BRITISH COLUMBIA

Ministry of
Forests, Lands, Natural
Resource Operations
and Rural Development

B.C.'s Bark Beetles: What does the science say?

Background

Over the past three decades, western Canada experienced multiple large outbreaks of native bark beetles. The mountain pine beetle (*Dendroctonus ponderosae*) outbreak affected approximately 20 million hectares of forests in British Columbia (BC) between 2000 and 2020. In addition to mountain pine beetle, more recent trends show widespread and concerning surges in bark beetle populations for spruce beetle (*Dendroctonus rufipennis*), Douglas-fir beetle (*Dendroctonus pseudotsugae*), and western balsam bark beetle (*Dryocoetes confusus*).

As natural forest disturbances, bark beetle outbreaks can result in increased ecosystem diversity and resilience but can also negatively impact forest values such as carbon sequestration, recreation, fish and wildlife, watershed management, range, landscape values and aesthetics, cultural heritage, old growth forest ecosystems, and timber production[26]. BC is still mitigating the environmental and socioeconomic impacts of the mountain pine beetle outbreak while simultaneously addressing the more recent impact of spruce beetle, Douglas-fir beetle, and western balsam bark beetle infestations. Bark beetles will continue to affect forests in BC, and a coordinated, effective provincial response is crucial for addressing ongoing negative impacts.

Figure 2 – A spruce beetle infestation in the Omineca Region. Photo credit: Alena Charlston

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Climate and weather contribute to widespread bark beetle infestations

Climate and weather patterns are changing around the globe - in western Canada, and in northern BC, these changes are significant[16]. Climate changes will impact both the susceptible host species and insects resulting in more eruptive outbreaks native bark beetles. Warming climate and weather patterns predict increased frequency and severity of mountain pine beetle and spruce beetle outbreaks, two of western Canada's major pest species and natural disturbance agents[3]. BC's Aerial Overview mapping data from the previous 10 years shows significant changes in four major eruptive bark beetles coinciding with the rapidly changing climate and weather patterns.

Figure 3 – Regional Entomologist Marnie Duthie-Holt pointing to diagnostic pitch tubes on a recently infested lodgepole pine tree in the Kootenay-Boundary Region. Photo credit: Marnie Duthie-Holt

Insect outbreaks interact with landscape-level processes such as fire, windstorms, drought, and floods

There is an established connection between large-scale bark beetle outbreaks and interacting environmental and physical processes. Insect outbreaks, fire return interval, drought and hydrology, and human-mediated disturbances define subsequent ecosystem function[7]. In addition, these factors interact.

There is conflicting evidence between risk of fire and tree mortality caused by bark beetles. There is some evidence to suggest that the risk of fire after attack by bark beetles increases[30], but the more recent literature suggests that the change in fire risk is not necessarily increased after insect outbreaks. A few studies do suggest that fire risk can increase the years following a bark beetle infestation[13]. Salvage of insect-killed trees does not always decrease fire likelihood or severity over time and space[6]. In studies conducted in North America, there was poor association with mountain pine beetle mortality and fire risk[12]. For spruce beetle[1], there was no increase in fire risk where underlying fire regimes were infrequent. Because insect outbreaks do not necessarily lead to increased frequency or severity of fire, even in disturbance-driven forest ecosystems, they should not be automatically used to justify forest harvesting. Methods employed to reduce fire hazard can also be used to simultaneously reduce bark beetle impacts[29].

Windthrow and drought can be common triggers for bark beetle outbreaks initiation or intensification. Increased consideration and better prediction of anomalous weather events are key areas for tool focusing resources on proactive beetle management techniques. Heightened detection and monitoring efforts, especially in areas susceptible to temperature driven moisture stress in host trees, must inform BC's bark beetle response[11].

Figure 4 – Windthrown spruce in the Omineca Region. Perfect spruce beetle habitat. Photo credit: Jeanne Robert

Figure 5 – Drought-killed lodgepole pine in the Thompson-Okanagan Region. Photo credit: Lorraine Maclauchlan.

