SALVAGING SOLUTIONS

Science-based management of BC's pine beetle outbreak

Canadian Parks and Wilderness Society

Forest Watch of British Columbia

A project of the Sierra Legal Defence Fund

David Suzuki Foundation

Finding solutions

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Executive summary

Since 1997, mountain pine beetles (*Dendroctonus ponderosae*) have infested over 300,000 hectares of lodgepole pine (*Pinus contorta* var. *latifolia*) forests in the central interior of British Columbia. In previous outbreaks, mountain pine beetles have killed as many as 80.4 million trees distributed over 450,000 hectares per year across the province, making them the second most important natural disturbance agent after fire in these forests.

The current approach of the British Columbia Ministry of Forests is to aggressively harvest infested and killed trees to slow the outbreak, mitigate its impacts on timber supply, and reduce losses in timber values. Measures to facilitate this approach include increases in the Allowable Annual Cut for some areas, reductions in environmental regulations and planning requirements on treatment units, and reduced stumpage – the fees paid for logging on public land. However, large-scale salvage and sanitation harvesting have long-term economic and social consequences, as well as important implications for the integrity and sustainability of the forest ecosystem.

We are concerned the current approach of mountain pine beetle management does not adequately address issues of conservation and long-term sustainability. Here, we review current understanding of lodgepole pine and mountain pine beetle ecology and management. Our goal is to evaluate the current approach of mountain pine management and identify more ecologically appropriate alternatives based on the scientific literature and other available information. This report focuses on management within the timber harvesting landbase, on the understanding that protected areas must remain unlogged, both to help meet regional conservation objectives and to provide opportunities for understanding unmanaged forest ecosystems.

On the basis of this review, we conclude that:

- **The mountain pine beetle and other bark beetles are native species and natural and important agents of renewal and succession in interior forests.** Beetle outbreaks create diversity in forest structure, tree ages and species composition at stand and landscape scales, which are important for forest ecosystem health, diversity, and productivity. Beetle-killed trees provide ecological services and functions well beyond their death. At the landscape scale, beetle infestations create a mosaic of forest patches of various ages, densities, species composition and successional stages.
- **The current outbreak in central BC is a socio-economic challenge, rather than an ecological crisis**. Mountain pine beetle outbreaks, like fire, are a natural disturbance to which interior forests are adapted and with which these forests have evolved for millennia. The current outbreak is a 'crisis' because of its potential impacts on timber supply, crown and industry revenue, and long-term community stability, rather than because of its impacts on biological diversity or ecosystem functions and integrity.
- **Management interventions have never before controlled a large outbreak.** It is unknown whether control efforts cannot work, or have just been improperly done, but despite nearly 100 years of actively managing the mountain pine beetle, efforts to suppress outbreaks across North America have been largely unsuccessful. Sanitation harvesting may slow the rate of spread of mountain pine beetles in some areas if efforts are well focussed, coordinated, and combined with early detection before outbreaks occur. However, as long as weather and habitat conditions remain favourable, previous

experience suggests this outbreak will continue until the supply of susceptible trees runs out or quick winter cold snaps destroy the larvae.

- **Sanitation and salvage clearcutting differ from natural disturbances in their effect on forest structure, and tend to reduce stand and landscape diversity.** Natural disturbances vary in their intensity, frequency and magnitude, and amount and type of forest structure they retain. A large-scale clearcut is a stand replacement event that differs from a natural disturbance, especially in its intensity (percent of woody structures removed), frequency over time, and magnitude. Structural diversity at both the stand and landscape level is important for maintaining biodiversity and for the ability of ecosystems to resist and recover from fires, diseases, and other disturbances. Reducing stand and landscape diversity through harvesting may increase the susceptibility of these forests to large mountain pine beetle outbreaks in the future.
- **Allowable Annual Cuts (AAC) in the beetle-affected area are either on the high end of or outside the natural range of variability for disturbances in interior ecosystems.** For example, given the recent AAC increase, the total area harvested in the Lakes TSA over the next 20 years will be approximately 28 to 36% of the harvestable landbase. In the long term, between 18 and 21% of the landscape will be harvested every 20 years on average. Knowledge of disturbance regimes in these forests is limited, but studies to date report disturbance rates that vary between 7 and 24% per 20-year period. Thus, long-term average rates of harvest are probably outside the range of natural variability, and short-term increases may also be. Even if the overall disturbance rate is within the natural range of variability, logging is not allocated according to the local variations in disturbance regime. This means that logging rates in areas that typically burned infrequently, such as moist, productive areas, are almost certainly too high. Current logging treatments and natural disturbances differ in other important ways, so increasing logging will continue to disturb these ecosystems outside their range of natural variability. Increased logging now will also foreclose future options for more ecologically appropriate approaches.
- **Increasing the AAC will have serious consequences for long-term social and economic sustainability.** The AACs in the Quesnel and Lakes Timber Supply Areas have been increased significantly above the Long Term Harvest Level, the rate of harvest considered sustainable by the B.C. Ministry of Forests. These increases in the AAC cannot be sustained and must be temporary. For example, to maintain long-term sustainability in the Lakes TSA, harvest rates will have to be reduced by nearly 50% after 10 years. This will likely result in significant job and revenue losses and social and economic disruption.
- **Current mountain pine beetle management fails to adequately ensure that ecological values are protected.** The current legal framework allows "emergency" exemptions from block-size requirements, terrain stability assessments, adjacency constraints and public review periods for operational plans. "Emergency" logging may also occur in Old Growth Management Areas, Wildlife Habitat Areas, riparian reserves, Wildlife Tree Patches, Forest Ecosystem Networks, ungulate winter ranges, thus affecting the implementation of higher level planning, e.g., Land and Resource Management Plans.
- **Low stumpage rates may subsidize logging of stands which could be more valuable if retained for environmental values or for future harvest.** Current policy allows stumpage fees to be reduced to 25 cents per M^3 for salvage logging.

- **Basic questions about mountain pine beetle ecology and management remain unanswered** despite nearly 100 years of management experience. This is in part because managers have failed to adequately monitor their actions and to evaluate their effectiveness in achieving management goals.

The above findings have implications regarding policies and practices for ecologically appropriate strategies of managing the mountain pine beetles. In particular, our findings suggest forest managers should:

- **Establish a comprehensive management strategy for the mountain pine beetle to adequately conserve and manage the ecosystem.** This strategy should focus on proactively managing the host lodgepole pine trees, rather than beetles. The strategy should entail policies and practices for:

i. prevention of an outbreak and reduction of long-term lodgepole pine susceptibility and risk;
ii. suppression during population buildup of mountain pine beetles to strive to contain and suppress initial outbreaks, especially when small; and
iii. salvage activities for ecosystem recovery after the outbreak to restore ecosystem diversity at all spatial and temporal scales.

- **Distinguish clearly between sanitation and salvage harvesting in forest policy.**
- **Subject salvage operations to full planning requirements and environmental regulations.**
- **Design a planning process to ensure that environmental values are protected during sanitation harvests.** Ensure that large-scale planning identifies key environmental values prior to operations. Assess these values for compatibility with beetle management strategies, and ensure ecological values are given priority where necessary. Allow opportunities for the B.C. Ministry of Water, Land and Air Protection and other stakeholders for meaningful input into Forest Development Plans and Silvicultural Prescriptions of sanitation activities.
- **Use existing harvest capacity first for insect suppression.** Coordinate and focus suppression activities on areas where they can be most effective and minimize the amount of roaded area, and its negative impacts on watersheds, wildlife, forest connectivity, and other non-timber values. Retain non-host and uninfested trees to make efforts most effective while minimizing the impacts of harvesting on forest structure and ecosystem function.
- **Mimic natural disturbance processes when harvesting** by retaining remnant patches of forest and coarse woody debris and employing a diversity of silvicultural systems across the landscape.
- **Vary amount and pattern of retention with forest type and natural disturbance pattern.** Since current information is inadequate to characterize local variation in various aspects of natural disturbances such as size and variability of retained forest structure, local guidelines should be considered tentative, and some process should be in place to incorporate new information as it becomes available.
- **Ensure that reduced stumpage rates do not subsidize salvage** in stands that would be more valuable if retained for environmental values or for future harvest.
- **Subject AAC determinations to a comprehensive Environmental Risk Assessment to**

assess and mitigate environmental impacts. At minimum, ensure that harvesting does not increase disturbance rates outside the range of natural variability over the long or short term.

- **Set AAC to ensure long-term social and economic sustainability** within natural variability constraints. More research is required to understand the long-term social, economic, and ecological consequences of temporary increases in the AAC.
- **Allocate harvest according local variation in disturbance regime** within each TSA.
- **Keep harvest rates low to maintain future options** until long-term consequences of harvest rates are better understood.
- **Commit to long-term planning, research, and proactive mountain pine beetle management.** Mountain pine beetle outbreaks will happen again. More research and planning during periods of low abundance will help to avoid panic and allow additional science-based approaches to managing future outbreaks.
- **Take an adaptive approach to mountain pine beetle management.** The current outbreak allows excellent opportunities for comparing different management approaches in various forest types. Capitalizing on these opportunities will require an actively experimental approach to management, as well as a good monitoring system and a process for incorporating monitoring results into subsequent decisions about beetle management.

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For clarity, Forest Watch of British Columbia's affiliate, Global Forest Watch, neither endorses nor rejects recommendations made in this report as these go beyond the scope of the organization's mandate of monitoring activities within forests.

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Introduction

Lodgepole pine (*Pinus contorta* var. *latifolia*) is an abundant and economically important species in the interior of British Columbia (B.C.). It is present in 5.7 million hectares of forest across the region, and supplies as much as 80% of the annual timber harvest in some central interior Forest Districts. Province-wide, lodgepole pine makes up 25% of the timber supply (B.C. Ministry of Forests 2001a). Lodgepole pine is also ecologically important, playing a range of successional and functional roles in 9 of the 12 forested biogeoclimatic zones in the province (Pojar 1984).

