GUIDELINES FOR THE OPERATIONAL DEPLOYMENT OF MOUNTAIN PINE BEETLE SEMIOCHEMICAL LURES

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Table of Contents

	Page
Table of Contents	(i)
List of Tables	(ii)
List of Figures	(iii)
1. INTRODUCTION	1
2. STAND SELECTION	1
2.1 Stand Hazard Ratings	2
2.2 Strategic Location	2
2.3 Historic Beetle Activity	2
2.4 Current Beetle Activity	5
3. TIMING	5
4. CONTAINMENT VS. SINGLE-TREE BAITING PROGRAMS	5
5. BAIT LAYOUTS	6
5.1 Containment Baiting	6
5.2 Single-tree Baiting	9
5.3 Other Techniques	12
6. LURE LOCATION AND HANDLING	13
List of References	14

List of Tables

Table		Page
1	Hazard rating for mountain pine beetle.	3

List of Figures

Figure		Page
1	Climatic hazard map for the interior of B.C. for the mountain pine beetle.	4
2	Decision-making flowchart for semiochemical-based mountain pine beetle control.	7
3	Deployment of semiochemical lures in a grid pattern for containment of mountain pine beetle.	8
4	Deployment of semiochemical lures in a double perimeter line pattern for containment of the mountain pine beetle.	10
5	Deployment of semiochemical lures around mountain pine beetle infestation centers.	11

1. INTRODUCTION

Semiochemicals have been used experimentally to manipulate bark and ambrosia beetle populations in western North America for decades. However, operational use of these compounds has only occurred in the last few years. The formation of a company (Pherotech Inc.) which has the capacity to produce large quantities of pre-packaged, ready to use lures, has made their operational deployment feasible for almost all user groups. Studies by Borden et al. (1983a) and Heath (1986) indicate the semiochemical lures marketed for mountain pine beetle (Dendroctonus ponderosae Hopkins) control can be effectively used to contain beetle populations within treated stands.

The lures contain two aggregation pheromones, trans-verbenol and exo-brevicomin, and an attractant host volatile, myrcene. It is probable that trans-verbenol is the primary D. ponderosae aggregation pheromone throughout its range. The exo-brevicomin also acts as an aggregation pheromone to B.C. D. ponderosae populations (Conn et al. 1983) but serves as an antiaggregant to the species in white pine forests (Pitman et al. 1978) and in southern lodgepole pine forests (Ryker and Rudinsky 1982). It also serves the beneficial function of attracting a higher proportion of female beetles than trans-verbenol alone. Myrcene displays minimal attractancy on its own but has proven to synergize the activity of the two pheromones (Conn et al. 1983, Borden et al. 1983b).

We anticipate the lures will have 3 broad use patterns within the Region:

(i) Containment - an estimated 30% of an emerging beetle population emigrates out of the area adjacent to their brood trees. The use of strategically deployed lures has proven effective in minimizing the spread of emigrating beetles out of infested stands.

(ii) Single-tree control - we anticipate that beetle populations which survived the Region's 1984/85 extremely low temperatures will generally be at low levels and widely dispersed. This phenomenon makes single-tree control a much more viable option in many areas but also means the use of semiochemical lures is essential to make the control projects cost-effective.

(iii) Monitoring - the lures can be effectively used to monitor the beginning and end of beetle flights and the level of beetle activity in a given stand.

2. STAND SELECTION

Proper stand selection is probably the most critical and difficult component of a semiochemical deployment program. The best bait layout pattern and tree selection possible will be essentially useless if the baits are placed in inappropriate stands. Priorization of stands for baiting involves the consideration of a number of factors, all of which must be considered before bait deployment begins.

2.1 Stand Hazard Ratings

Stands most susceptible to D. ponderosae attack should be given a high priority for treatment. Several rating systems exist that are designed to help foresters identify high hazard stands and thus minimize losses. The most intensively tested system in current use was developed by Amman et al. (1977) and uses climate, tree age and tree size as the primary variables in estimating stand susceptibility. Several more recent rating methods are based on estimates of tree vigour (e.g. Waring and Pitman 1980) and indicate that growth efficiency may be an important factor in determining stand susceptibility to D. ponderosae. Although there are indications in the U.S.A. that none of the vigour-related hazard rating systems are superior to the simpler methods (Amman and McGregor 1985), our experience in the Cariboo suggests tree vigour plays an important role in the determination of stand susceptibility. Beetle infestations which appeared at roughly the same time in West Chilcotin and Big Lake/Horsefly stands expanded much more quickly in the former area in spite of a significantly lower hazard rating there using only the climate, age and tree size variables. Stand vigour would appear to be the critical difference. It is unfortunately relatively difficult to measure and probably not a feasible element to quantitatively incorporate into stand hazard rating models at this time. However, we recommend that an estimate of average tree vigour within stands under consideration for baiting be at least taken into account.

