

Best Practices for Managing Douglas-fir Beetle

Management Strategies and Tactics

Several approaches are available to reduce the amount of mortality caused by Douglas-fir beetle (*Dendroctonus pseudotsugae*; DFB) outbreaks. The impact of DFB is not limited to timber loss. Other values impacted by DFB outbreaks and its management include:

- cultural heritage;
- recreation;
- integrity of Old Growth Management Areas (OGMAs);
- fish and wildlife (e.g. mule deer winter range);
- landscape and aesthetics;
- range management; and,
- watershed management.

The level of directed management (beetle control) is dependent upon the values at risk. For DFB management to be effective, a series of activities must be conducted in a timely manner with the biology of the beetle in mind. Management strategies range from no management action and monitoring DFB with the Aerial Overview Survey results, to, targeted harvesting using trap trees and other tactics. Harvesting infested trees is the key tactic used to mitigate DFB populations. DFB harvest should always be planned over multiple years and can range from harvesting small blocks containing attacked trees only to large cutblocks that encompass old DFB attack, current DFB attack and green trees. Harvesting plus the use of trap trees is the most effective tool to manage DFB. Occasionally, other management tactics (e.g. attractive pheromones, anti-aggregants) are used in conjunction with harvesting or on their own. Methods of population monitoring, detection (aerial and ground), treatment selection and application, and other management activities for DFB are described in the following sections.

The key to successful management of DFB is to prioritize and have treatment commitments from stakeholders in areas where the beetle population is new and damage is constrained to spots or relatively small patches. Management activities must be timely (e.g. removal of infested material before next beetle flight) and the most appropriate treatment or treatment combination be selected.

Population Monitoring

Two types of surveys are conducted to determine DFB population trends. Population trends are evaluated in several ways, primarily through ground surveys. The trend is estimated by calculating the ratio of currently attacked trees to one-year-old (last year's) attacked trees, often referred to as "Green-to-Red" ratios. A ratio substantially >1 indicates an increasing population; substantially <1 indicates a declining population. This estimate, however, should be combined with bark sampling in the early spring after attack when the number and vigour (e.g. parasitism or other mortality factors) of new beetles can be evaluated. The number of new beetles can be compared to the initial attacking population.

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

Various researchers have concluded that the greatest density of successful infestation and the least variation in brood numbers was found between 5 meters and 20 meters on attacked trees and recommended that brood sampling be conducted within this zone.

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

$$r = \frac{\frac{(a + b)}{c}}{\text{no. trees examined}} \quad \text{where} \quad \begin{array}{l} a = \text{number of eggs and larvae} \\ b = \text{number of pupae and adults} \\ c = \text{number of galleries originating} \\ \quad \text{within sample area} \end{array}$$

The average per stand or larger geographic area (R-value) is calculated by summing “r” values and dividing by the number of sites sampled.

R-value for Douglas-fir beetle (used by Cariboo Region):

R value	Interpretation	
0 - 0.7	Population decreasing	
0.71 - 1.3	Population static	
> 1.3	Population increasing	

Detection

Aerial detection procedures

There are three types of aerial surveys: overview, detailed and reconnaissance. These surveys are necessary for monitoring the incidence and severity of pests on the landscape, as well as for monitoring change over time.

The provincial aerial overview survey is the cornerstone of forest health monitoring in B.C. Like most forested jurisdictions across North America, B.C.’s annual aerial sketch mapping is done to record the location and severity of forest disturbances that are visible from the air. Combined with records from the Canadian Forest Service dating back to 1914, B.C.’s aerial

overview survey data provide invaluable historical information on the patterns of disturbance across the provincial forested land base. Information from aerial overview surveys is used to help understand the impacts of forest pests or other disturbances, and can highlight changing trends over time.