Mountain Pine Beetle Outbreak
Mountain pine beetles are an important landscape level disturbance agent in lodgepole pine forests.

Mountain pine beetles (*Dendroctonus ponderosae*) are a native insect of North America that co-evolved with lodgepole pines. These beetles feed on and breed in lodgepole pines and occasionally on other pine species, affecting an average of 50,000 hectares of forest in the province each year (Wood and Unger 1996). They periodically increase from low or 'endemic' levels of abundance to outbreaks. During outbreaks, mountain pine beetles may kill as many as 80.4 million trees distributed over 450,000 hectares per year across the province (Wood and Unger 1996), making them the most important predator of lodgepole pines and the second most important natural disturbance agent after fire in these forests.

Large areas of B.C.'s central interior are currently experiencing a mountain pine beetle outbreak. Since 1997, beetle populations have increased dramatically, impacting over 300,000 hectares in the Morice, Lakes, Vanderhoof, and Quesnel Forest Districts (B.C. Ministry of Forests 2001b). Recent distribution data show that the outbreak is continuing to expand, with a four-fold increase between 1999 and 2000 (B.C. Ministry of Forests 2001b).

Outbreaks of mountain pine beetles have important economic and social consequences (Wellner 1978; Leuschner and Berk 1985; B.C. Ministry of Forests 2001a). For example, in the Lakes Forest District, beetles infested 2.45 million cubic metres of timber, nearly twice the volume of timber cut each year in that district (B.C. Ministry of Forests 2001b). Beetle-killed trees retain economic value, and can be salvage[1] harvested. However, since wood quality and value decline with time since attack, there is strong pressure to cut beetle-killed timber promptly to maximize the economic value of salvaged trees. Pressure to quickly salvage beetle-killed timber prompted the Chief Forester to substantially increase the Allowable Annual Cut (AAC)[2] in the Quesnel and Lakes Timber Supply Areas this year (B.C. Ministry of Forests 2001d; 2001e). Although accelerated cutting of large attacked areas can prevent the 'waste' of timber value in the short term, it also disrupts forest plans, strains harvest and milling capacity, oversupplies markets and causes decreases in the price of lumber, and reduces long-term timber supply. Moreover, it is expensive in the short term, and has long-term social costs when the wood supply required to support harvest capacity and employment built for beetle kill can no longer be maintained.

Mountain pine beetle outbreaks are also important ecologically. Research in forest ecology has increasingly recognized the essential role that natural disturbances play in shaping forest structure and maintaining ecosystem processes (Turner and Romme 1994; Christensen et al. 1996; Rogers 1996; Foster et al. 1998). Mountain pine beetles are always present at low levels in these forests. Small attacked areas create patchiness at the stand level, increasing local diversity and creating habitat and food for a large number of species. Outbreaks accelerate forest succession to other tree species in some areas, as well as create the conditions for stand-replacing fires that maintain the dominance of lodgepole pines (see Fuchs 1999 for review). Outbreaks therefore promote a large patchy mosaic across the landscape of young lodgepole pine stands interspersed with later-seral conifer species and occasional remnants of rare 'old growth' lodgepole pine forests.

The B.C. Ministry of Forests has various policies in place to respond to mountain pine beetle outbreaks. These policies are largely strategies to reduce short-term losses of timber from 'beetle-kill'. Mountain pine beetle management activities also affect wildlife habitat, endangered ecosystems and species, the susceptibility of the forest to future outbreaks, and the long-term sustainability and stability of timber-dependent communities. We are concerned these longer-term ecological, economic, and social effects, especially at the landscape scale, are not adequately considered or planned for in the current approach to mountain pine beetle management.

Ultimately, sustaining ecological integrity, ecosystem function and biodiversity should allow humans to get the most value from forests over the longest period of time (Grumbine 1994; 1997; Christensen et al. 1996). With regard to the current outbreak, and to the management of bark beetles in general, the principal challenge is to minimize short-term losses from outbreaks without compromising the long-term integrity and sustainability of these ecosystems. To meet this challenge, it is necessary to understand how interior forest ecosystems work, and how management might affect them. Our goal in this report is to summarize the current scientific understanding of what effective and ecologically appropriate management entails for current outbreak in central interior B.C. To accomplish this, this report has the following objectives:

i. briefly outline the history and the interconnected roles of mountain pine beetles and fire in lodgepole pine ecosystems;
ii. review the scientific literature regarding how management might best reconcile short-term economic objectives with long-term sustainability in these forests, and;
iii. outline a more ecologically appropriate approach to managing the present outbreak.

NOTES

1 Salvage refers to the cutting and milling of dead timber before the wood degrades below merchantability.

2 The Allowable Annual Cut is a target for the volume of wood to be harvested annually. This figure is typically determined from a Timber Supply Review every five years, which considers long-term implications of different harvest levels. The 'beetle uplifts' are considered a temporary, extraordinary measure designed to deal with the mountain pine beetle outbreak.

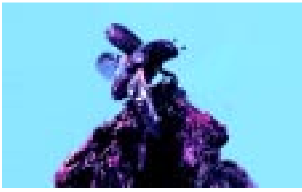
Pines, beetles, and fire: natural disturbances of interior forests

Endemic Populations
When mountain pine beetle populations are low, beetles persist by killing small numbers of old and weak trees.

Lodgepole pines, fire, and mountain pine beetles are intimately connected components of forest ecosystems in interior B.C. Mountain pine beetles are present everywhere there is lodgepole pine, decreasing in abundance north of 57° latitude, or roughly north of Fort St. John. Generally, lodgepole pines become susceptible to attack by mountain pine beetles when they reach at least 15 centimetres in diameter (typically, at about 60 to 80 years of age) and the phloem – the vascular tissue in which the beetles breed – becomes thick enough to support large beetle broods. While young vigorous trees can resist beetle attack[1], resistance decreases as their age increases and vigour decreases. Fungi or mistletoe infection can predispose trees to beetle attack (Geiszler et al. 1980; Nebeker et al. 1995a; Nebeker et al. 1995). Thinned or mixed-species stands tend to incur lower beetle mortality than dense lodgepole pine stands, although the exact reason for this is unknown (Geiszler et al. 1978; Romme et al. 1986; Raffa and Berryman 1987; Amman and Logan 1998; Goyer et al. 1998). At low, or 'endemic' population levels, mountain pine beetles persist by attacking mainly old and weak trees. However, if populations increase beyond some critical threshold, they can overwhelm the defenses of young vigorous trees[2]. Once beetles have passed this threshold, populations typically increase to outbreak levels and remain there until the supply of susceptible lodgepole pines is depleted, or a cold winter reduces populations to below critical outbreak numbers (Amman 1978; Samman and Logan 2000).

Following a mountain pine beetle outbreak, forests may burn, or continue through succession into different forest stages. Lodgepole pine is an early successional species that is intolerant of shade and competition and does not regenerate under a closed forest canopy in most locations (Pfister and Daubenmire 1973). Many lodgepole pines also have serotinous (sealed by pitch) cones that do not open until they are heated by fire or direct sunlight (Muir and Lotan 1985; Tinker et al.1994). Thus, fire is essential for the continued dominance of this species in many landscapes. Large areas of beetle-killed trees may increase the availability of woody fuels and therefore the hazard of fire, so beetle outbreaks may ultimately help to sustain lodgepole pine over the long term (Peterman 1978; Raffa and Berryman 1987).

Although mountain pine beetle outbreaks affect the loading of woody fuels in forests, evidence suggests that the progression from outbreak to stand-replacing fire is not inevitable. For example, in Yellowstone National Park, stands that experienced high beetle mortality (>50% of susceptible trees) in the 5 to 17 years preceding the 1988 fires typically burned more intensely than uninfested stands, as expected (Turner et al. 1999). However, the incidence of high intensity crown fire in stands with low to intermediate beetle mortality was lower than in uninfested stands. This suggests that in some stands beetle kill may actually decrease the hazard of high intensity crown fire by decreasing the continuity of woody fuels in the canopy (Turner et al. 1999). Fuel accumulation and fire hazard also vary with time since an outbreak, with hazard being high for one or two years while dead foliage remains on the trees, decreasing once foliage falls, and then increasing again as dead trees start to fall (Lotan et al. 1984). This is similar to the pattern of fuel succession after wildfire, where the likelihood of subsequent fire peaks after approximately 25 years (Lotan et al. 1984). Observations that large beetle-killed areas from a major outbreak in the Flathead region of southeastern B.C.



Emergence and Flight
Adult beetles emerge and fly in mid to late summer when temperatures reach 18° to 19°C. The peak of flight activity occurs at about 25°C.

nearly 20 years ago remain unburned also suggest that the progression from beetles to fire may not be immediate or inevitable (Borden, J., personal communication). Uninterrupted succession after an outbreak is probably more common than is often assumed[3].

In the absence of fire, the effect of mountain pine beetles on forest succession depends on the degree of mortality, the successional role of pine at a given location, and the presence and size of later successional species (see Fuchs 1999 for recent review). In general, beetle mortality opens the canopy, allowing more light to understory trees and plants, and promoting increased growth and succession to multi-layered, uneven aged stands. Where lodgepole pine is an early seral species, beetle-kill hastens succession to other species – typically Douglas-fir (*Pseudotsuga menziesii* var. *glauca)* and western larch (*Larix occidentalis*) in southern pine forests, white spruce (*Picea glauca*) and subalpine fir (*Abies lasiocarpa*) in more northern locations, and subalpine fir and Engelmann spruce (*Picea engelmannii*) at high elevations (Fuchs 1999). In some locations where other species are not present or cannot survive, especially in harsh climates with poor soils, lodgepole pine may self-perpetuate by regenerating in the understory of beetle-killed stands (Stuart et al. 1989).

Lessons from history – is the current outbreak unnatural?

