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Douglas-Fir Tussock Moth

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The Douglas-fir tussock moth (*Orgyia pseudotsugata* McDunnough) is an important defoliator of true firs and Douglas-fir in Western North America. Severe tussock moth outbreaks have occurred in British Columbia, Idaho, Washington, Oregon, Nevada, California, Arizona, and New Mexico, but the area subject to attack is more extensive (fig. 1).

Outbreaks of the Douglas-fir tussock moth appear to develop almost explosively, and then usually subside abruptly after a year or two. Some outbreaks in New Mexico, however, have persisted in the same general area for as long as 7 years. During a severe outbreak, caterpillars are found crawling on the ground or on

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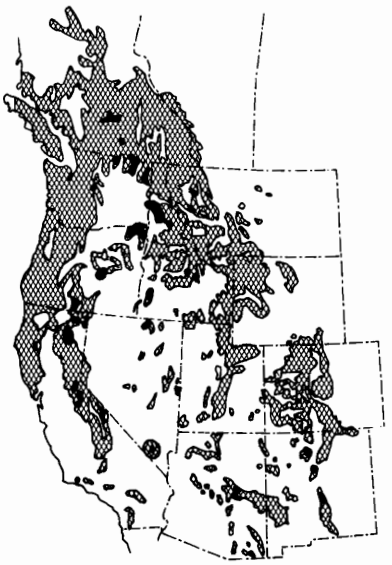

Figure 1.—Distribution of host type where Douglas-fir tussock moth may be found and location of outbreaks.

trees, brush, and buildings, but once an outbreak subsides, finding caterpillars is difficult.

Defoliation by the tussock moth kills or top-kills many trees, weakens additional trees that are eventually killed by bark beetles, and retards tree growth for several years. For example, a very large outbreak in the Blue Mountains of Oregon and Washington killed 39 percent of all trees in the heavily defoliated areas. Within these areas were patches where nearly all the trees died. Top-kill in the heavily defoliated areas amounted to 10 percent of the grand fir and 33 percent of the Douglas-fir.

Outbreaks of the tussock moth have caused similar serious damage in British Columbia, Idaho, California, and New Mexico (fig. 2).

Hosts

The tussock moth has three preferred hosts, and its preference appears to depend on locality. In the northern part of its range (British Columbia and northern Washington) Douglas-fir is preferred; in the central area (southern Washington, Oregon, and Idaho), Douglas-fir, white fir, and grand fir are all equally acceptable. In the south (California, Nevada, Arizona, and

Figure 2.—A stand of white fir in northeastern California heavily damaged by defoliation from the Douglas-fir tussock moth. F-701857

New Mexico), white fir is the preferred host.

In any locality, after the caterpillars have eaten the preferred foliage, they feed on many other trees and understory shrubs. Larvae have been found feeding on subalpine fir, red fir, ponderosa pine, Jeffrey pine, sugar pine, lodgepole pine, western hemlock, Engelmann spruce, and western larch after the preferred hosts have been stripped.

The insect also infests ornamental spruce and fir trees in many montane cities and towns. Some infestations occur on ornamental spruce many miles from the nearest host forests known to be infested with tussock moth populations.

Damage

Usually the first indication of attack appears in late spring. Larvae from newly hatched eggs feed on current year's foliage, causing it to shrivel and turn brown (fig. 3). These larvae are inconspicuous, but by mid-July they are larger, more colorful, and more easily visible. At that time, they may feed on both current and old foliage, although current needles are preferred. Defoliation occurs first in the tops of trees and the outermost portions of the branches, and then in the lower crown and farther back on the branches (fig. 4).

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Figure 3.—Young tussock moth larvae feed first on the undersides of new foliage, causing it to shrivel and die.

F-701859

Figure 4.—Defoliation occurs first in the tops of trees and outermost branches where new foliage is located.

