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TECHNOLOGY TRANSFER

Anti-aggregation pheromone

Using MCH to Protect Trees and Stands from Douglas-fir Beetle Infestation

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FHTET-2001-09
Revised November 2015

The Forest Technology Enterprise Team (FHTET) was created in 1995 by the Deputy Chief for State and Private Forestry, USDA Forest Service, to develop and deliver technologies to protect and improve the health of American forests. This manual was published by FHTET as part of the technology transfer series.

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Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered

On the cover: Image of Douglas-fir mortality resulting from Douglas-fir beetle infestation. Image UGA 1241472, by Ladd Livingston, Idaho Department of Lands, Bugwood.org

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Introduction

The Douglas-fir beetle (Fig. 1) is normally present in forests at low densities, breeding in Douglas-fir trees that are injured or have recently died. Tunneling by adults and larvae beneath the bark produces a characteristic pattern distinguishing the Douglas-fir beetle from other bark beetles (Fig. 2). The egg galleries excavated by adults are straight, vertical, and usually 1-3 feet long. Groups of one to several dozen larval tunnels extend on alternate sides of the egg gallery forming 'fan' shaped patterns in a horizontal direction. When trees are colonized by large numbers of beetles, the distinctive pattern may be less obvious due to crowding. Beetle larvae need fresh, moist phloem (inner bark) for food, so trees that have been dead for more than a year are not suitable habitat. Injured or recently killed trees have little or no defensive capabilities making them ideal sites for beetle larvae to feed and develop. Periodically, natural or human-caused disturbances such as windstorms, fire, defoliator outbreaks or logging create an abundance of suitable breeding sites that allow beetle populations to rapidly increase to high densities. At high densities, beetles are forced to attack healthy, live trees because there are not enough stressed and dead ones to support the population. By attacking a live tree in large numbers, the beetles are able to overcome the tree's natural defenses and successfully reproduce. If an attacked tree is not killed, then the beetle's eggs and larvae will not survive to the adult stage. Sometimes only a portion of the tree is killed and

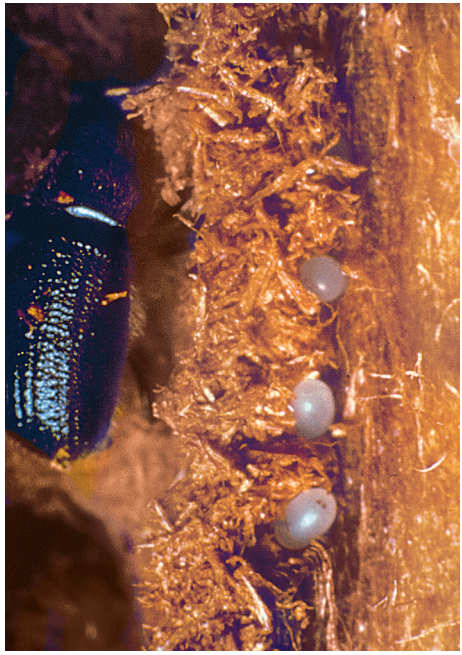

Figure 1. Adult Douglas-fir beetle and eggs in gallery. Actual size of the adult is 4.5 - 7.0 mm (about 3/16 – ¼ inch) long. Photo courtesy of Oregon Department of Forestry.

Figure 2. Characteristic pattern of Douglas-fir beetle egg and larval tunnels.

only the brood in that part of the tree survive. This is commonly referred to as a strip or partial attack. Douglas-fir beetle outbreaks typically last for several years and may result in the mortality of large numbers of trees. In some cases, this tree mortality may interfere with resource management objectives.

Douglas-fir beetles preferentially attack large, old trees in dense stands with a high Douglas-fir component. In general, for areas east of the Cascades in the Pacific Northwest and the northern Rocky Mountains, trees in stands with an average age over 120 years and diameter at breast height (dbh) of more than 14 inches are at the highest risk for infestation during outbreaks. These conditions are typical of late-successional or old-growth forests that are becoming increasingly valuable for recreational uses, watershed protection, wildlife habitat, and other reasons. Individual mature trees in residential settings may also be at high-risk for infestation when local beetle populations are at high levels. Mortality of large trees may reduce the value of residential properties, and such trees are often expensive to remove when they are near homes or other structures.