The current outbreak of the mountain pine beetle in central interior B.C. is larger than previous outbreaks recorded in the area (Wood and Unger 1996). Its rate of growth and spatial extent exceed that of outbreaks in the Flathead region during the late 1970s and early 1980s and in the Chilcotin region during the early-to-mid 1980s. This prompts questions of whether the current outbreak is outside the natural range of variability[4], and thus of ecological as well as economic concern.

Unfortunately, empirical data of the abundance and distribution of mountain pine beetles only date back to 1910. This period of record does not span enough outbreak cycles to provide a good indication of the range of variability in the magnitude and frequency of outbreaks over the short and long term. Until more information becomes available from historical records, traditional knowledge, dendrochronological studies or other means, we cannot determine whether or not the current outbreak is 'natural' (i.e., outside the range of natural variability for central interior B.C.).

Forest structures and disturbance regimes in many parts of North America have been altered since European settlement by a variety of causes. These causes include disruption of burning by aboriginal peoples, extensive fires during early European settlement, more recent fire suppression, and climate change (Safranyik 1995; Whelan 1995). Opinions diverge about whether recent changes in landscape and forest structure have altered population dynamics of mountain pine beetles, or outbreaks historically spread over equally large areas (Gara et al. 1978; Geiszler et al. 1980; Rogers 1996; Goyer 1998; McCullough et al. 1998). The speculation is that reduced burning has increased the amount of lodgepole pine forests in older age classes over historic levels, making them more susceptible to outbreaks of mountain pine beetles than they were in the past (Safranyik 1995; B.C. Ministry of Forests 2001a). However, long-term studies of fire history in Yellowstone National Park emphasize that although recent landscape changes may have affected the extent of the 1988 fires, large infrequent disturbances are not without precedent in these ecosystems, and cannot be automatically considered abnormal just because they are large (Romme and Despain 1988).

Fire history data from central B.C. show patterns of change consistent with those observed in Yellowstone and elsewhere (information summarized in Wong 2000). In particular, burn rates in the sub-boreal and subalpine forests of the Prince George Forest Region and the

Chilcotin Plateau have decreased. While 7 to 24% of this region burned every 20 years between 1851 and 1951, only 0.15% burned between 1970 and 1990 (Andison 1996; Dawson 1996; DeLong and Tanner 1996). Reasons for this decrease may include disruption of burning by aboriginal peoples and climate change, but it is largely attributable to active fire suppression. In the same period, logging rates have risen from zero to 12% of the landscape every 20 years. Logging has therefore replaced fire as the dominant disturbance in these forests. However, despite speculation, it remains uncertain whether these recent landscape-level changes are responsible for the magnitude of current outbreaks.

Climate change may also be a factor in the current outbreak. Winter temperatures directly affect mountain pine beetle populations[5], raising speculation that global climate change could allow populations to rise above historic levels (Safranyik 1990). The current outbreak is in part a direct consequence of recent warm winters, but it is uncertain whether these winters are a product of global climate change or a result of short-term natural climatic variation.

In summary, we can conclude the following:

i. the range of natural variability in mountain pine beetle dynamics is unknown,
ii. fire, the historically dominant natural disturbance agent in interior forest ecosystems, has been radically reduced while logging has increased,
iii. warmer winters and more old forest most likely increase the risk of large outbreaks, but
iv. the cumulative effect of recent landscape-level changes on the current outbreak is uncertain.

Mountain pine beetles play important ecological roles in these forests. Since we cannot conclude the current outbreak is outside the natural range of variability, attempts to actively suppress or eradicate beetles should not be undertaken on the grounds that the current outbreak is an ‘ecological disaster ‘in need of mitigation. Rather, forest managers should recognize that outbreaks of the mountain pine beetle are a natural agent of change in the interior forests of B.C. Dramatic and hurried management interventions are proposed to prevent short-term losses of timber. The immediate challenge is to minimize the ecological costs of these interventions so that ecosystem integrity is not compromised in the rush to meet economic objectives.

R. SCHWANKE

After an Outbreak
Following a mountain pine beetle outbreak, forests may burn or continue through succession. Here, an unburned stand in Waterton Lakes National Park is shown twenty years after an outbreak.

NOTES

1 Pines resist attack by secreting resins into the path of the mountain pine beetle. The resins physically impede beetle nesting, interfere with communication among the beetles, and seal the living tree cells from infection by blue stain fungi (*Ceratocystis* spp.) carried by the beetles.

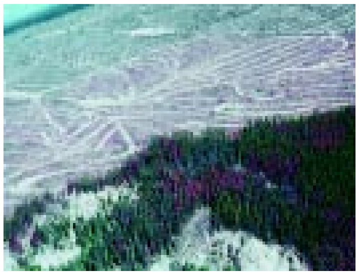
2 For general overviews of the ecology and population dynamics of mountain pine beetles, see Amman 1978; Coulson et al . 1985; Crookston and Stark 1985; Samman and Logan 2000.

3 The incidence of large stand-replacing fires following outbreaks is also reduced by active fire suppression.

4 The natural range of variability refers to the spectrum of conditions possible in ecosystem composition, structure and function, when considering both temporal and spatial scales. It is typically assessed as the spectrum of conditions present before the influence of European settlers (Swanson et al. 1994).

5 Climatic conditions are arguably the most important regulator of the population dynamics of the mountain pine beetle. Cold winters, especially sharp early cold snaps of -25°C temperatures early or late in the season, kill large amounts of larvae over-wintering in the trees.

Mountain pine beetle management: current approaches in B.C.



Harvesting Infested Trees
Harvesting infested areas by clearcutting is the principal tactic used to limit infestations. In this case, infested trees were missed when the block was cut out.

The provincial government has declared 'war' on the mountain pine beetle (B.C. Ministry of Forests 2001a). The current strategy of the B.C. Ministry of Forests can be characterized as an aggressive sanitation campaign targeted at the beetle-infested areas. Its principal goals are to mitigate timber supply impacts of the outbreak and reduce its extent and rate of spread. The primary method is logging, carried out as either sanitation or salvage depending on its primary purpose. Sanitation refers to logging of 'green' attacked areas[1] when broods are still present, primarily to reduce beetle abundance. Salvage, in contrast, refers to logging 'red and grey' trees after beetle broods are gone to capture economic value before timber has degraded beyond merchantability. Recently as much as 30% of all logging in the interior of the province and over 80% of some interior districts has been either sanitation or salvage logging (Sierra Legal Defence Fund 2001). In June and July of this year, the Chief Forester increased the Allowable Annual Cut (AAC) in two of the Timber Supply Areas (TSA) affected by the outbreak to permit further sanitation and salvage logging[2]. In the Quesnel TSA, the AAC rose by 39% to 3.248 million cubic metres, and in the Lakes TSA, the AAC increased by 103% to 2.962 million cubic metres (B.C. Ministry of Forests 2001c).

Although forest managers utilize a variety of treatments for salvaging timber and attempting to reduce the spread of the outbreak, the most commonly employed is clearcutting. This is largely because clearcutting is widely regarded as the most logistically and economically efficient method of harvesting timber and for 'control' of the mountain pine beetle (e.g., CLMA/NFPA Mountain Pine Beetle Emergency Task Force 2000). Clearcutting is a one-pass removal of most or all standing trees that creates the conditions for a largely even-aged stand of trees. As a silvicultural system aimed at establishing a free-growing replacement forest, clearcutting is typically accompanied by artificial regeneration, site preparation, and other intensive silvicultural treatments. Opening sizes range from four to several thousand hectares. While little information is readily available on the actual extent of clearcutting utilized to address the mountain pine beetle, clearcutting is the method of choice for over 90% of hectares logged in B.C. (B.C. Ministry of Forests 2001d). Alternative treatments to clearcutting used for sanitation and salvage include small-scale treatments such as patch cuts and selection harvesting for brood tree removal[3], pheromone baiting[4], fall and burn treatments, 'snip and skid'[5], and application of an arsenic-based pesticide called MSMA[6] (Maclauchlan and Brooks 1994; Natural Resources Canada 2001). Larger-scale treatments include helicopter logging of infested areas where conventional access is not available, mosaic burning[7], partial cutting for species and age class manipulations, and thinning[8] (Maclauchlan and Brooks 1994; Natural Resources Canada 2001). Typically, these alternative treatments are a small component of the treatment mix. For example, while sanitation harvesting represents 85% of the AAC in the Quesnel Forest District, less than 1% of sanitation activities utilize any of the above alternatives (Asher, D., personal communication).

The use of MSMA requires special mention. Recent evidence shows that pentavalent methylated arsenic, the form of arsenic present in MSMA, is reduced immediately to its trivalent methylated form when it enters the human body (Mass et al. 2001). The latter compound is carcinogenic and considered very toxic to humans (ATSDR 2001). This recent finding is not considered in the environmental assessment of MSMA (Dost 1995) that forms the basis for current practices regarding this very dangerous substance. It may therefore have extremely important implications for the health of forest workers, water quality and aquatic ecosystems, and non-target organisms. We strongly recommend the use of MSMA be discontinued until a full environmental assessment is conducted that incorporates these new findings. It is also of concern that little is known about the effects of MSMA on wildlife (Dost 1995), including especially woodpeckers and other birds that feed on these trees (Steeger et al. 1998).

Felling and Burning
Felling and burning is a commonly used tactic for killing the beetles where recovery of wood isn't practical. The fire must include the stump and be hot enough to burn wood thoroughly.

