Restoration of forests attacked by mountain pine beetle: Misnomer, misdirected, or must-do?

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Abstract

Much of the forest killed by the current mountain pine beetle outbreak in British Columbia will never be salvaged for commercial purposes. It has been suggested that large areas will need "restoration" to secure future timber supplies and habitat values in a timely manner. I argue that restoration is not the most appropriate term to apply to this scenario, as beetle-impacted forests generally are not ecologically degraded. Furthermore, available data indicate that pure pine stands constitute a minority of the forest area affected by the mountain pine beetle (*Dendroctonus ponderosae*), and that more than 40% of stands dominated by lodgepole pine (*Pinus contorta* var. *latifolia*) have adequately stocked understories. This implies that much of the affected area will recover on its own and can provide mid-term and long-term forest values without human intervention. While prescribed fire may be an appropriate tool for ecological restoration and stand renewal in selected landscapes, perpetuation of even-aged stands of lodgepole pine may not be prudent. It would be more appropriate to call stand conversion and accelerated regeneration activities "stand rehabilitation" when enhanced timber values are the goal. Ecological restoration may be needed to repair critical habitats or to safeguard aquatic resources in the wake of the pine beetle outbreak. However, restoration must be done with clear objectives, and is likely to be a minor component of the overall management picture. In all cases, an objective assessment should assure that intervention will not do more harm than good, and actions should be evaluated against the alternative of no treatment.

KEYWORDS: *advance regeneration, ecological restoration, ecosystem recovery, forest harvest scheduling, forest rehabilitation, forest stewardship, insect outbreak, lodgepole pine, rehabilitation, stand dynamics.*

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Introduction

It has been widely suggested that large areas of forest impacted by the current mountain pine beetle (MPB; *Dendroctonus ponderosae*) outbreak in British Columbia will never be harvested (Eng *et al.* 2005), hence will not be planted, and will require some form of "restoration" (Brinkman 2004; Markgraf 2005; Parfitt 2005). Even with the second round of uplifts to the Allowable Annual Cut (AAC) for the most heavily affected timber supply areas in the north-central interior, British Columbia's Chief Forester estimated that more than 40% of the affected timber supply would not be harvested before it loses commercial value (B.C. Ministry of Forests 2004). The fate of forests dominated by dead and dying trees is of concern to the forest products industry, timber-dependent communities, provincial government fiscal analysts, First Nations, land use planners, and environmental activists. There is a widespread feeling that we should "do something" to "help fix" the dying forests.

British Columbia's Mountain Pine Beetle Strategy calls for active restoration of forest resources in areas affected by the epidemic, more specifically, the application of silvicultural techniques to address the mid-term timber supply gap (Government of British Columbia 2005a). Indeed, "restoring the forest" is a recurrent theme in the Forests for Tomorrow (FFT) program, with the terms "restore" or "restoration" used 34 times in the FFT Program Management Plan (ENAR ESDE Inc. 2005). This provincial government initiative is budgeted to distribute $86 million of provincial funds over a 4-year period. The initiative is primarily meant to offset the timber supply impacts of forest fires and insect outbreaks through the regeneration of not-sufficiently-restocked (NSR) lands, and through the use of enhanced silviculture on land that would otherwise remain underproductive. The intention is that projects should benefit land that is principally within the timber harvesting land base yet outside of forest industry obligations (B.C. Ministry of Forests and Range 2005).

The Federal Forestlands Rehabilitation Program of the $40 million (over 6 years) Mountain Pine Beetle Initiative (MPBI) also offers to support "restoration activities" on federally managed lands (Pacific Forestry Centre 2005). Additional Government of Canada funding, in the amount of $100 million over 3 years, has been allocated to the British Columbia government for MPB problems. The provincial government has allotted $7 million to "ecosystem restoration" and $2.7 million to mitigating MPB impacts in parks and protected areas (Government of British Columbia 2005b). With a priority to protect sensitive fish-bearing streams and species at risk, it is understood that these public funds must be invested in the restoration of recently disturbed forests that cannot be harvested and managed by the forest products industry.

