

Mountain Pine Beetle Detection and Management in Alberta

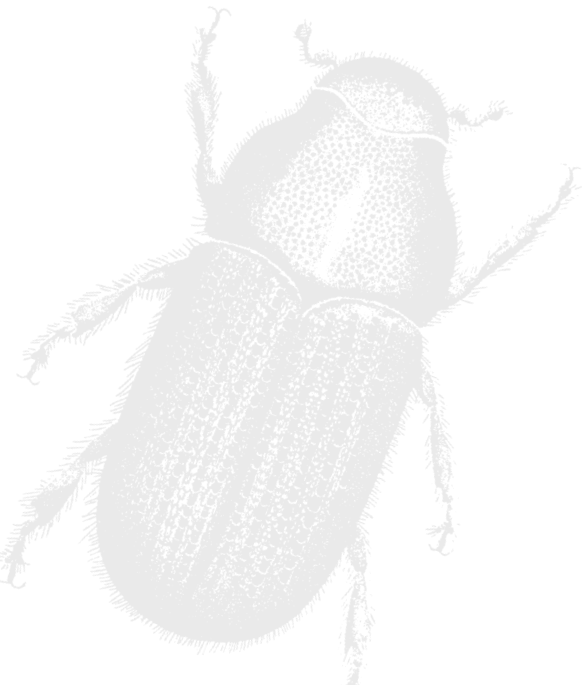


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1. Introduction

The mountain pine beetle (*Dendroctonus ponderosae* Hopkins, MPB) is native to western Canada. It attacks all pine including lodgepole, limber, white bark and jack pine. Over the past 40 years the range of mountain pine beetle has expanded, possibly due to changes in the area of climatically suitable habitat¹. It is thought that fire suppression in combination with climate change² has recently resulted in the largest insect epidemic in the history of British Columbia (BC). Populations in Alberta are increasing due to mild winters, dry summers and the influx of beetles immigrating from BC through the Rocky Mountains. The Alberta government is aggressively suppressing populations in Alberta to prevent an epidemic of the scale such as in British Columbia. This guide is to aid the detection of MPBs in the field and their effective control in Alberta.

¹ Taylor S.W., Carroll A.L., Alfaro R.I., Safranyik L. (2006) Forest, climate and mountain pine beetle outbreak dynamics in western Canada. Pp. 67-94 in L. Safranyik and W.R. Wilson, eds. The mountain pine beetle: a synthesis of biology, management, and impacts on lodgepole pine. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Victoria, British Columbia Pp. 304

² Carroll A. L., Taylor S. W., Régnière J., Safranyik L. (2004) Effects of climate change on range expansion by the mountain pine beetle in British Columbia. Mountain Pine Beetle Symposium: Challenges and Solutions. October 30-31, 2003, Kelowna, British Columbia. Shore T.L., Brooks J.E., Stone J.E. eds. Natural Resources Canada, Canadian Forest Service, Pacific Forestry Centre, Information Report BC-X-399, Victoria, BC. Pp. 298.

2. Life Cycle

Throughout most of its range the generation time of the MPB is one year (Figure 1). Generally, adult MPBs attack host trees in late July or early August and create galleries within which they lay their eggs. The eggs hatch and larvae develop over the fall. Typically, MPBs over-winter as larvae, pupate in the spring and emerge from the host as fully-grown adults.

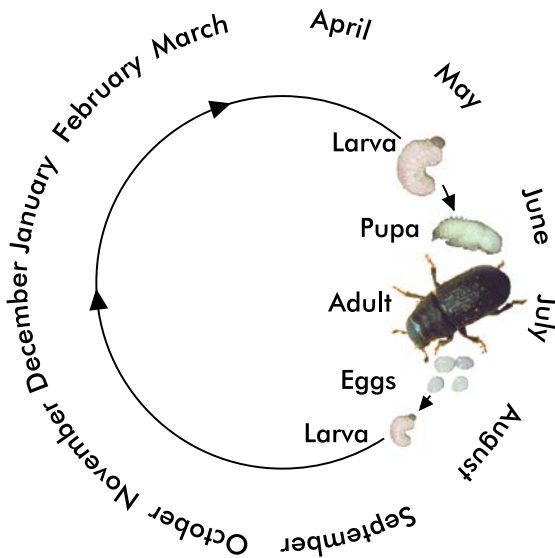


Figure 1. MPB life cycle.

Typically, it takes one year for eggs to hatch, larvae to grow, pupae to moult to adult beetles. However, temperatures may cause variation in the life cycle. In particular, beetles at the northern limits of its distribution may take more than one year to develop. In such populations all of the possible life stages may occur in a single tree at one time, although it is more common for one or two consecutive life stages to occur at one time.

Adults

Mature beetles are reddish brown to black and 5 to 7 mm long (Figure 2a). They emerge from the tree by chewing small round holes in the bark, then fly in search of new host trees during late July to September. When a new host is found, the female beetle bores an oval hole into the bark and constructs a vertical egg gallery that eventually may be 25 to 30 cm long. The gallery is uniformly wide along its length, has a “J-shaped” hook at the bottom, and is packed with boring dust except for the top few centimetres (Figure 2b).

The gallery extends within the inner bark and usually scores the cambium and outer sapwood. The attacking female releases pheromone compounds that attract other females as well as male beetles that are necessary for mating.



Figure 2a. Mountain pine beetle adult, *Dendroctonus ponderosae* Hopkins. J. J. Witcosky (2002) USDA Forest Service, Rocky Mountain Region Archives, www.forestryimages.org



Figure 2b. Mountain pine beetle galleries.

Eggs

In late summer to early fall, small white eggs are laid singly in niches along the sides of the vertical egg galleries. They hatch into larvae about two weeks later. On average, the adult female produces 60 eggs¹.

Larva

The larvae are white, legless grubs with brown heads (Figure 2c). They excavate horizontal tunnels (galleries) as they feed in the phloem.



Figure 2c. Mountain pine beetle larva. They are white grubs with brown heads. When fully grown they are approximately 6 mm long. S. Tunnock (2001) USDA Forest Service, www.forestryimages.org

While developing, they go through four stages called instars and continue to elongate and widen the tunnels as they grow. They over-winter under the bark in various instars, maturing by late June of the following year. When mature, larvae construct oval-shaped chambers to pupate. The normal over-wintering stage is the larva, although some pupae and adults may also over-winter.

¹ Furniss, R.L. and V.M. Carolin. (1977) Western forest insects. Forest Service Miscellaneous Publication No. 1339. Washington, DC: USDA, Forest Service.

Pupa

The mature larvae remain dormant in pupal cells for a short period of time, transforming to pupae by early July, and then to adult beetles. Pupae are white and may show some adult-like characteristics, e.g., wing buds (Figure 2d).



Figure 2d. Mountain pine beetle pupa. Pupae grow to approximately 5 mm long. USDA Forest Service (2002) Rocky Mountain Region Archives, www.forestryimages.org

Teneral or Callow Adults

Teneral or callow adults are fully formed adult beetles that have not deposited their hard exoskeleton (Figure 2e). This stage is the only stage, other than the adult, that can survive being exposed to the elements.



Figure 2e. Mountain pine beetle teneral adult. These young adults are pale coloured and soft. They darken and harden under the bark before they emerge from the tree. USDA Forest Service (2002) Rocky Mountain Region Archives, www.forestryimages.org

3. Damage Symptoms

External signs on the bole

- Pitch tubes surrounding beetle entry holes (cream to pinkish coloured mixtures of resin and boring dust) (Figure 3)
- Boring dust in bark crevices, particularly at the root-collar (Figure 4)
- Small round adult emergence holes approx. 2.5 mm in diameter (Figure 5)
- Bark flakes from wood-pecker activity (Figure 6)
- Bark flakes on the ground (particularly conspicuous on snow)



Figure 3. Pitch tube on pine tree attacked by MPB.



Figure 4. Boring dust on the base of the tree.



Figure 5. Emergence holes where adult beetles exited.



Figure 6. Woodpeckers peck the bark off infested trees to get to the larvae and beetles beneath it.

As other bark beetles may cause pitch tubes, boring dust, emergence holes and bark flakes, all of the above symptoms are not sufficient to determine MPB as cause.

Fading crowns

Successfully attacked trees are killed and their crowns fade from loss of moisture. The foliage changes its colour from green to yellow in the first few months after attack, followed by bright red, brown and eventually grey (Figure 7).



Figure 7. Pine trees attacked by MPB with fading crowns.

Symptoms under the bark

These are the most reliable indicators of MPB infestation. In August, shortly after beetles have attacked the tree they construct vertical galleries in the phloem with a diagnostic slight hook at the bottom (Figure 2b). Usually the bottom of the galleries is packed with boring dust. When completed, galleries may reach 2 m in length although galleries of approx. 30 cm are more common. Larval tunnels extend horizontally from the egg-galleries. In the year after the attack oval pupal chambers may be visible at the ends of some larval tunnels.

4. Identifying MPB

Signs of attack by other beetle species can look very similar to MPB attack. However, these other species mostly do not cause damage of the same severity as the MPB and do not need to be controlled. In order to save time in the field it is necessary to distinguish MPBs from other bark beetles. The most common associated beetles are listed in Table 1 and photographs are given in Figures 8 to 12. Identifying the MPB can be achieved by examining the adult beetle and its gallery for the following features¹:

- MPB gallery pattern shows a characteristic hook at the bottom of the vertical egg-gallery with larval feeding tunnels extending horizontally from the egg-gallery (Figure 2b).
- Head of adult beetle clearly visible from above (compare Figure 2a with 11a and 12a)

Table 1. Four common beetle species in lodgepole pine.

	MPB	Lodgepole pine beetle	Red turpentine beetle	Engraver beetles
Colour (adults)	Brown to black	Front is dark brown and back is reddish brown	Reddish brown	Dark reddish brown to black
Size	5 - 7 mm	5 - 8 mm	8 - 12 mm	3 - 5 mm
Adult body shape	Large, stout, body; head visible from above	Large, stout, body; head visible from above	Large, stout, body; head visible from above	Cavity at rear end of body; head not visible from above
Gallery	Vertical egg gallery, horizontal larvae mines, "J"-shape; egg niches along each side of gallery	Vertical; shaped irregularly, shallow expansions along side(s) of gallery, no egg niches.	Gallery is 1-3 cm wide; branched and irregularly caved; packed with granular reddish frass	Central chamber from which several egg galleries fork or radiate; star, "y" or "x" shaped
Part of bole attacked	Attacks may occur on the entire bole up to the crown	Lower part of bole, stumps	Attacks are concentrated at or near ground level	Attack spaces in between galleries of other beetles
Figure	2a-e	8a-c	9a-c	10a-c

¹ Arnett R. H., Thomas M. C. (2002) American beetles. CRC Press LLC, Florida, U.S.A. Pp. 861



Figure 8a. Lodgepole pine beetle, *Dendroctonus murrayanae* Hopkins. D. Jensen (1922) University of Alberta, Strickland Museum.



Figure 8b. Lodgepole pine beetle (*Dendroctonus murrayanae*) larvae. Note the brown anal shields that MPB larvae do not have. Province of British Columbia (2001)



Figure 8c. Lodgepole pine beetle gallery with adult. The gallery is vertical but shaped irregularly. Eggs are laid in groups on either side of the gallery and larvae feed communally, i.e. not in individual galleries.



Figure 9a. Red turpentine beetle, *Dendroctonus valens*. Pest and Diseases Image Library (2006) www.forestryimages.org



Figure 9b. Gallery of red turpentine beetle with a group of larvae.



Figure 9c. Gallery pattern of red turpentine beetle, *D. valens*. Since the adult red turpentine beetle is larger than MPB its galleries are also wider and deeper. K. E. Gibson (2006) USDA Forest Service, Ogden Archives, www.forestryimages.org



Figure 10a. Pine engraver, *Ips latidens* (LeConte). R. Long (2002) Simon Fraser University, www.forestryimages.org



Figure 10b. Declivital spines on adult male, *Ips latidens* (LeConte). R. Long (2002) Simon Fraser University, www.forestryimages.org



Figure 10c. *Ips* gallery patterns. Holsten (2000) USDA Forest Service; D. McComb (2000) USDA Forest Service; S. Tunnock (2001) USDA Forest Service, www.forestryimages.org



Figure 11a. Conifer ambrosia beetle, *Trypodendron lineatum* (Olivier). Adults are 2.7 to 3.5 mm long and dark brown to black with four pale stripes. The body is rounded and the head is not visible from above. M. Jurc (2006) University of Ljubljana, www.forestryimages.org



Figure 11b. Ambrosia galleries differ from bark beetle galleries since ambrosia beetles feed on sapwood. Galleries penetrate the bark and extend to sapwood and heartwood. J-F. Abgrall (2005) CEMAGREF, www.forestryimages.org



Figure 12a. *Hylurgops* spp. Adults are 3.4-5 mm long and are reddish brown to rusty brown or black. The body is small and stout and the head is not visible from above. E. R. Hoebeke (2006) Cornell University, www.forestryimages.org



Figure 12b. Gallery patterns of *Hylurgops* spp. S. Kinelski (2004) and W. M. Ciesla (2003) Forest Health Management International, www.forestryimages.org



Figure 12c. *Hylurgops* adult, larvae and pupae in pine log. W. M. Ciesla (2002) Forest Health Management International, www.forestryimages.org

Ground Survey Procedures

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1. Concentric Survey Procedures

Goal

Detect currently infested trees at sites with red-attack trees located from aerial surveys.

Equipment

GPS, compass and map

Knife/hatchet

Diameter tape

Red and pink pest management flagging tape

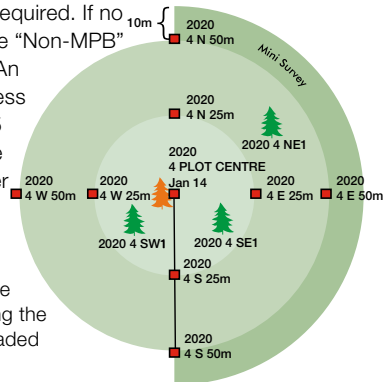
Black permanent marker and pencil

Data sheet

Procedure

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. Use GPS location provided by the Project Manager to find the plot centre. If the GPS location was derived during a Heli-GPS survey, it will be associated with a red or fading tree(s).
 - If GPS point is not close to red/fading trees, do a 30 meter sweep to locate red/fading trees.
 - If red/fading trees at GPS point is non-MPB tree, do a 30 meter sweep to ensure no MPB trees at the site. Flag and label plot as described in procedures 5 and 7 below, although measuring/flagging 50m distance markers is not required. If no MPB trees are found, mark the "Non-MPB" checkbox on the data sheet. An "unsuccessful attack" (40 or less entrance holes or less than 15 cm DBH) tree found within the 30 meter sweep will not trigger full plot layout.

Figure 1. Plot layout for concentric survey. Plot centre is an uninfested tree close to the fading tree identified during the aerial survey. All trees within green shaded areas must be checked for infestation.