Policies and regulations for managing the mountain pine beetle

The legal and policy framework for managing mountain pine beetles in B.C. encourages expedient logging of infested stands by reducing regulations, planning requirements, and stumpage fees in these areas. The *Forest Practices Code of British Columbia Act* ("*Code Act*") governs the salvage and sanitation logging of affected forests in the B.C. Unlike the literature regarding the management of mountain pine beetle, the *Code Act* does not distinguish between salvage logging and sanitation logging. Instead it refers to both as salvage logging.[9]

Under the regime of "salvage" logging, logging companies get exemptions from the recommended maximum size of clearcuts (60 hectares in interior B.C.) when they salvage log to recover timber damaged by insects[10] . This has resulted in some cutblocks in northern B.C. being as large as 1,300 hectares – over 20 times the recommended maximum (Sierra Legal Defense Fund 2001). Moreover, these salvage clearcuts can be placed adjacent to previously logged areas that have not yet regenerated, creating potentially very large contiguous openings[11] . The motivation for these large clearcuts and very large contiguous openings is driven, in part, by the increases in the AAC in areas impacted by the mountain pine beetle. The *Forest Act* requires that logging companies log their allocated AAC and provides penalties for failing to log enough timber[12] . Therefore, once the AAC is set, it becomes an input into operational planning, which greatly influences what silvicultural options are logistically and economically feasible.

The Chief Forester, under section 8 of the *Forest Act*, determines the Allowable Annual Cut. The Chief Forester is obliged to consider matters such as the rate of timber production that may be sustained over the long term and the social and economic impacts of alternative rates of logging. The Chief Forester is under no explicit obligation to consider the characteristics of the natural disturbance regime in an area although he must consider any "abnormal infestations in and devastations of, and major salvage programs planned for, timber on the area" when setting the rate of cut[13] .

If "salvage logging" is considered "necessary to enable measures to be taken to address an emergency", logging companies can have their operational plans (e.g., Forest Development Plans and Silvicultural Prescriptions) approved without certain assessments, including terrain stability assessments, and without public review and comment[14] . The term "emergency" is not defined in the *Code Act*, leaving District Managers of the Ministry of Forests with broad discretion to authorize "emergency" salvage harvest of uninfested trees and stands that are "in danger" of being attacked by insects. Otherwise, for "non-emergency" salvage logging of beetle-damaged timber, provincial regulations permit logging companies to put their operational plans through an abbreviated public review process[15] ; indeed, for smaller-scale salvage logging, the opportunity for public review may be eliminated altogether[16] . Additionally, the associated price of the salvaged Crown timber, stumpage fees, can be reduced by as much as 99% to approximately 25 cents per cubic metre[17] .

Despite the reduced planning requirements associated with "salvage logging," the *Code Act* requires that District Managers ensure that most "salvage logging" activities "adequately manage and conserve forest resources."[18] The "adequately manage and conserve" test acts as the ecological safety net for forest development planning. This is particularly important where the planning requirements are reduced or eliminated and where "emergency" logging and other "non-emergency" salvage logging may impact Old Growth Management Areas, Wildlife Habitat Areas, riparian zones, Wildlife Tree Patches, Forest Ecosystem Networks and ungulate winter range areas, thereby threatening critical environmental values and the implementation of higher level plans.[19]

The meaning of the term "adequately manage and conserve" must be broadened and deepened. It is impossible "to manage" without agreement on objectives, and it is impossible "to conserve" if ecological integrity is not maintained at all temporal and spatial scales. This calls for a renewed effort in developing comprehensive beetle management strategies and tactics that have shared objectives with protecting ecological integrity.

While this report draws a number of conclusions related to the adequacy of large-scale clearcutting as a tactic in coping with the current mountain pine beetle outbreak, it also identifies a number of significant uncertainties regarding the impact of large-scale salvage and sanitation logging on the forest ecosystem. In the context of applying the "adequately manage and conserve" test, District Managers must recognize that these uncertainties are cause for caution, particularly where the efficacy of sanitation logging is in question as a control measure. As the Supreme Court of Canada recently directed, "environmental measures must anticipate, prevent and attack the causes of environmental degradation" not threaten to exacerbate them[20] . In the context of the current outbreak, this Supreme Court directive calls for designing and implementing forest practices that invoke the *precautionary principle*. This principle states:

> "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof." (Ashford et al. 1998)

This report discusses the management implications of conclusions from the scientific literature on mountain pine beetle management, bearing in mind the Supreme Court's directive in doing so. Where the literature suggests that management of the mountain pine beetle by large-scale clearcutting may either threaten other forest resources or create conditions that exacerbate the mountain pine beetle crisis, the precautionary principle requires that management decisions meaningfully address those risks.

Can large outbreaks be controlled?

Despite nearly 100 years of active management of the mountain pine beetle, evidence for the efficacy of control is scant and contradictory (Wood et al. 1985). Aggressive sanitation harvest appears to have been effective in a few cases (Cahill 1978; Borden, J., personal communication). However, the weight of opinion seems to be that most control efforts to date have had little effect on the final size of outbreaks, although they may have slowed beetle progress and prolonged the outbreak in some cases (Klein 1978; Wood et al.1985; Amman and Logan 1998). Regardless of past experience, management of an outbreak as large as the one in central interior B.C. has never been attempted, and it is unknown how effective suppression can be in this case (Borden, J., personal communication; Shore T., personal communication).

According to models of the population dynamics of mountain pine beetles and other insects, control of outbreaks is theoretically possible, but requires treatment of almost all infected trees (Berryman 1978; Clark et al. 1979; Thompson et al. 1981; Raffa and Berryman

1986; Mawby et al. 1989). In the Lakes Forest District, the current rate of infestation spread is so high that at least 60% and perhaps as much as 80% of infested trees would have to be cut for control to be effective (Safranyik in Stadt 2001; Natural Resources Canada 2001). The current outbreak is so large that it is impossible or unpractical to effectively treat 60-80% of infested trees throughout the entire outbreak area, even if all available harvesting resources were devoted to this task. Thus, effective control of this outbreak is probably impossible. However, it may be possible to slow or stop the spread of beetles into selected areas if sanitation activities are well planned and coordinated. According to current understanding, this is most likely achieved by:

i. focussing available harvesting capacity on green attacked trees. This means postponing salvage until the beetle threat has subsided. Where practical, stands should be selectively harvested to maximize the amount of infested wood that is processed, and minimize future impacts on timber supply.
ii. focussing management effort where it can be most effective. Since suppression efforts are only effective when they are thorough, it is better to concentrate limited management capacity in a few selected locations rather than ineffectively spreading treatments across the entire infested area.

Chilcotin Plateau, 1982
In a large epidemic, like the one pictured above, control strategies may not be effective.

It is unclear whether effective suppression of large outbreaks is impossible, or has just been improperly done (Wood et al. 1985). While doubt about the effectiveness of control measures may not justify inaction, it does support caution. Large-scale efforts for beetle control are economically and ecologically expensive, and the uncertain benefits of control efforts should be weighed carefully against their costs.

Weighing costs and benefits of various treatments requires careful planning, which is typically not done because it is presumed to be too slow. In part, this dilemma between speed and care can be resolved by recognizing that beetle-killed trees do not decay immediately, but can remain salvageable for as long as 10 years or more. Salvage operations could therefore be subject to full planning requirements (requiring approximately five months, on average – Ebata 1999) without significant loss in timber values. Sanitation logging, on the other hand, must be carried out before mountain pine beetles fly from the trees for efforts to be successful, so an abbreviated planning process may be appropriate in this case. Creative ways to reconcile expedited approvals and meaningful environmental assessments are urgently required. If landscape-level planning was completed in advance, it would significantly improve the capacity to make decisions which "adequately manage and conserve" resource values at the stand level. At minimum, sanitation harvest blocks should be subject to ecological review by personnel from the Ministry of Water, Land and Air Protection or other appropriate agencies.

It is important the uncertainties regarding the efficacy of outbreak 'control' be incorporated into reviewing and forecasting timber supply. Since future outbreaks are inevitable, forest managers should include realistic estimates of beetle damage on projected long-term timber supply. This is especially relevant given the possibility of climate change, and the consequences of warmer winters for lowered beetle mortality and our capacity to manage beetles in these climatic conditions.

Raising the AAC: implications for long-term social and economic stability

A central question of the ongoing policy debate is whether raising the Allowable Annual Cut to salvage beetle-killed timber is an appropriate response to the current outbreak. The AAC in the Lakes Timber Supply Area (TSA) is now double the Long Term Harvest Level (LTHL), the rate the Ministry of Forests considers sustainable[21] . The Quesnel AAC increase is less, but still almost 50% more than the LTHL. Thus, current AAC increases must be temporary, and are expected to decrease again after 10 years in the Lakes TSA (B.C. Ministry of Forests 2001d), and five years in the Quesnel TSA (B.C. Ministry of Forests 2001e).

Analyses of the socio-economic impact of these 'beetle uplifts' includes estimates of the number of jobs that will be created during the AAC increase (e.g., 758 direct and 251 indirect person-years in the Lakes TSA), and the revenue to the Crown expected from increased harvesting (e.g., 74.8 million dollars annually). However, since the AAC increases are unsustainable, the new jobs and revenue will be temporary. In our opinion, insufficient consideration has been given to the longer-term social and economic consequences of a temporary AAC increase in these analyses, including the disruption caused when half the forestry workers in the Lakes TSA are laid off in 10 years.

Large-scale industrial forestry requires considerable physical and social infrastructure, including mills, equipment, and supporting services (e.g., housing) that are expensive and difficult to move. Reducing the AAC once this infrastructure and people are in place can therefore cause considerable social and economic disruption. Given these disruptions, there is considerable (and understandable) social, political, and economic pressure to continue supplying harvesting capacity once it has been built in an area. This raises serious concerns that the AAC will be difficult to reduce once increased and that environmental values and protected areas will be compromised in an effort to avoid the social and economic costs of reducing the AAC.