> *Is restoration an appropriate goal for the activities described in various strategies, policies, and programs of proposed research and management, and is such intervention widely warranted or likely to meet its goals in a cost-effective manner?*

In this paper, I question two concepts associated with the call for restoration of British Columbia's beetle-killed forests. First, is restoration the appropriate term or an appropriate goal for the activities described in various strategies, policies, and programs of proposed research and management? Secondly, is such intervention widely warranted or likely to meet its goals in a cost-effective manner? I conclude with recommendations that call for clear program objectives and terminology to support focussed intervention in promoting the recovery of beetle-damaged forests.

Restoration and Degradation

The Society for Ecological Restoration International defines restoration as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (Society for Ecological Restoration International 2004). As such, the Society and the term embrace a broad community of reconstructive activities that range from mine reclamation to ecosystem restoration, including the re-introduction of endangered species, reforestation, and the construction of wetlands designed to mitigate their displacement elsewhere. Emphasis is placed on the re-establishment of indigenous flora and fauna, the repair of hydrological and nutrient cycling functions, and a return to some baseline (pre-disturbance) level of primary productivity. In all cases, however, the term implies active intervention to repair human-induced damages from which it is beyond the ability of ecosystems to recover in a reasonable period of time (Jordon *et al.* 1987; Harker *et al.* 1993; Higgs 2003; Burton 2005; Stanturf 2005). A number of recent forest restoration programs in British Columbia have subscribed to these governing concepts (Douglas and Burton 2005). The three areas of restoration covered by British Columbia's Forest Investment Account Land Base Investment Program—aquatic, riparian, and terrestrial—are aimed at mitigating negative effects stemming from poor forest management practices in the past, such as fire suppression, inappropriate road construction, and the effects of harvesting on riparian functions (Government of British Columbia [no date]).

It is difficult to assert that beetle-damaged pine forests in British Columbia are ecologically degraded; rather, they have just undergone a shift—whether temporary or permanent—in composition and structure.

So is the current MPB outbreak in British Columbia an ecologically degrading process induced by human actions? Perhaps. Large expanses of mature (i.e., MPB-susceptible) lodgepole pine (*Pinus contorta* var. *latifolia*) may be a consequence of past fire and harvesting history—widespread fires in the late 1800s and early 1900s were associated with European settlement, resulting in an abundance of post-fire pine forests. Commercial timber harvesting largely ignored lodgepole pine until the 1970s, also contributing to an increase in the relative abundance of this species in many forests. Successful fire suppression policies and practices are commonly invoked as another reason for an over-abundance of mature lodgepole pine forests in western Canada (e.g., B.C. Ministry of Environment [no date]; Hughes and Drever 2001; Taylor and Carroll 2004). On the other hand, fire suppression may have had little to do with recent reductions in areas affected by big wildfires in some closed-canopy boreal and sub-boreal forests. This is because synoptic weather patterns associated with the outbreak of large forest fires have also been rarer since 1960, about the same time that firefighting is thought to have become widely effective (Johnson and Larsen 1991). Furthermore, elevated concentrations of atmospheric CO_2 due to worldwide fossil fuel consumption have also caused a trajectory of climate change (Intergovernmental Panel on Climate Change 2001) that is widely regarded as responsible for the recent lack of temperatures cold enough to kill overwintering MPB larvae (Carroll *et al.* 2004). Many paths of human influence can be interpreted as contributing to the MPB outbreak, but all of them are indirect and confounded with climatic variation.

How ecologically degraded are pine-dominated forests if most of the pine trees are killed by mountain pine beetle? A closer look at the "dead and dying forests" of pine throughout British Columbia reveals that stands suffering from MPB attack remain dominated by native species with intact understories, animal communities, and soils, but with primary productivity shifting to a wide range of non-pine (and sometimes non-tree) species. Though apparently unprecedented at this scale, landscape-wide MPB outbreaks have occurred in the past, most recently on the Chilcotin Plateau in west-central British Columbia in the late 1970s and early 1980s (Taylor and Carroll 2004). Several years later, attacked stands that were not harvested or otherwise managed have largely recovered, usually with full (though often irregular) stocking (Hawkes *et al.* 2004). So it is difficult to assert that such forests are ecologically degraded; rather, they have just undergone a shift (whether temporary or permanent) in composition and structure. Having recovered from MPB outbreaks in the past, British Columbia pine forests can be expected to recover on their own again. One notable exception is the case of many populations of high-elevation whitebark pine (*Pinus albicaulus*), which are facing multiple threats from MPB, white pine blister rust (*Cronartium ribicola*), and climate change (Zeglen 2002).

