PROVINCE OF BRITISH COLUMBIA

BARK BEETLE MANAGEMENT GUIDEBOOK

This Forest Practices Code Guidebook is presented for information only

Authority:

Forest Practices Code of British Columbia Act
Forest Road Regulation
Operational Planning Regulation

Contents

Introduction

The group of insects known as bark beetles are members of the family Scolytidae in the order Coleoptera. Most bark beetles cause little or no economic damage as they normally infest branches, stumps, and stems of standing dead, severely weakened trees or downed material. A relatively few species will attack and kill living, apparently healthy trees. Bark beetles are integral components in forest ecosystems and therefore can be viewed as beneficial or detrimental depending on the management objectives.

The major bark beetle species that have histories of causing significant damage to forests in British Columbia are listed in Table 1.

Table 1. Major damaging bark beetles of British Columbia

Common name	Species name	Insect code	Host species
Mountain pine beetle	*Dendroctonus ponderosae* Hopk.	IBM	Pl, Py, Pw, Pa
Spruce beetle	*Dendroctonus rufipennis* (Kirby)	IBS	Se, Sw, Ss
Douglas-fir beetle	*Dendroctonus pseudotsugae* Hopk.	IBD	Fd, (Lw)
Western Balsam bark beetle	*Dryocoetes confusus* Swaine	IBB	Bl

These bark beetle species periodically reach outbreak levels in British Columbia. During outbreaks, they kill large numbers of apparently healthy trees over extensive areas in many parts of the province. All of these beetle species attack and kill large diameter, mature and overmature trees. Outbreaks of bark beetles may be threats to sustainable harvest levels; in the short term, infestations can significantly disrupt five-year management plans.

A variety of approaches are available to reduce the amount of mortality caused by bark beetle outbreaks. Detection methods, treatment selection and application, and other management activities vary for individual beetle species. **This guidebook is designed to provide a background to bark beetle management and specific practices for managing mountain pine beetle, spruce beetle, and Douglas-fir beetle.** While the western balsam bark beetle causes substantial mortality in many areas of the province, few proven management tools exist. *Therefore, this guidebook does not provide information on the western balsam bark beetle.*

Where possible, biological features and activities that are common between the three beetle species are included in the first sections of this guideline. Those features and practices which differ are described under specific beetle species sections. Beetle biology has been summarized; complex beetle life cycles and population dynamics have not been included. Management practices are discussed in a “how to” manner; extensive background information or the rationales for certain items have not been included in this guidebook. Key references for more information on specific beetle species have been listed in the last section of this guidebook.

General description of bark beetles

All three species of bark beetles discussed in this guidebook are similar in appearance through all their life stages. Main differences between the species are in size, tree species attacked, and timing of parts of the life cycle. Life stages for bark beetles are described below:

Egg: pearly white, oblong, 0.75–1.0 mm long. Eggs are laid in individual niches or elongate grooves on alternate sides of the egg gallery.

Larva: creamy white, cylindrical, stout, wrinkled, legless grub, 6–7 mm long at maturity (fourth instar). Head is pale tan to pale rusty.

Pupa: creamy white, approximately 6 mm long, becoming pale tan near maturity. Pupae have legs and maturing wings that are visible.

Adult: immature, or callow, adults after transforming from pupae are initially white and then medium brown. Mature adults are mostly all black or have rusty coloured wing covers. Adults are approximately 6 mm long.

Distribution and host range

In general, the distribution of each species of beetle follows the distribution of its primary host. Figures 1 to 3 indicate the distribution of each species of bark beetle in the province.

Figure 1. Distribution map of mountain pine beetle in British Columbia.