The example of the Chilcotin outbreak in the 1980s demonstrates some of the consequences of beetle AAC increases for long-term sustainability. The AAC of the Williams Lake TSA was raised as an 'extraordinary, temporary' response to the 1980s outbreak, and operations and milling capacity were scaled up to salvage the beetle-killed timber. When winter cold snaps ended the outbreak, many contractors and at least one sawmill in Williams Lake faced bankruptcy. Vocal pleas erupted from the community for the government to prevent the negative social consequences of decreasing the AAC to its pre-outbreak level. This constrained the options available for wilderness and recreational protection in the Cariboo-Chilcotin land use plan, as well as for any economic development associated with non-timber forest values. To date, although the AAC of Williams Lake TSA decreased, it has never been reduced to its pre-outbreak level and remains 54% higher (over 1.3 million cubic metres) than what the Ministry of Forests considers sustainable (Marchak et al. 1999; B.C. Ministry of Forests 2001).

In terms of timber, some short-term losses may be offset by the benefit of maintaining a more even and flexible timber supply over time. Many beetle-impacted stands, especially those with light to moderate beetle mortality, light mistletoe infestation, mixed species, or a well developed understory, will continue to be productive if left unharvested for the present, and may be worth more later when timber is scarce. Leaving a variety of stand types across the landscape will also provide an array of species, timber grades and piece sizes to provide the forest industry more flexibility in responding to market changes. Finally, in as much as maintaining and enhancing landscape heterogeneity can help stabilize forest disturbance dynamics, it should also help to stabilize timber supply over the long term.

Fire and clearcutting: effects on forest structure and landscape pattern

Forest structure and landscape patterns left by disturbances have critical functional roles in forest ecosystems (Foster et al. 1998; Turner and Dale 1998). Forest ecosystems and their component structures and species have evolved with and are adapted to natural disturbance regimes. Therefore, maintaining biodiversity and ecosystem integrity in managed forests requires the implementation of silvicultural practices that "solve for pattern" by retaining elements of forest structure present before harvest (Franklin and Forman 1987; Franklin 1994; Franklin et al. 1997). As mentioned previously, in many cases, stand-replacing fires followed outbreaks of mountain pine beetle in boreal and sub-boreal regions. This has prompted suggestions that clearcutting is a good way to mimic natural disturbances, fire in particular, in these ecosystems, and thereby maintain habitat and ecosystem integrity (Bergeron et al. 1997). However, fire and conventional clearcutting in these ecosystems differ in important ways (Delong and Tanner 1996; Rogers 1996; Bergeron et al. 1997; Dale et al. 1998; Bergeron et al. 1999).

Fire and Clearcutting
Fire and clearcutting differ in their effect on forest structure at the stand and landscape level.

Fire and clearcutting differ at the stand level. In general, clearcutting retains less structure and coarse woody debris than fire, and woody debris retained by fire decays more slowly than debris left by logging (Wei et al. 1997; Clark et al. 1998; Delong and Kessler 2000; Tinker and Knight 2000). Disturbance and compaction from logging may affect the diversity of microbes, insects, and herbaceous plants (Radeloff et al. 2000). Clearcutting and fire also differ in their effect on decomposition and nutrient cycling in pine forests (Wei et al. 1997; Wei et al. 1998; Giardina et al. 2001). Clearcutting in pine forests reduces the diversity of species of ectomycorrhizal fungi, a symbiotic fungi associated with trees that aids in nutrient absorption (Byrd et al. 2000). This silvicultural system may also impact a positive interaction that exists between fire and wood decay in lodgepole pine forests that enhances their productivity. Fire and wood decay interact to create habitat for ectomycorrhizal and nitrogen fixing microbes, as well as sites for moisture storage in the development of high quality soils (Harvey 1979). Accumulations of dead and decaying wood are therefore essential to maintaining the productivity, health and diversity of lodgepole pine forests.

Despite important local differences at the stand level, the landscape level is where conventional clearcutting and fire differ most significantly (Coates 1997a; Bergeron et al. 1998; Bergeron et al. 1999; Bergeron et al. 2001). Fires generally disturb a greater array of patch sizes, have more irregular boundaries, and retain more refugia or remnant patches than logging (Franklin and forman 1987; Turner and Romme 1994; Delong and Tanner 1996; Foster et al. 1998; Bergeron et al. 1999). That some fires were large has prompted the suggestion that large salvage cuts may be appropriate in these forests (DeLong 1998). However, even very large fires do not burn evenly, but skip some areas and burn with varying intensity in others, leaving a variety of stand structures across the landscape (Turner and Romme 1994; Foster et al. 1998; Turner and Dale 1998; Weber and Stocks 1998). Mimicking the size of fires through harvesting without mimicking their pattern, internal heterogeneity of retained structures, and frequency is unlikely to maintain ecosystem structures and functions.

Lodgepole pine is present in a wide variety of forest types across B.C. Specific differences between clearcutting and fire regimes therefore vary with forest type, climate, and topography. For example, in the Sub-Boreal Spruce biogeoclimatic zone, estimated fire return intervals – the average time it takes for a given burned area to burn again – to be between 80 and 100 years (DeLong and Tanner 1996). However, in some wetter and cooler areas of the interior sub-boreal forest, fire return intervals may have been as high as 952 to 1666 years (DeLong 1998). DeLong and Tanner (1996) found that 3-15% of the area within burns was unburned remnant patches, and 62% of disturbed area was in burns greater than 500 hectares. Size distribution and abundance of remnant patches increased with the size of burns, and on average 72-94% of remnants were larger than one hectare. Alternatively, within the 230,000 hectares that burned during the 1988 fires in the lodgepole pine forests of Yellowstone National Park, 28% of the landscape was unburned, 16% was lightly burned, 25% was moderately burned, and only 31% burned by crown fires (Turner et al. 1994). All of the moderately burned area and 75% of the severely burned area was within 200 metres of a green edge. This diversity in how different forest types burn must be an important consideration when designing harvesting systems that emulate fire.

Fire also differs from clearcutting in the type of stands it affects, and the pattern of disturbance it creates across the landscape. Sanitation and salvage harvesting aim to remove all beetle-killed stands, and focus first on older and more productive stands that have the largest trees and highest timber values. In contrast, fires do not restrict themselves to beetle-killed stands, and tend to burn largely independent of forest age (Johnson 1992). However, fire patterns are not simply random. Turner et al. (1999) found that stands with low mistletoe infestation, intermediate beetle mortality or single layered canopies burned less often and less intensely than other stand types. Moist ecosystems within the landscape also tend to escape fire more often, but not necessarily escape beetle attacks (DeLong 1998). Fire disturbance also tends to be less dispersed across the landscape than logging (Reed et al 1996; Tinker et al. 1998).

Fire and logging rates: consequences for sustainability

Although knowledge of historic rates of disturbance in interior ecosystems is incomplete, studies to date report that between 1851 and 1951 disturbance rates varied from 7 to 24% of the area being disturbed every 20 years (DeLong 1998; Wong and Iverson 2000). In contrast, the total area harvested in the Lakes TSA over the next 20 years is predicted to be between 160,000 and 200,000 hectares, or approximately 28 to 36% of the harvestable landbase (B.C. Ministry of Forests 2001d). Once the temporary AAC increase has ended and harvest rates decrease to "sustainable" levels, between 18 and 21% of the landscape will be harvested every 20 years (B.C. Ministry of Forests 2001d). Thus, available information suggests that both uplifted and "sustainable" harvest rates are probably on the high end or above the range of natural variability, on average. Finally, irrespective of whether the overall harvest rate is outside the range of natural variability, harvest rates in some low elevation, moist, high productivity sites are almost certainly too high. This is be because harvesting is not allocated according to local variation in disturbance regime, but rather tends to focus on low elevation, moist, high productivity areas that historically burned infrequently.

Even if temporary increases in the AAC are within the range of natural variability for disturbances across the central interior, sustained increases are not. However, decreasing the AAC once it has been raised is costly and unpopular, raising concerns that ecological values may be sacrificed to keep harvest levels high. Increasing the rate of harvest now will also increase the abundance of young, even-aged pine stands, decrease structural diversity across the landscape, and foreclose future options for more creative silviculture. Finally, whether or not ecological values are sacrificed, recent AAC increases are well above the Long Term Harvest Level for both Timber Supply Areas (B.C. Ministry of Forests 2001d; B.C. Ministry of Forests 2001e). Thus, the most compelling reasons for not increasing the AAC may be economic, social and political, rather than strictly ecological.

In summary, fires tend to leave more beetle-impacted stands, more moist and productive stands, and more stands with big old trees than salvage and sanitation logging. These amounts vary with climate, topography, and forest type. It is these patterns of retention across the landscape that ecosystem-based salvage and sanitation should seek to emulate. Irrespective of whether recent AAC increases are within or outside the historic range for disturbance rate, increasing harvest rates without adopting an approach more fundamentally based on what the landscape can sustain is not ecologically appropriate.

NOTES

1 'Green-attack' refers to the first year, during which the insect migrates to and establishes 'brood trees' (where larvae will later mature into adults and eventually spread again to surrounding trees); 'red-attack' occurs the following year, beginning in spring, when the already-attacked trees are obviously dying and clearly identifiable visually from a distance; 'grey attack' in subsequent years when the trees are left standing dead without needles (B.C. Ministry of Forests 2001c).

2 Other beetle uplifts occurred in the recent past. In 1998, the Ministry of Forests increased the Allowable annual cut in the Merritt TSA by 38 % or 550,000 cubic metres per year to 'fight' the mountain pine beetle: http://www.for.gov.bc.ca/tsb/news/uplift.htm. In 2000, the Ministry of Forests raised the AAC by 3% or 80,000 cubic metres per year in the Okanagan TSA for similar reasons: http://www.for.gov.bc.ca/tsb/news/22tsnws2.htm.

3 This form of sanitation harvesting removes single infested trees.

4 This treatment involves luring beetles into pheromone-baited trees where the beetles can be contained and destroyed by de-barking the colonized trees.

5 Snip and skid refers to cutting and yarding groups of infested trees (< two hectares) scattered over large areas.

6 Monosodium methanearsonate (MSMA) is used similarly to the fall and burn treatment.

7 Mosaic burns are large-scale burns in areas of concentrated infested trees. This method is usually employed when commercial harvesting is either not appropriate or uneconomic, such as protected areas or remote locations. To be practical, areas of 50 to 500 hectares must be burned.