Active management, in the form of prescribed fire or forest clearing followed by planting, may be called upon to accelerate the timber recovery process along a more uniform and predictable trajectory. But if historical fidelity is a cornerstone of restoration (Higgs 2003), and if fire suppression has been a degrading force on British Columbia landscapes, then only the purposeful re-introduction of large crown fires would constitute ecological restoration. Yet, in the eyes of the forest products industry, government policy makers, and much of the public, such fires would be considered just as degrading as (perhaps more degrading than) the MPB outbreak. Even if we successfully restore forests to what they had been before the MPB epidemic—vast continuous stands of even-aged lodgepole pine—we may be setting the stage for a repeat MPB outbreak in 60 or 80 years, or some other unforeseen plantation pest before commercial sizes are reached. In the face of a changing climate (Intergovernmental Panel on Climate Change 2001; Hamann and Wang [2006]) and predictions of further outbreaks of forest insects and disease (Logan *et al.* 2003; Woods *et al.* 2005), it would be prudent to design a more diverse and resilient landscape (Oliver 1995; Haeussler and Kneeshaw 2003; Higgs 2003), rather than merely replacing what was there before. Even within the ecological restoration community, and especially in the context of a changing climate, it is realized that past conditions can provide guidance for ecosystem management, but that the complete re-creation of historical ecosystems is usually an unrealistic goal (Cairns 1988; Falk 1990).

When forest operations and silviculture are employed to shift production to commercially useful species, the process has generally been called "rehabilitation." For example, Allen *et al.* (2001) describe rehabilitation as "creating an alternative ecosystem following a disturbance, different from the original and having utilitarian rather than conservation values." Under the Forest Resource Development Agreements (FRDA) of the late 1980s and early 1990s, actions were undertaken to apply herbicide or to bulldoze productive sites that were occupied by ericaceous shrubs, broadleaf trees or overly dense stocking of pine, followed by site preparation using fire or machines, and the planting of commercially acceptable conifers (e.g., Butt 1988; Feller *et al.* 1988). Such treatments typically cost more than a $1000 per hectare, had mixed success, often caused soil degradation, and (other than through regional economic stimulation) would be regarded as poor financial investments. When one considers the ecological value of dead trees and diverse horizontal and vertical stand structures to wildlife and biodiversity, such actions are particularly destructive (McComb and Lindenmayer 1999; Stadt 2001; Bunnell *et al.* 2004). For example, many researchers and foresters who spent the 1980s trying to destroy aspen, birch, and salal are now pursuing means of actively promoting those species. Earlier stand conversion efforts were often too expensive to implement widely, were never completely successful on the one hand, or were over-zealously applied beyond any demonstrable benefit to crop trees on the other hand. By extension, it would be sensible to have a healthy level of scepticism regarding proposals for widespread stand conversion in general.

In summary, it is evident that many programs and policies calling for post-MPB forest restoration are simply pushing for accelerated forest management through harvesting and reforestation (i.e., basic silviculture). While some restoration for ecological values is planned in parks, protected areas, riparian zones, and critical habitats, most interventions to accelerate full stocking by desired conifers in unsalvaged stands would more properly be called stand rehabilitation or stand conversion.

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Is Intervention Necessary?

Lodgepole pine stands have been killed by MPB in the past throughout western North America, and have managed to recover. How can this happen if lodgepole pine primarily grows in pure, even-aged stands, if it is very shade-intolerant, and if natural regeneration depends on fire and (or) exposed mineral seedbeds (Lotan and Critchfield 1990)? The answer may lie in the many diverse roles that lodgepole pine play in British Columbia forests. Throughout its range, lodgepole pine can be found in even-aged post-fire stands, typically serving as a seral species that gives way over time to more shade-tolerant species such as Engelmann spruce (*Picea engelmannii*); however, lodgepole pine is also found in uneven-aged climax stands in the Sub-Boreal Pine and Spruce (SBPS) zone (Steen and Demarchi 1991), and in large areas of intimate mixtures with at least five other tree species in the rest of British Columbia (Figure 1). Even in stands nominally mapped as "pure pine," preliminary research indicates that other tree species can be found in the canopy and at significant densities in the understorey (Figure 2).