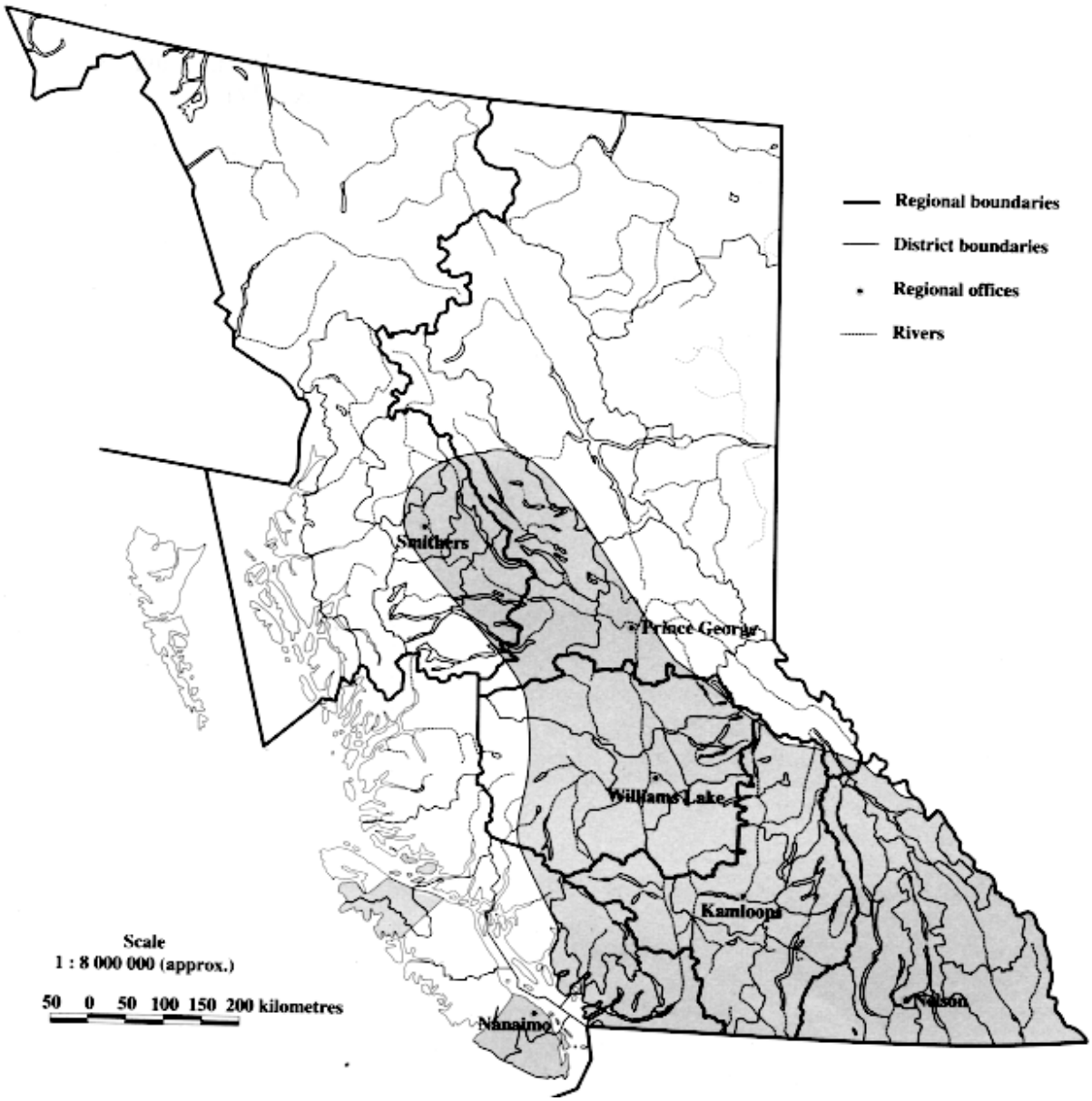


Figure 2. Distribution map of spruce beetle in British Columbia.