8 Thinning and spacing open a stand and affect how mountain pine beetles disperse and attack trees (Natural Resources Canada 2001). In brief, these treatments attempt to 'beetle-proof' a stand by interfering with how beetles locate hosts and communicate among themselves as well as increase the vigour, growth, and ability of trees to 'pitch out' attacking beetles.

9 *OPR*, s. 1, definition of "expedited major salvage operation"

10 Operational Planning Regulation, B.C. Reg. 107/98 ("OPR"), s.11(3)(b)(i)(a)

11 Timber Harvesting Practices Regulation, B.C. Reg. 109/98,s. 9(2)(g)

12 *Cut Control Regulation*, B.C. Reg. 360/96

13 *Forest Act*, s. 8(8)(e)

14 *Forest Practices Code of British Columbia Act*, R.S. 1996, c. 159 ("Code"),s. 42

15 OPR, s. 27(4)(b)

16 OPR, s. 18(2) and Code, s. 30(1)(c)

17 Minimum Stumpage Regulation, B.C. Reg. 354/87, s. 1

18 *Code*, s. 41, which applies to all "salvage logging" in the province except that which is conducted by the Province's Small Business Forest Enterprise Program.

19 *Timber Harvesting Practices Regulation*, B.C. Reg. 109/98, s. 28.

20 114957 Canada Ltée (Spraytech, Société d'arrosage) v. Hudson (Town), [2001] S.C.J. No. 42 at para 31 (Q.L.).

21 The LTHL, a key input into AAC determination, is an estimate of how much the second-growth stands in the timber harvesting landbase will grow each year, after all old-growth forests are harvested and converted into managed second-growth stands. It is based on certain assumptions regarding the regime of forest management (defined by the timber harvesting land base and objectives and guidelines for non-timber values) and modeled predictions of future timber growth and yield (Utzig and Macdonald 2000). The LTHL is not an ecologically sustainable measure; rather, it is a prediction of the harvest level that is biologically and economically sustainable as managed second-growth stands reach financial or technical maturity. The LTHL makes no provision for certain types of reserves, nor for maintaining all age classes and seral stages within the harvesting landbase.

Fires, forest structure and biodiversity conservation: the basis for a new approach

Since knowledge of ecosystems is incomplete, forest managers cannot predict the consequences of any management action with complete certainty. The most compelling reason for altering forest practices to maintain forest structure within the natural range of variability is to avoid unexpected disruptions due to imperfect understanding. This being said, we do know some of the specific ways in which different species are affected by structure in lodgepole pine forests, and can predict some effects of conventional forest management with reasonable certainty.

Coarse woody debris left by fire and beetle infestations provides habitat for mammals, amphibians, arthropods, nonvascular plants and fungi (see Steeger et al. 1998; Fuchs 1999; and Stadt 2001 for reviews). Standing dead and dying trees provide important habitat for approximately one-quarter of all wildlife species in B.C. (Machmer and Steeger 1995), including woodpeckers and other cavity nesting birds. Several of these birds feed on mountain pine beetles, and are important regulators of endemic beetle populations, keeping the risk of epidemics down (Steeger et al. 1998). Large inputs of coarse woody debris from fire and bark beetle infestations are important in the creation, abundance, and distribution of snags in these stands (Morrison and Raphael 1993; Clark et al. 1998; Brown et al. 1998), so interrupting these processes may affect the regulation of beetle populations. In general, species that are specialized to post-disturbance habitats are considered vulnerable to local extinction where disturbance regimes and the structure they create are disrupted by suppression and intensive salvage logging (Stadt 2001).

Fire burns with varying intensity across the landscape, creating a diversity of light environments and stand densities, and allowing some old and beetle-killed stands to continue through succession to shade tolerant tree species and multi-layered canopies. Several studies have shown that plant productivity and diversity vary with stand structure and age in lodgepole pine forests. For example, open forests generally have more understory plant productivity (Romme et al. 1996; Stone and Wolfe 1996), and conifer diversity (Brulisauer et al. 1996; Sullivan et al. 2000) than closed stands. The number of understory species peaks with intermediate levels of fire or beetle disturbance (Stone and Wolfe 1996), and old forests have more fungal diversity (Amaranthus and Perry 1994; Byrd et al. 1999), which contributes to soil productivity and stability. Thomas and Prescott (2000) found that Douglas-fir increases the availability of soil nutrients in pine forests. Moreover, forests with high diversity of understory plant recover most quickly from fire disturbance (Bergeron and Harvey 1997; Turner et al. 1999). Therefore, large-scale efforts to convert beetle-impacted stands to young pine stands will tend to disfavour species associated with old, multi-layered, and open forests, and decrease the overall diversity of plants and fungi across the landscape, which may in turn affect nutrient cycling in these forests and their resilience to disturbances.

Forest structure strongly influences the abundance and distribution of wildlife. Many species rely on the structure of old forests. For example, boreal owls (*Aegolius funereus*) prefer to nest in old spruce-fir forests over lodgepole pine forests (Herren et al. 1996). Flying squirrels (*Glaucomys sabrinus*) and red-backed voles (*Clethrionomys gapperi*) are more abundant in old forests than young ones (Ransome and Sullivan 1997; Sullivan et al. 2000a). Blue grouse

(*Dendragapus obscurus*) prefer to feed on Douglas-fir and lodgepole pine needles from the upper canopy of old trees in winter (Remington and Hoffman 1996). Woodland caribou (*Rangifer terandus)* near Takla Lake prefer to winter in open spruce-fir forests over lodgepole pine (Poole et al. 2000). Northern goshawks (*Accipiter gentilis atricapillus*) prefer to nest in even-aged mature lodgepole pine stands with high canopy closure (Squires 1996). Moose (*Alces alces*) prefer remnant patches to open areas within recent burns (Gasaway and Dubois 1985). Alternately, other species prefer the structure of young forests. For example, northwestern chipmunks (*Tamias amoenus),* heather voles (*Phenacomys intermedius*), western jumping mice (*Zapus princeps*), montane shrews (*Sorex minticolus*), and common shrews (*S. cinereus*) have higher abundance in young lodgepole pine stands, thinned stands, or seed tree treatments than in old forest (Sullivan et al. 1996; Sullivan et al. 2000b). Last, some species do not obviously respond to forest cover type at all (Mattson 1997; Ransome and Sullivan 1997; Sullivan et al. 2000).

The impacts of silvicultural activities on forest structure also affect regionally important wildlife like the Entiako woodland caribou herd. The effect of forest structure on ungulates depends on the relative abundance of different habitat types (see Fuchs 1999 for review). Thinning from beetle attacks, fire, or silvicultural activities may increase understory forage, but use may be impeded by large amounts of downed wood. Ungulates need closed forest for winter cover, and if cover is limiting, then beetles, fire, and harvesting may be detrimental. Harvesting and road construction following outbreaks may exacerbate negative effects on ungulates and other wildlife by disturbing habitat, predator-prey relationships, and decreasing residual cover needed for winter habitat (Steventon et al. 1998).

It is clear from this wide array of species responses that structure is important for forest functions and habitat. Changes in forest structure that favour one group of species will most likely disfavour another. All landscape elements are important in some way, meaning the best way to maintain all species is to maintain the distribution and abundance of their habitats within their natural range of variability.

Presently, it is left to the discretion of the District Manager of the Ministry of Forests to determine how sanitation and salvage affect higher level plans (e.g., LRMP) and strategic land use planning objectives for biodiversity, wildlife, and other forest values. A recurring theme in the conservation biology literature is that biodiversity cannot be adequately conserved in protected areas alone (Hansen et al. 1991). Adequate conservation efforts should maintain connectivity, refugia[1], and a diversity of habitats across managed landscapes as well as in protected areas (Saunders et al. 1991; Andren 1994; Bender et al. 1998; Poiani et al. 2000). In B.C., these values are maintained outside of protected areas in Old Growth Management Areas, Wildlife Habitat Areas, riparian reserves, Wildlife Tree Patches, Forest Ecosystem Networks, ungulate winter range areas, and other landscape- and stand-level planning objectives for biodiversity conservation. Current regulations do not ensure these objectives are adequately protected from the negative consequences of salvage and sanitation harvesting.

Landscape heterogeneity: implications for ecosystem stability and risk of future outbreaks

Whereas fires would typically leave a mix of stand types and structures, large-scale salvage and sanitation clearcutting and pine regeneration in stands affected by the current outbreak will establish a large 'pulse' of even-aged lodgepole pine stands across the landscape. A major ecological concern is that these uniform stands will become susceptible to mountain pine beetle in 60 to 80 years, supplying large amounts of habitat to fuel another large outbreak at that time. A more general concern is that increased forest homogenization might increase overall landscape susceptibility to fires, insects, and diseases (Franklin and Forman 1987; Turner and Romme 1994; Bergeron et al. 1998).

Landscape heterogeneity refers to the relative distribution and abundance of successional stages, vegetation types, and protected areas and other land use zones across the landscape (Perry 1994). In general, heterogeneous natural systems like forests are more stable than simpler artificial systems like crops and laboratory populations (Murdoch 1975). The reasons for this are not entirely known. However, research in the fields of landscape and disturbance ecology, epidemiology, and population ecology has provided some insights into how complexity affects natural systems. For instance, increasing the complexity or heterogeneity of landscapes may decrease the rate of spread and extent of diseases and disturbances (Turner et al.1989; Rodriguez and Torres-Sorando 2001), decrease the survival and reproductive rates of some organisms such as introduced species (Simberloff 1988; Cantrell and Cosner 1991; Saunders et al. 1991; Andren 1994; Bender et al. 1998; Hiebeler 2000), and globally stabilize locally unstable population dynamics (Hastings 1977; May 1978; Reeve 1988; Taylor 1990).

