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Douglas-fir Beetle Management

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Key Points

- Prevent outbreaks by removing windthrow and other damaged trees.
- Trap trees are effective in reducing local populations.
- Use hazard rating to identify susceptible stands.
- Pheromones can provide short-term protection of high-value trees.

***Dendroctonus pseudotsugae* Hopkins**

Douglas-fir beetle is the most destructive bark beetle of Douglas-fir in the northern and central Rocky Mountains.

Outbreaks are brief but damaging

Epidemics, though usually short-lived, may devastate susceptible stands before subsiding. Outbreaks are usually triggered by a disturbance such as wind-throw, fire scorch, or defoliation. Populations expand rapidly in such weakened material and subsequent generations of beetles attack and kill surrounding green trees. During outbreaks, groups of dead trees may total 100 or more and yearly mortality may extend into the millions of board feet. As more of the susceptible hosts are killed, and attacking beetles are forced into increasingly-less susceptible trees, populations decline. Thereafter, mortality is confined to individual trees or small groups. Low beetle populations are maintained in root diseased or other weakened trees.

Outbreaks typically last 2 to 4 years but may be prolonged during periods of drought.

Management options for Douglas-fir beetle include :

1. **Prevention. Prompt salvage of windthrown, fire damaged, or defoliated Douglas-fir; judicious timing of logging and prompt removal or disposal of logs, large slash and cull material to eliminate potential brood sites.**
2. **Hazard Rating and Stand Manipulation. Identification and silvicultural treatment of high-hazard stands to reduce susceptibility.**
3. **Trap Trees and Pheromone Tree Baits with Tree Removal. Felled trap trees and attractant pheromone baited trees are used to lure beetles into logs and trees that will be removed and processed.**
4. **Anti-aggregation Pheromones. Used to protect high-value trees and stands or prevent beetle colonization of windthrown trees.**

Recognizing Douglas-fir beetle attacks

Orange-brown boring dust is evidence of successful attack by Douglas-fir beetle.

Evidence that a tree has been successfully attacked is orange-brown boring dust found in bark crevices on the lower portion of the tree's bole or on the ground at its base. Wind and rain may remove the dust, however, and since beetle attacks are often high on the bole, careful inspection may be required to determine if beetles are present. An occasionally evident sign of infestation may be clear resin streams which have exuded from the upper level of attacks-typically 30 to 35 feet off the ground. These pitch streamers are often visible for a considerable distance. Streams of pitch lower on the bole may be evidence of unsuccessful attacks or other injury. As a rule, successful attacks can only be confirmed by removing sections of bark to reveal egg galleries, eggs, and/or developing brood.

Distinctive egg galleries are constructed beneath the bark by female beetles as they bore upward through the phloem. Galleries are parallel to wood grain and are commonly 8 to 10 inches in length, usually longer in downed logs. Eggs are laid in groups, alternately along opposite sides of galleries. After hatching, larvae mine outward from, and perpendicular to, the egg gallery as they feed in the phloem.

Several months after a tree has been attacked, its foliage begins to discolor. Needles first turn yellow, then orange, and finally a reddish brown. Discoloration rate varies with local conditions and individual trees. During dry years, trees fade more quickly-occasionally becoming yellowish-green to orange later the same year they are attacked. Typically, trees begin to fade the year following attack. Tree-to-tree fading also varies with resistance to the pathogenic fungi introduced by the beetles.

Egg galleries of Douglas-fir beetle are vertical and the larval galleries are in alternating groups.

Recognizing Douglas-fir beetle

When the larvae have completed their development, they construct pupal cells at the ends of their feeding galleries. Pupal cells may be well within the bark. Larvae are white, legless grubs with brown heads; pupae white to cream-colored. Immature beetles are light brown, becoming dark brown to black, with reddish wing covers, as they mature. Some beetles may be totally black.