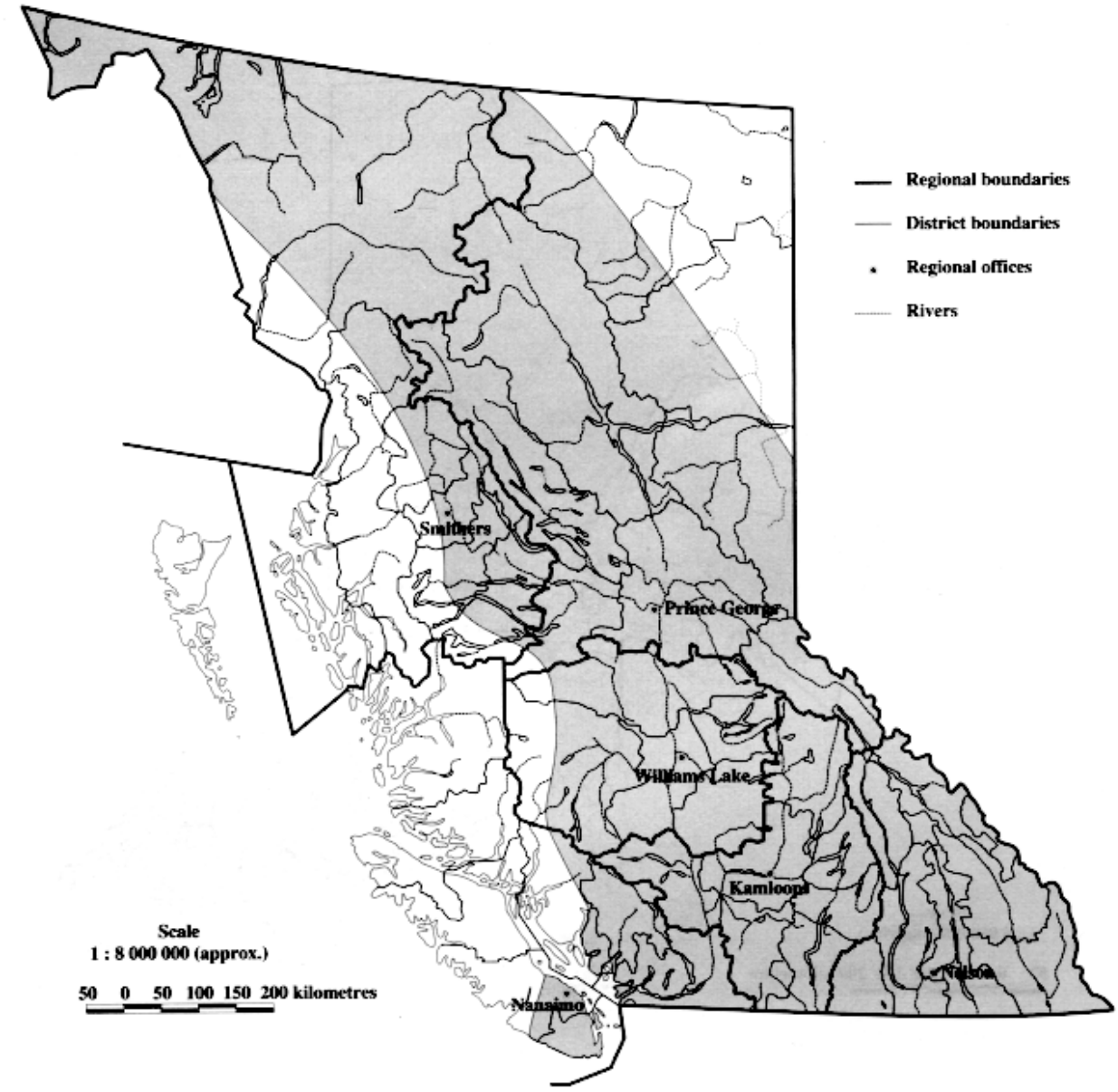