Apart from these general results, the effect of landscape heterogeneity on forest ecosystems in particular is not well known (Franklin and Forman 1987). Some evidence does confirm that landscape pattern is an important influence on disturbance in these ecosystems. In particular, fire behaviour data and models show that landscape pattern affects the spread of fire, and the juxtaposition of stands of different age classes appears to reduce overall landscape flammability (Franklin and Forman 1987; Turner and Romme 1994; Turner et al. 1999). The effect of landscape pattern on insects is less well known (Franklin and Forman 1987), but Bergeron et al. (1995) found that isolated forest patches are less likely to be infested by the western spruce budworm *(Choristoneura occidentalis)*.

From the perspective of biodiversity conservation, a major concern is that the benefits of heterogeneity may be used as an argument for "increasing" heterogeneity outside its range of natural variability and thereby fragment landscapes. There are several reasons why this is problematic from an ecological perspective. First, the deliberate fragmentation of forest landscapes by roads and harvesting could detrimentally affect many species which humans want to conserve (Saunders et al. 1991; Andren 1994; Bender et al. 1998; Poiani et al. 2000). Second, the effect of landscape pattern on insects and diseases is not well understood, so predictions with any confidence of the effects of "enhancing" heterogeneity are impossible or unreliable (Franklin and Forman 1987; Bentz et al. 1993; Kaufmann and Regan 1995; Irwin 1999). In general, the effect of landscape pattern depends on the complex interactions between landscape and the habitat preferences and dispersal ecology of individual species (Saunders et al. 1991; Andren 1994; Coulson et al. 1999). The effects of landscape pattern therefore vary with species, and increasing heterogeneity may even promote insect outbreaks in some cases (Franklin and Forman 1987; Kareiva 1987). While there is evidence that pattern does affect species, no convincing evidence exists that diversity promotes ecosystem stability (Murdoch 1975). Rather, natural systems may be more stable than artificial ones because their component species and habitats are co-evolved, not because they are complex. If this is true, then simplifying natural systems will tend to destabilize them, but making natural systems complex is not likely to make them more stable (Murdoch 1975). In summary, "increasing" forest heterogeneity by fragmentation may not only reduce the abundance of certain vulnerable species, but may inadvertently destabilize forest ecosystems, making them more vulnerable to disturbance by insects and diseases.

Does the size of mountain pine beetle outbreaks depend on the pattern of susceptible stands across the landscape? Unfortunately, the effect of landscape pattern on the risk and spread of outbreaks of the mountain pine beetle is unknown (Bentz et al. 1993). However, given the current understanding of the spatial ecology of mountain pine beetles, we can think of no obvious reason why these beetles should not respond to landscape patterns in ways similar to fires, and outbreak less dramatically on heterogeneous landscapes. Current models of beetle hazard and risk implicitly assume such effects by assessing the risk of beetle damage to be low when a stand is more than one kilometre from current infestations (Shore and Safranyik 1992; Coulson et al. 1999).

An intriguing possibility is that heterogeneity at scales smaller than a kilometre might help disrupt how mountain pine beetles spread. While mountain pine beetles can disperse over several kilometres, they can only communicate and aggregate over much smaller distances (~50-75 metres, Borden, J., personal communication). Effective aggregation of dispersing individuals is important for successful attack, so patches of unsusceptible trees on the scale of less than 100 metres might effectively slow beetle spread by reducing the efficiency of aggregation. Thinning reduces beetle damage (Mitchell et al. 1983; Waring and Pitman1985; McGregor et al. 1987; Mitchell 1994), possibly because openings in the canopy increase convective currents that interfere with pheromone communication and disrupt aggregation (Amman and Logan 1998). If this is the case, then structural elements such as veteran trees or snags that increase structural complexity and decrease canopy continuity might also disrupt beetles. In summary, there is reason to suspect that maintaining forest heterogeneity at a number of scales might slow mountain pine beetles, but these ideas remain untested.

Climate change appears to be a pending reality (IPCC 2001). Given the strong link between climate, fire and the population dynamics of mountain pine beetles, it is worthwhile to speculate how warming might affect these ecosystems, and how management might moderate or exacerbate those effects. Climate change is predicted to have variable effects on northern forests (Flannigan et al. 1998), and available empirical evidence supports this prediction, with fire frequencies rising in some areas (Weber and Stocks 1998), and declining in others (Flannigan et al. 1998; Bergeron et al. 2001). Although global circulation models predict a decrease or no change in fire frequency in central B.C. (Flannigan et al. 1998), a recent paleoecological study in south eastern B.C. predicts fires in this area may increase in both frequency and intensity, suggesting the circulation models' prediction may be wrong for this area (Hallet and Walker 2000). This casts some doubt on the model predictions for B.C. in general.

Warmer temperatures are expected to affect forest insects directly. In particular, survival of the mountain pine beetle, lodgepole pine needle miner (*Coleotechnites milleri*), and Douglas-fir tussock moth (*Orgyia pseudotsugata*) is expected to increase, while survival of the western spruce budworm is expected to decrease (Safranyik 1990). Recent mountain pine beetle outbreaks may already be a product of global warming and represent "a rather stern early warning of climate change" (Pollard 1985). In the face of such changes, Delcourt and Delcourt (1998) suggest that it is important to maintain processes and structures that allow ecosystems to resist and adapt to climate-induced changes.

Ecologically appropriate salvage and sanitation practices

While forest structure affects biodiversity and ecosystem integrity of forests in some ways that are understood, many other ways remain poorly known. Given this uncertainty, maintaining forest structure within the natural range of variability is thought to be the most likely way to sustain ecosystem function and integrity (Swanson et al. 1994; Lertzman et al. 1997; Landres et al. 1999; Wong and Iverson 2001). To this end, logging should approximate the effects of natural disturbance at the stand and landscape level. Recommendations to

Pine Removal from Mixed Stands
One way to reduce ecological impacts of harvesting is to retain non-host species. This 100 year-old mixed stand of Douglas fir (60%) and lodgepole pine (40%) was a good candidate for pine removal and Douglas-fir retention.

accomplish this include the use of mixed harvest regimes to create and maintain a variety of stand structures (Bergeron and Harvey 1997), with a focus on patch retention systems that enhance landscape heterogeneity without compromising ecosystem productivity or connectivity (Coates and Steventon 1995). Retaining forest patches and woody debris in logging-created openings should help decrease stand-level differences between fire and harvesting, and leaving some beetle-impacted stands to continue through succession should help retain old forest, alternate species, and a diversity of stand structures across the landscape (Bergeron et al. 1997; Coates 1997a; O'Hara 1998; Bergeron et al. 1999). Stands with low mistletoe infection, intermediate beetle mortality, large live and dead trees, nesting cavities, mixed conifer species, multi-layered stand structures, or moist cool microclimates are particularly good candidates for retention.

It is not possible to ensure that ecological values are maintained without landscape-level planning. Since beetle suppression efforts must happen quickly to be effective, an accelerated planning and approval process may be appropriate for harvest of green-attacked trees. However, since suppression efforts will not be effective unless they are well coordinated, some advance planning must occur to ensure that efforts are directed towards where they can be most effective and to minimize their impacts on other forest values. In contrast, salvage harvesting of red and grey attacked trees has no impact on beetle populations (as beetle broods have flown), so expediency is much less of a concern. While salvage value does decline over time, many stands are still being salvaged from pine beetle outbreaks in the 1980s and timber value is retained for 10 years or more in many areas. Dead trees and beetle-impacted stands are ecologically valuable and no less in need of protection than live stands. Thus, relaxed environmental regulations and inadequate landscape- and stand-level planning have potentially serious consequences that are unlikely to be offset by the questionable gains in timber value saved by accelerated approvals of salvage operations.

Ecologically appropriate salvage and sanitation practices: concerns and options

Concerns have been expressed about the potentially detrimental effects of retaining forest patches and stand-level structure on forest health and productivity (Schmidt and Alexander 1984). Some of these concerns may be ameliorated by appropriate forest practices. Others require striking a balance between the costs and benefits of retaining forest structure and emphasize the need for careful landscape-level planning to balance these costs and benefits. Important considerations when designing and implementing sanitation and salvage activities that retain forest structure at both the stand and landscape level include: stand-level productivity, other forest insects and pathogens, and windthrow.

Stand-level productivity – The current legal framework encourages and subsidizes salvage of beetle-impacted stands (i.e., > 30% mortality) through reduced stumpage and relaxed regulations. This is partly based on the premise that future growth in these stands cannot make up for the loss of killed trees. However, this is not always necessarily true. Several studies show that lodgepole pines 'release' relatively well following outbreaks, and that the forest may be resilient to beetle damage (Peterman 1978; Geiszler et al. 1980; Romme et al. 1986; Raffa and Berryman 1987; Nebeker et al. 1995). Wei et al. (2000) found lodgepole pine productivity does not decrease with thinning from above, and Romme et al. (1986) observed that productivity recovered or increased 5-15 years after a mountain pine beetle outbreak (41-67% mortality) in the Rocky Mountains. It is unclear whether gains in productivity can make up for volume lost to beetle attack (Romme et al. 1986). However, the above evidence suggests that outbreaks do not necessarily create "silvicultural slums", but retain or increase productivity in some cases by what may be the silvicultural equivalent of thinning. Research of forest stand dynamics following outbreaks would help clarify how stands recover from different infestation levels, and which stands may be worth more at full stumpage value later than they are worth if salvaged now.

As lodgepole pine is largely intolerant of shade and competition, it generally does not regenerate well under its own canopy or that of other species, except in very dry or harsh locations. Thus, mountain pine beetle outbreaks tend to favour succession of infected stands to other tree species, and some concern has been expressed that alternative harvesting practices may not allow adequate pine regeneration (Schmidt and Alexander 1984). However, lodgepole pine can regenerate in relatively small openings, meaning that large clearcuts are not necessary for pine regeneration, and patch retention is an ecologically viable silvicultural system in these forests (Coates and Steventon 1995; Coates 2000).