3. Select an uninfested tree close to the fading tree as the plot centre
4. If the plot centre location provided will result in some of the plot being located in a permanent sample plot (PSP), adjust the plot centre to ensure none of the plot will be located within the PSP.
5. Double flag the tree at the plot centre with red Pest Management Flagging. Label flagging with the beetle year (August 15 of current year - August 14 of following year), the site number, the words "PLOT CENTRE", and the survey date (e.g. 2020 4 PLOT CENTRE, JAN 14).
6. Take the GPS location of the plot centre and record it on the data sheet. Record the positional accuracy.
7. Measure 50 m in all cardinal directions from the plot centre, flagging 25 m and 50 m on each line with red Pest Management flagging (Figure 1). Flagging must be tied onto an uninfested tree, or if a tree cannot be found then any suitable marker can be used to tie a flag. Tie the knot of the flagging facing towards plot centre. Label each red flag with the beetle year, the site number, direction and distance from the plot centre (e.g. 2020 4 S 25m).
8. Examine every pine tree within the entire plot for entrance holes, pitch tubes and/or boring dust using the red flags as reference points.
9. If a tree has 40 or less entrance holes the tree does not have to be controlled as it is considered an 'unsuccessful attack'. If a MPB infested tree is less than 15 cm at DBH, regardless of the number of entrance holes on the tree, it is also an 'unsuccessful attack' and does not have to be controlled.
10. Flag each attacked tree greater than 15cm at DBH with more than 40 entrance holes and that has living brood/beetles, with pink Pest Management flagging tape and label it with the beetle year, the site number, quadrant and the tree number. For example, if the site number is 4, trees in the plot will be 2020-4-NW1, 2020-4-NW2, 2020-4-SE1, etc. Tie the knots of the flagging towards plot centre. Trees that have been wood-peckered and meet the current attack threshold will be pink flagged.

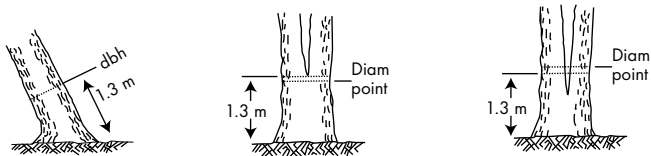


Figure 2

11. When a tree is forked below DBH (1.3 m), trees are counted by the number of stems below DBH and are flagged/labelled accordingly (Figure 2).

12. Where individual trees have grown together (i.e. have 2 separate piths/points of germination), and separate above DBH (1.3 m), trees

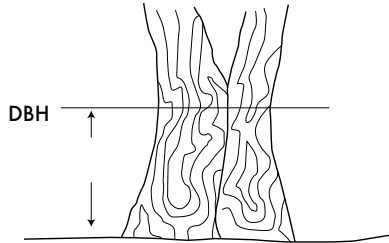


Figure 3

will be flagged/labelled separately only if a seam in the bark between the trees is present. If unable to flag trees individually due to height of separation, place 2 unique pink flags below separation (Figure 3).

13. Write the tree number at the approximate location of each of the trees requiring control (pink flagged trees) on the crosshair map on the data sheet. If a number of trees are located in a very close proximity, a small polygon can be drawn on the crosshair map with a tree number range. If there are more than 20 trees per quadrant, write the total in the quadrant summary field and do not draw dots on the map. Forked trees are counted by the number of stems below DBH (1.3 m from the ground).

14. If required by the Project Manager, measure and record the DBH (include one decimal place) of a tree that is representative of the currently infested trees (pink flagged) in the plot. Write "REP TREE" on the flagging of the measured tree. Map location of rep tree on data sheet field map using "R".

15. When tallying pink flagged trees, 'Red' trees have 100% of their needles red while 'Green' trees are attacked in the current year and are generally green but may show signs of fading.

16. If pink flagged tree(s) are located beyond the 25 m inner circle, i.e. between the 25 m and 50 m markers, complete a "mini-survey" 10 m past the 50 m marker of the two nearest quadrants (Figure 1). On the map portion of the data sheet, fill in the dotted line of the two quadrants surveyed in the mini-survey. Unsuccessful attack trees do not trigger a mini-survey.

17. Attacked trees found within the 10m mini survey may trigger a new concentric survey plot (additional plot). If mini-surveys are triggered around the entire parent plot (i.e. two mini-surveys), the trees in the portions of the mini-surveys bordering any two adjacent quadrants will be combined to determine whether an additional plot will be triggered.

The Project Manager will determine how many attacked trees are required to trigger the additional plot. It will vary by Corporate Area. Unsuccessful attack trees do not warrant an additional concentric survey. Trees found during the mini survey are to be tallied with the parent plot.

18. If an additional plot is triggered, move the new plot centre 50 meters away from the edge of the parent plot. Move the plot centre in the same bearing from the parent plot centre to the tree(s) in the mini-survey that triggered the additional plot. If the additional plot location does not meet a threshold of >25% pine composition (of stems >15 cm) then the plot can be moved up to 50 m in either direction while staying 50 m from the parent plot edge. If a suitable location is not found it can be dropped with comments explaining the situation.
19. Number the additional plot by using the parent adjacent site number and a letter. For example, if a green tree is identified outside the 50 m plot boundary near site number 4, the new site number will be 4a. (Figure 4)
20. To avoid overlap, note the location of other plots in the vicinity before making a new plot.
21. There will be a threshold number of concentric plots (parent plus additional) set by the Project Manager. This threshold may vary by Corporate Area. If there are more infested trees outside of the allowed number of concentric plots check with the Project Manager on direction for continuing the survey.
22. If the number/location of attacked trees does not require a mini-survey or additional plot, but attacked trees are located within 70 meters of the plot, they may be voluntarily pink flagged. Voluntary pink flagged trees are to be tallied with the nearest plot, labelled (V1, V2, V3..) mapped on the concentric survey tally card map with a "V1, V2.." and noted in the comments field (preferably include GPS coordinates of tree locations).
23. If GPS locations of other sites are found within a parent concentric plot, record the absorbed site number on the datasheet in the Survey Comments box. Do not perform another concentric survey and do not fill in a tally card for the absorbed site.
24. Whitebark and limber pine have been designated as Endangered in Alberta. If either of these species are attacked in the plot, record the number of attacked trees in the appropriate box on the datasheet. The attacked whitebark and limber pine are not totaled separately from the trees with live brood total.

Removing Baits

If concentric surveys are completed during a summer operation and baits are to be deployed as a cautionary procedure (i.e. in case control crews cannot get to the site before the beetles develop and fly), follow the Baiting Procedures. On the crosshair map of the MPB Concentric Ground Survey datasheet place the letter “B” at the approximate location from the plot centre.

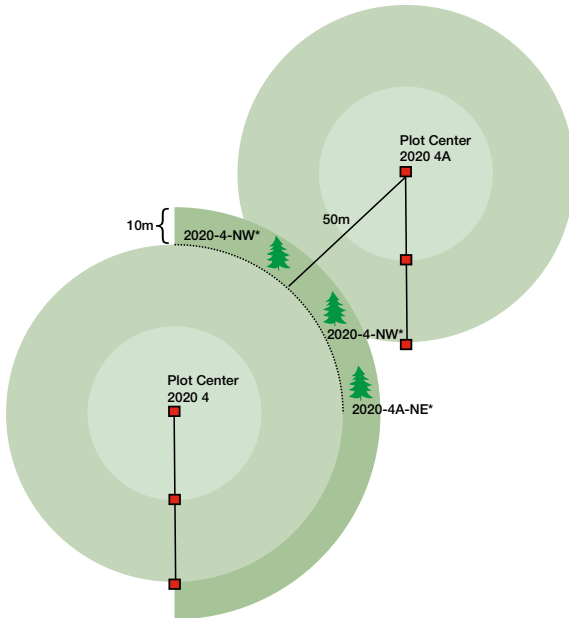


Figure 4. Additional plot centre placement to be 50m from edge of original plot. If the number of trees found during the mini survey triggers a new plot, the mini survey trees are to be tallied with the parent plot.

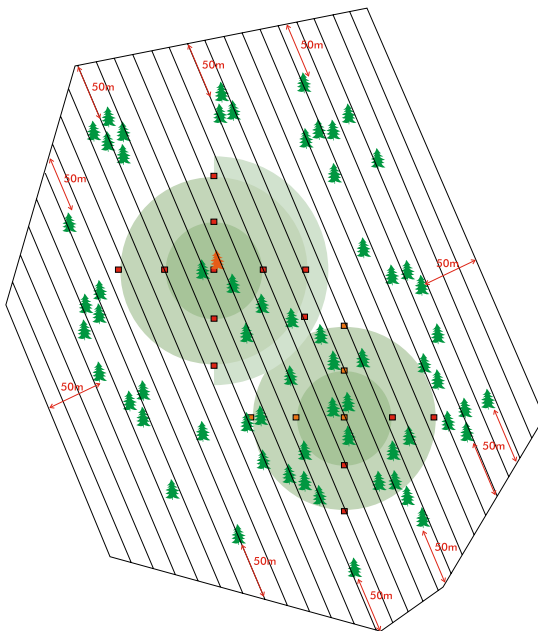


Figure 5. The number of plots required to switch from a concentric to a transect survey vary by area and will be determined by the Project Manager. If a transect survey is initiated, run the transect lines 50m past the furthest infested tree.

Deploying Baits

If concentric surveys are completed during a summer operation and baits are to be deployed as a cautionary procedure (i.e. in case control crews cannot get to the site before the beetles develop and fly), follow the Baiting Procedures. On the crosshair map of the MPB Concentric Ground Survey datasheet place the letter “B” at the approximate location from the plot centre.

Previously Identified Trees

For any trees that have flagging and numbers from a previous years operations or trees numbered during a summer program, the Project Manager will determine if the old trees need treatment (possible 2 year lifecycle).

For old trees that do not require treatment (i.e. beetles have developed and flown) remove the existing flagging.

For old trees that still require treatment, remove all old flagging and replace it with new pink flagging. Label them using the new numbering system outlined above.

Incidental Sites

While walking from the access location or from site to site, surveyors may detect current attacked trees that are not associated with fading or red trees. If this occurs, the patch of currently infested trees may trigger a new incidental concentric plot. The Project Manager will determine how many current attacked trees are required to trigger the incidental plot. Unsuccessfully attached trees do not warrant an incidental plot.

If a new incidental concentric plot is triggered, number the site using the last concentric site number and a letter (i.e. 2020-392A).

Record in the survey comments how the site was found (i.e. found while walking from site 392 to 393).

Data Collection

Record all information on the Mountain Pine Beetle Concentric Survey data sheet

Instructions for Concentric Survey data sheet

1. Name of the Project, e.g. Willmore or Kananaskis. A project is a geographically defined area that contains several infestations. Projects and Infestations are assigned by the Project Manager.
2. Name of corporate area, e.g. Foothills (SW3) or Clearwater (SW2)
3. The beetle year begins August 15 and spans until August 14 the following year.
4. The Project Manager is usually the Forest Health Officer for the corporate area.
5. The date (calendar year) the survey was conducted.
6. The Infestation will be assigned by the Project Manager. E.g. Smoky River in the Willmore Project or Spray Lakes in the Kananaskis Project.
7. Site Number, e.g. 4.
8. If you work for the Province under a contract, indicate your full name.
9. Describe how to get to the plot centre from the access location recorded in 11, e.g. walk 50 m north from wellsite.
10. Circle the access type used to get to the plot (i.e. last vehicle used prior to walking).
11. Measure latitude and longitude of access location (helipad or truck parking location only). Set your GPS to NAD83 and measure in degrees/ minutes/ decimal minutes (hddd°mm.mmm').
12. Measure latitude and longitude of the tree identified as the plot centre. Record the positional accuracy of the GPS.
13. Count the number of trees with green needles (i.e. current attack) that are flagged pink. Count the number of trees with red needles that are flagged pink. Total the number of attacked trees. If there are no tallies, record a '0'.
14. Of the total number of currently attacked trees how many are whitebark and how many are limber pine trees?
15. Record the representative tree DBH for infested trees only. Record the tree number measured.
16. If you find a bait, remove it and bring it to the Project Manager. Record the bait number (written on bait package).
17. Write the tree number at the approximate location of each of the trees requiring control (pink flagged trees) on the crosshair map on the data sheet. If a number of trees are located in a very close proximity, a small polygon can be drawn on the crosshair map with a tree number range. If there are more than 20 trees per quadrant, write the total in the quadrant summary field and do not draw dots on the map. Forked trees are counted by the number of stems below DBH (1.3m from the ground).
18. Surveyors may write down any additional comments. Record if the site is a non-MPB site or if any sites are absorbed by the plot here.

Mountain Pine Beetle Concentric Ground Survey

Project Name: _____ 1 _____			Beetle Year: _____ 3 _____		
Corporate Area: _____ 2 _____			Project Manager: _____ 4 _____		
Survey Date: _____ 5 _____		Infestation: _____ 6 _____		MPB Site Number: _____ 7 _____	
yyyy		mm		dd	
Contract # / Company Name; GOA Crew #, or Surveyor names: _____ 8 _____					
Site/Location Description: _____ 9 _____			Access: (circle one) 10 Heli _____ OHV _____ Truck _____ Other _____		
Access Location: (Deg Min Dec)		Positional Accuracy		Plot Center: (Deg Min Dec) 12 Positional Accuracy	
Lat: _____ 11 ± _____ meters		Long: _____		Lat: _____ ± _____ meters	
Long: _____				Long: _____	
# of attacked trees with LIVE brood marked for control 13			Species of Trees Attacked 14		Representative Infested Tree
					Bait Numbers Removed
Green Needles	Red Needles	Total	Whitebark Pine	Limber Pine	No: _____
					15
					DBH: _____
					16
<div style="text-align: center;"> <p style="text-align: center;">17</p> <p style="text-align: center;">25m</p> </div>				"B" - Baited Trees "R" - Rep Trees	
				Survey Comments	
				18	
				Non-MPB Site <input type="checkbox"/>	

Rev. 2020

2. Transect Survey Procedures

Goal

Systematic identification of 100% of the attacked trees within a transect survey site (or other predefined area).

Equipment

GPS

Compass and map Knife/hatchet

Diameter tape

Red and pink pest management flagging tape

Black permanent marker and pencil

Data sheet

Procedure

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. Before conducting the transect survey, the Project Manager will:
 - Delineate the transect survey site on a map or on aerial photos.
 - If the site is too large to survey with one crew, it should be subdivided into zones. The zones are to be identified by a letter. The name of each zone will therefore consist of the site number and a letter (e.g. 5a, 5b, 5c, etc.).
3. Determine the direction of transects based on topography or other landscape features.
4. The contractor/surveyor determines the flagged line spacing of transects based on factors such as the number of attacked trees, density of the stand and slope, from a minimum of 10 m up to a maximum of 50 m.
5. Locate the origin of the first transect line to be surveyed according to the schematic map (a corner of the survey polygon). Record the location on the Transect Ground Survey data sheet.
6. Double flag the transect line origin with red pest management flagging on an un-infested tree and label with the beetle year (August 15 -August 14 in the following year), the word "ORIGIN", site number (with zone if used), transect line number, bearing and the survey date (e.g. if the site number is 5, the first transect line origin will be labelled "2020 Origin 5-1 360°, Jan 14"). Sequentially number the transect lines.

