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The Spruce Beetle

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Figure 1 — Yellowish orange and reddish colors of faded spruce are evidence of an intense spruce beetle infestation in Alaska.

The spruce beetle, *Dendroctonus rufipennis* (Kirby), is the most significant natural mortality agent of mature spruce. Outbreaks of this beetle have caused extensive spruce mortality from Alaska to Arizona and have occurred in every forest with substantial spruce stands. Spruce beetle damage results in the loss of 333 to 500 million board feet of spruce saw timber annually. More than 2.3 million acres of spruce forests have been infested in Alaska in the last 7 years with an estimated 30 million trees killed per year at the peak of the outbreak. In the 1990's, spruce beetle outbreaks in Utah infested more than 122,000 acres and killed more than 3,000,000 spruce trees. In the past 25 years, outbreaks have resulted in estimated losses of more than 25 million board feet in Montana, 31 million in Idaho, over 100 million in Arizona, 2 billion in Alaska, and 3 billion in British Columbia (fig. 1).

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Spruce beetle outbreaks cause extensive tree mortality and modify stand structure by reducing the average tree diameter, height, and stand density. Residual trees are often slow-growing, small and intermediate-sized trees which eventually become dominant.

Spruce beetle outbreaks can affect non-timber resources as well. For example, as mature spruce are killed, forage may increase benefiting some wildlife species. But species that depend on mature spruce or clumps of spruce to meet habitat requirements may be adversely affected. There has been a significant change in fuel type and an increase in large woody debris accumulating on the forest floor following spruce beetle outbreaks in Alaska. Uncharacteristic, stand-replacing fires occurred in central Idaho spruce stands following 10 years of spruce beetle outbreaks. Extensive spruce mortality can also affect water yields resulting in water increases in rivers, lakes, and streams because of reduced transpiration from dead and dying trees. Scenic quality may also be diminished throughout affected landscapes.

Hosts

The spruce beetle infests all species of spruce within its geographic range (fig. 2). The more important commercial species of spruce attacked include white (*Picea glauca* [Moench] Voss), Lutz (*P.* X *lutzii* Little), Sitka (*P. sitchensis* [Bong.] Carr.), and Engelmann (*P. engelmannii* Parry ex Engelm.).

Evidence of Infestation

On standing trees, the first sign of spruce beetle infestation is reddish-brown boring dust accumulating at the beetles' entrance holes, in bark crevices, and on the ground around the trunk of infested trees. Masses of pitch may accumulate around entrance sites. These signs are most visible during the summer of attack and become less noticeable the following season.

Figure 2 — The geographic range of the spruce beetle.

On windthrown trees and logging residuals, spruce beetle attacks are readily detected on the lower surfaces of the material and should not be confused with engraver beetle (*Ips* spp.) attacks more commonly found on the upper surfaces.

Some standing trees may be attacked on only one side of the bole, creating a "strip attack." The infested area may die, but the tree usually remains alive so the foliage does not discolor. Trees with "strip attacks" frequently are infested by subsequent spruce beetle generations and may host two or more generations simultaneously.

During the first fall and winter following spruce beetle infestation, look for trees "debarked" by woodpeckers (fig. 3). Partially debarked, green trees are easily noticed. However, on trees without significant debarking, one must be relatively close to see boring dust in bark crevices and around the tree base.

The needles of infested trees do not usually fade or discolor within the first year following attack. However, during the second summer most needles turn yellowish-green or orange-red (Alaska). Some trees remain green until the third summer or up to 2 years after the initial infestation. The needles on separate branches of the same tree discolor at different times. Needles on infested trees commonly drop as a result of wind or thunderstorms the second summer after the tree was attacked. Upper crowns first turn yellow to reddish-orange. Entire crowns later turn grey.

Figure 3 — Infested spruce debarked by woodpeckers.

Identification of Life Stages

Adult beetles are dark brown to black with reddish-brown or black wing covers. The beetles are cylindrical, approximately 1/4 inch long, and 1/8 inch wide (fig. 4).

Spruce beetles are similar to other *Dendroctonus* beetles and, if no host material is present, can only be distinguished by microscopic examination. At first glance, spruce beetles may also be confused with *Ips* beetles in spruce. It is important to remember that the posterior margins of the wing covers on spruce beetles are evenly rounded, while *Ips* beetles have concave margins with teeth like projections.