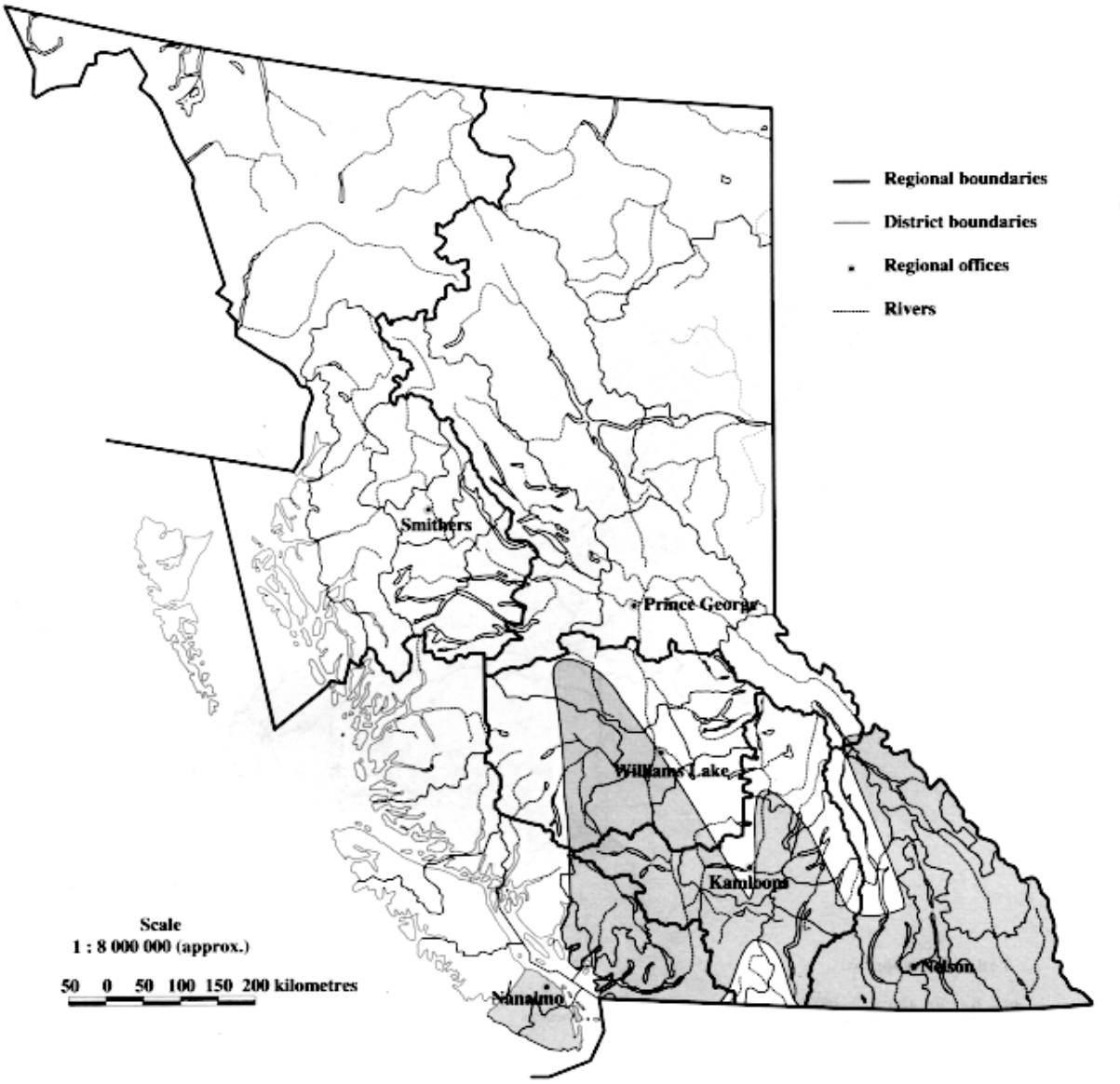