7. Examine every pine tree between transect lines i.e. transect line 1 survey area is located between transect lines 1 and 2. Look for entrance holes and/or boring dust.
8. If a tree has 40 or less entrance holes the tree does not have to be controlled as it is considered an 'unsuccessful attack' . If a MPB infested tree is less than 15 cm at DBH, regardless of the number of entrance holes on the tree, it is also an 'unsuccessful attack' and does not have to be controlled.
9. Flag each attacked tree greater than 15cm at DBH with more than 40 entrance holes and that has living brood/beetles, with pink pest management tape and label it with the beetle year, the site number, transect line number and tree number. For example, 2020 5-1-3 is the 3rd tree along transect line 1, in site number 5. Tie the knot of the flagging facing towards the transect line it is associated with.
10. On the data sheet, record the attacked tree number, its GPS location and the estimated distance along the transect line.
11. A distinct patch of adjacent attacked trees can be represented by a single GPS location taken from the centre of the patch. A patch is defined as a distinct area no larger than the line of sight from the centre of the patch (approx. 25-30 m across). All patches are numbered with the beetle year, the site number, the transect line number, patch number, and tree number (for example 2020 5-1-3-4 is the 4th tree in patch 3, along transect line 1, in transect site 5). Record the number of trees in the patch. If trees are found all along the transect line and not in distinct patches, record this in the survey comments box.
12. If required by the Project Manager, measure and record the DBH (include one decimal place) of a tree that is representative of the currently infested trees (pink-flagged) along the transect line. Write "REP TREE" on the flagging of the measured tree.
13. When tallying trees with live brood (pink flagged trees) 'Red' trees have 100% of their needles red while 'Green' trees are attacked in the current year and are generally green but may show signs of fading.
14. Continue surveying along transect line until reaching the end of the survey area as indicated on the schematic map.
15. GPS tracklogs from all surveyors must be submitted daily.

16. Double flag the transect line end with red pest management tape on an un-infested tree and label with the beetle year, the word “END”, site number (with zones if used) transect line number, and back bearing (e.g. if the site number is 5 and the line number is 1, the line end will be labelled “2020 End 5-1 0°”).
17. Whitebark and limber pine have been designated as Endangered in Alberta. If either of these species are attacked in the plot, record the number of attacked trees in the appropriate box on the datasheet. The attacked whitebark and limber pine are not totaled separately from the trees with live brood total.

Removing Baits

18. Some of the sites may be baited. Collect and remove all baits. Bring them to the Project Manager. Remove any existing flagging from the tree and re-label and flag any infested tree using the above procedures. Write the bait number on the data sheet.

Deploying Baits

If the transect surveys are completed during a summer operation and baits are to be deployed as a cautionary procedure (i.e. in case control crews cannot get to the site before the beetles develop and fly), follow the Baiting Procedures and use the Mountain Pine Beetle Containment Bait Deployment data sheet.

Previously Identified Trees

For any trees that have flagging and numbers from the previous year’s operations, the Project Manager will determine if the old trees need treatment (possible 2 year lifecycle – or trees numbered during a summer program)

For old trees that do not require treatment (i.e. beetles have developed and flown) remove the existing flagging.

For old trees that still require treatment, remove all old flagging and replace it with new flagging. Label it using the numbering system outlined above.

Instructions for Transect Survey data sheet

1. Name of the Project, e.g. Willmore or Kananaskis. A project is a geographically defined area that contains several Infestations. Projects and Infestations are assigned by the Project Manager.
2. The beetle year begins August 15 of the current year and spans until August 14 the following year.
3. Name of corporate area, e.g. Foothills (SW3) or Clearwater (SW2).
4. The Project Manager is usually the Forest Health Officer for the corporate area.
5. The date (calendar year) the survey was conducted.
6. If you work for the Province under a contract, indicate your contract number or company name. Indicate your full name.
7. The Infestation will be assigned by the Project Manager. E.g. Smoky River in the Willmore Project or Spray Lakes in the Kananaskis Project.
8. Site Number, e.g. 4.
9. Measure latitude and longitude of access location (helipad or truck parking location only).
10. Enter the GPS location of the tree identified as the origin of the transect line.
11. Enter the GPS location of the tree identified as the end of the transect line.
12. Record the transect line number. Use a new data sheet for each transect line.
13. Record the transect line bearing and use a compass, not the GPS. Make sure your compass declination is set up properly. Check with the Project Manager for the correct setting.
14. Distance between transect lines in meters.
15. Record the total length of transect line.
16. Record any comments about the site. Describe the site and how to get to it from the access, e.g. walk 50m from helipad.
17. Indicate names of surveyors.
18. Record the representative DBH for infested trees only. Record the tree number measured.
19. Circle the access type used to get to the plot (i.e. the last vehicle used prior to working).
20. Record tree or patch number (only unique number, i.e. 3 for the third tree/patch along transect line 1 at site number 5 labelled 2020 5-1-3). The next infested tree/patch will receive the next number in the sequence (e.g. 2020 4-1-4).
21. Record latitude and longitude of tree or patch.
22. Distance from the origin of your transect line in meters.
23. Count the number of trees with green needles (i.e. current attack) that are flagged pink. Count the number of trees with red needles that are flagged pink.
24. Total the number of trees that require control (have pink flags). If there are no tallies, record a "0".
25. Of the total number of currently attacked trees how many are whitebark and how many are limber pine trees.
26. Enter any comments about the tree or patch here. For example, if a large patch extends over two transect lines, indicate the other transect line it crosses. If trees are found all along the transect line and not in distinct patches spaced along the line, record this here. If you find a bait, remove it and bring it to the project manager. Record the bait number here.
27. If there are more trees to record for a transect line than can fit on the front page of the data sheet, continue on the back. Do not record more than one transect line on one data sheet.

Mountain Pine Beetle Transect Ground Survey/Control

Project Name: 1		Beetle Year: 2	Corporate Region: 3	Project Manager: 4		
Survey Date: 5		Contract#/Company Name: 6	Infestation: 7	MPB Site Number: 8		
Access Location: (Degrees-minutes decimal)		Line Origin: (Degrees-minutes decimal)		Line End: (Degrees-minutes decimal)		
Lat: 9	± _____ meters	Lat: _____	± _____ meters	± _____ meters		
Long: _____		Long: _____	± _____ meters			
Transect Line No.: 12		Line Length: 15		Line Survey Comment: (Reg. location description) 16		
Line Bearing: 13		Line Spacing: 14 m				
Surveyors Names: 17		Representative Tree/Patch # 18		Access: (circle one) 19		
				Heli OHV Truck Other		
Survey						
Tree or patch No.	Location (Degrees-minutes decimal) Lat (ex) (53. 46,2345 Long (ex) = 119. 44,6862	Meters from line origin	# of attacked trees with LIVE brood marked for control		Species of Trees Attacked	
			Green Needles	Pink Flaggings Red Needles	Total	Whitebark Pine
20	Lat: 21 Long: _____	22	23	24	25	
Comments: 26	Lat: _____ Long: _____					
Comments:	Lat: _____ Long: _____					
Comments:	Lat: _____ Long: _____					
Comments:	Lat: _____ Long: _____					
Comments:	Lat: _____ Long: _____					
Comments:	Lat: _____ Long: _____					
Comments:	Lat: _____ Long: _____					
Comments:	Lat: _____ Long: _____					

3. Walk Through Detection Survey

Goal

To confirm the presence of MPB, the intensity of an infestation, the values at risk and the site/stand characteristics that may affect treatment tactics. This is a general overview of the damage in the management area in a relatively short period of time to help determine the best management strategies. The walk through detection survey may identify the need for a more detailed concentric or transect ground survey to identify attacked trees.

Timing

To confirm the presence of MPB the survey should be conducted between Sept 15 and July 1 of the same beetle year. To assess attack in a stand to be harvested, the Walk Through Detection Survey could be conducted along with block layout after the beetle flight (Sept 15), as long as harvest is complete prior to next flight (July 1). If harvest is not completed until after the beetle flight (Sept 15), another survey will have to be conducted.

Equipment

GPS, compass and map
Knife/hatchet
Pencil and notepad
Data sheet

Procedures

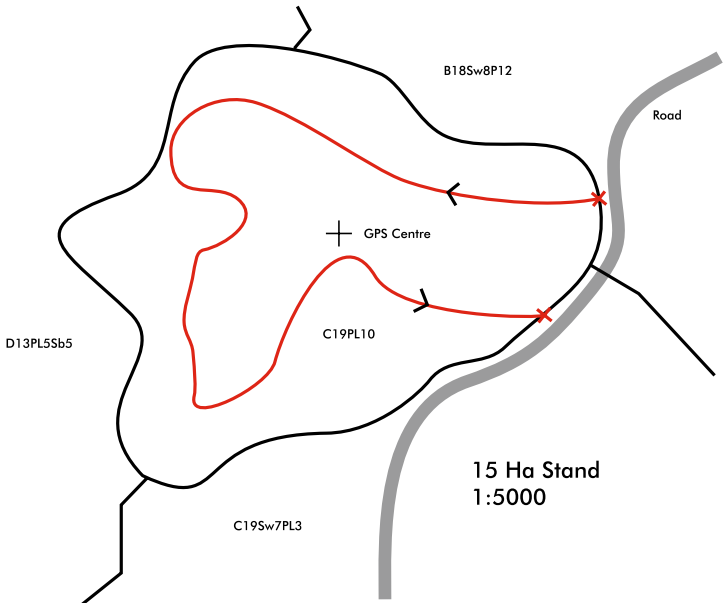
1. Walk through the block/stand/area to determine presence of MPB ensure thorough coverage to provide an accurate assessment. See example route below which illustrates the approximate amount of coverage required. Actual route walked will vary from stand to stand.
2. Target potential trees in stand for attack (forked trees, dry ridge, wood-pecker trees).
3. Keep track log on GPS of route walked.
4. Record GPS location of one tree or patch of infested tree in order for confirmation of infestation of stand.
5. Assess access and operability (existing access, slope, proximity of watercourses, etc.).

6. If required, assess stand characteristics (size, composition, density, tree age, etc.); and values at risk (fisheries, wildlife habitat, watershed, aesthetics, etc.).
7. If percent infested is the goal of the survey, run a compassed line(s) through the stand counting the number of infested and uninfested pine found 1 meter on either side of the line. The length of line(s) should reflect the size of stand.

Data Collection

Record location of confirmed MPB attack, percent infested area, and stand characteristics on the Walk Through Detection Survey data sheet.

Sample Walk Through Detection Route



Instructions for Walk Through Detection Survey data sheet

1. Name of the Project, e.g. Willmore or Kananaskis. A project is a geographically defined area that contains several Infestations.
2. The beetle year begins August 15 and spans until August 14 the following year.
3. Name of corporate area, e.g. Foothills (SW3) or Clearwater (SW2).
4. The Project Manager is usually the Forest Health Officer for the corporate area.
5. The date (calendar year) the survey was conducted.
6. The Infestation will be assigned by the Project Manager, e.g. Smoky River in the Willmore Project or Spray Lakes in the Kananaskis Project.
7. If you are a Provincial employee, indicate your name or if you work for the Province under a contract, indicate your contract number or company name.
8. Record the Block or polygon number.
9. Measure latitude and longitude of the access location (helipad or roadside truck parking location only). Set your GPS to NAD83 and measure in degrees/minutes/decimal minutes (hddd°mm. mmm').
10. Circle the access type used to get to the stand (i.e. the last vehicle used prior to walking).
11. Describe how to get to the stand from the access location recorded in e.g. walk 50 m north from helipad, quad 25 km south of road, etc.
12. Record the representative tree height and DBH for infested trees only. Record the tree number measured.
13. Indicate if the site is operable or not.
14. Record the causal agent (reason) for the dead or fading pine at site.
15. If the causal agent is MPB, indicate if there are galleries formed.
16. Record any MPB life stages found e.g. adults, larvae etc.
17. Number the patches of infested trees found.
18. Surveyors do not record anything in this box. A FIRES number will be assigned by the Provincial designate if site is to be entered into the provincial database.
19. Record the number of current mass attacked trees with brood in the patch.
20. Record the number of UA (unsuccessful attacked) trees in the patch.
21. Measure latitude and longitude of the infested tree or patch of infested trees in the stand.
22. If the site is controlled, indicate the control date.
23. Record any comments about the infested trees.
24. Estimate the number of uninfested pine.
25. Estimate the number of infested pine.
26. Calculate the infested pine percent.
27. Record the number of linear meters surveyed.
28. Record any comments about the stand level infestation.

Appendix 1

Performance Measures

Category	Allowable Error
Entrance hole judgement	± 5 entrance holes
Plot layout outer boundary distance	-1m to +5m
Plot center GPS location (tree/patch location for transect)	± 30 m
Representative tree	± 1 cm DBH

Pheromone Procedures

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1. Introduction	2
2. Grid Baiting	2
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4. Dispersal Baiting	8
5. Flight Monitoring	14

1. Introduction

Synthetic aggregation pheromone baits can be used to detect and/or monitor MPB. Under certain conditions, the use of pheromones in conjunction with control operations can maximize the effectiveness of control by containing and attracting beetles to the treatment area. Pheromones may also be used for follow-up control to attract residual beetles to areas previously treated.

2. Grid Baiting Procedures

Goal

Where a sanitation harvesting or prescribed burning treatment is the selected control tactic, areas slated for treatment can be grid-baited prior to tree removal or burning to contain and concentrate beetles within the block. This tactic of using baits in conjunction with sanitation harvest or prescribed burning should be a high priority where there is a threat of beetles infesting adjacent stands or migrating to new areas (i.e. priority in new and/or isolated infestations).

Equipment

GPS, compass and map
Pink and blue pest management flagging tape
Black permanent marker and pencil
Data sheet
Baits
Stapler with staples

Procedure

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. Baits are placed on susceptible pine trees within the block on a 50 m grid. This will result in an average density of 4-5 baits/ha.

3. Place baits on the closest, largest, uninfested, healthy pine tree. Baits must only be placed on lodgepole or jack pine trees. DO NOT bait whitebark or limber pine trees.
4. Baits should not be placed within 50 m of the block boundary to minimize beetle dispersal outside the boundary.
5. Staple baits approximately two meters above the ground on the north side of the tree. Be sure to place the staple in the upper portion of the bait casing ABOVE the heat-seal line (i.e., the section of the bait casing that DOES NOT contain the pheromone dispenser). Do not puncture the lower portion of the bait casing below the heat-seal line; pheromones will dissipate through the plastic at the appropriate rate without the need to puncture the bait casing.
6. Flag each baited tree with blue and pink pest management flagging.
7. Write the bait number on the flagging. If the bait packages are pre-numbered (ask Project Manager), use the number on bait package. If they are not pre numbered, label the baits by writing the beetle year, followed by the letters "CB", site number and an individual bait number (count baits sequentially starting at 1, e.g. 2020 CB381-1, 2020 CB381-2, etc.) on the bait package.

Data Collection

Record all information on the MPB Containment Bait Deployment data sheet.