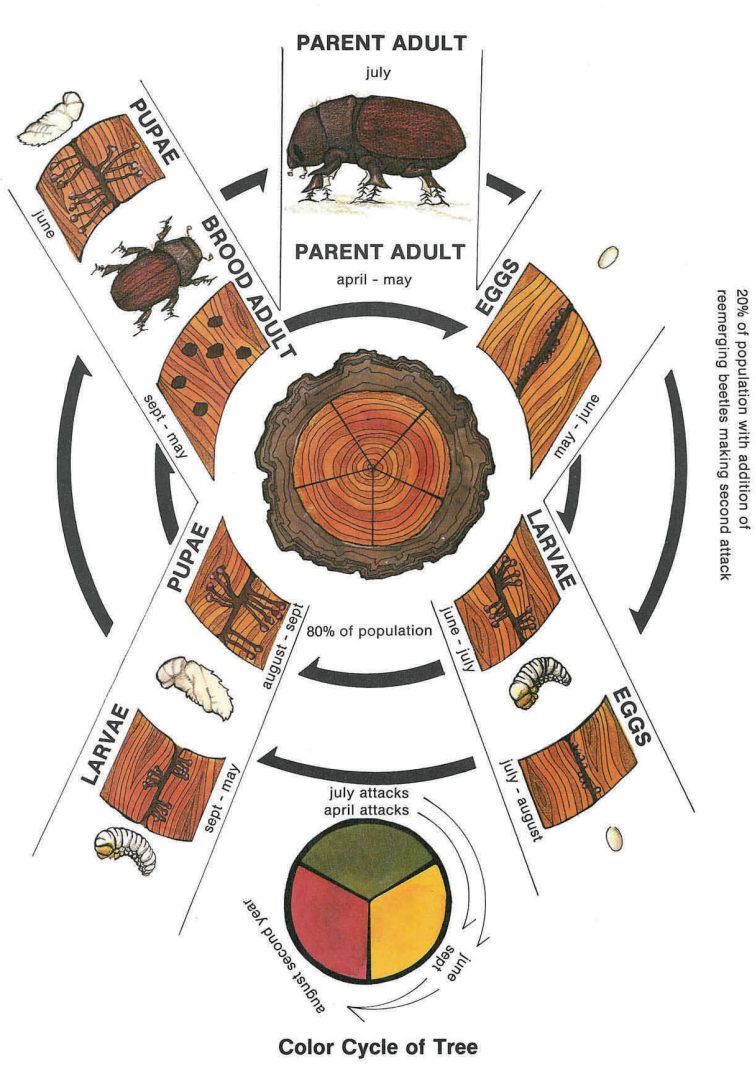
Life History

Douglas-fir beetle has one generation each year. Over wintering takes place beneath the bark of the tree in which they developed and occurs mainly as adults. A small percentage may over winter as larvae. Spring emergence of adult beetles varies with location and weather, but usually occurs from mid-April to early June. Beetles that have passed the winter as larvae complete their development in spring and early summer. Those emerge and attack host trees in mid-summer.

In addition, a few adults that made initial attacks in the spring may re-emerge to make a second attack in mid- to late-summer. This second flight (in some years nearly a continual flight) usually accounts for less than ten percent of the yearly total of attacked trees. Often, these later attacks fill in trees which were attacked during the initial spring flight.

Broods require one year to complete their development. Beetles emerging in spring are from the previous spring's brood and beetles flying later in the summer are typically from summer broods.

Western larch may occasionally be attacked, but successful brood development has only been recorded in downed trees.



Trees killed by Douglas-fir beetle will have red crowns several months after a successful attack.

Douglas-fir beetle has one generation each year.

Characteristics of Susceptible Douglas-fir Stands

Old, dense stands of large diameter Douglas-fir are highly susceptible.

Density
Density-related factors reflect the importance of moisture stress and shaded-stem environment. The denser the stand, the higher the susceptibility to beetle attack. Data suggest stands over 80 percent of normal stocking are most vulnerable.

Habitat Type and Species Diversity.
No definitive correlation between habitat type and beetle- caused mortality has been developed. However, mortality is usually greatest on the more moist habitat types where Douglas-fir grows most productively. Warm, dry sites may produce susceptible stands unless they are so harsh that tree growth is sparse and slow. Little mortality has been observed on most of the subalpine fir types in which Douglas-fir is seral. The most susceptible stands have a high percentage of Douglas-fir.

Douglas-fir beetle often kills groups of adjacent trees in successive years. Older dead with a little remaining foliage are commonly found near recent mortality. Groups such as this are a good place to look for fresh attacks which will have boring dust on stems but green crowns. However, groups of beetle killed trees can also occur miles from previous year mortality.

Stand Age and Tree Diameter.
Average age of most Douglas-fir killed exceeds 120 years. In outbreaks and in densely-stocked stands, younger trees may be killed. Larger diameter dominant and co-dominant trees are more susceptible than intermediate and suppressed trees.

Disease.
There is a relationship between root-diseased Douglas-fir and endemic populations of beetles. That relationship is not as pronounced during outbreaks. The presence of root disease in mature trees likely contributes to their susceptibility to beetle attack by exacerbating the effects of moisture stress.

Injury.
Injuries such as wind and snow breakage, fire scorch, or defoliation predispose trees to beetle attack.

Resistance to beetle population expansion increases as:

1. susceptible trees are killed by beetles,
2. stand density is reduced through harvesting,
3. or environmental stress is reduced through improved moisture/ weather conditions.