Until recently, resource managers and homeowners had only one option for protecting high-valued trees from Douglas-fir beetle infestation during outbreaks. They could spray a chemical insecticide on the bole of the tree to kill arriving insects. Effective insecticide applications require the entire lower and middle portion of the bole be completely covered. This requires special equipment that is not easily transported in the forest. Because of logistics and costs, only very high-value trees in accessible areas can feasibly be treated with insecticides. In addition, concerns about non-target effects of insecticides further limit their application.

An alternative to insecticide applications became available for the first time in spring 2000. This treatment involves application of the Douglas-fir beetle's anti-aggregation pheromone, MCH. (The chemical names of all pheromones mentioned in this paper are given in the appendix). This paper briefly describes MCH and how to use the material to protect live trees from infestation.

Douglas-fir Beetle Pheromones

Bark beetles, including the Douglas-fir beetle, rely on chemicals known as pheromones to communicate with one another. Pheromones are chemicals that are released by one individual that affect the behavior of others of the same species. The two most important types of bark beetle pheromones are aggregation and anti-aggregation pheromones. As for all beetles in the genus *Dendroctonus*, female Douglas-fir beetles initiate new attacks. Upon finding a suitable breeding site, the female releases an aggregation pheromone that is a blend of several compounds including frontalin, seudenol, and MCOL that is attractive to both male and female beetles. Additional host tree odors may enhance attraction to the pheromone. As more beetles arrive and mate, the concentration of aggregation pheromone declines while the concentration of anti-aggregation pheromone increases. The changes in pheromone concentrations result from females ceasing to release aggregation pheromone while males release the

anti-aggregation pheromone, MCH. The anti-aggregation pheromone serves to prevent overcrowding and optimize brood survival. In simple terms, MCH acts as a "no vacancy" signal to late-arriving beetles, causing them to avoid that tree or log.

MCH was first isolated from Douglas-fir beetles and identified in 1971. The ability of MCH to interrupt the aggregation of Douglas-fir beetles was demonstrated in the early 1970's. Subsequently, an operational treatment for aerial application of MCH to windthrown trees was developed and demonstrated to be highly effective. This treatment was developed with the intent that it could be used to prevent outbreaks by keeping beetles from breeding in trees killed or damaged during windstorms. However, since this formulation of MCH was never registered with the Environmental Protection Agency (EPA), it was never available for widespread use. In the early 1990's, several studies consistently demonstrated that MCH could be used to prevent the infestation of live trees in high-risk stands. These studies used MCH formulated in individual releasers that were stapled to trees, snags, and shrubs throughout areas to be protected. In 1999, the first EPA registration for a bubble capsule formulation of MCH was obtained for use in the U.S. Each year since spring 2000, several thousand acres of high-value Douglas-fir stands have been treated with MCH throughout the western U.S. to prevent Douglas-fir beetle attacks. To date, there have been no reports of unsatisfactory results.

MCH Application

Where to Apply MCH

MCH applications should be prescribed in the context of a long-term resource management plan. The treatment is appropriate for any stand where Douglas-fir beetle-caused tree mortality is expected to be high enough to significantly impact resource management objectives. In research and operational tests, areas from less than one acre to over 300 acres have been successfully treated. State or federal forest entomologists or private forestry consultants can help to assess the risk of beetle infestation and the potential value of an MCH application. Initially, MCH sales were limited to those with forest pest management expertise, and knowledge of the product and its use. This policy was designed to prevent misuse of MCH and dissatisfaction that might result. While MCH is now available to the public from several sources, consultation with pest management specialists is still recommended to ensure its proper use.

MCH effectively protects treated stands by preventing beetles from initiating new attacks. Beetles will move through a treated area and continue to disperse until they find suitable habitat elsewhere or until they die. Because beetles moving through a treated stand will spend more time searching for a host, they presumably will have a greater chance of dying as a result longer exposure to natural enemies and other mortality factors. There is, however, no evidence tree mortality in areas directly adjacent to those treated with MCH is any higher than it would

be in the absence of MCH treatment. Consequently, landowners and managers do not need to fear that beetles will "move" from treated stands into neighboring ones.