The hazard rating system used in the Protection Manual (Table 1, Figure 1) should be used until something better comes along. Semiochemical deployment should normally be carried out in stands with at least a "Moderate" hazard rating.

2.2 Strategic Location

The highest priority for treatment should be given to stands where semiochemical deployment will serve to protect them and other highly valued stands in the District or Region. Baiting areas for beetle containment which meet all other criteria for lure deployment but are surrounded by already heavily attacked stands or non-susceptible types is normally a useless exercise. There should be some nearby high-risk stands threatened by D. ponderosae present to justify lure deployment. For the most part, the Class B and C zones identified by Districts serve to identify strategically important stands.

2.3 Historic Beetle Activity

The level of D. ponderosae activity in stands under consideration for baiting and in areas adjacent to them in previous years must be evaluated to priorize lure deployment programs. Stands which have been under attack for 2 or more years often have the majority of their susceptible pine already attacked, leaving relatively few healthy, large diameter stems to bait. It is possible that D. ponderosae will consistently attack baited small diameter pine in the absence of alternative larger host material but this has yet to be demonstrated.

Table 1. Hazard rating for mountain pine beetle

Step	Procedure
1.	For each area in question, determine which climatic hazard zone the area is in from the accompanying map (i.e. very low, low to moderate, or high to extreme).
2.	For each area, obtain information on each of the factors (a-e) given below and determine for each factor whether the area is low, moderate, or high hazard.

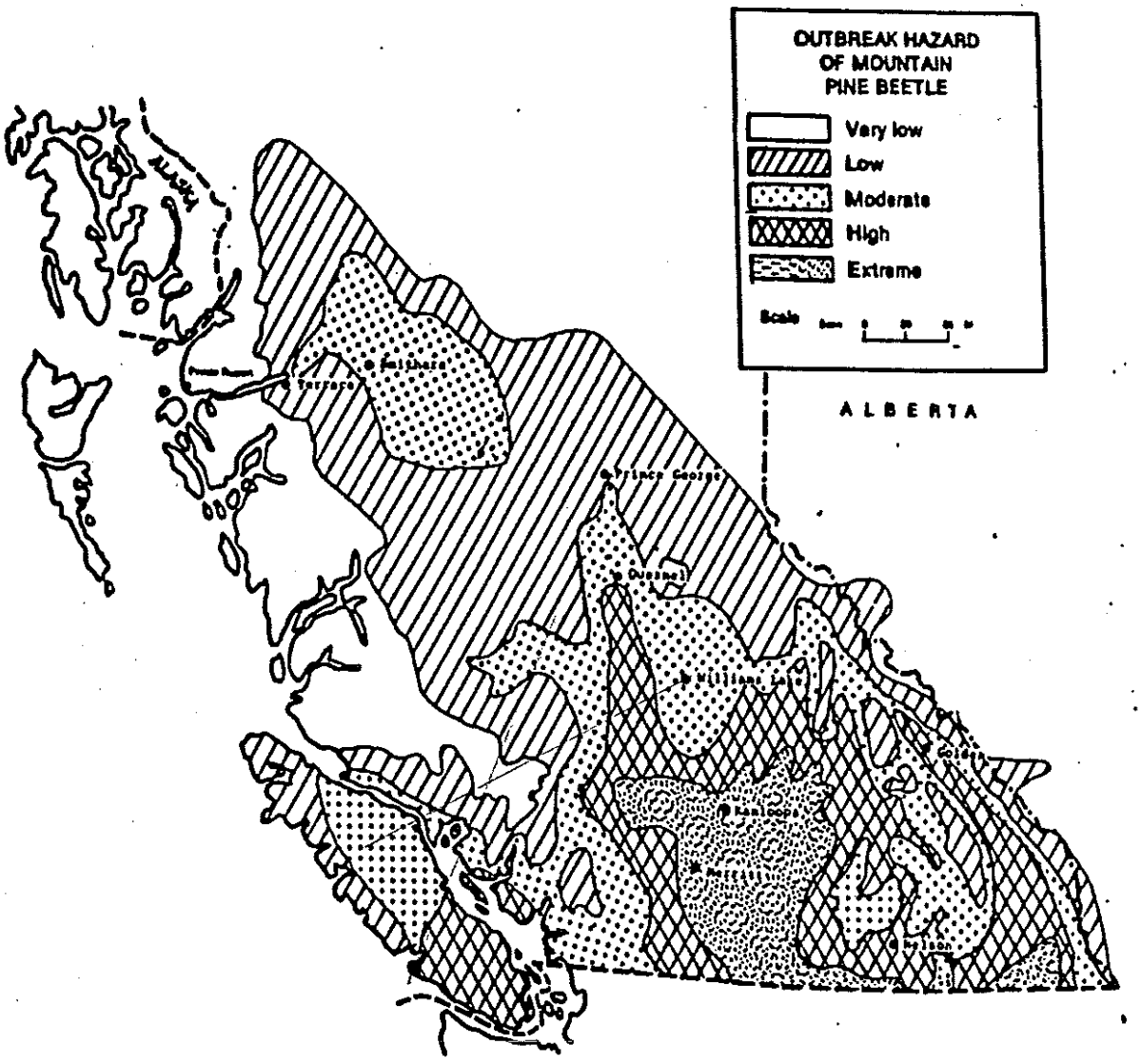
Factor	Value =	Hazard Level: Low 1	Moderate 2	High 3
			4 or less	5 or more
(a) Climatic hazard zone*		Very low ✓	Low, moderate	High, extreme
(b) Elevation within Pl zone		High	Mid	Low
(c) Ave. dbh (Pl) (cm)		<17	17-20	>20
(d) Ave. age (Pl)	≤3	<60	4 60-80	5? >80
(e) Site	p	Poor	Medium	Good