By August, as the larvae reach pupation, the upper crowns of most of the firs may be completely bare (fig. 5). At this time, large numbers of colorful caterpillars drop from defoliated trees and crawl almost everywhere. The brown tips, bare twigs, and damaged needles give the stands a brown, dead appearance (fig. 6).

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Figure 5.—By late summer, dense larval populations can completely strip the upper crown of foliage.

F-701861

Figure 6.—A stand in the Blue Mountains severely defoliated by the tussock moth.

Description

The adult male, as shown on the cover of this publication, is an ordinary looking gray-brown to black-brown moth with feathery antennae and a wingspread of 1 to 1¼ inches (2.5–3.1 cm). The forewings are gray brown and have two indistinct, irregular dark bars and two vague whitish spots. The hindwings are a contrasting brown.

The female (fig. 7) is very different in appearance, having tiny rudimentary wings, small threadlike antennae, and a large abdomen. She is usually about ¾ inch (1.9 cm) long and is grayish in color. Her abdomen is conspicuously darker at the tip because of a dense coat of exceptionally long, dark hairs. Her eggs are deposited in a mass on top of the cocoon from which she emerged. The 1-inch-long (2.5-cm) masses have a gray mottled appearance (fig. 8).

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Figure 7.—The adult female is unable to fly and remains on top of her cocoon.

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Figure 8.—Eggs are deposited in a mass on top of female cocoons.

Young larvae are ⅛ to ¼ inch (4–7 mm) long and have long, fine body hairs which later develop into tufts (fig. 9).

Mature larvae are up to 1¼ inches (3.1 cm) long and very colorful. Two long, dark tufts or pencils of hair similar to horns are located right behind the head; a similar but longer pencil is on the posterior. Four dense, buff-colored tussocks are located forward along the middle of the back (fig. 10). The rest of the body, except for the legs and head, is covered with short hairs radiating from red, buttonlike centers.

Larvae may vary from light to dark, but two main color variations are especially noticeable in mature larvae—light cream or "blonde" and dark brown or "brunette." Larval body hairs irritate the skin of some people. Those working in the woods during an outbreak may develop an itching rash from contact with the larvae or airborne caterpillar hairs.

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Figure 10.—Mature larva feeding on fir foliage.

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Figure 9.—Young larvae are very small and have long, fine body hairs.

Life Cycle

The tussock moth produces one generation each year. Adults appear from late July into November, depending on the season and location. Male flight activity is apparently stimulated by light and temperature. It begins about midday, peaks in late afternoon, and rapidly diminishes at dusk.

The female emits a sex pheromone that attracts males during their flight period. Females mate soon after they emerge from their pupal cocoon. They cling tenaciously to the outside of the cocoon and lay eggs on its surface immediately after mating. In light infestations, cocoons with their attached egg masses usually are scattered on the foliated twigs throughout the tree crowns. In heavy infestations, they are concentrated on the lower parts of trees. Where defoliation is severe, egg masses on cocoons may be bunched on the trunk, on the lower side of larger limbs, or on objects some distance from the tree.

Each female lays her eggs in a single mass (about ½ inch (1.3 cm) in diameter) of a dry, tough, frothy, substance containing many hairs from her body. She may lay only a few, or as many as 350 nearly spherical, white eggs, in one to three layers in this mass. The number of eggs per mass varies with geographical location, but on the average, egg masses from the northern part of the moth's range contain fewer eggs than those from the southern part. After egg laying is complete, the female dies, leaving the eggs to overwinter in the gray, woolly mass attached to the cocoon.

Egg hatch in late May or early June coincides with bud burst and shoot elongation of the host trees. One to seven days after the eggs hatch, the tiny, hairy caterpillars crawl to new needle growth and begin feeding.

Since the female moth does *not* fly, major dispersal is by windborne young larvae. When the larvae drop off foliage, they produce long silk threads that, combined with their hair and light weight, allow them to be carried by air currents. The distance most caterpillars travel, however, rarely exceeds 500 m (0.25 mi). Any longer range dispersal by a few individuals does not produce new outbreaks.