There is no conclusive evidence that MCH applications alone will actually reduce tree mortality at the landscape scale during an outbreak. At the least, however, MCH acts to redistribute tree mortality by protecting stands that are considered particularly valuable because of their unique characteristics or special uses.

How to Apply MCH

MCH is most effective when it is applied before beetles begin to fly and attack trees in the spring. However, if it is applied early in the flight season but after beetles have initiated attacks on some trees, it may still reduce the number of trees that are killed within the treated area as compared to doing nothing. Throughout much of the interior Pacific Northwest and northern Rocky Mountains, Douglas-fir beetles begin flying in late April or early May, so MCH applied by the third week in April should be fully effective unless it is an unusually warm year. The bubble capsule formulation of MCH will last throughout the period that beetles fly and attack trees, but needs to be reapplied each year that protection is desired. During a typical outbreak, this may require 1-3 annual applications. For maximum benefit, protected areas should be treated every year during an outbreak.

For areas greater than ½ acre, bubble capsules should be applied at a rate of 30/acre. The current price of bubble capsules is about $1.50 - 2.00 (U.S.) each, but may be lower for large volume orders. If added insurance against infestation is desired and cost is not prohibitive, a slightly higher rate may be applied. However, rates higher than 30/acre should not be necessary in most situations and MCH should never be applied at a rate higher than described on the product label. The first step in conducting a treatment is to determine the size of area to be treated and calculating the number of bubble capsules needed.

Bubble capsules are applied by stapling or otherwise attaching them to trees, snags, shrubs, fence posts or any other object (Fig. 3). They are usually applied at a height that applicators can easily reach (i.e., 6-8 feet), but they can be placed higher in areas such as campgrounds or residential sites where it is likely that they may be disturbed. Ladders or a special long-handled hammer, known as a Hundle hammer, can be used to attach bubble capsules at a height where they are beyond reach.

Figure 3. MCH bubble capsule stapled to a tree.

If it is necessary to achieve the proper spacing, they can also be attached to objects such as stumps or logs as low as 1-2 feet above the ground. They should be attached on the north side of trees and snags where possible to protect them from direct sunlight, although this is not critical for an effective treatment.

MCH contained in a bubble capsule diffuses through the plastic and is dispersed by air movement. In essence, an invisible cloud of MCH develops around the point at which it is dispensed. The shape and distribution of the MCH cloud depends upon the rate of diffusion, wind speed, and wind direction. The objective in area-wide treatment is to place bubble capsules in a pattern that results in a cloud of MCH sufficient to affect beetle behavior when beetles are searching for host trees.

Several different patterns of placing MCH bubble capsules have been used in research and operational tests and they seem to be equally effective. Since air movement disperses MCH as it diffuses out of the bubble capsules, there is a lot of flexibility in the distribution of bubble capsules provided the entire area is covered. In the following descriptions, distances between bubble capsules are only approximate and pacing is accurate enough for effective treatments. In all cases, bubble capsules should be placed about 30 feet beyond the boundary of the area to be protected to avoid an edge effect. If this is not possible, placing bubble capsules closer together along the unit boundary will also help to prevent any untreated spots. For areas less than about 2 acres, the best approach is to place the bubble capsules evenly around the perimeter of the unit. Spacing them about 15 feet apart will result in a dose close to 30/acre.

For larger areas, bubble capsules can be placed around the perimeter and in parallel lines across the unit spacing them about 15-20 feet apart (Fig. 4). The number of parallel lines and spacing between them will depend upon the size and shape of the unit. The lines of bubble capsules will need to be spaced about 115-165 feet apart to achieve the desired dose. If possible, these lines should be placed perpendicular to the expected wind direction on warm afternoons in the spring when beetles are most likely to be dispersing. After treating the perimeter and determining the number of parallel lines that will be needed to cover the unit, the remaining bubble capsules from the predetermined number needed to treat the unit should be divided into a number of lots equal to the number of parallel lines. This will help to ensure that the bubble capsules are evenly spaced across the unit. An alternative is to place the bubble capsules in an even grid pattern across the area (Fig. 5). Spacing the bubble capsules 38 feet apart in the grid will result in the desired dose. Using the grid pattern may require a little more time since more of the unit must be covered by applicators. However, this pattern may be easier for the applicators to follow and result in better coverage, particularly on large areas. Either pattern of deploying the bubble capsules will provide an effective treatment provided the unit is evenly covered. If bubble capsules are left over from the predetermined number needed to treat a given size unit, they should be evenly distributed throughout the unit or placed