*Categories are taken from accompanying map

Step	Procedure
3.	Assign a value to each factor of 1, 2, or 3 for low, moderate, or high hazard respectively.
4.	Sum the assigned values for each of the 5 (a-e) factors for each stand to obtain a Total Hazard Value.
5.	Assign a Stand Hazard Rating on the basis of the following ranges of Total Hazard Value:

Total Hazard Value	Stand Hazard Rating
5-7	Low
8-12	Moderate
13-15	High

Figure 1. Climatic hazard map for the interior of B.C. for mountain pine beetle



Climatic Hazard Map for the Interior of B.C. for Mountain Pine Beetle (after Safranyik et al 1974)

2.4 Current Beetle Activity

The approximate number of successful green attacks/ha should be known prior to lure deployment. This information can be taken from probe data or less reliably, from cruise results. If these data are not available, the stand should at least have a systematic walk-through carried out and green-attack information collected. The threshold level of green-attack density necessary to trigger a lure deployment program will naturally vary with the infestation situation in a given District each year, but all other factors being equal the heaviest attack levels should be given highest priority for baiting. Studies carried out in the Region during 1985 indicate the benefits of containment baiting are correlated with higher levels of beetle activity (Heath 1986).

If significant larval overwintering mortality is even suspected, a representative number of green attacks should be examined in late spring/early summer to establish if they will be producing enough teneral adults to justify lure deployment. Cases have occurred previously where baited stands had reasonably high green-attack densities but overwintering mortality levels were high enough to almost completely negate the value of the lure deployment.

3. TIMING

Although the commercial D. ponderosae lures have a 150 day life span, there are indications that their effectiveness decreases over time (Lindgren 1986). This phenomenon has been noted with a variety of release systems; volatile emission levels characteristically peak shortly after deployment, then either drop to a lower stable level or decrease constantly throughout the life of the lure. Studies are planned by Pherotech Inc. to determine if there is a decrease in lure efficacy over time, especially towards the end of its life span. Until these are complete, we are recommending that May 1 be the start-up date for lure deployment unless strong logistical considerations dictate an earlier placement date. All lures should be deployed by July 1 to ensure they are in place before beetle flight commences.

4. CONTAINMENT VS. SINGLE-TREE BAITING PROGRAMS

The type of lure deployment program carried out will be a function of the level of beetle activity and what is planned for the stand in question. Containment baiting programs should be directed to areas with moderate-high levels of current beetle activity and stands planned for harvest after beetle flight. There should also be susceptible stands in the immediate area which would benefit from beetle containment and eventual control. Stands along the leading edge of large infestations are good candidates; those 100 km behind the front normally are not.

Semiochemicals are valuable tools for single-tree control projects and should serve to increase their efficiency significantly. These projects should be directed to stands which have a low-moderate beetle population, are not scheduled for harvest in the near future, are at the extreme outer edge of larger infestations, and not immediately adjacent to untreated active infestations capable of consistently feeding beetles into treated areas. It is important to coordinate single-tree projects with Timber and Licencee personnel to ensure the time and money spent on single-tree projects are not wasted through the immediate harvesting of treated stands. Single-tree projects are rarely successful over the long term unless closely coordinated with other beetle control programs like directed harvesting.

Figure 2 contains a flowchart which outlines and summarizes the semiochemical deploymemt options available to treat the most common D. ponderosae infestation patterns. These are guidelines, not rules, and may vary with specific situations. However, if an alternative strategy is chosen, there should be sound, well defined reasons to do so.

