trees. These stands may actually serve to both recover salvage volume that is relatively young (and hence still quite valuable) and to reduce MPB population levels significantly (and perhaps achieve greater population reductions than in 'leading edge' stands that may exhibit some detectable attack, but may not yet contain large numbers of MPB).

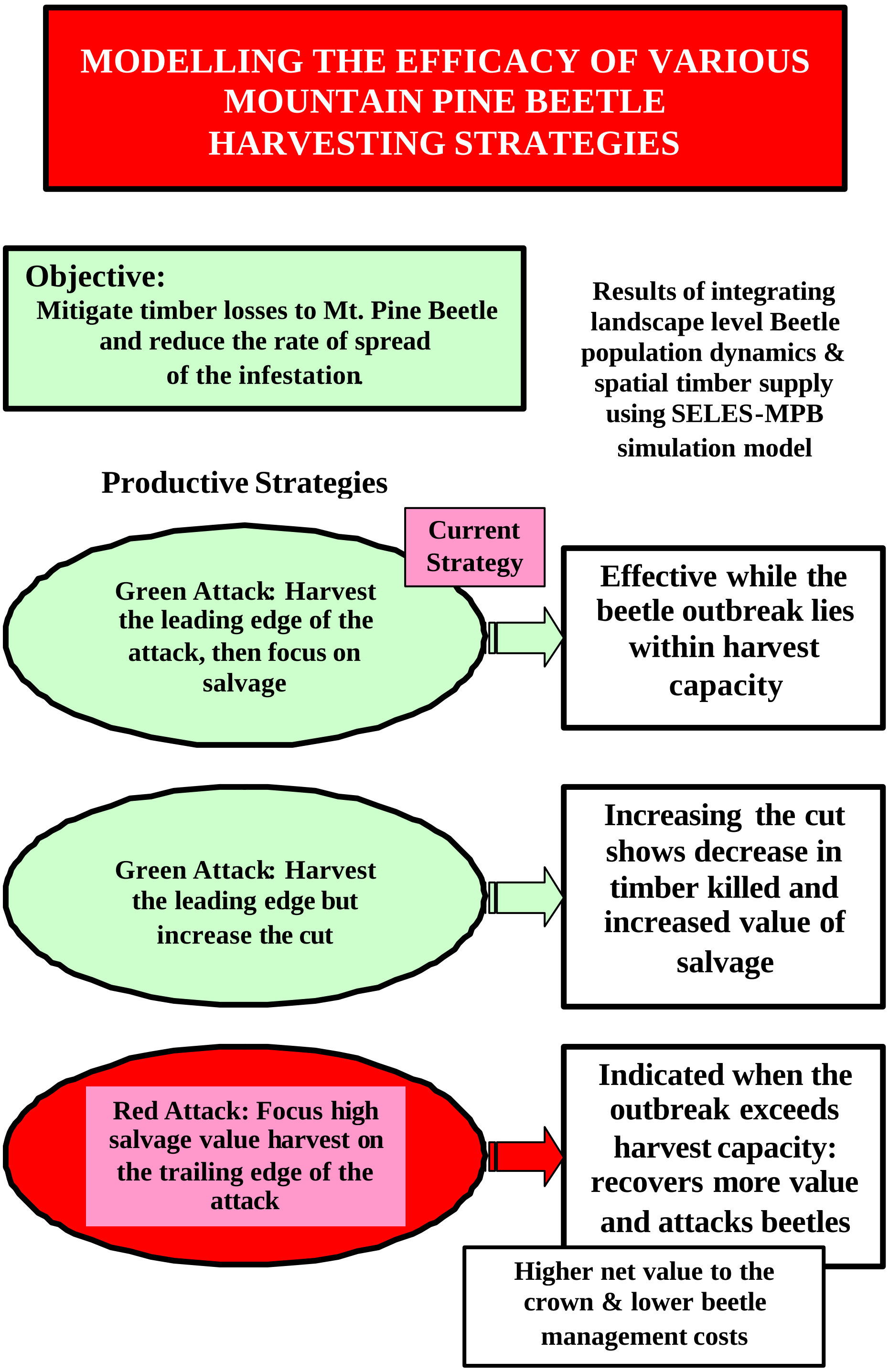
Actual beetle management performed at least as well as most of the various management strategies, with the exception of doubling the harvesting in the LUs and the TrailingEdge strategy outlined above.

The portion of the timber volume killed that is at risk of being lost to decay before it could potentially be salvaged, was also examined. Actual beetle management performs at least as well as most scenarios with the exception of doubling the harvest and TrailingEdge. The 'trailing edge' strategy reduces timber risk modestly in Cheslatta (10 percent) and substantially over the TSA as a whole (50 percent).

In conclusion, the computer simulation model indicates that the effectiveness of forest harvesting operations, in protecting forest health against the MPB outbreak and maintaining timber values, over the 1997-2003 period, were reasonable given the scale of the outbreak in this area. There was approximately a 25 percent improvement in minimizing timber losses over management approaches that ignored MPB activity (no beetle management strategies). Most alternative management strategies did no better at reducing MPB impacts.

The only exception to this was the 'trailing edge' strategy (which effectively focuses on the areas with high levels of early salvage). In conditions where the outbreak exceeds current harvest levels (such as the Cheslatta landscape unit), it may be more appropriate to switch to a 'trailing edge' strategy with a focus on high-value salvage opportunities. These concepts are summarized in Figure 2.

Figure 2: Modelling the efficacy of various mountain pine beetle harvesting strategies.



A significant and growing portion of the MPB-affected areas in BC have reached infestation levels that would support the implementation of a trailing edge strategy. As the 'trailing edge' of the outbreak has both high levels of salvage and MPB populations, this strategy appears to have relatively high effectiveness in terms of both maximizing salvage recovery and reducing MPB populations.

In addition to reduced timber impacts, a 'trailing edge' strategy may have reduced operational costs and generated higher net stumpage revenues to the Crown over the course of the outbreak (since salvage is undertaken in stands that have been killed relatively recently).

Maintaining Environmental Values at the Landscape Scale

The effectiveness of forest development planning in maintaining environmental values at the landscape scale was evaluated using three indicators. Landscape-level biodiversity objectives were evaluated by examining the age classes of the remaining forest (seral stage) and the areas of patches of even-aged forest (patch size distribution) and comparing these to recommended levels in the *Biodiversity Guidebook*. The risk of high peak flow in streams, due to more rapid snowmelt in clearcuts, was evaluated by examining the clearcut area in all of the watersheds of the two landscape units.

Compliance with landscape biodiversity objectives for the Cheslatta and Burns Lake East landscape units was examined by analysing the forest age class distribution and the distribution of patch sizes. With the exception of a small area of the Burns Lake East landscape unit, harvesting over the past 20 years has not altered the seral distribution beyond the recommended levels. There is currently a significant surplus beyond the recommended levels in the mature and old categories. The patch size analyses suggest that future harvest planning should consider aggregating new cutblocks with existing cutblocks to bring more patches into the 80 to 250 hectare range or into the 250 to 1000 hectare range, depending on the vegetation zone.

A risk of high peak flow in streams was not found to be a common problem in Cheslatta or Burns Lake East landscape units at the present time. Three watersheds in Cheslatta landscape unit (out of 12) are rated as having a high clearcut area; two others in Burns Lake East had moderate clearcut areas. There is a risk, however, if the current intensity of the MPB infestation continues, and is followed by an aggressive salvage program, that the risk of increased peak flows in some watersheds could become very high. Future salvage harvest should be planned such that all areas of green tree forest (non-pine stands, younger age class pine stands, and uninfested older age class pine) are retained to moderate hydrological impacts.

Effectiveness in Achieving Environmental Values at the Site Level

The effectiveness in achieving site-level objectives for soil, riparian, stand-level biodiversity and future forest (stocking) values was examined in the field using a system of criteria and indicators. The results are:

Overall soil conservation values have been maintained. The area occupied by permanent structures is appropriate for the sites. The temporary roads, however, have not yet been rehabilitated and restocked. The overall level of dispersed and concentrated soil disturbance was low, with the exception of four blocks where small portions of the blocks exceeded recommended levels of soil disturbance.

Riparian (streamside) values are being maintained at the site level. Riparian objectives for channel and bank stability, supply of large woody debris, connectivity, sediment inputs, and shade are being achieved.

Overall, the implementation and effectiveness of measures for stand-level biodiversity through wildlife tree patches was considered high. The majority of wildlife tree patches contained features such as wildlife trees or nest sites. Most patches had similar ages and species of trees to that of the harvest unit. Partial cutting or windthrow had not diminished the value of the wildlife tree patches. The patches were considered to provide high ecological value.

It is too early yet to determine whether stocking objectives are being met. At the time of the field survey, most cutblocks had not yet been restocked but all have plans for reforestation. The temporary roads have not yet been rehabilitated and restocked. The lag is within the allowable Code regeneration time window, but raises concerns about the magnitude of the restocking task when upcoming salvage areas are added to the current unplanted area.

For all four environmental values, no significant difference was found between the environmental impact of conventional forest development plan blocks and blocks harvested under the *Bark Beetle Regulation* (BBR), even though the BBR removes many administrative requirements. As BBR is a results-based planning regime, this is a hopeful sign for future harvesting under the results-based *Forest and Range Protection Act*.

Conclusions

An important conclusion of this report is that the current MPB-related forest harvesting program, in the Hallett, Cheslatta and Burns Lake East landscape units, fully complies with the Forest Practices Code and has been effective in maintaining key environmental values. Some improvements can be made by reducing areas of concentrated soil disturbance and aggregating cutblocks into larger openings.

The MPB program, focusing on 'leading edge' or 'green attack' harvesting has also been reasonably effective in reducing timber losses to MPB attack. However, the harvesting has not slowed the spread or intensity of the infestation significantly. Also, when under epidemic conditions, the current focus on newly-infested trees may not be the most optimal strategy in reducing timber losses to MPB attack.

Harvesting stands at the 'trailing edge' of the infestation, where there are high levels of salvage and high MPB populations, appears to be more effective in terms of both salvage recovery and

MPB population reduction. A ‘trailing edge’ strategy may also offer reduced operational (e.g., MPB probing and small-scale salvage blocks are not required) and administrative costs (the emergency nature of block layout and approval is reduced), and higher net value to the Crown over the course of the outbreak (since salvage is taken when relatively recently killed). The ‘leading edge’ strategy is still appropriate for endemic attack areas.

These conclusions are made just prior to the commencement of a large-scale salvage program in the Lakes, Prince George and Quesnel TSAs. The salvage program strategy will have to include plans for reforestation, areas of retained forest, maintenance of riparian forest and wildlife tree patches, as well as adherence to best management practices to maintain this encouraging environmental record.

Part 1: Biology and Management of the Mountain Pine Beetle

Biology of the Mountain Pine Beetle

The mountain pine beetle (MPB) is native to North America and it ranges throughout the pine forests from northern British Columbia and western Alberta south into northwestern Mexico. While the MPB is most commonly known to attack lodgepole pine, it also attacks a variety of pine species including ponderosa pine, white pine, and whitebark pine in British Columbia.

The MPB takes usually 1 year to complete its life cycle and develops through four stages: egg, larva, pupa and adult. Except for a few days during the summer when the adults emerge and fly to new trees, all stages are spent under the bark of infested trees. Flights can begin in June as the weather warms and the air temperature reaches 18 degrees celsius, but generally occur in July and August and can also extend into early fall. Emergence may occur over a period of several days to several weeks. The dispersal season is the only time in its life history when the MPB are exposed to the environment and typically lasts less than 24 hours. A significant proportion of MPB population also move out of its original stands and is blown to new areas by wind currents. The MPB carried by high wind current can travel many kilometres before attacking new trees.

Colonization of the tree begins once a MPB has accepted the host, which is exclusively standing live pines. Once a female MPB has found a suitable tree, she will give off a scent, a pheromone, which attracts other MPB to the tree. The MPB are first attracted visually to the trees and stimulated by feeding. Secondly the MPB respond to pheromones produced by the pioneer MPB. This is known as secondary attraction. MPB responding to secondary attraction have increased chances of success due to the proven nature of the host and reduced dispersal time. If the infestation level within the stands is endemic, (at natural low population levels) then the MPB generally attacks trees which are physiologically weakened. Under epidemic conditions it kills healthy, vigorous trees.

If MPB attacks are to be successful, the attacking insects must be present in sufficient numbers to overcome the resistance of the tree. The tree's protection mechanism is to produce sap in order to expel or 'drown' the invading insects. In order for MPB to successfully overcome the defence mechanisms of the tree, large numbers of MPB must aggregate and attack within a very short time. This behaviour is known as mass attack.

Egg laying occurs in late July through mid-August. As a pair, male and female MPB burrow under the tree bark creating an egg gallery which is nearly straight and vertical. Once the eggs hatch, after two weeks, small white larvae eat the tissue between the tree bark and the wood. These feeding tunnels extend at right angles to the egg galleries.

Finally, from mid to late July, mature MPB bore out of the bark and attack new hosts, thereby completing the cycle.

The MPB carry a fungi on their bodies, which when introduced to the tree's sapwood, creates a blue stain. As the fungi develop and spread throughout the sapwood, they interrupt the flow of water to the crown. The MPB larva eating the tissue under the bark, combined with the blue stain fungus in the sapwood, strangles the tree's circulatory system. If there are enough MPB feeding around the entire bole of the tree, the tree is killed within a year of initial attack. If only portions of the tree are attacked, say on one side only, the tree will survive, albeit not as healthy. It is quite possible that the surviving tree can be re-attacked in subsequent years.

Temperature affects both rate of development and survival of the MPB. Cool summers prolong development and cause the broods to require two years for development. Cool summer temperatures also cause the MPB flight to be late, and late flights decreased the chance of a hatching before winter. Survival of all stages is reduced by cold temperatures and extremely high summer temperatures. Come late fall, the MPB larva create a form of antifreeze (glycerol) which helps prevent them from freezing during the winter. The glycerol can protect them from temperatures as low as –35 degrees celsius.