Eggs of the spruce beetle are oblong, pearly white, and 1/16 inch long. The cream-colored larvae are stout, cylindrical, legless grubs that pass through four larval stages (instars) and reach a length of l/4 inch at maturity. The pupae are opaque, inactive, and somewhat similar in size and shape to adults.

Figure 4 — An adult spruce beetle.

Life Cycle

Spruce beetles may complete their life cycle in 1 year on warm sites at lower elevations or take up to 3 years in cool, well-shaded locations on north slopes.

However, throughout most of its range and in most seasons, 2 years are generally required for the spruce beetle to complete its life cycle. Although adults may emerge any time from May to October, depending on temperature, most attacks occur in early summer. Adult beetles attack host material soon after emerging. Adults that appear in August to October may represent a re-emergence of parent adults or a movement of maturing brood adults to hibernation sites.

To deposit eggs, females bore through the outer bark of host trees and create egg galleries in the underlying phloem tissue. Eggs are laid on either side of the egg gallery (fig. 5). Egg galleries are slightly wider than the beetle and, except for the terminal portion, are packed with frass and boring dust. Egg gallery length ranges from about 2.5 to 12 inches (fig. 6). Eggs are usually deposited in short rows along alternate sides of the gallery in numbers ranging from 10 to 30 eggs per inch of gallery.

Figure 5 — Spruce beetle eggs along side of egg gallery.

Figure 6 — Spruce beetle larval galleries.

Most eggs hatch by August. Larvae bore outward from the egg gallery and feed as a group for the first and second instars. Third and fourth instars construct individual feeding galleries. The larval stage dominates during the first winter, although parent adults and eggs may also be present. During the 2-year life cycle, most larvae pupate approximately 1 year after attack.

Pupation lasts 10 to 15 days and usually takes place in pupal chambers at the end of larval galleries.

During the second winter of the 2-year life cycle in standing trees, some beetles overwinter in their pupal sites but the majority, often as high as 95 percent of the new adults emerge, move to the base of the tree, and bore into the bark near the litter line to overwinter. Overwintering at the base of the infested tree reduces predation by woodpeckers and reduces winter mortality due to extremely cold temperatures. In windthrown trees, most adults overwinter in place.

Approximately 2 years after attack, adults emerge from overwintering sites and attack new host material.

Stand Conditions Conducive To Infestations

Endemic spruce beetle populations usually live in windthrown trees (fig. 7). When populations increase to high levels in downed trees, beetles may enter susceptible, large-diameter standing trees. Most outbreaks in standing timber originate in windthrown trees.

In mature stands, larger diameter (> 18 inches d.b.h.) trees usually are attacked first, an obvious characteristic denoting susceptibility to spruce beetle attack. If an infestation persists in a stand, smaller diameter trees are attacked. Recent evidence from Alaska indicates that tree diameter is important in determining susceptibility only when coupled with less-than-average radial growth in the preceding 5 years.

In the Rocky Mountain area, susceptibility, or hazard of a stand to spruce beetle attack is based on physiographic location, tree diameter, basal area, and percentage of spruce in the canopy. Spruce stands are highly susceptible if they grow on well-drained sites in creek bottoms, have an average d.b.h. of 16 inches or more, have a basal area greater than 150 square feet per acre, and have more than 65 percent spruce in the canopy.

In Alaska, susceptibility of a spruce stand is based on average tree diameter, age of stand, condition of the stand, and proportion of spruce in the canopy. A spruce stand of old-growth or damaged host trees is susceptible to spruce beetle attack, particularly if larger diameter trees have a slower-than-average growth rate, have an average d.b.h. greater than 12 inches, and if the stand is more than 70 percent spruce.

Susceptibility of a spruce stand to spruce beetle attack in British Columbia and the northeastern United States is based on criteria similar to that used in the Rocky Mountains and Alaska.

Hazard and risk (= probability of an outbreak) rating systems based on the stand and site conditions discussed above have been developed which enable managers to identify stand susceptibility to spruce beetle attack.

Figure 7 — Windthrown trees and large diameter logging residuals — prime habitats for beetle populations.