5. BAIT LAYOUTS

5.1 Containment Baiting

Lure deployment to reduce beetle emigration out of infested stands until they can be harvested is the best way to utilize semiochemicals in moderate-heavily infested areas. Two deployment strategies are currently recommended and studies carried out in the Region indicate they are equally effective (Heath 1986). Stands up to 30 ha in size should be baited on a grid basis with the lures placed on trees at approximately 50 m intervals (Figure 3). Baits on the outside perimeters of the stand should be placed 25 m in from the edge of the proposed sanitation cut blocks. Although a systematic approach to lure deployment is desirable to minimize exit corridors for the flying beetles, there is nothing written in stone about the 50 m interval. Lure effectiveness is enhanced by their placement on large diameter pines and it is often necessary to increase or decrease the recommended baiting interval to utilize the more attractive trees.

The lures can be deployed during stand entries for other reasons (e.g. cruising) to lower deployment costs. If cruise strips are run at 200 m intervals, the lures can be placed every 50 m along them, then filled in at 50 m intervals between the cruise lines. The 50 x 50 m grid pattern gives a lure density of 4/ha and most stands can be baited relatively quickly by personnel using hand compasses and hip chains. This equipment is highly recommended to ensure the lures are deployed systematically. Flagging tape should be hung between bait trees to make finding them easier.

Figure 2. Decision-making flowchart for semiochemical-based mountain pine beetle control.