Symptoms of Mountain Pine Beetle Attack

Generally MPB attack the large trees that are older than 80 years. The MPB invade the truck of a tree and bore holes through the bark. In doing so, the pine trees try to expel the adult MPB by producing lots of sap. The sap flows out of the hole made by the MPB, forming a small whitish cone or tube. Examining the infested trees reveals the presence of pitch tubes. Successfully infested trees will also have dry boring dust, similar to fine sawdust, in bark crevices and around the base of the tree. Sometimes, however, infested trees can have boring dust, but not pitch tube.

The terms green, red, and grey attack are based on foliage and stand coloration. Green attack refers to most recently attack trees containing brood and generally still retaining their green foliage color. Green attack can only be assessed by ground surveys. Once a tree is infested and it begins to be choked by the MPB, the needles will begin to fade and turn red. This occurs in the year following the initial attack. Yearly surveys make note of the 'red attacked' trees as a starting point to look for the current MPB infestation. Trees containing no brood that have been dead for more than a year and lost most of their foliage are referred to as grey attack.

What are the Contributing Factors to the Current Infestation?

A few key factors have contributed to the current MPB infestation. Warmer winters and summers have resulted in the MPB infestation recently expanding into areas previously unsuitable. For example, the MPB infestation is occurring further north and at higher elevations. The hot and dry summers leave pine drought-stressed and more susceptible to attack by the MPB.

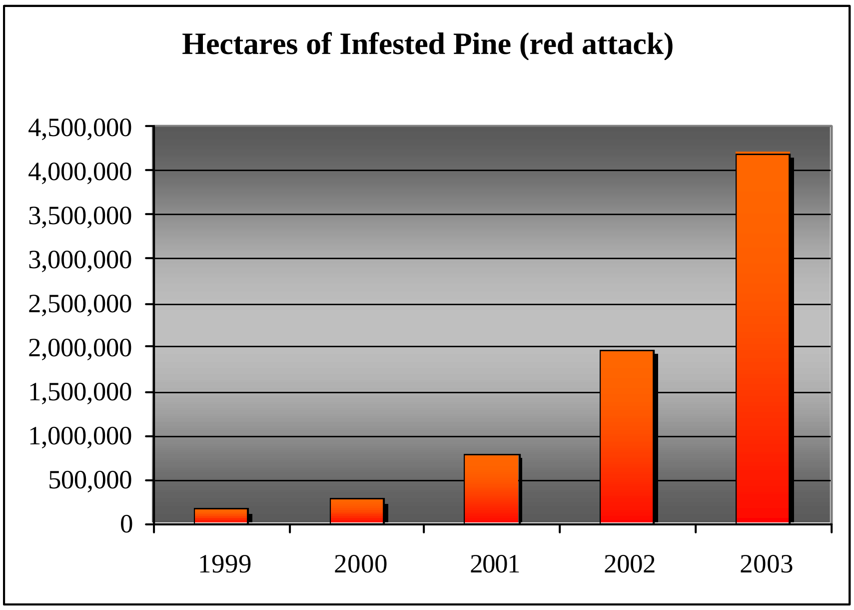
The amount of mature pine has also increased. In 1910, there was approximately 2.5 million hectares of mature pine (trees older than 80 years old) and that grew to about 8 million hectares in 1990.

What is the Volume of Infested Wood?

The Province of BC has approximately 14.9 million hectares of lodgepole pine. Of that, over 8 million hectares are mature – over 80 years old –and susceptible to attack.

The MPB infestation has been growing in size and severity since 1994, when it covered 164,000 hectares. Estimates for 2003 indicate that red attack areas have doubled and cover about 4.2 million hectares[1] (Figure 3). Generally speaking, the infestation has been doubling in size every year.

Figure 3: Areas of infested pine in BC, from provincial overview surveys.

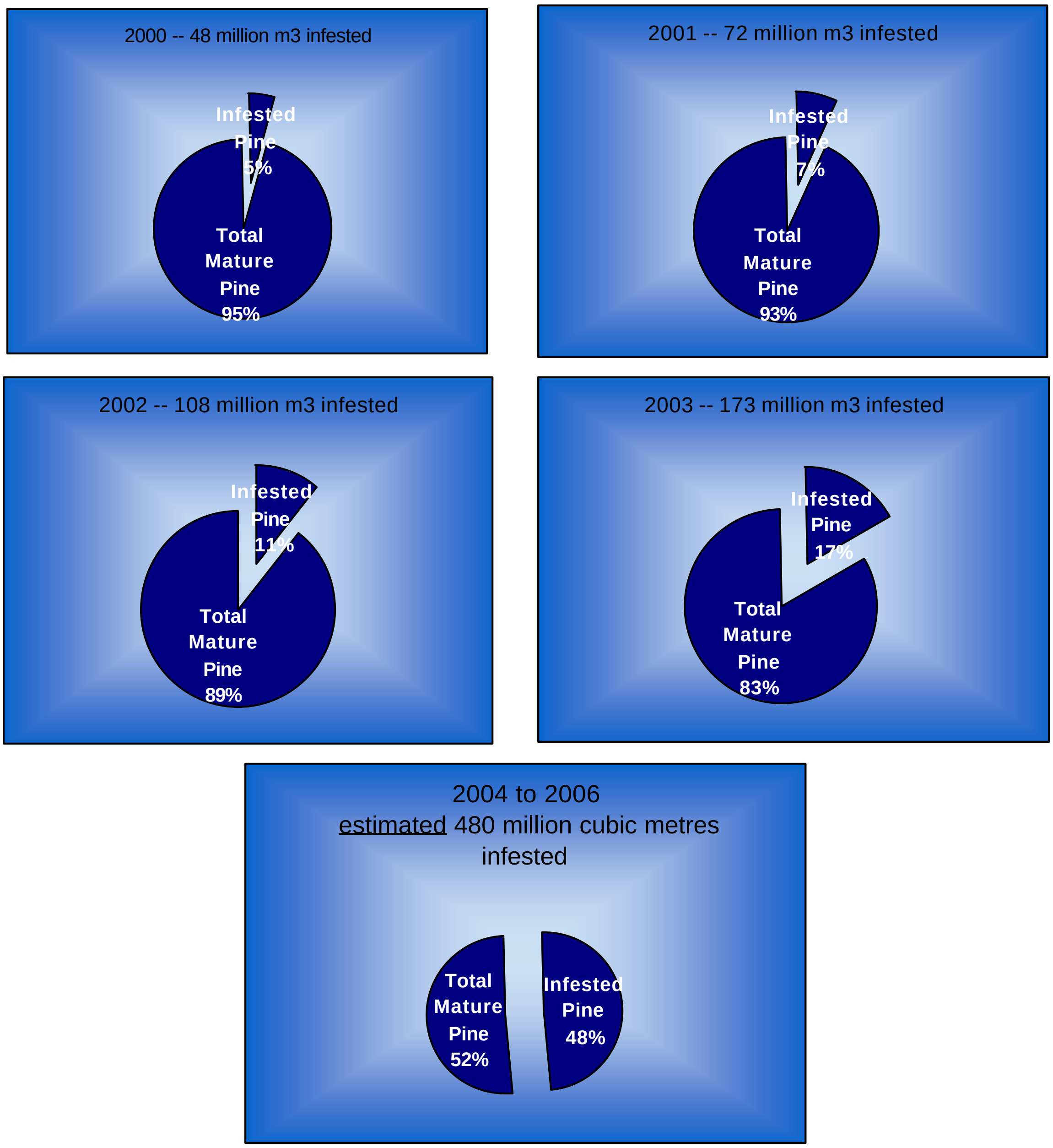


One concern with the MPB infestation is being able to determine how much of our forests are affected. The level of infestation in a stand varies significantly from 15 percent infested to 100 percent; and taken out of context the numbers may be overstated. As well, the Ministry of Forests MPB aerial surveys were not standardized until 1998, making it difficult to compare numbers year to year.

[1] A summary of Ministry of Forests aerial surveys for 1999-2002, Forest Practices Branch. The areas are not cumulative.

The following charts (Figure 4) indicate the volume of pine (in cubic metres) infested by the MPB has grown from 48 million in 2000 to 173 million in 2003. That means, that approximately 15 percent of all the mature pine in BC has some level of MPB infestation. The total amount of wood infested is approximately 2.5 times the allowable annual cut of 72 million cubic metres. The Chief Forester notes in his *Timber Supply and the Mountain Pine Beetle Infestation in British Columbia - October 2003* report that it is possible, that if BC continues to have warm weather over the next 3 years, the amount of wood infested could reach 480 million cubic metres. The Ministry of Forests Research Branch (Eng et al, 2004) is even more pessimistic, modeling that the ultimate MPB spread will consume 1 billion cubic metres.

Figure 4: The cumulative portion of MPB-infested pine in BC, by year.



Forest Health Strategies

The provincial map of the Emergency Bark Beetle Management Areas (EBMA) designates those areas with significant MPB populations where the *Bark Beetle Regulation* (BBR) applies. These areas are subdivided into emergency management units (EMUs). The management zones are: Aggressive Management; Containment; and Salvage/Limited Activity. The classification of the management zone is determined by the nature of the infestation in the area and composition of the forests.

Within each EMU management zone are several Beetle Management Units (BMUs) that are assigned one of four specific MPB management strategies: Suppression; Holding Action; Salvage; and Monitor. The most common management zone is Aggressive Management, where BMUs are mostly assigned suppression strategies. The goal in Aggressive Management zones is to kill 80 percent of the MPB brood in the first year and 100 percent in the second year before the next MPB flight. Green attacked trees are the priority. By achieving these targets, it has been shown that local MPB populations can be controlled and reduced to endemic levels.
The remaining management zones, Containment and Salvage/Abandon, will have a mix of BMU strategies. The target in the Containment zone is to slow the expansion rate of the MPB infestation by eliminating 50 to 80 percent of the MPB population. The Salvage/Abandon zones will have predominately monitoring strategies, although some BMUs may have suppression strategies when there are high resource values that might be protected if not infested. The holding strategy is applicable to chronically infested stands where the MPB population has collapsed but where there are still susceptible stands.

Operational Planning

MPB related harvesting has taken place under three different operational planning regimes:

- Forest development plans
- Small-scale salvage
- *Bark Beetle Regulation* (BBR)

The most volume has been harvested using regular Code forest development plans. The *Operational Planning Regulation* required the licensee to evaluate any forest health factors causing damage in its operating area. If risks were significant, the licensee was required to propose strategies to reduce those risks during the term of the forest development plan. Harvesting and road construction are subject to the same approval processes and restrictions on cutblock size as elsewhere.

In order for forest harvesting to be used as a control option for MPB, the planning and permitting process must be conducted in an effective time frame. Ideally, infestation centres located in August should be harvested or destroyed within 9 months (before the next MPB flights in June). There should be no MPB flights between identification of the infestation and harvesting. However, the time taken to monitor and map the MPB infestation centres and then to propose cutblocks in a development plan for public review and comment could easily take 6 months to one year.

Because of the dynamic nature of MPB spread and the suppression of green attack being the most common strategy, it has been difficult to expedite plan approvals quickly enough. On December 10th, 2001, the BBR was proclaimed. To facilitate timely treatment, certain portions of the Forest Practices Code were waived, specifically:

- providing maps and schedules in the forest development plan, including showing road locations
- requirement for a silviculture prescription

Harvesting is restricted to trees with brood and incidental uninfected trees that must be removed to harvest infested trees. No more than 5,000 cubic metres of timber may be removed from one opening, not taking into account timber from the road. The maximum clearcut size is 15 hectares. Special standards for exempted operations include:

- ensuring soil disturbance does not exceed 10 percent
- re-establishing natural surface drainage on an access trail
- minimizing soil erosion and sediment delivery risk to streams
- if the opening is greater than 1 hectare, establishing a free-growing stand within 15 years

The BBR has been extensively used by some licensees, but not by others; the chief reason being the 15 hectare maximum clearcut size.

Tactics

The tactics of the MPB forest health program include:

1. detecting the location of the MPB
2. treatments to reduce MPB populations to acceptable levels.
3. salvage of MPB-killed timber

Detection

The first step in managing forest health and MPB is to locate the MPB. Managers use the aerial surveys and ground surveys to understand MPB population trends and determine the placement, size, and shape of cutblocks.

There are two types of aerial surveys – overview and detailed. Overview surveys are conducted annually using fixed wing aircraft, commonly mapped at 1:100 000 or 1:250 000 in scale. This helps in identifying the general areas under attack and aids in tracking the growth or decline of the infestation. For planning operations, licensees and the MOF conduct detailed surveys at 1:30:000. At this scale, red attack areas can be accurately mapped.

To locate MPB for operations, managers use either walk-throughs or probes. Generally, managers locate red attack trees from aerial surveys and look for current green attack trees in the vicinity. Walk-throughs are informal surveys which consist of someone walking an area and keeping notes of what they see. The information gathered is not statistically based. Walk-throughs are useful to identify pockets of MPB infestations and sometimes they are sufficient to plan harvesting cutblocks when infestations are heavy and uniformly located in the stand.

MPB probes are formal surveys that provide statistically based information on MPB infestations and timber volume. The probes consist of a series of parallel strip surveys in a forest stand. Probes collect detailed stand and infestation information that is useful in determining exact levels of infestation and in identifying areas that have small pockets of MPB infestation or scattered levels of MPB.

Types of Treatments

The most common method of control of MPB is conventional harvesting. Clearcutting is the most economically efficient treatment. Alternative treatments include small-scale treatments such as patch cuts, selection harvesting followed by burning treatment, and application of pesticides. Individual tree or patch felling and burning is mostly used where recovery of the wood is not practical. A variation of fall and burn is controlled burns, to target whole stands of trees where harvesting is not an option.