Figure 3. Distribution map of Douglas-fir beetle in British Columbia.



Life cycles and dynamics

The life cycles of the beetles are similar with some variation in timing and effect. Also, while the mode of action in killing individual trees is the same for all three species, affected trees vary in their display of symptoms. It is necessary to know the differences when identifying the causal agent, establishing where the infestation is in its cycle, and for selecting the most appropriate treatment prescription.

Life cycles

All three beetle species have similar life cycles, progressing from egg, through four larval instars, to pupa, and finally to adult. The life stages for each insect closely resemble each other; however, differences in timing and duration affect the selection and application of management tools. The timing

of various components of the life cycles are summarized in Table 2. The timing of life cycle events for any species of bark beetle will vary from year to year and from location to location due to variations in climate and local weather.

Table 2. Timing of life cycle events

Factor	Mountain pine beetle	Spruce beetle	Douglas-fir beetle
Main adult flight	July through August	May through June	April through July
Host preference	living trees	windfall/slash, or living trees	windfall/slash, or living trees
Normal length of life cycle	1 year	2 years[a]	1 year
Overwintering stage	larvae	larvae and adult[b]	larvae and adult

A brief synopsis of the life history of all three beetle species is as follows:

- Adult females emerge when ambient air temperature exceeds approximately 16* C, find new suitable host material, and emit aggregating pheromones to initiate mass attack.
- Males join the females and each pair construct an egg gallery under the bark, parallel to the grain.
- The sapwood is inoculated with spores of a blue stain fungus as the egg gallery is built.
- Eggs are laid and hatch into larvae which feed on the phloem in feeding channels constructed at right angles to the egg gallery.
- After four instars, larvae pupate and develop into adults under the bark.
- Young adults pick up blue stain fungal spores while in the pupal chamber.

The action of the larval feeding in the phloem and fungal colonization of the sapwood completely blocks all translocation tissues and kills the infested tree. In some cases only one side of a tree will be successfully attacked (strip attack); this tree will survive unless living portions are reattacked in subsequent years.

Symptoms of successful attack

Successfully attacked trees display symptoms that are utilized in ground and aerial surveys. These symptoms are summarized in Table 3 and 4 below. The information presented in the tables are generalized and will vary from year to year depending on weather patterns, and will vary in different areas of the province due to local conditions. Refer to management descriptions for specific bark beetles (later in this guidebook) for further information on survey procedures and interpretations.

Other bark beetle species, such as *Ips* spp., may be found under the bark of trees. Identification of these usually lesser important beetles is done by examining egg gallery patterns and adult morphology which differ significantly from the major bark beetles. Adults and larvae of wood borers may also be found

under the bark or on the boles of trees. Proper identification of the insect is necessary to ensure that the appropriate management strategy is selected.

Table 3. Bole symptoms of successful bark beetle attack

	Mountain pine beetle	Spruce beetle	Douglas-fir beetle
Pitch tubes	• usually present and obvious • boring dust at base of tree	• may be present but small • boring dust at base of tree and in bark crevices	• rarely present • boring dust at base of tree and in bark crevices • resin flow on upper bole
Position of attack on host	• lower 3/4 of bole of living trees only	• usually lower 4 m on live standing trees • underside of downed material	• lower 2/3 of bole on live standing trees • downed material
Woodpecker signs	• extensive bark stripping in winter and spring following attack	• extensive bark stripping late summer and winter after attack (bole appears reddish)	• little bark stripping

Table 4. Foliage symptoms of successful bark beetle attack

	Mountain pine beetle	Spruce beetle	Douglas-fir beetle
1-year post attack	• bright red crown in spring following attack[a]	• no colour change in first spring following attack	• bright red crown in spring following attack • may turn red in year of attack
2-year post attack	• dull red foliage remains on tree	• general yellowing or graying of crowns after 24 to 30 months • colour change not reliable	• crowns gray in spring 2 yrs after attack
3-year post attack	• crowns gray • little foliage remains	• gray crowns • needle drop	• crowns gray • little foliage remains

Population prediction

Two types of surveys can be conducted annually in areas of infestation in order to determine beetle population trends. The trend of an infestation in a specific stand may be measured in a number of ways, primarily through ground surveys. The trend can be estimated by calculating the ratio of currently attacked trees to one-year-old attacked trees. A ratio substantially >1 indicates an increasing population; substantially <1 indicates a declining population. This estimate, however, should be viewed in light of bark sampling in the early spring after attack when the potential new brood can be compared to the initial attacking population.

Overwintering brood assessments surveys (r value) are conducted in the spring. They are used to estimate brood mortality and determine health and vigour of progeny. These results are supplemented by the fall surveys which determine current attack and help estimate volume losses and infestation trends. In this case, the number of entrance holes on the bark sample represents the number of attacking female beetles. One half the number of brood under the bark estimates the numbers of females that will emerge to attack new host trees. Bark sampling should be done in the spring following attack to account for overwinter mortality and losses to parasites and predators, particularly woodpeckers.

The equation below details how to calculate and interpret “r” values.

$$r = \frac{\text{sum of } (a + b/c)}{\text{no. of trees examined}}$$

where

a = number of eggs and larvae

b= number of pupae and adults

c = number of galleries originating within sample area

Interpretation of “r” values to determine population status:

r value	Population trend
≥2.5	decreasing population
2.6-4.0	static population
≤4.1	increasing population

General impacts

The impact of bark beetles is not limited to timber loss. There are also impacts upon a variety of other resource values, which include:

- recreation
- landscape and aesthetics
- cultural heritage
- range
- fish and wildlife

- watershed management.