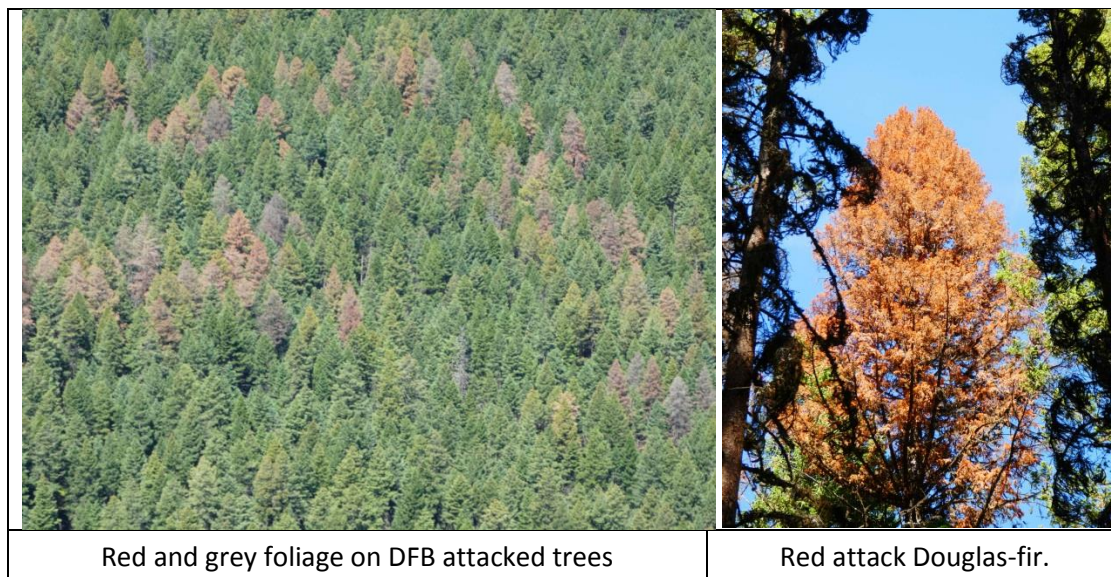
Aerial overview surveys are usually done from fixed-wing aircraft flown at 500 to 1,000 metres (1,500 to 3,000 feet) above ground level, and at speeds of 100 to 140 knots (185 to 260 km/hr). The survey is designed to cover as much area as possible, while retaining the ability to identify and map infested stands at map scales of 1:100,000 to 1:250,000. They also indicate where detailed surveys are required (<https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys>).

Damaging agents are usually identified using:

- unique damage characteristics;
- prior knowledge of pest activity; and,
- ground survey verification.

In areas where additional, much more spatially accurate data are required to direct operational activities, detailed aerial surveys may be performed.

Detailed surveys are performed in areas where more spatially accurate data are required to direct operational activities. Detailed surveys are performed by District staff, licensees or contractors using rotary wing aircraft (helicopters) and Global Positioning System (GPS) navigation equipment. They may also be conducted using a map with a scale of 1:40,000 or 1:50,000 and a satellite or photo-base.



Purpose and protocol

The main purpose of a detailed survey is to guide operational activities such as sanitation harvesting and trap tree programs in the region; therefore, the preference for end-users of these data is to have active infestations mapped as spots. Spot infestations are collected as point

features. A spot is defined as 3 to 50 fading to red trees within an area less than 3 hectares that is greater than 200 meters from another infestation.

Larger continuous patches will be mapped as polygon features only if the attack severity (mortality) within these polygons is $\geq 30\%$ and the infestation is clearly continuous. If there are numerous active infestation centres (fading) within a possible polygon, the preference is to map the mid-point of these centres as spots. Mapped polygons will be provided as digital polygon data in shape file format.

The following information is collected for each located and mapped Douglas-fir beetle infestation:

- a) Site number – unique number that will not change;
- b) Mapsheet number;
- c) District identifier (e.g. DCC for Central Cariboo; DMH for 100 Mile House);
- d) UTM coordinates;
- e) Forest health factor: DFB (Douglas-fir beetle), or other if identified;
- f) Spot or polygon;
- g) Number of fading trees (recent attack) and last year's red attack in spot infestation;
- h) Spot or polygon area. For 3-30 tree spots use 0.25 ha; for 31-50 tree spots use 0.5 ha;
- i) Polygon severity: only fading and red trees are included (do not count grey trees) as an estimate of percent infested within a mapped polygon, using the following severity codes.

Severity Code	Current Attack Severity (% attack)
0	Codes excluded
1	
2	
3	31-40
4	41-50
5	51-60
6	61-70
7	71-80
8	81-90
9	91-100

Planning and timing

Detailed aerial surveys for DFB can begin in the southern regions of the province as early as June (dependent upon annual weather and progression of foliar fade) and in July in the northern regions. Flight times should be limited to 5 hours per day to reduce error due to fatigue. Surveyors should be equipped with suitable GPS units, tablets or laptops, notebooks, maps and camera.

Check the weather to ensure that there will be good visibility and a minimum ceiling of about 1,000 metres. Clear days are preferred since red foliage is most visible for both observation and photography. Flight conditions are often unstable after 13:00 hours, so try to arrange flights for

the morning. Shadows caused by the angle of the sun can obscure features early or late in the day, especially in areas of significant relief.

Flight lines are usually run parallel over level terrain. Over mountainous terrain, flight lines must be adapted to suit the terrain. Flight lines should be placed closer together over moderate or severe infestations. The Forest Health Aerial Overview Survey Standards for British Columbia can be found on the following web site:

<https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys/methods>

Detailed aerial surveys or Heli-GPS surveys are used to accurately locate, map and later assess all red and yellow/fading DFB in a delineated survey area. Map tracking software should be used during detailed aerial survey flights to ensure adequate coverage. Each survey will result in a single flight track, spot and polygon infestation shape files and dbf, shp, shx and kmz files. Heli-GPS surveys provide GPS coordinates for detected centres of red attack with a horizontal accuracy of approximately 20m.