The third method of killing MPB is the injection of Monosodium Methanearsonate (MSMA) into the tree. To apply MSMA an axe or chain saw is used to cut a ring around the tree trunk, deep enough to allow injection into the tree's circulatory system. MSMA must be applied within 4 weeks of heavy MPB attack, to be effective. While alternative treatments are an important part of the sanitation strategy, less than one percent of the MPB harvest volume comes from these alternatives.

Issues

The Timber Supply

The long term timber supply is a key issue in all of the areas infested with the MPB. The infestation is currently affecting 17 percent of the mature pine volume. However, predictions indicate up to 54 percent of the mature pine volume could be infested by 2008. A timber supply analysis, conducted by the Ministry of Forests, in 2004, concludes the MPB infestation will likely have a significant impact on the timber supply in the midterm. The analysis projected a significant decline in the timber supply over the next 15 years. The projected reduction in timber supply was 19 percent relative to the pre-uplift cut. About 200 million cubic metres of dead pine would not be harvested. More detailed assessment of the Quesnel TSA predicted a 29 percent decline in annual allowable cut about 15 years from now.

Salvage

The deterioration of MPB-killed trees is an important factor to consider when planning salvage operations and for estimating the economic impact of the epidemic. The time that a tree can remain standing in the forest, before it has no commercial value, is known as its 'shelf life'. Shelf life is most affected by weather. The infestations of the 1970's in the Chilcotin showed that the dry and warm weather resulted in a shelf life for MPB-killed forests of more than 15 years. It is likely that in the wetter and colder areas of the province, such as Prince George, the shelf life may be less than 10 years. In his October 2003 report[2], the chief forester demonstrated what the varying effects of shelf life had on the timber supply. If the shelf life is longer than 15 years, then more salvaging will occur and less will be lost to rot. Therefore, the decline in timber supply would occur later than projected. If MPB-killed trees rot more quickly than 15 years, the losses (impact on the timber supply) would be greater and the decline in timber supply would occur sooner.

Road Transportation

One of the challenges in addressing MPB infestation is roads. A lack of roads in infested areas delays harvesting operations from suppressing MPB populations. As the province begins to address MPB-killed stands through salvaging, roads will again be an issue. The cost of building road networks is prohibitive and combined with low revenues from dead timber, more so. For example, in the Nadina District, accessing MPB areas required extensive road networks to link into the existing roads and highways and barges across lakes.

Environmental Effects

A number of potential environmental issues can result from the direct and indirect impacts of MPB attack. During the endemic phase, individual trees are killed, resulting in patchy mortality throughout the stand. Canopy gaps created by the death of individual trees allow light to reach the forest floor, creating opportunities for herbaceous species. Epidemics in pine are often stand replacing events because of fire. The fire provides the necessary conditions for stand regeneration back to lodgepole pine. If fire does not follow the outbreak, the understory trees, typically spruce, assert dominance of the stand.

Reductions in tree canopy densities caused by MPB mortality can increase runoff by deeper snowpacks due to less interception and accelerated snowmelt due to decreased shade. Stand level mortality rates of 20 percent or greater are required before additional water yields are noticeable. Increased runoff can increase rates of soil erosion and stream bank instability. Post outbreak wildfires can affect water quality.

[2] *Timber Supply and the Mountain Pine Beetle Infestation in British Columbia* Ministry of Forests, Forest Analysis Branch – October 2003.

MPB populations favour several wildlife species. For example, woodpeckers use MPB larva as the primary food source. MPB-killed trees also provide nesting sites for many woodland bird species. Other species may not thrive in killed stands.

Implications to Land and Resource Management Plans

Strategies and objectives identified in the plan may be at risk due to MPB infestation. For example, objectives such as minimizing road development and meeting seral stage targets may be at risk. Old-growth management areas are currently being planned, in accordance with provincial direction. However, protected areas will be created that may become breeding grounds for insects which will further the insect spread. These strategies and objectives can also place constraints on effective MPB management. Nadina district has formally modified its LRMP for the heavily MPB-infested areas by developing a SRMP that has modified landscape level biodiversity objectives.

Part 2: Auditing Compliance with the Forest Practices Code: Mountain Pine Beetle Management in the Hallett Landscape Unit, Vanderhoof Forest District

Introduction

As part of the Forest Practices Board's 2003 compliance audit program, the Board selected the Hallett draft landscape unit within the Vanderhoof Forest District for audit. The area-based audit examined the activities related to MPB management under the *Forest Practices Code of British Columbia Act* and regulations (the Code).

The 102,000 hectare Hallett draft landscape unit is located in the west-central part of the Vanderhoof Forest District. Vanderhoof, Fraser Lake, and Fort Fraser are the main communities near the audit area. The Nechako River defines the southern boundary of the landscape unit (see map 1). The landscape unit lies within the Prince George timber supply area (TSA). The audit area is characterized by rolling terrain and pine flats with few areas of unstable terrain and few riparian features.

The MPB infestation is driving the harvesting within the audit area. In 2002, the chief forester temporarily increased the allowable annual cut in the Vanderhoof Forest District by 2.5 million cubic metres to permit more harvesting of MPB-infested timber. All of the harvesting in the landscape unit during the audit period focused on the leading edge of the infestation in an attempt to slow the spread of the MPB.

The main parties with forest activities in the audit area were:

- L. & M. Lumber Limited (L&M), FL A55578
- Pacific Inland Resources (PIR) a division of West Fraser Mills Ltd., FL A16830
- Fraser Lake Sawmills (FLS), a division of West Fraser Mills Ltd., FL A18162
- Canadian Forest Products Ltd., (Canfor) FL A18165 & FL A40873 and
- British Columbia Timber Sales (BCTS)

Two smaller non-replaceable forest license holders, Fort Fraser Chamber of Commerce and Castle Creek Forest Products (1993) Limited, were not audited because their activities were in the planning stages and no operations had taken place by the time the audit began.

The MPB infestation is at epidemic levels in parts of the Vanderhoof Forest District. In early 2003, the Ministry of Forests estimated that 20 percent of the mature pine in the district was infested with MPB.

The audit area was part of an ‘emergency bark beetle management unit’. This meant that licensees could harvest under the former BBR (this regulation was repealed January 31, 2004). BBR allowed for the harvest of volumes less than 5000 cubic metres per cutblock or areas less than 15 hectares, when the harvest is aimed at removing MPB-infested timber. Under BBR, the district manager could exempt licensees from most operational planning requirements, such as providing maps and schedules in forest development plans and preparing site plans. Harvesting under the BBR was restricted to trees infested with MPB, and those trees that must be removed to reach infested trees. In addition to harvesting under the BBR, licensees in the landscape unit are planning and harvesting blocks within the normal forest development planning process, and undertaking minor salvage of dead or infested timber.

There are no declared higher level plans applicable to the audit area. General guidance for resource management in the district is provided by the Vanderhoof Land and Resource Management Plan (LRMP) which was approved by government in 1999. The LRMP establishes general objectives for water, fish, wildlife, biodiversity and cultural values. The LRMP is not a higher level plan under the Code, so licensees do not have to comply with it.

Audit Scope

The audit examined operational planning and activities related to MPB management, including forest development plans ; silviculture prescriptions , site plans ; timber harvesting; road construction, maintenance and deactivation; site preparation; planting; and hazard abatement. Hazard abatement means burning slash piles to reduce fire hazard. These activities were assessed for compliance with the *Forest Practices Code of British Columbia Act* and related regulations (the Code).

A note about terminology:

The size of harvest openings to manage MPB infestations and the operational planning requirements vary. The following describes the terminology used in this report.

FDP cutblocks: These are cutblocks planned and approved in a forest development plan. The public has an opportunity to review and comment on the planned blocks. Generally these cutblocks are larger than 15 hectares.

Minor salvage: Harvest of dead or infested timber less than 2000 cubic metres in volume. These blocks do not have to appear in a forest development plan and are not subject to public review and comment.

BBR blocks: Harvest openings less than 15 hectares and less than 5,000 cubic metres in volume. The district manager may exempt licensees from preparing site plans for BBR blocks. These blocks do not appear in a forest development plan and are not subject to public review and comment.

Site plan exemptions: Volumes less than 500 cubic metres and if clearcut less than 1 hectare in size. This exemption is permitted under section 36.3 of the *Operational Planning Regulation*.

Small scale salvage blocks: Blocks harvested under the Ministry of Forests Small Scale Salvage Program, with a volume normally less than 500 cubic metres.

All planning and activities relevant to the September 1, 2002, to September 26, 2003 audit period were included in the audit.

The activities carried out within the Hallett draft landscape unit during the audit period, and therefore subject to audit, are set out in Table 1 below.

Table 1: Licensee activities during the audit period.

Licensee	Number of harvest sites	Roads constructed (km)	Roads maintained (km)	Roads deactivated (km)	Bridges Constructed	Bridges maintained	Planting	Site Prep
L&M	1 FDP cutblock	1.1	1.1	0	0	0	0	0
Canfor	4 BBR blocks	0.0	4.0	0	0	0	0	0
PIR	55*	15.1	0	1.8	1	0	0	0
	*5 FDP blocks; 50 BBR blocks, 18 of the 50 are less than a hectare with no silviculture obligations.							
Fraser Lake Sawmills	259*	100.3	206.5	0	3	5	84 sites totalling 886 ha	11 sites totalling 102 ha
	*36 FDP blocks; 223 BBR blocks. 77 of the 223 are less than a hectare with no silviculture obligations.							
BCTS	396*	28.0	46.1	0	0	0	1 site totalling 92 ha	0
	*5 FDP blocks; 181 harvest units (in 11 minor salvage blocks); 195 SP exemption blocks; 15 small scale salvage blocks.							

Four of the licensees had approved forest development plans. Pacific Inland Resources normally operates in the neighbouring Skeena - Stikine Forest District. However, the ministry approved a transfer of allowable annual cut to the Vanderhoof district to allow PIR to harvest timber to manage the MPB infestation. PIR and Fraser Lake Sawmills are both divisions of West Fraser Mills Limited. PIR prepared and obtained the approval of an amendment to Fraser Lake Sawmills' forest development plan, and the amendment serves as the planning document for PIR's activities within the Hallett draft landscape unit.

The individual licensees and the applicable approved forest development plan that covered activities within the audit area are shown in the Table 2 below.

Table 2: Licensees and applicable approved forest development plan.

Licensee	Approved forest development plan
L&M Lumber Ltd.	2000-2006 forest development plan
Canadian Forest Products	2002-2007 forest development plan
Fraser Lakes Sawmills	2000-2005 forest development plan
Pacific Inland Resources	Amendment #16 to the FLS forest development plan
BC Timber Sales	2000 -2005 forest development plan

The Board's audit reference manual, *Compliance Audit Reference Manual, Version 6.0, May 2003*, sets out the standards and procedures that were used for this audit.

Audit Findings

Planning and Practices Examined

The audit work on selected roads and cutblocks included ground-based procedures and assessments from the air using a helicopter. The audit examined the sites set out in Table 3 below.

Table 3: Sites inspected during the audit.

Licensee	Number of Cutblocks	Roads constructed (km)	Roads maintained (km)	Roads Deactivated (km)	Bridges Constructed	Bridges maintained	Planting	Site Prep
L&M	1	1.1	1.1	0	0	0	0	0
Canfor	4	0.0	2.9	0	0	0	0	0
PIR	20*	11.2	0	0.8	1	0	0	0
	*3 FDP blocks; 17 BBR blocks. Five of the 17 are less than a hectare.							
Fraser Lake Sawmills	65*	33.8	144.3	0	3	5	12 sites totalling 197 ha	4 sites totalling 23 ha
	*17 FDP blocks; 48 BBR blocks. Ten of the 48 are less than a hectare.							
BCTS	86*	13.0	21.0	0	0	0	1 site totalling 92 ha	0
	*5 FDP blocks; 55 minor salvage units; 19 SP exemption blocks; and 7 small scale salvage sites.							

Operational Planning

The audit also examined the applicable forest development plans for L&M, Canfor, FLS and BCTS and one major amendment covering operations by PIR, for compliance with the Code, including consistency between the plans and objectives in designated higher level plans. Only the portions of the forest development plans that applied to the audit area were examined.

Overall Findings

The audit found the licensees to be in compliance, in all significant respects, with the Code's planning and practices requirements as they relate to MPB management within the audit area for operational planning; harvesting; road construction, maintenance and deactivation; site preparation; planting; and fire hazard abatement.

Audit Opinion

In my opinion, the operational planning; timber harvesting; road construction, maintenance and deactivation; site preparation; planting; and hazard abatement activities carried out by the auditees in the Hallett draft landscape unit related to MPB management were in compliance, in all significant respects, with the requirements of the Code as of September 2003.

In reference to compliance, the term "in all significant respects" recognizes that there may be minor instances of non-compliance that either may not be detected by the audit, or that are detected but not considered worthy of inclusion in the audit report.

The audit was conducted in accordance with the auditing standards of the Forest Practices Board. Such an audit includes examining sufficient forest planning and practices to support an overall evaluation of compliance with the Code.

Grant Loeb RPF
Auditor of Record
Victoria, British Columbia

April 2004

Part 3: Evaluating Effectiveness: Mountain Pine Beetle Management in the Cheslatta and Burns Lake East Landscape Units, Nadina Forest District

Introduction

The MPB strategy aims to reduce the present and future rate of spread of MPB infestation while recovering timber values, and maintaining environmental values (*A Bark Beetle Management Strategy for BC, 2003 -2008*). To date, there has not been a test of the efficacy of the MPB management strategy, as applied on the ground, in achieving these objectives. The goal of this chapter is to present results from an efficacy test conducted on two landscape units (Cheslatta and Burns Lake East) in Nadina Forest District.

