

Managing Douglas-fir Beetle Post-Wildfire

Introduction

Fire plays a major successional role in British Columbia (B.C.) ecosystems. Flames and smouldering stumps are merely the beginning of the subsequent numerous biological and physical processes, which can occur in fire-affected landscapes. One of the most noticeable of these processes is the assemblage of insects post-fire.



2017 fire, Princeton, B.C. – flames erupt in gully with young, regenerating pine.



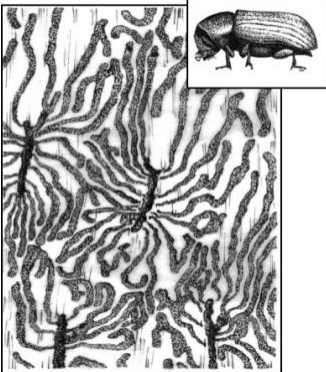
Aerial view of 2017 Elephant Hill fire – mature forests and young pine plantations burnt.

Fires are a frequent occurrence in B.C.'s summer months, burning both high and low elevation stands, which contain a preponderance of Douglas-fir (*Pseudotsuga menziesii*; Fd), Ponderosa pine (*Pinus ponderosa*; Py) and lodgepole pine (*Pinus contorta*; Pl) mixed with spruce (*Picea* sp.; Sx) and other species. The possibility of insect damage and build-up must be considered when developing management plans for burnt areas.

Many bark beetles (Scolytinae), woodborers (Cerambycidae, Buprestidae), ambrosia beetles (Scolytinae) and wood wasps (Siricidae) are attracted to fires and fire damaged hosts. These insects typically attack and breed in weakened, stressed, damaged or recently killed trees. Trees become weakened or stressed in a number of ways including drought, lightning, windthrow, mechanical injury, disease, insect attack or **fire**. Each type of insect (e.g., bark beetle or woodborer) has its own "signature" impact on its host tree or stand, and is attracted to a particular degree of fire damage.

Woodborers, ambrosia beetles and wood wasps damage the sapwood portion of burnt trees. The trees must be severely stressed or dead for these insects to attack. Bole symptoms include reddish boring dust (woodborers) or white sawdust (ambrosia beetles), which could be mistaken for bark beetle attacks; therefore, one should check to see if the attacking insects have entered the sapwood. They will not affect living, vigorous trees.

Numerous secondary insects such as the engraver beetles may colonize fire-damaged trees or those trees under attack by primary bark beetles such as DFB. Bole symptoms are similar to DFB so identification of the attacking species must be verified by checking under the bark. These beetles seldom build to numbers that pose a threat to green, healthy trees.

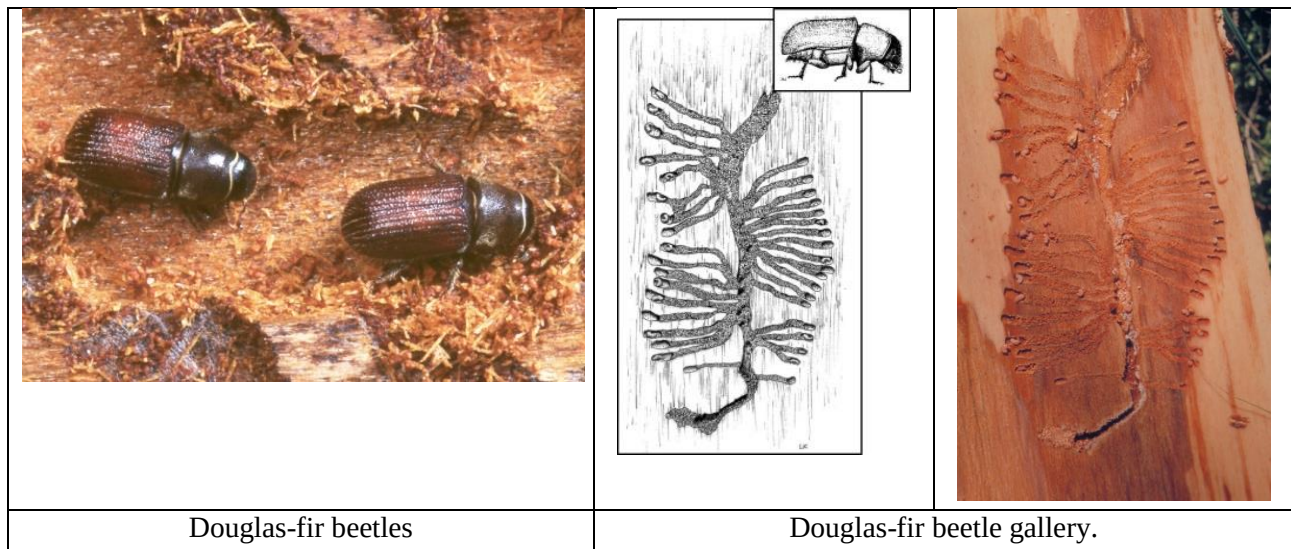
		
Douglas-fir pole beetle galleries and adult.	Douglas-fir engraver beetle gallery and adult.	Woodborer galleries.