Mountain pine beetle in BC and Alberta

Mountain pine beetle not only caused unprecedented host tree mortality in BC, but also expanded geographic and host range within northern BC and Alberta within the last 20 years[9]. This "megadisturbance"[25] is attributed to large areas of even-aged host trees on the landscape resulting from forest management practices as well as warming climate and weather trends[3]. The economic salvage of dead standing pine resulting from the outbreak continues through the present day, but the timber value, or shelf life[21], of the dead pine is rapidly diminishing in recent years. This directly affects BC's short and mid-term timber supply and forest ecosystems[22]. In addition, sizable infestations are still active where susceptible host trees remain (or where young trees have since grown to susceptible size)[37]. In addition, restricted hauling and storage of infested logs during the beetle flight window is important to reduce unintentional beetle spread.

Reduced timber supply resulting from the mountain pine beetle outbreak has far-reaching environmental and socioeconomic impacts throughout BC, Canada, and North America, primarily affecting timber prices and community sustainability in forestry-dependent regions. The re-establishment and diversification[14] of mountain pine beetle-killed stands must be conducted with foresight for prevention of future outbreaks[20]. In the long term, this insect will continue to have recurring outbreaks when hosts attain susceptible age and diameter.

Figure 6 – The left picture shows a recently infested lodgepole pine tree studded with pitch tubes, photo credit: Marnie Duthie-Holt. The right pictures are adult mountain pine beetles, photo credit: Lorraine Maclauchlan.

Spruce beetle in BC

In 2014, spruce beetle populations were detected increasing north-central BC and they are continuing to expand throughout this region where there is susceptible host tree species[37]. Cumulatively, between 2014 and 2021, the total area impacted by spruce beetle (including 'trace' levels of attack) is approximately 1.8 million hectares provincially; most of the outbreak area is in northern interior BC.

Spruce beetle-killed stands differ from mountain pine beetle-killed stands in several key ways. First, the pattern of insect dispersal within a stand and across the landscape is patchy[33]. Primarily localized dispersal, in combination with a mixed one-year and two-year life cycle for spruce beetle, supports the lower rate of spread for spruce beetles in the current outbreak in BC's northern interior. Second, the mortality patterns within an infested spruce stand often show much less than 100% mortality[32]. Mountain pine beetle's preferred host species, lodgepole pine, is a shade intolerant pioneer species, generally occurring in fire-driven ecosystems, and therefore tends to grow in large, even-aged monocultures in BC[2]. Conversely, white spruce and hybrid white spruce stands develop at a later seral stage, often succeeding lodgepole pine stands along with Douglas-fir and subalpine fir. The rate of conversion to a mixed stand of spruce, subalpine fir, or Douglas-fir depends on site conditions, and therefore spruce stands are inherently more heterogeneous than pine stands[34]. In general, the percentage mortality of spruce during a spruce beetle outbreak is correlated with tree size; larger diameter trees have a higher risk of dying during an outbreak. Smaller harvested areas or patches rather than large clear cuts, are recommended in spruce-dominated ecosystems. Although the current spruce beetle outbreak cumulatively affects large areas, the impact on ecosystems generally less devastating than for mountain pine beetle, but the impact on local industry and communities compounds the lingering effects of the preceding mountain pine beetle outbreak.

Management recommendations for susceptible areas include a focus on proactive pest reduction, including the reduction of breeding sites wherever possible. This includes the use of trap trees, anti-aggregation pheromones, and the prompt removal of, or application of anti-aggregation pheromones on, windthrown host trees[4]. Early identification of new infestations is key to proactive spruce beetle management and therefore ground surveys of susceptible stands containing aerially recorded dead spruce should be conducted annually to efficiently focus pest reduction harvesting. Additional focus to develop clear criteria for the more efficient identification of susceptible stands before infestations begin, is a key goal for the response to spruce beetle.

Figure 7 – The left picture shows a spruce beetle-attacked tree in the Omineca Region. Photo credit: Hardy Griesbauer. The right photo shows an adult spruce beetle. Photo credit: Jeanne Robert

Douglas-fir beetle in BC

Although affecting less area than mountain pine beetle or spruce beetle, Douglas-fir beetle populations are high through the range of Douglas-fir, the primary host tree species. Increasing frequency and severity of forest fires, drought and windthrow events within the host tree range of southern BC have contributed to a rise in Douglas-fir beetle populations. Large, old Douglas-fir stressed by root disease, drought, or fire are susceptible to attack[10]; Douglas-fir beetle populations often build up and spread from the stressed and damaged trees affected by wildfire. Continuing host tree stress from fire, weather, disease and management practices are likely to maintain or enhance Douglas-fir beetle infestations in susceptible stands.