Effectiveness was evaluated using three techniques:

1. Application of a landscape scale MPB model (MPB-SELES) to examine the effectiveness of the forest health measures and the effectiveness in achieving timber objectives.
2. A GIS landscape analysis for assessing achievement of objectives for landscape level biodiversity and watershed hydrology.
3. Field examination of the success in achieving specified stand-level objectives for soils, riparian, stocking and stand-level biodiversity.

Two landscape units in Nadina district were evaluated. The Cheslatta landscape unit and the Burn's Lake East landscape unit are located south and east of Burns Lake. The area is characterized by rolling terrain and pine flats with numerous lakes. Soils are stony loam tills with few areas of unstable terrain.

The main parties with forest activities in the study area were:

- Babine Forest Products (BFP)
- Pacific Inland Resources (PIR) a division of West Fraser Mills Ltd., FL A16830
- Fraser Lake Sawmills (FLS), a division of West Fraser Mills Ltd., FL A18162
- Cheslatta Forest Products (CFP) and
- British Columbia Timber Sales (BCTS)

The MPB infestation is driving the harvesting within the study area. Prior to 1992 MPB was at endemic levels in the Nadina district. The strategy at the time was to use fall and burn and harvesting of infestation centres to control the problem. Between 1992 and 1994, the MPB were still at endemic levels in the north area of the district, but there were pockets of infestations in the south of the district and in Tweedsmuir Provincial Park.

From 1994 to 1996 the level of MPB in Tweedsmuir Provincial Park were rapidly building. Concerned with the potential spread of the MPB into the Nadina District, two controlled burns in 1995 and 1996 took place. Unfortunately the weather was wet during the burn and its effect was small. In 1997 and 1998 burns were again used but the effects were limited.

Prior to the MPB flight in July 1998, the MOF had identified every infested tree along the park boundary using MPB probing. Over 5000 trees were marked, and then harvested using snip and skid operations. In spite of these efforts, by August, 1998 there were patches of MPB-infested wood in the Nadina district. Warm weather resulted in an explosion of the MPB population, now covering an area of 700,000 hectares in the district. The projected cumulative volume of MPB-killed pine in the Lakes TSA by 2005 is 25 million cubic meters. In 2002, the chief forester temporarily increased the allowable annual cut in the Nadina Forest District by 2.5 million cubic meters to permit more harvesting of MPB-infested timber.

MPB movement and corresponding MPB management strategies across the Cheslatta and Burns Lake East landscape units from 1996 to present are summarised in Table 4.

Table 4: The shift in MPB strategies 1996 to present.

Cheslatta Landscape Unit

Period	MPB status	Management Strategy
1996 to June 2000	Endemic	Suppression
June 2000 to June 2001	Transition	Suppression
June 2001 to present	Epidemic	Holding/Salvage

Burns Lake East Landscape Unit

Period	MPB status	Management Strategy
1996 to June 2003	Endemic	Suppression
June 2003 to present	Transition	Suppression

Note that the Western portion of the Cheslatta LU has seen a slower progression of the MPB population and the transition period between endemic to epidemic status in this portion occurred in 2003.

Achieving Forest Health and Timber Objectives

Introduction

The efficacy of the MPB harvesting strategy in achieving forest health and timber objectives was tested. Forest harvesting in Nadina district has been driven by the MPB strategy for the past six years, using a mosaic of small 'snip and skid' cuts, cutblocks of various sizes and single tree treatments focused on the leading edge, or green attack phase, of the MPB epidemic. The success of the MPB management strategy in reducing the spread of infestation was tested by comparing estimates of MPB attack impacts using the actual harvest record carried out from 1997-2003 with alternate scenarios of no harvesting, conventional harvesting patterns and alternative management options. The goal of recovering value from damaged timber was examined by determining if timber harvesting was directed at stands with the greatest risk of spreading MPB to adjacent stands or losing merchantable value.

The efficacy of past forest management actions over the 1997-2003 period was measured using a spatial simulation model (called SELES-MPB). This model integrates landscape-scale MPB population dynamics with a spatial timber supply model (based in part on the aspatial timber supply model FSSIM) augmented with various MPB management options. This model has been previously used to explore the expected trends of MPB outbreak under various management options at a strategic level.

The goal is to make a more detailed assessment of actual management in two landscape units (Cheslatta and Burns Lake East) in terms of how well MPB management was applied. That is, how effective was MPB management in these two units relative to other plausible management options?

Detailed information on block locations, sizes, shapes and strategies, as well as weather conditions (primarily wind speed and direction) during the flight period were used. This information is used to precisely capture the dynamics of harvesting and MPB activity in the two focal landscape units. Due to the spatial extent of the current outbreak and the scale at which the AAC is set, the entire timber supply area was simulated. This ensured that the focal landscape units were embedded in the context of the overall outbreak. Indicator outputs focus on these two landscape units as well as the TSA.

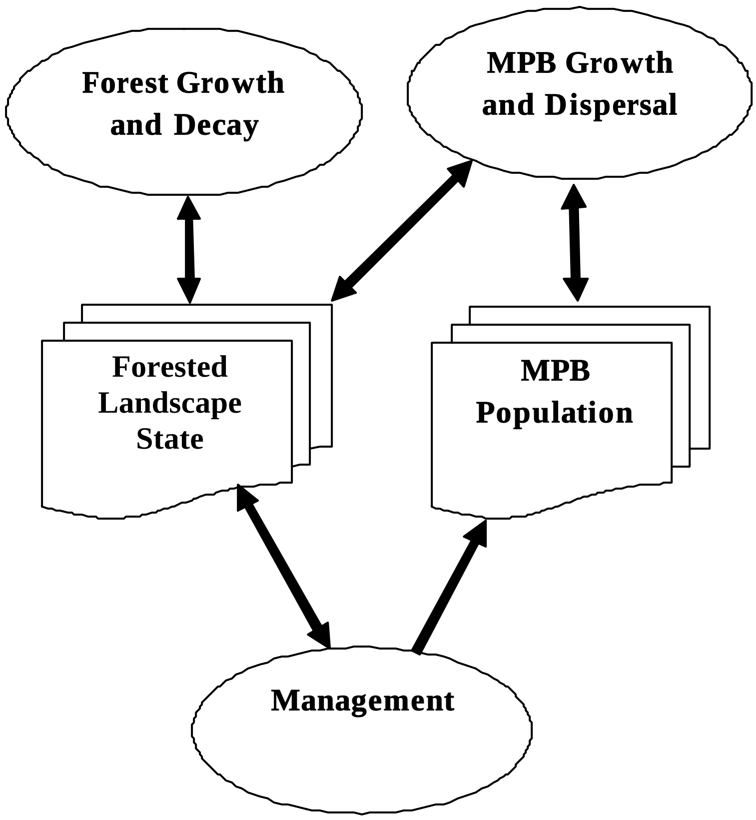
Methods

Lakes Landscape Model Overview

This section briefly describes the conceptual basis of the Lakes Landscape Model (LLM). See Fall et al. (2002) and Fall et al. (in press) for more details and results from the strategic issues it was originally designed to address. The LLM consists of a linked set of sub-models that simulate forest growth, MPB outbreak disturbance, forest harvesting and road construction

(Figure 5). The basis of the spatial harvesting model is the Spatial Timber Supply Model (STSM; Fall 2002b).

Figure 5: Conceptual design of the Lakes Landscape Model. Each main modeled process is shown as an oval, which interact with the landscape and MPB state (represented as spatial data layers and tables) shown in the centre. Arrows indicate whether a process depends on and/or modifies the connected landscape state.



The first step in the development of the LLM was to calibrate harvesting and forest growth with the most recent timber supply analysis done aspatially using FSSIM (B.C. Min. of Forests, 2001). This ensured that the LLM accurately captures the timber supply assumptions in the Lakes TSA, and to assess the impacts of applying spatial effects and constraints such as road access/development and spatial blocks (Fall 2002a). The next step was to adapt the MPB-SELES landscape scale MPB population model, scaled from stand-level MPB models developed at CFS (Safranyik et al. 1999). To assess the adequacy of this model, it was calibrated against the outbreak progression from 1991-2002 by estimating landscape and MPB conditions in 1991 at the start of the current outbreak (Fall et al. 2002). The LLM harvesting component was then enabled with MPB management options including targeted harvesting with leading-edge of attack focus (current MPB management), trailing-edge of attack focus, salvage focus, or high risk focus. Finally, a single tree treatment (fell and burn and MSMA) component was adapted to the study area.

The inputs to the LLM consist of digital maps describing the land base and files that control model behaviour. All data layers were derived from inventory information at a1 hectare cell resolution. Digital maps describe physiography, ecology, timber values, land-use units and roads. New information required for this analysis is primarily related to harvest details in the two landscape units of interest. This included maps of actual harvesting, along with strategies applied during block placement derived from interviews with licensees. Also required is detailed weather information on wind speed and direction during the flight period over the years of interest.

The dynamic portion of the Lakes Landscape Model consists of a set of sub-models that simulate ecological and management-induced change (e.g., stand aging; MPB development, dispersal, and pheromone production/diffusion; forest harvesting, single tree treatments and access development). Other within-stand disturbances, caused by disease, insects and windthrow, are not explicitly modeled; however, their timber-related impacts are accounted for in estimates of volume harvested. The model projects initial landscape conditions forward through time, using processes represented in the sub-models to estimate future landscape conditions, which are then summarized in output files and spatial maps. The forest is represented using species (inventory type group, percent pine) and age. It also includes volume (standing green, salvageable) and stand height estimates. The MPB Population tracks estimates of MPB/cell, starting from an estimate of the initial MPB/cell derived from current infestation data. It also tracks the number of years since last attack in cell, MPB Susceptibility computed according to the index developed by CFS (Shore, 1998), and MPB Risk, which combines susceptibility with MPB locations. The LLM models time in 1-year steps, and was designed to project outbreaks over a time horizon of up to 2 decades (in this analysis the time horizon is 7 years).

The LLM simulates specific processes; it does not determine optimal solutions. The model is stochastic, generating disturbance events in space and time using probability distributions. Thus, each model run may produce different results and hence in general the model must be run several times to determine averages and ranges for each scenario modeled.

During processing, the LLM outputs a time series of projected landscape indicators (volume and area killed by MPB, volume lost to economic decay, volumes and areas harvested as green and salvage wood, etc). These indicators form the primary model outputs for assessment and interpretation.

Refinements to Support Efficacy Assessment

This section describes the key modifications made to the LLM to support the current analysis.

To capture past actual management strategies and patterns, the harvesting model required more detailed information than currently employed in the original LLM. The original harvesting sub-model is a strategic level model, that doesn't focus harvesting specifically within different LUs and that applies relatively broad management strategies. A series of interviews was held with licensees operating in these two LUs. Based on these interviews and other information provided, general strategies employed in the placement of harvest blocks was extracted and used to guide the base management scenario (see Appendix 1). An assessment was made of GIS data of actual block patterns (e.g. number, size distribution) and harvest records to capture more detailed management focus in terms of areas harvest annually in each landscape unit and the patch size distribution of actual blocks. A spatial analysis was completed of actual block patterns to assess the size distribution, aggregation (block "clumping"), and distance to roads effects. The latter two effects were not significant enough to integrate into the analysis. The refinements included:

- Allowing control of area harvested within the two landscape units. This supports scenarios that match the same harvest level as actually occurred or setting levels higher or lower.
- Estimating MPB status (from a management perspective) within each landscape unit (LU) and classifying each as endemic, transition or epidemic depending on level of detectable attack (Table 4). If harvesting capacity exceeded MPB attack, the LU was classified as endemic. If MPB attack exceeded harvesting capacity, but not by more than 100 percent, then the LU was classified as transition. Otherwise the LU was classified as epidemic.
- Management was designed to allow differential focus within the different LU classes, as well as difference prior to and after the MPB regulations coming into effect in 2001. See Appendix 1 for detailed descriptions of management within the different LU classes. In general, current management used a mixture of small to medium blocks to target detectable MPB infestation at the leading-edge of the outbreak in an effort to reduce MPB population growth and spread.

The MPB model in the LLM is a landscape-scale population dynamics model that captures expected trends of outbreak growth and impacts. Weather has a substantial influence on dispersal (wind speed and direction influences dispersal, especially over long-distance), flight period length and over-winter survival. The original model was designed to project expected progression into the future, and so uses general wind patterns (speed and direction) from probability distributions. We examined weather records for the 1997-2003 period to constrain the MPB model to use actual weather history. Although it doesn't make the model deterministic (there are some fundamental stochastic elements to capture other sources of variation as well as uncertainty in specific effects), it does cause the model to follow the actual trends more closely. It additionally reduces the differences between scenarios, and so facilitates comparison of scenario outcomes.

Scenarios Assessed

1. Actual Management

The main reference scenario (actual beetle management or BM) attempts to capture the essence of the objectives used to place the actual blocks in the two landscape units. To parameterize this scenario, the strategy descriptions arising from the interviews were matched with the spatial data of actual block patterns. In this scenario, stands identified as leading edge (detectable red and green attack treed) have highest priority, followed by high levels of salvage and then high risk stands.

2. Comparison (Frame of Reference) Scenarios

To put the management scenarios in a context of the range of possible outcomes, scenarios were run to capture upper and lower limits of MPB impacts. For worst-case bounding, a no management scenario (no harvesting and no single tree treatments; NoHarvesting) and a no beetle management scenario (same level of harvest as in reference scenario, but applying an oldest-first harvest rule that ignored MPB; NoBM) was run. For best-case bounding, the reference scenarios with a doubling of entire harvest level for the TSA, but otherwise applying the reference scenario rules (BM_cut2x) was run. These scenarios help to properly frame the efficacy of the management scenarios, by exposing how much flexibility there is in the system for management to have an effect.