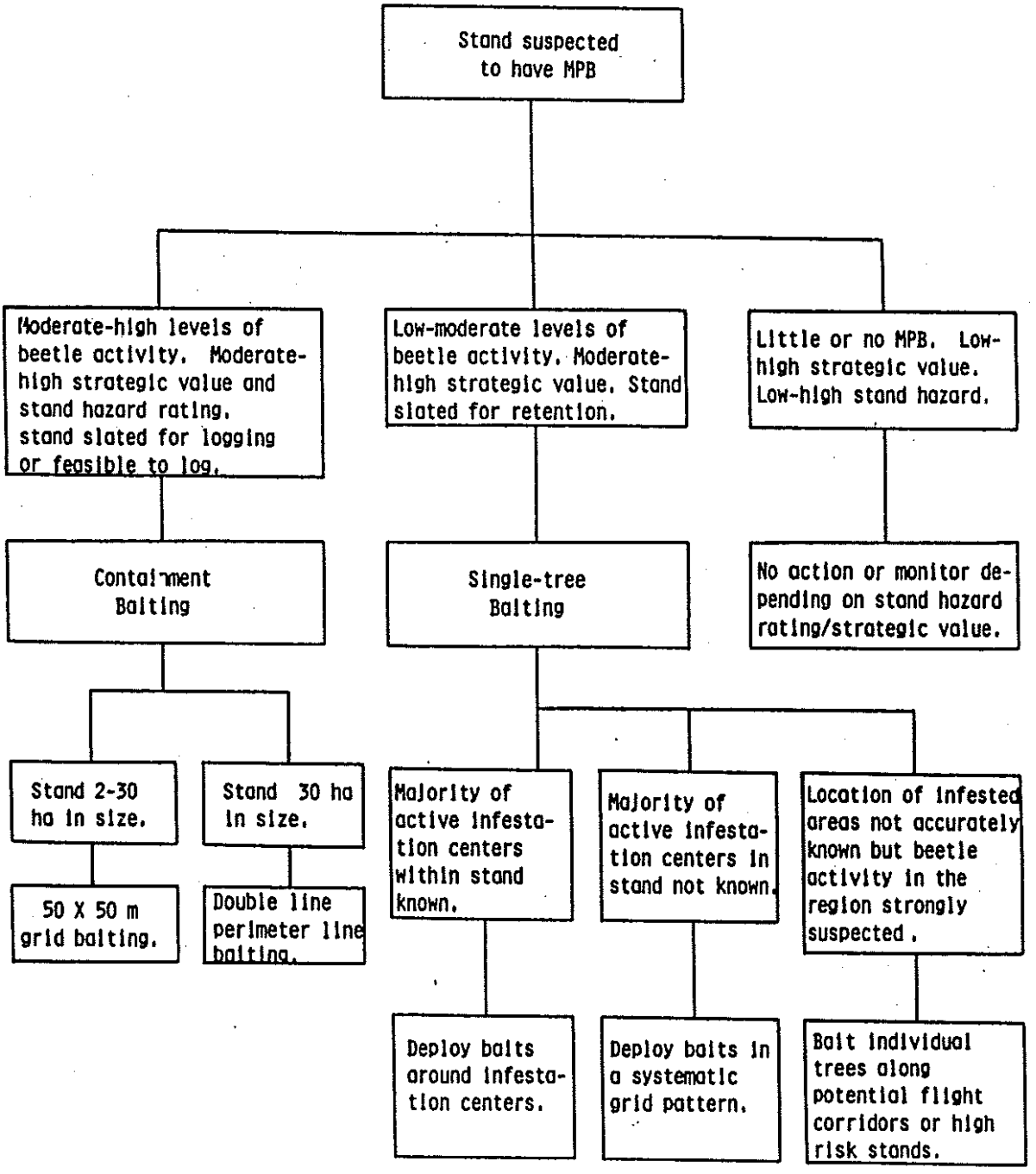
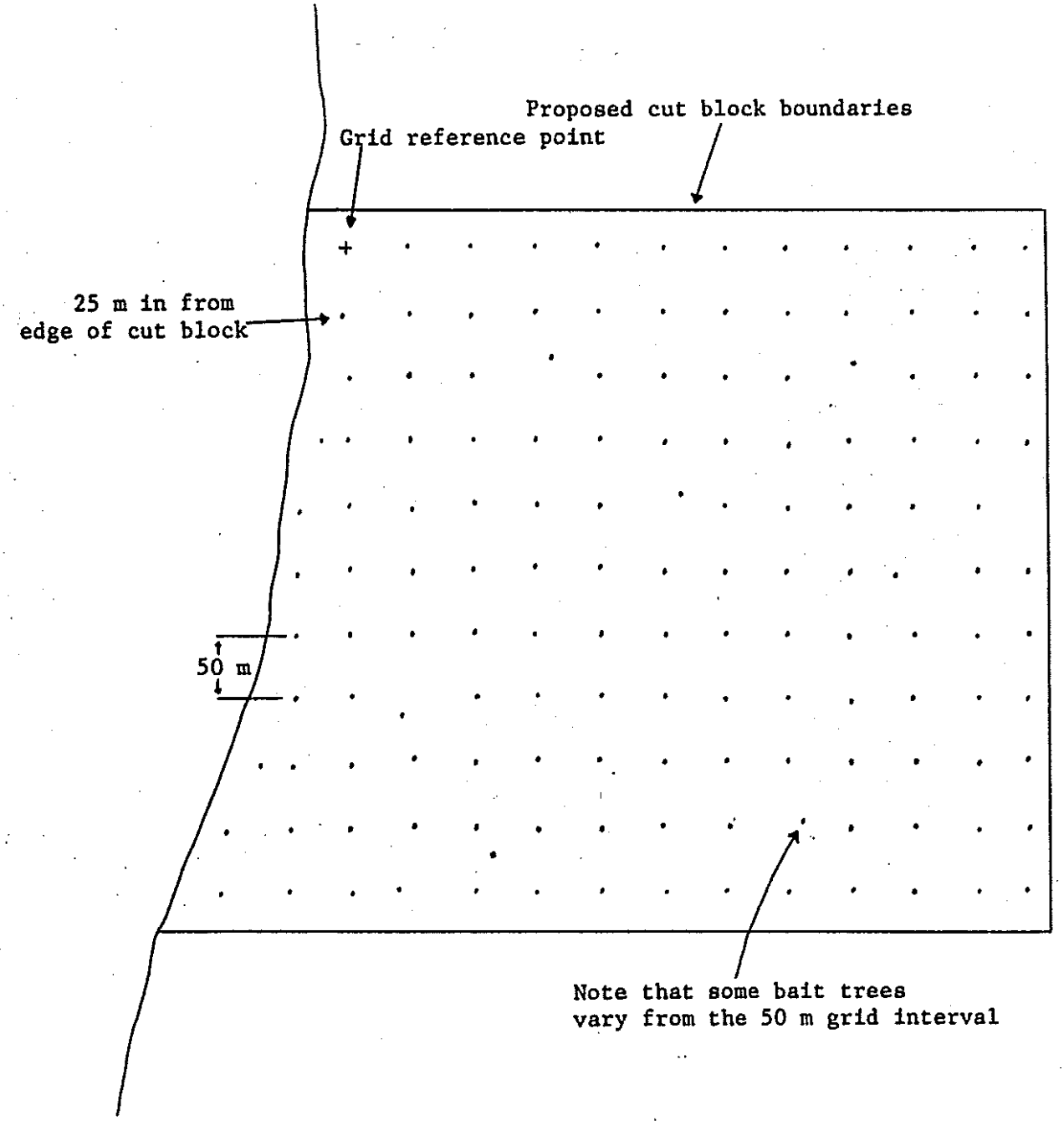


Figure 3. Deployment of semiochemical lures in a grid pattern for containment of mountain pine beetle.