Calls for forest restoration or rehabilitation presume that large areas of unsalvaged MPB-killed pine will be found in discrete patches amenable to stand-level treatments. However, province-wide only 37% of the attacked lodgepole pine is found in pure stands, and pure forests of all pine species make up only 26% of the area attacked by the beetle (Figure 1). Elsewhere (i.e., on most of the landscape affected by MPB), existing trees of other species contribute significant volumes available

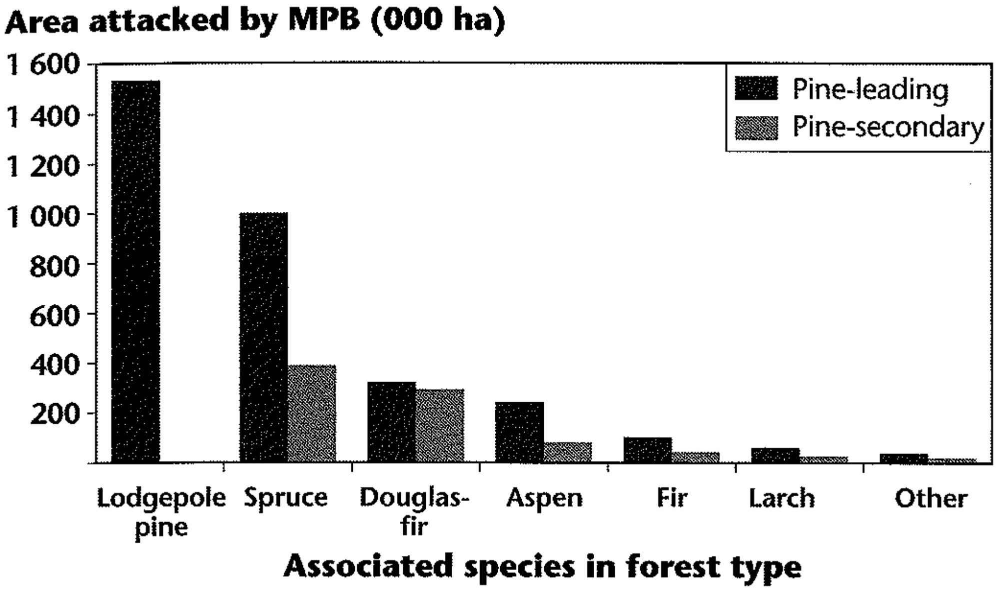

FIGURE 1. Composition of the lodgepole pine forests affected by mountain pine beetle, 1960–2002; 25.8% of beetle-attacked forest is pure lodgepole pine and 43.1% consists of mixed lodgepole pine stands (shown here), while 31.1% of beetle-attacked forest has other leading and secondary species (not shown). Data from Taylor *et al.* 2006.