3. Potential Management

To assess how well the reference scenario performed at MPB management, a range of scenarios to capture potential management options was designed. These primarily vary targeted harvest focus on MPB infestation, risk and/or salvage levels, and modifying harvest levels. Scenarios were compared by assessing change in expected levels of attack (volume killed) within each landscape unit and within the TSA as a whole relative to the reference scenario. The following scenarios were assessed:

- BM_LUcut0: same as reference scenario except no harvesting in the two landscape units, effectively shifting harvesting to other areas (i.e., the base AAC for the TSA remains unchanged).
- BM_LUcut0.5: same as reference scenario except harvesting at 50 percent of the actual level in the two landscape units, effectively shifting harvesting to other areas.
- BM_Lucut2x: same as reference scenario except doubling harvesting in the two landscape units, effectively shifting harvesting towards these LUs.
- BM_RiskFocus: same as reference scenario except that treatment priority is first targeted at leading edge (detectable red and green attack treed) as in the BM scenario, but secondary preference is change to high risk stands instead of salvage.
- RiskFocus: same as reference scenario, except that treatment priority first targets high risk stands, followed by leading edge and salvage opportunities.

- TrailingEdge: same as reference scenario, except that treatment priority first targets stands with high levels of salvage volume, followed by leading edge.

Output Indicators

The primary indicator of interest is the volume of timber killed in the THLB by MPB over the course of the 1997-2003 time period. Also of interest is the total volume of timber lost or standing dead (but potentially salvageable) on the landscape at the end of the time horizon. This wood represents the risk a given scenario poses to current growing stock (since not all standing dead wood can feasibly be salvaged). Although absolute values may be useful for strategic planning, a relative comparison against actual management captures the increase or decrease in impact that may have been expected under various management alternatives.

Limitations of Approach

To truly assess MPB management efficacy from a practices audit perspective requires answering the question "how would the outbreak effects have differed if different practices had been employed?". However, for situations that cannot be replicated in the field (e.g. situations with multi-year time lags and large areas, such as in the present case), and for which precise predictive models are not available, this question cannot be fully addressed. Using a population/outbreak projection model, means that the question has to be somewhat limited to "how would we expect the outbreak effects to have differed if different practice strategies/tactics had been employed?". That is, using a modelling approach, we can compare how we expect the MPB outbreak to have evolved under a range of management scenarios, to compare the strategies actually employed with other plausible options, and in the context of the range of potential influence management has on the outbreak.

Hence, the approach is to strive to capture the essence of the practices employed, using information from harvest records, and to constrain the MPB model as much as possible with actual weather records. One cannot simply run the MPB model combined with the actual harvest blocks, because that would unduly constrain management. MPB-SELES contains substantial stochastic elements (over-winter survival, dispersal mortality and succession, long-distance dispersal, etc.) and isn't designed to simply re-play the actual outbreak history. So, if the management regime was simply to apply the blocks actually created, there is a high chance that the conditions used to plan those block placements wouldn't occur in the model simulations precisely where they occurred in reality. Furthermore, a lack of adequate fine-scale information on MPB progression or exact stand conditions at time of harvest doesn't allow a more static, empirical assessment.

The approach proposed creates a feasible compromise between the precision desired and the level of knowledge and information available to make an efficacy assessment.

Results and Discussion

The primary result is shown in Figure 6. The reference scenario (BM, representing past actual management) by definition has a relative change in volume killed of 0 percent. To interpret these relative impacts, one must bear in mind that there is approximately an order of magnitude difference between Burns Lake East and Cheslatta, and between Cheslatta and the entire TSA in terms of absolute volumes killed over the time period (i.e., < 50,000 cubic metres in Burns Lake East, over 500,000 cubic metres in Cheslatta and in the millions of cubic metres for the entire TSA). Hence, a small difference in TSA-level results likely has a higher absolute magnitude than a larger difference in results for Burns Lake East. The following are some key points:

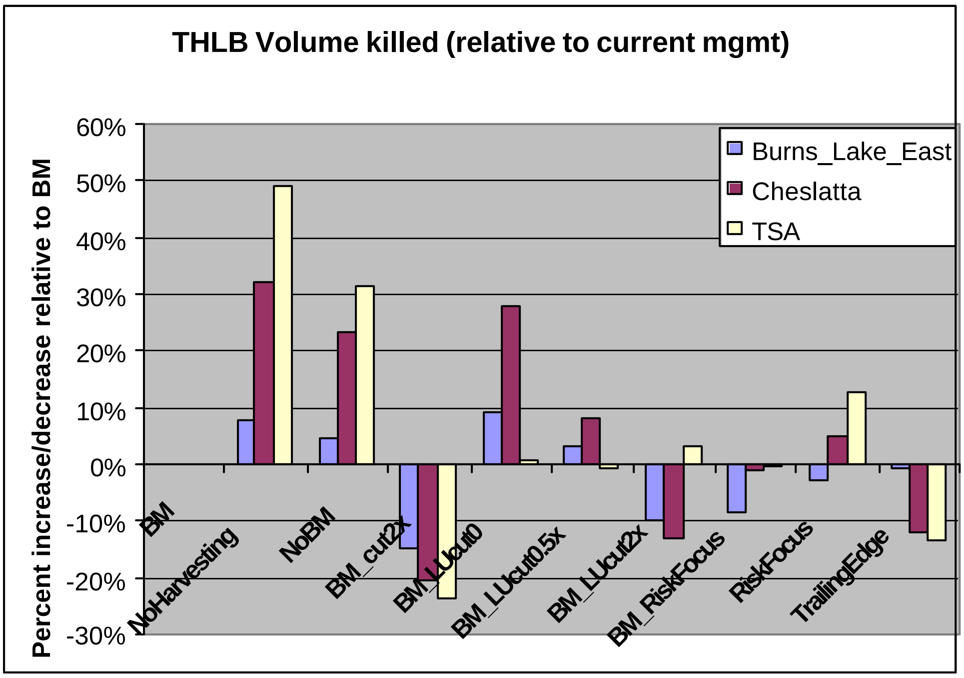
1. Frame of reference scenarios: The no harvesting and no beetle management scenarios clearly lead to a dramatic increase in volume killed. Hence actual management may have reduced volume killed by almost 25 percent in Cheslatta over applying no beetle management effort. Conversely, doubling the harvest level led to a fairly large drop for both LUs and the TSA as a whole. Note that since the base harvest level includes the post-2001 uplift, it represents a substantial increase in harvesting pressure.
2. Changing harvest levels within the two LUs (but otherwise applying the same strategies as actual management): When harvest was reduced or eliminated in the two LUs (BM_LUcut0 and BM_LUcut0.5x), impacts increased in the two LUs. However, little change occurred over the entire TSA. When harvest was increased (BM_LUcut2x), impacts decreased in the two LUs, but increased overall. This implies that the harvest level applied in these LUs appears reasonable.
3. Changing harvest priorities:

   BM_RiskFocus: Changing secondary focus from salvage to high risk stands (but otherwise targeting leading edge first) had little impact in Cheslatta and the TSA, but reduced impacts by almost 10 percent in Burns Lake East. However, due to the low level of attack in Burns Lake East, this likely does not represent a significant difference from actual management.

   RiskFocus: Shifting to a risk focus (i.e., target high risk stands before leading edge) led to increased impacts in Cheslatta and the TSA (by over 10 percent), but a slight reduction in Burns Lake East. This strategy appears to be reasonable at low infestation levels where host removal has the potential to circumvent the outbreak. In this context, however, with a large outbreak and substantial host stands it doesn't appear to be effective. Since MPB are selective and search for hosts, removing a high risk stand may simply increase pressure in remaining nearby susceptible stands.

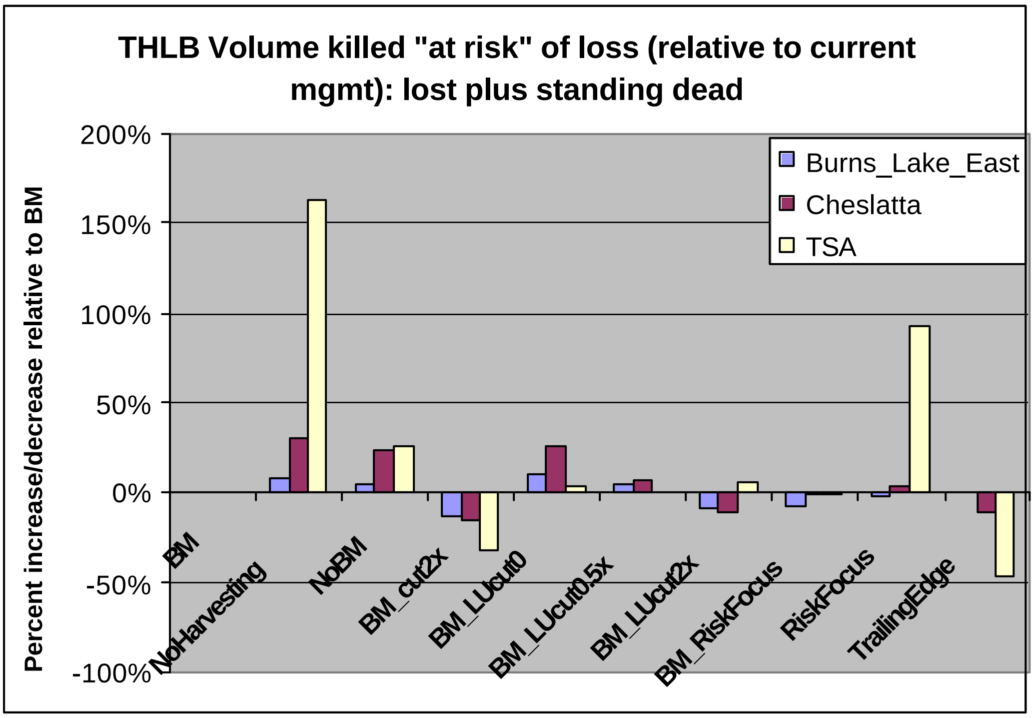
   TrailingEdge: Shifting to a trailing edge focus (i.e., target stands with high levels of merchantable salvage) reduced impacts significantly in Cheslatta and the TSA, but not in Burns Lake East. Stands with high levels of merchantable salvage (as opposed to simply high levels of any type of salvage) coincide with stands that have a few years of consecutive attack due to the relatively rapid economic decay rate of pine for sawlog production. Such stands likely contain a mixture of recent attack, attack that is one to a few years old and some unattacked trees. The high level of salvage implies that such stands are capable of high production of MPB. Hence targeting these stands may actually serve to both recover salvage volume that is relatively young (and hence still quite valuable) and to reduce MPB population levels significantly (and perhaps more than in leading edge stands that may exhibit some detectable attack, but may not yet contain large numbers of MPB).

Figure 6: Relative increase (positive values) or decrease (negative values) of volume killed in the THLB over actual management (BM) of the various scenarios assessed. A value of +x% means that the scenario resulted in an increase of x% volume killed over the level estimated for current management.



The overall risk to timber, in terms of the portion of the volume killed that is lost to decay or still standing dead timber that could potentially be salvaged, should also be taken into account (Figure 7). Clearly the no harvesting scenario results in the highest volume placed at risk, but the risk focus scenario also creates a relatively high risk compared to actual management (although the difference in the two LUs of interest is low). Actual management (BM) performs at least as well as most scenarios with the exception of BM_cut2x and TrailingEdge. The former is clearly due to the increase harvesting power applied. The trailing edge strategy reduces timber risk modestly in Cheslatta and substantially over the TSA as a whole. Doubling harvest levels in the two LUs (BM_LUcut2x) decreased risk somewhat within these LUs, but resulted in a slight increase overall.

Figure 7: Relative increase (positive values) or decrease (negative values) of volume killed in the THLB that is "at risk of loss" at end of time period over actual management (BM) of the various scenarios assessed. "At risk" volume is defined as volume killed but not salvaged (i.e., standing dead wood plus non-recovered loss). A value of +x% means that the scenario resulted in an increase of x% at risk volume over the level estimated for current management.



Conclusions

The results of the analysis indicate that the effectiveness of operations over the 1997-2003 period were reasonable given the scale of the outbreak in this area. There was a clear improvement over management approaches that ignored MPB activity (no harvesting and no beetle management scenarios). Most alternative management strategies did no better at reducing MPB impacts.

The only exception to this was the 'trailing edge' scenario (which effectively focuses on the areas with high levels of salvage), which was more effective in the Cheslatta LU. This result is consistent with results from other MPB outbreak projection analyses, which also indicate that in conditions where the outbreak exceeds harvest capacity (such as the Cheslatta LU), it may be more appropriate to switch to a trailing edge strategy with a focus on high-value salvage opportunities. As the trailing edge of the outbreak has high levels of salvage and MPB populations (since it takes several years for MPB to fully develop within a stand), this strategy appears to have relatively high effectiveness from both a salvage recovery and MPB population reduction perspective. In addition to reduced impacts, a trailing edge MPB management strategy may have reduced operational costs (e.g., less probing may be required) and higher net value to the crown over the course of the outbreak (since salvage is taken when relatively recently killed).

Note that this strategy differs from a grey salvage focus: the former targets stands with high merchantable salvage (which implies recent kill and hence also a high likelihood of relatively high MPB populations and some living hosts as well), whereas the latter targets stands with high levels of any age salvage (which may have few MPB or residual susceptible hosts).

Achieving Landscape-level Environmental Objectives

MPB harvest is often associated with extensive clearcut areas and rapid rates of cut. Environmental concerns associated with this harvest may include clearcut effects on peak flows, forest fragmentation, and shifts in the stand age distribution of the remaining forest. This can have implications for wildlife and fish habitat.

Landscape-level objectives for biodiversity and water were evaluated by examining the equivalent clearcut area (ECA) and the seral stage and patch size distribution in the two Nadina landscape units. The Cheslatta Unit is representative of a landscape unit at the trailing edge of the epidemic, and will shortly become a salvage unit. The Burns Lake East unit is a transition unit moving from the endemic to epidemic status.