3. Spot Baiting Procedures

Goal

Spot baiting can be used in conjunction with control treatments to effectively contain and eliminate small infestations. This tactic is used if small patches of infested trees cannot be controlled before the beetle flight. The baits are used to attract emerging adult beetles from adjacent attacked trees. Spot baiting is effective when populations are small and only isolated fading trees are present and visible from the air.

Equipment

GPS, compass and map

Pink, blue and red pest management flagging tape

Black permanent marker and pencil

Data sheet

Baits

Stapler with staples

Procedure

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. If provided, use the GPS location from Heli-GPS survey to find a fading or red tree on the ground.
3. Examine the fading or red tree to confirm MPB as the cause of mortality.
4. Ensure the beetles are alive and will fly the year of bait deployment.
5. If baits are to be deployed at the plot, it must receive a unique plot number.
6. Flag the closest uninfested tree near the aerial survey identified tree (red or fading tree) with red flagging tape, and mark it as the bait plot centre.
7. The bait site number consists of the beetle year (15 August - 14 August in the following year), "CB" (for containment bait) and the site number. For example, if the site number is 14, the bait site number is 2020 CB14.
8. Write the bait site number on the red flagging tape and the words "PLOT CENTRE".
9. Measure the GPS location of the plot centre and record it on the data sheet.

10. Examine all red or fading trees associated with the bait site number.
11. Place one bait for every five infested trees per patch on the closest, largest, uninfested, healthy pine tree or one bait for every five scorched trees (at the discretion of the Project Manager). Baits must only be placed on lodgepole or jack pine trees. DO NOT bait whitebark or limber pine trees.
12. Staple bait(s) approximately two meters above the ground on the north side of the tree. Be sure to place the staple in the upper portion of the bait casing ABOVE the heat-seal line (i.e., the section of the bait casing that DOES NOT contain the pheromone dispenser). Do not puncture the lower portion of the bait casing below the heat-seal line; pheromones will dissipate through the plastic at the appropriate rate without the need to puncture the bait casing.
13. Flag each baited tree with pink and blue pest management flagging.
14. Write the bait number of the flagging. If the bait packages are pre-numbered (ask Project Manager), use the number on bait package. If they are not pre numbered, label the baits by writing the beetle year, followed by the letters "CB", site number and an individual bait number (count baits sequentially starting at 1, e.g. 2020 CB14-1, 2020 CB14-2, etc.) onto the bait package.
15. GPS the location of all baits and record all information on the datasheet.
16. If deploying baits as part of a concentric survey, write a "B" at the approximate location on the crosshair map of the Concentric Survey data sheet.

Data Collection

Record all information on the MPB Containment Bait Deployment data sheet.

Instructions for the MPB Containment Bait Deployment data sheet

1. Name of the Project you are working on, e.g. Willmore or Kananaskis. A project is a geographically defined area that contains several Infestations.
2. The beetle year begins August 15 of the current year and spans until August 14 the following year.
3. Name of corporate area, e.g. Foothills (SW3) or Clearwater (SW2)
4. The Project Manager is usually the Forest Health Officer for the corporate area.
5. The date (calendar year) the survey was conducted.
6. The Infestation will be assigned by the Project Manager. E.g. Smoky River in the Willmore Project or Spray Lakes in the Kananaskis Project.
7. Circle the appropriate one.
8. Block or Burnt Unit number will be provided by Project Manager
9. If you are a GOA employee, indicate your name or if you work for GOA under a contract, indicate your contract number or company name.
10. Record the bait site number (the beetle year followed by the letters “CB” and the site number, e.g. 2020 CB7). Each site may have several baits; make sure to enter the next bait site number in an empty row below the individual bait numbers of the previous bait site.
11. If you were flown to the site by helicopter, record the location of the helipad using your GPS. Measure it in degrees/minutes/decimal minutes (hddd°mm.mmm') using NAD 83.
12. Measure the latitude and longitude of the bait site in degrees/minutes/decimal minutes (hddd°mm.mmm') using NAD83 on your GPS.
13. Estimate the number of trees with current attacks at the site.
14. Record individual bait number (the entire number if the bait packages were pre-numbered or, if you labelled it “2020 CB14-2” for example.
15. Record the latitude and longitude of the individual trees baited in degrees/minutes/decimal minutes (hddd°mm.mmm') with your GPS using NAD83.
16. Enter any comments about the site or individual trees baited (e.g. forked tree) in this field.

4. Dispersal Baiting

Goal

To ensure early detection of MPB into currently uninfested areas located in the likely pathway of beetles dispersing from infested areas. The dispersal baits are intended to detect large scale aerial dispersal events of MPB during the same year as the attack to allow control activities to be carried out in a timely manner. Monitoring dispersal bait sites for MPB activity will also assist forest health specialists in determining the leading edge of MPB range expansion by detecting resident, low-density beetle populations that are not yet sufficient to attack and kill trees on the landscape.

Timing

1. Deploy baits by July 1st.
2. Remove baits between September 15th and October 10th.
3. Submit final report by October 15th.
4. Control attacked trees before June 15th (for level II harvest refer to the MPB Log Management Directive) of the following year.

Site Selection

1. The Project Manager identifies pine stands that are considered the most likely path of beetle advance.
2. Space the bait sites so there is one per township. Do not put baits up in townships that already have baits for other purposes (e.g. containment).
3. Within a township, deploy baits in stands of extreme or high susceptibility (>60 SSI CF) where possible.
4. Deploy baits in areas of good accessibility, where possible.
5. Ensure good geographic coverage of the areas identified as potential dispersal pathways and areas of contiguous mature pine.

Deploying baits

Equipment

GPS, compass and map

DBH tape

Pink and blue pest management flagging tape

Black permanent marker and pencil

Data sheet
Baits
Stapler with staples

Procedure

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. At each site, select three uninfested, healthy, large (>20 cm DBH) lodgepole or jack pine trees that are 45m apart. The trees should form an approximate triangle. DO NOT bait whitebark or limber pine trees.
3. Record GPS location of each baited tree.
4. Measure and record DBH of each baited tree.
5. Staple baits approximately two meters above the ground on the north side of the tree. Be sure to place the staple in the upper portion of the bait casing ABOVE the heat-seal line (i.e., the section of the bait casing that DOES NOT contain the pheromone dispenser). Do not puncture the lower portion of the bait casing below the heat-seal line; pheromones will dissipate through the plastic at the appropriate rate without the need to puncture the bait casing.
6. Flag all three baited trees with pink and blue pest management tape wrapped around the tree bole.
7. Write bait tree number on flagging. Baited trees are numbered with the following information: the "beetle year", acronym for dispersal bait (DB), township, range, meridian, and tree number. For example, in the 2020 beetle year, Tree #1 at a bait site in township 71, range 20, west of meridian 4 would be numbered as, 2020 DB71204-1, tree #2 at that same site would be labelled 2020 DB71204-2, and tree #3 would be 2020 DB71204-3. Note: the "beetle year" begins August 15 of the current year and spans until August 14 the following year.
8. Record all information on the MPB Dispersal Baiting data sheet.

Collecting Dispersal Baits

Upon arriving at a dispersal bait site, navigate to each pine that was baited and remove the bait prior doing any other task (e.g., fixing ripped flagging, looking for pitch tubes, etc.). If the bait has been torn down by wildlife, spend some time to locate the missing bait (i.e., 1-2 min.). For trees that have had their baits torn down, make a record of "BOG" (i.e., bait on ground) in the comment section of the datasheet.

Re-tie and label any missing blue and pink flagging – this will make locating the tree much easier the following spring. For trees that have had the pink and blue flagging torn down from the bole, consider retying the flagging as a hanging “streamer” from a branch – it is less likely that wildlife will remove the streamers. Remove torn flagging from the site and dispose of it.

Surveying a Dispersal Bait Site

Surveys for trees attacked by MPB at dispersal bait sites are conducted in the fall when the baits are being collected. There is a two-stage process by which a dispersal bait site may be surveyed. The first stage is a “targeted” survey that is conducted at every bait site – this survey examines the baited pines and the un-baited pines nearby. The second stage is a “general” site survey consisting of a modified concentric ground survey of the entire site – this survey examines all pines at a bait site. Not all bait sites will require the “general” survey and whether this survey is conducted will depend on the results of the “targeted” survey.

Targeted Survey

Examine each baited tree for entrance holes and/or pitch tubes created by MPB attacks. If attacks are found, record the data for each baited pine on the datasheet.

Next, examine the un-baited pines within a 10 m radius of each baited pine for entrance holes and/or pitch tubes created by MPB attacks. If attacks are found, record this observation in the comments field of the datasheet indicating the number of attacks found on each un-baited pine.

If the baited and un-baited pines are not mass-attacked (i.e., have 40 or less entrance holes) no further work needs to be done so long as all relevant information is filled out on the MPB dispersal bait card.

If a baited or un-baited pine is found during the targeted survey that is ‘mass-attacked’ (i.e., has 40 or more entrance holes), remove a section of bark directly under an entrance hole and determine if live MPB larvae are present. Record this observation in the comments section of the datasheet.

The presence of a baited or un-baited pine that has been ‘mass-attacked’ triggers the ‘general site’ survey to determine if more mass-attacked pines exist at the bait site.

General Survey

Determine plot centre as the near-central position in the middle of the three baited pines. Select a healthy tree to serve as plot centre.

To conduct a general site survey to locate any other mass-attacked pines on site, refer to the Concentric Survey Procedures in the Ground Survey Procedures section of the MPB Detection and Management in Alberta field guide. However, modify the concentric ground survey so that the survey extends to 75 meters in all cardinal directions from plot centre.

Data collection

Ensure you have recorded all information on the MPB Dispersal Baiting data card before you leave the site.

Instructions for filling in the MPB Dispersal Baiting data sheet

1. Name of Project you are working in, e.g. Willmore or Kananaskis.
A project is a geographically defined area that contains several infestations. The Project name will be provided by the Forest Health Officer.
2. The beetle year begins August 15 of the current year and spans until August 14 the following year. E.g., July 12, 2020 is Beetle Year 2019.
3. Name of corporate area, e.g. Foothills (SW3) or Clearwater (SW2).
4. The Project Manager is usually the Forest Health Officer for the corporate area.
5. Site number, e.g. DB followed by township, range, meridian.
6. Record the latitude and longitude of the access location using GPS (e.g., landing location for helicopter, parking location for truck) in degrees/minutes/decimal minutes (hddd°mm.mmm') using NAD 83.
7. Describe site features and how to get to it from the access, e.g. 20° slope, walk 50 m north from helipad.
8. Indicate the main means of access.
9. Record the bait number.
10. Record the species of pine that is baited.
11. Measure DBH in cm.
12. Determine the total number of attacks that can be observed on the baited pine.
13. Indicate whether the tree resisted attack or whether the beetles were able to produce brood (eggs, larvae, or young beetles).
14. Record any important comments for that tree (e.g., bait on ground, tree blown over and new tree needed, etc.)
15. Add the GPS coordinates for each baited tree.
16. Record any relevant comments about the site (e.g., landing area needs clearing), GPS coordinates of mass-attacked trees), etc.

Mountain Pine Beetle Dispersal Baiting

Project Name: _____ 1		Beetle Year: _____ 2				
Corporate Area: _____ 3		Project Manager: _____ 4				
Site No.	Access location (hddd.mmm.mmm)	Site Description				
5	Lat: _____ 6 Long: - _____	7				
Access (circle one)	Setup Date (yyyy/mm/dd)	Setup By (name, company)	Collected (yyyy/mm/dd)			
Heli 8 Truck OHV Other						
Tree #	Bait #	Pine spp. (circle or specify)	DBH (cm)	# Attacks	Successful attacks (Y/N)	Comments
1	9	PJ PI 10	11	12	13	14
2		PJ PI				
3		PJ PI				
Baited pine location					Additional comments	
1	Lat: 15 _____	Long: _____	16			
2	Lat: _____	Long: _____				
3	Lat: _____	Long: _____				

Mountain Pine Beetle Dispersal Baiting

Project Name: _____		Beetle Year: _____				
Corporate Area: _____		Project Manager: _____				
Site No.	Access location (hddd.mmm.mmm)	Site Description				
	Lat: _____ Long: - _____					
Access (circle one)	Setup Date (yyyy/mm/dd)	Setup By (name, company)	Collected (yyyy/mm/dd)			
Heli Truck OHV Other						
Tree #	Bait #	Pine spp. (circle or specify)	DBH (cm)	# Attacks	Successful attacks (Y/N)	Comments
1		PJ PI				
2		PJ PI				
3		PJ PI				
Baited pine location					Additional comments	
1	Lat: _____	Long: _____				
2	Lat: _____	Long: _____				
3	Lat: _____	Long: _____				

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5. Flight Monitoring

Goal

Flight monitoring is used to detect the flight of local populations of MPB currently resident in Alberta lodgepole, hybrid and jack pine stands. The main aim is to gather data on the timing of onset, peak, and completion of adult beetle flight and attack of the next generation of hosts. It is not intended, although this may be a secondary benefit, to detect immigration of beetles from other source populations, should another mass migration flight occur.

Procedure

Timing

1. Deploy traps between June 1st and June 15th
2. Trap checking schedule:
 - Starting June 1st, check once every two weeks until July 1st
 - Starting July 1st, check once weekly until no MPB are caught
 - Once no MPB are caught, check once every two weeks until the end of September.
3. Replace vapona strips once during the last week of July or first week of August.
4. Replace myrcene once during the last week of July or first week of August.
5. Remove traps on or after September 30th.

Site Selection

Traps should be placed in natural mature pine stands, preferably in areas where the risk of vandalism or other human interference is low.

Set-up

1. Two lindgren funnel traps (12 funnel models) are set out in each site, about 50 meters apart, baited with standard MPB baits comprised of myrcene, exo-brevicommin, and trans-verbenol. Commercial baits come with installation instructions.
2. Place one vapona no-pest strip placed in the bottom of the collecting cup.

3. Traps are suspended on ropes tied between two trees, in such manner that the traps are at least 2 meters from any tree, and that the white collecting cup at the bottom is approximately DBH (1.3 m). Traps should be in open areas and visible to beetles – avoid dense underbrush.
4. Traps locations should be recorded by GPS coordinates. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'). Traps should be numbered by Corporate Area, site, and trap number (e.g. for Edson Forest Area, site 20, traps 1 and 2 would be labelled EFA20-1 and EFA20-2).
5. Once traps are installed they must be checked as per schedule described above.
6. Beetles entering the trap will be killed by a piece of vapona no-pest strip placed in the bottom of the collecting cup. Replaced vapona strips once as per schedule described above.
7. Replace myrcene once at the end of July.
8. During each collection the entire contents of traps should be placed in sandwich-sized Ziploc bags and frozen or refrigerated if not being counted immediately. During peak flight when large numbers of beetles are being collected it may be desirable to double-bag the samples to prevent breakage.
9. Label collection bag with trap site, trap number, and collection date once all sites have been confirmed and trap installation is complete. Note: marking on the outside of the bag, while useful for quick checking, tends to erase over time, especially from frozen and frosty plastic.
10. Beetle counts must be done by an individual with MPB identification training.
11. Enter data into the excel spreadsheet provided by the Forest Health and Adaptation Section in Edmonton.