As infested-group size declines, and a higher proportion of attacked trees survive, natural enemies of the beetle play a bigger role in population reduction. Populations are then maintained at endemic levels through host resistance and natural enemies until conditions conducive to population buildup occur once again.

Reducing Stand Susceptibility

Reducing stand susceptibility is best accomplished by changing one or more of the "high hazard" conditions through some type of stand manipulation. Alternatives include commercial thinning, or any of the several regenerative methods, which will help meet stand and site resource objectives. Any method which will ultimately reduce stocking, percent of Douglas-fir, average stand age or size, will produce stand conditions less favorable to Douglas-fir beetles.

In many Douglas-fir forests, the presence of root disease should be considered and evaluated before thinning. Any type of partial cutting in root-diseased stands can increase root disease severity, spread, and subsequent tree mortality.

A necessary first step in the prevention of beetle outbreaks is the identification of stands most likely to support an epidemic-hence, the value of a hazard-rating system.

Hazard Rating: Identifying susceptible stands

Stand susceptibility is based on characteristics associated with past outbreaks. Furniss, and others (1979), stated stand susceptibility is positively correlated with the proportion of Douglas-fir in the stand, its density, and its age.

Furniss, and others (1981), identified individual tree susceptibility characteristics as well as those factors which seem to delimit susceptible stands. Trees on which attacks are more dense and successful are those which are older, larger, more dominant, and more productive of attractant resins.

Landscape-scale hazard rating

A technique to query stand data for hazard classification has been developed by Randall and Tensmeyer (1999).

Stands are hazard rated according to the system of Weatherby and Thier (1993). This system provides an easy way to hazard rate stands over a landscape and can help prioritize areas for treatment.

Weatherby and Thier (1993) Hazard Rating system for the Intermountain West

Based largely on the observations of Furniss, and others (1981), but on other published and observed data as well, their hazard-rating system enumerates the following **"high hazard"** conditions for Douglas-fir stands:

Stand density:
- Stocking greater than 250 square feet basal area

Percent Douglas-fir in stand:
- Greater than 50 percent

Average stand age:
- Greater than 120 years

Average diameter Douglas-fir sawtimber:
- Greater than 14 inches

Risk Rating:
Predicting levels of mortality in highly susceptible stands

Preventive management is the most effective and economical method of reducing mortality attributable to the beetle.

Model to Predict mortality
(Negron and others 1999)

A model to predict Douglas-fir beetle-caused mortality in highly susceptible stands of Douglas-fir

For western Montana/northern Idaho, for Douglas-fir stands of otherwise high-hazard conditions this formula can be used to approximate anticipated beetle-caused tree mortality.

DF mortality = 13.2 + 0.33(DF basal area)

The following damage class levels based on Douglas-fir basal area and average basal area killed by DFB were determined

Douglas-fir Basal Area (ft^2/acre)	Risk of Tree Mortality	Average Douglas-fir Basal Area Killed by DFB (ft^2/acre)
<115	Low	37
115-230	Medium	69
>230	High	112 or more

Factors initiating outbreaks

Douglas-fir beetle outbreaks are typically initiated by some type of stand disturbance-the most common being windthrow, snow breakage or other weather-related phenomena. Downed trees, logs, or other large-diameter debris are very attractive to Douglas-fir beetles. Partially burned trees after fires and trees defoliated by western spruce budworm or Douglas-fir tussock moth may also trigger outbreaks. Beetles are capable of building high populations in such material in a short period of time because of little or no host resistance. New generations emerge and attack susceptible green trees in the surrounding stand. Once an outbreak has started it normally lasts 2-4 years in an area. During droughty conditions, the beetle outbreak may be prolonged for several years.

Prompt Removal of Windthrow

Timely salvage of down, damaged or severely weakened Douglas-fir is a primary means of preventing beetle outbreaks. Such activity must be accomplished either before beetles attack it initially, or before they emerge the following spring. Beetle-infested material, hauled from the woods, must be processed prior to beetle flight to prevent new outbreaks from being initiated near mill sites.

Trap Trees

Because Douglas-fir beetles prefer freshly downed trees to standing ones, a trap-tree program can be useful in suppressing beetle populations. Beetles are so effectively attracted to felled trees that green trees in the area are rarely attacked except for a few standing trees immediately adjacent to the downed trees. Trap trees are used to lure beetles into felled trees that will be subsequently removed.