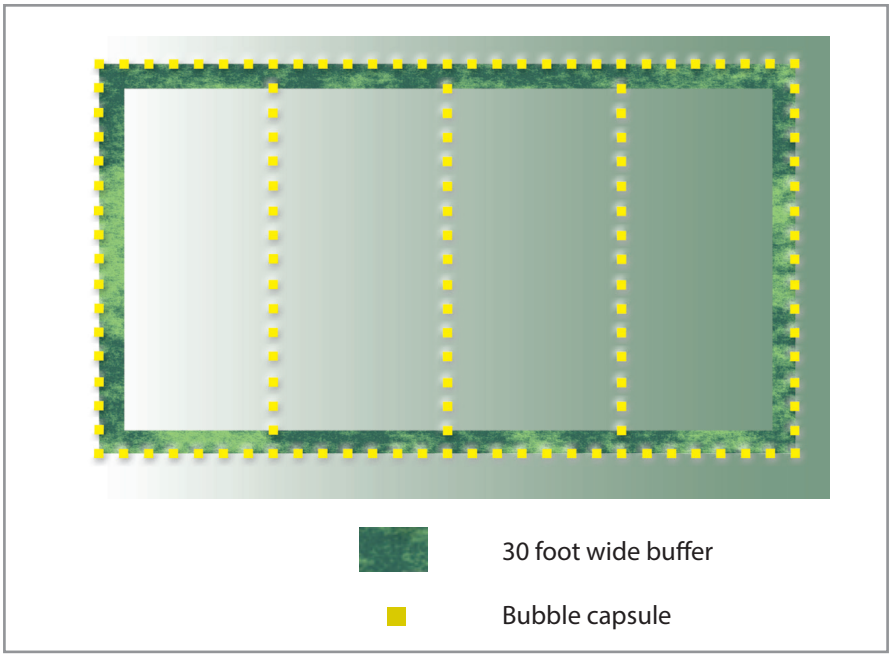

Figure 4. Diagram of the perimeter and parallel line method of deploying MCH bubble capsules. Bubble capsules are spaced about 15 feet apart and lines are spaced 115-165 feet apart. Not drawn to scale.

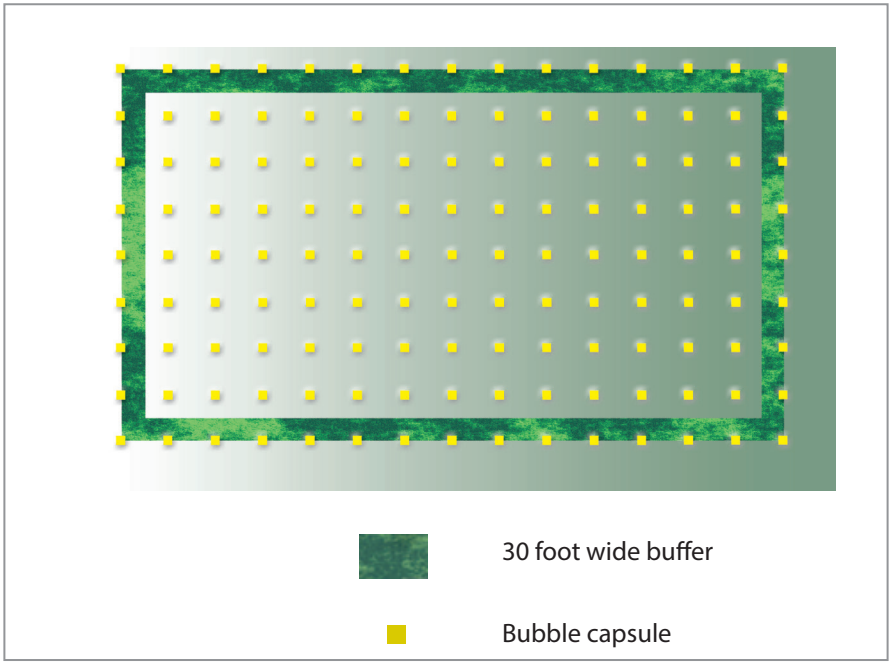

Figure 5. Diagram of the grid method of deploying MCH bubble capsules. Bubble capsules are spaced about 38 feet apart. Not drawn to scale.