Control Procedures

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Control Procedures

1. Introduction

There are several different procedures that can be used to control MPB infestations. All of the procedures kill live beetles before they have a chance to develop and fly to new pine trees. The Project Manager may determine the technique to be used.

2. Locating Trees to be Treated

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. The locations of control trees are recorded in one of two formats depending on how the stand was surveyed.
 - a. If using results from a concentric survey:
 - i. Locate the plot centre tree indicated on the MPB Concentric Ground Survey sheet. It will be flagged with red pest management flagging labelled with the beetle year, the site number, the words "PLOT CENTRE" and the survey date (e.g. 2020 137 Plot Centre Dec 13).
 - ii. All trees that are to be controlled will be flagged with pink pest management flagging and labelled with the beetle year, the site number, quadrant and tree number (e.g. 2020 137 NW1).
 - iii. Approximate locations of control trees will be indicated on the cross hair map of the MPB Concentric Ground Survey sheet (if less than 10 per quadrant).
 - b. If using the results of a transect survey:
 - i. Locate the tree/patch to be controlled by going to the GPS location supplied for each tree/patch in the transect area.
 - ii. All trees that are to be controlled will have been flagged with pink pest management flagging and labelled with the beetle year, the site number (and zone if used), transect line number, and tree/patch number (e.g. 2020 4-3-1).
 - iii. The start of a transect line is indicated by a double red-flagged tree labelled with the beetle year, the site number (and zone if used), transect number and the word "START" (e.g. 2020 START 5-1). The end of a transect line is indicated by a double red-flagged tree that is labelled with the beetle year, the word "END", site number (and zone letter if used), transect line number and bearing (e.g. 2020 END 5-1 0°).

4. Extra control trees (i.e. trees with live MPB brood) found by the control crew that were not previously flagged with Pink pest Management flag are not allowed unless verified by QI or a Provincial designate.
5. Approved extra control trees must have a double vertical line marked with the chain saw on the bole and stump "II".
6. If there are excess control trees (pink flagged) in the field as compared to the survey sheet, the excess trees must be left in the quadrant indicated by the survey sheet. These excess trees may be controlled only if approved by a Provincial designate.

3. Control Treatments

3.1 Conventional Fall and Burn

1. Fall, limb and buck control trees into manageable sized pieces.
2. Control tree must be bucked and limbed up to 10 cm diameter.
3. If it is necessary to cut trees that are not infested with MPB (incidental trees), trees must lie flat on the ground (de-limbing and/or bucking may be required to ensure tree is flat on ground). Stumps must be marked at the cut surface with a chainsaw single vertical line "I". Incidental trees are defined as being trees with >10 cm dbh.
4. Stump heights for control and incidental trees must not exceed 30 cm at point of germination (see Appendix 1 for diagram) or as outlined in the control contract.
5. Burn piles must not be located on a watercourse (classified as transitional, small permanent, or large permanent as per the Alberta Timber Harvest Planning and Operating Ground Rules Framework for Renewal).
6. Using dead material and accelerant (oil, diesel fuel), build a fire. Once the fire is burning well, add control tree pieces.
7. Take care not to damage or scorch other trees in the area. Trees must be felled and laid flat on the ground



Figure 1. Pitch tubes on a tree attacked by mountain pine beetle.

(de-limbing and/or bucking may be required to ensure tree is flat on ground) if:

- a. any live pine (>15 cm DBH) has >50% of the crown scorched; or
 - b. any live pine (>15 cm DBH) has >50% of circumference of bole (or roots) killed; or
 - c. any live or dead tree (conifer or deciduous >10 cm DBH) has >1/3 of the bole diameter that is not structurally sound (i.e. burned out or mechanically damaged).
8. Ensure fire remains burning by adding more dead material, limbs, etc.
 9. Monitor the burning of the green pieces to ensure all the bark and cambium is completely destroyed. Pieces may need to be turned to ensure complete burning (Figure 2).
 10. If the infested tree is not burned on the stump, all bark that is higher than 30 cm on the bole (from point of germination) must be removed.
 11. Once burning is complete, take appropriate action to ensure the fire does not spread (Figure 4).
 12. Complete the daily data entry requirements as specified in the contract.



Figure 2. Burn pile with infested logs. Rotate logs to ensure that all of the bark is burnt.

3.2 Conventional Fall and Peel

1. Fall pink flagged tree(s) and limb up to a top size of 10 cm.
2. If it is necessary to cut trees that are not infested with MPB (incidental trees), trees must lie flat on the ground (de-limbing and/or bucking may be required to ensure tree is flat on ground). Stumps must be marked at the cut surface with a chainsaw single vertical line 'I'. Incidental trees are defined as being trees with >10 cm dbh.
3. Stump heights for control and incidental trees must not exceed 30 cm at point of germination (see Appendix 1 for diagram) or as outlined in the control contract.
4. Using a mechanical planer attachment on a chainsaw, drawknife or another acceptable tool, debark the tree completely up to a top size diameter of 10 cm.



Figure 3. Left: Beetles can emerge from stumps if they are not controlled. Right: Control crew member peeling a stump to ensure that beetles living in the stump cannot survive.



Figure 4. After all the bark is burnt, spread the logs and ensure the fire is out.

5. Control trees must be bucked into maximum 8' sections.
6. Complete the daily data entry requirements as specified in the contract.
7. The Project Manager will provide direction on how to dispose of the bark and debris.

3.3 Rotary Wing Assisted Fall and Burn

Rotary wing assisted fall and burn is defined as the utilization of rotary wing aircraft to create burn piles.

1. After control trees have been felled and flown to the burn pile location, ignite fire and ensure that the bark and cambium of all infested trees is completely destroyed.
2. Tree must be controlled up to 10 cm diameter or as per contract specification.
3. If it is necessary to cut trees that are not infested with MPB, or if tops of un-infested trees are broken off as a result of control operations, disposal of the cut trees and/or broken tops (incidental trees) is required to reduce debris and to facilitate quality inspection is as follows (incidental trees are defined as being trees with >10 cm dbh):
 - a. incidental conifer trees within the plot must be burned to a 10 cm top;
 - b. incidental conifer trees outside the plot must lay flat on ground (de-limbing and/or bucking may be required to ensure tree is flat on ground; and

- c. incidental deciduous trees within or outside the plot must lay flat on ground (de-limbing and/or bucking may be required to ensure tree is flat on ground).
4. Stump heights for control and incidental trees must not exceed 30 cm at point of germination (see Appendix 1 for diagram) or as outlined in the control contract.
5. Take care not to damage or scorch other trees in the area. Tree must be cut and burned (to a 10 cm top) if:
 - a. any live pine (>15 cm DBH) has >50% of the crown scorched; or
 - b. any live pine (>15 cm DBH) has >50% of circumference of bole (or roots) killed; or
 - c. any live or dead tree (conifer or deciduous >10 cm DBH) has >1/3 of the bole diameter that is not structurally sound (i.e. burned out or mechanically damaged).
6. Complete the daily data entry requirements as specified in the contract.

3.4 Mechanical Fall and Burn

Mechanical fall and burn is characterized by the use of any type of machinery (other than a chainsaw) to cut or move trees. Skidders are not permitted in any mechanical fall and burn operations.

1. Prior to commencing operations, a plan for the use of machinery must be submitted to the Province for approval. The proposed plan must follow section 6.0 and 11.4 of the Operating Ground Rules applicable to the area of work. The proposed plan must indicate the general timing of operations, and must include a map that clearly indicates:
 - a. names and locations of control sites proposed for mechanical fall and burn,
 - b. type of machinery planned for use
 - c. planned route for machinery to access the general work area,
 - d. planned route for machinery to move between control sites,
 - e. location and classification of all water courses to be crossed, and the type of crossing to be constructed by the contractor, and
 - f. location of pipeline and power line crossings, and the type of crossing to be constructed by the contractor.
2. Information specific to the location and type of water course crossings, and the status/date of the construction or removal, must be submitted in the format and timeframe indicated by the Provincial designate. Be aware that crossings of industry dispositions may require industry

approval. All approvals are the responsibility of the contractor. Be aware of all road use agreements and weight restrictions.

3. When choosing access routes and in-stand access trails, the expectation is to keep the number of incidental trees to a minimum. A recommended guideline is to choose routes that minimize the number of merchantable trees that are felled by utilizing previously disturbed access where appropriate. In addition, the number of water course crossings (especially higher order water courses) should be kept to a minimum.
4. Rutting and ground disturbance must be kept to a minimum and must not exceed the requirements set out in section 9 of the Operating Ground Rules applicable to the area of work.
5. After control trees have been felled and are at the burn pile location(s), ignite fire and monitor the burning of the tree pieces to ensure all the bark and cambium is completely destroyed. Pieces may need to be turned to ensure complete burning.
6. Control trees must be treated up to 10 cm diameter or as per contract specification.
7. If it is necessary to cut trees that are not infested with MPB, or if tops of un-infested trees are broken off as a result of control operations, disposal of the cut trees and/or broken tops (incidental trees) is required to reduce debris and to facilitate quality inspection is as follows (incidental trees are defined as being trees with >10 cm dbh):
 - a. incidental conifer trees within the plot must be burned to a 10 cm top
 - b. incidental conifer trees outside the plot must lay flat on ground (de-limbing and/or bucking may be required to ensure tree is flat on ground)
 - c. incidental deciduous trees within or outside the plot must lay flat on ground (de-limbing and/or bucking may be required to ensure tree is flat on ground)
8. Stump heights for control and incidental trees must not exceed 30 cm at point of germination (see Appendix 1 for diagram) or as outlined in the control contract.
9. Take care not to damage or scorch other trees in the area. Tree must be cut and burned (to a 10 cm top) if:
 - a. any live pine (>15 cm DBH) has >50% of the crown scorched; or
 - b. any live pine (>15 cm DBH) has >50% of circumference of bole (or roots) killed; or

- c. any live or dead tree (conifer or deciduous >10 cm DBH) has >1/3 of the bole diameter that is not structurally sound (i.e. burned out or mechanically damaged).
10. Complete the daily data entry requirements as specified in the contract.
11. Daily GPS tracklogs (gpx files) for all machinery used must be submitted within seventy-two (72) hours of the works being conducted as either in progress or completed.

3.5 Whole Tree Chipping

1. Pre-locate access routes that are suitable for the equipment being used. Assess water course crossings required for access. The location and type of all water course crossings to be constructed by the contractor requires pre-approval from the local Provincial designate, and shall follow section 6.0 and 11.4 of the Operating Ground Rules applicable to the area of work. Be aware that crossings of industry dispositions may require industry approval. All approvals are the responsibility of the contractor. Be aware of all road use agreements and weight restrictions.
2. When choosing in-stand access trails, the expectation is to keep the number of incidental trees to a minimum. A recommended guideline is to choose routes that minimize the number of merchantable trees that are felled.
3. Rutting and ground disturbance must be kept to a minimum and must not exceed the requirements set out in section 9 of the Operating Ground Rules applicable to the area of work.
4. Control trees must be treated up to 10 cm diameter or as per contract specification.
5. Stump heights for control and incidental trees must not exceed 30 cm at point of germination (see Appendix 1 for diagram) or as outlined in the control contract.
6. If it is necessary to cut trees that are not infested with MPB (incidental trees), all incidental trees within or outside the plot must lie flat on the ground (de-limbing and/or bucking may be required to ensure tree is flat on ground). Incidental trees are defined as being trees with >10 cm dbh.
7. The chip mat cannot exceed 10 cm. Chips must be spread out as widely and as evenly as possible. Chip size must not exceed 5.1 cm in width and 24 cm in length with both bark and sapwood attached.
8. Complete the daily data entry requirements as specified in the contract.
9. Daily GPS tracklogs (gpx files) for all machinery used must be submitted within seventy-two (72) hours of the works being conducted as either in progress or completed.

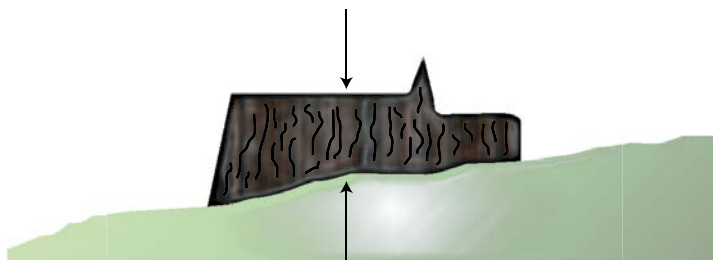
Appendix 1

Control Stump Marking Summary

Stump Marking Summary	
Treatment Type	Stump Markings
Treatment (pink flagged)	Burned or debarked above 30 cm (from point of germination)
Extra Treatment	
Non MPB (e.g. hazard trees)	I

Stump Height Measurement at Point of Germination

Measure stump height at the point of germination, and to the midpoint of the undercut and back cuts if the cuts are uneven.



Incidental Tree Disposal Requirements

	Cut to lie flat (inside plot)	Cut to lie flat	Burned to a 10 cm top (inside plot)	Burned to a 10 cm top (outside plot)
Conventional fall and burn	Yes, all species	No	No	No
Conventional fall and peel	Yes, all species	No	No	No
Rotary wing assisted fall and burn	Yes, deciduous	Yes, all species	Yes, conifer	No
Mechanical fall and burn	Yes, deciduous	Yes, all species	Yes, conifer	No
Whole tree chipping	Yes, all species	Yes, all species	No	No

Note: For control in transect survey areas, a patch is considered the plot when determining incidental tree disposal requirements.

Quality Inspection

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1. Level 1 Survey Quality Inspection

Goal

A minimum of fifteen (15) % of all completed survey sites or transect lines should be inspected for accuracy and quality of information. Inspectors should follow closely behind the crews (target maximum three day lag) to determine if there are any deficiencies in detection or plot layout. Follow-up may also be required on additional plots.

Timing

While surveys operations are ongoing.