However, timber loss, and more importantly, the disruption of long-term forest management plans, are major concerns to forest managers and planners.

General management strategies

Long- and short-term strategies must be developed and implemented to successfully manage bark beetles. Strategies for dealing with bark beetle populations should be addressed in the forest five-year development plan, at the silviculture prescription (pre- and post-harvest), and followed throughout the life of the stand. It is critical to address all forest health concerns at the planning and prescription stages, particularly where root diseases such as *Armillaria* are involved, as they could significantly impact the choice of silviculture system selected to address bark beetle concerns. For example, selective, single tree removal of beetle infested stems in an area with a high incidence of *Armillaria* may not be the appropriate treatment, and small clearcuts may have to be considered.

Beetle management units (BMUs) are the basis for developing landscape level management strategies to deal with bark beetles. BMUs are intended to identify areas where specific beetle management strategies can be applied. BMU boundaries should coincide with established boundaries of existing management units. Beetle management strategies are broad approaches that have specific objectives. Each strategy has an associated array of applicable tactics or treatments. These treatments are applied to specific infestations or areas within the BMU to achieve the objective of the strategy. BMUs will provide a basis for evaluating damage to timber, impact on other resources, effectiveness of treatment, and resource allocation and monitoring. BMU strategies should be incorporated into all higher-level planning processes such as development plans.

BMUs cannot be considered in isolation as each will have an effect on the beetle situation of its neighbor. Therefore, the strategy selected for a BMU must be compatible with those taken in adjacent units and with the overall integrated resource use plans for the area.

Strategies

There are six strategies that can be used to address bark beetle infestations. Selection of the relevant strategy is based on the extent and distribution of beetle infestations in an area. Strategy selection must also consider resource management objectives and the expected impact of the beetle in adjacent management areas. The selected strategy will define which treatment combinations are most appropriate and the intensity and frequency of their application. A combination of strategies is possible within different sub-units.

The six strategies are:

1. Prevention (long-term)
2. Suppression
3. Maintain low
4. Holding action
5. Salvage
6. Abandon (no control)

The strategy chosen should remain in place for as long as the objectives are being met or until additional resources become available to allow a more aggressive strategy to be implemented. However, situations change from year to year and therefore strategies must be reassessed on an annual basis. The most technically correct strategy may not always be selected since other criteria can override technical considerations.

Prevention (long-term approach)

Prevention as a strategy is applicable to a large area of uninfested or lightly infested timber with a moderate to high hazard rating. The prevention strategy can also be used concurrent with other strategies in infested areas. The intent of the strategy is to reduce future losses through manipulation of forest cover. Long-term landscape level management includes plans aimed at age and species mosaics unfavourable for large outbreaks of bark beetles. This includes planning for construction of major access routes into moderate and high hazard drainages.

Prevention strategies also indicate that harvesting plans should be based on existing hazard and risk criteria. That is, stands with high hazard and close to beetle population centers (high risk), should be logged or modified on a priority basis. The overall strategy is to remove the susceptible host in an organized manner that will not create extensive and continuous stands of susceptible forest over the next rotation. Allowance should be made in landscape level plans for encouragement of insectivorous birds (e.g., woodpeckers) that aid in maintaining beetle populations at low levels.

Prevention also relates to reducing the susceptibility of a particular stand or to reducing its attractiveness to the beetles. This could also be considered a “tactic” to be incorporated into all strategies. The most common method is to selectively log a stand to a pre-determined spacing that reduces subsequent beetle attack. This is sometimes referred to as “beetle proofing” a stand and should be considered a “holding tactic” rather than a silvicultural system. Currently, this technique is acceptable for management of mountain pine beetle only. This technique is not applicable on a widespread basis and suitable stands must be carefully selected.