Minimum standards for detailed surveys for DFB are:

Symbol	Data description
X	For single trees, or for polygons estimate the number of red trees (or grey if needed)
L (light)	0-5% of total stems affected in the stand
1	6-15% of total stems affected in the stand
2	16-30% of total stems affected in the stand

Surveyors conducting Heli-GPS surveys must be able to identify both the number and location of individual red (or fading) tree crowns, and the species of tree killed (if other than Douglas-fir). The final product of a Heli-GPS survey shall be a map (and GIS files) showing:

- pest codes;
- location(s) of red attacked trees;
- tree counts (if spots, +/- 10%) or severity (if polygons +/- 5%); and,
- GPS coordinates adequate to allow ground crews to find the centre of an infestation site with +/- 25m accuracy.



Infestations will be depicted as either points (spots) with tree counts or polygons with infestation severity (in 10% increments). Detailed surveys are primarily point sources but when a larger attack polygon is observed the perimeter must be mapped and the attack severity noted.

Spatial Data Standards for Detailed Aerial Surveys are on the following web site:

<https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys/methods/standards-for-detailed-surveys>

Reconnaissance surveys are conducted in a fixed wing or rotary-wing aircraft (helicopters are the most commonly used for this type of survey). These surveys are typically done by Ministry staff (with interested stakeholders on-board). General reconnaissance surveys are essential for Ministry staff, licensees and other stakeholders in order to keep apprised and familiar with the current bark beetle and forest health situation. Aerial reconnaissance surveys can be conducted at any time during a field season and are typically of short duration (± 2 hours), area-specific flights, designed to gain specific information such as:

- timing of foliar fade for planning DFB detailed flights;
- terrain assessment (e.g. for operational purposes, access, environmental considerations);
- pre-planning for operational activities (e.g. trap trees, heli-logging, MCH); and,
- general familiarization of District/TSA bark beetle and forest health conditions.

Ground detection procedures

There are two levels of ground survey: general walkthroughs and probes. Both levels of survey are informative, yet vary in intensity, quality and quantity of data collected. Ground surveys are necessary to confirm information gathered from aerial surveys and to obtain information on the state of the infestation. Ground surveys gather data on the levels of current (green) attack, unsuccessful or strip attack, and amount of remaining susceptible host material.

Current attack (currently infested) trees are defined as trees that contain larvae, pupae or adult beetles. In many situations, current attack trees may be green, red or grey. Red and grey trees must be checked to determine if they contain larvae, pupae or adults. In the early spring before beetle flight, many red and grey trees may still contain beetles. After beetle flight in early summer, most red and grey trees should not have current attack (live beetles). By late-June and early-July the new current attack trees may begin to turn colour; however colour change is highly variable and full colour change can take 12-15 months after attack. By mid-winter approximately 50% of the current attack will be red and 15% will be grey.

Definition of terms used in ground surveys are listed below.

Current attack: A Douglas-fir containing any live DFB life stage (eggs, larvae, pupae, and adults) is considered “current”. Resin streaming may be visible on the upper bole and reddish-brown sawdust and frass will be visible in bark crevices and around the base of the tree. There are no obvious emergence holes and the phloem is still moist.

Strip attack: A Douglas-fir that has been attacked on one side only of the tree and has not been killed. Strip attacked trees contain DFB galleries and live DFB life stages.

Fill-in attack: A Douglas-fir that has been attacked but still has areas on the bole that are not attacked and the phloem is suitable. Since DFB often attacks higher on the bole, fill-in attack often occurs low on the bole later during DFB flight period.

Pitchout or unsuccessful attack: To be considered a ‘pitchout’ tree, the phloem must be pink and beetle galleries must be full of sap and “walled-off” by the tree (wound response). Pitchout trees do not contain any live DFB life stages.

Old attack: An old attack is a Douglas-fir from which all DFB have emerged. Old attacks are characterized by having dull red needles to no needles on the crown (grey); there may be

Cryptoporus fungi on the boles; numerous exit holes; dull brownish-red sawdust around the base of the tree; and, checks and sloughing bark. There will be no DFB life stages under the bark.

Foliage colour is not always an accurate indicator of whether there is live brood under the bark. Some Douglas-fir may be classified as “current” attack red or grey trees. This must be confirmed by physically chopping the bark to see if there are DFB life stages under it. Seasonal weather may influence foliage fade and strip attacks or fill-in attack may change the normal sequence of foliage fade.