Stands over 30 ha in size should be baited using the double perimeter line system (Figure 4). Baits are placed at 50 m intervals along 2 lines 50 m apart around the outside edge of proposed cut blocks. The outside line should be at least 25 m in from the cut block margin. Ideally, the lures on the inside line should be offset approximately 25 m from those on the outside to decrease the width of potential beetle escape corridors; in practice this is difficult to do and "best guesses" may be in order. The two bait lines are designed to minimize beetle movement out of the infested area; how they rattle around inside is largely irrelevant. If it is suspected that the stand contains a relatively large active beetle population, the perimeter lures should be supplemented by baits placed inside the stand, ideally near the highest concentration(s) of infested trees. Again, the recommended baiting intervals should be modified when necessary to select the most attractive trees.

An alternative to the 2 systematic approaches of containment baiting is lure deployment around the edges of small infestation centers (Figure 5). This containment strategy may be applicable when the location of almost all infested trees is known and may serve to decrease the deployment costs and the number of lures used. As a general rule, bait at least 1 large diameter tree for every 2 currently infested pines. The lures should be placed around the periphery of the infestation with a slightly higher concentration in the direction of beetle movement. The approach does have 2 disadvantages:

(i) if all incipient infestation centers are not found and treated, significant beetle emmigration could occur;
(ii) there have been indications that a significant number of beetles may blow by baited trees immediately adjacent to their brood trees. If only a few centers are baited, there will be no other attraction sources to pick them up.

Infestation center containment baiting may be a viable option in some cases but it should be used with caution and it may be prudent to supplement the center baits with a few others in the proposed cut block.

5.2 Single-tree baiting

Single-tree treatments (especially fell and burn operations) have traditionally been a reasonably effective, but very expensive, *D. ponderosae* control technique. Both tree location and disposal costs have been consistently high, primarily because of the large inputs of time required to find, then treat infested stems. The use of aggregating semiochemicals in conjunction with insecticides promises to reduce these costs dramatically. Lures which have been strategically deployed and their locations accurately tied in and mapped should simplify the process of finding green attacks. Post-attack insecticide treatments of baited and associated spillover trees will drastically decrease brood destruction costs.

Figure 4. Deployment of semiochemical lures in a double perimeter line pattern for containment of the mountain pine beetle.