Fire for Short-term Mountain Pine Beetle Control
Prescribed burning is also an option for management. A fire intensity of rank 4 (as illustrated in this photo) or more is needed to kill beetles.

Forest pathogens and insects – An important agent of damage in lodgepole pine forests is western dwarf mistletoe (*Arceuthobium campylopodium*). This parasitic plant, which can cause severe reductions in the growth of its coniferous hosts, is transmitted vertically from older hosts to young uninfected trees, so infection rates increase with time since fire and are highest in old and multi-layered stands (Kipfmeuller and Baker 1998). Retaining forest structure will likely increase mistletoe infection rates in some regenerating stands, though this effect can be ameliorated by retaining trees and stands with little mistletoe. Evidence from Yellowstone National Park that stands with mistletoe are more likely to burn lends some ecological support to this practice (Turner et al. 1999). Finally, although mistletoe does somewhat affect stand productivity and tree mortality, it is not necessarily an overwhelming problem (Kipfmeuller and Baker 1998). Some rate of mistletoe infection may be justified as a tradeoff for the various ecological benefits of retaining structure at the stand and landscape levels.

Concern has also been raised about increased risk of infestations of the western spruce budworm arising in response to retention of spruce, true firs and Douglas-fir, and successional conversion to these species. Wilson et al. (1998) found that mountain pine beetle outbreaks do indeed increase the risk of subsequent budworm infestation, and suggest that converting stands back to lodgepole pine can most effectively mitigate risk of budworm infestations. However, increasing lodgepole pine dominance increases risk of future mountain pine outbreaks, so a tradeoff exists between these two options. Maintaining both stand types across the landscape may most effectively 'hedge' the risks and reduce the chance of catastrophic outbreaks by either insect.

Windthrow – Several authors have expressed concern about the risk of windthrow in retained forest and leave patches, especially where spruce, typically shallow-rooted trees, is the main alternate species (Stadt 2001). In general, windthrow is minimized by silvicultural treatments that retain windfirm trees, appropriate orientation of openings with prevailing wind patterns, 'edge feathering', and by the creation of small openings and retention of large patches (Franklin and Forman 1987). For example, Delong and Kessler (2000) found no evidence of increased windthrow after fire in retention patches of 0.2-10 hectares in sub-boreal spruce forests (SBSmk1), and Coates (1997b) found no significant difference in windthrow among partial cut stands harvested with 30% and 60% retention and adjacent unlogged forests. Further studies would be useful to quantify relationships between windthrow and various harvesting practices in different forest types.

Uncertainty and adaptive management

Despite nearly 100 years of beetle management, considerable debate and uncertainty remains about the efficacy of the various management approaches. It is possible to actively learn from past and ongoing resource management by treating management as an experiment, i.e., through adaptive management (see Walters and Holling 1990 for a brief summary of the principles and approaches of adaptive management). The current mountain pine beetle outbreak provides remarkable opportunities for adaptive management because it spans large areas of both protected areas (to serve as experimental controls) and industrial forestry lands (experimental treatments). This allows comparisons among a range of management options. To take most advantage of this opportunity, effort and resources should be put towards the following:

i. specifying alternative management strategies and opinions about their efficacy,
ii. using different policies and practices in different places, as well as using the same policies and practices in different places,
iii. recording management decisions and their intended outcomes,
iv. designing and implementing monitoring programs of forest structure, beetle abundance and distribution, timber values, wildlife, and a host of other variables of interest to forest managers, and,
v. implementing a well-articulated processes of integrating monitoring information with decision-making.

NOTES

1 Refugia are areas of relatively unaltered climate inhabited by plants and animals during periods of climatic change (e.g., glaciation) that later allow dispersion and speciation after the climate readjusts.

Summary and management implications

Forest practices

Current situation

The existing framework of laws, regulations and policies:

- Makes no distinction between salvage and sanitation activities;
- Allows great variation in how different Forest Districts set policies regarding salvage and suppression activities;
- Allows exemptions from block size requirements, terrain stability assessments, and adjacency constraints for salvage and sanitation activities (as well as for other issues besides forest health);
- Leaves to the discretion of the District Manager whether biodiversity objectives such as Old Growth Management Areas, Wildlife Habitat Areas, riparian zones, Wildlife Tree Patches, Forest Ecosystem Networks, and ungulate winter range areas may be disrupted for salvage;
- Allows abbreviation of the public review period for operational plans for salvage and sanitation logging, and its elimination for "emergency" salvage and sanitation;
- Encourages sanitation and salvage harvesting in most Districts to be predominantly carried out by clearcutting with little or no retention of forest structure. This has serious consequences for the susceptibility of forest landscapes to future outbreaks of the mountain pine beetle;
- Makes salvage and sanitation timber subject to stumpage as low as 25 cents per cubic metre;

Implications for forest practices

It is important that forest managers:

1. Make ecological sustainability the fundamental goal of mountain pine beetle management.
2. Design and commit to a comprehensive management plan that is consistent with the above goal. This should include strategies for prevention before outbreaks, suppression during outbreaks, and salvage operations for ecosystem recovery following outbreaks.
3. Distinguish clearly between sanitation and salvage harvesting in forest policy, and subject salvage operations to full planning requirements and environmental regulations. Some areas (e.g., some Forest Districts in the Kamloops Forest Region) already have guidelines and decision-making processes that make the distinction between salvage and sanitation. Standardization is necessary across all Forest Districts affected by the mountain pine beetle.
4. Design abbreviated planning processes to ensure that environmental values are protected during sanitation harvest. At minimum, allow the public and B.C. Ministry of Water, Land and Air Protection meaningful input into operational plans. Again, while this already occurs in some Forest Districts, it is absent from many others. The above should be done in conjunction with the completion of Landscape Unit planning. If not done already, this will direct stand-level activities and provide generic silvicultural

prescriptions to help protect environmental values during sanitation harvest and salvage.

5. Continue to use existing harvest capacity first for insect suppression by harvesting principally green attacked trees. Coordinate and focus suppression activities where they can be most effective and minimize the building of additional logging roads. Retain uninfested trees and non-host species (including deciduous trees) to make efforts most effective and minimize the impacts of sanitation and salvage on forest structure and ecosystem function.
6. Mimic natural disturbance processes by retaining adequate amounts of remnant patches and coarse woody debris, and by employing a diversity of silvicultural systems across the landscape.
7. Vary amount and pattern of retention with forest type and natural disturbance pattern. Since the current information is inadequate to characterize local variation in natural disturbances, local guidelines should be considered tentative and some process should be in place to incorporate new information as it becomes available.
8. Increase the role of prescribed burning as a management tool. Fire, with no salvage, can act as an agent of both beetle control and forest regeneration much more effectively and cheaply than building roads, logging, planting, and other intensive silvicultural activities.
9. Design appraisal systems to ensure that reduced stumpage rates do not subsidize salvage in stands that would be more valuable if retained for environmental values or for future harvest.
10. Expediently complete Landscape Unit planning to direct stand-level activities.

AAC determination

Current situation

The AACs for the Lakes, Quesnel, Merritt and Okanagan TSAs have been increased well above the Long Term Harvest Level, the rate of harvest considered sustainable by the B.C. Ministry of Forests. This has occurred with what we consider insufficient analyses of long-term social, ecological and economic consequences of the 'beetle uplifts.' Although the AAC increases are considered temporary, no clear plan or criteria exist for reducing the AAC in the future.

Implications for AAC determination

The process of ACC determination must:

1. Predict timber supply based on forest practices and a management plan that adequately conserves and protect the forest.
2. Reduce long- and short-term harvest rates to within the natural range of variability.
3. Study the long-term social, economic, and ecological consequences of previous AAC increases to manage beetle outbreaks such as in the Williams Lake TSA.
4. Within natural variability constraints, set AAC to ensure long-term social and economic sustainability.
5. Within each TSA, allocate local harvesting according to historical (i.e., pre-European) variation in disturbance regime.
6. Keep harvest rates low to maintain future options and minimize risks to ecosystem integrity.

7. Incorporate realistic estimates of beetle damage to long-term timber supply projections, with special consideration given to climate change and the consequences of warmer winters for increased abundance of the mountain pine beetle.
8. Outline a clear plan and criteria for reducing the AAC, including clear timelines and contingency plans if cold snaps end the outbreak.

Long-term planning and research

Current situation

Our current understanding of long-term beetle management strategies is limited because:

- The efficacy of conventional beetle management strategies is poorly known;
- The impacts of outbreaks on forest dynamics and the long-term effects of forest management on reducing the risk and magnitude of outbreaks are poorly known; and
- No process exists to assess the larger social, ecological, and economic consequences of beetle management activities.

Implications for long-term planning and research

To allow learning by doing and for effective long-term management, strategies for managing the mountain pine beetle should:

1. Commit resources and staff for long-term planning, research, and proactive mountain pine beetle management.
2. Take an adaptive approach to managing the current outbreak that favours precaution in the face of the identified potential risks posed by large-scale clearcutting as a management strategy. Use protected areas as the control and the forest industry landbase for various treatment options. Monitor treatments over time and make adjustments based on empirical data.
3. Include as priorities for research the role of beetles in forest ecology and the economic implications of and strategies for marketing salvaged wood.

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Forest Watch of British Columbia is currently a project of the Sierra Legal Defence Fund, and will become an independent organization in the fall of 2001. By providing training, conducting investigations and authoring publications about the state of BC's forests, Forest Watch seeks to encourage the participation of BC citizens in sustainable forest mangagement.

The David Suzuki Foundation explores human impacts on the environment, with an emphasis on finding solutions. The Foundation was established in 1990 to find and communicate ways in which we can achieve a balance between social, economic and ecological needs.

The Canadian Parks and Wilderness Society is Canada's grassroots voice for wilderness. Since its founding in 1963, CPAWS has played a lead role in protecting over 50 million hectares in Canada's most treasured wild places.