Not all successfully attacked trees will have attack at DBH (diameter at breast height=1.3 m). Woodborer galleries at DBH are good indicators of successful DFB attack higher on the bole. In March and April, many red and grey trees, without much obvious external evidence of bark beetle emergence, will still contain beetles, and should be checked to ascertain whether beetles are present. “Late summer” flight-attacked trees will have overwintering larvae. *Cryptoporus* pouch mushrooms will become evident on trees infested during the previous year: common in the ICH (Interior Cedar Hemlock), and less common in the IDF (Interior Douglas-fir) biogeoclimatic zones.

Some currently infested trees begin to fade in September. About 90% of current attack will have green crowns in October-November. However, many trees lose their needles within a year (prior to the Aerial Overview Survey in late July), so detailed surveys should be done as early as possible (April - June).

		
<p>Fresh reddish-brown frass on current attack</p>	<p>New adult DFB in pupal chamber</p>	<p><i>Cryptoporus</i> fungi on old attack</p>

Walkthroughs are non-systematic preliminary ground reconnaissance surveys done by Regional, District or licensee staff, prior to probes being done. Walkthroughs locate and delineate spatially discrete pockets of infestation and determine the general vigour of the DFB population (e.g. attack density, parasitism, mass attack vs. strip, or unsuccessful attack). They will determine if a more detailed survey is required and potential management options.

Collect or estimate the following information during a walkthrough:

- attack levels (current and past) and pattern (dispersed, small clumps);
- stand characteristics (age, size, density, amount of windthrow, if any);

- values at risk;
- merchantability;
- treatment prescriptions; and,
- DFB vigour.

Probes are systematic surveys through a stand, designed to locate infested trees. Probes continue through a stand until no more infestation is noted (or a pre-determined distance beyond the last infested tree is reached) or there is a timber type change. Probes collect more detailed stand and infestation data than walkthroughs. There are two types of probes done to locate DFB: star probes and grid probes.

Star Probe:

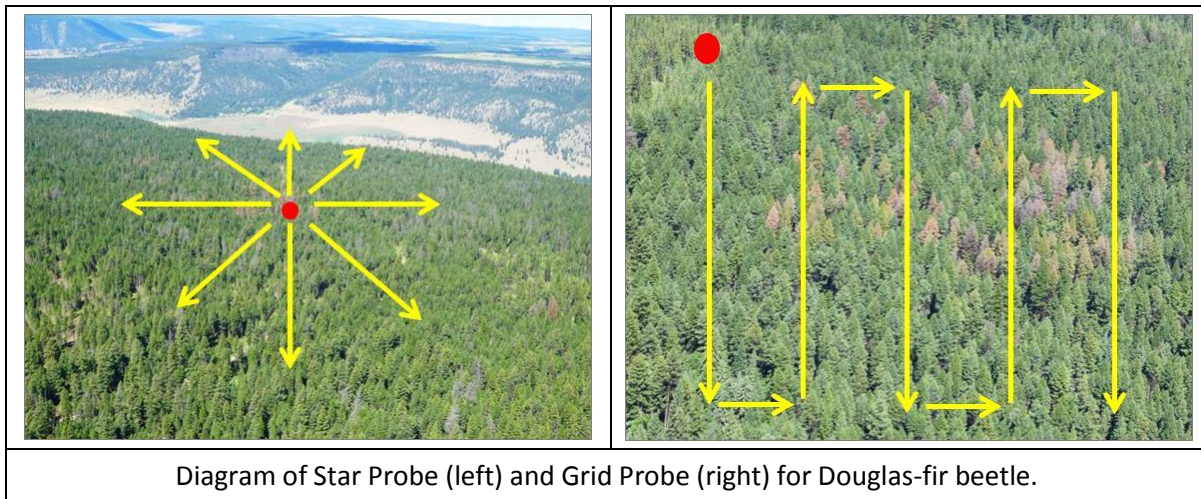
- start probe at mapped infestation centre (red, green & old attack);
- work around centre looking for current attack;
- search at least 50 m (up to 300 m) beyond the last current attack found; and,
- GPS all current attacks.

Grid Probe:

- survey throughout infestation centre or interest area;
- uniform survey lines 50 m to 100 m apart;
- probe lines (strips) are a minimum 5 m wide;
- walk through and beyond attack centre looking for current attack; and,
- GPS all current attacks.

Ground survey data are used to delineate infested areas and make management decisions. Data that should be collected and tallied for each infested polygon include:

- location of probe or walkthrough lines and intensity of attack;
- size of the infested polygon surveyed;
- stage(s) of beetles under the bark (egg/larva/pupa/adult); ratio of different stages; and, relative brood success (check on average 1 green attack tree per 100 m of survey);
- percentage of various attack categories (current attack vs. old attack);
- rate of spread;
- amount of susceptible host remaining;
- average diameter of susceptible host remaining;
- total stems per hectare;
- estimate of the operability;
- access;
- potential other resource use issues or constraints; and,
- other forest health agents which may influence the final prescription (e.g. root disease, defoliation).