Equipment

GPS, compass, map

Yellow, red, pink pest management flagging tape

Data sheets

Black permanent marker and pencil

Camera

Knife/hatchet

Procedure

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. QI should follow closely behind the crews to ensure inspections are distributed throughout each infestation, or as directed by the Project Manager.
3. Hang yellow pest management flagging at plot centre or line origin. Indicate QI crew names and QI survey date.
4. Assign all applicable deficiencies to the plot. Quality Inspectors are to fix deficiencies in the parent plot during check and apply demerits accordingly.
5. If inspecting transect surveys, QI must inspect entire lines instead of portions of lines.
6. Assess the following:
 - Field Inaccuracies
 - a. Missed Control Tree
 - » Missed a tree that meets the pink flagged thresholds (>40 entrance holes, >15 cm, live brood)

- » Double numbered and/or not tallied correctly (e.g. two trees of NW2, 12 trees in the forest; only 11 recorded on total of tally sheet)
 - » Number of deficiencies equals number of occurrences
- b. Excess Control Tree
- » Tree is flagged pinked but does not meet threshold
 - » Tree tallied on data sheet but doesn't exist in field
 - » Tree not tallied on data sheet but exists in field, and does not meet pink flag thresholds
 - » Rules apply to voluntary pink flagged trees
 - » Number of deficiencies equals number of occurrences
- c. Plot Centre tree (or line origin/end) not to standard
- » Infested tree as plot centre tree (or line origin/end)
 - » No double ribbon
 - » Majority of plot located in non-pine area (<25% pine composition of stems >15 cm DBH)
 - » Location of plot centre tree results in plot being partially located within a permanent sample plot
 - » Number of deficiencies equals number of occurrences
- d. Plot layout
- » Plot layout ribbons in wrong locations (distance from plot centre)
 - » Plot lines are not laid out within 20° of cardinal directions
 - » Plot layout flagging on infested tree
 - » Number of deficiencies equals number of occurrences
- e. Representative tree diameter inaccurate (if applicable)
- » Measurements are outside of allowable error margins
 - » Maximum 1 occurrences
- f. Representative tree not representative (if applicable)
- » Broken top
 - » Gross misjudgment of rep tree selection
 - » Maximum one occurrence
- g. Ribboning/Labelling error
- » Missing or incorrect information on plot layout flagging (e.g. plot number, beetle year, date, direction, distance) (max one occurrence per error type e.g. wrong beetle year on 9 plot layout ribbons = 1 occurrence)

- » Two trees with same tree number (number of deficiencies equals number of occurrences i.e. 2 tree NW3 = 1 occurrence, 2 tree NW3 and 2 tree NW7 = 2 occurrences etc.)
- » Missing tree number on flagging (number of deficiencies equals number of occurrences)
- » Skipped a tree number (NE3, NE5) (occurrence # based on # of deficiencies)
- » Conventionally numbered (e.g. NW5) voluntary trees located more than 10 m past outer boundary of plot or mini-survey (occurrence # based on # of deficiencies)
- » Wrong ribbon color used (maximum one occurrence)
- » Control tree flagging not oriented with knot facing plot centre (occurrence # based on # of deficiencies)

Plot Card Inaccuracies

h. Form not filled out to standard or illegible

- » Helipad or other forms of access not identified properly (i.e. is the access type recorded? Does the record match the site?)
- » GPS records given in the incorrect units
- » Empty fields on the data sheet where there should be "0"s
- » Surveyor writing illegible
- » Incorrect site number (e.g. two site numbers are mixed up but all other data is correct)
- » Number of deficiencies based on number of occurrences

i. Field Map

- » Did not map control trees correctly when 20 or less/quadrant
- » Did not map control trees correctly when more than 20/quadrant
- » Quadrant tally incorrect (but total number of trees correct)
- » Did not map rep tree location on field map (if applicable)
- » Number of deficiencies based on number of occurrences

j. Incorrect plot centre (or tree/patch) or line origin/end coordinates (+30m)

- » Number of deficiencies based on number of occurrences.

Data Inaccuracies and data management

k. Scanning and posting of cards (>24 hr)

- » Number of deficiencies based on number of days

l. Database entry timeline (>24 hr)

- » Number of deficiencies based on number of days

- m. In progress sites not marked complete within specified time
 - » Maximum one occurrence
- Other areas of concern
- n. Garbage located on site
 - » Take pictures
 - » Maximum one occurrence
- 7. Indicate deficiencies on the Survey Quality Inspection data sheet and correct the original survey data sheet where necessary. Initial any changes made to the original survey data sheet.
- 8. Hang yellow pest management flagging on tree, if applicable, with deficiency. Indicate in writing on yellow flagging what deficiency was found (e.g. “missed control tree”). Hang the correct pest management flagging, if applicable, to correct the deficiency.
- 9. If removing pink flagging from an excess tree, or from a tree that meets attack threshold but does not contain live brood, hang yellow pest management flagging on tree and label it as “unsuccessful attack”.
- 10. QI will only call for a follow up survey in the following situations:
 - a. There are missed control trees in the mini-survey triggering an additional plot to be surveyed.
 - b. The plot is at an incorrect location or the additional plot has been placed in an incorrect location.
 - c. The survey incorrectly identified the site as non-MPB and it should have been surveyed originally.
 - d. Garbage on site.
- 11. Provincial designate to mark in FIRES any additional plots for follow-up based on poor QI assessments (e.g. completed by same crew, etc.). Although the plot marked for follow-up was not visited in the field, a QI assessment will be created with the comments indicating that follow-up is based on poor QI assessment on another plot (referenced) completed.

Instructions for filling in the Concentric Survey Quality Inspection data sheet

1. Name of the Project you are working on, e.g. Willmore or Kananaskis.
A project is a geographically defined area that contains several Infestations.
2. The beetle year begins August 15 and spans until August 14 the following year.
3. Name of corporate area, e.g. Foothills (SW3) or Clearwater (SW2).
4. The Project Manager is usually the Forest Health Officer for the corporate area.
5. The date the inspection was conducted (yyyy mm dd).
6. Indicate if you are a GOA employee, or if you work for GOA under a contract. Provide your contract number or company name.
7. Indicate full name(s) of inspector(s).
8. The Infestation will be assigned by the Project Manager. E.g. Smoky River in the Willmore Project or Spray Lakes in the Kananaskis Project.
9. Site number, e.g. 4
10. If coordinates for plot centre must be corrected.
11. If representative tree measurements must be corrected.
12. Mark appropriate field inaccuracies and number of occurrences.
13. Mark appropriate plot card inaccuracies and number of occurrences.
14. Mark appropriate data management issues and number of occurrences.
15. Mark appropriate other areas of concern and number of occurrences.
16. Include comments to provide additional or supporting information related to inaccuracies.
17. Check the box if no deficiencies found or follow up required.

Mountain Pine Beetle Level 1 Concentric Survey Quality Inspection (OI)

Project Name: 1 Beetle Year: 2 No deficiencies **17**
 Corporate Area: 3 Project Manager: 4 Follow up required
 Inspection date: 5 Contract #/Company Name: 6
 Inspector 1: 7 Inspector 2: 9
 Infestation: 8 MPB Site #: 9
 Revised concentric centre coordinates: Lat. 10 ° Long. ° DBH cm
 Revised representative tree measurements: Height 11 m

FIELD INACCURACIES

Type	Check if applicable	Number of Occurrences
Missed control tree	<input type="checkbox"/>	<u>12</u> <small>gross</small>
Excess control tree	<input type="checkbox"/>	
Plot centre tree not to standard	<input type="checkbox"/>	
Plot layout	<input type="checkbox"/>	
Representative tree diameter inaccurate	<input type="checkbox"/>	
Representative tree not representative	<input type="checkbox"/>	
Ribboning/Labeling error	<input type="checkbox"/>	

DATA ENTRY & MANAGEMENT

Type	14	Check if applicable	Number of Occurrences
Scanning and posting of card (>24 hr)		<input type="checkbox"/>	
Database entry timeline (>24 hr)		<input type="checkbox"/>	
In progress sites not marked complete in given time		<input type="checkbox"/>	

OTHER AREA OF CONCERN

Type	15	Check if applicable	Number of Occurrences
Garbage located onsite		<input type="checkbox"/>	

PLOT CARD INACCURACIES

Type	13	Check if applicable	Number of Occurrences
Form not filled out to standard or illegible		<input type="checkbox"/>	
Field map		<input type="checkbox"/>	
Incorrect plot centre coordinates (>+/-15m)		<input type="checkbox"/>	

COMMENTS **16**

Instructions for filling in the Transect Survey Quality Inspection data sheet

1. Name of the Project you are working on, e.g. Willmore or Kananaskis.
A project is a geographically defined area that contains several Infestations.
2. The beetle year begins August 15 and spans until August 14 the following year.
3. Name of corporate area, e.g. Foothills (SW3) or Clearwater (SW2).
4. The Project Manager is usually the Forest Health Officer for the corporate area.
5. The date the inspection was conducted (yyyy mm dd).
6. Indicate if you are a GOA employee, or if you work for GOA under a contract. Provide your contract number or company name.
7. Indicate full name(s) of inspector(s).
8. The Infestation will be assigned by the Project Manager. E.g. Smoky River in the Willmore Project or Spray Lakes in the Kananaskis Project.
9. MPB Site number, e.g. 36
10. Transect line number, e.g. 4
11. Meters checked, e.g. 0m to 475m
12. Total meters checked, e.g. 475m
13. If coordinates for line origin must be corrected.
14. If coordinates for line end must be corrected.
15. Indicate revised line length if appropriate.
16. If representative tree measurements must be corrected.
17. Mark appropriate field inaccuracies and number of occurrences.
18. Mark appropriate plot card inaccuracies and number of occurrences.
19. Mark appropriate data management issues and number of occurrences.
20. Mark appropriate other areas of concern and number of occurrences.
21. Include comments to provide additional or supporting information related to inaccuracies.
22. Check the box if no deficiencies found or follow up required.

Level 1 Control Quality Inspection

Goal

A minimum of fifteen (15) % of all completed Level I control sites must be inspected. Inspectors should follow closely behind the control crews to (maximum one week unless otherwise directed) determine if there are any deficiencies within or outside the plot related to control treatments, ground rule standards, or other areas of concern.

Timing

While control operations are ongoing.

Equipment

GPS, compass, map

Yellow, red, pink pest management flagging tape

Data sheets

Black permanent marker and pencil

Camera

Knife/hatchet

Tape measure

Procedure for Conventional Fall and Burn/Fall and Peel

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. QI should follow closely behind the crews to ensure inspections are distributed throughout each infestation, or as directed by the Project Manager.
3. Assess the following:
 - a. Control tree(s) not controlled to standard
 - » Pink flagged not felled, flown or controlled to standard.

Reasons pink flag trees are considered not controlled to standard:

- Bark and cambium not completely destroyed (if burning) (includes stump untreated above 30cm)
- Bark still attached (if peeling) (includes stump untreated above 30cm)
- Debris not disposed of according to instructions (if peeling)
- Tree not controlled to a 10 cm top

- b. Other areas of concern
 - » Burn pile located on a watercourse (record coordinates and take photo)
 - » Scorched or damaged tree not felled and laid flat on ground
 - » Incidental tree (>10cm dbh) not laid flat on ground
 - » Stump of control or incidental tree >30cm height
 - » Danger tree located on site or at burn pile location
 - » Stump of incidental tree not marked with a chainsaw "I"
 - » Garbage located on site
- c. Data entry and data management
 - » Scanning and posting of cards (>24 hr)
 - » Database entry timeline (>24 hr)
 - » In progress sites not marked complete within contract specific timeframe
- 4. Indicate deficiencies on the Control Quality Inspection data sheet.
- 5. Where applicable, hang yellow pest management flagging at the location where the deficiency is located. Indicate in writing on the yellow flagging what deficiency was found.
- 6. If there are any trees with current attacks that were not flagged by the survey crews, record the information on the Survey Quality Inspection data sheet, not on the Control Quality Inspection data sheet.
- 7. QI will only call for a follow up control in the following situations:
 - a. Control tree(s) not controlled to standard
 - b. Scorched or damaged tree not felled and laid flat on ground
 - c. Incidental tree (>10cm dbh) not and laid flat on ground
 - d. Stump of control or incidental tree >30cm height
 - e. Garbage on site

Procedure for Mechanical Fall and Burn

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. QI should follow closely behind the crews to ensure inspections are distributed throughout each infestation, or as directed by the Project Manager.
3. Assess the following:
 - a. Control tree(s) not controlled to standard
 - » Pink flagged not felled, flown or controlled to standard

Reasons pink flag trees are considered not controlled to standard:

- » Bark and cambium not completely destroyed (includes stump untreated above 30 cm)
- » Tree not controlled to a 10 cm top

b. Other areas of concern

- » Burn pile located on a watercourse (record location and take photo)
- » Scorched or damaged tree not felled, limbed to lay flat, or bucked into 8 foot sections
- » Incidental tree (>10 cm dbh) not laid flat on ground
- » Incidental tree (>10 cm dbh) within the plot not burned to a 10 cm top
- » Stump of control or incidental tree >30 cm height
- » Danger tree located on site or at burn pile location
- » Chip mat exceeds 10cm in depth
- » Garbage located on site

c. Ground Rule Standards

- » Watercourse crossing not installed or removed as per ground rule standard
- » Rutting or ground disturbance exceeds ground rule standard

d. Data entry and data management

- » Scanning and posting of cards (>24 hr)
- » Database entry timeline (>24 hr)
- » In progress sites not marked complete within contract specific timeframe
- » GPS tracklogs of machinery not submitted within contract specific timeframe

4. Indicate deficiencies on the Control Quality Inspection data sheet.
5. Where applicable, hang yellow pest management flagging at the location where the deficiency is located. Indicate in writing on the yellow flagging what deficiency was found.
6. If there are any trees with current attacks that were not flagged by the survey crews, record the information on the Survey Quality Inspection data sheet, not on the Control Quality Inspection data sheet.
7. QI will only call for a follow up control or remedial work in the following situations:
 - a. Control tree(s) not controlled as per standard
 - b. Scorched or damaged tree not felled and layout flat on ground

- c. Incidental trees not disposed of as per standard
- d. Watercourse crossing not installed or removed as per ground rule standard
- e. Rutting or ground disturbance exceeds ground rule standard
- f. Stump of control or incidental tree >30 cm height
- g. Garbage on site

Procedure for Rotary Wing Assisted Fall and Burn

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. QI should follow closely behind the crews to ensure inspections are distributed throughout each infestation, or as directed by the Project Manager.

3. Assess the following:

- a. Control tree(s) not controlled to standard

- » Pink flagged not felled, flown or controlled to standard

Reasons pink flag trees are considered not controlled to standard:

- » Bark and cambium not completely destroyed (includes stump untreated above 30 cm)
- » Tree not controlled to a 10 cm top

- b. Other areas of concern

- » Burn pile located on a watercourse (record location and take photo)
- » Scorched or damaged tree not felled and laid flat on ground
- » Incidental tree (>10 cm dbh) not laid flat on ground
- » Incidental tree (>10 cm dbh) within the plot not burned to a 10 cm top
- » Stump of control or incidental tree >30 cm height
- » Danger tree located on site or at burn pile location
- » Stump of incidental tree not marked with a chainsaw "I"
- » Garbage located on site

- c. Data entry and data management

- » Scanning and posting of cards (>24 hr)
- » Database entry timeline (>24 hr)
- » In progress sites not marked complete within contract specific timeframe

4. Indicate deficiencies on the Control Quality Inspection data sheet.

5. Where applicable, hang yellow pest management flagging at the location where the deficiency is located. Indicate in writing on the yellow flagging what deficiency was found.
6. If there are any trees with current attacks that were not flagged by the survey crews, record the information on the Survey Quality Inspection data sheet, not on the Control Quality Inspection data sheet.
7. QI will only call for a follow up control in the following situations:
 - a. Control tree(s) not controlled to standard
 - b. Scorched or damaged tree not felled laid flat on ground
 - c. Incidental tree (>10 cm dbh) not laid flat on ground
 - d. Stump of control or incidental tree >30 cm height
 - e. Garbage on site

Procedures for Whole Tree Chipping

Background

Trees infested with MPB can be controlled by chipping them into small enough pieces so that the number of surviving beetles, larvae or pupae is sufficiently reduced to prevent further infestation of healthy trees. During the chipping process the beetles are mechanically destroyed or die due to starvation, desiccation or freezing. All trees must be completely chipped as per the contract specifications.

