Spruce Beetle Management in B.C.

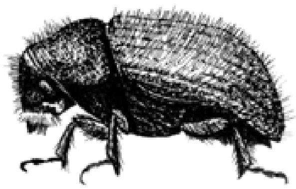
Hazard rating, risk rating, ground detection, prevention, and management options.

Province of British Columbia

Forests, Lands & Natural
Resource Operations

Spruce Beetle

Contents



Hazard rating

Hazard rating identifies those stands where substantial losses can be expected if an outbreak of spruce beetle occurs. This valuable planning tool identifies those stands that are highly susceptible to attack. Once all spruce stands in an area have been rated, resources can be directed toward those stands with the highest hazard so that losses can be minimized. Hazard rating of stand susceptibility considers factors of: site quality, stand age, proportion of susceptible basal area, and stand location, density, and growth rate.

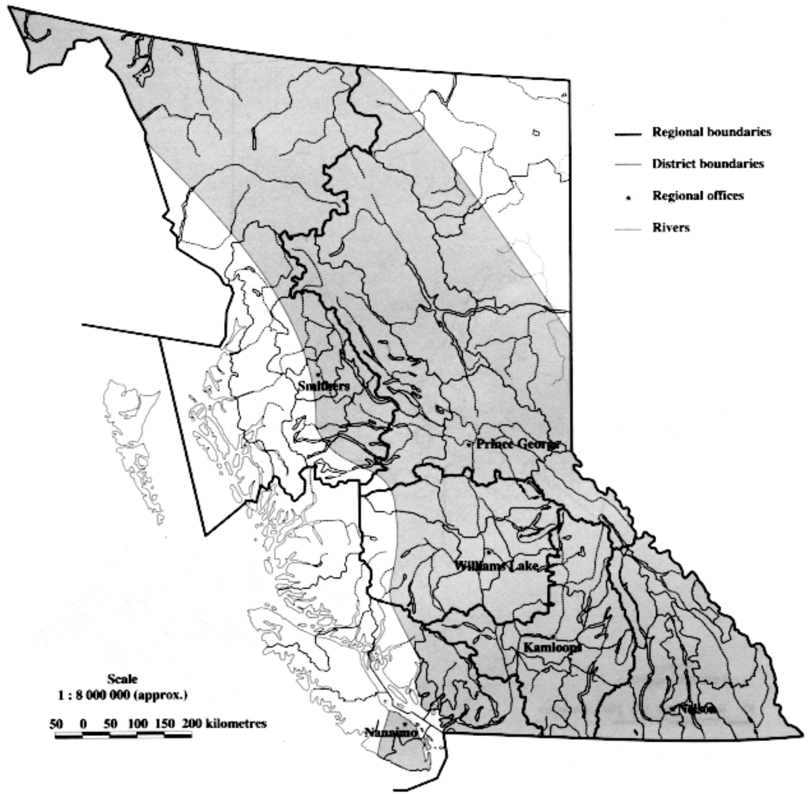


Fig. 1 Distribution of spruce beetle in British Columbia

To determine stand hazard, the following formula is applied:

$10 \times (Q \times A \times P \times L \times S_2) \times 0.5$

Where the formula factors are:

Q = Site quality (good = 1.14; medium = 0.60; poor = 0.27)
A = Age (> 120 = 1.21; 100-120 = 0.74, <100 = 0.07)
P = Proportion of susceptible basal area
 = (basal area of spruce $\geq$ 17.5 cm)/(basal area of all species $\geq$ 12.5 cm) x 100
L = Location
 = (24.4 x absolute longitude) – (121.9 x latitude) – (elevation (m)) + 4408.1)
S_2 = Stand density and growth rate (see the following link to calculate):

➲ For more detail on S_2, see: Spruce Beetle Hazard Rating Documentation PDF.

Hazard ratings can be used to set priorities for surveys and treatments and may be used during the preparation of site plans as a tool in preventative management.