Bark beetles will infest recently fire-killed trees and fire-scarred trees that are dead but with suitable phloem or still alive. These beetles have the potential to move onto and attack healthy, live trees. Bark beetles that are most likely to be active in fire-impacted areas are western pine beetle (*Dendroctonus brevicomis*), mountain pine beetle (*Dendroctonus ponderosae*; MPB), and turpentine beetle (*Dendroctonus valens*) in Ponderosa pine; and, Douglas-fir beetle (*Dendroctonus pseudotsugae*; DFB) in Douglas-fir. Mountain pine beetle and turpentine beetle also attack lodgepole pine, but lodgepole pine is less fire tolerant than Ponderosa pine and therefore is more likely to be killed outright by wildfire or reach an “unacceptable” stage by the time of MPB flight the following year. Therefore, only lightly charred or weakened lodgepole pine may still be susceptible to attack in years following wildfires. The issues surrounding post-fire beetle kill will be addressed separately for Ponderosa pine and Douglas-fir.

Tree mortality is influenced by many factors following wildfires. In B.C.’s interior, Douglas-fir and Ponderosa pine are fire-tolerant species, due to thick, insulating bark that develops with age and protects the inner cambium from heat injury. Mortality following fire depends not only on species-specific traits and tree age, but also on the type and degree of fire-caused injuries, initial tree vigour, and the post-fire environment. Trees that are only moderately injured by fire and capable of recovery can subsequently be attacked and killed by bark beetles and associated insects. DFB can have a significant influence on post-fire delayed Douglas-fir mortality, killing trees that would otherwise survive fire. Post-fire tree mortality due to DFB is augmented when beetle populations are already present and active near a recent wildfire.

Douglas-fir beetle biology and symptoms

DFB is normally present in forests at low densities, breeding in Douglas-fir trees that are injured or have recently died. DFB preferentially attacks freshly downed trees and trees stressed by a variety of factors, including drought and fire. Outbreaks are typically initiated by a stand disturbance, the most common being windthrow, snow breakage or other weather-related phenomena.



DFB adults and larvae create distinctive galleries beneath the bark that distinguish them from other bark beetles. DFB larvae require fresh, moist phloem (inner bark) for food, so trees that have been dead (or down) for more than a year are not suitable habitat. Trees damaged by fire or drought are sometimes attractive for longer periods because they may not be immediately killed by the stress event. Injured or recently killed trees have little or no defensive capabilities making them ideal sites for beetle larvae to feed and develop. Periodically, natural or human-caused disturbances such as windstorms, fire, defoliator outbreaks or logging create an abundance of suitable breeding sites that allow beetle populations to rapidly increase. At high densities, beetles are forced to attack healthy, live trees because there are not enough stressed and dead ones to support the population. By attacking a live tree in large numbers, the beetles are able to overcome the tree's natural defences and successfully reproduce. If an attacked tree is not killed, then the beetle's eggs and larvae will not survive to the adult stage. Sometimes only a portion of the tree is killed and only the brood in that part of the tree survive. This is commonly referred to as a strip or partial attack. DFB outbreaks typically last for several years and may result in the mortality of many trees. Key hazard and risk parameters for DFB attack:

- **Biogeoclimatic zone** - the Interior Douglas-Fir (IDF) is highest hazard;
- **Stand density** - increased stem density increases stand hazard;
- **Proportion of Douglas-fir** - the higher the percentage of host trees, the higher the hazard;

- **Diameter of Douglas-fir** - larger diameters preferentially attacked;
- **Aspect and slope** - south facing slopes of > 40 degrees have highest hazard;
- **Drought, fire, or lightning strikes**;
- **Recent windthrow** - highest hazard is full trees blown down or tops broken in winter through spring storms;
- **Recently felled trees** – in road building or along fire guards;
- **Debris piles** left unburned, high stumps, and/or bole damage;
- **Root disease** (*Armillaria ostoyae*) is the most frequently observed pathogen, but laminated root rot (*Phellinus weirii*) may also be a predisposing factor; and,
- **Previous defoliation** (e.g. western spruce budworm, *Choristoneura freemani*).