This analysis considers the current state of the two landscape units. Key uncertainties regarding landscape level planning which must be considered are when the outbreak will subside and with what levels of pine left on the landscape when it does. Secondly, it is unclear how industry will approach the issue of large-scale salvage.

Watershed Hydrology

Landscape level objectives for watershed hydrology were evaluated by looking at the equivalent clear-cut area (ECA) in all third-order watersheds in each landscape unit.

The amount of clearcut area in a watershed is a concern because of the linkage to peak flows. Snowpack in clearcuts accumulates to greater depths, because of the loss of tree canopy interception. In the spring, the snowpack melts more rapidly because of the lack of shade. The net effect is higher peak flows, occurring earlier in the season, compared to a forest. As second growth develops the effect on hydrology is reduced. Once the second growth is 10 metres high it is hydrologically similar to the original stand. Equivalent clearcut area (ECA) is the measure of the hydrological equivalence of the second growth stand to a clearcut area. For example, a 6 metre stand is 50 percent hydrological recovered, so a 10 hectare area of 6 metre trees has an ECA of 5 hectares.

Equivalent clearcut areas in a watershed in excess of 30 percent are normally a concern for peak flow hazard. The Nadina landscape units historically have large patches of fire disturbance. For this reason, higher than normal equivalent clearcut areas are appropriate as objectives. Watersheds were rated according to Table 5 below.

Table 5: ECA peak flow hazard rating.

Equivalent Clearcut Area	Hazard Rating
<25%	Low
25-35%	Moderate
35-45%	High
45-60%	Very High

Each landscape unit was divided into 10-12 third order watersheds (see Appendix 2). Individual watershed areas ranged from 1000 to 22,000 hectares, and averaged 5000 hectares. The equivalent clearcut area was calculated from the total area and age of cut blocks within each watershed (Tables 6 and 7).

Cheslatta landscape unit has a large proportion of its remaining forest infested or at high risk of becoming infested by MPB. The Potential ECA was calculated from the MPB overview flights, which maps currently infested stands (Table 7). This area could potentially become defoliated or harvested in future.

Table 6: ECA of the Burns Lake East Watersheds.

Burns Lake East Watersheds	ECA
1	18%
2	21%
3A	14%
3B	5%
3C	17%
4A	23%
4B	27%
5	15%
6	20%
7	19%
8	11%
9	28%
10	16%

Table 7: Current and Potential ECA in Cheslatta.

Cheslatta Sub-basin Unit	Current ECA	Potential ECA
1	11%	56%
2	18%	85%
3	37%	74%
4	37%	74%
5	30%	63%
6	32%	82%
7	30%	77%
8	22%	79%
9	10%	54%
10	32%	66%
11	15%	85%
12	47%	84%

In conclusion, high hydrological ECA was not found to be a common problem in Cheslatta or Burns Lake East landscape units at the present time. Three watersheds in Cheslatta landscape unit are rated as high ECA. Two watersheds in the Burns Lake East landscape unit had moderate ECA. There is a risk, however if the current intensity of the MPB infestation continues, that ECA could potentially become very high. Potential ECAs in Cheslatta range from 56 percent to 85 percent, representing a very high potential hydrological hazard for peak flows in the future for every watershed. Future salvage harvest should be planned such that all areas of green tree forest (non- pine stands, younger age class pine stands, and uninfested older age class pine) be retained to moderate hydrological impacts.

Landscape-level Biodiversity

The current conditions of the Cheslatta and Burns Lake East landscape units were examined by analysing the age class distribution for a seral analysis and the distribution of patch sizes for a patch analysis and comparing these to recommended levels in the *Biodiversity Guidebook*.

As per the *Landscape Unit Planning Guide* methodology, only patches 20 years of age or younger were included in the patch assessment. Adjacent patches that were within 20 years of age were recorded as one patch.

Cheslatta Landscape Unit - Seral stage

The Cheslatta landscape unit has an intermediate biodiversity emphasis applied. There are three biogeoclimatic subzones in the landscape unit, the ESSFmv1 in natural disturbance type 2 (NDT2) and the SBSdk and SBSmc2 in NDT3. The amount of NDT2 was too small to include in the analyses therefore only NDT3 is reported. For NDT3 subzones the definition of early seral forest is less than 40 years of age. Mature seral is defined as forest over 100 years and old is forest over 140 years of age.

Table 8 presents the recommended levels of seral stages (in parentheses), together with the actual percentages found in the analysis. The analysis showed that the recommended levels for each seral stage are being achieved.

Table 8: Actual and recommended levels of seral stages[i].

	Early seral	Mature + old seral	Old seral
NDT 3	29% (< 54%)	46 % (> 23%)	29% (> 11%)

[i] The recommended levels are shown in parentheses.

Cheslatta Landscape Unit - Patch size

Table 9 indicates the recommended distribution of patches for NDT 3 (in parentheses) and the actual sizes for patches aged 0-20 years. The proportion of patches less than 40 hectare size was within the recommended range. The proportion of patches in the 40 to 250 hectare size range exceeds the recommended target level and the proportion of patches in the 250 to 1000 hectare size range is much lower than the target level.

Table 9: Actual and recommended distribution of patches for NDT 3[i].

Patch size	% crown forest area in LU
< 40	20 (10-20)
40-250	60 (10-20)
250-1000	20 (60-80)

[i] The recommended distribution is shown in parentheses.

Burns Lake East Unit - Seral Stage

The Burns Lake East landscape unit has a lower biodiversity emphasis applied. There are five biogeoclimatic subzones in the landscape unit, the ESSFmc and ESSFmv1 in NDT2 and the SBSdk, SBSdw3 and SBSmc2 in NDT3. The NDT3 subzones cover over 90 percent of the landscape unit. For all subzones the definition of early seral forest is less than 40 years of age. For the NDT2 subzones, mature seral is defined as forest over 120 years and old is forest over 250 years of age. For the NDT3 subzones mature seral is defined as forest over 100 years and old is forest over 140 years of age.

Table 10 sets out the recommended levels of seral stages for a lower emphasis landscape unit in NDT 3 (in parentheses), together with the actual percentages of the landscape unit in these categories. The analysis indicates that the recommended levels for each seral stage are being achieved with the exception of the old seral category in NDT2. However, NDT2 only makes up

7.5 percent of the landscape unit, so it is not unexpected to find this result over a small area. The mature plus old seral target is met within NDT2.

Table 10: Actual and recommended levels of seral stages[i].

	Early seral	Mature + old seral	Old seral
NDT2	10% (no recommendation)	25.5% (> 14%)	3.5% (> 9%)
NDT3	22% (no recommendation)	32 % (> 11%)	21% (> 11%)

[i] The recommended levels are shown in parentheses.

Burns Lake East Unit - Patch size

Table 11 outlines the recommended distribution of patches for NDT 2 (in parentheses) and the actual patch sizes for patches aged 0-20 years. This indicates that the proportion of cutblocks in the 40-80 hectare range exceeds the recommended target level and there is very little in the 80-250 hectare range.

Table 11: Actual and recommended distribution of patches for NDT 2[i].

Patch size	% crown forest area in LU
< 40	33 (30-40)
40-80	67 (30-40)
80-250	<1 (20-40)

[i] The recommended distribution is shown in parentheses.

Table 12 presents the recommended distribution of patches for NDT 3 (in parentheses), together with the actual patch sizes for patches aged 0-20 years. The proportions of patches less than 40 hectares in size and between 40 and 250 hectares exceed the recommended target levels. The proportion of patches in the 250 to 1000 hectare category is much lower than the target.

Table 12: Actual and recommended distribution of patches for NDT 3[i].

Patch size	% crown forest area in LU
< 40	34 (10-20)
40-250	62 (10-20)
250-1000	4 (60-80)

[i] The recommended distribution is shown in parentheses.

Summary

With the exception of a small area of the Burns Lake East landscape unit in NDT2, the seral analyses for both landscape units indicates that harvesting in the past 20 years has not altered the seral distribution beyond the recommended levels. There is currently a significant surplus beyond the recommended levels in the mature and old seral categories.

The patch analyses for both landscape units suggest that future harvest planning should consider aggregating new cutblocks with existing cutblocks less than 20 years old to bring more patches into the 80 to 250 hectare range in NDT2 or into the 250 to 1000 hectare range for NDT3.

Achieving Stand-level Objectives

Introduction

Forest development, including MPB related harvesting, has the potential to affect environmental values at the stand level through the direct effects of forest removal, harvesting operations, windthrow and construction of roads. This report evaluates the success in achieving stand-level objectives for the following four forest values in the Cheslatta and Burns Lake East landscape units of Nadina District:

- Soil conservation
- Stand level biodiversity – wildlife tree patches
- Riparian condition
- Stocking

A comparison was also made between the relative successes in achieving objectives under three different administrative regimes:

1. Small scale salvage (snip and skid)
2. Harvest under BBR
3. Harvest under forest development plans

There is no large-block salvage harvest to date in these districts, so this treatment was not assessed.

Methods

Blocks were chosen for inspection using a stratified random approach using an initial list of all blocks logged during the last two years within the selected landscape units. A total of 141 blocks were examined in the field (see Table 13). Blocks were identified on map sheets and flight plans created to facilitate viewing of numerous blocks per flight. Almost half of the blocks had some ground assessment.

The indicators used for assessment of soil, riparian, and stand level biodiversity, values were developed by working teams coordinated by the Forest Practices Branch, Ministry of Forests. The indicators used are the 'routine' and 'extensive' indicators. This report is part of the pilot testing of those indicators. The indicators used for stocking values were developed by the Forest Practices Board team that conducted this investigation.

Table 13: Blocks inspected in Cheslatta and Burns Lake East landscape units.

	Cheslatta	Burns Lake East
Air or Ground		
Air	60	15
Ground	37	29
By Licensee		
FLS	7	0
PIR	4	0
BCTS	66	29
Babine	18	15
Cheslatta	2	0
Treatment Regime		
FDP	26	5
BBR	71	19
SSS	0	20
Total	**97**	**44**

Soil Conservation Value

Criteria used to assess the effectiveness of soil conservation measures were:

1. Is the area occupied by permanent access structures (roads and landings) appropriate? Are temporary access structures used wherever practical?
2. Is there minimal disruption of natural drainage, such that soil productivity is unimpeded?
3. Is the level of dispersed and concentrated soil disturbance minimized?
4. Are areas of excessive soil disturbance rehabilitated and regenerated?
5. Are there any areas of harvesting related landslides?
6. Is there sufficient retention of coarse woody debris?

Results

1. Is the area occupied by permanent access structures (roads and landings) appropriate? Are temporary access structures used wherever practical?

Indicator: area in permanent access

Overall low levels of permanent access and roadside disturbance were found.

For 99 percent of the openings, permanent access was well within Code regulatory limits. The amount of permanent access including landings was high on two blocks. One landing occupied 5 percent of the block area. A second block had a wider than normal road (7 metre wide) resulting in approximately 9 percent of the area in permanent access.

Roadside disturbance was not an issue in most blocks. A total of five blocks (3 percent) were found to have higher than expected levels of disturbance at roadside, mostly due to skidding in wet conditions, rutting was present up to and along roadside. The level of temporary access was deemed appropriate overall. Three blocks (2 percent) had levels that were higher than what would have been deemed optimal.

2. Are temporary roads rehabilitated and restocked?

Indicator: percent of roads rehabilitated and restocked

At the time of the survey, temporary roads had not been rehabilitated and restocked. The roads had been inactive for 0 – 2 years and planting had not yet occurred in the cutblock.

3. Is there minimal disruption of natural drainage, such that soil productivity is unimpeded?

Indicator: number of cut blocks with disrupted natural drainage

Disrupted drainage occurred as a minor issue in eight blocks where skidding occurred within non classified drainages.

Disrupted drainage overall was not an issue. Minor portions of eight blocks had skidding within non-classified drainages (NCDs). The amount of disrupted drainage was estimated at 1 percent to 2 percent in the affected blocks. In no cases was the disrupted drainage associated with fish bearing streams. The total area affected by the disrupted drainage was small, and will not affect overall site productivity.

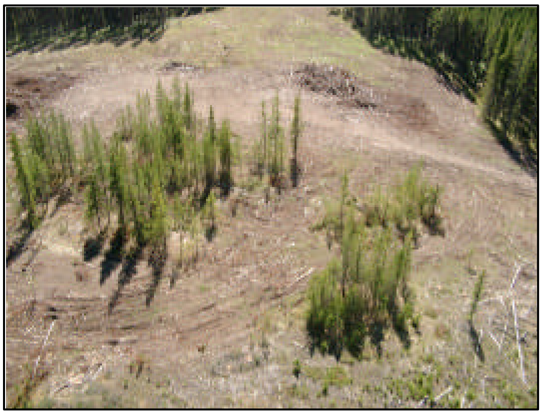
4. Is the level of dispersed and concentrated soil disturbance minimized?

Indicator: percentage of net area to be reforested with dispersed and concentrated soil disturbance

Soil disturbance overall was low, with over 95 percent of the blocks viewed having less than 5 percent countable disturbance, and approximately 88 percent with 2 percent or less disturbance. A total of 4 portions of 141 openings (3 percent) were found to have areas within the block that neared or exceeded the compliance limits for soil disturbance. The total amount of area that was above or near the maximum was less than 1 percent of the total area observed.

Areas that were seen as having higher disturbance levels were stratified into 0.2 hectare areas.

Areas that were seen as having higher disturbance levels were stratified into 0.2 hectare areas. These areas were then surveyed using a series of short transects recording the length and type of disturbance.



Concentrated disturbance was occasionally found where trails merge.