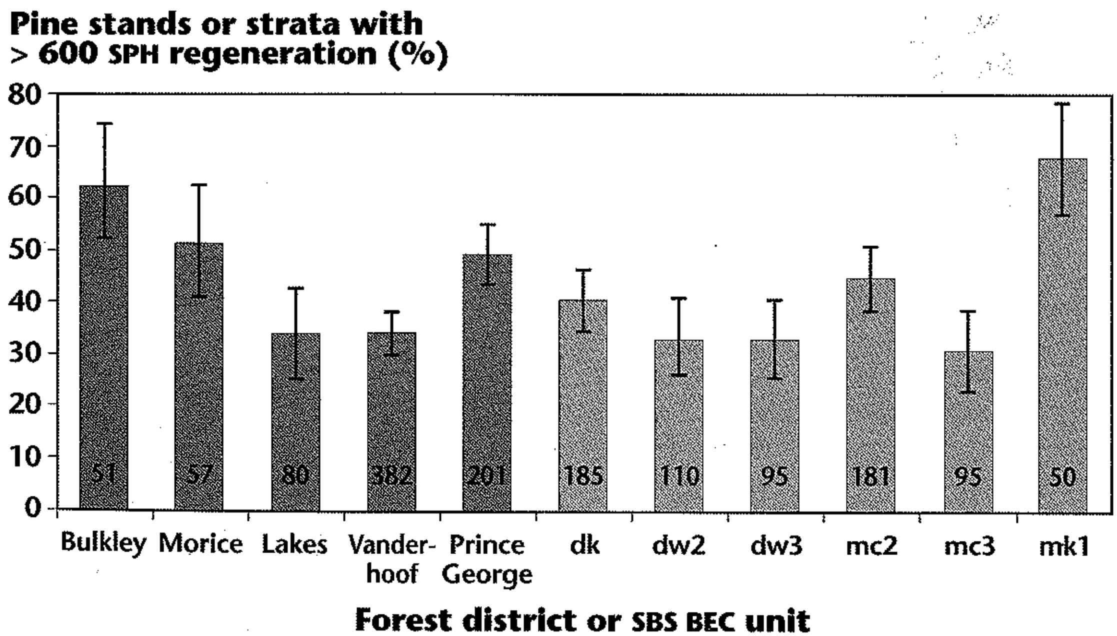

FIGURE 2. Proportion of forest stands or strata dominated by lodgepole pine (> 80% by volume), which have regeneration (seedlings, saplings, and poles < 7.5 cm DBH) in the understorey at densities ≥ 600 stems per hectare (SPH) (i.e., minimum stocking standards for modal 01 site series in these six Sub-Boreal Spruce biogeoclimatic units of the Prince George Forest Region [B.C. Ministry of Forests 2000]). The number of stands or strata for which data were recorded are indicated at the base of each bar. Error bars denote 95% confidence limits based on the binomial distribution of percentage data and the sample sizes given. Data were collected from pre-harvest surveys of cutblocks conducted for major forest licensees over the last 10 years.

for future harvest, and complex vertical and horizontal structure quite suitable to meet a broad array of habitat needs.

Understorey inventories are unfortunately sparse, even with the implementation of British Columbia's newer Vegetation Resource Inventory standards. Nevertheless, a quick survey of available data (771 pre-harvest field cards completed in support of silvicultural prescriptions) reveals that 41% of the north-central interior land base labelled as "pure pine" can be expected to leave more than 600 stems per hectare of well-established conifers in the understorey after the overstorey dies (Figure 2). Advance regeneration by more shade-tolerant species, such as spruce (*Picea engelmannii*, *Picea glauca*, *P. engelmannii* x *glauca* natural hybrids, and *Picea mariana*), subalpine fir (*Abies lasiocarpa*), and Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), constitute most of these seedlings, saplings, and poles. These trees often represent decades of growth, but are ignored or purposely destroyed in silvicultural prescriptions because:

- they are not of commercial size,
- they typically have clumped spacing,
- they are expected to die after canopy opening, or
- they are presumed to interfere with the establishment of more desirable new seedlings to be planted.

Research is needed to determine the fate of these trees after canopy death. It is likely that undisturbed trees found in sufficient densities and with sufficient advanced growth will be more effective in establishing full stocking and natural habitat values in a timely manner than destructive and expensive rehabilitation methods.

At this point in the MPB outbreak, all mortality of well-established non-pine tree species—whether in the overstorey or understorey, whether salvaged for fibre or as a result of incidental damage or to clear the way for planting—adds insult to injury, and further threatens mid-term timber supply and habitat values. If the extensive wildfires of a century ago, which generated today's MPB-susceptible forests, were a degrading force due to human actions, then killing much of this spruce and fir regeneration would also undermine the ability of the ecosystem to restore itself to a state more in balance with pre-European fire regimes. With foreseeable shortages in timber supply and mature-forest habitat in many parts of interior British Columbia, it is not compatible with the principles of sustainable forest management to salvage-log or rehabilitate all MPB-attacked stands. What is needed is a much more strategic approach to achieve the most effective balance of clearcut harvesting and regeneration, careful logging to protect advance regeneration, and conscious deferral to the processes of natural stand development and recovery (Coates 2006). Rehabilitation and restoration activities may also have their place, but are likely to play a minor role in overall forest management, and must be the most appropriate means of attaining identifiable objectives.

If land managers are compelled to intervene with the natural dynamics of unsalvaged stands after MPB attack, it behooves them to clarify what they are trying to restore. There is validity in protecting and repairing particularly high values, such as potable water supplies, spawning beds, and the habitat of species at risk. Yet pure lodgepole pine forests rarely dominate riparian zones, and threats to vulnerable species (e.g., woodland caribou) stem more from road development and forest fragmentation than from the direct loss of live tree cover (Environment Canada 2004). It could be argued that salvage operations and their associated roads are causing more harm than good to water quality and caribou. It is possible that some resource management policies and plans for threatened forest values may need to be altered in response to landscape-level insect outbreaks; ecological restoration may be an important component of those modified strategies. However, few systematic surveys have been conducted to evaluate the spatial overlap—and hence the degree of conflict—between MPB attack and non-timber values. One such assessment has been the hydrological evaluation of third- and fourth-order watersheds in the Vanderhoof Forest District conducted by B.C. Ministry of Forests and Range researchers in the Northern Interior Forest Region (Dubé 2005). Not all MPB-induced tree mortality necessarily compromises non-timber values. These values need to be assessed and related to the degree of MPB attack to identify thresholds of degradation and to determine whether any intervention is warranted.