Table 1. Spacing of release points with different release rates relative to the standard (1X) to insure effective treatment.

MCH release rate	Spacing in feet	Spacing in meters
Standard (1X)	38	12
2X	54	16
3X	66	20
4X	76	23
5X	85	26
6X	93	28
7X	101	31

in areas with a particularly high concentration of host trees.

Recent research has demonstrated that using higher release rates of MCH at each release point and spacing the release points farther apart to keep the MCH released per unit area the same is as effective as the established standard treatment described above. The standard treatment refers to using formulations containing about 400 mg of MCH and releasing 7-11 mg/day at a constant 25°C applied at a rate of 30 releasers/acre. Release rates as high as seven times (7X) the standard rate with correspondingly wider spacing were as effective as the standard treatment. However, a nine times (9X) higher release rate was not effective for protecting trees from infestation. Consequently, the threshold for effective treatments is in the range of 7-9 times the standard. Consequently, we recommend that operational treatments not exceed 4-5 times the standard to provide a margin of error and ensure treatment efficacy. The appropriate spacings for releasers on a grid pattern at correspondingly higher release rates are listed in Table 1. At the present time, only one manufacturer produces MCH formulations that release at higher rates than the established standard release rate. That formulation releases at two times the standard. Higher release rates can be achieved by placing multiple releasers at each release point, e.g. 4 standard releasers at each point to achieve a four times (4X) higher release rate.

For all areas less than ½ acre, a minimum of 16 bubble capsules should be evenly placed around the unit boundary. Although this is a higher dose than recommended for larger units, it is necessary to ensure complete coverage of small areas.

Individual-tree tests and operational use since 2001 have consistently shown 2 bubble capsules per tree placed on opposite sides of the tree will protect all but the largest susceptible Douglas-fir. For trees larger than 24 inches dbh, we suggest 4 bubble capsules per tree placed equidistantly around the bole. Height of placement is not critical; however, it may be preferable to place them out of reach (10-12 feet from the ground) in recreational areas. Campgrounds and residential areas wih scattered, large Douglas-fir trees are ideal for an individual tree

protection strategy.

If bubble capsules are left in place after treatment, they will eventually fall to the ground and become less noticeable as they break apart over time. However, if this is unacceptable, they can be collected and disposed of after the beetle flight period has ended. Bubble capsules should not be collected before September.

Checklist for Prescribing and Applying MCH

- Seek guidance from a forest health management specialist.
- Determine if the stand is at high risk for Douglas-fir beetle infestation
    - Does the stand have a significant component of large, old Douglas-fir trees?
    - Has the Douglas-fir beetle been causing mortality in the stand or adjacent stands in recent years?
    - Has there been a disturbance such as a fire or windstorm that killed or weakened Douglas-fir trees in the stand or adjacent stands in the last 2 years?
- Develop MCH prescription consistent with an integrated resource management plan
- Determine size of the treatment area
- Determine number of bubble capsules needed to treat the area
- Order bubble capsules and store in a freezer, refrigerator or cold room whenever possible
- If necessary, flag treatment area boundaries and lines through the unit to facilitate the application
- Avoid prolonged exposure to bubble capsule fumes during transport and application
- Wear gloves when handling bubble capsules
- Apply bubble capsules at 30/acre before the third week in April in the interior Pacific Northwest and northern Rocky Mountains
- Attach bubble capsules at a height of 6-8 feet on the north side of objects
- In high use areas, attach the bubble capsules at a height that is out of reach
- If desired, collect bubble capsules no earlier than September
- Evaluate treatment effects one year after the application
- Re-treat the area each year that Douglas-fir beetle infestation is likely

Appendix

Pheromone Names

Common name	Chemical name
Frontalin	1,5-dimethyl-6,8-dioxabicyclo[3.2.1} octane
Seudenol	3-methylcyclohex-2-en-1-ol
MCOL	1-methylcyclohex-2-en-1-ol
MCH	3-methylcyclohex-2-en-1-one