Recommended ground survey method based on infestation ratings gathered from aerial surveys.

Aerial survey rating	Recommended ground survey method
<5% visible attack	Thorough walkthrough of area to delineate and evaluate recent (current) attack
5-25% visible attack	Full probe of area if harvestable
26% and greater visible attack	Walkthrough of area to verify status of beetle population

Treatments

Trap Trees

Trap trees are used to reduce overall beetle population levels and are used in conjunction with, and following other treatments used to manage DFB, such as harvesting and single tree treatments. Trap trees are large, healthy Douglas-fir trees that are felled into the **shade** to attract DFB. Trap trees attract and absorb emerging beetles and must be removed after the end of beetle flight. Use one trap tree for every four standing current attack. Falling more trees than this can provide excessive host material and can actually increase or maintain the beetle problem if not managed properly. When trap trees are removed from the site, DFB are killed during timber processing. Trap trees mop up beetles emerging from windthrow, stumps, and slash, thereby protecting adjacent healthy timber.

Guidelines for trap tree site location, tree selection and removal:

- select and place trap trees as close to the infestation as possible;
- fall one trap tree for every three to four currently attacked trees. Green windthrown trees already present on-site may be used as trap trees, thereby reducing the number of trap trees required (if both felled trap trees and windthrow are removed post-beetle flight);

- trap tree diameters should be greater than or equal to 30 cm;
- trap trees should be cut prior to beetle flight in early spring (by April 1);
- in chronic beetle areas, or stands with scattered beetle populations, grid with groups of trap trees at 400 m to 600 m intervals;
- optimally, trap trees should be cut in groups of minimum 3-5 trees;
- trap trees should be felled into the **shade** in such a way as to facilitate removal or subsequent treatment (trap trees left in direct sun do not attract beetles as well as those in a shaded environment);
- trap trees should be left unlimbed and unbucked;
- trap trees should be left on-site until at least mid-July to attract beetles throughout their flight period;
- pre-felled rights-of-way, landings and skid trails can be used as trap trees to absorb beetle populations. Due to the large volume of timber felled during these operations, improper shading should not impede the effectiveness of control;
- large openings **should not** be created at trap tree sites;
- remove trap trees as early as possible after beetle flight (late summer – early fall). If infested logs are not removed prior to beetle emergence, tree mortality will increase; and,
- probe trap tree sites for spillover/overflow attack in adjacent standing trees before trap tree extraction and mark these attacked trees for removal. Trap trees should be removed as soon as practical following beetle flight but certainly before the next generation of beetles fly the following April 1.



Douglas-fir beetle attack on trap tree.

Sanitation Harvesting

Sanitation harvesting maximizes the removal of currently attacked Douglas-fir in order to reduce the existing population and inhibit the expansion of the infestation. All trees containing beetles (typically green crowns and newly faded red crowns) should be harvested and milled prior to adult emergence (April onward). Harvest priority should be given to active beetle infestations

and adjacent high hazard stands. Various harvesting methods may be used to remove infested trees. Harvesting and trap tree programs must be planned over multiple years (minimum two years).

Sanitation harvesting must-do's:

- Remove all currently infested trees and mill logs before beetle flight (April);
- Avoid mechanical damage (scars, root damage, and broken tops) to residual trees as this will attract beetles;
- Keep stumps as low as possible, with a maximum height of 30 cm. Stumps greater than 30 cm should be peeled;
- Remove, destroy, or peel bark off all debris containing beetle progeny if it is greater than 20 cm in diameter and greater than 2 m in length;
- Do not long butt or top in the bush. Tree length logging is preferred. If, however, damage to residuals or regeneration is foreseen, topping and bucking trees in the bush is acceptable, but should not be greater than 10 cm diameter;
- Eliminate all infested material from sanitation sites;
- Burn all debris piles completely before beetle flight; and,
- Remove all infested decked logs and windthrow for milling before beetle flight (April).

Residual stands and/or trap tree sites should be monitored to ensure all infested material is eliminated. Residual stands and trees injured during harvesting and road construction should be marked, monitored and infested trees removed. A study comparing the survival of DFB in peeled and unpeeled logs and stumps concluded that peeling logs reduced beetle populations, particularly if done early in the summer. Also, DFB survival in unpeeled stumps was good and in the study it was estimated that it would take beetles emerging from 24 stumps to kill one tree.

N.B. If you want to use DFB-infested trees for firewood, peel off all bark and leave the cut wood exposed over the winter to kill the beetles. DFB can survive in wood that has been sheltered from the elements and could emerge to attack nearby trees the following spring if this procedure is not followed.