Larvae growth is slow at first, but becomes progressively faster as larvae pass through four to six moults. They also eat proportionately more. They require current year's foliage when young, but once they are about half grown, they can complete their development on a diet of old foliage.

Pupation occurs any time from late July to the end of August inside a thin cocoon of silken webbing mixed with larval hairs. The pupal stage lasts from 10 to 18 days, depending on temperature. Then the moth emerges to begin the life cycle again.

Natural Control

Many natural controls exist that keep the number of tussock moths low most of the time. In populations that persist at low densities, over 90 percent of the larvae and at least 75 percent of the pupae and eggs are killed each generation by natural causes. If such mortality does not take place, the population will increase rapidly.

Overwintering eggs are usually heavily parasitized by small

wasps (fig. 11). Birds, such as the mountain chickadee and red-breasted nuthatch, also feed on tussock moth eggs and may destroy a large portion of the overwintering masses.

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Figure 11.—A small wasp, *Telenomus californicus* (Ashmead), ovipositing in tussock moth eggs in the laboratory.

After the surviving eggs hatch, some young larvae are lost while dispersing from the egg mass to feeding sites on new foliage. Others are eaten by birds, spiders, and predaceous insects. Insect parasites attack all ages of larvae, but a parasitic fly, *Carcelia yalensis* Sellers, is an especially effective enemy (fig. 12). It lays its eggs on the backs of mature tussock moth larvae. The maggot enters the caterpillar's body and eventually kills the host in the pupal stage. Pupae are also killed by a variety of wasplike parasites that attack the cocoon directly. Birds also prey on cocoons and can destroy a significant proportion of the pupal population at low tussock moth densities.

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Figure 12.—A parasite fly, *Carcelia yalensis*, lays eggs on the back of a mature larva.

At outbreak numbers, tussock moth populations have escaped their usual natural controls and have been affected by additional mortality factors related to their high numbers. A nuclear polyhedrosis virus capable of wiping out large numbers of larvae and pupae usually appears only in relatively dense populations. Its presence, in combination with other mortality factors, frequently causes collapse of outbreak populations. When diseased larvae die, their internal organs liquefy (fig. 13). The virus spreads through the population when these bodies fall to the ground and rupture or lie smeared over the foliage. Virus particles may persist in the environment for many years thereafter.

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Figure 13.—Larvae killed by natural virus hang head downward from the foliage.

In the absence of viral disease, outbreak populations of tussock moth are ultimately limited by the quantity and quality of available food. Early defoliation of the current year's needles eliminates the preferred food and forces larvae to feed on less nutritious older needles. This causes starvation and lowered production and survival of eggs, and helps reduce population numbers to a level where they are again regulated by the usual natural enemies.

Applied Control

Management recommendations to prevent tree damage from tussock moth outbreaks involve four major activities: early detection, evaluation, suppression, and prevention. These activities must be well integrated to insure adequate protection from the pest.

Defoliation of trees is easily detected from the ground or air when outbreaks occur. To prevent damage caused by such defoliation, tussock moth populations that are increasing in density need to be detected early and controlled before tree defoliation occurs. Population trends can be determined by annual monitoring of adult males or larvae. Adult numbers are evaluated by attracting flying males to sticky traps with a sex pheromone. The number of larvae in the population can be estimated by sampling foliage in the lower crown of host trees. Therefore, if an outbreak is developing, it can be detected 1 or 2 years early by an increase in the number of insects, so that suppression, if needed, can be initiated before significant damage to trees occurs.

The need to suppress a tussock moth population depends on the impact an uncontrolled outbreak is expected to have on the forest. Decisions for control must be based on a thorough evaluation of the potential of the insect population and the resource values at stake. Models of insect population behavior, stand dynamics, and economic variables are available for use in integrated pest management systems.