Key forest health objectives post-wildfire: Douglas-fir forests

1. Minimize future tree mortality from Douglas-fir beetle (DFB) and secondary bark beetle attack.
2. Maximize removal of DFB during the operational salvage of burned wood.
3. Apply the most current DFB mapping results, hazard rating and burn severity maps to prioritize stands at highest risk to DFB attack within and outside fire perimeter.
4. Monitor bark beetle populations within the burn perimeter and within a critical distance (1-5 km) outside the burn perimeter.
5. Monitor for DFB and secondary bark beetle attack in stands outside the burn perimeter – most critical 2nd to 3rd year post-fire.

Quick Facts:

DFB is consistently associated with fire-injured trees, first attacking larger trees with scorched crowns (blackened, no foliage) and blackened boles, or trees with red crowns and moderate to high levels of basal bole injury. Logs and other large-diameter debris are also attractive to DFB.

The potential for DFB attack and build up depends on:

- Pre-existing populations (outbreak) of DFB;
- proximity to DFB populations;
- amount of susceptible host (large, old Douglas-fir; blackened, large Douglas-fir);
- burn severity (Blackened with phloem intact; red foliage and blackened bole; through to lower severity burn damage)
- degree of pre-emptive management actions deployed (salvage of blackened wood prior to beetle flight; baiting/trapping high priority blocks prior to DFB flight)



Highest susceptibility to DFB – blackened tree (no foliage, blackened bole; thick bark with acceptable phloem)



DFB attack on blackened bole of Douglas-fir with close-up (right) of frass at base of tree.



Black boles with scorched foliage – next in susceptibility rating for DFB attack.



Ground fire with some bole scorch and green crowns – low susceptibility to DFB attack.

Burn Severity and susceptibility to DFB attack:

- **Severe Black with split bark:** Tree boles are completely blackened, bark exfoliated, damaged/dry phloem, foliage destroyed, boles charred and understorey vegetation burned. These trees are less likely to have significant beetle problems.
- **Blackened bole and crown:** tree boles and foliage blackened but phloem intact (acceptable to beetles) – typically in stands containing large trees. These areas will be attacked first and have the largest build-up of DFB. **Most at-risk in year-1 post-fire.**
- **Black/brown:** Mostly black but some red/brown foliage. These areas may develop beetle populations in large, old thick barked trees but less in smaller thin barked trees.
- **Brown/black/some green:** Mostly red-brown foliage, some blackened spots, but some green foliage as well. These areas may be attacked by DFB especially if also drought stressed. These stands are more susceptible 2-3 years (plus) post-fire.
- **Mixed green/brown/black:** mostly green foliage, with brown and black spots. DFB attack in these areas will likely depend on the significance of ground fire effects and drought stress. These stands are more susceptible 2-3 years (plus) post-fire.

Risk factors and associated mitigation techniques:

Strategic level planning to address DFB must be conducted at the landscape level with all agencies involved (FN, industry, government, and others). Direct management of DFB must then be directed at defined geographic areas and will take a minimum of two years, and usually longer, to attain strategic goals. Anticipate in advance the timing, placement and harvest sequence of harvest/salvage blocks, trap trees, tree baits, mass (funnel) trapping and other tactics such as MCH (3-methyl-2-cyclohexen-1-one) (anti-aggregation pheromone).

1. **Current beetle populations** – risk is highest when significant DFB populations (outbreak) are active in the fire and adjacent stands. Overall risk is reduced if there are no current significant DFB populations in the area. Burnt stands within a 1 km radius of current DFB populations are at very high risk.
2. **Timing and intensity of burn** - This equates to the acceptability/suitability of trees to DFB. Early season fires occurring prior to beetle flight increase the risk of attack, by increasing tree susceptibility. July-August fires (post-beetle flight) pose a wide range of risks dependent upon the degree of tree damage by fire. Generally, DFB will not attack Douglas-fir with crown and stem injury that is >80%. *Douglas-fir exhibiting exfoliated bark and dry phloem are not colonized by beetles.*

The first year following a wildfire DFB will select the largest of the fire-impacted trees. In subsequent years, smaller diameter trees may be attacked and killed by DFB and secondary bark beetles. The following criteria may be used to estimate the risk:

- Trees are at highest risk, the first summer post-fire. The risk decreases in the second year. Largest diameter trees are attacked first.