Management Strategies

Forest managers can develop various strategies to avoid or reduce resource losses to spruce beetles. Before developing a strategy, the forest manager must evaluate resource values and economics of management actions for each stand combined with overall management objectives. The beetle population level must also be considered because population levels will determine the priority of management actions and the type of strategy to be invoked.

A principal strategy that should be considered for susceptible sites would consist of silvicultural treatments of moderate-to-high hazard stands that result in maintaining their health with a moderate growth rate. The first step in this strategy is to hazard rate spruce stands, which will designate the most susceptible stands. Moderate-to-high hazard stands can then be treated using silvicultural strategies that reduce stand susceptibility. Infested logging residuals will not become a significant contributor to spruce beetle populations if stump height is kept below 18 inches and cull logs and tops are limbed, cut into short lengths, and left unshaded, unpiled, and exposed to sunlight. Silvicultural treatments have greater long-term effectiveness because treatments modify stand conditions that contribute to spruce beetle population increases.

Silvicultural strategies may be more effective if beetle populations are not immediately threatening resource values. If beetle populations are threatening, then strategies that include suppression methods are more appropriate. Suppression methods, including silvicultural, physical (fire and solar heat), and chemical measures, are available to forest managers for reducing spruce beetle populations. Some methods are suitable only for populations in windthrown host material; other methods are better suited for infestations in standing trees. Most

Figure 8 — Green trees ("trap trees") felled to capture emerging spruce beetles.

suppression methods are short-term responses to existing beetle populations and, therefore, address only an immediate need.

Silvicultural Methods

Sanitation overstory removal entails removal of all infested and susceptible spruce to encourage regeneration of a new vigorous stand. Sanitation partial cut includes the removal of infested and susceptible spruce to improve the growth of the residual stand. Sanitation partial cuts remove most of the larger trees but may leave a residual stand that is below the recommended level of basal area. This residual stand may be more susceptible to windthrow. Pruning the lower one-third of the live crown of smaller diameter trees significantly reduces the susceptibility of spruce to beetle attack in Alaska.

- **Trap trees** are green trees with a d.b.h. greater than 12 inches that are felled before beetle flight. Trap trees can absorb up to 10 times the number of spruce beetles that a standing tree will absorb. Once infested, trap trees **must** be removed.

Trap trees shaded from direct sunlight attract the most beetles. Spruce beetles attack cool, shaded portions of the trap tree boles (fig. 8). Felled trees should not be delimbed. Limbs on the upper side of the bole provide shade while limbs on the underside permit the beetles to colonize the underside of the bole by keeping it off the ground.

Past ratios of trap trees to infested standing trees have ranged from 1:2 to 1:10. Current ratios vary with the size of the green trees to be felled as traps compared to the number and size of infested trees and the existing beetle population.

Physical Methods

● **Solar heat** involves exposing infested logging residuals or windthrow to direct sunlight to kill inhabiting larvae. To maximize brood mortality, all host material greater than 8 inches d.b.h. should be cut into 5-foot lengths. All branches and debris shading the host material should be removed. The infested material should be rotated at 2-week intervals during the summer to expose all surfaces. While using solar heat is effective on some sites in the Rocky Mountains, it is not effective in Alaska because summer temperatures are not warm enough.

Fire involves piling and burning infested logging residuals and windthrow to destroy inhabiting broods. The infested material is usually green and difficult to burn, but only the bark has to be burned to destroy the inhabiting brood.

Chemical Methods

● **Pheromones** are chemical substances produced by insects that influence their behavior. Synthetic aggregating and anti-aggregating pheromones increase attractiveness of trap trees, attract beetles into trees to be cut, or discourage infestation of high-value trees. Aggregating pheromones are effectively used with trap trees. Under some circumstances, aggregating pheromones have also been used successfully in catchment traps to reduce small, isolated beetle populations.

● **Insecticides**, such as carbaryl and pyrethroids, can be applied to the boles of uninfested trees to kill attacking adults. In Alaska, carbaryl applied as a 2 percent spray has provided 100 percent protection from attacking beetles for at least 2 years.

Assistance

More information about the management of the spruce beetle may be obtained from the State Forester's office or the U.S. Department of Agriculture, Forest Service, Forest Health Protection.

The publications listed in the references provide more information on the biology, ecology, and management of the spruce beetle.

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