Risk Rating

Stand risk is the probability that the stands will be attacked or re-attacked based on the proximity and incidence of a spruce beetle infestation. If the stand is not currently infested, it may be attacked by spruce beetle adults immigrating from adjacent infested stands. Any susceptible stand within 2 km of a spruce beetle infestation is a high risk. Stands with high hazard and risk values are a high priority for management.

Ground Detection

Spruce beetle infestations located from aerial surveys or other sources are surveyed using a two-stage system. The first survey, the walkthrough, is a "course filter" that quickly determines the extent of the infestation and the options that are available based on the sanitation harvest index thresholds described below. Probes are used to gather more precise information to clarify management alternatives. A treatment decision is then developed for the stand based on the size, shape and intensity of infestation, the beetle life cycle, and other management considerations.

Walkthroughs are non-systematic preliminary ground reconnaissance surveys conducted to estimate:

- the size and spatial distribution of the infestation
- the incidence and severity of the infestation as measured by:
    - % of spruce attacked in the last three years
    - attack densities and success
    - vigour of the new broods as measured by random bark samples
    - beetles on a 1-year or 2-year life cycle
- access, operability, and integrated resource management issues
- sanitation harvest index
- the necessity to obtain further information or take action as detailed below (Table 12).

The configuration and extent of walkthroughs are site-specific decisions made by the surveyor. Surveyors should conduct their walkthrough and then attempt to select a representative portion of the area to collect 100-200 m of probe (or 10 x 100 m "pixel") data. Regardless of the walkthrough technique, the surveyor can classify the area/stand by calculating a sanitation harvest index using the data described below. If the sanitation harvest index is between 600 and 999, a grid-probe is recommended to more accurately classify the infestation (Table 12).

The stand hazard index is used to rank the sanitation/salvage harvesting priorities for stands attacked by spruce beetle. Larger numbers indicate a higher priority for sanitation harvesting. Note that the salvage component also includes older attacks. This portion of the formula may be deleted if the salvage component is unmillable, e.g., for plywood.

The sanitation harvest index is calculated as follows:

Sanitation harvest index = (A+B+C) x D

Where:
A = % most recent attack in stand
B = % second most recent attack in stand/1.5
C = % third most recent attack in stand/2.0
D = total % of healthy and attacked spruce in stand

Table 1. Recommendations for further action based on walkthrough estimates

Sanitation harvest index	Recommendation
0 - 599	leave (monitor, trap trees, baits, etc . .)
600-999	probe to obtain more precise information
1000+	operational cruise prior to sanitation harvest[a]

[a] Assuming road access exits or could be in the near future

Probes are systematic and detailed secondary ground reconnaissance surveys. Probing will determine detailed, more precise estimates of the same information gathered from walkthroughs, and will provide sufficient information to stratify the area for various management actions. If probing is recommended, delineated stands should be probed via systematic parallel probe lines as follows:

- survey lines are spaced at 100 m intervals
- probe lines (strips) are 10 m wide (5 m on each side of centre line)
- strips are continuous and extend at least 100 m past the last infested trees
- all trees $\geq$ 17.5 cm within the 10 m wide strip will be recorded within one of the existing diameter classes.
- Information will be summarized in 100 m units, so all lines should be in multiples of 100 m
- Features pertinent to harvesting, such as creeks, roads, marshes, and cutblock openings should be noted.

All spruce beetle-attacked trees will be recorded by attack codes 1-6 as summarized in Table 13. Surveyors must remove at least a small portion of phloem from every infested tree within their 10 m strip to ensure coding accuracy. All attacked trees must also be mapped.

Table 2. Spruce beetle attack codes

Attack code	Year of attack	Type of attack
1	most recent	full attack
2	most recent	strip attack
3	second most recent	full attack
4	second most recent	strip attack
5	third most recent	full attack
6	third most recent	strip attack

Cruising is conducted to assess the merchantability and value of timber prior to harvesting. Although spruce beetle impact can be estimated from a cruise, cruises are:

1) not detailed enough,
2) not designed to record beetle attack severity, vigour, and multiple-year attacks, and
3) might not be conducted by sufficiently experienced beetle attack surveyors.