Goal

A minimum of fifteen (15) % of all sites controlled by chipping infested trees should undergo Quality Inspection. The Quality Inspection should be conducted within the first three days of chipping commencement to ensure the standard is being met. Quality Inspection should be conducted on a regular basis to ensure operators' performance does not compromise the standard.

Equipment

Datasheet

Pencil

Permanent Marker

Plastic bags

Disk 5.1 cm (2 in.) in diameter or a screen* of 5.1 cm Calculator
(if necessary)

Tape measure (at least 1m long)

4 liter bucket (for example, an ice cream pail)

**Please note, the contractors are required to supply a screen as part of their contracts*

Procedures

1. Look over the entire site for large pieces that are greater than 24 cm long and 5.1 cm in width with both bark and sapwood attached. If the site is very large, a smaller sampling area can be identified where the number of infested trees to be treated is known.
2. Assess the large pieces for evidence of attack (pitch tubes, entrance holes, blue stain, or beetle life-stages).
3. If there is one piece with intact bark that is larger than 1m long and 5.1 cm in width with evidence of attack, the site was not adequately treated. If there are more than 5 pieces larger than 24 cm in length and 5.1 cm in width per tree, with intact bark and evidence of attack, the site was not adequately treated.
4. Gather two buckets of chips per tree. Sample at least 10% of the trees at a site. Scoop chips into a 4 liter bucket from random places of the chip pile. If the chips are spread over a large area and not in discrete piles, collect a representative sample of the chips from the entire site.
- 5a. If using a screen with 5.1 cm mesh size: Run the collected chips through the screen. Rotate the chips caught on the screen to allow all chips that fit through the holes to fall through. Count the number of chips with bark and sapwood attached that do not fall through the screen.

Table 1 Bark chip thresholds for acceptable control of MPB infested sites

Length	Width	Other criteria	Thresholds for acceptable treatment
Greater than 5.1 cm	Greater than 5.1 cm	Sapwood and bark attached	Leading Edge: 5 chips on average per 4 L bucket sample Holding Zone: 10 chips on average per 4 L bucket sample
Greater than 24 cm but smaller than 1 m	Greater than 5.1 cm	Sapwood and bark attached with evidence of attack	5 pieces per tree
Greater than 1 m	Greater than 5.1 cm	-----	0 pieces per site

5b. If using a disk 5.1 cm in diameter: Compare all chips in the bucket with bark and sapwood attached with the disk. If the chip is larger than the disk, test whether it exceeds the size of the disk in two perpendicular directions (i.e. in width and length). Count the number of chips exceeding 5.1 cm in both width and length. Average the number for all bucket samples. The thresholds for acceptable control treatment are the following (also see Table 1):

- Holding Zone: 10 chips with bark and sapwood greater than 5.1 cm in width and length
- Leading Edge Zone: 5 chips with bark and sapwood greater than 5.1 cm in width and length

6. If the average number of chips larger than 5.1 cm exceeds the threshold, collect the chips that exceeded 5.1 cm from each bucket and put them into a plastic bag. Label the bag with the site number and sample number, e.g. 1734-1.

7. Assess the following:

a. Control tree(s) not controlled to standard

- » Pink flagged not felled, flown or controlled to standard

Reasons pink flag trees are considered not controlled to standard:

- Tree not controlled to a 10 cm top
- Stump not treated above 30 cm
- Chips exceed size/quantity threshold - include comments

b. Other areas of concern

- » Incidental tree (>10 cm dbh) not limbed to lie flat or not bucked into 8' sections
- » Stump of control or incidental tree >30 cm height
- » Danger tree located on site or at burn pile location
- » Stump of incidental tree not marked with a chainsaw "I"
- » Chip mat exceeds 10 cm depth
- » Garbage located on site

c. Ground Rule Standards

- » Watercourse crossing not installed or removed as per ground rules
- » Rutting or ground disturbance exceeds ground rule standard

d. Data entry and data management

- » Scanning and posting of cards (>24 hr)
- » Database entry timeline (>24 hr)
- » In progress sites not marked complete within contract specific timeframe

8. Indicate deficiencies on the Control Quality Inspection data sheet.
9. Where applicable, hang yellow pest management flagging at the location where the deficiency is located. Indicate in writing on the yellow flagging what deficiency was found.
10. If there are any trees with current attacks that were not flagged by the survey crews, record the information on the Survey Quality Inspection data sheet, not on the Control Quality Inspection data sheet.
11. QI will only call for a follow up survey in the following situations:
 - a. Control tree(s) not controlled to standard
 - b. Incidental tree (>10 cm dbh) not laid flat on ground
 - c. Chip mat exceeds 10 cm depth
 - d. Watercourse crossing not installed or removed as per ground rules
 - e. Rutting or ground disturbance exceeds ground rule standard
 - f. Stump of control or incidental tree >30 cm height
 - g. Garbage on site

Instructions for filling in the Control Quality Inspection data sheet

1. Name of the Project you are working on, e.g. Willmore or Kananaskis.
A project is a geographically defined area that contains several Infestations.
2. The beetle year begins August 15 and spans until August 14 the following year.
3. Name of corporate area, e.g. Foothills (SW3) or Clearwater (SW2).
4. The Project Manager is usually the Forest Health Officer for the corporate area.
5. The date (calendar year) the survey was conducted (yyyy mm dd)
6. Indicate if you are a GOA employee, or if you work for GOA under a contract. Provide your contract number or company name.
7. Indicate full name(s) of inspector(s).
8. The Infestation will be assigned by the Project Manager, e.g. Smoky River in the Willmore Project or Spray Lakes in the Kananaskis Project
9. Site Number, e.g. 4
10. Circle appropriate status of plot.
11. Indicate the appropriate control type.
12. Mark number of control trees not felled, not flown, or not controlled.
Mark number of missed (+) or excess (-) trees. Mark # of stumps not treated above 30cm.
- 13-15. Check boxes for any of the listed deficiencies, as well as the number of occurrences. Provide comments.
16. Provide further details in the comments field, including presence of smouldering burn pile.
17. Check the box if no deficiencies found or follow up required.

Mountain Pine Beetle Level 1 Concentric Control Quality Inspection (QI)

Project Name: _____ **1** **Beetle Year:** 2 **17**
Corporate Area: _____ **3** **Project Manager:** _____ **4** No deficiencies **17**
Inspection date: 5 / 11 / 11 **Contract #/Company Name:** _____ **6** Follow up required
Inspector 1: _____ **7** **Inspector 2:** _____
Infestation: _____ **8** **MPB Site #:** _____ **9** **10 Control site status (circle):** In Progress / Complete
Control type (circle): **11** Conv. fall & burn Conv. fall & peel Rotary wing assisted fall & burn Mechanical fall & burn Whole tree chipping Other

TREATMENT TREES NOT CONTROLLED TO STANDARD

# Pink Flag Trees Not Controlled		# Additional Trees Missed (+) or Excess (-)		# of Stumps (over 30cm) Not Treated Properly	
(Not Filled)	(Not Filled)	Controlled	Failed	Flown	Controlled

Reasons pink flag trees are considered "(Not) Controlled":

- Bark and cambium not completely destroyed (if burning)
- Bark still attached (if peeling)
- Debris not disposed of according to instructions (if peeling)
- Tree not controlled to a 10 cm top
- Chips exceed size/quantity threshold (if whole tree chipping) - include comments

GROUND RULE STANDARDS (Specific to mechanical or chipping operations)

Type	Check if applicable	Number of Occurrences
Type 14 Watercourse crossing not installed or removed as per ground rule standard	<input type="checkbox"/>	
Rutting or ground disturbance exceeds ground rule standard	<input type="checkbox"/>	

DATA ENTRY MANAGEMENT

Type	Check if applicable	Number of Occurrences
Type 15 Scanning and posting of cards (>24 hr)	<input type="checkbox"/>	
Database entry timeline (>24 hr)	<input type="checkbox"/>	
In progress sites not marked complete in given time	<input type="checkbox"/>	
Mechanical GPS tracklogs not submitted in given time	<input type="checkbox"/>	

COMMENTS **16**

Smouldering burn pile	<input type="checkbox"/>

OTHER AREAS OF CONCERN

Type	Check if applicable	Number of Occurrences
Type 13 Burn pile located on a watercourse	<input type="checkbox"/>	
Scorched or damaged tree not felled and laid flat on ground	<input type="checkbox"/>	
Incidental tree (>10cm dbh) not laid flat on ground	<input type="checkbox"/>	
Incidental tree (>10cm dbh) within the plot not burned to 10cm top (mech and RW assist only)	<input type="checkbox"/>	
Stump of treatment or incidental tree >30cm height	<input type="checkbox"/>	
Danger tree located on site or at burn pile location	<input type="checkbox"/>	
Stump of incidental tree not marked with a chainsaw "I"	<input type="checkbox"/>	
Chip mat exceeds 10 cm in depth	<input type="checkbox"/>	
Garbage located on site	<input type="checkbox"/>	

2. Aerial Survey Quality Inspection

Goal

Inspectors should follow closely behind the crews to determine if there are any deficiencies in detection or accuracy.

Timing

While surveys are ongoing.

Equipment

GPS, compass, map

Camera

Knife/hatchet

Procedure

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. 100% of the area identified by the Project Manager must be surveyed. Determine the extent of the surveys by creating and reviewing a map with the identified area and surveyor track logs. Area GIS support may be necessary for mapping.
3. 10% of the sites/area respectively must be surveyed. The Project Manager will randomly determine the location of the sites to be inspected.
4. Assess the following from the air:
 - Were there sites missed?
 - Are tree counts and locations accurate?
 - Do the polygon boundaries encompass all the infested trees?
 - Is the polygon infestation level accurate?
 - Do the sites GPS'd follow instructions from Project Manager regarding the number of trees to survey?
5. If deficiencies are found, 5 – 10 additional sites of that surveyors sites will be audited. If all additional sites fail, that surveyor will be removed from the survey project. That surveyor must be replaced with another certified surveyor. If less than all the sites fail, corrective action or removal from the project will be at the discretion of the Project Manager.

6. The Quality Inspector will record missed patches of red and/or fading trees. If deficiencies are found, corrective action or removal from the project will be at the discretion of the Project Manager

Performance Measures

1. Detection Accuracy
 - Only patches of three (3) or more fader trees are to be detected unless the Provincial Designate directs surveyor to detect one (1) or two (2) fading tree patches.
 - Based on the Province's quality inspection of 10% (minimum) of the spots/polygons detected by the Contractor, the number of missed and/or excess spots must not exceed 7% of the total checked.
2. Spatial Accuracy
 - GPS locations of spots must be within +/- 30 meters.
 - Based on the Province's quality inspection of 10% (minimum) of the spots detected by the Contractor, the number of inaccurate spot locations must not exceed 5% of the total checked.
3. Tree Count Accuracy
 - The accuracy of fader tree counts in spot infestations is relative to the number of faders in the spot as follows:
 - » 1 or 2 trees - +/- 0 trees
 - » 3 - 5 trees - +/- 1 tree
 - » 6 – 10 trees - +/- 2 trees
 - » 11 – 15 - +/- 3 trees
 - » 16 - 24 trees - +/- 5 trees
 - » 25+ - +/- 10 trees
 - Based on the Province's quality inspection of 10% (minimum) of the spots detected by the Contractor, the number of spots with inaccurate fader tree counts must not exceed 10% of the total checked.
4. Ground Truthing
 - A minimum of 1% of spots/polygons up to a maximum of 5% must be ground truthed for mortality agent. The Provincial Designate will set the sampling percentage prior to beginning the survey
5. Polygon Mapping
 - Polygon boundaries must encompass all fading/red trees
 - Polygon infestation severity is the percent affected pine in the polygon, not the percent of the total polygon
 - Polygon infestation severity estimated must be within +/- 10%

3. Green:Red Quality Inspection

Goal

Inspectors should follow closely behind the crews to determine surveys are being completed correctly.

Timing

While survey operations are ongoing.

Equipment

GPS, compass, map

Data sheets

Black permanent marker and pencil

Camera

Knife/hatchet

Procedure

1. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
2. Access site as per data sheet.
3. Locate plot centre.
4. Survey all pine trees within a 50m radius concentric plot around plot centre and assess:
 - Both Green and Red tree counts accurate to:
 - » ~ 1 - 4 trees: +/- 1 tree
 - » ~ 5 - 10 trees: +/- 2 trees
 - » ~ 11 - 24 trees: +/- 3 trees
 - » ~ 25+ trees: +/- 4 trees
 - Green tallied trees are greater than 15 cm at DBH, have more than 40 entrance holes, and contains living brood/beetles to be considered a successfully attacked tree.
 - 10%, up to a maximum of 10 trees, of the successfully attacked trees were examined for beetle presence, life stages present, and to define the year of attack.

Population Monitoring Procedures

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1. Spring Population Forecast (r-Value) Survey

Goal

To identify MPB population trends by determining r-value which is a measure of the rate of increase of a population.

Equipment

GPS, compass and map
Knife, hatchet
DBH tape
6-10 power hand lens
Cordless power drill
4 inch hole saw bit (Figure 1)
Spare drill (Figure 1)
1 inch wood chisel
Hammer
Snow probe
Shovel
Large storage bag (backpack)
Sandwich bags
Leather gloves
Eye protection
Ear protection
Black permanent marker and pencil
Data sheet



Figure 1. Cordless power drill with hole saw bit. Ensure the pilot auger extends $\frac{1}{2}$ inch beyond the hole saw bit.

Procedure

1. Sites selected for population forecast surveys are determined by the Project Manager with direction from the Forest Health Specialist.
2. The number of disks to be taken depends on the size of the site/patch. Take disks from trees at least 10 meters from the edge of the stand. Sampled trees should be contained in an area of 50 m radius, i.e. the maximum distance between trees sampled at a site should not be more than 100m.
 - If less than 10 trees per site, sample them all
 - If 10-29 trees per site, sample 10 of them
 - If 30 - 49 trees per site, sample 15 of them
 - If > 50 trees per site, sample 20 of them
3. Randomly choose trees that are at least 15 cm in diameter.
4. Avoid sampling trees with woodpecker activity (Figure 2). If no other trees are available, take samples as described in step 11 below.
5. Do not sample unsuccessfully attacked trees. Ensure that there are more than 40 entrance holes on the tree.
6. Measure DBH (cm) of tree and record on data sheet. Take the diameter reading at breast height (1.3m from the ground). If necessary, use a snow probe to determine ground level and use shovel to dig down to 1.3m from the ground.



Figure 2. Avoid sampling trees with woodpecker activity.