- Douglas-fir with (high) 60-80% bole char and/or crown volume scorch are most likely to be attacked in Year 1;
- Large Douglas-fir will produce the most beetles; therefore priority should be given to removing or disposing of these trees first;
- Large, thick-barked Douglas-fir with total crown defoliation (**100% crown scorch**) is at high risk the first summer post-fire.
- Douglas-fir with (moderate) 50-60% bole char and/or crown volume scorch are selected by DFB in Year 2; and
- Smaller diameter trees with total crown defoliation (**100% crown scorch**), significant phloem damage (dry, burnt) and cracked/exfoliated bark dramatically **decreases** the likelihood of DFB attack.

3. **3. Fire-fighting activities that create host material for DFB (e.g. fireguards, decks) -** Douglas-fir may take up to one year to dry out (due to thick bark) and become unacceptable to beetles. Therefore, any large diameter Douglas-fir felled during summer wildfires will likely be exposed to at least one beetle flight. Douglas-fir burned or felled from August through late fall and winter are at higher risk of attack than those felled earlier in the year. Douglas-fir burned or felled prior to August will be at lower risk, but could still be attacked by DFB depending on piece size and phloem moisture.

Any Douglas-fir left on-site must be checked for beetle attack/emergence and follow-up control actions **must be implemented**. Limbing and exposing the bole of felled trees to direct sunlight to dry the phloem will make them less attractive to beetles.

All trees attacked by DFB **must be removed** prior to the next beetle flight.



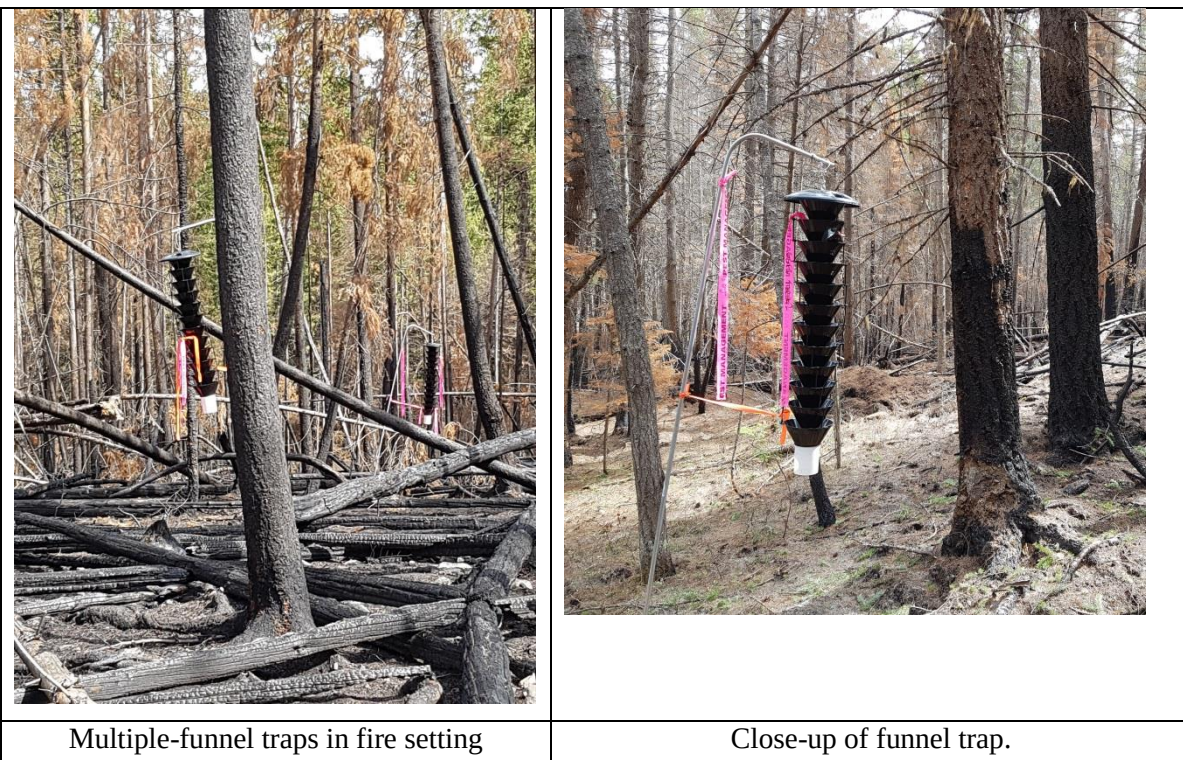
Trees felled in the course of firefighting are good potential host material for DFB the year following the wild fire.