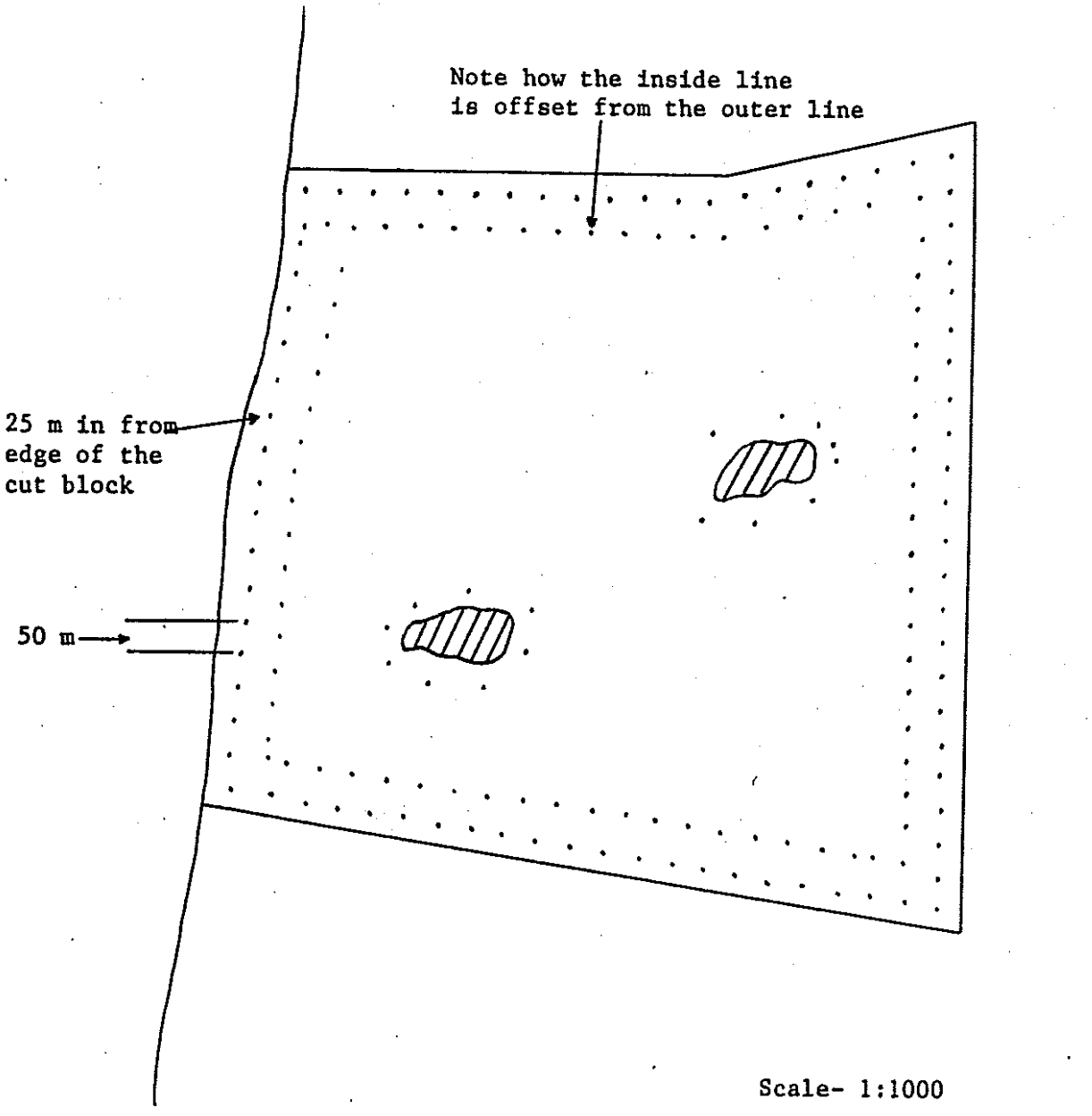
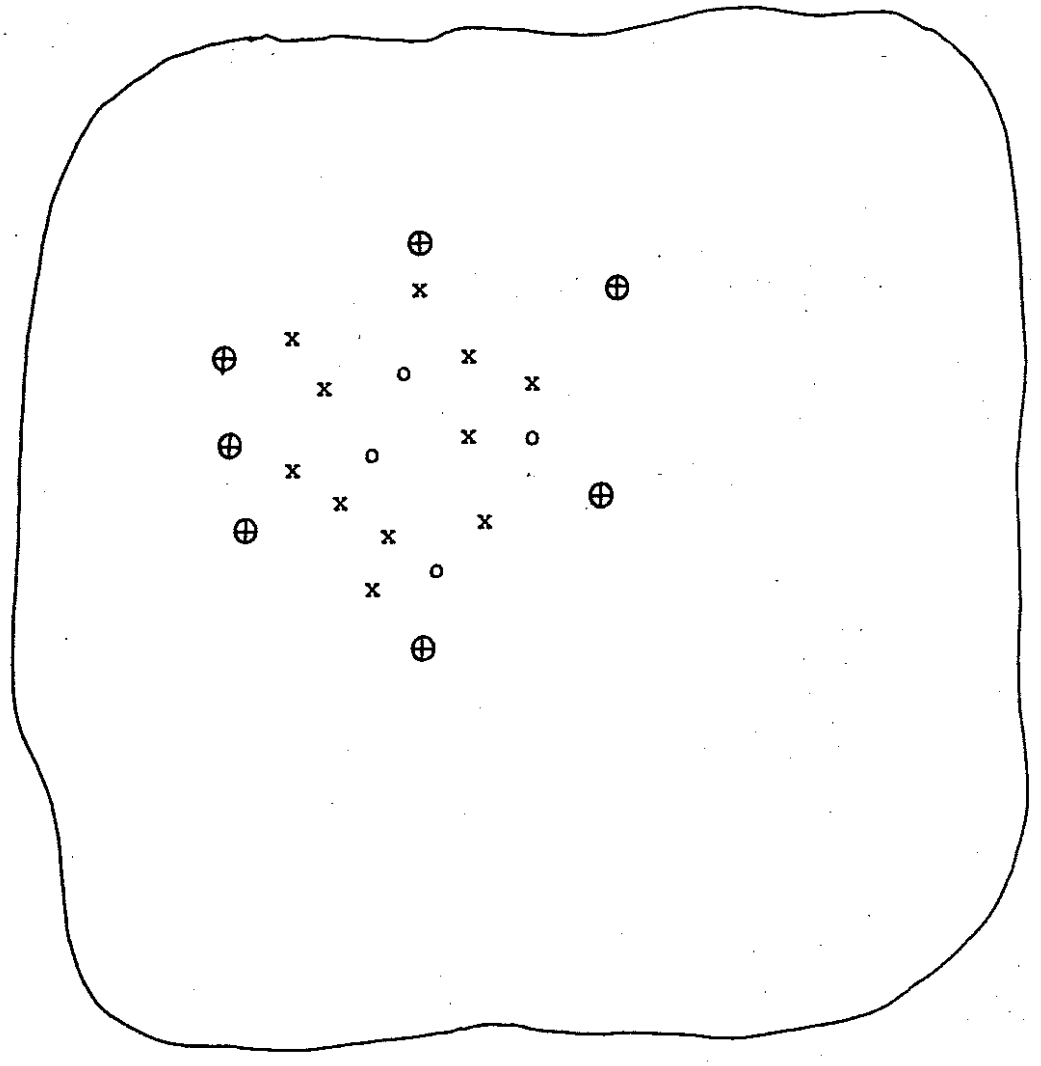


Figure 5. Deployment of semiochemical lures around mountain pine beetle infestation centers.