MCH

Anti-aggregation pheromones can successfully repel DFB from vulnerable areas and can be used to help protect small, groups of high-value trees. The anti-aggregation pheromone MCH (3-methylcyclohex-2-en-1-one) is used to disrupt or prevent beetle attacks. Through its application, DFB attacks have sometimes been reduced by over 90%. It is most effective when the number of infested or susceptible trees is low and it is applied prior to the annual beetle flight (typically in mid to late April) on windthrown trees; large, susceptible trees (veterans); and damaged or severely stressed trees.

In a stand, place MCH bubble caps on the north side of trees, as high as possible, at a 10m x 10m spacing. To protect individual trees, place two bubble caps on the tree (opposite sides).

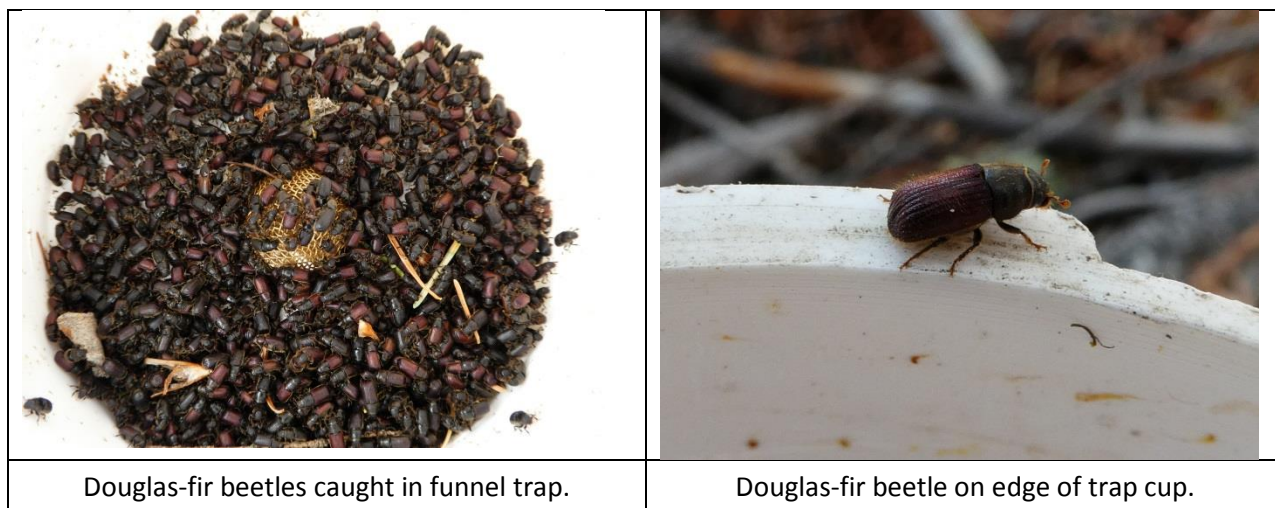
Mass Trapping Douglas-fir beetle

Mass trapping employs clusters of funnel traps baited with lures containing Douglas-fir kairomone, frontalin, ethanol and seudenol to attract and capture large numbers of DFB. The objective of mass trapping is to absorb DFB adults emerging from nearby currently infested Douglas-fir and reduce attacks on adjacent susceptible trees. This tactic is meant to compliment other management strategies and tactics such as sanitation harvest, fall and burn, or deployment of trap trees. Mass trapping with funnel traps can be used as a “mop-up” tool after sanitation harvesting, or in conjunction with MCH repellent in a “push-pull” operation. Serviced funnel traps do not become “saturated” (unlike trap trees) and can continue to capture beetles throughout the flight period. It is estimated that it takes about 1,700 beetles (1:1 ratio of females and males) to kill a tree. Therefore, if 100,000 DFB were trapped near susceptible trees, an infestation could be reduced by about 59 trees.

Mass trapping with funnel traps can be used in areas where logging and/or felling and retrieval of trap trees is not possible because:

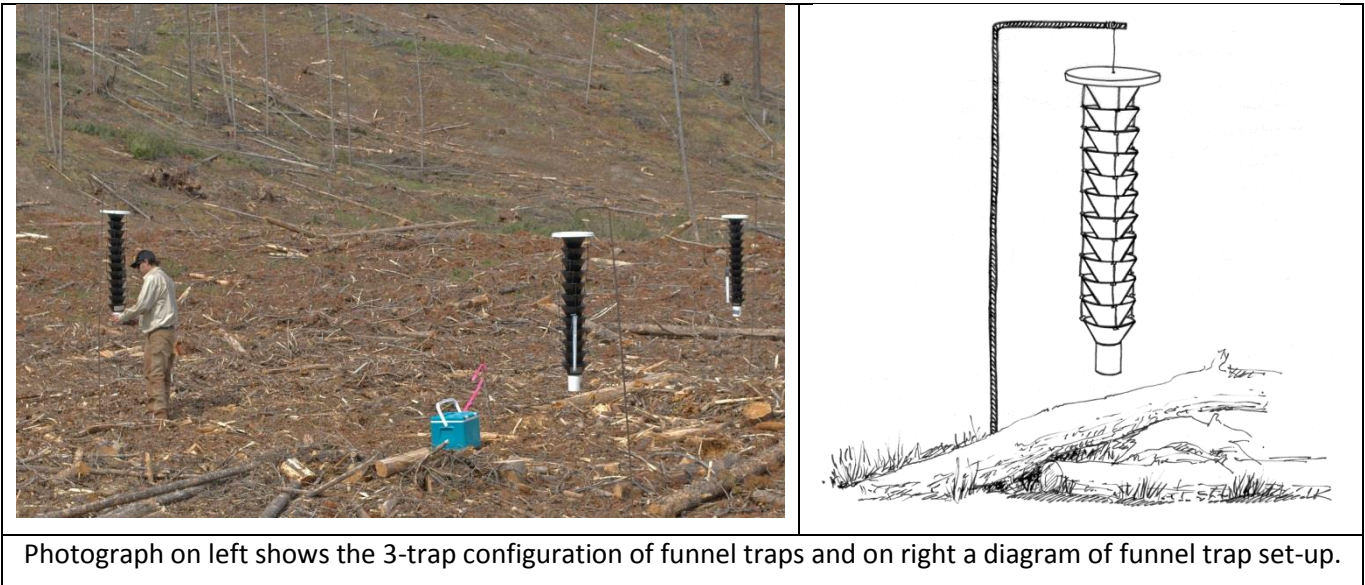
- Major licensees are not operating in the infested area;
- There is no current market for small scale salvage operations;
- Terrain is inoperable or outside the timber harvesting land base; or,
- Infested area has other values, e.g. mule deer winter range, old growth management area, recreation trails, First Nations, and other.

Mass trapping requires that traps be “serviced” from set-up in April until takedown in late August-September. Therefore, placement of traps is critical and access must be considered when planning their location. Traps require bi-weekly servicing or more depending on the number of beetles flying. They are occasionally damaged by bears, cattle and vandalism; therefore, they must be checked regularly.



Trap set-up: Use a 3-trap triangle of baited Lindgren funnel traps, with inter-trap spacing at 5 to 10 meters. Use multiple-funnel traps (4 to >12-funnel traps can be used, dependent upon

supplier model) with a dry-cup, which will allow liquid to drain. Traps should be hung from rebar ($\frac{1}{2}$ inch conduit) poles bent at the top. The DFB trap lures should be hung on the inside of the traps and a piece of Vapona™ placed in the dry-cup. Vapona™ (Dichlorvos, domestic formulation) is usually sold in a “rubber” bar 2 inches wide x 6 inches long x $\frac{3}{8}$ inch thick, which can be cut into 10 pieces and then set with a thin wire to hang in the cups. The Vapona™ should be replaced periodically throughout the April through September trapping season. Pheromone lures should also be replaced in mid-June.



Trap set-up protocol

1. Trap sets must be at least 100 m from Douglas-fir trees in susceptible stand edges.
2. Traps set in cutblocks must be at least 200 m from standing residual trees, and even then, the standing trees should be protected with MCH.
3. Maintenance of traps weekly to every 2 weeks, depending on trap catch.
4. Trap sites exposed to knockdown by animals can be protected with “Critter Gitter Alarms”.
5. Hang lures on the outside of traps, at about $\frac{1}{3}$ or $\frac{1}{2}$ the height.
6. Lures must be replaced in the second week of June.
7. A “dry-cup” set up is easier to maintain and environmentally more manageable than “wet-cups”. Use pieces of Vapona™ to kill beetles in cups.
8. Place beetle collections into Ziploc™ bags (label with site and collection date). Freeze 24-48 hours to ensure all beetles are killed.



9. Move trap sets that are not catching beetles to another site or to an established site that is catching many beetles.
10. Keep traps reasonably proximal to established roads to facilitate trap establishment and servicing.
11. The easiest way to count trapped beetles is by volume. However, weight can also be used.

Suppliers of funnel traps, Douglas-fir beetle funnel trap lures, tree baits and MCH:

Synergy Semiochemicals Corporation
synergy@semiochemical.com

WestGreen Global Technologies
net2officebthomson@shaw.ca

Distributions Solida Inc.
www.solida.ca

Tree Baiting in stands

Tree baiting infested stands is a good option when DFB attack levels are relatively low and dispersed throughout the proposed harvest block. Tree baiting is also employed when proposed harvest blocks are larger than targeted sanitation or trap tree placement, and removal is not operationally feasible. Tree baiting is used to contain beetle populations within the baited area and does not usually attract beetles from outside the block boundaries. DFB tree baits (containing attractive pheromones) are deployed in a grid pattern within a harvest block at 50 meter intervals. Tree baits are stapled onto the bole of large Douglas-firs at about 2 m height on the north aspect. Baiting harvest blocks in fire-impacted stands is a good option because it is often difficult to determine how much pre-existing attack exists in a post-fire block, and baiting will contain the population and may hold beetles that fly through the block from outside block boundaries. Baits must be placed prior to April 1st and all attacked trees (baited and overflow) must be removed prior to April 1st of the following year.