Suppression

Suppression is the most aggressive of the available strategies. It is selected when the infestation status is such that aggressive direct control actions are expected to keep an area at a low level of infestation. The strategy demands that each infested polygon be addressed. All possible direct control tactics (treatments) should be considered and applied where suitable. Long-term approaches to reducing future threats to timber or other resources should also be applied.

Suppression is the appropriate strategy for lightly infested areas where resources for direct control or harvesting and milling capacities equal or exceed the amount of infestation. Access must exist or be imminent. The strategy demands detailed detection and follow-up every year to ensure complete sanitation of infested stands. The intent of the strategy is to reduce the outbreak to a size and distribution that can be handled with normal resources. In most cases, this objective should be achievable within a three-year time span.

Maintain low

The maintain low strategy is applicable in chronically infested stands where the spread of the beetle has been reduced to a level that can be dealt with under a base or normal level program and within the allowable annual cut. This also includes areas where the outbreak has collapsed but where extensive susceptible stands remain. The strategy can be considered as a sub-set of suppression. The intent is to accommodate expected beetle activity in the normal planning process and to deal with new infestation polygons as they arise. Detection is critical for application in harvesting programs and other treatments. All major access will be in place or planned in conjunction with hazard rating.

A maintenance program will incorporate all relevant activities to prevent rapid increases in the beetle population. A maintain low program is a base level program and would continue indefinitely.

Holding action

The intent of a holding action strategy is to maintain an existing outbreak at a relatively static level. It is a delaying strategy until adequate resources are available or access created, allowing for more aggressive management. This strategy is appropriate in areas with chronic beetle infestations, some of which are too large to deal with using single tree treatments, or where access is poorly developed for directed harvesting. Holding action would be recommended for a BMU or a sub-unit where aggressive suppression would be appropriate but the unit has a lower priority than other areas. It could also be used where resources are inadequate to deal with all infestations.

A holding action is a temporary strategy and should not be maintained indefinitely. There must be a clear time horizon for access development to permit more aggressive sanitation harvesting and for the application of other control options. Depending on the hazard and risk of the area, the infestations should be dealt with in two to three years.

Salvage

This strategy is applied to areas where management efforts would be ineffective in substantially reducing the beetle population and subsequent levels of damage. Areas where a salvage strategy is appropriate usually have extensive outbreaks covering a large proportion of susceptible stands and where access is planned or possible within a five-year period. Infested areas will have relatively high proportions of red and gray attack indicating that the outbreak has been ongoing for several years. Smaller, moderate, or low hazard stands are commonly infested.

BMUs with a salvage strategy are basically left alone and no resources are allocated to control. As harvesting capacity becomes available, timber in these areas can be salvaged and the sites returned to production. Long-term silvicultural strategies would be implemented at this point.

Abandon (no control)

This strategy is applied to areas where management efforts would be ineffective in substantially reducing the beetle population and subsequent levels of damage, or where there is no short term (less than five years) possibility of salvaging dead timber. This may be due to management constraints such as wilderness or parks, or because access cannot be put in place before substantial merchantable degradation of the dead material occurs.

Managing specific bark beetles

Managing forests to reduce the impacts of bark beetles and treating individual infestations to reduce subsequent spread require the application of a combination of treatments. No single treatment is suitable for dealing with all bark beetles or for all situations. The key to reducing losses is a prompt and thorough annual detection program followed by the timely application of the most appropriate treatment or treatment combination.

Aerial survey procedures

There are two types of aerial surveys: general and detailed. These surveys are recommended as data collecting techniques for landscape level surveying. The differences between them are:

- **Detailed surveys** are typically conducted with either a fixed or rotary wing aircraft, on a map with a scale of either 1:40 000 or 1:50 000. The purpose is to accurately map the type and location of beetle problems so that general treatment strategies can be discussed.
- **General surveys** are usually conducted in a fixed wing aircraft at low flight line intensities on topographic maps at scales smaller than 1:40 000 (i.e., 1:100 000 or 1:250 000), by either Ministry or Forestry Canada staff. They are conducted for non-operational purposes (e.g., access or environmental considerations), where treatments will not be possible. Often these flights are conducted for forest health factors other than bark beetles, which are not currently being treated but may receive management in the future. The accuracy of general overviews is not good enough for most operational purposes, however, such flights may be sufficient for historical or research purposes. They will also indicate where detailed surveys are required.