Not to scale

x- Green attack

o- Red attack

⊕- Baited tree

There are currently 2 approaches recommended for single-tree baiting:

(i) if the location of the majority of infested trees within a stand is known, trees around the infestation centers should be baited as discussed in Section 5.1 (Figure 5). Again, bait at least 1 tree for every 2 green-attacks. This ratio should be increased in small centers; for example, if a center contains only 3 green-attacks over a fairly large area, at least 3 healthy trees should be baited. The ratio should also be increased if it is suspected the green-attacks contain extremely large brood populations. It is important to deploy the lures around the entire periphery of larger centers and not leave the emerging beetles an escape corridor. The concentration of lures can be increased in the general direction of beetle movement if it is readily apparent.

(ii) stands which are known to have low numbers of widely dispersed green-attacked trees can be grid-baited at 50 m intervals in the same manner as containment baiting. The majority of attacks will normally be concentrated in and around the baited trees but a few may occur in areas away from the bait lines. These should be watched for during follow-up insecticide application or fell and burn operations. Flagging of bait lines and trees to ensure infested trees can be easily located is critical with this deployment technique.

Single-tree baiting can also be utilized to mop up residual beetle populations left after fell and burn, MSMA treatments, or other direct control operations. Deployment of 2-5 lures (depending on the number of trees treated) around the periphery of infestation centers should effectively contain the majority of remaining insects until further action can be undertaken.

5.3 Other Techniques

Situations occasionally occur where there is known beetle activity in an area but populations are low and/or their locations are not precisely known. Although as yet untested, there are a few techniques available which don't require great time or semiochemical investments. The lures can serve as beetle population monitoring devices and/or control agents.

If beetle activity is suspected in a stand, a single line of lures deployed at 50-100 m intervals can be run through it. In the event the majority of baited trees are heavily attacked, they can be treated on an individual basis or a recommendation made to harvest high hazard areas. Low attack levels suggest the stand is not currently under heavy beetle pressure.

Logging roads make excellent beetle flight corridors and lure deployment along them in areas of moderate-high levels of beetle activity may be an inexpensive way of pulling substantial number of pioneer adults from a population. The lures could be placed out every 500-1000 m along roads of interest in a very short period of time and all attacked trees easily dealt with after beetle flight. The baited trees could also serve as excellent monitoring tools to pick general beetle movements through an area and help establish the initial date of beetle flights.

New beetle infestation centers often appear on the edge of cut blocks, probably arising from infested trees missed during harvesting operations or from infested stumps within the block. If this type of attack pattern has historically occurred in an area, the periphery of cut blocks could be considered for lure deployment. A single line of bait trees at 75-125 m intervals should be established 15-25 m into the stand in susceptible types completely around the cut block. These trees should be well flagged to facilitate follow-up treatments such as harvesting or single-tree control

6. LOCATION AND HANDLING OF LURES

As noted earlier, placement of baits on the largest diameter, most susceptible trees should enhance their effectiveness. The odor plume emitted by the lures is slightly heavier than air; thus in calm weather conditions the attractant compounds will tend to pool near the ground. Most beetle attacks are found 2-4 m above the ground in the majority of lodgepole pine sites, and it is therefore beneficial to place the lures high as possible on the tree boles, especially where heavy brush or dense understory conditions will force the flying insects higher.

Like most complex organic molecules, trans-verbenol, exo-brevicomin, and myrcene are susceptible to polymerization or photo-degradation. In addition, exposure to more or less direct sunlight will inevitably increase their release rates and shorten the lure's life span. It is therefore strongly recommended that the lures be placed on the north side of trees wherever possible. Any brush or branches interfering wih the lure should be removed. Baited trees should be flagged to facilitate their relocation after beetle flight. This is particularily critical if single-tree disposal is planned.

The semiochemical lures effective life span will be enhanced if they are kept in cool shaded locations as long as possible. They are normally stored in a reefer at Williams Lake and should remain there until shortly before deployment if there are no similar cooling facilities available at a District Office.

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