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

Baiting in blocks scheduled for harvest is effective in containing and concentrating DFB attack within the block boundary. When tree baits are employed, baited trees and many surrounding trees (overflow attack) may be attacked by DFB. Attack on the baited and overflow trees may not utilize as much of the tree bole as attack on trap trees, but it is spread over more trees. Harvest of baited blocks should ideally be completed by late summer through fall (late August-November) because snow and spring break-up may compromise the access to stands the following spring and the removal of DFB-infested trees may be delayed or impossible.

Douglas-fir beetle, windthrow and slash

Windthrow may act as a pre-cursor to DFB population build-up. Larger areas of windthrow are generally detected in the Aerial Overview Survey, but smaller patches or single-tree events are not often detected. Ground detection and communication of observed windthrow events is important for planning subsequent actions. Slash created from harvest must be carefully managed with regard to DFB. The following section addresses DFB, windthrow and slash.

1. **Context:** If an area is in or adjacent to a high-value stand/area such as susceptible private land, Parks, recreation areas, OGMAs and others, then implement the more aggressive of measures mentioned below.
2. **Coarse woody debris (CWD):** Leave already dead (no live brood in wood) trees if CWD is an issue on a block.
3. **Current beetle populations:** Risk is reduced if there are no current significant beetle populations in the area. Confirm beetle activity by checking with Regional and District MFLNRORD Forest health staff or the annual report of forest health conditions (<https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/aerial-overview-surveys/summary-reports>).

4. **Limbing:** Increases rate of phloem drying in situations exposed to sun, but still leaves the underside half of a log suitable for beetle attack. Limbing is helpful, but ineffective in shaded situations.
5. **Scoring the bark:** Increases rate of phloem drying, which can kill eggs and larvae. This is possible on spruce, but not on Douglas-fir or Ponderosa pine because the bark is too thick. If tried, scoring has to be intense.
6. **De-barking:** Labour intensive. It is effective in most situations where larvae are present at the sapwood surface. However, starting about 21 July, DFB move into the bark to overwinter and are able to survive the winter in bark pieces on the ground. Therefore, bark pieces **must** be burned for Douglas-fir peeled from late summer on.
7. **Burn debris piles:** Burn thoroughly within 1 year of falling, prior to the next beetle flight.
8. **Other ideas:** Consider a trap tree program, baited funnel traps, or MCH to control active DFB populations.
9. **Shading:** Tree pieces located in the shade will be ideal DFB habitat; pieces in the sun less so, but they should be checked in the fall for live brood.
10. **Time of falling:** Douglas-fir may need up to a year to dry out (due to thicker bark), and so will likely be exposed to at least one beetle flight. Douglas-fir felled from August on could be exposed to attack the following year.
11. **Piece size:** Fresh, uninfested, shaded Douglas-fir down to firewood size (15 cm x 50 cm in the shade) can attract and produce beetles; even 20 cm x 3 m slabs pushed into the dirt bark side down will produce beetles. Realistically, pieces ≥ 20 cm diameter x ≥ 2 m length will be attractive to DFB. Smaller pieces can be left if exposed to all day sun. **Keep stumps low** (30 cm height max). In very sensitive situations, peel stumps.
12. **Numbers of pieces:** One tree felled in the shade is not going to start an epidemic. "Endemic" level DFB typically occurs in widely (1 - 5 km) scattered spots of 1-2 fallen trees, which result in patches of 1-5 dead trees before the spot subsides. Higher levels of DFB will likely result in more standing tree mortality.

Operational timetable of main Douglas-fir beetle management activities.

Activity	Optimal Time Frame*	Possible
Detection		
Funnel trap monitoring	April - August	
Aerial surveys		
Overview	Mid-July - Sept. 15	July 25 - Oct. 15
Detailed	May - June	April - July
Ground surveys		
Walkthroughs	Late July - Oct.	Sept. - March
Probes	Late Aug. - Nov.	Sept. - March
Population prediction	Feb. - March	Jan. - April
Control		
Harvesting		

Trap tree placement	Jan. - March	Nov. - May
Trap tree removal	Sept. - Dec.	Sept. - April
Sanitation harvest	Sept. - Dec.	Sept. - March
Heli-logging	Sept. - Nov.	Sept. - March
Single tree treatments		
Fall and burn	Nov. - Dec.	Nov. - March
Debarking	Sept. - Oct.	Sept. - March
*There is some flexibility in these time frames dependent upon annual weather conditions, location and other operational parameters.		

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