The prevention of outbreaks is the ultimate aim of pest management. Much additional knowledge of insect-host relations and stand dynamics, however, is needed before silvicultural systems can be

prescribed to reduce susceptibility of host stands. There is some indication that fir growing in pine sites and fir stands growing on warm, dry sites are most susceptible to Douglas-fir tussock moth damage. Where offsite fir is well established and conversion to the proper tree species would be uneconomical, some form of annual population monitoring should be considered to detect increases in population numbers. The preferred way to keep losses low is to work toward healthy, thrifty stands, growing on a proper site.

Two materials are registered and available that might be used to reduce outbreak population numbers. Carbaryl is the only chemical presently registered for aerial application against the tussock moth. The microbial pesticide *Bacillus thuringiensis* (*B.t.*) is a commercially available material that is not hazardous to most beneficial insects, birds, small mammals, and aquatic systems. However, results with *B.t.* against the tussock moth have not been consistent. If control is necessary, a State or Federal pest control specialist should be consulted for current recommendations.

Caution: Pesticides used improperly can be injurious to man, 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 exten-

sion specialist to be sure the intended use is still registered.

The United States Department of Agriculture has issued a series of Douglas-fir tussock moth handbooks and additional issues are in press. Copies can be obtained from the U.S. Government Printing Office.

References

Beckwith, R. C.
1976. Influence of host foliage on the Douglas-fir tussock moth. Environmental Entomology 5(1):73–77.

Brookes, M. H., R. W. Stark, and R. W. Campbell (editors).
1978. The Douglas-fir tussock moth: A synthesis. U.S. Department of Agriculture Technical Bulletin 1585, 331 p.

Campbell, Robert W., and Lorna C. Youngs.
1978. Douglas-fir tussock moth: An annotated bibliography. U.S. Department of Agriculture Forest Service General Technical Report PNW-68, 168 p. Pacific Northwest Forest and Range Experiment Station, Portland, Oreg.

Daterman, G. E., Linda J. Peterson, Richard G. Robbins, Lonne L. Sower, G. Doyle Daves, Jr., and Ronald G. Smith.
1976. Laboratory and field bioassay of the Douglas-fir tussock moth pheromone, (Z)-6-heneicosen-11-one. Environmental Entomology 5(6):1187–1190.

Mason, R. R.
1976. Life tables for a declining population of the Douglas-fir tussock moth in northeastern Oregon. Annals of the Entomological Society of America 69(5): 948–958.

Mason, R. R.
1978. Tussock moth life tables. *In* McGraw-Hill Yearbook of Science and Technology, p. 181–183. McGraw-Hill Book Co., New York.

Mason, Richard R.
1978. Detecting suboutbreak populations of the Douglas-fir tussock moth by sequential sampling of early larvae in the lower tree crown. U.S. Department of Agriculture Forest Service Research Paper PNW-238, 9 p. Pacific Northwest Forest and Range Experiment Station, Portland, Oreg.

Mitchell, R. G.
1979. Dispersal of early instars of the Douglas-fir tussock moth. Annals of the Entomological Society of America 72(2):291–297.

Torgersen, Torolf R.
1977. Identification of parasites of the Douglas-fir tussock moth based on adults, cocoons, and puparia. U.S. Department of Agriculture Forest Service Research Paper PNW-215, 28 p. Pacific Northwest Forest and Range Experiment Station, Portland, Oreg.

Wickman, B. E., R. R. Mason, and H. G. Paul.
1975. Flight, attraction, and mating behavior of the Douglas-fir tussock moth in Oregon. Environmental Entomology 4(3):405–408.

Wickman, Boyd E.
1978. Phenology of tussock moth. *In* McGraw-Hill Yearbook of Science and Technology, p. 183–185. McGraw-Hill Book Co., New York.

Wickman, Boyd E.
1978. Tree mortality and top-kill related to defoliation by the Douglas-fir tussock moth in the Blue Mountains outbreak. U.S. Department of Agriculture Forest Service Research Paper PNW-233, 47 p. Pacific Northwest Forest and Range Experiment Station, Portland, Oreg.

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