Management options

Strategies for spruce beetle are similar to those for mountain pine beetle and other bark beetles.

Selection and application of management strategies

Choice of management strategies for spruce beetle will depend on:

- The size and pattern of the infestation
- The severity of the attack in each of the last three years
- The vigour and survival of the new broods
- The stand hazard
- Integrated resource management issues/constraints
- Existing and future access
- Harvesting operability

Selection of the most appropriate course of action is illustrated below in Fig. 2.

Fig. 2. Selection of management actions for spruce beetle

Step #	Consideration	YES - Go to:	NO - Go to:
1.	Sketchmap/Heli-GPS survey	2	2
2.	Walkthrough/probe as necessary?		
3.	Is access available for harvesting?	4	10
4.	Are there resource management issues?	5	8
5.	New attack or highly susceptible timber?	6	Monitor
6.	< 8% attack	Trap trees	7
7.	$\leq$ 2% ha	Trap trees	Harvest & monitor
8.	New attack or highly susceptible timber?	9	Monitor or salvage
9.	$\leq$ 2% ha	Trap trees	Sanitation & monitor
10.	New attack or highly susceptible timber	11	Monitor
11.	Are there resource management issues?	12	Trap trees &/or develop
12.	< 8% attack and road-accessible	Trap trees and/or monitor	Trap trees & develop

Treatment options

Some of the treatments for spruce beetle differ from other bark beetles and timing of activities differ to variations in the life cycle. Timing of management activities for spruce beetle are given in Table 14.

After detection, treatment options are limited to three general tactics:

- harvesting
- conventional trap trees
- prevention (including hauling and milling restrictions)

Harvesting

A. **Sanitation harvesting** for spruce beetle suppression maximizes the extraction of currently infested spruce stands in order to reduce the existing population and to prevent their spread. The highest priority is given to stands with high levels of new attack, high hazard, and a high risk of spread. All harvesting methods can be used.

B. **Salvage harvesting** recovers most spruce that were attacked by spruce beetle and such trees no longer have any living broods. Salvage harvesting is primarily conducted to recover damaged timber before it loses its value for potential wood products. This tactic does not reduce spruce beetle populations, but is the first step in returning the site to forest production.

Table 3. Recommended management activity time table for spruce beetle

Activity	Timing	
	Priority time frame	Available time frame
Detection		
Aerial surveys	July 25 to Aug. 30	July 25 through Sept.
Walkthroughs	complete by Sept. 30	July 25 through Oct.
Probes	complete by Oct. 15	July 25 through Nov.
Cruising	complete by Nov. 15	as per cutting permit
Harvesting		
Cutting permits	issued by Jan. 30	
Sanitation logging	Feb, 1 to March 15	July 25 through March
Update harvesting Plans	by April 15	
Other treatments		
Conventional trap trees	felled in March removed in early winter of the same year	Jan. through March
Pre-felling infested timber one year after attack*	June to early August	May through Sept.
Pheromone grid-baiting	deployed in early May & logged within a year	April to early May
Hauling & milling restrictions	June	mid-May to mid-August

* If the population is on a 2-year life cycle, felling infested trees the following summer can reduce beetle emergence for hibernation by 69-88% and result in greatly enhanced sanitation harvesting during the upcoming winter.

Applicable harvesting systems

1. **Clearcut** harvesting is normally the most effective and cost-efficient control strategy for extracting large aggregations of infested trees.

2. **Partial harvesting systems**: partial harvesting is an uneven-aged silvicultural system in which infested patches of spruce are sanitation harvested, creating small openings which are usually no larger than twice the height of mature spruce. The objective is to extract as much infested spruce as possible but still leave a mosaic of various aged groups of trees. Careful planning, layout, harvesting and monitoring are required to ensure wind firmness and prevention of damage to the residual mature stand.