Because of the more localized nature of Douglas-fir beetle infestations, restricted host species range, and effective management tactics, this insect has potential for targeted, effective mitigation. Management tactics include identification and monitoring of high-hazard stands, especially after fire. Prompt removal of infested trees and concentration of Douglas-fir beetle populations prior to harvest will limit ongoing impacts in surrounding healthy stands.

Figure 8 – The left picture shows a mix of healthy (green), beetle-infested (red), and recently killed (grey) Douglas-fir trees. The right picture is a closeup of an adult Douglas-fir beetle ready to fly. Photo credit: Marnie Duthie-Holt

Western Balsam bark beetle in BC

Western balsam bark beetle causes widespread, low intensity, mortality of subalpine fir (*Abies lasiocarpa*). Over the past five years, the province's aerial overview survey has identified western balsam bark beetle as the forested land base's single largest biotic factor by area. Much of this attack is considered trace severity though the cumulative impact is significant, and mortality is likely to increase with changing climate and weather patterns[2315]. The provincial infestation area for western balsam bark beetle was over two million hectares each year, since 2014[37].

Although western balsam bark beetle does not historically rank highly for economic and ecological impacts, the scale of the provincial and regional damage, along with the significant increase in affected area, warrants further attention. The widespread nature of low-level damage requires additional information to understand whether there is a risk to these ecosystems and how mortality may impact forest ecosystems within the coming decades. Evidence of increasing percent mortality in subalpine fir, combined with other pressures on this tree species, strongly suggest a near-term impact on these ecosystems.

Despite the key role of subalpine fir in BC's forested ecosystems, more research is needed to understand the changing stand dynamics, the biotic and abiotic risks associated with changing climate, mortality rate, shelf life, or its value for traditional Indigenous peoples' use. Initial studies of baited trees shows promise for concentration of local beetles populations prior to pest reduction harvesting[24].

Figure 9 – Left figure shows an adult female western balsam bark beetle. The right photo shows the bright red foliage of a dying subalpine fir. Photo credit: Lorraine Maclauchlan.

Bark Beetles in BC's Future Forests

Any process, such as stand harvesting or natural disturbances that results in large areas of even-aged stands, large areas of a single species, or large areas of low genetic variability increase risk of future large-scale insect outbreaks. The evidence suggests that large areas of similar treatment (e.g., large-scale clear cutting) are not a good mid- to long-term management practice for bark beetle-killed stands, given that the risk of drought and insect outbreaks is likely to rise as climate change favours bark beetle development and phenology. A good strategy to ensure resilience of forested ecosystems in the face of predicted climate change, including variable weather patterns and drought, is diversity. Ecosystem resilience is defined by a mix of host and non-host tree species as well as host genetic diversity retained in the surviving trees after insect outbreak. Leaving structure and habitat, even large beetle-killed trees, supports plant, invertebrate and vertebrate biodiversity in recovering stands moderates impacts on hydrology and soils. In addition, there is some evidence that suggests trees that escape the patchy beetle mortality may be good sources of genetic adaptation for future forest regeneration[35]. Recently public attention in BC is focused on the preservation of old growth stands, ecological effects of climate change on community water resources, as well as flood and fire risk[18]. Bark beetles are prime competitors for the stands that people value most, and they must be incorporated into landscape level planning for forest resources. Increased stress on forested ecosystems in the form of drought, fire, insect damage and pathogens and a recent shift towards non-timber values of forested ecosystems, especially water supply, flood control, habitat values and carbon sequestration means that large-scale clearcut harvesting is unproductive for managing current and future bark beetle infestations than proactive, natural disturbance management approaches, smaller-scale focused pest reduction harvesting tactics, and diversity in regeneration.

“Resilient and productive forested ecosystems incorporate the critical role of natural disturbances.”

Figure 10 – Moderate spruce beetle infestation in the Northeast Region with a few brighter western balsam bark beetle-killed trees. Photo credit: Anne Marie Dube.

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