In two blocks, soil disturbance levels exceeded the prescribed maximum for the block. Two additional blocks with excessive concentrated soil disturbance in a 0.2 hectare stratum were also noted. Noted disturbance included rutted sections or excessive wide scalps in a localized portion of the block. Block A was found to have a total of 13.2 percent soil disturbance, 18.3 percent including the landing. A 0.2 hectare area had 25.4 percent disturbance. The soil disturbance resulted from skidding when soils were saturated. A second 2.04 hectare block had 16 percent disturbance. This block had converging trails that resulted in very wide scalps. A third block had one 0.2 hectare area with 13.7 percent disturbance, with overall block disturbance at 8.1 percent. The fourth block was measured at 8.9 percent disturbance in 0.2 hectare with an overall block level at 3.2 percent.

5. Are there any areas of harvesting related landslides?

Indicator: number of landslides in or adjacent to cutblocks

No landslides or erosion of gullies were identified in the sample blocks.

6. Is there sufficient retention of coarse woody debris?

Indicator: number of pieces of coarse woody debris per hectare of cutblock

Coarse woody debris (CWD) was left in varying amounts over the sampled blocks. Most (85 percent) had low levels of CWD where it was mainly tops with the occasional full sized older log. Thirteen percent of the blocks had a moderate level with one percent considered as having high levels of CWD. Overall, there were relatively low levels of CWD.

Conclusion

Overall, soil conservation values have been maintained. The area occupied by permanent structures is appropriate for the sites. The temporary roads, however, have not yet been rehabilitated and restocked. Overall levels of dispersed and concentrated soil disturbance were low with the exception of four blocks where small portions of the blocks exceeded compliance levels of soil disturbance. Overall, there were relatively low levels of CWD.

Riparian Values

An evaluation of the effectiveness of harvest activities in maintaining riparian values was conducted using the following criteria:

1. Are riparian reserves intact, and free of any disturbances attributable to on-site or adjacent forestry activity?
2. Have riparian reserves or wildlife patches in RMAs been impacted by windthrow?
3. Have forest practices disturbed the channel bed or morphology of the stream?
4. Has harvesting in the RMA ensured a supply of large woody debris has been maintained?
5. Has road and trail construction allowed for the normal, unimpeded movements of fish, organic debris, and sediments?
6. Has the introduction of fine sediments at stream crossings been minimized?
7. Has sufficient streamside vegetation been retained to provide shade and maintain an adequate root network?

Results

1. Are riparian reserves intact, and free of any disturbances attributable to on-site or adjacent forestry activity?

Indicator: number of riparian reserves that are significantly disturbed

Much of this landscape unit is upland with few riparian features. Most blocks viewed did not have a riparian feature in the block or adjacent to it (85 percent). This was due to the limited number of riparian areas along with a risk adverse policy approach to avoid riparian infringement.

Overall, 15 percent of the blocks viewed had a classified riparian feature, of which 88 percent (21/24) had a fully intact riparian reserve zone. Windthrow affected two of three reserves, while the third had pine selectively removed to avoid future damage due to windthrow within the reserve.

2. Have riparian reserves or wildlife patches in RMAs been impacted by windthrow?

Indicator: number of riparian reserves that have been impacted by windthrow

Windthrow along bank edge. Pine were harvested up to the bank edge to control MPB resulting in windthrow along the gully wall.

Windthrow is occurring at low levels (1-3 percent) over approximately half of the observed reserves and WTPs. Two features had 5 percent blowdown, one with 10 percent and one with 20 percent estimated blowdown. These values are low and the blowdown had no observable consequences except for one stream edge where the block is located along a fish-bearing stream with a relatively steep gully wall.

3. Have forest practices disturbed the channel bed or morphology of the stream?

Indicator: area of channel bed disturbed by forestry practices

There were no instances of forestry related disturbances of channel beds, with the exception of the previously discussed windthrow event.

4. Has harvesting in the RMA ensured a supply of large woody debris has been maintained?

Indicator: length of streams that are deficient in a supply of streamside trees greater than 15 centimetre width

Along streams with reserves there is an ample supply of large woody debris. Along streams with no reserves, sufficient retention was made within the inner five meters of the management zone to supply the woody debris requirements of these small streams.

5. **Has road and trail construction allowed for the normal, unimpeded movements of fish, organic debris, and sediments?**

Indicator: number of streams that are hydrologically disconnected by road and trail construction

All classified streams had unimpeded water flow through the cutblocks. Three instances were found where drainage along non-classified drainages was dammed by temporary road construction with no culverts. These dammed areas resulted in localized ponding but had no downstream consequences.

6. **Has the introduction of fine sediments at stream crossings been minimized?**

Indicator: number of stream crossings with observable erosion within 25 metres of the stream crossings

The soil texture was mostly coarse textured till, hence there was little source of fine sediment. There were no special sediment control provisions at any of the crossings. There were also no sediment problems noted.

7. **Has sufficient streamside vegetation been retained to provide shade and maintain an adequate root network?**

Indicator: length of the stream with at least 50 percent original shade cover averaged over the East, West and South aspects

Riparian features were mainly well buffered from harvesting operations.

All streams with reserves and all classified streams without reserves had a sufficient amount of shading to provide at least 50 percent of the original shade. In no cases was there found to be insufficient root mass development in the streambanks.

Conclusion

Overall riparian values are being maintained at the site level. Riparian objectives for channel and bank stability, supply of large woody debris, connectivity, sediment inputs, and shade are being maintained. One problem was identified with harvesting to the edge of a gully wall, otherwise there were no negative riparian issues identified. In spite of large areas of harvested forest, the riparian reserve and riparian management zones are in good condition.

Timber Value (Stocking)

The timber value requires adequate regeneration to meet future forest objectives. All blocks greater than 1 hectare have a regeneration obligation. The small scale salvage blocks that were below this threshold were therefore exempt.

The criteria used to evaluate stocking objectives were:

1. Are silviculture opportunities planned at the landscape level to address the risk of future MPB outbreaks?
2. Have all available sites been restocked?
3. On sites prescribed for natural regeneration, has the seedbed been adequately prepared?
4. In partially cut areas, is retention affecting the growth or regeneration?

Results

1. Are silviculture opportunities planned at the landscape level to address the risk of future MPB outbreaks?

At the time of the assessment there was no mention of reforestation plans being planned at the landscape level to address the risk of future outbreaks.

2. Have all available sites been restocked?

Most (72 percent) of the cutblocks had not yet been restocked at the time of the survey, but all had plans for reforestation. Forty of the 142 cutblocks with reforestation obligations had been planted. The standard prescription was planting of pine and/or spruce within 3 years of harvest.

Snip and skid blocks, below 1 hectare, do not have a regeneration obligation. Two potential regeneration trajectories are possible for these openings. One is they will become part of a larger opening that will have regeneration obligations (numerous BBR blocks were once SSS blocks but were expanded to address the MPB and now have regeneration obligations). A second trajectory is the blocks will remain as small openings within the forest matrix and become somewhat stocked through natural regeneration.

3. On sites prescribed for natural regeneration, has the seedbed been adequately prepared?

The blocks were not set up for natural regeneration, as cones were not intentionally left on site, additionally no action was taken to provide for a suitable seedbed (e.g., mixed mineral and duff). Instead the blocks were planted or planned for planting to pine and spruce.

4. In partially cut areas, is retention affecting the growth or regeneration?

No openings were considered partially cut; all were clearcut with low levels of retention. The retention included riparian areas with the full compliment of species (where there are no regeneration objectives), minor portions of the block with spruce advance regeneration, individual mature spruce, and aspen both as small clumps and dispersed. In no cases was retention seen as limiting growth of new regeneration in a significant amount.

Conclusion

It is too early yet to determine whether stocking objectives are being met. Most cutblocks had not yet been restocked at the time of the survey but all have plans for reforestation. The temporary roads have not yet been rehabilitated and restocked. The lag is within the allowable Code regeneration time window, but raises concerns about the magnitude of the restocking task when upcoming salvage areas are added to the current unplanted area of NSR.

Stand Level Biodiversity Value (Wildlife Tree Patches)

Wildlife tree patches (WTP) are a stand level retention requirement for maintaining biodiversity. Blocks harvested under Silviculture Prescriptions or site plans have identified WTPs in the prescription/plan and map. Blocks harvested under the *BBR* are required under legislation to provide the location of the WTP and riparian reserves on a map every year.

Criteria used to assess the effectiveness of stand level biodiversity were:

1. Were wildlife tree patches equal to prescribed areas present in all blocks, and do the majority of patches fall within cutblock boundaries?
2. Is there a range of patch sizes to maximize diversity?
3. Are there high value wildlife trees, habitat, resource or ecological features that anchor the patch?
4. Is the species profile similar to that of the pre-harvest cutblock?
5. Has partial cut harvesting impacted the ecological function of the WTPs or damaged residual trees?
6. Has windthrow impacted the ecological function of the WTPs?
7. What was the overall ecological value of the retained WTPs?

Results

1. Were wildlife tree patches equal to prescribed areas present in all blocks, and do the majority of patches fall within cutblock boundaries?

Where WTPs were mapped they were accurate and consistent with the map. MPB blocks did not have updated maps at the time of the assessment to show the locations of the WTPs. Additionally it is a practice within the district to wait for local pine mortality to express itself prior to designating WTPs in Beetle Regulation Areas. At the time of the sample significant unharvested areas were available as WTPs.

Most of the WTPs viewed were located on the block edge or within 50 metres of the edge. There are overall a range of sizes and locations within blocks. From a sample of 53 WTPs identified on Silviculture Prescription maps, a total of 60 percent are located either on the block edge (34 percent) or in the adjacent matrix forest away from the block edge (26 percent). A total of 36 percent were located wholly within the block with an additional 4 percent intruding into the block as a peninsula.

2. Is there a range of patch sizes to maximize diversity?

There are a range of WTP sizes. The sample found a mapped range from 0.3 hectare to over 15 hectares, with a mean area of 2.7 hectares. As over half are within matrix forest the size is not representative of what is presently found on the landscape.

3. Are there high value wildlife trees, habitat, resource or ecological features that anchor the patch?

The WTPs viewed in this sample contained or were anchored on a range of biological features. Twenty-seven percent were located on matrix forest without a discernible anchor. Thirty percent were anchored on a riparian feature, the remaining were associated with rock, aspen, wet ground, and one goshawk nest. Smaller pine and patches of spruce were also used to locate WTPs. In all cases wildlife tree class 1 (living and healthy) dominated the patches with a mix of class 2, 3, 4 6 and 8 found over the sample set. Most (88 percent) of the assessed WTPs included dominant trees, 84 percent of the groups have pine as a component, 33 percent have aspen and 60 percent have a spruce component. Most of the trees were considered healthy but there were MPB attacked pine within some of the groups.

4. Is the species profile similar to that of the pre-harvest cutblock?

Because of the uniformity of the forest stands in the area, most of the WTPs provided a similar profile to that of the harvested block. Riparian areas were used where found to anchor retention, providing some variation from the preharvest profile.

5. Has partial cut harvesting impacted the ecological function of the WTPs or damaged residual trees?

One WTP had pine removal to minimize potential future bank stability. There was no other harvesting within any of the assessed WTPs. Damage to residual trees on WTP edges was non-existent.

6. Has windthrow impacted the ecological function of the WTPs?

Windthrow in wildlife tree patches was minimal. Approximately 30 percent of the WTPs assessed had no windthrow at the time of assessment, the remaining 70 percent had low levels (1-3 percent) windthrow, with a single WTP having 20 percent of the stems windthrown. Overall windthrow has not impacted the ecological function of the assessed WTPs.

WTPs ranged from pure pine to a mix of species.

7. What was the overall ecological value of the retained WTPs?

For the subzones assessed, remnant patches were considered as providing high ecological value. Overall, with two exceptions, the ecological value of the reserves was considered as high. The two exceptions were rated as having medium ecological value as one was dominated with small stems, the other had the pine removed.

Conclusion

Overall the implementation and effectiveness of measures for stand level biodiversity through wildlife tree patches was considered high. Wildlife tree patches contained or were anchored on a range of biological features. Most patches had a similar profile to that of the harvest unit. Partial cutting or windthrow had not diminished the value of the wildlife tree patches. The patches were considered to provide high ecological value.

Part 4: Conclusions

An important conclusion of this report is that the current MPB related forest harvesting program, in the Hallett, Cheslatta and Burns Lake East landscape units, fully complies with the Forest Practices Code and has been effective in maintaining key environmental values. Some improvements can be made by reducing areas of concentrated soil disturbance and aggregating cutblocks into larger openings.

The MPB program, focusing on 'leading edge' or 'green attack' harvesting has also been reasonably effective in reducing timber losses to MPB attack. However, the harvesting has not slowed the spread or intensity of the infestation significantly. Also, when under epidemic conditions, the current focus on newly-infested trees may not be the most optimal strategy in reducing timber losses to MPB attack.

Harvesting stands at the 'trailing edge' of the infestation, where there are high levels of salvage and high MPB populations, appears to be more effective in terms of both salvage recovery and MPB population reduction. A 'trailing edge' strategy may also offer reduced operational (e.g., MPB probing and small-scale salvage blocks are not required) and administrative costs (the emergency nature of block layout and approval is reduced), and higher net value to the Crown over the course of the outbreak (since salvage is taken when relatively recently killed). The 'leading edge' strategy is still appropriate for endemic attack areas.

These conclusions are made just prior to the commencement of a large-scale salvage program in the Lakes, Prince George and Quesnel TSAs. The salvage program strategy will have to include plans for reforestation, areas of retained forest, maintenance of riparian forest and wildlife tree patches, as well as adherence to best management practices to maintain this encouraging environmental record.

Appendix 1: Treatment and Harvest Rules

The objective of this appendix is to describe the set of rules that reflect the MPB management effort completed since 1996 in Lakes TSA based on harvest records and interviews with licensees. The main rules pertained to:

- resource constraints which could delay harvest/treatment or eliminate the option for harvest/treatment
- harvesting operation and treatments which addressed MPB infestations

During the week of February 23, 2004, interviews were completed with all licensees operating in Cheslatta and Burns lake East Landscape units. These two LUs were used to calibrate the management effort for the entire district for a given scenario. The following are the results of the interviews and proposed rules that were used for the SELES modeling. Rules were captured as completely as was feasible given the scale of the modeling approach and information available.