3. **Diameter limit** sanitation harvesting is a selective harvest in which infested spruce of a minimum diameter or greater are removed throughout the stand. Older attacked spruce of a minimum diameter may be included in the logging as a salvage component or left standing for various ecological reasons.

4. **Single tree selection** sanitation harvesting is a selective harvest designed to extract infested spruce throughout the stand regardless of their diameter.

Pheromone grid-baiting (associated with harvesting) - The use of semiochemical tree baits in grid-patterns in spruce beetle infested stands is a temporary holding tactic until the stand can be sanitation logged. Baiting should be done on a 50 m x 50 m grid throughout the entire infested portion of the stand(s) proposed for sanitation logging.

Appropriate situations for deploying spruce beetle baits on standing trees:

- smaller, distinct blocks having a light scattered attack with no heavily-infested patches
- stands where it doesn't matter if many additional trees are attacked within the stand prior to clearcut sanitation logging
- stands where sanitation clearcutting is clearly scheduled to occur at the soonest opportunity after the beetle flight and before emergence for hibernation
- stands where the licensee/contractor could not otherwise pick up smaller patches of attacked conventional trap trees in early winter (for whatever legitimate reason) and/or where early deep snow would make trap tree retrieval difficult (e.g., at the bottom of a shaded slope).

Conventional Trap Trees

Conventional trap trees are living, large-diameter spruce that are felled to attract spruce beetle. Spruce beetle prefer downed material which they attack more extensively and at a greater mean attack density than they do standing spruce. Trap trees felled into the shade and left unbucked and unlimbed may absorb up to 10 times the number of beetles a standing tree will. Trap trees will effectively attract beetles from up to 0.4 km away, and less effectively for up to 0.8 km.

Trap trees are deployed to:

- contain emerging beetles in cutblocks prior to sanitation logging
- protect adjacent healthy timber or reserves
- "mop-up" beetles emerging from stumps and slash following sanitation logging.

Conventional trap trees must be subsequently removed or treated to kill trapped beetles prior to their emergence.

Trap tree deployment should consider:

- Sites should be clearly flagged and must be mapped to facilitate felling and subsequent extraction.
- Trees must be uninfested.
- Trees should be $\geq$ 35 cm dbh, and have thick bark.
- Trees should be cut with low stumps.
- Trees should be felled in a direction which provides the greatest amount of shade. If possible, fell conventional trap trees so that their butts face towards a road to facilitate eventual skidding.
- Trees should not be bucked or delimbed.
- Trees should be felled as close to an infestation as possible and no further away than 0.8 km.
- Shaded, freshly windthrown spruce can be used as trap trees and must be removed (or treated) with the other traps.

Trap tree quantities

The number of trap trees to be felled mainly depends on the size of the attacking beetle population, which is usually estimated by the number of adjacent infested standing trees. One trap tree should be felled for every 10 infested standing trees for static infestations; and ratios as high as 1:4 for more severe infestations. Felling more than one trap tree for every five standing infested spruce will excessively deplete the canopy and reduce shading.

Trap trees are most effective when deployed against heavy infestations in very small areas or against light to moderate infestations over larger areas. In heavy infestations over larger areas it may not be efficient to fell sufficient traps to absorb such a large population.

Conventional trap tree felling and extraction periods

- Conventional trap trees should be felled in late winter, e.g., early March, so that such trees lie on top of most of the accumulated snow.
- Infested traps should be removed early in the next winter logging season of the same year, e.g., late November, before they become covered with excessive snow and frozen in place.
- Conventional traps trees left on site after April of the following spring may yield early-maturing one-year cycle adults which could attack adjacent timber.
- In any event, conventional trap trees must be removed or treated prior to beetle emergence.