Trap trees should be cut prior to beetle flight in early spring (by April 1). Trap trees could be dropped in late fall, if done sufficiently late that they don't dry significantly before spring. Felled trees should be cut in groups of 3 to 5 trees. Diameters should be 15 inches or larger. Trees should be dropped in the shade and left unlimbed and unbucked. Trees left in the sun, or where a major portion of the bole receives direct sunlight, do not attract beetles nearly as well as those in a shaded environment. Trap trees should be left on site until about mid-July to attract beetles throughout their flight period. They should be removed as soon as practical following beetle flight but certainly before the next generation of beetles fly the following April 1. If infested logs are not subsequently removed, tree mortality will likely increase.

Trap trees must be removed as soon as practical following beetle flight to be effective.

Timing of Harvest

An adjunct to a trap tree program is the judicious timing of harvests to take advantage of the beetles' natural attraction to downed trees. Trees dropped in early spring, prior to about April 1, and left through beetle flight, can attract and hold beetles to the site being harvested. This technique can effectively prevent any beetles in the area from dispersing to other sites. Again, infested trees must be removed before subsequent beetle emergence.

A common and practical application of this technique is to cut the right-of-way trees immediately prior to, or during beetle flight and allow the cut trees to serve as trap trees. The cut trees need to be removed prior to fall snows to assure the brood is removed from the forest.

Attractant pheromone tree bait

Pheromones

Attractant pheromones to manipulate beetle populations

When contemplating harvest in Douglas-fir forests with low beetle populations, attractant pheromone tree baits can be used to keep beetles in a specific stand that is scheduled for removal. Tree baits can be used in planned clearcuts, along rights-of-way, or in any other situation where beetle populations exist and baited trees are certain to be removed following their attack. Attacked trees must be removed prior to the next generation of beetle flight or additional tree mortality is likely to occur. Tree baits effectively attract beetles not only to the baited tree, but there is almost always "spill over" to adjacent, unbaited trees. Harvest plans should include removal of all attacked trees. In partial cutting, tree baits should be used with caution to make sure that beetles do not attack any selected leave trees.

MCH provides short-term protection of high-value trees but must be applied before beetles fly in the spring.

Anti-aggregation pheromones to protect trees and stands

MCH (3-methylcyclohex-2-en-1-one) is a natural anti-aggregation pheromone produced by Douglas-fir beetles to prevent overcrowding and optimize brood survival in individual trees or logs. It gives a "no vacancy" signal to other beetles in the area, causing them to avoid an already fully colonized tree. Commercially available MCH is a tool that can be used to protect trees and stands from Douglas-fir beetle-caused mortality that would adversely impact resource management objectives. MCH can also be used to reduce beetle colonization of windthrown trees and therefore prevent population buildup and subsequent tree mortality.

MCH has been synthetically produced and formulated in two different, currently registered, releasing devises:

- plastic bubble capsules that are stapled to individual trees
- tiny polymer flakes that are aerially applied

MCH has successfully provided short-term protection of trees in campgrounds, administrative sites, and high value stands. However, this temporary approach should only be applied until stand conditions are changed to be less susceptible to Douglas-fir beetles or until beetle populations subside. To be most effective, MCH should be applied before beetles fly in the spring. For more specific information in using MCH bubble caps, see Ross et al. 2006.

Above: MCH bubble capsule

Right: MCH polymer flakes

Natural Control

According to Furniss and Orr (1978), resistance of live trees is the most important natural factor controlling Douglas-fir beetle populations. As an outbreak progresses and beetles are forced into increasingly less susceptible trees, the proportion of unsuccessful beetle attacks increase and populations decline.

Climate and weather also influence beetle populations. A sudden, severe cold snap in late fall before beetles are prepared for winter can cause significant beetle mortality. Prolonged cold, rainy spring weather may disrupt the beetles' flight period. At the other extreme, droughty conditions stress host trees and favor population buildups.

Naturally occurring parasites and predators play a role in population reduction during non-outbreak conditions, but apparently are not important regulating factors when beetle populations are extremely high during outbreaks. The most important insect parasite is a Braconid wasp which parasitizes the beetle's larval stage. Predators include Dolichopodid flies, the larvae of which prey upon beetle larvae; and Clerid and Ostomid beetles which are predaceous on both the larval and adult stages.

Woodpeckers feed on wood borers in Douglas-fir trees but have minimal effect on Douglas-fir beetle populations.

Predatory beetles that help to keep bark beetle populations in check.

The checkered beetle (Clerid) is predatory on adult bark beetles.

Ostomid adult beetle. They are predatory on adult bark beetles; attacking them on the outside of the tree.

This is the larval form of a predatory beetle. It preys on bark beetle larvae under the bark of attacked trees.

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Forest Health Protection and State Forestry Organizations

Assistance on State And Private Lands

Montana: (406) 542-4300

Idaho: (208) 769-1525

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Nevada: (775) 684-2513

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