DFB mitigation techniques post-wild fire:

1. Concentrate efforts (multi-faceted approach) on target, defined management units. DFB cannot be managed over the entire landscape in a haphazard manner.
2. Maximize removal of DFB-infested tree during all harvest operations.
3. **Mass Trapping with Lindgren[®] funnel traps to enhance Douglas-fir beetle control in cut blocks and special management areas.** This technique can be employed in the following scenarios: Multiple-funnel traps baited with DFB pheromone and host odor may be employed as follows:

Augmentation tool to maximize DFB extraction in cut blocks:

- hang traps in groups (2-3 traps) within cut block boundaries
- hang traps 2.5 m-3.0 m above ground to avoid damage from bears, cattle or humans
- traps will capture beetles throughout DFB flight period plus induce overflow attack on surrounding tree (acceptable when within cutblock boundary)
- maintain collection cups periodically (empty and destroy captured beetles)



Harvest is not an option:

- place traps in severely burned areas or clearings where spillover unlikely or is less of a problem
- hang traps in groups of three in the shade if possible

- hang traps 2.5 m-3.0 m above ground to avoid damage from bears, cattle or humans
- place traps at least 100 m away from standing, live, mature Douglas-fir (or susceptible burnt Douglas-fir is harvest not imminent) in order to avoid spill-over attack
- maintain collection cups periodically (empty and destroy captured beetles)

	
<p>Funnel traps placed in opening to minimize overflow attack.</p>	<p>DFB caught in cup.</p>

- 4. Baiting stands** – DFB tree baits (containing attractive pheromones) can be deployed in a grid within a cut block at 50-meter intervals or in “spots” (spot baiting). Tree baits are stapled on to the north aspect of large, live host trees. They are intended to contain beetle populations within the baited area, and do not necessarily attract beetles from outside block boundaries. Baiting harvest blocks in fire-impacted stands is a good option because it is often difficult to determine how much pre-existing attack exists in a post-fire block, and baiting will contain the population and may hold beetles that fly through the block from outside block boundaries. Baits must be placed prior to beetle flight (April-May) and all attacked trees must be removed prior to the next beetle flight period.



Grid-bait infested stands to prevent DFB from leaving block.

5. **MCH** can successfully repel DFB from vulnerable areas and can protect small, high-value stands. The anti-aggregation pheromone **MCH** is used to disrupt or prevent DFB attack. It is most effective when the number of infested or susceptible trees is low and is applied before annual beetle flight occurs (typically May-June but can be as early as April) on blowdown (or fireguard) trees; large, susceptible trees; and damaged or severely stressed trees. Stapling the pheromone packages on adjacent standing trees or at 2 or 3 m spacing on felled logs might significantly reduce/eliminate attack by DFB.
6. **Trap trees** - This is a management tactic used in conjunction with traditional or salvage harvesting in live Douglas-fir stands containing active DFB populations. Because DFB prefers freshly downed trees to standing trees, trap-tree programs are employed at an operational level to suppress beetle populations. Live, large diameter Douglas-fir is felled in early spring and remains on the ground throughout the beetle flight. Trap trees are then removed and processed before beetle flight the following year.

Trap trees should be felled prior to beetle flight in early spring (April). Trees should be dropped in the shade and left unlimbed and unbucked. Trees left in the sun, or where a major portion of the bole receives direct sunlight, will not attract beetles as effectively as those lying in a shaded environment. Trap trees should be left on site until late summer to attract beetles throughout their flight period.

In standard harvest (no burnt wood), trap trees are the preferred option because they attract beetles from outside as well as inside block boundaries. In fire-impacted stands, trap trees may not be an option. There are many competing susceptible host resources and any remaining live, green Douglas-fir may be a priority for protection. In this scenario, the use of other options such as tree baiting and mass trapping with funnel traps should be considered.



Trap trees should be placed within stand and not limbed.



Frass piles indicate attack by DFB.

7. **Trap trees and secondary beetles** – when the DFB populations are declining or trap trees are placed in sub-optimal locations, secondary beetles may attack. Often when trap trees are limbed or left in direct sunlight, secondary beetles will displace DFB in the trap trees.



Poor trap tree deployment – trees are overexposed to sunlight and drying.



Parasitized Douglas-fir beetle larvae (box).



Cryptoporus fungi on Douglas-fir attacked by DFB.