Minimum suggested survey standards

Table 7 in the *Forest Health Surveys Guidebook* describes the minimum suggested standards for aerial surveys by forest region. General surveys are usually conducted at a scale greater than 1:100 000. Flight lines and the location of the surveys are plotted on these maps.

Table 7. Location factor for mountain pine beetle hazard rating

Y	Factor
>0	1.0
0 to -500	0.7
< -500	0.3

All forest regions conduct their detailed surveys at either 1:40 000 or 1:50 000 scale. The map base used may be the National Topographic Series, the B.C. Geographic System, or licensee operational maps.

Experience has indicated that colouring both topographic features and susceptible stands can increase the accuracy of polygon placement by 25% and decrease flying costs by up to 20%. Two different methods are currently used to colour maps:

- hand-colouring general topographic features such as water bodies, rivers, swamps, harvested areas, NPBR and NCBR areas
- coloring using computer assisted design equipment. The advantage of using this approach is that susceptible stands can also be mapped for less cost and be more easily updated.

Aerial surveys for bark beetles can begin in the southern regions of the province July 1 (Kamloops, Nelson, Vancouver) and in the northern regions of the province July 30. Attack intensity classes for mapping bark beetles are:

X	For single trees, or for polygons estimate the number of red or grey trees
L (light)	0-5% of total stems affected in the stand
1	6-15% of total stems affected in the stand
2	16-25% of total stems affected in the stand

Usually two people are used on survey flights over severely infested areas; one individual can help the other to pick out attack. The best product is achieved when the two sketch maps are compared and amalgamated immediately after the flight. A third person may assist with navigation or recording data such as GPS coordinates or treatment particulars.

Either fixed wing or rotary wing aircraft can be used for detailed flights. If ground work is being directed based on the results of the flights then helicopters are preferred as more accurate GPS coordinates can be obtained. A high winged aircraft with retractable landing gear will give the mappers an unobstructed view of the ground. Bubble type windows are of further value. Both aircraft types should come equipped with a GPS unit.

Flight times should be limited to 5 hours per day to reduce error due to fatigue. Mappers should come equipped with:

- maps
- clipboard
- coloured pens or pencils
- camera with spare film
- note paper to record observations or GPS data.

Check the weather to ensure that there is good visibility and a minimum ceiling of about 1 000 metres. Clear days are preferred since red foliage is most visible for both observation and photography. Flight conditions are often unstable after 1 p.m. so try to arrange the flights in the morning. Shadows caused by the angle of the sun can obscure features early or late in the day, especially in areas of significant relief.

Flight lines are usually run parallel over level terrain. Over mountainous terrain flight lines must be adapted to suit the terrain. Flight lines should be placed closer together over moderate or severe infestations.

When planning flight lines consider the following:

- Plan flight lines so that the sun is not shining in the observer's eyes.
- Make passes at a slow speed of 80 knots at 500 to 700 metres above the ground. If the aircraft is too high, it will be difficult to map areas accurately; if too low it will be difficult to stay oriented. At this height it should be possible to map an area of about 1 square kilometre out one side of the aircraft. In sparsely attacked areas the speed can be increased.
- Record GPS coordinates for areas where further treatment is required. Most districts, contractors, and licensees now have hand-held GPS units which can save considerable time on the ground trying to locate infestations.

As a general guide, it takes about 30 minutes to map one 1:50,000 mapsheet with a moderate level of infestation.

Analyzing, recording, and storing data

Rarely is sufficient funding available to treat or ground survey all beetle infestations in an epidemic situation. Therefore, think carefully about how the survey data will be used. Refer to the appropriate sections of the Bark Beetle Management Guidebook for more details on these systems.

It is usually undesirable to conduct both general and detailed surveys over the same ground, unless the general survey can be processed immediately and used to specify where the detailed surveys are to be conducted.

The following sections of this guidebook lay out specific methodologies appropriate for mountain pine beetle, spruce beetle, and Douglas-fir beetle. The appropriate section should be consulted when developing a management program after the species of beetle in question has been identified.

For more information on managing specific bark beetles, please refer to the management guidebooks for those species.