MPB Movement across the Two LUs during the Study Period

Cheslatta Landscape Unit

Period	MPB status	Management Strategy
1996 to June 2000	Endemic	Suppression
June 2000 to June 2001	Transition	Suppression
June 2001 to present	Epidemic	Holding/Salvage

Note that the Western portion of the Cheslatta LU has seen a slower progression of the MPB population and the transition period between endemic to epidemic status occurred in 2003.

Burns Lake East Landscape Unit

Period	MPB status	Management Strategy
1996 to June 2003	Endemic	Suppression
June 2003 to present	Transition	Suppression

The following are definitions used for the purpose of this project:

- Transition: threshold period when the current MPB infestation starts to exceed the harvesting/treatment capacity within an area. Transition period between endemic to epidemic translate into a significant increase in the MPB population where by most of the MPB population is coming from outside the transition zone area.
- Endemic: current MPB level below the transition definition.

- Epidemic: current MPB level above the transition definition. Transition becomes epidemic when the MPB population is so large that it becomes a source for spread for another location.

Percentage of Current Infestation Treated or Harvested Annually

This table represents the percentage of current infestation treated or harvested annually following the end of the endemic level period (after 2000) found in the Cheslatta LU. 90 percent of current infestation was treated or harvested annually during the endemic period (1996 to June 2000).

	Year 1 (transition) (2000/01)	**Year 2 (epidemic) (2001/02)**	**Year 3 (epidemic) (2002/03)**
Treatment/harvest level of current infestation (%)	80%	50%	40%
Salvage (%)	5%	5%	10%

For the most part, treatments and harvesting operations were completed within the first year of identifying the MPB infestation during the endemic and transition periods. During the epidemic period, every effort was made to harvest within a year of identifying the MPB, despite the fact that the infestation levels far outweigh the harvesting capacity. As time elapses from the onset of the epidemic level, the amount of current attack increase annually and addressing the current infestation within the first year of identification becomes increasingly difficult to impossible. Many areas had repetitive treatments over the years until the entire susceptible type was removed (harvested).

Hauling

In some instances, the hauling could not be completed promptly after harvesting due to road closure (break up) and hauling restriction. Ever year, a certain amount of infested timber could be decked in blocks during part of the MPB flight.

Road Development

Most of the roads in the study areas already existed; therefore, only the constructions of spur roads were needed to address MPB infestation.

Resource Constraints Rules

Resource Constraints	**Rules**
OGMA	Candidate OGMAs did not constrain MPB management effort in the study areas until 2003. Since the approval of the SRMP in July 2003, the OGMA have been defined and no MPB management is implemented in OGMA except in area where MPB control (suppression) is possible (the leading edge zone), (maximum size opening in OGMA is 0.16ha).

VQO	VQO did not constrain MPB management effort in the study areas.
Bio-ecosystem network (BEN) which became under the SRMP the landscape corridors	Prior to 1998, there was no district limit on management, except what was already in place by the *Forest Practices Code* before 1998 (district manager policy). Management of these areas became limited after the approval of the LRMP in 1998. MPB management could only occur if "form and function attributes" were maintained and if less than 30% of the stand was removed (maximum opening size was 4ha). Snip and skid and fall and burn treatments were completed in the BEN. Since 2002, the licensees have been following the intent of the SRMP (signed in July 2003) and the management of MPB has been limited in the critical landscape corridors. The SRMP transfer some of the BEN into landscape corridors. MPB management is allowed in landscape corridors only if there is a chance of controlling the MPB population (suppression).
Riparian Reserve Zone	MPB management in riparian reserve zone was very restricted after 2001 and the common practice was to stay away for these areas. Some snip and skid operations were completed before 2001.
Green up	Green up did not constrain MPB management effort in the study areas.
Wildlife Tree Patch	WTP requirements in Cheslatta LU: 6% WTP requirements in Burns Lake East LU: 5% Upon increasing the AAC in 2001, the % requirement of WTP doubled in areas where there were no OGMA established. Therefore, Cheslatta became 12% and Burns Lake East became 10%. Usually the WTP consisted of a combination of none susceptible trees and none infested trees. In the epidemic zone, some WTP became infested following harvesting and were not subsequently removed.
Cultural Heritage	Significant impact on MPB management around Knapp Lake (Cheslatta LU) and in Burns Lake East LU. Between 1% to 5% of the MPB-infested areas were not managed due to cultural heritage values over the study areas.
High Biodiversity	Did not constrain MPB management effort in the study areas.

Treatment/Harvest Rules Prior to MPB Regulation (August 2001)

Management	**Rules**
Harvesting >1ha	• Clear cut with WTP • High susceptible type (Pl stand >= to age class 7) • Within 3 km of existing road • Prioritize the harvesting process if MPB infestation is present in block. • Must be in operable areas • Infestation level>30% of the volume or stems, clear cut with WTP (rule started in 2000)
Harvesting (snip & skid) <1ha	• 1 harvested stems out of 3 must be infested • must be in average 600m from existing road, up to 2 km skid distance • Minimum of 1 load available from adjacent groupings • Avoid inoperable areas • Avoid riparian zones
Fall & Burn	• Must be on average, greater than 600m from existing road • Located in inoperable areas or inaccessible areas • required too much removal of none attacked trees for snip and skid treatment (ratio none attack: attack >3:1)

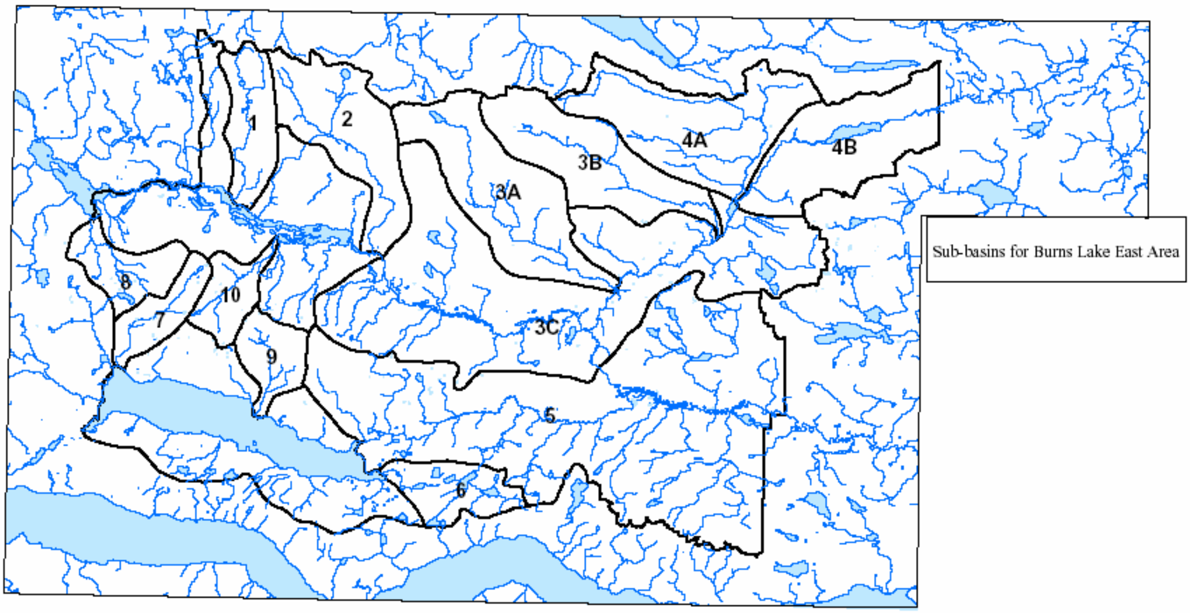
Treatment/Harvest Rules after MPB Regulation (August 2001)

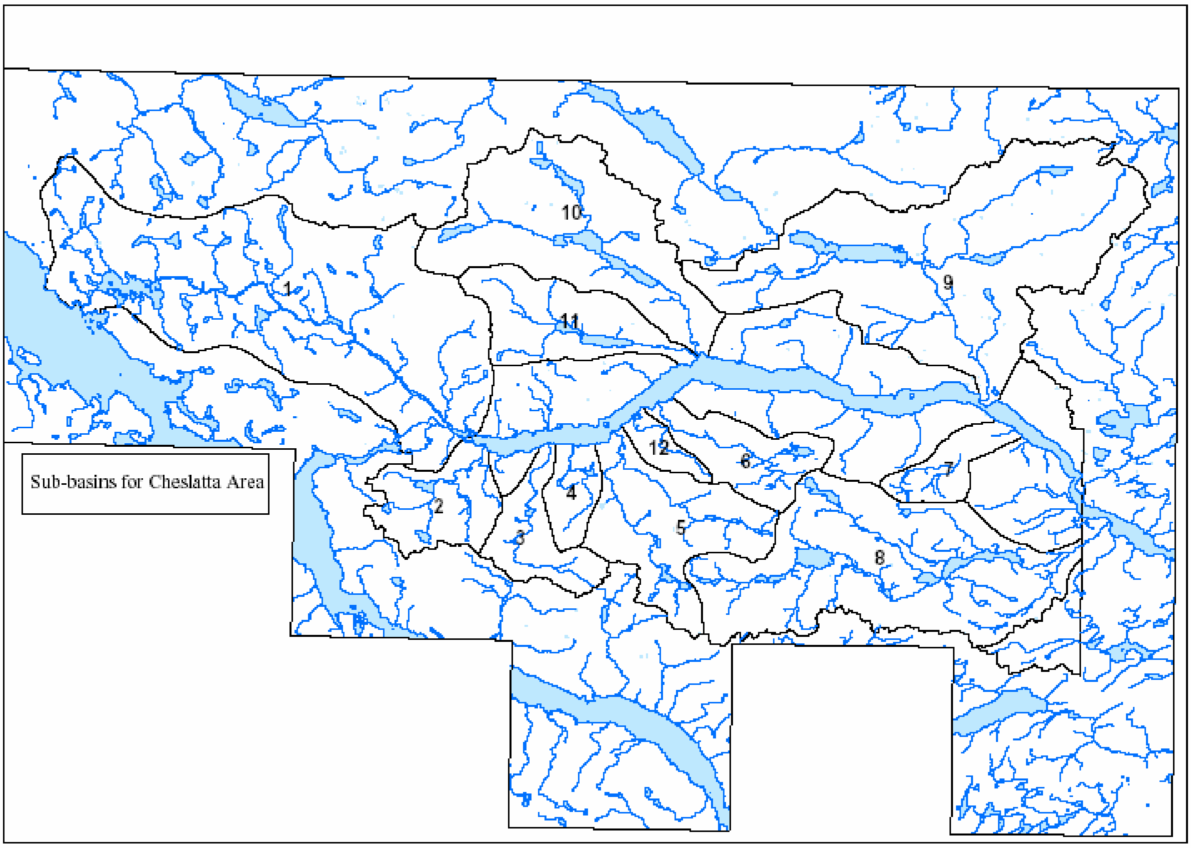
Management	Endemic Zone	Transition Zone	Epidemic Zone
Harvesting >15ha	• High susceptibility (Pl stand ≥ age class 7) • Within 3 km of road • Must be in operable area • Block this size not used in endemic zone to control MPB but used to reduce susceptibility	• Infestation level > 30% of the volume or stems; clear cut with WTP • Lay out follows MPB boundary • Must be in operable area • No resource constraints • Within 3 km of road	• Infestation level > 30% of the volume or stems, clear cut with WTP • Maximum block size increased to reflect size increase of infestation • Lay out follows MPB boundary • Within 1 km of road • Must be in operable area • No resource constraints
Harvesting >7ha & <15ha	• Infestation level > 30% of the volume or stems, clear cut with WTP • Lay out follows MPB boundary • Must be in operable area • No resource constraints • Within 3 km of road • Seldom used due to low occurrence of infestation this large in endemic zone	• Infestation level > 30% of the volume or stems, clear cut with WTP • Lay out follows MPB boundary • Must be in operable area • No resource constraints • Within 3 km of road	• Infestation level > 30% of the volume or stems, clear cut with WTP • Lay out follows MPB boundary • Must be in operable area • No resource constraints • Within 1 km of road
Harvesting >1 ha and <7ha (average size for 2,000m^3)	• Infestation level > 30% of the volume or stems, clear cut with WTP • Lay out follows MPB boundary • Must be in operable area • No resource cons traints • Within 3 km of road • Adjacency rule apply: must be >100m from any other blocks	• Infestation level > 30% of the volume or stems, clear cut with WTP. • Lay out follows MPB boundary • Must be in operable area • No resource constraints • Within 3 km of road • Adjacency rule apply: must be >100m from any other blocks	• No blocks < 7ha in the epidemic zone
Harvesting (snip & skid) <1ha	• 1 harvested stems out of 3 must be infested • must be 600m from existing road, maximum skid distance 2 km • Minimum of 1 load available per groupings • Avoid inoperable areas • No resource constraints	• 1 harvested stems out of 3 must be infested • must be 600m from existing road, maximum skid distance 2 km • Minimum of 1 load available per groupings • Avoid inoperable areas • No resource constraints	• No snip & skid in the epidemic zone
Fall & Burn	• Must be beyond 600m from existing road • Located in inoperable areas or inaccessible areas	• Must be beyond 600m from existing road • Located in inoperable areas or inaccessible areas	• No fall and Burn in the epidemic zone

	• No resource constraints	• No resource constraints

Note: Harvesting operation took place usually in age class 7-9 but could be as low as age class 5 in the epidemic zone.

Appendix 2: Sub-basins in Burn Lake East and Cheslatta Landscape Units





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