7. Indicate whether DBH height (1.3m) is above or below the snow line by circling appropriate choice on data sheet.
8. Estimate height of last visible pitch tube on tree (m).
9. Estimate the number of hits on the sample tree and record on the data sheet.
10. At breast height (1.3m from ground), two disks are to be taken from each of the north and the south side of the tree, resulting in four disks per tree. Take one disk just above 1.3 m and one just below 1.3 m so the two sample spots are aligned vertically on the tree (Figure 3). When sampling the first tree, ensure there is a minimum of 1 entrance hole in one of the four disks collected from that tree. If necessary, move the drill up to 20 cm from DBH to capture a hole. There should be a minimum of 1 entrance hole collected per site, so once a pitch tube is collected in the first tree, all other trees should be sampled without purposefully choosing samples with holes. (Figure 4).
11. Do not take disks where bark has been damaged by woodpeckers. Take disks as far as possible from woodpecker damage but no further than 20 cm from DBH. Make a note on the data sheet if disks were collected from a tree with woodpecker damage.
12. Using drill and 4 inch hole saw bit, drill out a sample of bark and wood approximately 2.0 - 2.5 cm ($\frac{3}{4}$ - 1 inch) deep (Figure 5). Note the following:
 - Ensure pilot auger extends $\frac{1}{2}$ inch beyond the hole saw bit (Figure 1). This will aid in ease of starting the cut.

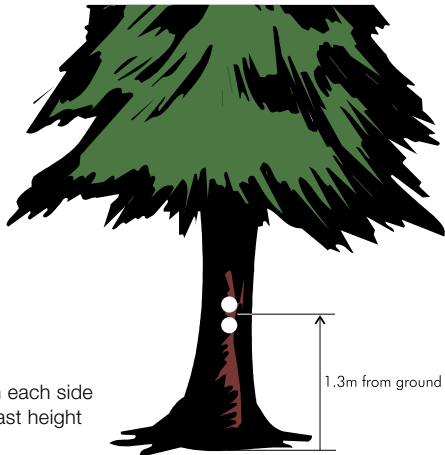


Figure 3. Take two disks from each side of the tree, one just above breast height (1.3m) and one just below.

Figure 4. Pitch tube within a hole saw cut. Take the samples such that there is an entrance hole in at least one of the four disks on the first sampled tree.



Figure 5. Taking a sample for population forecast survey



- Hole saw bit teeth will become clogged with fibre. Remove saw bit from cut and clean away fibre from teeth when halfway through the cut. Sawing will be more efficient.
13. Using chisel, remove wood 1 inch away from the edge of the cut, at approximately 10, 2 and 6 o'clock positions. Ensure depth of wood removed is equal to depth of hole saw cut. Invert chisel and wedge out disk (Figure 6).

14. Label disks with permanent marker indicating MPB site number, tree number, side of tree and disk number (Figure 7), e.g. MPB Site 105: 105-1-N-1, 105-1-N-2, 105-1-S-1, 105-1-S-2.
15. Hole punch sandwich bags to let air in. Place each disk into a sandwich bag. If the sample broke, place all pieces in a sandwich bag and label the bag.



Figure 6. Remove wood ¼ inch away from hole saw cut, loosen disk from sides and wedge out with inverted chisel.



Figure 7 Label disks with permanent marker.

16. Do not allow disks to warm and become cold again. Store in a cool (1-5 °C, in fridge), dark place until disks can be warmed and counted.

Counting Life Stages

17. Disks will be warmed and counted by a Forest Health Specialist.
18. If disks were collected at temperatures below -10°C, store disks in an area at temperature just below freezing for 48 hours prior to warming them to room temperature. Disks must be warmed to 15 – 20°C for a minimum of 5 days before counting MPB.
19. Once disks are warm, peel off bark and count the number of live and dead larvae, pupae and adults as well as entrance holes on each disk.
20. When determining if the larvae are live or dead, color and plumpness is not an accurate assessment method. They must move.
21. Do not count head capsules as dead larvae. A dead carcass must be attached to a head capsule to count as a dead larva.
22. Do not count larval galleries.
23. Live larva will be:
 - whitish
 - slightly curved
 - moist and firm
 - moving or move when probed with a sharp fine instrument
24. Dead larvae may be:
 - cream color or brown
 - bloated and still moist if recently dead
 - straight, not curved
 - not moving or does not move when probed with sharp fine instrument
25. Fill in the MPB Population Forecast Survey data sheet.
26. Enter data into database.

Instructions for Population Forecast Survey Data Sheet

1. Name of the Project you are working on, e.g. Willmore or Kananaskis. A project is a geographically defined area that contains several Infestations.
2. The beetle year begins August 15 of the current year and spans until August 14th the following year.
3. Name of corporate area, e.g. Foothills (SW3) or Clearwater (SW2).
4. The project manager is usually the Forest Health Officer for the corporate area.
5. The date (calendar year) the survey was conducted.
6. The Infestation will be assigned by the Project Manager. E.g. Smoky River in the Willmore Project or Spray Lakes in the Kananaskis Project.
7. Record the MPB Site Number, e.g. 105.
8. If you work for GOA under a contract, indicate your contract number or company name. If you are a GOA employee record your name.
9. Indicate number of trees with more than 40 MPB hits within the 50m radius plot.
10. Indicate elevation in meters.
11. Indicate snow depth in cm. If no snow, record a "0".
12. Record aspect in degrees. If site has no aspect, record "flat".
13. Describe site features and how to get to it from the access, e.g. walk 50 m north from helipad.
14. Circle the main means of access.
15. Measure latitude and longitude of helipad location or other access point. Set your GPS to NAD83 and measure in degrees/minutes/decimal minutes (hddd°mm.mmm').
16. Record GPS location of concentric plot centre using NAD83 and degrees/minutes/decimals (hddd°mm.mm'). If a transect area, walk to the centre of the trees sampled and GPS the location using NAD83 and degrees/minutes/decimal minutes (hddd°mm.mmm').
17. Record the sample tree number, e.g. 105-1 for the first tree sampled at site 105. Sample tree # shall be in sequence as a method to ensure no trees are missed.
18. Record the MPB tree number assigned during ground survey, e.g. 2020-105-1 in a concentric survey plot with site number 105, or 2020 4-2-1 for the first tree along transect line 2 at site 4.
19. Measure DBH (diameter at 1.3m from the ground) with DBH tape.
20. Check green if majority of foliage on tree is green or yellow. Otherwise check red.
21. Estimate the height of the last visible pitch tube in meters.
22. Indicate approximately how many hits are on the sample tree.
23. Leave blank when collecting samples, Forest Health Specialist enters counts of life stages and holes for each disk.
24. Record any additional comments about tree. E.g. larval gallery development but no larvae present; bottom 2m of tree peeled after sampling completed; lps present etc.

Mountain Pine Beetle Population Forecast Survey

Project Name: <u>1</u>		Beetle Year: <u>2</u>							
Corporate Area: <u>3</u>		Project Manager: <u>4</u>							
Survey Date: <u>5</u> / <u> </u> / <u> </u> <small>Year Month Day</small>		Infestation: <u>6</u> MPB Site Number: <u>7</u>							
Contract # / Company Name GOA Crew #, or GOA Employees Names: <u>8</u>		# infested trees <u>9</u> Elevation <u>10</u> m							
		Snow depth <u>11</u> cm Aspect <u>12</u> °							
Site/Location Description: <u>13</u>		Access: <small>(Circle one)</small> <u>14</u> Heli OHV Truck Other _____							
Access Location: <small>(Degrees minutes decimal)</small> <u>15</u>		Plot Center: <small>(Degrees minutes decimal)</small> <u>16</u>							
Lat <u> </u> <u> </u> <u> </u> Long: - <u> </u> <u> </u> <u> </u>		Lat <u> </u> <u> </u> <u> </u> Long: - <u> </u> <u> </u> <u> </u>							
Sample Tree # <u>17</u>									
MPB Tree Number <u>18</u> DBH <u>19</u> cm		Foliage: green <input type="checkbox"/> red <input type="checkbox"/> <u>20</u>							
Height of last pitch tube <u>21</u> m		#hits [40-70 70-100 >100] <u>22</u>							
Sample	# Larvae		# Pupae		# Brood Adults		# Parent Adults		# Entrance Holes
	Live	Dead	Live	Dead	Live	Dead	Live	Dead	
North Sample 1									
North Sample 2									
South Sample 1									
South Sample 2									
Comments <u>24</u>									
Sample Tree # _____									
MPB Tree Number _____		DBH _____ cm		Foliage: green <input type="checkbox"/> red <input type="checkbox"/>					
Height of last pitch tube _____ m		#hits [40-70 70-100 >100]							
Sample	# Larvae		# Pupae		# Brood Adults		# Parent Adults		# Entrance Holes
	Live	Dead	Live	Dead	Live	Dead	Live	Dead	
North Sample 1									
North Sample 2									
South Sample 1									
South Sample 2									
Comments									

Only count beetles and/or stages that are predicted to fly this year.

2. Green to Red

Goal

To determine the ratio of trees attacked in the current year to those attacked in the previous year. This ratio can indicate status of local populations, identify if immigration is occurring, and help predict numbers of currently infested trees for control operations.

Equipment

GPS, compass and map
Knife/hatchet
Diameter tape
Red pest management flagging tape
Black permanent marker and pencil
Data sheet

Survey Procedure

1. The area to be surveyed and the density of survey sites at the landscape level are assigned by the Project Manager.
2. Survey sites should have 3 or more fading/red trees. If only sites with 1 or 2 trees are available, still conduct a survey, but make note in comments.
3. Sites are to be numbered uniquely within infestations. For example, Waskahigan may contain site 1,2,3, etc. and Rat may contain site 1,2,3, etc.
4. Set GPS to NAD83 and collect data in degrees/minutes/decimal minutes (hddd°mm.mmm'), e.g. N51°11.055' latitude, W116°21.101' longitude.
5. Use GPS location provided by the Project Manager to find the plot centre. If the GPS location was derived during a Heli-GPS survey, it will be associated with a red or fading tree.
6. If GPS point is not close to red/fading trees, do a 25 meter sweep to locate red/fading trees. If red/fading trees at the GPS point is a non-MPB tree the Project Manager may identify an alternate site.
7. Choose a fading/red tree to be the Plot Centre and flag the tree with red Pest Management tape.
8. Label the flagging with the beetle year, site number (The Project Manager will give instructions on numbering sites), and the words "PLOT CENTRE".

9. Take the GPS location of the plot centre and record it on the data sheet. Record the positional accuracy.
10. Survey all pine trees within the 50m radius concentric plot around plot centre.
11. Count and record the number of currently attacked trees within the concentric plot.
12. Currently attacked trees are those trees that are greater than 15 cm at DBH, have more than 40 entrance holes, and contains living brood/beetles. Trees that have been wood-peckered and meet these criteria will be counted. Include details in comments if site has a high incidence of >1 year old pitch tubes, or if needles of attacked trees are primarily red in color.
13. Record the number of currently attacked trees in the Current Attack column.
14. Previously attacked trees are those which produced the currently attacked trees, are greater than 15 cm at DBH, and will be tallied in the Old Attack column.
15. The number of previously (old) attacked trees is to be determined from aerial survey results. If no aerial survey was conducted in the area, determine the trees that were attacked the previous year by considering the red needle color, the amount of needle retention, bark and wood condition and the presence of wood borers.
16. Of the successfully attacked trees, 5% (at least one, up to a maximum of 10 trees) must be examined for beetle presence, life stages present, and to define the year of attack. Record notes on life stages in the comments field of the data sheet.
17. The Project Manager will specify a trigger for a reconnaissance survey. For example, if the G:R is 3 or greater additional plots may be required in the stand. Conduct a reconnaissance survey around the plot up to a maximum distance of 100m from plot centre. Start the reconnaissance survey around the quadrant with the most currently attacked trees.
18. If one or more currently attacked trees are found in the reconnaissance survey an additional plot needs to be surveyed.
19. If an additional plot is triggered, move the new plot centre 50 meters away from the edge of the parent plot. Move the plot centre in the same bearing from the parent plot centre to the tree(s) in the reconnaissance survey that triggered the additional plot. If the additional plot location does not meet a threshold of >25% pine composition (of stems >15cm) then the plot can be moved up to 50m in either direction while staying 50m from the parent plot edge. If a suitable location is not found it can be dropped with comments explaining the situation.

20. Number additional plots by using the parent site number and a letter. For example, if a currently attacked tree is identified in the reconnaissance survey around site number 4, the new site number will be 4A. When entered into the database data from these sites will be pooled.
21. The number of previously (old) attacked trees in the additional plots need to be determined from the ground. Assess whether the attacked trees died one year ago by considering needle color, amount of needle retention, bark and wood condition and the presence of wood borers.
22. A maximum of three concentric plots (parent plus additional) may be surveyed within the same stand. Write a note on the parent plot datasheet how many additional plots were surveyed.
23. If the G:R is unusually high and no currently attacked trees are found in the reconnaissance survey the Project Manager may identify another close stand to be surveyed.

Instructions for Green:Red Survey Data Sheet

1. Name of the Project you are working on, e.g. Willmore or Kananaskis. A project is a geographically defined area that contains several Infestations.
2. Name of GOA corporate area, e.g. Foothills (SW3) or Clearwater (SW2)
3. The beetle year begins August 15 of the current year and spans until August 14 the following year.
4. Record the Project Manager (generally the Forest Health Officer for the Area).
5. The date (calendar year) the survey was conducted.
6. The Infestation will be assigned by the Project Manager. E.g. Smoky River in the Willmore Project or Spray Lakes in the Kananaskis Project.
7. Survey Site Number, e.g. GR4.
8. Record the name of the person/people conducting survey and company name (if applicable).
9. Describe site features and how to get to it from the access, e.g. walk 50 m north from helipad.
10. Circle the main means of access.
11. Measure latitude and longitude of helipad/access location. Set your GPS to NAD83 and measure in degrees/minutes/decimal minutes (hddd°mm.mmm').
12. Measure latitude and longitude of the plot centre and positional accuracy using NAD83 and degrees/minutes/ decimal minutes (hddd°mm.mmm').
13. Record the number of trees with current year's attack.
14. Record the number of trees from previous year's attack.
15. Record the location of the trees included in the G:R using a • for current and an X for old.
16. Record any survey comment here, e.g. note if additional plots are associated with the (parent) plot.

Mountain Pine Beetle Green:Red Ratio Survey

Project Name: _____ 1 _____		Beetle Year: _____ 3 _____	
Corporate Area: _____ 2 _____		Project Manager: _____ 4 _____	
Survey Date: _____ 5 _____ yyyy mm dd		Infestation: _____ 6 _____	
		MPB Site Number: _____ 7 _____	
Contract # / Company Name; GOA Crew #, or Surveyor Names: _____ 8 _____			
Site/Location Description: _____ 9 _____		Access: (circle one) 10 Helij OHV Truck Other _____	
Access Location: (Deg Min Dec) _____		Positional accuracy: _____	
Lat: _____ 11 ± _____		Plot Center: (Deg Min Dec) _____	
Long: _____		Lat: _____ 12 ± _____	
		Long: _____	
Forked trees: count number of stems below DBH		Survey Comments	
Current Attack	Old Attack	16	
13	14		

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