Whether rehabilitating forests for fibre production, or restoring them to accelerate the recovery of ecological values, it is important to recognize the importance of biological legacies (e.g., standing dead trees, fallen logs, clusters of regeneration, and other vegetation) after disturbance (McComb and Lindenmayer 1999; Franklin and MacMahon 2000). This means that wherever possible, restoration activities (e.g., planting) should be conducted without first removing the standing and fallen timber. No one knows which techniques will be effective in achieving specific restoration objectives. Consequently, widespread adaptive management trials, monitoring, reporting, and the building of expertise and capacity are needed. It is expected that many compatible objectives can be co-ordinated with appropriate planning, but only if timber values are not considered primary in all situations. Leaving untreated areas as experimental controls will provide future learning opportunities. Sufficient resources allocated to the comparison of salvaged-logged, partially cut, rehabilitated, and unmanaged stands will allow us to make better forest management decisions in the future.

As with accelerated harvest and salvage operations, a large program of restoration or rehabilitation may cause more harm than good to biodiversity values and the future resilience of British Columbia's forest landscapes.

Conclusions

With the growing need to repair human damage to natural ecosystems around the world, "restoration" is considered an environmentally responsible activity, a fashionable paradigm to which few would object (Hamilton-Smith 2004). However, the damage caused by the MPB outbreak in British Columbia, even if rooted in human causes, may not benefit from such interventions unless they target specific values rather than being applied as a panacea. It is argued that MPB-killed pine stands are not unprecedented as a natural phenomenon, and will recover on their own. Expensive manipulations may be undertaken to guarantee and guide forest regeneration and future timber supplies, but such actions are more accurately described as "stand rehabilitation" rather than "ecosystem restoration," and are not necessary across the land base. These activities will certainly be costly and are not needed on many site types; as such, they must be used with caution, targeting specific strategic goals.

The diversity of forest types containing lodgepole pine in central British Columbia indicates that the harvesting of MPB-killed timber should concentrate on those stands with little representation by non-pine tree species and with negligible advance regeneration; the Chief Forester has already offered some direction in this regard (Snetsinger 2005). The outbreak is so large and its progression so advance that preventing MPB population build-up and spread is no longer the issue. Existing processing facilities are working at full capacity, so any attempt to capture more commercial value will result in short-term, unsustainable ventures. Rather, it is suggested that harvest planning must now be guided by principles of sustainability, with a goal of designing forests more resilient to such disruptions in the future.

Yet there remain knowledge gaps in making the transition to an alternative set of forest management guidelines. For example, it is not known how complex stands consisting of intimate mixtures of lodgepole pine and other tree species will respond to the selective removal of pine trees through careful logging or to the gradual loss of pine trees in unmanaged stands. Inventories or models indicating the presence of adequate understorey stocking in pine stands are also needed for good planning. Additional studies are needed to identify the thresholds of size, vigour, and density required for successful release and the attainment of target stocking levels by this advance regeneration.

It is recognized that interventions to accelerate or direct stand recovery may be needed to protect critical habitats. Likewise, rehabilitative actions to accelerate the development of commercial timber volumes or old-growth attributes in existing second-growth stands can help offset canopy death in vast tracts of mature and old lodgepole pine forests. It is not likely that management activities can or should restore the forest to its previous condition. As with accelerated harvest and salvage operations, a large program of restoration or rehabilitation may cause more harm than good to biodiversity values and the future resilience of British Columbia's forest landscapes. In seeking guidance for remedial intervention, we are well advised to consider the ancient advice of Hippocrates:

> *The physician must be able to tell the antecedents, know the present, and foretell the future—must mediate these things, and have two special objects in view with regard to disease, namely, to do good or to do no harm.* (Epidemics, Book I, Section XI, cited by Gill 2005)

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