Conventional trap tree deployment tactics

Although felling trap trees in a dispersed pattern throughout an infested stand may be the most effective deployment, this treatment is constrained by the problems of economics and safety in felling, and difficulties in trap tree extraction if the entire stand is not scheduled for harvest. Therefore, other tactics may be employed:

- **Trap tree patches** are usually 12-25 trap trees felled into standing timber in a single, narrow, and shaded group adjacent to a road, to facilitate eventual skidding and hauling. Of all the deployment tactics, trap trees felled in patches have the best shading and, therefore, have been the most effective at absorbing spruce beetle adults.

- **Pre-felled road rights-of-way, cutblock strips, landings, and to a lesser extent, decks** can be used during cutblock pre-development as relatively large conventional trap tree programs. Their sheer numbers can usually compensate for lack of ideal shading.

Prevention

Hauling and milling restrictions

Restrictions on hauling and milling of spruce beetle infested logs are occasionally necessary if the hauling routes and, especially, the destinations are located adjacent to high-hazard spruce stands. If hauling is permitted at the beginning and end of the spruce beetle flight, there must be a stipulation that the logs be milled within 24 hours. During the main beetle flight in June, hauling through and to areas with susceptible timber should only occur if the daytime temperature will be less than 16° C.

Utilization

In spruce beetle sanitation-logged areas, there may be long butts, tops greater than 10 cm in diameter, decked logs, and stumps containing mature spruce beetle adults. Maturing beetles will emerge to attack new hosts unless the infested material is either burned, removed and milled, or otherwise treated. Prudent utilization requires that:

- stumps be cut as low as possible
- a 10 cm diameter top utilization be used and all tops be scattered on the block or piled and burned on site.
- Long butts (if permitted) should be piled and burned on site
- All recently killed host material such as recent edge blowdown, larger broken tops, and spilled logging loads should be removed before they are attacked.

Climate Influences

In a 2013 US study, although minimum cool season temperatures and maximum warm season temperatures were important in modelling spruce beetle range expansion, habitat variables of spruce basal area and spruce composition were more influential for predicting spruce beetle expansion. Habitat variables such as tree diameter and age that characterized current spruce beetle susceptibility changed as future temperatures increased (DeRose et al. 2013).

In Alaska, Berg et al. (2006) established the direct effects of warming on spruce beetle survival and development and the indirect effects on host susceptibility. In the Rocky Mountain States, Hansen and Bentz (2003) and Berg el al. (2006) noted that heat accumulation associated with unusually warm summers caused a shift from the predominant 2-year cycle to 1-year cycle beetles, thereby doubling the rate of increase and spread of populations.

The combination of warmer temperatures and long-term drought stress can also increase tree susceptibility (Barber et al. 2000)

References

Barber, V.A., G.P. Juday, and B.P. Finney. 2000. Reduced growth of Alaskan white spruce in the twentieth century from temperature-induced drought stress. Nature 405: 668-673

Berg, E.E., J.D. Henry, C.L. Fastie, A.D. De Volder, and S.M. Matsuoka. 2006. Spruce beetle outbreaks on the Kenai Peninsula, Alaska, and Kluane National Park and Reserve, Yukon Territory. Relationship to summer temperatures and regional differences in disturbance regimes. For. Ecol. & Manag't 227: 210-232.

DeRose, R.J., B.J. Bentz, J.N. Long, and J.D. Shaw. 2013. Effect of increasing temperatures on the distribution of spruce beetle in Engelmann spruce forests of the Interior West, USA. For. Ecol. & Manag't 308: 198-206.

Hansen, E.M. and B.J. Bentz. 2003. Comparison of reproductive capacity among univoltine, semivoltine, and re-emerged parent spruce beetles (Coleoptera: Scolytidae). Can. Ent. 135: 697-712.

Hodgkinson, R., A. Stock, and B.S. Lindgren. 2015. Reducing spruce beetle *Dendroctonus rufipennis* (Kirby) emergence for hibernation in central British Columbia by felling infested trees. J. Agric. & For. Ent. 17: 430-444.